P-1

Soil animal distribution mapping in Germany

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This study investigated the influence of soil parameters on the modelling accuracy and distribution of soil animals in Germany. The main problem, however, is that the spatial distribution of soil animals in Germany is widely unknown. As an initial step, a nationwide Lumbricidae reference map for Germany based on species distribution modelling was developed. Therefor appropriate predictors with full spatial coverage like small-scale soil data from the national soil map 1 : 200,000, climate and meteorological data   were used. Species point data were drawn from Edaphobase, a database with approximately 400,000 soil fauna find (point) data, partly with additional ecological site data. Missing data for were determined at the national level. The first model results show the spatial distribution of Lumbricidae in Germany with different distribution patterns of species and functional groups (endogeic, anecic, and epigeic). The analyses will be extended to further soil animal groups. In a later stage of the project, regionalization with the soil map polygons will enhance the usability of the results in the pan-German soil information system.
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P-2

Validation of soil erosion risk assessment using varied observational data

Dr Nikki Baggaley, Dr Allan Lilly, Dr Jacqueline Hannam, Professor Jane Rickson

Managing soils and waters sustainably relies on an understanding of areas that are at risk of causing diffuse pollution due to their vulnerability to soil degradation. A soil erosion risk assessment based on the inherent landscape characteristics of runoff based on the Hydrology of Soil Types (HOST) classification, soil texture and slope gradient was developed and applied to soil map units. Observational data from the National Soil Inventory of Scotland, previously published observations of erosion events and data collected by the Scottish Environment Protection Agency staff on catchment walks and farm visits were used to validate the erosion risk assessment and to subsequently quantify the probability of erosion occurring in mineral, organo-mineral and peat soils in each of the risk classes. The analysis demonstrates the value of systematic and non-systematic data for validating the erosion risk assessment. Limited measurements of rates of erosion were then combined with the probability of any particular land parcel/soil map unit eroding thereby quantifying the annual sediment loss. The nutrient concentrations in the soil and, therefore, in the sediment lost was used to calculate both on-field costs (cost of replacing fertiliser) and off-field cost (pollution of aquatic ecosystems) and the overall cost of soil erosion to the Scottish economy.

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P-3

Climate Smart Agriculture: Articulating the Landscape of Data and Information Challenges and Community Expertise to Support Climate Smart Agricultural Practices

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In the United States, much recent research and policy directed towards the goals of climate-smart agricultural practices that result in measurable, and verifiable carbon reductions and sequestration. This focus on agriculture in tackling the climate crisis is important, as agricultural soils and practices contribute more than 10% of U.S greenhouse gas emissions. Climate-smart agriculture is an approach to reorient agricultural systems to adapt and build resilience to climate change while reducing and/or removing greenhouse gas emissions. In supporting climate-smart agricultural practices - data are critical infrastructure, strategic assets that can enable a groundswell of activity in the areas climate action. However, there are substantial challenges and gaps within the agricultural and climate data ecosystems that need to be addressed to bring the full potential of Earth science data and information to bear on tackling the climate crisis by supporting climate smart agricultural practices.

Barbieri works with the Earth Science Information Partners (ESIP) community to assess these information challenges, and identify the gaps in data ecosystems that need to be addressed. For over 20 year ESIP has been the place where U.S. (and increasingly international) Earth science data professionals gather to work though data management challenges. We present a summary of a “Grand Challenges” white paper, highlighting the frontiers of data and information for climate smart agriculture in the United States. This includes a data ecosystem network map, connecting data expertise and outputs already in existence within the broader ESIP community that can help address the data challenges identified.

Data and information challenges were put forth as three of the top 6 grand challenges across all Earth science research towards a sustainable environment (Acocella, 2015) and examples of pressing data gaps for climate-smart and sustainable agriculture are highlighted in places such as the USDA’s recently released Innovation Strategy summary.

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P-4

A web-based operational tool for assessing the vulnerability of groundwater to pesticides

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Many policies such as the European Water Framework, Nitrate and Pesticides directives have as objective the protection of groundwater resources from non-point-source pollutants, such as those coming from agricultural practices.
The fulfillment of this objective is strongly hampered by the lack of operational tools to be used by the local, regional and national public authorities.
This work presents a new web-based, freely-available dynamical tool, named the pesticide fate tool, developed within the geospatial Decision Support system (DSS), LandSupport, for the assessment of groundwater vulnerability, specific for type of pollutant. The tool is based on the extended transfer function model, specifically expanded to consider the transport of reactive solutes, such as pesticides. The model complexity is transparent to the end-user who has only to set the area of interest, the climate (current or future), the crop and the pesticide from a drop-down menu.
Results of the model are shown through the LandSupport GUI both as colored maps, representing the relative concentration of pesticide at the arrival to the water table at the end of the simulation period, and as cumulative charts of the solute arrival at the depth of interest.
Three case studies, with different spatial scales and pedo-climatic conditions along Europe are shown.
Bancheri, M., Fusco, F., Dalla Torre, D., Terribile, F., Manna, P., Langella, G., ... & Basile, A. (2022). The pesticide fate tool for groundwater vulnerability assessment within the geospatial decision support system LandSupport. Science of the Total Environment, 807, 150793.

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P-5

A web-based operational tool for supporting the implementation of the European Common Agricultural Policy (CAP)

Dr. Angelo Basile, Dr. Giuliano Ferraro, Dr. Marco Botta, Prof. Alessia Perego, Dr. Francesco Vuolo, MSc Francesco Novelli, Dr. Piero Manna, Dr. Giuliano Langella, Dr. Marialaura Bancheri, Prof. Fabio Terribile

Many policies such as the European Common Agricultural Policy (CAP) pursue a two-fold objective: the food security in a healthy environment.
The new CAP requires that Member State have to build a plan containing an intervention strategy which includes: (i) conditionality obligations with minimum standards and good practices, (ii) must consider specific characteristics of the areas concerned, including soil and climatic conditions, land use, existing farming system, practices and farm structures, and (iii) specific design or requirements of intervention to ensure an effective contribute to the objective.
The fulfillment of the above needs is strongly hampered by the lack of operational tools to be used by the public authorities.
This work presents a web-based, freely-available dynamical tool, named Best Practice tool, developed within the geospatial Decision Support system (DSS), LandSupport.
The tool allows – with a great level of flexibility – to choose the best practice under a specific goal to be reached and defined by the end-user.
The tool, operating thanks to the process-based crop-growth model Armosa, is conceived in two sections: (1) the end-user chooses as far as five best practices (organic farming, intercropping, fertilization, type of tillage, and retainment of crop residues) to compare for a specific climate (current, future), area of interest and crop; (2) an index of best practice based on the linear combination of three main results – crop production, N-leaching and soil carbon stock change – is automatically updated on the base of the weight assigned by the end-user to the three outputs.

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P-6

Integrating proximal gamma ray spectrometry and apparent electrical conductivity to monitor SOC content at field-scale

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Proximal soil sensing methods have been largely used as cost-effective ways for monitoring SOC content, despite numerous drawbacks can limit its effectiveness. In this context the aim of the present work was to evaluate the combination of two proximal sensors, an electromagnetic conductivity (ECa) meter and gamma-ray detector –it quantifies the natural soil radioactivity from Thorium, Uranium and Potassium isotopes– to obtain high detailed maps of SOC content.
Field surveys were conducted in 2019 on five agricultural areas of northeastern Italy, whose texture ranged from silty clay to sandy loam, and SOC from 0.8% to 9.4%. A total of 712 undisturbed soil samples were collected at different depths down to a maximum of 45 cm, and analyzed for texture, bulk density, and SOC content. Proximal sensing data were collected simultaneously using ECa (CMD-Mini Explorer, GF Instruments) and gamma-ray (MS-2000 Agri Detector, Medusa) detectors connected to a DGPS. Soil moisture was also recorded on the field for gamma-ray spectrum correction. Spatial dependence between ECa, natural soil radioactivity, physical and chemical soil properties was explored with factorial kriging analysis (FKA).
Results showed that gamma-ray detector was generally correlated with soil texture, in particular clay content, in mineral soils. In contrast, SOC and soil moisture were predictors of gamma-ray sensed spatial variability in the peaty soil. ECa conductivity meter and gamma-ray detector proved to be effective for capturing the spatial and temporal variability of SOC, suggesting their use in the framework of carbon farming policies.

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P-7

Spatial modeling of soil moisture dynamics for the Rákos catchment, Hungary

Mr Vinicius Deganutti De Barros, Miss Malek Abidli, Mr Gábor Halupka, Miss Dana Kaldybayev, Mr János Grósz, Mr. István Waltner

The knowledge about soil moisture dynamics is an important factor for understanding some key soil functions, controlling the water fluxes between soil, vegetation and atmosphere. A proper spatial soil moisture management plan has a lot of difficulties to implement, but in contrast it is of extreme importance, specially for agricultural studies and practical applications. This study aims to summarize the results of an ongoing research project (FK 124803) focusing on the development of a spatial monitoring scheme for soil moisture in the Rákos watershed, in Hungary. The study aims at the combined application of remote sensing techniques and modeling in order to extend the capabilities of field-based monitoring networks. Our study focuses on the application of calibrated virtual profiles, modeled using the Hydrus – 1D version in Python (Phydrus). For the creation of timely, spatially explicit maps of soil moisture distribution, a regression kriging-based approach was used, utilizing a number of environmental co-variants, including spatial predictions of soil moisture by remote sensing techniques.

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P-8

Large-scale mapping of Algerian coastal dunes: a spatial analysis of sediment imbalance in the western Algerian coast

Miss Hadjer Dellani

Coastal erosion is a global phenomenon accelerated by several factors such as sea-level rise and coastal urbanization, especially on Mediterranean coasts with high anthropic pressure. This impact is often due to the imbalance of the dune system, a natural source of beach nourishment. This study aims to assess the morphology evolution of the Algerian west coasts (around 500 km) over a period up to 70 years and predict the erosion of sandy soils in the next years depending on the level of sediment supply. The proposed framework quantifies the impact of environmental factors such as wind, water flow concentration, relief, and anthropization on dune soil evolution. Furthermore, it provides indicators of the resilience of sandy beaches according to the vitality of their dune source. An analysis of geological, pedological, and topographical maps of the period (1950, 1956 and 1957) was conducted and coupled to a diachronic approach of Landsat/Sentinel-2 optical imagery and also on a better scale with the Algerian satellite Alsat-2 2013-2020 datasets. The final result is a synthesis map of the coastal sedimentary system: “Source, Transport Vector, Beach”, which will be reported in the final version of the paper. This framework is carried out for the first time in the western region of Algeria and represents an essential decision-support tool for the integrated management of these highly valuable coasts.

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P-9

Digital rating of land suitability to crops and land use in Romania

Phd Andrei Dornik, Phd Marinela-Adriana Cheţan, Phd Lucian Drăguţ, Phd Daniel Dorin Dicu, Phd Andrei Iliuţă

Land suitability (LS) assessment contributes to the goals of sustainable agriculture, which expects a quality production, harmless to the environment, and economically profitable, especially within the newly approved EU Farm to Fork Strategy. This work presents the first version of a digital application to determine and map the land suitability to crops. The proposed application is based on the existing Romanian rating methodology for LS, which was developed based on FAO guidelines for land evaluation, using a huge amount of data consisting of in-depth knowledge of the conditions for plant growth, environmental conditions of the land, and agricultural yield, and statistical analysis to calculate the suitability rating. While the rating is currently performed manually, the algorithmic nature of the existing methodology makes it well suited to be implemented as a computer application, using geographic information systems and digital geospatial data. Our application uses soil field data (georeferenced soil profiles with measured soil properties) and soil predictors (digital terrain models) to create digital maps for 18 eco-pedological indicators (e.g. soil porosity, gleization, carbonate content, soil pH, base saturation, soil texture) through Random forests spatial prediction technique. Subsequently, based on several lookup tables, the application transforms these maps into digital maps with suitability ratings for each crop, ranging from 0 (not suitable) to 1 (maximum suitability). The final step is the multiplication of the 18 raster suitability maps. The provided results consist of suitability maps to 14 crops, 8 fruit trees, and 3 land-use types, as well as maps with land limitations.

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P-10

Effects of the advance of the rice agricultural frontier on the transformation of flooded savannas of the Colombian Orinoquia

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The advance of the rice agricultural frontier on the flooded savvanas of Colombian Orinoquia generates effects in the changes of the vegetal cover and contributes to the degradation of strategic ecosystems. The hydric dynamics of this territory presents naturally, in some places floods for prolonged periods and in others drought also for long periods, causing losses in crops, pastures and livestock. The transformation of gallery forests, estuaries, wetlands and areas traditionally dedicated to livestock contribute to the loss of soil quality, biodiversity and water regulation, among others. This research sought to determine the effects of the growth of rice production areas on the transformation of the flooded savvanass of the Colombian Orinoquía at the municipalities of Paz de Ariporo (Casanare) and Arauca (Arauca), in a period between 2000 and 2020. From the analysis of multispectral optical images, Landsat and Sentinel 2, it was possible to evaluate the change in land cover and determine the landscape unit using the hydrographic basin, which allowed to generate the units for analysis. With the multitemporal images, the loss or not of the already classified covers is evidenced (using the corine land cover methodology (LULAC) and spectral indices) in three periods 2000, 2010 and 2020, generating the cartography as an input to quantify the increment of rice plantations.

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P-11

Mapping of potential wetlands at the national scale in France

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Wetlands ecosystems represent a key environmental compartment, regulating hydrological, biogeochemical and ecological processes. In France Attention paid to theses ecosystems has increased over the past decade in response to recent evolution of the legislation concerning water authorities' activities. Indeed, criteria for identification and delineation of wetlands based on soil and vegetation characteristics are considered in the French legislation since 2008.
This study aimed at providing a predictive map of wetlands at the scale of the metropolitan territory of France, in a raster format of 25m resolution. The mapping approach was based on a machine learning method (Random Forest algorithm), using environmental variables available for the entire study area: change in elevation from the nearest stream, topographic wetness and position indices (TWI and TPI), distance to waterbodies, geology, and more than 100,000 punctual observations of soil hydromorphic features. To assess the quality of prediction, an independent data set of more than 4,000 observations was collected in 2021 and the expertise, knowledge and practices of local stakeholders were taken into account. This map should be an major tool to consider the area and nature of wetlands impacted by urban and rural planning, and to elaborate and evaluate public policies et national, but also regional and local scales.

P-12

Off-site impacts of water erosion - Identification of hotspots on arable land for small scaled land use conversions

Mr. Marvin Melzer, Ms. Sonoko Bellingrath-Kimura

For performance-based remuneration of ecosystem services (ESS) and better management of the field, quantification of ESS is of urgent need. Erosion control was identified as one pivotal ESS strongly impacted by agricultural land use changes. While well studied in the past, there is little quantitative information on the amount of soil relocated from arable fields to aquatic ecosystems. Small-scaled, highly concentrated erosion occurs within arable fields caused by specific relief characteristics and insufficient soil cover. Small scaled land use conversions in these hotspots may effectively reduce soil loss and off-site impacts. At the same time, related economic losses have to be considered.

This study aims to i) quantify the current soil relocation from arable fields to aquatic ecosystems and the potential to reduce it, ii) identify small scaled erosion hotspots for land use conversions and iii) quantify related profit losses.

Soil relocation was calculated using the software InVEST SDR, relief data, soil and climate data, the current crop rotations and a map of waterbodies. Results were further processed by GIS-based threshold analysis and buffering to identify erosion hotspots, confirmed by overlapping soil degradation visible on areal images. Economic losses by land use conversions were quantified using the profit calculator of KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft e. V.). Results show hotspots within fields and that their conversion into grassland buffer strips are highly effective against erosion and minimize profit losses. The spatially explicit localization and evaluation of this and other measures enables performance-based remunerations of farmers.

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P-13

Application of Spectral Library for Rapid Prediction Soil Attributes: Pest County.

Mr Mohammed Mohammed Zein, Dr Adam Csorba

Development and updating of soil information system's (SIS) has to include the use of alternative laboratory technologies to support the time- and cost-effective and environment-friendly soil data collection. Such SIS's are required to satisfy the growing need for soil data. The goal of this paper was to test the application of the MIR spectral library combined with partial least square regression (PLSR) for predicting selected chemical soil attributes. This study is part of the development of a national mid-infrared spectral library based on the soil samples collected in the frame of the Hungarian Soil Conservation Information and Monitoring System survey. Archived soil samples of Pest County were prepared, scanned based on DRIFT technique and spectra was saved in the FTIR spectrometer OPUS software. Absorbance spectra were pre-processed with moving average, Savitzky-Golay and first-order derivative filtering methods. H-distance outlier detection method and Kennard-Stone calibration sample selection method were applied on principle component scores of moving averaged spectra data. Pre-processed spectral data and reference soil data were merged and split into calibration and validation datasets. PLSR models were built for organic carbon, clay content and cation exchange capacity (CEC), then attributes were predicted using calibration and validation datasets. R2 and RPD were used to assess the goodness of calibration models. The calibration results showed that the organic carbon and clay content were predicted with high accuracy level (R2 > 92, and RPD > 3.5), while CEC was predicted also with high accuracy level (R2 > 0.76 and RPD > 2.0).

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P-14

Lithium exploration in Australia using the digital soil mapping approach

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Lithium is the lightest metal and solid element found in trace amounts in soils. There has been an increasing demand for lithium-bearing minerals as a source of lithium-ion batteries for energy storage. Digital soil mapping (DSM) has been widely applied on assessing and mapping the world soil resources. In Australia, lithium occurs mostly in the form of minerals such as spodumene. In this study, we utilize the DSM framework to explore and delineate lithium resources within Australia. We utilized data collected from national geochemical survey of Australia and selected environmental covariates that reflect the presence of rock minerals in the soil forming process, including climate, elevation, and gamma radiometric data. Despite that mineral explorations were mainly done on the western Australia region, particularly within Pilbara and Yilgarn cratons, we found that areas on the east coast within Queensland and New South Wales could potentially have a high concentration of Lithium through the DSM approach. The findings would provide a potential approach for the exploration of deeply buried mineral deposits in Australia and elsewhere globally.
N/A

P-15

Towards a hierarchal classification of soil capacity and condition.

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Provision of ecosystem services is governed, in large part, by the soil's capacity and condition. While soil condition can change at faster rates due to differences in management or disturbance (dynamic soil properties), soil capacity is determined by soil properties which develop over longer time scales (pedogenesis). This temporal discrepancy poses significant challenges for developing a national hierarchical classification of soil property-based spatial units which share similar properties (e.g. soil texture, soil mineralogy, soil depth, and topography) and similar short-term dynamics in response to management, disturbance, and climate change. Leveraging soils and ecological data from national databases (National Soil Information System and Ecosystem Dynamics Interpretive Tool), we developed rule-based classification algorithms to group soil properties into Ecological Site units for the U.S. and to characterize the ecological dynamics for those soil groups.

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P-16

Soil information for supporting new redevelopment and rural development processes in industrial areas: a case study in Sardinia (Italy)

Prof. Andrea Vacca, Dr. Stefania Fanni, Dr. Vittorio Alessandro Marrone, Dr. Rita Puddu, Dr. Marco Cocco, Mr. Daniele Manca, Mr. Massimo Melis, Mr. Lorenzo Zucca

Industrial settlements may reduce agricultural land, causing its complete abandonment and compromising the quality of soils and the possibility of recovering the ancient agricultural vocation. This is the case in two industrial areas of southern Sardinia (Italy), where heavy chemistry plans were settled in 1960's in former agricultural land. The aim of the present study is to provide soil information to local authorities to identify and evaluate the extent of the phenomenon and for supporting new redevelopment and rural development processes. A GIS approach was used. Air photo interpretation with field checks allowed the analysis of the transformations of the agricultural landscape due to industrial activities. The following areas were identified: traditional areas (areas where agricultural use continues), abandoned areas (areas where agricultural use has been abandoned) and consumed areas (urbanized areas and industrial infrastructures no longer classifiable as rural areas). Existing and new soil data were collected to produce a Land Unit and Land Capability Map. Most of the map units represent soil consociations, while soil associations and complexes characterize few map units. Soil data were also used to assess five ecosystem services: habitat for soil organisms, soil purification capacity, potential carbon sequestration, potential food provision and potential water regulation-water storage. A single value for each ecosystem service was attributed to each map unit. Results provide a wide set of information about the characteristics and potential services of soils in the considered industrial areas, supporting local authorities in outlining new rural redevelopment strategies.

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P-17

Recent field-scale trends in soil fertility status across agricultural catchments in Ireland

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Here, we present the results from the soil geodatabase of the Agricultural Catchments Programme, collected over 12 years in three meso-scale agricultural catchments in Ireland (Fealy et al., 2010). The entire agricultural area of each catchment is divided into defined sampling units and soil samples are repeatedly taken from each unit every 4 years. The overall results (n=1311) show the increasing trends in soil pH, soil test potassium (K) and soil organic carbon (SOC) content, while soil test phosphorus (P) and total nitrogen (N) declined slightly and remained unchanged, respectively. Notable are the overall 6% decrease in number of fields with P index 4 (above optimal) and the 18% increase in the number of fields with optimal soil pH. However, the results are more variable when observed at the individual catchment scale and in relation to farming enterprise. SOC content decreased by 0.35% on average in the tillage dominated catchment, while it remained steady or increased in two grassland catchments. Furthermore, while there has been a general decrease in P content in all catchments, the number of fields with P index 4 was lower in the tillage catchment only. At the enterprise scale, most notable is a substantial decrease in P index 4 fields in tillage and drystock fields, while there was a slight increase in the case of dairy. Despite many positives in the trends analysed, there is still a lot of work to do in relation to on-farm nutrient management planning in order to reach the agri-environmental goals.

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P-17A

SoilHub - Reusing the UKs soils

Mr Steven Philp

In 2019 I worked for one of the largest groundworks contractors in South West England, and we had a lack of topsoil on one of our developments. The housing developer tasked us to plug the shortfall and find some topsoil to complete the development. After a few weeks, I was beginning to lose hope; I spoke to every groundwork contractor I knew and every haulier we worked with to find suitable topsoil. Then by chance, I drove past a development that contained heaps of topsoil. Some testing and regulation later, and we were importing this clean, suitable topsoil into our development. The amazing thing was it was the same housing developer on both sites! And this got me thinking, how often are our soils getting mismanaged? How often are soils transported miles and miles when a much more suitable option is closer to hand? And so I created SoilHub - a marketplace for Soils and Aggregates. I would welcome the opportunity to talk about this project and how it can help the sustainable reuse of UK soils.

P-18

Improving USLE-based soil erosion modelling in data sparse regions: methodological insights, accuracy analysis and examples from India

Mr Anindya Majhi, Mr Rohit Shaw, Mr Kunal Mallick, Dr Priyank Pravin Patel

The Universal Soil Loss Equation (USLE) is one of the most popular approaches for modelling soil erosion worldwide. However, methodological discrepancies in its application often skew the elicited soil loss amounts, the accuracy of which is seldom examined, precluding even a qualitative interpretation. Such issues are even more pronounced for Global South regions, primarily due to the use of methods originally developed for other locales and the paucity of available data, in terms of both its resolution and historicity. Here, we review the raft of methods that have been generally used in India to compute the five individual factors (R: rainfall-runoff erosivity, K: soil erodibility, LS: slope length and steepness, C: cover and management and P: support practice) that comprise the USLE. The marked over- and underestimations of these factors in the computations undertaken across India are highlighted along with identification of the best possible ways to enumerate each of them and thereby derive more accurate soil loss estimates using the USLE for the country. The most apt local/global databases currently available to compute each parameter and suitable accuracy/uncertainty analysis methods that should be employed in these investigations are also explained in detail, taking the example of the Upper Brahmani River Basin in eastern India to showcase their application. While focused on India, the methods outlined in this study can also be used to conduct more precise USLE-based soil erosion modelling in other data sparse regions, particularly across tropical/monsoon Asia and places where soil erosion has a marked seasonality.

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Majhi, A., Shaw, R., Mallick, K., & Patel, P. P. (2021). Towards improved USLE-based soil erosion modelling in India: A review of prevalent pitfalls and implementation of exemplar methods. Earth-Science Reviews, 221, 103786.

P-19

Using pedometrics to identify soils diversity and pedogenetic processes in complex tropical mountain landscapes

PhD(c) Alma Barajas-Alcala[1], Biol. Jorge Larson-Guerra[1], MC Javier Rodríguez-Rodríguez[1], Ing. Carlos Eduardo Aroyo-Cruz[1], MSc Fabiola González[1], Biol Claudia Aguilar-Zúñiga[1], Master Student Axel Cerón-González[1], Master Student Yabin Salmerón[1]
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The soils in the Southern Sierra Madre, Oaxaca, Mexico have been subject to systematic pedogenetic studies. High dynamic slope processes and tropical highland humid conditions are the main forces that shape the landscape. Our aim was to design a sampling strategy to identify soil-forming processes and soil diversity. In this region, a local community required soil descriptions of their region for land planning, conservation, and economical activities. The implementation of a Conditioned Latin Hypercube (LHc) suggested 40 soil sampling sites, considering color, texture, depth, and pH as in situ measurements. Results showed three edaphoecosystems: 1) Upper mountains; 2) Moderately steep; 3) Deposition and accumulation soils. For a better understanding of soil diversity, 12 soil profiles were described and classified using WRB (2015), considering the three major land uses in the region: shade-grown coffee, milpa fields, and forest. Pedometrics helped to optimize time in the field and the representation of the diversity of. The soils described resulted in 8 Phaeozems, Leptosol, Cambisol, Luvisol, and Arenosol. The Colluvic qualifier was added to most profiles, except in Arenosols. We highlight the continuous reactivation of the pedogenic clock, with transport and deposition as the main phenomenon of pedogenesis. Also, Mollic horizon -associated with litter accumulation- in semi-preserved forest results of great importance in environmental functions and agroforestry coffee production. The main conclusion is that stoniness, depth, and stagnic properties could limit the management of the soil diversity. In this way, the soils should be evaluated according to these three properties and their land use.
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P-20

A GIS weighted-suitability model approach for assessing soil contamination risk from historical mining in the Forest of Dean, UK.

Ms Victoria Lewis, Ms Angeliki Savvantoglou, Dr Adrian Crew

Due to the unique history and ownership of collieries within the Forest of Dean (FOD), UK, the area was largely granted exemption from the nationalisation of coal mines in 1946; leading to unregulated and non-existent abandonment management strategies. Studies undertaken in the 1990s identified extensive contamination of soil and water associated to Acid Mine Drainage (AMD) originating from abandoned coal mines within the FOD. The extent of the contamination is unknown and 'hotspots' remain unrecorded. This novel study combined available GIS datasets to successfully identify the locations where AMD-contaminated runoff from abandoned coal mines may accumulate in the FOD. The remotely sensed data was used with a customised Weighted Suitability Model with ranked landscape, environment and soil predictors (Tercan & Dereli, 2020). The results indicated that 80% of the study area (430km^2) was characterised as areas that are 'Likely', 'Very Likely' and 'Highly fitting' to be contamination hotspots. Moreover, the study found that 53% (112) of the registered abandoned coal mines in the FOD are within regions categorised as 'Likely to detect contamination hotspot', while a further 19 collieries are located in regions classified as 'Very likely to detect contamination hotspots', suggesting a wide extent of environmental contamination. The model also located high-risk areas of particular concern, where remediation efforts, conservational work and soil or freshwater management practises may be necessary. This innovative analysis demonstrated the application of GIS to identify extensive, remote or complex environments that may be susceptible to the legacy of past industry.
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P-21

Risk mapping to quantitatively assess the relative contribution of pathways of phosphorus (P) agricultural diffuse pollution

Dr Zisis Gagkas, Dr Allan Lilly, Dr Nikki Baggaley

Agricultural diffuse phosphorus (P) pollution to watercourses is an important environmental issue, influenced by soil type, climate, landscape and land management. Identifying areas most at risk of exporting P is crucial for the design of efficient practical diffuse pollution mitigation measures. We developed a method to quantify and map soil P source and export from all cultivated land in Scotland for both the surface and subsurface flow pathways (i.e., particulate P loss due to runoff and soil erosion and for P loss by leaching to artificial drainage systems). P loss due to runoff and soil erosion was estimated by combining measurements of soil total P from the Scottish Soils Database with soil risk maps, erosion rates and sediment yields. P leaching to drains was estimated using published relationships linking agronomic P data with P concentrations in drainflow in Scottish agricultural catchments. We also developed a land use intensity index using time-series of crop type that was then related to soil erosion rates to consider the impact of different cultivation and management practices on diffuse pollution risk. Maps of harmonized estimates of P loss (in g P/year) were produced for both pathways at 50m grid resolution that were combined to estimate total P export and relative pathway importance. Risk mapping showed that runoff and soil erosion cause most of P loss in drier cultivated soils while P loss through drains is the dominant pathway in improved grasslands on wetter soils at higher altitudes receiving greater rainfall.

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P-22

Can spatial variation of orchard soil properties at intra-field scale be estimated by kriging of data collected at inter-field scale?

Dr. Kaori Matsuoka, Dr. Naoki Moritsuka, Dr. Ryohei Nakano, Dr. Tetsuya Nakazaki

Soil sampling interval determines the spatial resolution of a soil map. However, kriging may help to predict local soil information where sampling has not been done. In this study, we examined whether spatial variation of soil properties at intra-field scale can be estimated from their kriged maps drawn at inter-field scale. At inter-field scale, twenty-three orchard fields were divided into 67 grids at 16.67 m (N-S) and 20 m (E-W) intervals. At intra-field scale, one of the fields (a peach field) was divided into 128 grids at 2.5 m (N-S and E-W) intervals. Soil samples were collected at 0–20 cm (inter-field scale) and 0–10 cm (intra-field scale) depths in each grid were analyzed. Kriged maps of soil properties in the peach field were drawn at intra- and inter-field scales. Based on the difference of mean (< ±10%) and positive statistical significance ($P < 0.01$) between the two scales, the spatial variation of soil color parameters a* and b*, pH (H_2O), and citrate-dithionite extractable-Fe at intra-field scale could be estimated from their variation at inter-field scale (R^2 = 0.17–0.36). The R^2 values were statistically significant, when the soil properties showed high spatial dependence at inter-field scale with a Q value ≧ 0.998. In contrast, sand content, soil color parameter L*, EC, and loss-on-ignition could not be estimated. Overall, the spatial variation of soil properties at intra-field scale could be roughly estimated from their variation at inter-field scale, when the semivariogram at inter-field scale showed high spatial dependence.

P-23

Spatial Variability of Soil Phosphorus under contrasting tillage systems in Eastern Canada

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Conventional tilling practices (CT) were replaced by conservation tillage for mitigating soil erosion and runoff. However, under the no-tillage (NT) practice, phosphorus (P) can accumulate at the soil surface causing P stratification, increasing P losses via runoff and erosion. Little information is known about P spatial variability at field-scale under contrasting tillage systems. This study investigated spatial variability of soil available P under two contrasting tillage systems in a maize–soybean rotation in Eastern Canada. A CT field (10.8 ha) and a NT field (9.5 ha) were managed under maize–soybean rotation since 1994. Both fields were classified as Humic Gleysol and received NPK fertilizers following local recommendations. Soils samples were taken, based on 35-m by 35-m triangular grids at two depths (0–5 cm and 5–20 cm). Available P and other elements were determined by Mehlich-3 method (M3). Agri-environmental P saturation index (P/Al)M3 was calculated. Data were analyzed using statistics, geostatistics, and multiple regressions. Under CT, average PM3 and (P/Al)M3 values were similar (30 mg/kg and 3%) in both layers. Under NT, these P values were higher (80 mg/kg and 8%) in the 0–5 cm layer than 5–20 cm layer. Phosphorus stratification was observed under NT. Spatial variability of soil P varied from moderate to very high (32 to 60%) in both fields. Tillage practices affect relationships between P indices and other elements. This study demonstrated the importance for applying the P fertilizer at the right rate and place.

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P-24

Using regionalized soil data in soil process models – definition and valuation of similarity between soil profiles

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Optimizing soil management in agriculture is a main intention of the BonaRes funding initiative. Site specific soil process models will be used to predict and quantify the impact of management measures on soil functions and to create nationwide soil functional maps. The soil information stored in the gen-eral soil map of Germany 1 : 200 000 (BÜK 200) will indirectly be used for simulations: Whereas the models need numeric input data, the BÜK 200 database provides only classified data. Therefore as-signment of real soil profile data to the BÜK 200 profiles is required. For this assignment we used 2234 soil profiles of the agricultural soil inventory (BZE-LW) of Germany, covering the whole country in a raster of 8 x 8 kilometres, and additional 1270 profiles, mostly of Eastern Germany.
We defined assignment rules based on similarity between soil profiles. Similarity is determined com-paring soil parameter values, treating value classes as fuzzy. We developed a valuation method that allows quantifying the similarity concerning each parameter as percentage with regard to the profile depth. Several similarity indicators were derived which serve to select the best matching real soils.
Similarity analysis was conducted for the whole profile as well as separately for the topsoil. With the real soil data used we could provide 90,5 % of the agricultural BÜK 200 profiles and 100 % of the topsoils with numeric parameter values. As an example serve nationwide maps on the carbon storage potential of topsoils and the actual degree of fulfilment of this potential.
Schmelmer, K., Eberhardt, E. (2019): Regionalisierung bodenkundlicher Modellierungsergebnisse. Berichte der DBG, http:// www.dbges.de

P-25

Soil mapping using electromagnetic induction in association with Leptospermum nitens survival and growth in Western Australia

Miss Hira Shaukat, Dr. Matthias Leopold, Dr Ken Flower

Leptospermum sp. is a source of high value medicinal honey production and can provide income from marginal lands, especially when reforestation is market driven. However, the survival and growth performance of Leptospermum when under cultivation at the field scale has not been investigated. The current study was from two newly planted Leptospermum nitens sites with variable soil characteristics in Western Australia with the aim of identifying key soil parameters influencing the plantation survival and growth. Electromagnetic induction (EMI) was used to investigate the possible impact of soil variability at different depth on Leptospermum plantation. Two EMI surveys were conducted at each site, at different times of the year to account for soil moisture variability (relatively dry and wet conditions). A least square inversion algorithm was used to determine the electrical conductivities at three individual soil depths (0 – 0.5, 0.5 – 0.8 and 0.8 – 1.6 m) to produce quasi-3D maps of soil ECa. Soil samples from the aforementioned depths were used for physico-chemical analysis of soil parameters and to develop laboratory based electrical resistivity to soil volumetric moisture calibrations with R^2 values between 0.95 and 0.99. Plant survival and growth was estimated using unmanned aerial vehicle (UAV) images and machine learning. Principal component analysis (PCA) identified soil water, pH and exchangeable aluminium (ex-Al) most related to soil ECa range with robust Leptospermum crown growth. Such soil mapping may be a robust and effective method for risk assessment of the survival of Leptospermum nitens plants for establishing the new plantations.
N/A

P-26

No-tillage increased SOM in labile fraction but not in stable fraction of Andosols in Japan ~from a long-term experiment

Ms Jeannette Aduhene-Chinbuah, Professor Soh Sugihara, Professor Masakazu Komatsuzaki, Professor Tomoyasu Nishizawa, Professor Haruo Tanaka

No-Tillage (NT) fosters carbon (C) sequestration, increases soil organic matter (SOM) stock, and improves “soil health”. However, its effect on SOM accumulation in Andosols, which has high OM stabilization characteristics due to its specific mineral properties, is still unclear. Our objectives were to 1) evaluate the effect of NT on SOM amounts and its distribution by physical fractionation method, and 2) to assess the quality of accumulated SOM in each fraction. We collected the soil samples at 0-2.5, 2.5-7.5, and 7.5-15 cm depth from NT and conventional tillage (CT) plots in a long-term (19 years) field experiment of Andosols in Ibaraki, Japan. Soil samples were separated into light fraction (LF), coarse-POM (cPOM:0.25-2mm), fine-POM (fPOM:0.053-0.25mm) and silt+clay (mOM:<0.053mm), and analyzed the C, nitrogen (N) and organic phosphorus (Po) contents of each fraction. C content of cPOM and fPOM in NT at 0-7.5 cm were 6.6-7.4 and 8.6-10.7 g C kg-1, respectively, and were larger than those in CT (3.8-4.4 and 5.3-5.5 g C kg-1, respectively), while there was no clear difference in mOM fraction or deeper layer (7.5-15cm). We also found similar trends of N and Po contents. There was no significant difference in C:N ratio for all fractions throughout the depths, except LF, and C:Po and N:Po ratio also did not show consistent differences. These results indicate that NT increases C, N, and Po contents in labile POM fractions at the surface layers, but didn’t increase the stable fraction and also did not change the quality of Andosols in Japan.
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P-27

Incorporation of straw based on C:N:P:S stoichiometric ratios to increase stabilized SOC in soils with increasing silt and clay content

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Consistent element ratios in both the total soil pool and the soil microbial pool have been shown to exist globally and demonstrate the nutrient requirement for soil carbon sequestration. The constant ratio of elements for homoeostatic microbial growth is the basis for the ecological stoichiometry theory and mainly concerns C, N and P. This study aims to test C:N:P:S stoichiometry to increase the rate of stabilized SOC in soils with increasing silt and clay content. The objectives are to determine (i) the change in stabilized SOC following nutrient supplementation of incorporated straw under balanced nutrient (NPS) inputs and N-, P- or S-deficient treatments and (ii) the dynamic change in soil physical and chemical properties that occurs in association with SOC. In an ongoing experiment wheat straw (8 t ha-1 equivalent) was added to 3 kg of soil and incubated in an environmental controlled chamber over consecutive cycles of straw incorporation with or without supplementary nutrients to achieve a target 30% conversion of fresh C-inputs to SOC. Soil organic carbon will be measured with the following soil physical and chemical properties over consecutive 12-week cycles of straw decomposition; aggregate mean weight diameter, % water stable aggregates, particle density, pH, total CNPS, and plant available nutrients. SOC sequestration potential will be compared for balanced nutrient inputs and N, P, or S-deficient scenarios. The dynamic change in soil properties associated with SOC will be determined in an effort to establish the quantitative relationship between SOC and soil physical and chemical properties.

P-28

Vertical distribution of total organic- and BPCA derived carbon in centennially old Technosols as determined by FTIR-MIR spectra PLSR prediction

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Centennially old charcoal rich Technosols found on relict charcoal hearth sites (RCH) in forests of central Europe and the North-Eastern USA are an ongoing subject of research regarding their physical- and chemical soil properties. The most commonly described feature among these soils is the increase in total organic carbon (TOC) concentration and stocks in comparison with adjacent reference forest soils. In addition, multiple studies have determined their pyrogenic/black carbon concentration using various chemical digestion approaches. The higher TOC concentrations and stocks of RCH is thereby not solely the result of an enrichment of pyrogenic carbon stemming from charcoal, but also caused by an enrichment of non-pyrogenic soil organic matter. In this study, we determine the total carbon content of 52 Technosol sites in Litchfield County, Connecticut, USA. Furthermore, we analyse their concentration of highly aromatic carbon using the biomarker benzene polycarboxylic acid (BPCA) that we determine on samples from selected sites (n=100) using a modified approach utilizing a HNO3 microwave pressure digestion. On this basis, we created a PLSR prediction model to quantify BPCA contents on the complete FTIR-MIR soil spectra dataset (n=1200) created in this study. The RCHs' multi-layered stratigraphy, including reworked mineral horizons between charcoal rich technogenic horizons, allows us to determine the presence of vertical carbon leaching. The results indicate a general enrichment of total- and BPCA-derived carbon in RCH soils with a vertical concentration gradient for both carbon fractions in the topmost technogenic horizon and the mineral substrate intermediate layer.
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P-29

Water-extractable soil organic matter: predicting compositional characteristics using soil mid-IR spectra coupled with partial least square regression analysis

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Water-extractable organic matter (WEOM) is an important fraction of soil organic matter, playing key functions in soil environment biogeochemical processes (Bolan et al., 2011). Understanding the relations between WEOM and soil chemical compositions is of primary interest and could significantly contribute to better soil management and improved environmental quality. This study links IR-spectral compositional fingerprints of soils with composition-related optical characteristics of soil extracts and WEOM. Mid-IR spectra were obtained for 216 Israeli soil samples collected from different climate regions, land use types, depths and sampling seasons. Aqueous soil extracts were characterized for UV absorbance, emission intensities of components identified using parallel factor analysis of the excitation emission matrices of fluorescence, dissolved organic C (DOC) concentrations as well as for the above-mentioned optical properties normalized by DOC. Optical attributes of the soil extracts and WEOMs, related to presence of certain organic components, were predicted from the soil mid-IR spectra, using partial least square (PLS) regressions. The prediction results suggest that (i) presence of aromatic and fluorescent WEOM components in soil extracts is better represented by soil mid-IR spectra compared to aliphatic constituents; (ii) differences between concentrations of aromatic (and fluorescent) components in soil extracts are better predicted than differences in WEOM composition (i.e., DOC-normalized optical attributes). Thus, optical properties of soil extracts that are associated with the presence of organic components rich in aromatic rings and double bonds may be better linked to soil chemical composition than the concentration of total DOC present in extracts.

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P-30

Dynamics of C and N in contrasted Histosols following straw and wood chips incorporation as soil conservation treatments

Ms. Karolane Bourdon, Prof. Josée Fortin, Prof. Jacynthe Dessureault-Rompré, Prof. Jean Caron

This study investigated how adding plant biomasses (miscanthus, switchgrass, willow, and birch) to cultivated Histosols to compensate for organic matter decomposition can affect C stock and N availability.

Two contrasting Histosols, a hemic material and a highly degraded sapric material, were mixed with different biomasses in glass jars at a rate corresponding to 15 t ha-1 incorporated on 20 cm, maintained at a matric potential of -15 kPa, and incubated at 21-25°C for 144-122 days. Soil respiration was measured once a week using alkali trap and acid-base titration. The inorganic N was measured at the end of the experiment using KCl 1M extraction and immobilization was calculated as compared to the controls.

The cumulated CO2 emission in the control treatments were 10-fold higher in the hemic material than the sapric material, 7.5 and 0.65 t C-CO2 ha-1, respectively. The C balance of the biomass treatments was negative for the hemic material, -3.8 to -2.6 t C ha-1, and positive for the sapric material, +5.1 to +5.8 t C ha-1. However, the inorganic N immobilization was more pronounced in the sapric material (-127 kg ha-1) than the hemic material (-58 kg ha-1).

These results show that the humification degree can have a considerable influence on biogeochemical processes in Histosols. As a result, the less humified soils might require more biomass to achieve C equilibrium, and the N immobilization might last longer in highly humified soils. Therefore, biomass application rates need to be modulated according to soil specificities when designing conservation strategies.

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P-31

Estimating the carbon storage capacity of full soil profiles over 50 years for different soil types and land uses

Dr Clementine Chirol, Dr Geoffroy Séré, Prof Laurent Saint-André, Dr Paul-Olivier Redon, Dr Delphine Derrien

The capacity of soils to store organic carbon is increasingly recognised as an opportunity to mitigate for greenhouse gas emissions while increasing biomass production and improving drought resilience[1]. However, soils are heterogeneous and dynamic systems: carbon storage capacity and residence time depend on intrinsic soil properties, but also on land occupation and management choices. Gaps in knowledge also need to be addressed: in particular, the behaviour of deep soil carbon (below 30cm) plays an important role in carbon storage due to its longer residence time, but remains poorly considered and understood[2].
This study analyses soil carbon dynamics and storage capacity over 50 years, distinguishing between 8 soil types and 3 land covers (cropland, grassland, forest). Carbon stocks are calculated based on 190 profiles covering a depth up to 2m. We compare two methods to assess C storage potential: the soil carbon saturation within the fine fraction using the Hassink method[3] and the maximum total carbon content using a data-driven approach[4]. We then model the carbon stocks that could be stored in each soil type within 50 years, based on annual carbon inputs estimated for different land covers and uses, and from previously defined vertical profiles of carbon mean residence time[5].
Finally, we map the additional carbon storage potential after 50 years within a 900 km2 region (Meuse / Haute Marne, France), and discuss the potential of different combinations of soil type and land use to store carbon: what are the optimal management strategies for carbon storage at the regional scale?

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P-32

Soil – atmosphere exchange of greenhouse gases under future climates

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This research investigates the cascading effects of elevated carbon dioxide (eCO_2) fumigation of a mature temperature forest, with a particular focus on the greenhouse gas (GHG) fluxes nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2). A field experiment was performed at the Birmingham Institute of Forest Research Free Air Carbon dioxide Enrichment facility (BIFoR FACE), where an oak dominated mixed mature woodland has been under eCO_2 since 2017. Fluxes were quantified in situ using the Licor 8100A – an infrared gas analyser measuring total soil respiration (Rs) as CO_2, and a Picarro greenhouse gas analyser (G2508), measuring N_2O and CH_4. With more carbon allocation belowground, we expect an increase in microbial activity and consequently larger Rs. Data from 2019 – 2021 were analysed and are built on an earlier dataset from 2017-2018, and the role of soil temperature and soil moisture is considered. Overall, Rs was higher under eCO_2 in 2017-2018; however, in years 2019 to 2021, the absolute difference in respiration between eCO_2 and control forest plots gradually decreased and even switched in 2021, with a slight increase in Rs for control plots compared to eCO_2 plots. Moreover, annual fluxes of N_2O and CH_4 were detectable and in general we observed N_2O emission and CH_4 consumption. My presentation will discuss Rs and N_2O and CH_4 fluxes and highlight the role of eCO_2 as well as environmental and soil conditions that regulate the GHG fluxes, allowing us to compute the net global warming potential of forests under future climates.

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P-33

Is Mob Grazing beneficial to Soil Health and the Environment?

Miss Poppy Frater

Agriculture is an important contributor to global climate change. 38% of the global land area is managed for agriculture, of which two thirds consist of grasslands for grazing livestock. Poor soil management can increase carbon and nitrous oxide emissions, yet soil management can also reduce carbon dioxide in the atmosphere through carbon sequestration.

Grasslands store more carbon than cropped land. The process of sequestration in degraded soils can take over 100 years before the carbon accumulation begins to plateau. Various studies have compared the net greenhouse gas emissions of pasture-based livestock production and grain-based livestock production and indicated that sequestration is highly influential to the result. However, we need better understanding of carbon sequestration potential in soils with high carbon levels and methods that promote greater carbon sequestration.

Mob grazing is a form of managed livestock grazing, it involves short intensive grazing intervals followed by long rest periods (40-80 days). The practise has the potential to enhance the carbon sequestration and improve soil health. We will investigate the impact of mob grazing using three farm sites that implement different grazing management strategies (one of which uses mob grazing). Our findings will determine whether mob grazing is worthwhile pursuing to offset greenhouse gas emissions and help us to understand the role of livestock to global agroecosystems of the future.

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P-34

Simulation of soil organic carbon in two chronosequences of land use intensification with agrosilvopastoral systems in the Brazilian Cerrado

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The adoption of production systems that promote the accumulation of soil organic matter must be encouraged to maintain the sustainability of agriculture, livestock and forestry. Agrosilvopastoral systems can increase the soil carbon (C) stocks, and became essencial the simulation studies to evaluate the soil C accumulation in the long term, analyzing the effects of management and climate changes. The objective of this study was to simulate the soil C dynamics in two chronosequences of land use with native vegetation, degraded pasture and agrosilvopastoral system in the Brazilian Cerrado. In addition, we predicted future scenarios to verify the potential of soil C accumulation considering variations in precipitation and temperature rates. Our results showed that the Century model reliably simulated the SOC stocks of the two chronosequences. The model predicted an increase in soil C stocks by converting the degraded pasture (46.04 Mg ha-1 and 42.38 Mg ha-1) into agrosilvopastoral systems (54.94 Mg ha-1 and 51.71 Mg ha-1) in the two chronosequences, respectively. The model also predicted that a 20 mm decrease in rainfall and a 2 °C increase in temperature in the tropical regions studied could cause a decline in SOC stocks, especially in degraded pasture systems, while agroforestry systems could show a small reduction in SOC stocks. Our study also confirmed that the replacement of degraded pastures, especially in soils with a clay texture, contributes to increase soil C stocks over time. Thus, agroforestry systems are potentially viable to maintain the sustainability of agriculture in the face of climate changes.

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P-35

Soil organic carbon content from old growth forests in the Basque Country

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Old growth forests may be secondary forests in which human intervention ceased and they may have maturity characteristics of primary forests. The values associated with mature forests are often related to biodiversity but these forests accumulate high amounts of carbon in their soils.
The aim of the study was to determine the amount of organic carbon present in the soil in old growth forests in the Basque Country and to compare it with that of other European forests (ICP Forests).
Nine old growth forest stands were selected in the region considering the results of a previous study. In each of them, a pit was dug down to a depth of 1 m or to the parent material if this was at a shallower depth. Soil samples and undisturbed soil cores were taken from the following depths: 0-10cm, 10-30cm, 30-50cm, 50-75cm and 75-100cm. In addition, 8 probes were taken to the east and to the west of the pit and mixed samples from the same depths were taken. Leaf litter samples were also taken (OL, OF, OH). Total soil carbon was determined in a LECO TruSpec autoanalyzer.
The results for total soil organic carbon content showed that old growth forests in the Basque Country had values of between 128 and 231 t C ha-1. The carbon content of these soils was found to be lower than that of equivalent forest soils in the ICP. These results show that the impact of the intensive historical use of Basque forests is still evident.

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P-36

Regulation of Soil Carbon Sequestration and Greenhouse Gas Emissions in Semi-arid Cropping Systems

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Greenhouse gas (GHG) emission is the main pathway of soil organic carbon (SOC) loss to the atmosphere. In arid and semiarid ecosystems, soil temperature and water content, which are influenced by air temperature and precipitation, vegetation cover, and soil management, play a critical role in SOC sequestration and GHG emissions. We evaluated SOC, soil CO2 and N2O emissions, and net global warming potential (GWP) in irrigated cropping systems and net ecosystem carbon balance (NECB) in dryland cropping systems through field experiments varying in cover cropping and tillage practices. In irritated cover crops study, CO2 emission was up to 5–10 times greater with cover cropping than without (8-10 kg CO2-C ha-1 day-1). However, fallow treatment released 44-77% less or comparable N2O-N emissions with cover crop treatments. This study found no treatment differences in net GWP and cropping system scale GHG emission, although cover cropping increased GHG emissions during cover crops growth. Cover cropping and reduced tillage systems stored more SOC than the conventional system and maintained a positive NECB. In these studies, soil temperature and moisture played a crucial role in regulating SOC dynamics and GHG emissions. Any treatments including no-tillage reduced tillage, or cover crops had 5°C to 6°C lower soil temperature and stored 2.3% to 3.9% more soil moisture content compared to the conventional system. Maintaining a low temperature could reduce GHG (CO2 and N2O) emissions and enhance SOC sequestration. Water limitation decreases net ecosystem productivity. Maintaining optimum moisture increase SOC sequestration and mitigate GWP in semiarid cropping systems.

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P-37

Soil carbon stocks and emissions across two common agroforestry systems are affected by deadwood

Mr. Cole Gross, Dr. Edward Bork, Dr. Cameron Carlyle, Dr. Scott Chang

Agroforestry systems (AFS) are recognized as sustainable agroecosystems that can contribute to climate change mitigation. However, differences in the management of AFS may affect greenhouse gas emissions and carbon (C) sequestration. In this 3-y field study conducted in central Alberta, Canada, we assessed greenhouse gas emissions and various C stocks across two common AFS (hedgerows and shelterbelts) and their component land-use types: perennial vegetated areas without trees (grassland), with planted saplings in grassland, and with mature trees (woodland) and adjacent cropland. Between 2018 and 2020, nitrous oxide emissions were 9.42 times greater in the cropland relative to the perennial vegetation. In 2020, heterotrophic respiration was 2.15 times greater in the hedgerow woodland relative to the shelterbelt woodland (600 and 279 g C m^{-2} y^{-1}, respectively). Within the woodland, deadwood C stock was positively correlated with annual heterotrophic respiration and cumulative (to 100 cm depth) soil organic C, water-soluble organic C, and microbial biomass C. Total ecosystem C was 1.74–2.44 times greater in the woodland relative to the other land uses (178, 225, 249, and 434 [321 and 547 for shelterbelt and hedgerow, respectively] Mg C ha^{-1} for the cropland, saplings, grassland, and woodland, respectively). Deadwood was an important C stock in the hedgerow woodland (34 Mg C ha^{-1}) and also affected C dynamics. Our findings emphasize the importance of AFS for climate change mitigation, particularly retaining hedgerows (legacy woodland) and their associated deadwood, and support a shift in shelterbelt management to more natural woody perennial buffers to foster C sequestration.

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P-37A

Evidence for formation of fused aromatic ring (FAR) structures in an organic soil

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Fused aromatic rings (FAR) structures in soil define the stability of recalcitrant soil organic matter (RSOM). FAR can be identified as an important skeletal component in RSOM which contributes to an extended residence time (>1000 yr) of RSOM. During humification, non-pyrogenic FAR can be formed through condensation and polymerization of biomolecules (Chen et al., 2020). Studying specific depth levels of an organic soil can give important insights to showcase the formation of FAR during the humification process. We conducted molecular level characterization of RSOM giving special emphasis to FAR in an organic soil (>40% organic matter) from the Muck Research Station, University of Guelph. Advanced solid-state 13C NMR, including recoupled long-range C−H dipolar dephasing, exchange with protonated and non-protonated spectral editing (EXPANSE), experiments on humic acids (HA) extracted from organic soil consisted fused-ring aromatics that have formed during the humification. We calculated the aromaticity and the fraction of FAR in each depth level (surface, 50 cm, 90 cm). It was evident that the characteristic peaks of FAR are clearly observable in an increasing level from surface to 90 cm depth. Prevalence of more FARs in 90 cm (12.7% higher) in HAs at 90 cm depth can be due to the formation of FARS at deeper soil layers or slow decomposition of organic matter due to a partially anaerobic environment. These data further strengthen our understanding of the process of humification occurring during organic matter decomposition and help to explain chemical reactions responsible for long-term carbon sequestration in soil.

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P-38

Root-driven clay aggregate disruption is a key mechanism of rhizosphere priming across land uses and soil depths

Mr. Cole Gross, Edward W. Bork, Bjoern Wissel, Cameron N. Carlyle, Scott W. Chang

Rhizosphere priming (root-related enhanced soil organic carbon decomposition rates) plays an important role in soil carbon-climate feedbacks. However, the mechanisms of rhizosphere priming, especially across land uses and soil depths, are not well understood. Here we examined rhizosphere priming effects and the interdependence of soil properties, microbes, and living roots with respect to organic carbon protection and decomposition across soils collected from three different land uses (cropland, grassland, and woodland from ten annually cropped agroforestry sites in central Alberta, Canada) and soil depths (0–10, 10–30, and 30–50 cm). The stable carbon isotope natural abundance technique was used to quantify rhizosphere priming by planting a native perennial C4 plant species (blue grama, Bouteloua gracilis) in these soils derived from C3 plant systems. Following a 150-d controlled growth-chamber incubation, paired planted and nonplanted root-free soils were fractioned into particulate organic matter (> 53 µm), coarse and fine silt, non-aggregated clay, and aggregated clay within stable silt-size aggregates. Preliminary results show that rhizosphere priming was greatest within the aggregated clay fraction across land uses and soil depths. Root-induced losses of C3-derived carbon from clay aggregates increased with the relative initial carbon concentration within this fraction and were strongly related to aggregate disruption. Our findings suggest that root-driven clay aggregate disruption is a key mechanism of rhizosphere priming across land uses and soil depths, which can counteract both mineral and physical protection of carbon and thus has important implications for soil carbon models in our changing world.

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P-39

Carbon sequestration in restored heathlands: a viable climate mitigation tools?

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The conversion of lowland heathland to agricultural land in Europe significantly depleted soil carbon stocks. Restoring heathlands has been proposed as a mechanism to sequester soil carbon. However, it is unclear whether restored heathlands develop carbon stocks similar to their native heathland counterparts. Many heathland restoration techniques have been employed, including acidifying agents (e.g. elemental sulphur). In an 18-year longitudinal field experiment on the Isle of Purbeck, Dorset, we compared soil C contents in bulk soil and physical organic matter fractions in (i) agricultural pasture; (ii) native heathland and (iii) restored heathland with elemental sulphur. After 18 years of acidification altered soil chemical properties, fauna and vegetation assemblage resembled that of native heathlands. However, native heathland was found to contain more than double the total soil carbon than the acidified pasture. Native heathland was also found to have significantly higher active C, total N, C:N ratio and soil organic C (SOC) stock than the acidified pasture. After 18 years the restored heathland whole bulk soil was not significantly different to the control pasture in any of the soil C or N parameters measured. This has implications for climate change mitigation policy that assumes that land-use reversion back to heathlands from agricultural land can sequester carbon. The high C in native heathland was attributed to a higher proportion of particulate organic matter, and the proportion of SOC that consists of active C was significantly lower in the native heathland than the acidified pasture. This emphasises the need for long-term heathland protection.

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P-40

Grounds for assessing regional reference values for organic carbon contents in soil

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Although soil organic carbon (SOC) levels are considered important for agriculture production and climate change, reference values for SOC and/or related indicators are poorly defined. We hypothesize that indicators for active and/or stable SOC fractions show regional differences in relation to carbon storage. Data were collected within a farmers' network of 16 arable farms on mineral soils throughout The Netherlands. In autumn 2019, samples of 32 fields were analysed for organic carbon (Kurmies), Hot Water Exchangeable Carbon (HWC), permanganate-oxidizable carbon (POXC) and the I- and R-index following Rock Eval pyrolysis. Details of soil and farm management over the period 2010-2019 were collected, and additionally, regional statistics. The ROTHC-model was used for modelling carbon storage. In 2019, SOC-contents in the fields ranged from 1.1 to 4.8 g/kg, HWC from 214 to 824 mg/kg and the I/R-ratio from -0.165 to 0.365. For sandy soils, a north-south gradient was shown for SOC- and HWC-contents. The I/R-ratio decreased in the order sandy > löss > old clay > young clay soils, indicating differences in organic matter lability. During the decade, additions of organic matter had increased in all fields. Modelling results however indicate decreasing SOC-trends in 26 fields. Upscaling to the regional level revealed that regions may differ in risk of SOC decline. The conclusion is that regional references for SOC indicators alone do not suffice for evaluating carbon storage. It is recommended that sets of agro-ecological indicators are developed, including SOC fractions and soil management, and relative to regional weather conditions.

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P-40A

Effects of long-term (70 years) nitrogen fertilization and liming on carbon storage in water-stable aggregates of a semi-arid grassland soil

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Grasslands cover up to 40.5% of the world's landmass and stores a tremendous amount of carbon (C). Fertilization and liming are used to manage these ecosystems with potential long-term effects on carbon dynamics. This study examines long-term effects of nitrogen fertilizers and liming on soil organic carbon storage and dynamics in soil water-stable aggregates. Soil samples (0-10 cm) were collected from Ukulinga long-term grassland trial in Pietermaritzburg, South Africa where nitrogen fertilizers have been applied annually and lime every five years for 70 years. Ten treatments were studied including the control (C; 0 kg/ha), lime at 2250 kg ha-1 (L), ammonium sulphate (AS) at 70 kg ha-1 and 211 kg ha-1; ammonium nitrate (AN) at 70 kg ha-1 and 211 kg ha-1 ; AS70 + lime; AS211 + lime ; AN70+ lime and AN211+ lime. Nitrogen or lime application had no significant effects on SOCc and SOCs. Nitrogen fertilizers significantly reduced soil pH and increased total soil N. Nitrogen application decreased MWD, macroaggregates and increased C associated with microaggregates while liming increased C stored in macroaggregates. The lack of response in total SOC under both liming and N fertilization suggests the importance of soil pH on soil aggregation and possible decoupling of aboveground and below-ground C. The results show that N addition is associated with more protected C and soil acidification while lime promotes the accumulation of particulate organic C. This redistribution of OC in water-stable aggregates maybe useful indicators of long-term carbon sequestration and soil fertility in human-managed grasslands.
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P-41

Changes in Danish agricultural soil SOC inventory between 2008 and 2018 and improved estimation method

Miss Laura Sofie Harbo

Soil can act as both a source and a sink of CO2, which affects the atmospheric greenhouse gas balance. Soil organic carbon (SOC) is essential for agricultural production, as many physical and biological soil functions are closely linked to SOC. Having accurate estimates of the SOC pools is essential for calculating the effect of land use change and agriculture on the climate, but are also important in the quantification of the carbon cycle to gain deeper understand of our changing planet.
Since 1986, the National Square Grid of Denmark has been surveyed once per decade to estimate the SOC stock in Danish agricultural soils. In 2008, a new procedure was implemented to improve the accuracy of the estimates by minimizing errors during sampling. The new procedure allowed for highly precise relocation of the sampling sites in 2018, reducing the impact of field scale variation. Additional measurements of local bulk density and stone fractions in 2018 has also allowed for more accurate SOC stock estimations.
The results from 2008 and 2018 show that the Danish agricultural soils tend to lose SOC stock in the topsoil (0-25 cm), while gaining in the lower layer (25-50 cm), which results in a small net gain of SOC stock for the whole profile to 0.5 m. Sandier soils are observed to lose more SOC stock compared to the more clayey soils, but the sandier soils also tend to have a greater SOC pool overall. Larger pools are overall more likely to experience SOC loss.

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P-42

Effect of waterlogging on carbon dynamics in agricultural mineral soil.

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Predicted increase in winter rainfall may cause more frequent soil waterlogging in Northern Europe, which can lead into reduction of iron minerals and dissolution of stable forms of organic carbon. Thus far, the significance of such reaction path, as well as the fate of liberated carbon remains unknown in agricultural mineral soil. We have established a soil monolith experiment to study the interactive effects of soil waterlogging, soil type and overwintering cover crops on soil carbon dynamics. In total 32 intact soil monoliths (l=60 cm, d=16 cm) with two contrasting soil types (clay, sandy loam) are cultivated (Barley, Barley + Tall Fescue) for three alternating growing and off-seasons in the greenhouse. During off-seasons, half of the monoliths are irrigated to reach waterlogged conditions while the rest are kept below field capacity. Soil moisture, temperature, electrical conductivity and redox potential are continuously measured at three soil depths. Soil pore water samples are collected for dissolved organic carbon (DOC), iron and nutrient analysis, and CO2, CH4 and N2O emissions are measured. We expect that the effects of soil waterlogging depend on the amount of Fe-bound organic carbon, soil texture and structure. In coarse textured soil, larger fraction of DOC may leach, whereas in fine textured soil, longer residence time of water and DOC can favor mineralization or re-stabilization upon soil drying. Elucidating the linkages between soil moisture and carbon dynamics is essential in evaluating the future impacts of climate change on soil´s ability to sequester carbon and in developing sustainable management practices.

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P-43

Land use change and related impacts on carbon stocks in Ferrasol of southeastern Benin

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Soil and biomass organic carbon (C) stocks are indicators for monitoring soil and environmental degradation[1]. They are sensitive to land use, which may change rapidly due to demography and pressure on land[2]. The study focused on a highly populated agricultural region in south Benin, the Allada plateau (2140 km^2). The objectives were to (i) assess C stocks in 5 carbon pools (aboveground, belowground biomass, necromass, litter and upper 0-30 cm soil layer) according to land uses and to (ii) evaluate their spatial distribution and evolution over 18 years (2000-2018). Field measurements of C stocks in the land uses and classification of Landsat image were performed. InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) model was used to map C stocks in 2000 and 2018. Forests have the highest total C stocks (389 Mg C.ha-1) compared with other land uses (222, 154, 105, 77 Mg C.ha-1 in plantations, palm groves, crops under plantation and croplands, respectively). C was mostly stored in the C biomass pool[3]. Plantations, palm groves and built up areas surfaces increased at the expense of forests and crops under plantation. From 2000 to 2018, carbon stocks in the region decreased by 208 Gg C. The most significant values were reported for soil (-179 Gg C) and aboveground biomass (-123 Gg C).Our results confirm that afforestation and limiting deforestation are essential to maintain C stocks. They also highlight the interest in accounting C losses from soil to avoid an underestimation of the C stock dynamics of a rural region.

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P-44

Investigating the potential of vineyard soils for carbon sequestration and greenhouse gas emission mitigation after subsoil incorporation of organic matter.

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Soils in perennial cropping systems, such as vineyards, have good prospects for storing carbon since less management is required with minimum disturbance to the soil that might prevent rapid turnover of organic matter.
In our study, the stability of high carbon organic materials (i.e., compost and a Terra Preta-like material) after deep (30-60 cm) incorporation into the soil of a vineyard in western Germany was investigated with respect to greenhouse gas emissions. Portable gas analyzers were used for long-term in-situ monitoring of greenhouse gas emissions. Additional parameters quantified were soil redox potential using Pt electrodes and the concentration of greenhouse gases in pore space of the soil using air samplers.
The deeply incorporated soil organic amendments showed good stability with respect to N_2O and CH_4 emission, whereas 30.4% and 51.7% of the compost and the Terra Preta-like material, respectively, was decomposed and released as atmospheric CO_2 after two years of observation. Oxygen availability at different soil depths throughout the sampling period, indicated by redox potential values of 300 to 700 mV, played a role in the turnover of organic matter in the treatments. Higher CO_2 concentration in the treatments in the deeper soil layer (30-50 cm) compared to the control was also consistent with higher CO_2 emission at the soil surface.
To investigate the site-specific influence on stability of organic matter, the emission of greenhouse gases will also be quantified in different vineyards at different locations with similar management.

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P-45

Organic carbon storage capacity and deficit in the topsoil of Hungary

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Soil organic carbon (SOC) is a crucial property affecting almost all functions of the soil. Intensive agricultural activities triggered relevant SOC losses in most cultivated topsoils leading to degradation and decreasing soil health. Alternative tillage systems aim to reload the missing SOC content to the topsoil with particular attention to keep crop production efficient. Several initiations were introduced to increase the SOC content of cultivated topsoils, however the limitations, for instance, the potential storage capacity, is rarely taken into account due to the lack of a widely accepted, precise, country scale prediction method to estimate organic carbon storage capacity. The present study aims to compile such a SOC saturation prediction method using machine-learning-based pedotransfer functions. Based on the Hungarian Soil Information and Monitoring System, 183 permanent forest sites were considered SOC saturated soils., each saturated SOC content was empirically referred to the local values of 28 environmental (soil, climatic, topographic) variables. As a result, four hierarchical rules were determined using the cubist algorithm. The rules cover the country's territory and estimate the SOC saturation using four different pedotransfer functions reflecting the local environmental conditions. Consequently, a theoretical SOC saturation map for Hungary's uppermost 0-30cm soil was constructed with 100m spatial resolution. Comparing this map with the actual SOC concentration database, the increasing potential map was compiled, indicating >80% of the country is unsaturated and the highest increasing potential under moderate or even high current SOC content. The study was supported by the Development and Innovation Fund of Hungary [NKFIH 123953].

P-46

15-years of organic fertilization led to an increase of total C but also turnover of native-C using 13C

Mrs Floriane Jamoteau, Mr Baptiste Hulin, Mrs Isabelle Basile-Doelsch, Mrs Christine Hatté, Mr Emmanuel Tillard, Mr Antoine Versini

Application of organic fertilizers (OF) on crop soils is often considered as a way to stabilize C in topsoil and potentially in subsoil. But OF are also potential promoter of mineralization of native-C (soil C before OF input) through priming effect [1]. Understanding carbon stabilization can be achieved by characterizing the mean carbon residence times in soil particle size fractions, within which different stabilization mechanisms might be invoked [2]. We here aimed to track OF-derived C (OF-C) in soil fractions to understand its stabilization mechanism and potential native-C destabilization in two tropical grasslands (Andosol/Arenosol). To do this, we took advantage of distinct ^{13}C signature between soil native-C and compost/slurry applied during 14 years [3]. We measured total C and $\delta^{13}C$ of bulk soil and particle size fractions (>50;20-50;<20 µm). Results in both grasslands and down to 20 cm show that (i) the amended plots increased in total bulk C; (ii) the >50 µm fraction shows an increase of C content but no significant change is observed in the 20-50 µm and the <20 µm fractions; (iii) in all fractions, $\delta^{13}C$ signature indicates a shift towards $\delta^{13}C$ of compost/slurry. In deeper Arenosol layers (20-100 cm), C remains constant and $\delta^{13}C$ shifts towards $\delta^{13}C$ of OFs whatever the fraction. The results suggest that application of OFs leads to C stabilization in the >50 µm fraction of the upper soil layer, whereas in the finer fractions and subsoil, $\delta^{13}C$ tends to show a replacement of native-C by OF-C or/and preferential stabilization of OF-C.

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P-47

Relationships between carbon sequestration and physicochemical properties of forest soils in a Central European detritus manipulation experiment

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The interactions of climatic and geochemical factors control soil organic carbon (SOC) sequestration capacity and C-turnover of the forests. The comprehensive evaluation of the effect of long-term detritus manipulation on the SOC, soil-forming processes and the soil physical and chemical properties will help better understand the carbon sequestration of forest soils. The long-term (19 years) effect of detrital input and removal treatments (DIRT) on physicochemical soil properties were investigated at a Central-European forest site (47°55′34′′ N and 20°26′ 29′′ E, Hungary). Compared to the other DIRT sites and other similar experiments in the world, our experimental site is considered unique, as it has the highest clay content (32.6–40.1 m/m%) and the driest climate (mean annual precipitation is 590 mm). In contrast to the results of similar experiments in other parts of the world, the detritus input treatments significantly affected the SOC and soil physicochemical indicators for the upper 15 cm layer. Soil pH, potential acidity and exchangeable Ca++ decreased in the litter removal plots and increased in the detritus doubling treatments. A decrease in SOC in the litter removal plots explained the changes in bulk density, as the stability of aggregates also decreased with the decrease of exchangeable bases and organic colloids. We conclude that potential cation exchange capacity and exchangeable Ca++ play a fundamental role in predicting the occurrence of the carbon sequestration mechanisms. We suggest to include these parameters into current C-turnover and soil carbon sequestration models.

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P-48

Drought increased the forest's belowground sink strength towards temporarily increased soil carbon stocks

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Reduced carbon assimilation by plants and increased net ecosystem exchange are often considered to reduce the overall carbon sink function of drought-stressed forests. However, plants and soil may respond in different trajectories under drought, leading to imprecise predictions of carbon sequestration in soil when mainly aboveground processes are considered. We determined the net carbon assimilation, soil organic carbon (SOC) stocks including their qualitative characteristics, and collected root exudates to measure belowground carbon allocation to soil from mature trees (F. sylvatica and P. abies) exposed to experimental drought for five growing seasons. Despite more than 50% reduction in net carbon assimilation under drought, SOC stocks increased on average by more than 30%. The proportion of carbon allocated as root exudates increased by two- to threefold under drought. Our data indicate that the belowground sink strength increases rapidly for the ecological and economic most relevant tree species in Europe; i.e., focusing mainly on aboveground carbon fluxes neglects belowground SOC accumulation under drought. Although belowground-invested carbon could contribute to reducing the carbon-climate feedback temporarily and may support ecosystem resilience, SOC accumulated primarily in dry surface mineral soil may be vulnerable upon exposure to rewetting events.
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P-49

Tracing added carbon from wood fibre amended soils

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Analysis of total carbon (C) concentration has proven to be inadequate in examining the fate of C added to soil in organic amendments (Rasa et al., 2021). In order to detect changes that are small against the background and its variability, separation of the C pool into selective fractions may be useful (Poeplau et al., 2018). In this study, soil samples collected from two field experiments in which wood fibre had been applied on a clay and a coarse mineral soil were fractionated according to particle size and density prior to C analysis. The soils were dispersed in either water or sodium hexametaphosphate and wet sieved on 250 µm and 63 µm sieves. The material remaining on the sieves was further separated into light and dense fractions both in water and in sodium polytungstate (1.8 g cm-3). In the end, each sample was divided into five fractions: 1) > 250 µm particulate organic matter (POM), 2) > 250 µm mineral associated organic matter (MAOM), 3) 63-250 µm POM, 4) 63-250 µm MAOM, and 5) <63 µm MAOM. The results of the study will be available early 2022.

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P-50

Soil carbon loss in changing climate: boreal evidence from agricultural mineral soils

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The soils of high latitudes constitute a globally significant soil organic carbon (SOC) stock recognized to be the most vulnerable to environmental warming (Koven et al., 2017). In this study, the influences of climate change and management practices on SOC in agricultural mineral soils of Finland were examined by a Bayesian model using a data-set created by combining nationwide soil monitoring data (Natural Resources Institute Finland; Heikkinen et al., 2013, 2021), climate grids (E-OBS or Finnish Meteorological Institute data) and database of management and cultivated crop plants (Finnish Food Authority). The topsoil SOC content was found to have decreased between 2009 and 2018 by on average 0.12 g/kg (0.35%) with combined contribution from soil properties, cultivation practices and climate change. Soils with high SOC-to-fine-fraction ratio proved to be particularly susceptible to lose SOC. Increase in summertime precipitation and temperature over the study period both accelerated the SOC loss. Perennial cropping system was identified as most carbon-friendly followed by rotations of annual and perennial crops and diverse cropping systems, whereas cropping systems based on annual crops were most liable to lose SOC. We conclude that it is highly challenging to counterbalance climate change induced SOC losses by management choices.
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P-51

Legacy of plaggen agriculture: High soil organic carbon stocks as result from high carbon input and volume increase

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Plaggic Anthrosols are anthropogenic soils formed by former plaggen agriculture in north-western continental Europe. We present an inventory of organic carbon (OC) concentrations and stocks of Plaggic Anthrosols and of reference soils in the vicinity without plaggen fertilization history from eight sites in northwest Germany and the eastern parts of The Netherlands. The plaggic topsoils are characterized by high OC concentrations (6.5–36.9 mg g−1) and a thickness of 53−124 cm, in contrast to the modern cultivated ~ 30 cm thick topsoils of the reference soils (10.6–24.0 mg g−1 OC). The addition of plaggen material to the topsoils induced a volume increase as well as higher OC concentrations in the Ap horizons, resulting in significantly higher OC stocks in the Plaggic Anthrosols compared to the reference soils. The additional soil volume amounted to 30–56% to the total soil profile depth (1.0 to 1.6 m) and comprised 25–62% of the total OC stocks. The volume increase of the plaggic topsoil increased the PAWC in the effective rooting zone by 1.6 to 3.4 times. Plaggic Anthrosols represent a relic of historical farming with preserved high OC concentrations and improved storage capacity for plant-available water, causing higher nutrient availability and an increase in yields, which in turn result in higher in-situ OM input, additionally contributing to high OC stocks. The results of this study demonstrate the potential of soil melioration practices similar to the former plaggen management to induce high OC concentrations and increase OC stocks in sandy agricultural soils.

323 Urbanski L, Schad P, Kalbitz K, Van Mourik J, Gehrt E, Kögel-Knabner I (2022) Legacy of plaggen agriculture: High soil organic carbon stocks as result from high carbon input and volume increase. Geoderma 406, 115513.

P-52

Water-extractable organic matter in the mosaic of natural habitats and human-induced areas of SE Iceland

Aleksandra Kot, Ms. Urszula Norton, Mr. Grzegorz Kulczycki, Mr. Jon Gudmundsson, Ms. Agnieszka Medynska-Juraszek, Mr. Szymon Jedrzejewski, Mr. Jaroslaw Waroszewski

Soil water-extractable organic matter (WEOM) is a mixture of macromolecules and low molecular weight compounds formed by the decomposition of old and fresh soil organic matter. Due to its composition of easily degradable molecules, WEOM is the most dynamic and bioavailable soil organic matter (SOM) fraction (considering WEOM as dissolved organic matter (DOM) extracted by aqueous solutions).
While high-latitude regions reveal temperature increase at an amplified rate and contain large amounts of organic carbon, it is crucial to recognize and minimalize factors inducing warming of circumpolar regions. Andosols are the dominant soil type in Iceland possessing exceptional amounts of organic carbon (up to 25%). WEOM studies have never been carried out in Iceland in detail while additionally, the soils are currently under environmental pressure both changes in land use and natural transformations. It is known that land use type is one of the main factors determining WEOM source and its dynamism.
To implement the research scopes we investigated natural lands (tundra, wetlands, lava fields, outwash plain) and human-induced areas (intensively and extensively grazed pasturelands, mowing meadow) between Kotafjall Mt. and Skeiðarársandur outwash plain in the southwest from the Vatnajökull ice cap.

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P-53

Effect of long-term organic matter manipulation on soil labile carbon content and biological activity

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Soil enzyme activities are relevant indicators of soil organic matter decomposition since they provide up to date information about microbial status and physico-chemical condition of soils. Our studies were carried out in a temperate deciduous oak forest in Hungary. The Síkfőkút Detritus Input and Removal Treatments (DIRT) Project includes treatments with doubling of leaf litter and woody debris inputs as well as removal of leaf litter and trenching to prevent root inputs. Our aim was to compare the effects of permanent withdrawal or doubling of organic matter on soil biological activity and changes in labile carbon content in a long-term organic matter manipulation experiment. We measured soil dehydrogenase and glucosidase enzyme activity and labile carbon content after 20 years of treatment.
Based on our results, we found that the enzyme activities of the litter withdrawal treatments were significantly decreased compared to the doubling treatments. The same significant difference was also found in the labile (easily available to microbes) C content of the soils in the treatments. We found that the enzyme activities of the litter withdrawal treatments were significantly reduced compared to the litter doubling treatments. The same significant difference was also found in the labile (readily available to microbes) carbon content of the soils in the treatments. Long-term organic matter withdrawal caused a decrease in the labile C content of the soils. This trend persisted in the deeper soil layers, but the differences were more evenly distributed, as the labile C content of the doubling treatments decreased with depth.

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P-54

Effects of long-term wheat production management on aggregate dynamics and intra-aggregate carbon in semi-arid South Africa

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Soil aggregate dynamics have received renewed interest due to their relevance in carbon (C) stabilization. This study evaluated changes in aggregate-size distribution and intra-aggregate C following 41 years of wheat production in semi-arid central South Africa. Management practices that have been applied for 41 years include two straw management (unburned and burned), three tillage systems (no-tillage, stubble mulch and mouldboard ploughing) and two weeding methods (chemical and mechanical). Soil cores were taken at 0-10 cm and 10-20 cm depths and fractionated to aggregates of different sizes using wet sieving. All the fractions including bulk soil were analysed for C. Unburned plots had more small macro-aggregates (35% and 33%, respectively) in the 0-10 cm and 10-20 cm depths, but 26% and 27% lower large macro-aggregate and bulk C, respectively in the 10-20 cm depth compared to the burned plots. No-tillage stimulated re-aggregation, especially large macro-aggregates by 68% in the 0-10 cm depth compared to stubble mulch. Small macro-aggregates, large micro-aggregates and bulk soil under no-tillage had on average 25% higher C compared to those under mouldboard ploughing in the 0-10 cm soil layer. Although signs of aggregate equilibrium state were evident, future studies focusing specifically on this subject are needed.

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P-55

Drivers of the amount of organic carbon protected inside soil aggregates estimated by crushing: A meta-analysis

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Soil aggregates can provide effective protection of organic carbon (OC) from microbial decomposition. There is no systematic method for estimating the amount of protected carbon within aggregates. However, difference between CO2 emissions from incubation of intact versus crushed aggregates have been widely used as a proxy for OC physical protection within aggregates. There is no global analysis on this type of experiment nor on the drivers of the amount of OC physically protected in soils yet. Using a meta-analysis including 165 pairs of observations from 22 studies encompassing a variety of agro-ecosystems, climate and soil types, we investigated the crushing effects on cumulative carbon mineralization from lab incubation experiments. Our results indicated that aggregate crushing led on average to 31% extra OC mineralization compared with intact aggregates, which represents 0.65 to 1.01% of soil OC. This result suggests the mineralization of a previously protected pool of labile OC. The amount of de-protected OC by crushing was positively correlated with soil pH and clay content. The crushing effect on OC mineralization depended on the aggregate size and crushing intensity. The intense destruction of aggregates to <0.05 mm had a greater effect than the destruction of aggregates to > 2mm, < 2mm and < 0.25mm, regardless of the initial aggregate size. These results suggest that macroaggregates (>0.25 mm) are less protective than microaggregates (<0.25 mm). Furthermore, the crushing effect is no influenced by the type of agro-ecosystems.

Keywords: Organic carbon; aggregates; physical protection; crushing; mineralization

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P-56

Microbial necromass as the source of soil organic carbon in global ecosystems

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Despite the importance of microbial necromass contribution to soil organic carbon (SOC) sequestration, the quantifications for cropland, grassland, and forest ecosystems are absent at a global scale. We estimated the contents of fungal and bacterial necromass based on glucosamine and muramic acid contents in cropland (986 samples), grassland (278 samples), and forest (452 samples) soils. Microbial necromass contributed 51%, 47%, and 35% to SOC in cropland, grassland, and forest soils, respectively. The necromass contribution increased with depth in grasslands and forests. The ratio between necromass and living microbial biomass was higher in soils from croplands (41) and grasslands (33) than in forests (20). Consequently, microbial turnover is faster in grasslands and croplands than under forests. Fungal necromass (>65% of total necromass) had higher contributions to SOC than bacterial necromass in all soils due to i) larger living fungal than bacterial biomass, and ii) fungal cell compounds are decomposed slowly and persist longer in soil. The ratio of fungal:bacterial necromass increased from 2.4 to 2.9 from croplands to forests, because fungi are the principal decomposers of complex substrates dominant in forest soils. Lower temperature and soil pH (temperate and boreal ecosystems) stimulate fungal and bacterial necromass accumulation. This shifts in the bacterial:fungal necromass ratio and the microbial necromass contribution to SOC are ecosystem-specific and depend on climate. In conclusion, microbial necromass contributes to approximately half of the SOC in cropland and grassland soils, and 35% in forest soils; whereas two-thirds of microbial necromass are of fungal origin.

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P-57

Crop rotation and fertilization effects on soil carbon dynamics from Swedish long-term field experiments

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Increasing soil carbon storage in agricultural soils has great potential to mitigate climate change. Using perennial forage crops in rotations and increasing crop production through optimal fertilization are two management strategies for achieving this. In the Swedish long-term soil fertility field trials, two crop rotations, four levels of phosphorus & potassium and four levels of nitrogen fertilizer were setup and meta-replicated in 1966. One rotation includes a forage crop, exports straw and receives manure, while the other includes only annual crops without exporting straw and does not receive manure. We analyzed topsoil carbon and phospholipid fatty acids from two extreme treatments (zero NPK and highest NPK treatments) in each rotation at three sites to investigate the management effect on soil carbon dynamics. All treatments showed losses of topsoil carbon over time, but the rotations with a forage crop displayed significantly positive effects on the topsoil carbon content. After 10 years, there was significant differences in topsoil carbon between the two rotations and this relative difference remain the same after 50 years. Least-square means of topsoil carbon content were 2.05±0.04% and 1.92±0.04% for rotations with and without a forage crop, respectively. Applying nitrogen fertilizer also slowed down carbon loss rate in both rotations. Furthermore, viable microbial biomass and bacteria/fungi ratio were significantly higher in the rotation with forage crops, suggesting that different quality of carbon inputs modified the microbial communities and carbon dynamics. In conclusion, including forage crops in the rotations and nitrogen fertilization had positive effects on topsoil carbon.

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P-58

Soil organic matter density fractions and mean residence time across a 56-year agri-recultivation chronosequence after open-cast lignite mining in Germany

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Lignite mining will be phased out by 2038 in Germany. However, in the Rhineland, a large area of soils with extremely low soil organic carbon (SOC) content (<0.5%) will remain due to opencast lignite mining. Here, we investigated how agricultural recultivation affects SOC stocks and soil organic matter (SOM) stability in these soils. Soil samples (0-30 cm depth) were collected along a chronosequence of 0 to 56 years of continuous recultivation. An agricultural soil near the mining front was sampled as original soil (OS, Luvisol). Different SOM fractions (free light, FLF; occluded light, OLF; and heavy fraction, HF) were isolated, and their SOC content was determined. Soil samples were incubated at 12 °C (233 days), their respiration was monitored, and the mean residence time of fast (MRTf) and slow (MRTs) SOM turnover pool was estimated. The development of SOC stocks over recultivation time best fit an equation with exponential increase to maximum (R2 = 0.88), and recovery relative to OS (57.3 Mg ha-1) ranged from 22 to 80%. The variable SOC stocks of the FLF (1.3-4.2 Mg ha-1) and MRTf (14.6-54.8 days) likely reflected recent cultivation of the fields at sampling date. Maximum recoveries of SOC stocks of OLF and HF were 109 and 70%, respectively, compared with OS stocks (14.5 and 38.6 Mg ha-1, respectively), which partly explains the recovery of only 48% of MRTs of OS (51.8 years). A linear equation (R2 = 0.92) indicated that 190 years of recultivation would be required to reach OS's current MRTs.

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P-60

Effect of rice cultivation on the soil carbon stock in mangrove ecology

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Over 3.6 million ha of global mangrove forest has been lost between 1980 and 2005 due to anthropogenic activities like cultivation. These cause soil perturbation and disrupt the balance between the input and output of C in soils. However, the impact of agriculture on mangrove soil remains largely unexplored. We assessed the impact of rice cultivation on stock and stability of C in soils under natural mangrove vegetation. To do this, we collected soils with mangrove vegetation (M), mangrove vegetation replaced by rice (MR), and typical rice (R) for long from 28 locations along the coastal Sundarbans, India. We estimated different forms of organic C in soils.
The total carbon of M was found to be ~26% higher than R and MR in 0-60cm soil layers. In consequence, higher soil organic C and microbial biomass C were observed with M than other land uses. However, regular inundation with seawater in soils under M imparted 21 and 27% higher recalcitrant C values in M than those of soils under MR and R respectively in 0-60cm soil layers. Rice cultivation enhances aeration in surface soil, consequently, 52 and 56% of organic C of 0-60cm were allocated in the surface soil of MR and R, which was significantly higher than that in M. In contrast, recalcitrant C contents were observed low in surface soils of MR and R . Thus, results indicated that the cultivation effect on C stock was more pronounced at the surface than those at sub-surface layers.

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P-61

Understanding Spatial Distribution of Tidal Marsh Soils for Carbon Accounting

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Tidal marsh soils serve as important sinks for atmospheric carbon storing an order of magnitude more carbon per unit area than terrestrial forests. Recent reports have questioned the validity of order 2 soil maps for blue carbon accounting of tidal marshes. Assessing carbon stocks in tidal marshes is challenging because: 1) the landscapes are typically flat; 2) many marshes may be 1000's of meters wide and hard to access and traverse; and 3) there is a poor understanding of plant-soil type relationships that can assist in the mapping. Our overall objectives are to understand the pedo-geomorphologic parameters that contribute to the spatial distribution of tidal marsh soils in the United State's northeastern Atlantic Coast and to utilize these factors for blue carbon accounting and modeling. Tidal river, tidal creek, back barrier, open water, and cove were identified as the most common pedo-geomorphic settings in the study area. Soils were described and samples collected from over 30 marshes along transects extending from the water's edge to the upland in these settings. Initial data analysis indicate that carbon-rich organic horizons are thicker adjacent to the water in the tidal rivers and decrease toward the upland while in back barrier systems that relationship does not exist. Carbon stocks and soil properties are being accessed relative to spatial data including land use/cover, marsh area, distance along marsh transects, fetch, elevation, and adjacent upland soil type. Machine learning algorithms will be applied to estimate the carbon stocks and distributions across the study area.
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P-62

Reversion of perennial biomass cropping systems co-target POM and MAOM and sustain both fertility and climate goals

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Soil organic matter (SOM) formation and decomposition are determinants of SOM persistence and soil functions under perennial biomass crops (PBCs). Targeting mineral-associated organic matter (MAOM) for SOM sequestration is logical for persistence, but not always feasible, as MAOM can saturate[1] while particulate organic matter (POM) cannot. The POM vs MAOM framework has been recently proposed to support recommendations on SOM management to practitioners and policy makers[2]. PBCs during their cultivation accumulate substantial amount of C in their belowground biomass (BGB)[3]. BGB is incorporated into soil at the reversion, thus entering the upper soil layers mainly as POM[4] and promotes high C sequestration rates[5]. A reversion experiment of a 11-y old multispecies with 6 PBCs trial was used to operationally link and understand how POM and MAOM dynamics during reversion of PBCs plantations contribute to two important management goals: fertility (nutrient cycling) and climate goal (soil C sequestration). Fertility goal was measured through the analysis of labile C, soil protein and soil hydrolitic enzyme activities while climate goal was quantified as POM-C and MAOM-C sequestration rates. First results indicated that PBCs are responsible of POM-dominated systems during their cultivation while with reversion they target both POM and MAOM pool. Already after 1 y from reversion, MAOM-C formation rate resulted 4x higher than one of cultivation period, while POM stock increased 3x (up to 11 Mg POM-C ha^{-1}) correspondingly promoting 3x higher soil enzymes activities. Cultivation of PBCs co-targets POM and MAOM meeting both C sequestration and soil fertility goals.

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P-63

The effect of different agricultural management on Soil Organic Matter content
A case study: Józsefmajor, Hungary

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Soil organic matter (SOM) content is an effective parameter of soil properties in agricultural fields. However, different agricultural management (tillage operation) influences SOM, and eventually soil quality. Tillage systems can prompt immediate soil disturbance and ambient environmental changes that can fundamentally alter inputs and decomposition rates and eventually affect soil carbon content. In this study, we assessed the impact of six different tillage operations including disking (D), shallow tine cultivation (SC), no-tillage (NT), deep tine cultivation (DC), ploughing (P), and loosening (L) on SOM content. For this purpose, a total of 24 soil samples were collected from 0-10 cm of a small arable field in Jozsefmajor located in Hungary. SOM content estimated using Turin methodology and the one-way analyses of variance (ANOVAs) were used for quantifying the effect of different land management on SOM content. According to the results, conservation tillage such as D and NT showed a higher amount of SOM content and more intensive tillage like P showed a lower proportion. Also, we could find a significant difference between P-NT, P-D, P-DC, D-DC, D-L, D-SC. The results suggest that changes in agricultural management from conservational to conventional tillage may significantly affect the SOM content.
Keywords: Tillage operation, Impact assessment, Soil organic matter content, Agriculture
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P-64

Reduced soil tillage intensity increases C sequestration through Ca retention in topsoil

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Management practices can significantly modify soil structure, which impacts soil quality and productivity. By reducing tillage intensity, soil disruption decreases and thus the aggregation takes place. This process is influenced by soil organic carbon (SOC), biota, ionic bridging, clay and carbonates in soil. Furthermore, aggregation is stimulated by polycation bridging, like calcium (Ca), which act like bonding agent for negatively charged clay and SOC. Aim of our study is to research impacts of different tillage systems on carbon sequestration. The thesis is, that reduced tillage increases the saturation of the sorptive complex with Ca in the upper soil, C content and the stability of structural aggregates. Samples from topsoil (0-10 cm) were taken in October 2021 from two long-term field experiments (started in 2011), with very different soil type (shallow cambisol with 22% clay in comparison to deep alluvial gleysoil with 54% clay; both ca. 2 km apart in the humid temperate climate of Slovenia). Tillage systems, used in research are: tillage with ploughing (T; 25 cm deep), minimal tillage (MT; 10 cm deep), and no tillage (NT). Samples are being analysed for cation exchange capacity (CEC), base saturation including exchangeable Ca, total Ca, pH, C-fractions (total, DOC, POX-C, organic, mineral), clay content and water stable aggregates.

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P-65

Evidence supporting rhizosphere priming in the field based on tight coupling between photosynthesis and soil carbon turnover

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Rhizosphere priming effects are well-documented under laboratory and controlled-environment conditions, but their significance in undisturbed systems under field conditions is less clear. This is in part because it is impracticable to measure rates of rhizodeposition in the field with high resolution over a substantial period. We propose that photosynthesis, closely linked to rhizodeposition, can be used as a proxy for plant root activity.

We have used a field system containing 24 0.8-m diameter, 1-m deep lysimeters holding naturally-structured soil monoliths from two contrasting C3 soils sown with a C4 grass (Bouteloua dactyloides) to measure carbon (C) fluxes at a high temporal resolution, exploiting isotopic differences to allow partitioning of plant and soil fluxes. This system also allowed measurement of net ecosystem exchange, and soil temperature and moisture, and we have generated a dataset of measured and modelled respiration and photosynthesis fluxes over two years.

Our dataset has revealed clear seasonal and diurnal patterns in plant and soil fluxes. We have assessed the relationship between diurnal patterns in soil respiration and potential drivers, and examined whether model estimates of soil respiration are improved by the inclusion of photosynthesis as an explanatory variable alongside soil moisture and temperature. We found a significant positive relationship between photosynthesis and soil respiration, and inclusion of photosynthesis improves models of soil respiration. This is best explained by rhizosphere priming enhancing soil C turnover.
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P-66

Quantifying impacts of forest fire on erosion and soil carbon in an intensively managed forest in the western Oregon Cascades

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Forest fire influences the immediate post-fire soil carbon (C) pool by contributing increased amounts of pyrogenic carbon (PyC) while consuming above and belowground organic matter. Wildfire also impacts physical aspects of soil, leading to decreased bulk density, increased erosion, and fire-induced hydrophobicity. The C, nitrogen (N), and PyC storage of forest soils immediately after a fire are therefore uncertain as a result of multiple physiochemical factors. Understanding post-fire C trends is essential to predict future ecosystem responses due to increased wildfire frequency.

We seek to determine the impact of wildfire on forest soil C. Specifically: (i) how do soil stocks of C, N, and PyC change throughout the soil profile after a fire and (ii) how does post-fire erosion influence these soil stocks?

The project utilizes an intensively studied soil carbon site of 8-year-old Douglas-firs in the western Cascades in Oregon, US. The site was sampled pre- and post-harvest in 2010 and 2015, with a harvest in 2012; a stand-replacing wildfire burned the site in September 2020 as part of the 170,000- acre Holiday Farm Fire. Forest floor biomass and 0-30 cm soil samples were collected at the three sampling points and are utilized to compare C stocks and contents.

Preliminary results indicate that a high severity fire causes a 97% decrease in forest floor C stock and a 25% decrease in soil C (0-30 cm) stock. Future analysis includes PyC determination through benzene polycarboxylic acid analysis (BPCA) and use of coarse content as a conservative tracer for erosion.

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P-67

A radiocarbon-based approach to explore dissolved organic carbon cycling in Swiss forest soils

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Anthropogenic climate change perturbs the carbon cycle. Interactions between terrestrial, aquatic and atmospheric carbon reservoirs represent a great uncertainty in the global carbon cycle and its feedback with climate change. Dissolved organic matter transfers carbon within soils and links soils with aquatic ecosystems. However, knowledge on dissolved organic carbon (DOC) sources and transfer is limited. Here, we analyze radiocarbon (^{14}C) signatures of DOC in soil solution and water extractable organic carbon (WEOC) in samples from Swiss forest soils to identify the magnitude and pathways of C fluxes from the terrestrial to the aquatic domain. The study includes five long-term monitoring sites, which cover the different ecoregions of Switzerland. They provide a long-term record in DOC concentrations and the opportunity to analyze $DO^{14}C$ and $WEO^{14}C$ in archived samples. We will use ^{14}C measurements of bulk DOC and WEOC across soil profiles to constrain flux rates and pathways of different carbon age classes and their potential export to the aquatic continuum. With the comparison of ^{14}C signatures of DOC and WEOC at two time points, that span a gradient in the atmospheric bomb ^{14}C curve, we can constrain the sources and turnover rates of DOC. In conjunction with the long-term record of DOC and parallel ^{14}C measurements of OC in soil fractions, as well as in downstream reservoirs (rivers, lakes), this will allow us to quantify the importance of DOC for C storage in soils and C transfer to aquatic systems, and to elucidate the impact of environmental changes on these fluxes.

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P-68

Important constraints on soil organic carbon formation efficiency in subtropical and tropical grasslands

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More than 10% of Australia's 49 M ha of grassland is considered degraded, prompting widespread interest in the management of these ecosystems to increase soil carbon (C) sequestration – with an emphasis on long-lived C storage. We know that management practices that increase plant biomass also increase C inputs to the soil, but we lack a quantitative understanding of the fate of soil C inputs into different SOC fractions that have fundamentally different formation pathways and persistence in the soil. Our understanding of the factors that constrain SOC formation in these fractions is also limited, particularly within tropical climates. We used isotopically labelled residue (13C) to determine the fate of residue-C inputs into short-lived particulate organic matter (POM) and more persistent mineral-associated organic matter (MAOM) across a broad climatic gradient (ΔMAT 10℃) with varying soil properties. Climate was the primary driver of above-ground residue mass loss which corresponded to higher residue-derived POM formation. In contrast, MAOM formation efficiency was constrained by soil properties. The differential controls on POM and MAOM formation highlight that a targeted approach to grassland restoration is required; we must identify priority regions for improved grazing management in soils that have a relatively high silt + clay content and CEC, with a low C saturation in the silt + clay fraction to deliver long-term SOC sequestration.

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P-69

Soil moisture conditions as a key factor for organic carbon content in soils

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In the past the common hypotheses for long-term soil organic matter dynamics was based on controlling factors like biomass source, sorption and desorption processes, climate, land use and soil texture. New research, however, revealed that this hypothesis may have to be adapted. It is already common that biomass source and carbon pools are not relevant in the long-term. All physically reachable carbon gets microbial degraded over time, even charcoal. However, how big is this carbon pool physically not reachable? Plus, which are the parameters truly triggering the differentiation of organic carbon stocks in soil? A statistical evaluation of Germany wide topsoil data, considering new hypotheses of long-term organic carbon dynamics in temperate soils, indicated that soil moisture condition are the key factor controlling soil organic carbon content in addition tosoil genesis and land use. On the other hand, results indicated that soil age also has to be considered. Comparing soils of the younger Weichsel with the older Saale glacial era in the lowlands of northeast Germany showed significant differences over all investigated different soil moister regimes. Thus, less the age of the soil may cause the difference, but more the mineral composition of the soils, similar to the effect known from podsols. Even after hundreds of years of intensive agriculture, sandy podsols revealed significantly higher carbon content in the plowed layer, than most other soils. In contrast, air temperature and soil texture revealed to be less important for the carbon content in temperate soils.

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P-70

Long-term trends of soil organic carbon of mineral grassland soils in Switzerland – measured and modelled results

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Soil organic carbon (SOC) storage plays a major role to mitigate climate change. Since 1985, the Swiss Soil Monitoring Network (NABO) has been assessing SOC stocks in the topsoil (0-20 cm depth) of 24 grassland sites (mineral soils) in Switzerland. The overall trend (average of the 24 investigated sites) of SOC evolution between 1985 and 2014 was stable. However, at a single site perspective, six out of the 24 sites revealed an increasing and two sites a decreasing trend in SOC stocks when 0.25 t ha^{-1} yr^{-1} is assumed as relevant change.

For Switzerland's greenhouse gas (GHG) inventory, the Rothamsted Carbon Model (RothC) [1,2] is used for modelling SOC stock changes across different management intensities. Using the same model, we applied the initially measured SOC stocks of the 24 sites, and estimated the carbon (C) inputs from manure of these specific parcels of land to simulate SOC trends with RothC. On 11 sites C inputs were estimated based on manure application data. On the remaining sites, where no data were available, the estimates used for the Swiss GHG inventory for the respective region and management intensity were applied [3]. The comparison of the modeled SOC stock evolutions to the measured ones revealed a good fit: 67% of the sites had a deviation of less than 0.25 t ha^{-1} yr^{-1}. This underlines the importance of long-term measurements to validate models and accurately predict future SOC stocks.

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P-71

Carbon storage as pedogenic carbonate and bicarbonate in the major land regions of the United States—Some knowns and unknowns

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As a negative emissions technology, the removal of atmospheric carbon by enhanced weathering and its storage as pedogenic carbonate in soils or as bicarbonate in groundwater has high potential. In the United States, much is known about the location and size of pedogenic carbonate pools and the major aquifers for bicarbonate storage. Much is also known at the continental scale about the relationships between inorganic carbon sequestration, parent material, and climate, and at the bench scale about CO2 consumption rates during basalt weathering.
Much less, however, is known about the best and worst regions for sequestration, the variability of rates, the best methods for scaling up, and the breeding of various crops and microorganisms to enhance chemical weathering and facilitate carbonate mineralization. Much less is also known about the error bars associated with measuring inorganic sequestration and the number and magnitude of unintended consequences of this geoengineering technique. Hypothesis testing is urgently needed at multiple temporal and spatial scales in both the lab and in the field.

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P-72

The validity of particulate and mineral-associated organic matter as quick and dirty indicators for agricultural management

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Soil organic matter (SOM) fractionation is a widely used tool to separate and study soil organic carbon (SOC) pools with different properties and functions. In recent years, studies have emphasized the great value of separating particulate organic matter (POM) and mineral-associated organic matter (MAOM), as these are obtained by simple particle-size fractionation and are a good indicator of the degree of stabilization of OM (Hassink, 1997).
MAOM is considered to be protected from decomposition, while POM is largely available in the short term. We quantified POM and MAOM using a simple fractionation approach in 26 agricultural long-term experiments from Germany and Austria that were focused on different SOM management practices such as mineral/organic fertilization and crop rotation. We determined the OC saturation on the basis of the soil C saturation concept (Stewart et al., 2007). In addition, we investigated the impact of other inherent soil parameters, climatic factors, management factors and other soil quality indicators on POM/MAOM stocks. In this way, we are assessing the suitability of MAOM and POM derived from a simple fractionation approach as fast and cheap indicators for OC sequestration potentials and adequate agricultural management, respectively. We hope to gain new insights into how agricultural management affects the long-term storage of OC and how the investigated parameters affect the C saturation in agricultural soils.

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P-73

Assessing carbon stock changes in French top soils in croplands and pastures: Comparison of fixed depth and equivalent soil mass.

Dr Jose Luis Munera-echeverri, Dr Manuel Martin, Dr Line Boulonne, Dr Nicolas Saby, Dr Dominique Arrouays

Assessment of changes of soil organic carbon (SOC) stocks based on equivalent soil mass (ESM) are rare, even in cases with changes of bulk density (BD). In this presentation, we use data from the first and second campaign of the French soil quality monitoring network (RMQS) to compare stock changes based on ESM and fixed depth (FD) in top soils (~30 cm depth) in croplands and pastures. We will illustrate a methodology for ESM calculation, and we discuss cases where SOC stock changes are overestimated by FD. Sites were selected based on the availability of data of the second campaign (ongoing sampling). Besides, only the sites in which BD and coarse fragments (CF) were measured by the volumetric ring method in both campaigns (42 sites in croplands and 15 in pastures) were selected. The sampling protocol involved a composite soil sample for SOC analysis taken from a 400 m2 grid, and adjacent to it, a soil pit dug up to 50 cm depth in which three rings of 500 cm3 each were used estimate BD and CF in each horizon. The average time between campaigns was 14 years. The preliminary results show that in the second campaign, the difference between SOC stocks based on ESM and FD was not significant. However, the linear regression between SOC stocks of the first and second campaign improved with the estimates based on ESM compared to FD (R2: 0.95 vs 0.90), suggesting that ESM is more accurate for studying SOC changes.

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P-74

Effects of rewetting peatlands on soil CO2 and CH4 emissions in West Kalimantan, Indonesia

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Rewetting of degraded peatlands in Indonesia is reported as one of the most cost-effective mitigation pathways to achieve the national emissions reduction target (Griscom et al., 2020). However, there is high uncertainty to quantify net carbon benefits from this mitigation activity. To fill this gap, we will assess the impacts of rewetting on CH4 and CO2 emissions (total and heterotrophic) during a one-year period in three landcover types on peatlands using 50 chambers: oil palm plantations (n = 20), shrub ecosystems (n = 20), and secondary forest (n = 10, control) in West Kalimantan, Indonesia. Both oil palm and shrublands contain two transects: one in rewetted peatlands and one in drained peatlands. Each of these transects contains five paired chambers, one serving as a control and one serving to measure the heterotrophic microbe respiration using the trenching method. GHG emissions are measured biweekly using LGR's ultraportable greenhouse gas analyser. In addition, other supporting parameters are measured including microbe composition, water table depth, and other relevant climatic variables. Our hypothesis is that there will be higher net carbon emissions in non-rewetted plots compared to rewetted plots. These results will refine estimations of GHG emissions reduction from rewetting peatlands in Indonesia to achieve the nation's NDC target by 2030, facilitating improving emission factors for IPCC from tropical countries.
Griscom Bronson W., Busch Jonah, Cook-Patton Susan C., Ellis Peter W., Funk Jason, Leavitt Sara M., Lomax Guy, Turner Will R., Chapman Melissa, Engelmann Jens, Gurwick Noel P., Landis Emily, Lawrence Deborah, Malhi Yadvinder, Schindler Murray Lisa, Navarrete Diego, Roe Stephanie, Scull Sabrina, Smith Pete, Streck Charlotte, Walker Wayne S. and Worthington Thomas 2020National mitigation potential from natural climate solutions in the tropicsPhil. Trans. R. Soc. B37520190126220190126

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Carbon Pools Across Aggregate Fractions and Time For Different Land Use Systems.

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Soil carbon audits and monitoring activities are increasing across soil management and land use systems to quantify their impact on carbon sequestration, soil quality, and sustainability. However, the extent of soil organic carbon changes in response to soil aggregate dynamics varies between land-use systems, and the mechanisms of organic matter stabilization in these systems are unclear. We sampled soil from fields representative of grassland, grazed pastures, and forest land-use systems in New Jersey, USA. In all cases, fields were selected to represent uniform initial conditions (soil and climate) but different time under a given land-use. In each sample, we measured the content of five carbon pools (decomposable plant material, resistant plant material, microbial biomass, humified organic matter, and inert organic matter) associated with three aggregate size classes (> 250 µm, 53–250 µm, and < 53 µm). In this presentation, we will discuss temporal shifts in carbon allocation across aggregate-size classes and land use types. An attempt will be made to quantify the effect of carbon allocation on the structure of pore networks inside each aggregate size class. These data have implication for carbon sequestration in soil because it provides carbon accrual rates needed for decisions related to climate change mitigation. Extrapolation beyond the time period assessed can be achieved by using the data from this investigation to calibrate mechanistic models linking soil structure and organic carbon dynamics.

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The relationship between soil organic carbon and dynamic soil properties following straw incorporation

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Soil quality assessment measures the capacity of soil to perform a specific function. Soil organic carbon (SOC) is recognised as a keystone indicator of soil quality yet quantitative relationships between SOC and soil properties do not exist to adequately prescribe sustainable soil management targets. This experiment explores C:N:P:S stoichiometry as a mechanism to increase stabilised SOC in soils and measure the associated change in soil chemical and physical properties. The aims are to (i) determine if a quantitative relationship can be found to describe SOC and soil fertility/soil aggregation in soils with increasing fine silt and clay content and (ii) if the dynamic change in soil properties can be monitored by visible near-infrared (vis-NIR) spectroscopy. A soil incubation experiment is being run to simulate straw incorporation at a rate of 8 t ha-1 with or without supplementary nutrients as inorganic N, P and S to achieve a target 30% conversion of fresh C-input into SOC based on a C:N:P:S stoichiometric ratio of 10000:833:200:143, as determined by the fresh C-input of the straw. Soil organic carbon will be measured with the following soil physical and chemical properties over consecutive 12-week cycles of straw decomposition; aggregate mean weight diameter, % water stable aggregates, particle density, pH, total CNPS, plant available nutrients. Representative soil samples will be scanned by vis-NIR spectroscopy and modelled to determine if dynamic changes in SOC and soil properties can be detected and used to monitor the relationship between SOC and soil fertility/soil aggregation following straw decomposition.

None-applicable

P-77

The role of pH management and reseeding events on soil organic carbon

Miss Kirsty Paterson, Dr Joanna Cloy, Professor Robert Rees, Professor Elizabeth Baggs, Dr. Sarah Buckingham

Soil organic carbon (SOC) sequestration in soils offers a significant opportunity to remove CO2 from the atmosphere and store it into long-lived C pools. Stabilisation of organic carbon (OC) in the mineral associated organic matter (MAOM) pool is considered an important long-term store of SOC. If correctly managed, grasslands provide an opportunity to be utilised as a carbon store. Agricultural grasslands are maintained to increase productivity, with the adjustment of soil pH via liming applications, and rejuvenation of swards by reseeding, playing an important role. We will present results from soils sampled from grass rotations of a long-term experimental pH trial, at two depths: 0 – 20, and 20 – 40 cm. Bulk and physically isolated MAOM fractions were analysed for total OC, total nitrogen, and microbial biomass C (not for the MAOM fraction). Carbon associated with Fe and Al, oxides were also determined using dithionite-citrate-bicarbonate extractions. This work aims to better understand the influence of grassland management (reseeding and pH), and soil depth on the persistence of bulk and mineral associated organic C. Improving our understanding of the effect of grassland management on SOC pools, will help to identify ways to utilise grasslands as a climate change mitigation tool.
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P-78

Evaluation of soil glomalin protein by thermogravimetry coupled with mass spectrometry

Phd Sneha Patra, Vojtěch Polách, Prof. Josef Čáslavský, Dr Karel Klem

Glomalin, a vital soil glycoprotein produced by arbuscular mycorrhizal fungi, accounts for a substantial component of organic soil carbon. This extremely stable protein helps in soil aggregation, erosion resistance, soil carbon and nitrogen storage etc. The present work combines the glomalin content (GC) data with thermogravimetric analysis (TGA) coupled with and mass spectrometry (MS) to anticipate the soil properties.

In sum, 50 soil samples representing the variability of soil types in the Czech Republic were examined, where GC varies up to ten times. The TGA data exhibited three consequential temperature ranges with a higher correlation between GC and the weight loss data. While each temperature range has different possible reasons to correlate with GC, a negative correlation at higher temperatures (>600 °C) indicates an inverse relation between glomalin and soil inorganic components. The most significant temperature range is ascribed to the co-occurrence of glomalin with other soil organic matter components, which is supported by the MS evolved gas data.

On the basis of the TGA data, glomalin also revealed a correlation with the soil organic carbon and clay content. Both positive and negative correlations of glomalin with various soil compounds indicate a broader soil composition scenario that influences glomalin production in soil. The strong correlation with the humic acid/fulvic acid ratio affirms its role in soil biochemistry.

This study is a novel approach to understanding the potential of TGA/MS analysis for the complex evaluation of soil organic carbon quantity and quality, including GC and the interdependence of various soil parameters.

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Microcosm translocation reveals potential impacts of land use change on mechanisms of soil organic matter decomposition in subarctic soils

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Climate change is expected to enhance the potential for agriculture in subarctic regions. Subarctic forest soils store large amounts of soil organic carbon (SOC) and deforestation is acknowledged to lead to considerable losses of SOC. However, the actual mechanisms behind such losses are not well understood, hampering a precise prediction of the magnitude of losses. Especially the microclimate effect of different vegetation covers on SOC mineralization is understudied. Therefore, we conducted a microcosm translocation experiment in Yukon, Canada, to understand the fate of fresh organic matter (OM) in the soil under different land use types and under different microclimatic conditions. To do so, we transferred microcosms filled with soil from cropland into adjacent forest and vice versa. Additionally, microcosms from the north of the research area have been transferred to the south of Yukon. To track the processing of fresh organic matter within the soil, we applied 13C-labelled oat litter (straw and leaves) to the microcosms and resampled them two years after. The samples were fractionated into pools of mineral associated organic matter and particulate organic matter in order to test for differences in SOC decay as affected by microclimate alone. The results will help to understand processes of OM-degradation and -stabilization within the soil with regard to human-induced changes in microclimatic conditions.

P-80

Origin, distribution, and nature of soil calcium carbonate along Chile's climatic gradient

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Soil inorganic carbon (SIC) represents around one third of the total soil carbon pool worldwide, with soils from arid, semiarid, and Mediterranean regions accounting for 90% of the global SIC pool. Chile has 55% of its territory located on those climates, however there are only a handful of studies focusing on SIC. A proper assessment of the SIC component in Chile is of particular interest, as the country offers an extraordinary latitudinal climatic gradient with considerable geographic similarities due to its tectonic setting, from Earth's driest dessert in the north to the very humid conditions of the Patagonian fjords. Here, we review the occurrence of calcium carbonate in Chilean soils by analyzing more than 400 profiles distributed along the entire country. Calcium carbonate rich soils are mostly concentrated between 22˚S and 34˚S, with the richest calcium carbonate soils concentrated in the semi-arid and Mediterranean areas. The precipitation gradient where pedogenic carbonates are located suggests that they might occur due to similar processes than in other regions of the world, however the wet threshold of occurrence in Chile is at around 500mm MAP instead of the 760mm MAP proposed in the literature. The usually reported lower threshold of 50 mm MAP is not observed in Chile, which is mainly attributed to relict features in old geomorphic surfaces and azonal areas.

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P-81

Recarbonizing global soils: a technical manual of recommended management practices

Prof. Rosa M Poch

Soil organic carbon (SOC) is a key indicator of soil health: productivity, quality, biodiversity and ecosystem services, being outstanding as global Carbon reservoir. It is a direct indicator of SDG 15.3.1 but it also affects other ones. Several soil use and management practices proved to conserve or recover SOC around the world, but their performance is site specific, because it varies under different conditions of soils and climates. As outcome of the Global Symposium on Soil Carbon (GSOC17, FAO, Rome), an open call for experts was launched by ITPS/GSP, to develop a technical manual of BMPs for SOC management. The contributions were reviewed by the GSP/ITPS, STC of the 4 per 1000, CIRCASA, UNCCD/Science Policy Interface and a board of five experts. The published version is the effort of more than 400 specialists around the world including proved efficient standardized and locally tailored SOC management practices (73), 11 hotspots and 81 case studies around the world. The manual is an element of the RECSOIL toolkit. Being the first attempt to gather the existing data on managing SOC content in a wide arrange of environments in standardized format, including also the advantages, drawbacks and constrains of each BMP. The exhaustive review identifies research gaps and limited results of some practices; therefore, it opens new research lines in SOC management. The manual is not closed, since it will be updated in the future.

P-82

ORGANIC CARBON CONTENT AS AFFECTED BY LAND MANAGEMENT PRACTICES IN MONOCULTURE OF SPRING BARLEY

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Total organic carbon content and humic substances quality were estimated in three different straw management practices in monoculture of spring barley: straw harvested; straw incorporated; straw burning. Furthermore, the effect of minimum tillage and conventional tillage on carbon content and humic substances quality was evaluated. The long-term field experiment was established in 1969 in Žabčice at the Experimental Stationary of Mendel University in Brno (Czech Republic). The mean annual air temperature is 10.3 °C. The mean annual precipitations are 491 mm. Gleyic Fluvisol Clayic was classified according to the IUSS Working Group WRB (2014). Total organic carbon content was determined by oxidimetric titration method. The short fractionation method was used for the determination of humic substances, humic acids (HA) and fulvic acids (FA). The quality of humic substances was assessed by HA/FA ratio and by UV-VIS and infrared spectroscopy. ANOVA analysis (program StatisticaCZ12 software) and Fisher test ($p \leq 0.05$) were applied for data set evaluation.
The correlation between carbon dynamics and straw management and tillage practices based on the long-term field experiment data set is documented. Obtained results showed also the other negative consequences of monoculture farming such as soil aberration, acidification, and a gradual decline of soil organic matter content and quality.

Keywords: Monoculture of spring barley, Straw management practices, Soil tillage.

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P-83

Traffic and tillage effects on soil organic carbon dynamics and crop yield.

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A long-term field-scale experimental site was established at Harper Adams University (United Kingdom) to study the impact of traffic and tillage systems on the distribution and mineralization rate of soil organic carbon (SOC) in the profile and the associated effects on crop productivity. The experiment combines three tillage (Deep, Low and Zero-tillage) with three traffic (Standard tyre pressure, Low tyre pressure and Controlled traffic farming) treatments.

The site was established to barley (Hordeum vulgare L.) in autumn 2020 and harvested in July 2021. Overall treatment effects on yield were not significant ($P>0.05$), but the yield recorded on untrafficked crop beds of the controlled traffic system under zero-tillage was significantly higher compared to the same traffic system under deep tillage.

Soil samples collected after the 2021 harvest (0-100, 100-200, and 200-300 mm depth) were used for determination of soil organic matter (SOM) by loss-on-ignition, particulate organic C (POC) (Combardella and Elliott, 1993; Cortufo et al., 2019), and microbial biomass C (Vance et al., 1987). Initial results by loss-on-ignition suggested that deep tillage had significantly lower SOM content across traffic and tillage treatments at the 0-100 mm depth interval. Further soil samples will be collected in spring and summer 2022 following the next crop cycle, and natural abundance 13C analysis will be used to investigate soil C dynamics.

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P-84

Whole-profile soil carbon response to crop-livestock integration

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Crop-livestock reintegration may reduce the environmental footprint of decoupled crop and livestock production systems. Predicted soil organic carbon (SOC) losses in the high soil organic matter (SOM) Andisols of central-southern Chile necessitate land management to maintain or increase SOC. Field trials show that integrating grazed pasture phases into annual crop rotations (“crop-livestock integration”) increases surface SOC stocks measured to a fixed soil depth. Yet topsoil sampling can produce erroneous conclusions about SOC response to practices like cover crops and no-till and quantifying SOC at fixed depths can overestimate SOC stocks under practices that affect bulk density like grazing. We test whether higher SOC stocks observed with crop-livestock integration hold across: i) whole-profile (0-1 m) SOC stocks ii) measured on an equivalent soil mass rather than fixed depth iii) on paired commercial farms with and without crop-livestock integration in cereal-based rotations in central-southern Chile. Soils cores at 10 site-pairs (20 sites) will be sampled in March-April 2022 and analyzed for bulk density, total C and nitrogen (N) by dry combustion, and near-infrared (NIR) spectral signatures. We will report responses of SOC and N stocks and C/N ratios to crop-livestock integration and whether they vary through the soil profile. Soil NIR spectral signatures from paired sites will be compared to confirm similar soil type and underlying mineralogy and evaluate if crop-livestock integration changes SOM chemistry. By evaluating if crop-livestock integration leads to SOC accrual and N retention, we aim to support efforts to diversify working landscapes for climate mitigation and soil multifunctionality.

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P-85

DRIVERS CONTROLLING ORGANIC CARBON CONTENTS IN FORESTED LANDSCAPE SOILS, CZECHIA

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An Inventory of two decades of data (1998-2019) has been used to assess the influence of the drivers controlling the soil organic carbon (SOC) content in the mineral topsoil layer (0-30 cm) across the forest vegetation zones (FVZ) and forest ecological series of the Czech Republic. The mean value of the SOC content in forest soils of the Czech Republic was determined to be 3.35 % ± 1.96 %. 20 variables were analyzed grouped as follows: soil organic carbon (dependent variable), terrain parameters, forest vegetation cover and soil. The soil sample datasets were characterized with descriptive statistics. The data, including SOC exhibited non normal distribution ($p < 0.05$). Spearman's correlation coefficients were determined to estimate the related variables. A collinearity test was performed, subsequently, a principal component analysis (PCA) was applied to illustrate linear relations between the site-specific SOC contents and the predictors. An ordinary Kriging was used to model and map the spatial distribution of SOC in forests of the Czech Republic. The SOC content showed an increasing tendency in the function of the decrease in pH (5). The analysis performed show that the most influencing variables were: slope (SL), aspect (AS), LS factor, TWI, altitude, fine silt, pH_{H2O} and total Aluminum (Al).

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P-86

Profile soil C and N and biological properties after 32 years fo no-tillage and compost in central Kansas, USA

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Soil carbon, nitrogen, and microbial properties can be managed through tillage and fertilization. The experimental site was a rainfed continuous corn (Zea mays L.) system with fertilizer treatments (168 kg N ha-1) of composted organic waste (OrgF), urea (MinF), and no fertilizer addition (Ctrl) and tillage treatments of no-till (NT) and conventional till (CT). Changes in SOC SON, δ13C, δ15N, and microbial properties were measured through the 1 m soil profile after 32 years. No-till and organic amendments restore soil carbon through increased carbon input and reduced disturbance, potentially leading to effective carbon saturation. We measured a range of soil microbial and chemical properties along a carbon gradient from long-term tillage and fertilization. Soil β-glucosidase activity and microbial biomass plateaued at high carbon content, suggesting saturated microbial properties with no microbial benefit to additional carbon gains. Further analysis confirmed saturation of physically protected SOC at the surface of this NT soil. After reaching effective saturation, carbon translocation to underlying carbon-depleted layers increased microbial biomass and activity. Surface management effects on soil C were confined to the surface 30 cm even with additional C inputs after 32 years. In these annual cropping systems, considerations need to be made for deep-rooted crops and rotations to deliver C inputs into the subsoil; however, this must include no-tillage as tillage loses the benefits of additional C inputs. We conclude that interactions between mineral, physical, and biological factors control soil carbon saturation and must be considered to manage current and future soil carbon sequestration.

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P-87

Assessing the effects of earlier snowmelt on nitrogen and carbon content in Pyrenean snowbed soils

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Accrual of carbon and nitrogen in soil is an essential process to mitigate climate change; thus, understanding the mechanisms controlling their persistence in soil organic matter across different ecosystems is necessary. Snowbeds are scattered habitats highly dependent on snow cover duration distributed throughout temperate alpine mountains and threatened by climate change. In this study, we aimed to understand how soil properties in snowbeds vary along the snowmelt gradient and under different plant species to assess the role of these ecosystems in terms of carbon and nitrogen storage. We sampled soil profiles at three points along the snowmelt gradient under a snowbed specialist dwarf shrub and under generalist alpine grassland species in three non-calcareous Pyrenean localities, where we measured pH, Total organic C content (TOC), Total N content (TNC), texture and bulk density. Snowbed soils are characterized by a low pH and a high TOC, which is more abundant (together with TNC) at early snowmelting profiles and at the topsoil. Soils on shales have the highest TOC and TNC mean values and the lowest variability, by favoring TOC protection by the interaction with clay surfaces, metal ions and physical entrapment in aggregates. At plot level, we did not observe a clear trend in soil properties under the different plant species. Our results show that TOC and TNC are mainly explained by the situation along the snowmelt gradient, soil depth and parent material, and suggest that changes in snow cover duration will translate into a higher TOC accumulation in current snowbed patches
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P-88

Effects of long-term cultivation on soil organic matter fractions in various soil depths in Boreal climatic conditions

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Soil organic matter (SOM) is beneficial for soil quality and crucial for ensuring sustainable agriculture. However, the decrease of arable soil organic matter is a global tendency that has also been reported in Finland. For better future control over soil organic matter balance, further understanding of the factors regulating its stabilization and turnover processes in different soil environments is needed.

SOM contents of Finnish arable soils are relatively high as there are several environmental- and soil related factors favoring SOM preservation and accumulation. To explore the effect that 1) soil properties, such as soil texture and Fe- and Al- oxides, and 2) long-term agricultural management have on SOM quality in boreal climatic conditions of Finland, SOM was divided into two distinct fractions: mineral-associated organic matter (MAOM) and particulate organic matter (POM). One-meter deep soil samples were obtained from a long-term field experiment located in Jokioinen, South-Western Finland (Natural Resources Institute Finland). The experiment has three cultivation treatments on a clayey soil: permanent unmanaged grassland, organic cereal crop rotation and conventional cereal crop rotation.

Top soil layers down to 40 cm depth were studied in 10 cm intervals and layers below 40 cm were pooled together. All studied soil layers were analysed for SOM, MAOM and POM contents. SOM fractions were related to the rooting depth and root biomass, Fe- and Al- oxides and clay content and the results of these analyses will be shown.

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P-89

Terrestrial-aquatic fluxes of organic carbon in an intermittent low mountain catchment – final results of PhD field campaign.

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The terrestrial and aquatic carbon cycles are both well researched areas, but the linkage between them, especially in intermittent catchments is not yet fully understood. Climate change will affect the hydrology of catchments and even permanent water bodies can temporarily dry out or decrease their discharge and thus alter the streambed through which they flow. Additionally, the lack of a functioning permanent stream network will also alter the drainage of the soils in the hillslopes via subsurface runoff This will lead to a change of subsurface hydrological pathways and to an alteration of the storage and the export of organic carbon of the catchment. Therefore, it is necessary to investigate the changes in the transport and export of organic carbon from the soils via the fluvial network to the catchment outlet due to an altered runoff regime. Thus, this project studied these processes in an intermittent and a permanent headwater catchment over one year including all seasons. Altogether, ~700 soil samples and ~900 water samples were taken in two forested catchments (intermittent and permanent), which are located in the Lahn basin (Germany, Hesse) and analyzed in the lab by using WSOC extraction and TOC measurement for DOC. First results indicate lateral as well as horizontal transport regardless of water content. In addition, results from the EEM analysis (fluorescence analysis) give a good indication of changes in the quality of the carbon. In combination with the lateral relocation, this provides evidence of altered flow paths due to the lack of water.

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P-90

DeepC: How whole-soil warming affects plant- and microbial-derived soil organic carbon (SOC) – the molecular perspective

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Subsoils, i. e. horizons below 30 cm, store more than half of the global soil organic matter (SOM), which represents more carbon than cycles in the atmosphere or is stored in living biomass. This deep half of SOM, will warm in synchrony with air temperatures, and by the end of the century this subsoil organic matter could be 4°C warmer than today. But how will the deep SOM respond to the warming? During the last years, several novel field experiments have been started to simulate whole soil warming. Within a few seasons, SOM decomposition accelerated and greenhouse gas emissions increased rapidly by 30-50%, while SOM stocks started to decline.

Using molecular markers we traced the fate of plant- and microbial-derived biomass, assessed the degree of decomposition of plant biomass, and assessed changes in microbial community structure in temperate and boreal forests.

We will present several key insights from the molecular perspective, detectable after two to five years of warming. There was a distinct depth-specific response of SOM to warming, both in the amount and type of biomass, and degree of decomposition. Actinobacteria decomposed previously less degradable SOM. Also presumably difficult to degrade compounds decompose in parallel with bulk SOM. So far, few soil models include microbial thermal adaptation, but they would describe observed trends more accurately if they did. Open questions include how long this rapid decomposition will continue until a new steady state equilibrium will be reached.

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SOIL ORGANIC MATTER FRACTIONS UNDER ALLEY CULTIVATION SYSTEM ENRICHED WITH CALCIUM AS A FUNCTION OF BIOMASS QUALITY

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Small changes in SOC stocks impact atmospheric CO2 levels and further influence the global climate significantly because the large size of the soil organic C (SOC) pool. The aim of this study was to evaluate the effect of soil cover with a combination of four leguminous on increasing soil organic matter stable fractions. The experiment was conducted with 6 treatments: Clitoria fairchildiana + Leucena (C+L); Leucaena + Acacia mangium (L+A); Leucaena + Gliricidia sepium (L+G); Acacia + Glyricidia sepium (A+G); Clitoria fairchildiana + Gliricidia sepium (C+G) and control. The parcels were subdivided with grass and without grass and soil enriched with 1.020 Mg ha -1of calcium. The particulate organic carbon (POC) in depth (10-20 cm) the treatment that obtained the best result was C + L (with grass) 7.5 g/kg represent 275% higher than the control. The treatment C + G (without grass) obtained 4.5 g/kg representing 28% higher than the control. In the analysis of organic carbon mineralization (OCM) in depth (10-20) the treatments A+G and S+G (with grass) 9.5 g/kg and 137% increased of control. Another treatment L+G (without grass) obtained significant results with 10 g/kg and elevated 122% when compared to control. The results showed that the addition of leguminous tree and calcium increased the amount of POC and soil carbon stabilization. This capacity of soils to store organic carbon represents a key function that is for climate regulation which is an important aspect in land use and management planning.

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P-93

Long-term application of sewage sludge affects organic carbon pools and stability of a Mediterranean calcareous soil

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Soil degradation is a growing problem worldwide; in particular, farmlands in semiarid and sub-humid regions, which are usually depleted in organic matter. Soil organic matter (SOM) is key for guaranteeing soil quality and its evaluation is crucial. Soil organic C (SOC) preservation and storage is determined by the interactions between the soil mineral and organic fraction with soil biota. The use of soil fractionation to assess the SOM cycle is consensual, but a major challenge is to identify different components within SOM that correspond to the characteristics of the conceptualized SOC pools. One promising analytical technique is Rock-Eval® thermal analysis. It can be an economic and time-efficient method, used to quantify soil organic and inorganic carbon fractions regarding their chemical and thermal stability. In this framework, a field experiment (25 years) in sub-humid Mediterranean rainfed agricultural conditions was set to evaluate the effect of the continuous application of sewage sludge (SS) on SOM quality of a calcareous soil. The SS treatments at different rates were compared with a mineral fertilization (MF) treatment, and with a control treatment (no fertilization). We observed that SOM storage was affected by the dose of SS as well as other soil indicators. However, the relationship between them was not straightforward. Studying the thermodynamic lability of SOM in the different treatments, as studied from Rock-Eval® pyrograms, can help us understanding the correlation between the amount and stability of organic C stored in the form of SOC and other soil properties after long-term SS application.
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P-94

Understanding root-microbial interactions and soil carbon sequestration under different soil health practices

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Farmlands can store a substantial amount of soil organic carbon (SOC) under appropriate land management practices that increase C-sequestration (C-seq) (Paustian et al., 2016). Root and microbial biomass are potential indicators for assessing C-seq under different land management practices (Somenahally et al., 2020). Root-microbial interactions are major drivers of C-cycling processing and contribute to belowground-C stocks (Sokol and Bradford, 2019). Soil microbial biomass (SMB) in particular is highly responsive to management practices and a potential indicator of immobilization and C-seq potential (McDaniel et al., 2014). This study compared SOC, microbial and root biomass under different agronomic practices. Field comparisons included scenarios of higher crop biodiversity vs monocropping, organic vs inorganic fertilization and high vs low fertility within wheat cropping systems. Seasonal soil core samples were collected from 0-60cm soil profile and analyzed for stocks of soil nitrogen (SN), SOC, SMB, root biomass and microbial diversity. Results showed that higher SOC:SMB and higher SN:SMB correlated with higher SOC stocks and plant productivity. Higher SMB did not correlate with SOC accumulation and plant productivity in low fertility soils. Higher SMB in soils which also recorded higher microbial diversity correlated with higher SOC stocks. Higher root biomass did not always correlate to higher SOC stocks. Results suggested higher C-seq in soils with SOC:SMBC ratio >10 and higher microbial diversity. Negative impacts of immobilization on plant productivity were noted when SN:SMBC ratio was <1.0. These belowground comparisons have potential to serve as relevant indicators of soil health, plant productivity and C-seq trends.

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P-95

Unraveling the significant mechanisms regulating soil organic matter stabilization under the long-term application of diversified organic amendments

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The mechanisms underlying soil organic matter (SOM) stabilization in the long-term application of organic amendments (OAs) are far from fully understood. For more effective comprehension on such matters, SOM in soils from six treatments in a long-term field experiment (26–31 years), namely, chemical fertilizer (CF) alone (CF), bark compost plus CF (BC+CF), coffee residue compost plus CF (CRC+CF), cattle manure compost plus CF (CMC+CF), and cattle manure compost (CMC) or sewage sludge compost (SSC) alone at a higher application rate, was fractionated using heavy liquid separation. Four SOM fractions, i.e., free particulate SOM (fSOM), free SOM occluded in aggregates (oSOM), and SOM weakly bound to minerals (wSOM; s.g. 1.6–2.0 g/cm^3) and strongly (sSOM; s.g. > 2.0 g/cm^3), were characterized using ^{13}C nuclear magnetic resonance (NMR) along with OAs and bulk soil samples. The long-term application of OAs promoted the total C accumulation, and the amount of C stored in fSOM fraction was enhanced by the BC or CRC application. Whereas the SSC or CMC application, which has a high N content and low C/N ratio, resulted in a greater accumulation of C, mainly as wSOM. This study demonstrates that the forms of C accumulation are regulated by both quality and quantity of OAs used via the distinct mechanistic pathways, e.g., the abundant alkyl C in the wSOM and sSOM fractions was SSC-derived SOM in the SSC soil (ex vivo pathway) while in the CMC soil, this was owing to the increased contribution of microbial-derived SOM (in vivo pathway).

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P-96

Oxidable fractions of organic matter in fields of fire in the Chapada Dos Veadeiros

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One of the best indicators of soil quality is organic matter, which contains 58% of organic carbon. The objective of this work was to determine the oxidizable fractions of carbon, in soils of the national park Chapada of the Veadeiros. The areas were divided between burned and unburned soils in three phytophysiognomies: Campo Limpo, Campo Sujo, and Stricto Senso. When the phytophysiognomies were compared, the Cleaned Field and the Dirty Field presented a greater increase of the TOC over time, with higher indices in burned soils, differentiated from the Stricto Senso where it occurred in the opposite way. In the fractions F1 + F2, Clean Field and Dirty Field obtained a significant increase in burned soils, in Stricto Senso there was a larger drop in values with the soil without burning with greater amount of carbon. In the F3 + F4 fractions in the Clean Field and Dirty Field, the highest values were found for the soils without burning, in Stricto Senso obtained higher values in burnt soil.
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P-97

Alteration of soil organic matter composition after 130 years of afforestation assessed by molecular markers

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Afforestation is a promising strategy for soil organic matter (SOM) conservation. However, there are contrasting results following afforestation of former pastures including decrease or increase of SOM 30 to 40 years after afforestation. Thus, there is a need for site-specific experiments over several decades to investigate changes in SOM dynamics following afforestation to predict the behaviour of carbon sequestration under changing environmental conditions.

The analysis of plant- and microorganism-derived molecular proxies in soil such as free extractable lipids and phospholipid fatty acids (PLFA) allows tracing the source and transformation of SOM. Focusing only on individual molecular compound classes may lead to flawed conclusions due to missing information offered by complementary information. One option to achieve a more solid conclusion on SOM dynamics is the combination of several compound classes. In this project, we aim at identifying the major sources of SOM in a subalpine afforestation sequence (0-130 years) with Norway spruce (Picea abies L.) on a former pasture in Jaun, Switzerland, by combining plant- and microorganism-derived molecular proxies from several compound classes.

Highest carbon stocks (14.0±0.8 kg m-2) are in the youngest (40yr) followed by the 130yr old (11.0±0.3 kg m-2) and 55yr old (9.6±1.1 kg m-2) forest. Other than expected afforestation of former pasture (11.2±0.0 kg m-2) did not change (p=0.37) the total (0-45cm) organic carbon stock throughout the observation period. Input as well as transformation of SOM is further analysed by PLFA, free extractable fatty acids and alkanes, which improves our understanding of litter incorporation and cycling.

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P-98

Accurate Soil Organic Carbon Sequestration Accounting in Tidal Marshes

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Accurate Soil Organic Carbon Sequestration Accounting in Tidal Marshes

Tidal marshes are broad flat wetlands that have some of the highest carbon stocks of any ecosystem. Although the amount of carbon stored in these soils in undeniable, there are a number of uncertainties regarding carbon sequestration rates of these systems. One of the timeliest is related to the usefulness of a single sequestration rate for carbon accounting purposes. We measured soil organic carbon (SOC) sequestration rates across an elevation gradient in three back-barrier tidal marshes in New England to test if a single sequestration value can be used for such marshes. Time zero was marked by deposition of overwash sediments from hurricane Sandy in 2012. A total of 52 sampling locations were established at the 3 marshes. Eight years after overwash deposition average plant cover ranged from 55 to 94%. Soils developed thin A horizons over underlying overwash C horizons. Sequestration rates ranged from 52 to 637 g C/m^2/yr. These rates are 3 to 4 times that of the average SOC-sequestration rate in New England forests. Sequestration rates increased as elevation decreased (p values were 0.006, 0.020, and 0.16 for the three sites). Average SOC-sequestration rates for the lowest elevation marshes (296 and 326 g/m^2/yr) were significantly higher than the higher elevation marsh (186 g/m^2/yr). Our studies suggest that there is a significant elevation relationship in SOC sequestration within marshes and a single sequestration rate is not representative of all marshes in similar settings.

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P-99

Lysimeter study investigating soil inorganic carbon sequestration processes using engineered and natural soils from two experimental sites incorporating industrial by-products

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Sequestration of carbon is a vital process for the future of the planet to reduce the effects of climate change (Lal,2004). One option is to facilitate sequestration of already emitted CO_2 by promoting carbonate precipitation and formation of soil inorganic carbon (SIC) by amending soils with basic silicate rock quarry fines or construction and demolition wastes (Renforth et al, 2009, Beerling et al, 2020). This provides an alternative and sustainable route for industrial by-product management.

The soil microbial biodiversity in engineered and natural soils is important for sustaining the function of carbon capture through a range of biological and chemical interactions and processes (Dubey et al. 2019). There is evidence of both aerobic and anaerobic microorganisms involved in CO_2 sequestration in soils (Mohan et al. 2016) yet the biological and geochemical mechanisms remain to be investigated.

A lysimeter experiment will be used to assess microbial and geochemistry control on carbonate precipitation. The lysimeters enable the sampling of water down the depth of the substrate using rhizon samplers and capture of leachates from the system so water geochemistry can be determined (anions and cations). This will also allow us to determine at what depth calcium carbonate is precipitating or leaching out of the system.

We also present data collected from plots of engineered soils consisting of dolerite-sand or concrete-sand mixtures which were established in 2015. Soil samples were collected in summer 2021 and analysed to assess the change in soil carbon (total, organic and inorganic) since 2015.

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P-99A

Soil carbon stock and biogeography in Atlantic Canada

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Soil carbon and microbial biogeography, the study of the distribution of organic matter dynamic on a wide spatial scale, aims at understanding biodiversity regulation and its link with ecosystem biological functioning, as well as ecological goods and services, such as maintenance of productivity, soil quality, and soil health. Microbial biodiversity and soil carbon stock are central to soil fertility and crop productivity. However, the determinants influencing soil biodiversity and carbon stock are still inadequately understood, particularly in temperate and humid regions like Atlantic Canada.
This project evaluated the diversity and the abundance of soil microbial communities and their relationships with soil carbon pools, land-use and management practices on a biogeographical scale. A monitoring network of over 500 sampling points was done across different land-uses and landscape positions of Atlantic Canada. Microorganism richness, variation in diversity and abundance of micro-arthropod and microbial communities, soil organic matter characteristics, and soil functions were determined across the region to identify the ecological processes influencing microbial distribution.
Results showed positive correlations between collembola and mite abundance with soil carbon concentration, and a negative correlation with nematode abundance. The analyses also evaluated the relationship between mycorrhiza, bacteria, fungi diversity, extracellular enzyme activity, soil physico-chemical properties and topographical features with soil carbon stock. Summarizing maps were produced and validated using a nested-cross validation procedure and uncertainty rasters was performed. These maps will address national priorities to better understand the potential for carbon sequestration in different land-uses and to meet greenhouse gases mitigation targets.

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P-99B

Management of abandoned cropland areas as a tool for enhancing soil quality and carbon sequestration and adapting to Global Change.

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During the 20th century, Mediterranean mid-mountains suffered the abandonment and successive shrub encroachment of its croplands and pastures due to rural exodus, with some consequent disservices as increase in wildfires, homogenization of landscape, and what is our concern, changes in soil characteristics. This is the context of MANMOUNT project, whose main aim is to analyse how post-land abandonment management through shrub-clearing and livestock grazing of selected mountain areas influences soil properties, soil quality, carbon dynamics and carbon sequestration.
Five land uses have been selected in the study area (Leza Valley, Spain): control pasture, 3 shrub clearing sites of different ages; and shrubland after cropland abandonment. For each study site, 6 replicates have been collected at different depths (0-40 cm), then, the physico-chemical (C, N, OM, P, etc.) and biological properties of the soil have been analysed, distinguishing between basic and acid soils. In addition, a soil quality index is created, while a theoretical mapping of future shrubland areas and its potential to sequester organic carbon is discussed.
Significant differences are observed between post-land abandonment practices. Carbon concentration and storage increase with management, while the time since intervention is a key factor in carbon dynamic evolution.
To conclude, soils of abandoned areas in the Mediterranean mid-mountains can offset carbon emissions to the atmosphere with an adequate management, becoming an important tool against global change, besides offering socio-economic and ecological benefices.
This research is part of the MANMOUNT project (PID2019-105983RB-100/AEI/ 10.13039/501100011033) funded by the MICINN.

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P-100

Response of a Humic Haplustands soil to the application of humic acids extracted from Leonardite

Msc Angie Suárez

The use of organic substances as a nutritional source, maintenance and management of organic matter in soils, has increased in some agricultural areas of Colombia, especially in vegetable producing areas, but the effect that liquid organic substances may have on the characteristics of the soil, for this reason the present investigation has been proposed, whose objective was: to evaluate the effect of the application of humic acids (HA) extracted from Leonardite, on the pH, CO, CICE and the phosphorus (P), potassium contents (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), iron (Fe) and zinc (Zn) in a Humic Haplustands soil of the Bogotá Savanna. A repeated measures design associated with a completely randomized design, with four treatments, was used as a between-subject factor: control 0 l ha^{-1} (T0); 20 l ha $^{-1}$ (T20); 40 l ha^{-1} (T40) and 60 l ha^{-1} (T60), four repetitions and as an intra-subject component two production cycles. Data were analyzed using multivariate and univariate statistics. The results showed that the HA increased the CO, the CICE, the content of K, Zn and partially (in a single cycle) the contents of S, Fe, Mn and Cu, being the T60 the one that achieved the best results. It is concluded that the application of HA extracted from Leonardite generated positive effects on most of the chemical parameters of soils evaluated in this investigation.

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P-101

Organic carbon stock in sandy soils of post-agrogenic ecosystems: a case study in NW Smolensk region, Russia

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According to estimates (ROSSTAT, 2017), the area of abandoned agricultural land in Russia exceeds 38 million hectares. Analysis of carbon content dynamics during a post-agrogenic succession is important for understanding the rate of natural restoration of soil and vegetation and for an effective decision-making on the post-agrogenic ecosystems (Lyuri et al., 2010).

We studied changes in sandy soils of post-agrogenic pine forest ecosystems abandoned at different periods of the XX century in Smolensk Lakeland National Park to assess the soil organic carbon stock dynamics at different stages of recovery.

The results showed a maximum value of carbon stocks in the meadow soils (about 3.5 – 5.5. kg/m2) due to the influence of the large amounts of above- and below- ground grass litter entering the soil. The change from meadow to woody vegetation causes a reduction in root deposit input and the formation of a litter horizon on the soil surface. It results in the reduction of organic C stocks in the mineral soil. The minimum of the soil organic carbon stock was observed at the middle-aged (a 50-70-year old) pine forest (about 1.5 – 2.5 kg/m2). The soil organic carbon stock of old-growth primary and secondary pine forests are higher (about 2 – 4.5 kg/m2) due to more intensive litter humification and increasing root phytomass.

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P-102

Soil Carbon Sink under Agriculture Depends on Microbial Stress Alleviation by Biosolids: 50 years of Observations in United States Midwest

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Soil carbon sink (C gain>loss) mitigates climate change, however, difficult to achieve it in agricultural soil. Even with crop residue-C input at 4-5 Mg C ha-1 yr-1 vs. soil organic C (SOC) decomposition loss at 0.5 Mg C ha-1 yr-1 for reduced tillage corn-soybean system, SOC remained unchanged, based on continuous field observations starting in 1970s in western Illinois, US. Our concept to achieve C sink in agricultural soils relies on improvement of soil conditions through an amendment to microbes to reduce microbial maintenance respiration for allocating more crop residue-C to growth as biomass and eventually stabilized as SOC. We tested this concept in long-term studies of 18 production fields using municipal biosolids as soil amendment, applied during 1972-1984 (455-644 Mg ha-1 cumulatively), and 1972-2002 (903-1131 Mg ha-1). We found decrease in microbial maintenance respiration rate in g CO2-C kg-1 biomass d-1 from 34.2±7.6 (no-biosolids) to 24.2±2.8 (low biosolids) and 16.4±2.1 (high biosolids), and increase in the rate of transformation of crop residue-C to SOC correspondingly from no-biosolids to biosolids. In 2018, excluding the biosolids residual C, ecosystem SOC for both groups of biosolids fields was much higher than the initial levels, soil is C sink, with a net soil C sequestration at 1.01 Mg C yr-1 from 1972 to 2006 and 0.31 Mg C yr-1 from 2006 to 2018 for the fields of 455-644 Mg ha-1 biosolids. Our results suggest reducing microbial stress by biosolids amendment be effective in achieving C sink in agricultural soils for mitigating climate change.
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Organic matter accumulation on pristine minerals buried in temperate forest and grassland soils

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Formation of mineral-associated organic matter (MAOM) supports accumulation and stabilization of carbon in soil, and thus, is a key factor in the global carbon cycle. Little is known about the interplay of mineral type, land use, and management intensity on extent and time scale of MAOM formation. We addressed this research question by exposing mineral bags with pristine minerals (goethite and illite) for five years to ambient conditions at 5 cm soil depth in 150 grassland and 150 forest plots in three regions across Germany. After recovery, the content of organic carbon (OC) of the minerals was determined by dry combustion. More OC accumulated on goethite than illite (on average 5.16 and 3.18 g/kg) across land use types and management practices, reflecting the different nature of the surfaces of the two minerals. For each mineral, general linear models revealed that study region explained the largest share of total variance, with greatest carbon accumulation in the region with sandy soils, where forest soils were most acidic and grassland soils richest in organic matter. Carbon accumulation was consistently greater in coniferous than deciduous forests and increased with sand content and the CN ratio of the surrounding soil. In grasslands, carbon accumulation was not directly affected by management (fertilization and grazing), but increased with soil OC content and declined with soil pH. Our results suggest that MAOM formation is mineral type specific and dependent on both, local soil properties and vegetation type, but their relative importance varies between grassland and forest ecosystems.
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RECSOIL implementation proposal in Costa Rica

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RECSOIL-CR is the Costa Rican version of FAO's Global-Soil-Partnership project on soil recarbonization. It is part of a financial scheme that encourages farmers to promote soil ecosystem services, particularly the increase in Soil Organic Carbon (SOC) sequestered, by applying Sustainable-Soil-Management (SSM) practices that lead to a healthy soil, boost crop productivity and contribute to atmospheric decarbonization. Funding for the incentives will come from green line funds or emission reduction certificates. RECSOIL-CR adapted the 6 tools developed by GSP/FAO including the map of SOC potential sequestration to their particular conditions, for two agricultural sectors: coffee and livestock. An RECSOIL-CR partner, named FONAFIFO (a national institution with 25 years of experience in payment of environmental services) will capture the resources and pays them through 8-year contracts to the farmers that implement SSM practices. The payment will be made annually and the net increase in SOC will be quantified and verified later from an initial baseline, at 4 and 8 years, considering the total number of participating farms. Two GSP/FAO protocols will be used: "Protocol for the assessment of SSM" and "GSOC-MRV: Protocol for MRV and Monitoring to Assess SOC Sequestration" plus one designed in Costa Rica, named “Annual Valuation of SSM practices”, to define the fulfillment of contracts by farmers and the incentive payment. The three protocols will be applied by technicians linked with NAMA projects to each activity. The amount to be paid was set at $115/ha/year including the costs of laboratory analysis necessary to comply with the protocols.

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A complex system approach for soil organic matter persistence

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Soils hold the largest terrestrial carbon pool, essential to a multitude of ecosystem services. Understanding how soils are capable of storing such vast quantities of organic matter remains one of the biggest challenges in soil science and is particularly relevant in the context of climate change mitigation. The last decade saw a growing consensus that biota themselves play a regulatory role in soil carbon sequestration, yet a nexus remains to be found between that new insight and physico-chemical aspects of carbon storage. In ecology, the adoption of a Complex Adaptive System (CAS) approach provided a long-needed framework for linking the massive biotic and abiotic diversity to the overall functioning of an ecosystem. Hence, the approach may be a powerful avenue to link information on soil biota to our understanding of SOM persistence. In this contribution, we describe the first comprehensive CAS for soil carbon cycling in natural systems, comprising interactions among five main components, i.e., vegetation, microorganisms, soil fauna, mineral surfaces and organic substrates. Ecological constraints imposed by the edaphic environment can lead to changes in the nature and intensity of these interactions and eventually may cause mechanisms of SOM persistence to emerge or subside in a non-linear way. We illustrate the potential of the CAS approach by reviewing how well-known thresholds in oxygen availability, acidity and temperature can enhance or subdue soil carbon persistence mechanisms in topsoils. Finally, we demonstrate how the CAS approach will help prioritize future research and policies related to soil carbon storage.
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Characteristics of the humin fraction isolated from different soils in Poland

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Humin is the most stable fraction of soil organic matter and therefore plays an important role in various soil services (Hayes et al. 2017). This work concerns humin isolated from the mollic horizon of several Chernozems and Phaeozems, which are used as arable soils in various regions of Poland. The soils studied differed in basic properties: TOC (13.3 - 41.7 g kg−1), texture (loam, silt loam, sandy clay loam, and clay), pH (5.64 - 7.71), and CEC (21.6 - 53.2 cmol(+)kg-1). Humin was isolated according to Weber et al. (2022) and analyzed using several methods (elemental analysis, UV-Vis, FTIR, EPR, and CPMAS 13C NMR). The humin studied differed in the ash content (22.89-54.50%), which was not correlated with the colloidal fraction of the soil or the TOC content. The high ash content proves that the obtained fraction consists of strongly bound organo-mineral compounds. Its chemical composition showed a different H/C ratio (0.87-1.28) indicating a wide range of aromaticity/aliphaticity or unsaturation (Rice and MacCarthy 1991). UV-Vis and FTIR spectra confirmed results from elemental analysis and enabled us to point the most aromatic samples. Data from CP MAS 13C NMR showed that aromatic structures dominated the other forms, which distinguished the analyzed samples from the DMSO isolated humin (Song et al. 2011).

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P-106

Microspectroscopic visualization of how biochar elevates the soil organic carbon ceiling

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The soil carbon saturation concept suggests an upper limit to store soil organic carbon (SOC), set by the mechanisms that protect soil organic matter from decomposition. Biochar has the capacity to protect new C including rhizodeposits and microbial necromass. However, the decadal scale mechanisms by which biochar influences the molecular diversity, spatial heterogeneity, and temporal changes of SOC persistence remain unresolved. Here we show that the soil C saturation ceiling of a Ferralsol under subtropical pasture could be elevated by 2 Mg (new) C ha-1 by the application of Eucalyptus saligna biochar 8.2 years after the first application. Using one, two-, and three-dimensional analyses, significant increases were observed in the spatial distribution of root-derived 13C in microaggregates (53-250 µm, 11 %) and new C protected in mineral fractions (<53 µm, 5 %). Microbial C-use efficiency was concomitantly improved by lowering specific enzyme activities, contributing to the decreased mineralization of native SOC by 18 %. We provide evidence that the SOC ceiling can be elevated using biochar in Ferralsols by 0.01-0.1 Pg new C yr-1 worldwide.

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Fungal residues dominate mineral-associated organic matter in a temperate forest

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We lack crucial knowledge about the contribution of plant vs. microbial residues to specific soil organic matter (SOM) pools. To address this, we investigated the sources of OM contained in particulate and mineral-associated organic matter (POM and MAOM) pools in a temperate deciduous forest in Indiana, USA. We analysed the 13C and 15N signatures of large- (> 63 µm), medium- (> 20 µm) and small-sized (< 20 µm) POM and MAOM fractions, in combination with measurements of microbial residues using amino sugars. The 13C and 15N values of the SOM were compared with those in leaves and roots of the two dominant tree species (Quercus alba and Liriodendron tulipifera), as well as those from mycorrhizal and saprotrophic fungal biomass. Sources of C and N to SOM fractions were calculated using a Bayesian inference isotope mixing model.
We found a higher contribution of plant (~ 76 %) than fungal inputs to POM for both tree systems, with a higher contribution of saprotrophic (SAP) fungi than ectomycorrhizal (ECM) fungi (~ 17 % and ~ 5 %, respectively). In contrast, MAOM fractions were dominated by fungal residues (relative to plant C). Microbial necromass confirmed the important role of ECM and SAP fungal residues for SOC storage in both, POM and MAOM fractions.
We were able to demonstrate that fungal residues clearly dominate the mineral-associated OM. Thus, we highlight that the transition of plant residue dominated POM towards the microbial residue dominated MAOM is fostered by both, mycorrhizal and saprotrophic fungi.

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P-108

Changes in soil C pools and fluxes under elevated CO2 concentration and soil nutrient levels

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Carbon-rich exudates derived from roots serve as an energy source for soil microbes. Plants may increase belowground allocation of photosynthetically fixed carbon (C) under elevated carbon dioxide (CO_2) concentrations, potentially influencing the microbial turnover of existing soil C. However, these processes may vary depending on the soil nutrient status (van Groenigen et al., 2014; van Hees et al., 2005). To better understand how soil nutrient conditions modify the response of plant-soil interactions to elevated CO_2, two mesocosm experiments were conducted. A total of 64 trees (Carpinus betulus L. in the first experiment, and Fagus sylvatica L. in the second experiment) were exposed to ambient (400 ppm) or elevated (580 ppm) CO_2 concentration, and ^{13}C-enriched CO_2 (100 permil) was used to trace C in the system. Above and belowground C fluxes were continuously monitored for partitioning of soil heterotrophic and autotrophic respirations. In the first experiment, two levels of nitrogen (N) were applied to the trees in the form of ^{15}N-labelled ammonium nitrate (NH_4NO_3) and in the second experiment, four different treatments of control, N, phosphorus (P), and NP were applied. Soil samples were analyzed for CN and microbiological activities through microbial biomass C and enzyme measurements. Trees were separated into aboveground (leaves, branches, stems), and belowground (main, coarse, and fine roots) parts for CNP analyses. We will report first results on the changes in C fluxes and storage in soils, which show that soil nutrient conditions affected the belowground C allocation of trees and subsequent microbial responses under elevated CO_2.

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P-109

Clay mineralogical control of soil organic matter turnover in 13 temperate forest soils from Hungary

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Complex mineralogical analysis of the clay fraction is needed in order to better understand SOM stabilization processes (Barré et al., 2014). Therefore, the aim of this work was to investigate the influence of the soil mineral phases on the decomposition of SOC pools of soils under forest vegetation.
Thirteen topsoil samples were incubated for 163 days at 20°C and 70% field capacity. The soil respiration was measured at specified intervals and decomposition rate constants of the easily (k_1) and slowly (k_2) mineralizable carbon pools were calculated using a first-order two pools model.
The textural and mineralogical properties (clay content, clay composition, crystalline and poorly crystalline Fe- and Al-oxide concentrations) of the soils were determined.
The results showed that the volume of SOM mineralization was reduced to the greatest extent by the illite (R^2=0.797, p<0.001), non-swelling clay mineral (R^2=0.767, p<0.001), AlDCB (R^2=0.708, p<0.001) and AlOX (R^2= 0.627, p<0.01) content. Strongest negative relationship was found between the k_1 value and the AlDCB (R^2=0.681, p<0.001), AlOX (R^2=0.583, p<0.01) and illite (R^2=0.545, p<0.01) contents.
The k^2 value was only affected by the non-swelling clay mineral (R^2=0.467, p<0.05) and illite (R^2=0.574, p<0.01) contents. These results confirm that the mineral composition of the soil, including the Al oxide, non-swelling clay mineral and illite contents, may significantly inhibit the decomposition of SOM.
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P-110

Abiotic controls of priming effect in 13 temperate forest soils from Hungary

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There is growing interest in the mechanisms and controls of the changes in SOM decomposition caused by fresh C inputs across varying ecosystems (Chen et. al., 2019). Therefore, this work aimed to determine which soil parameters affect the magnitude and direction of priming effect (PE) in temperate acidic forest soils.
Thirteen topsoil samples were amended with maize residues and incubated for 163 days. The soil respiration was measured at specified intervals and the proportion of maize-derived and SOM-derived C and the dynamics of the PE were monitored during the incubation period.
Abiotic properties (e.g., pH, C/N ratio, cation exchange capacity, texture and clay mineralogy) of the soils were determined and linear regression was applied to determine how these soil indicators were related to the PE.
The results showed that organic matter content and soil texture were important parameters affecting the proportions of soil respiration sources during the 163 days. Results also showed that the C/N ratio of the soils affected the magnitude and direction of PE and determined the duration of negative PE.
PE was reduced to the greatest extent by the AlDCB (R^2=0.454, p<0.05), silt+clay (R^2=0.421, p<0.05), non-swelling clay mineral (R^2=0.396, p<0.05) and illite (R^2=0.389, p< 0.05) contents. The texture and mineral composition of the soil, including the Al oxide, non-swelling clay mineral and illite contents, may thus significantly inhibit the magnitude of PE, and consequently the decomposition of SOM under acidic conditions.
This research was financed by the Development and Innovation Fund of Hungary [grant No. NKFIH 132191].
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P-111

The effect of chemical characteristics of organic matter fractions on carbon mineralization in soils with different vegetation coverage

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Soil organic matter (SOM) plays a potential role in the release and sequestration of CO_2, through the decomposition of organic matter (Lal et al., 2015). However, soil organic matter is not a homogeneous material but consists of molecules ranging from the simple to the more complex in very different stages of decomposition, therefore, the residence time of SOM is very diverse (Lehmann and Kleber, 2015). These differences also divide the SOM into pools of different bioavailability and therefore different turnover times. Understanding how the chemical characteristics of SOM fractions affect the turnover of C is critical. To study this effect physical fractionation procedure were used to separate chemically and physically different SOM compartments from the bulk soil according to Zimmermann et al. (2007). In this study, the CO_2 evaluation of SOM fractions (POM, S+A and S+C) was measured in 4 soils with different vegetation coverage. To characterize the chemical structures of SOM fractions ^{13}C-NMR and elemental analysis (C/N, H/C and O/C ratio) was applied. For a detailed understanding turnover processes, we combined the measurement of heterotrophic respiration with ^{14}C analyses of CO_2 in a long-term laboratory mineralization experiment determining mean residence times (MRT).

This research was supported by the National Research, Development and Innovation Office of Hungary (NKFIH 132191).

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P-112

Disentangling interactions of soil structure and particulate organic matter dynamics through explicit spatial modelling

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The structure of soil aggregates plays an important role for the turnover of particulate organic matter (OM) and vice versa. Analytical approaches usually do not disentangle the continuous re-organization of soil aggregates, caught between disintegration and assemblage. This led to a lack of understanding of the mechanistic relationship between aggregation and OM sequestration in soils.

In this study, we take advantage of a process-based mechanistic model based on [1,2,3], that describes the interaction between the dynamic (re-)arrangement of soil microaggregates, based on realistic shapes obtained by dynamic image analysis of wet-sieved microaggregates, the turnover of particulate organic matter, and simultaneous alteration of soil surface properties in a spatially and temporally explicit way.

We used this modelling approach to investigate the impact of the following factors for aggregation: soil texture, OM input and OM decomposition rate. Our model enabled us to quantify the temporal development of the aggregate size distribution, the OC content in POM fractions of different ages and the surface coverage.

Our simulations provided important insights into the sequestration of OM in soils. First, aggregation was largely determined by the POM input and mostly decoupled from the soil texture. Second, the OM storage as POM increased with clay content, with both findings confirming experimental results [4,5]. Third, we could contribute to the understanding of a structural priming effect, where the increased input of POM stimulated the mineralization of old POM.

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P-112A

Short-term response of stable soil organic carbon to chestnut forest recovery

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We hypothesized a short-term response of the soil organic carbon (SOC) physically-protected to the replacement of unmanaged chestnut forest (UF) with chestnut forest for wood and fruit production (WF and CF, respectively) after clearcutting practice. The study was conducted in chestnut stands located in the northern part of the Apennine chain (Italy). On average the tree density was of 370 plants ha^{-1} for UF and 125 plants ha^{-1} for WF and CF. In each site, soil profiles were dug, characterized diagnostic horizons, and then sampled. Soils were classified as Leptic Skeletic Dystric Regosol [1]. SOC was physical fractionated obtaining free-particulate organic C (f-POC), organic carbon in sand-size fraction (sand-C) and the mineral-associated organic C (MAOC). Also, the easily and total extractable glomalin-related soil protein (EGRSP and TGRSP, respectively) were determined. Although the SOC content of bulk soil did not show differences, in A horizon a higher MAOC content was observed in CF and WF compared to UF. The greater SOC stabilization in recovered chestnut stands than in UF could be partially due to the greater glomalin accumulation as observed by the higher EGRSP:TGRSP ratio [2]. Since MAOC has a vital influence on soil's capacity for resisting disturbance and sequestering carbon [3], this study confirmed the necessity to evaluate SOC pools to better understand the influence of land-use managements on SOC dynamics. The similar SOC content and MAOC accumulation into A horizon of WF and CF would suggest how such land use managements allowed a prompt SOC recovery and stabilization.

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P-113

The Carbon sequestration Potential of Waste Cement Bypass Dust as a Soil Amendment.

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To overcome the increasing rates of anthropogenic CO2 emissions, there are new initiatives to both eliminate further carbon emissions, new carbon sources and to return anthropogenic carbon back into terrestrial and marine storage – it is the latter which this research is focused. Of the terrestrial carbon storage sinks, soil is key as it is a naturally carbon-rich from biotic activity. It also can store sequestered carbon resulting from the enhancement of natural weathering processes of rocks. Previous studies have focused on using calcium and silicate-based crushed rocks, rich in Ca and Mg, which react with water once entering the soil system to produce bicarbonate and carbonate anions.This research focuses on the use of cement bypass dust (CBD), a waste material from the production of cement, as a soil amendment. Like crushed rocks, its high potassium content makes it a suitable fertiliser for crops, while its abundance of calcium allows enhanced weathering to take place, sequestering carbon into the soil for stabilisation. The research approach taken is a mixture of field trials, pot experiments and a soil column experiment. Measurements will be taken from bulk soil, rhizospheric soil, soil leachates and plant tissues to determine the net sequestration potential of CBD. The aim of this research is to encourage a circular economy, reduce raw material extraction emissions, reduce landfill waste and sequester atmospheric carbon. This will result in lower net CO2 emissions which are associated with agricultural fertilisers and cement production.

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P-114

The land use impact on long term soil organic matter content in Croatia

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Intensive agriculture can result in soil degradation, especially under conditions of inefficient management of soil organic matter (SOM), which may be due to land use. The change in soil properties after a 15-year period (2005-2020) was analyzed as a part of the research on the impact of soil use on soil properties. For this purpose, in 2020, from the same coordinates as in 2005, 500 average soil samples selected based on the spatial distribution in eastern Croatia were collected (depth of 0-30 cm). There were 386 samples from arable land and 114 samples form orchards. The values in 2005 show that soils included ranged from strongly acidic to alkaline (pHKCl 3.63-7.49; pHH2O 4.24-8.13), and SOM content was 0.99-5.48% (average 2.21%). The SOM content in orchard samples was 0,99-4,05% and in arable land 1,06-5,48% and there were no significant differences comparing other soil properties (pH, plant available potassium and phosphorus) comparing orchards and arable lands. SOM content decreased on average from 2.21% to 2.13% over 15 years (3.5% less SOM in the soil after 15 years). However, in orchard soils, an increase in SOM content was found from an initial average of 2.0% to 2.3% after 15 years (an increase of 17.8%). At the same time, in arable land after 15 years of field crops growing, the average SOM content decreased from the initial 2.28% to 2.08% (SOM content 8.48% lower), clearly indicating increasing SOM in orchards and degradation of soil used for crop production.

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P-115

Multi-dimensional environmental factors drive soil organic matter formation across vegetation communities in a temperate freshwater wetland.

Miss Maria Nolan

Lower Moors is a temperate freshwater wetland in the Isles of Scilly, which is experiencing seawater ingression. This ingression is believed to have changed the wetland's vegetation, increasing the deposition of low-quality litter into the soil. The purpose of the study was to understand the applicability of soil organic matter (SOM) formation theories in a complex wetland ecosystem ranging from saltmarsh to wet woodland, lowland fen, and transitional ecotones. In particular, understanding whether higher soil salinity resulted in lower levels of SOM and soil organic carbon (SOC), whether lower quality vegetation resulted in lower levels of SOM and SOC.

Vegetation surveys and field measures of CO2 efflux were carried out. Soil samples were analysed for pH and electrical conductivity, soil moisture content, and SOM and SOC were measured gravimetrically through loss on ignition. Rothamsted Research undertook fibre analysis. Statistical analysis was performed in R, including principal component analysis, to reduce the dimensionality of the data.

No significant relationship was found between electrical conductivity or litter quality and SOM or SOC. Unexpectedly a weak negative correlation was found between SOM and soil moisture content. This relationship may be explained by root oxygen loss and substrate priming by the vegetation. Principal component analysis showed that a single variable could not explain SOM formation at Lower Moors and that a multidimensional approach is more appropriate. This supports recent findings indicating that combinations of multiple factors and parameters are more relevant than single predictors to estimate SOC.

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P-116

CARBON STORAGE IN AN AGRICULTURAL SOIL AFTER 29 YEARS OF APPLYING DIFFERENT TYPES OF FERTILISATION

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At a time of global change, when food production should be able to meet high population demand, agricultural land can be a key tool, acting as a carbon storage and food supplier (Lal et al., 2011). This role will depend on its use and practices.
The objective was to test the soil organic C (SOC) storage and yields in a rainfed cereal plot, with stubble removal, as a function of the fertilisation applied. The study samples came from trial carried out between 1992 and 2021 in Arazuri, (Navarra, Spain) on a calcareous soil. The treatments included annual mineral fertilisation at recommended dose (180 units of Nitrogen Fertilizer (UNF)), annual doses of mineral fertilisation combined with sewage sludge (SS) to reach approx. 150 and 240 UNF, fertilization with only SS (61 UNF), and an unfertilised control (n=4). The SS came from the local urban sewage treatment plant and was applied every 3 years at a rate of 40 t/ha.
Total nitrogen, organic carbon and C:N ratio, were determined from each soil sample (0-30 cm).
After 29 years, it was observed that the control, the plots receiving only SS, and the combination of mineral fertiliser with SS, resulted in a higher stock of SOC in the depth studied than mineral fertilisation. However, the combination of inorganic and organic fertilisation, together with the recommended annual mineral fertilisation, produced the highest yields. This means that an adequate combination of SS and mineral fertilizer can grant cereal yields while favouring SOC storage.

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P-117

Spatial dynamics of Oxidized Carbon, Organic Matter, Macro, and Microelements in tropical dry forest soils in the Colombian Caribbean

Ms Sonia Aguirre Forero, Mr Nelson Piraneque Gambasica, Miss Rosmery Cruz O'Byrne

The world faces multiple challenges, including food security, environmental sustainability, soil protection, and climate change. In Colombia, the Tropical Dry Forest (TDF) is one of the most threatened ecosystems and presents a high vulnerability to the impacts of global warming. Based on this, the present study analyzed the concentrations of macro (N, P, K, Ca, Mg, Na, S) and microelements (Fe, Mn, Cu, Zn, B, S) and their relationship with the content of Oxidizable Carbon (Cox) and Organic Matter (OM) in 25 TDF soil sampling points in the Colombian Caribbean at two depths: 0-10 and 10-20 cm. The results showed that cultivated soils present high levels of OM and N with significant correlations with the variables studied, corroborating that the concentrations of Cox and OM are related to fluctuations in N and other nutrients. OM, N, and Mg showed significant differences regarding depth and sampling points. P, Ca, Na, S, Fe, Mn, Cu, Zn, and B only significant differences between points, while K does not present significant differences between depth or points. It is possible to conclude that the OM, Cox, and N are constituted as variables of interest for establishing the soil health of the BSTs, and their monitoring is essential for decision-making in favor of sustainable soil management.

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Aggregate-associated soil organic carbon distribution under different land use systems in a semi-arid ecosystem

Dr Chukwuebuka Okolo, Prof Girmay Gebresamuel, Dr Amanuel Zenebe, Prof Mitiku Haile, Professor Peter Eze

Soil organic carbon sequestration potentials of terrestrial ecosystems is largely dependent on the dynamics of aggregation and structural stability of the soil. The study aimed to determine water stable soil aggregates, dry stable aggregates, and soil organic carbon (SOC) associated with aggregate sizes in topsoil (0-5 cm) and subsoil (5-15 cm and 15-30 cm) soil layers under four land use systems typical of semi-arid area northern Ethiopia (forests, exclosures, grazing lands and cultivated lands). Soil fractionation with the aid of dry- and wet-sieving analysis was applied to obtain macroaggregates (> 0.25 mm) and microaggregates (< 0.25 mm). Result shows that land use systems had impact on soil aggregate distribution: microaggregates were dominant (> 60%) under cultivated land while macroaggregates were preponderant in grazing land (72-95%). Aggregate stability index (ASI) followed the increasing order of grazing land > forest land/exclosure > cultivated land, in the surface layers, while structural stability index (SSI) was in the increasing order of forest > grazing land > exclosure > cultivated land for the top soils. SOC had strong and weak positive correlation with SSI and ASI respectively. Correlation and regression analyses implied that dry-sieving of soil is as good as wet sieving in determining aggregate size distribution and soil aggregation in the study area. From sustainability point of view, dry-sieving could be described as a "climate-smart" and a simpler alternative to the more time-consuming and laborious wet sieving method in a semi-arid dryland. Vegetation restoration improved SOC sequestration associated with aggregate sizes in the exclosures.
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P-119

Characteristics of organic carbon physical fractions and oxides in water-stable aggregates under Chinese milk vetch returning in paddy soil

Characteristics of organic carbon physical fractions and oxides in water-stable aggregates under Chinese milk vetch returning in paddy soil Yanan Huang, Characteristics of organic carbon physical fractions and oxides in water-stable aggregates under Chinese milk vetch returning in paddy soil Mingjian Geng, Characteristics of organic carbon physical fractions and oxides in water-stable aggregates under Chinese milk vetch returning in paddy soil Li Huang

Soil organic carbon (SOC) and oxides widely considered as cementing agents due to major role in soil aggregates formation and stability. Long-term experiment was conducted to investigate the effects of reduced chemical fertilizer by Chinese milk vetch (MV) (no fertilizer, CK; 100% NPK fertilizers, F100; 2.5 Mg ha-1 MV with different percentage of NK and 100% P, MV+F100, MV+F80, MV+F60 and MV+F40) on organic carbon fractions in macroaggregates (0.25-2mm) and microaggregates (0.053-0.25 mm), and Fe, Al, Mn oxides in paddy soils in southern China. The values of mean weight diameter (MWD) of aggregates increased with a decrease in chemical fertilizer application under MV returning treatments (except MV+ F60). Compared with MV+F60, MV+F80 promoted the relative mass content of fPOC (0.25-2mm) and mSOC (<0.053 mm). FTIR results showed polysaccharide-C peak intensity in mSOC was increased correlated with MWD under MV+F80, indicating that polysaccharide-C may easily bind with minerals and improve clay particles aggregation. Compared to F100 (3.59%), the mSOC under MV+F60 (4.87%) contained more Alkanes-C in microaggregates, and its hydrophobicity helped prevent microbial degradation and promoted the formation of aggregate. 13C NMR results further strengthened MV+F80 enhanced aromaticity and aliphaticity in mSOC, showing higher SOC stability. Amorphous iron oxide (Feo) was the key binding agent in macroaggregates (positively correlated with MWD, $p<0.05$), while manganese oxides played an important role in the cementation of microaggregates with organic carbon. MV returning (especial MV+F60 and MV+F80) increased SOC and oxides contents in organic carbon fractions, which interaction was responsible for aggregate stability.

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P-119A

Particulate organic carbon mediates changes in carbon storage of cropped subtropical soils rather than clay content

Miss Meghan Barnard, Professor Peter Kopittke, Dr Han Weng, Dr Cristina Martinez, Professor Ram Dalal AM

Conversion of native land to agriculture drives loss of soil organic carbon (SOC)[1]. This has repercussions for climate change, soil fertility, and ecosystem services provided by soils[2]. The objective of this investigation is to establish whether cropping duration and clay content exert differences in SOC distribution and chemistry. We examined the changes in SOC across four fractions of Australian Vertisols from a cropping chronosequence (0-70 years) using synchrotron-based near-edge X-ray absorption fine structures (NEXAFS) spectroscopy. These fractions comprise free and intra-aggregate particulate organic matter (POM) and mineral-associated clay+silt (<20 µm) and sand (20 µm-2 mm).

It was found cultivation caused a decline in SOC stocks of ≤56% across all soils, irrespective of clay content. Most losses occurred within POM fractions, with limited changes in the mineral-associated fractions, suggesting cultivation has limited influence on the mineral protection of SOC. This chronosequence also demonstrates the relative abundance of microbially-derived compounds increases as plant-derived compounds, predominantly within the POM fractions, decline. This is also reflected by the soil C:N ratio. Overall, it was deduced that fractions with greater diversity in C functional groups had greater SOC persistence. As molecular diversity and spatial heterogeneity of SOC have become recognized as controllers of SOC persistence[3], this enhances our understanding of C sequestration in cultivated soils, particularly in subtropical regions. An attempt to characterise the loss of SOC stock and diversity through time was made. It is anticipated these findings can highlight points in cultivation that require additional management to minimise SOC losses in cropped lands.

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P-120

Biogenic carbon sequestration potential in manmade and forest systems.

Mrs Panchami Jaya

Among the various approaches to securely reduce carbon emissions and atmospheric build-up, sequestration of carbon in terrestrial systems is considered the most promising technique to offset unbalanced carbon in the atmosphere. Carbon biogeochemically sequestrated within the silica presents an extremely stable form of carbon in terrestrial systems. The present study concentrates on phytoliths abiogenic siliceous carbon in the plant systems. Phytoliths in forested and cultivated systems were explored in Wayanad Plateau and Granite Syenite of Kerala part of Southern Western Ghats. Results indicate Wayanad Plateau and Granite Syenite contain Trapeziform corniculate shaped Phytoliths and in the vertical distribution of soil average PhytOC content were estimated as 2.83%(B1 horizon)and 0.02% in O and B horizon. Based on the experimental results, selection of high PhytOC-yielding cultivars and standardization of soil management strategies under different ecosystems offer an opportunity to enhance terrestrial carbon sequestration.

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P-121

How do different sedge species affect methane emission from boreal wetlands and what are possible implications under a warming climate?

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Wetlands have higher rates of carbon sequestration than any other terrestrial ecosystem. Due to the anaerobic conditions they are also the largest natural source of methane (Saunois et al., 2016), which is an important greenhouse gas with 33 times the radiative forcing of CO_2 (Myhre et al., 2013). However, especially for the non-growing season the processes driving methane emissions from wetlands are not well understood and current process-based models underestimate non-growing season emissions of CH_4 by 67% and annual emissions by 25% (Treat et al., 2018). I investigate the impact of different sedge species on the three components of CH_4 emissions (production, transport, oxidation) in order to explain spatial and seasonal variations in CH_4 emissions from a Finnish wetland. During intensive seasonal field campaigns, I measure CO_2 and CH_4 fluxes from vegetation removal plots and from individual sedges using manual flux chambers at Siikaneva bog, Southern Finland. Combining these measurements with soil pore water and pore gas analysis as well as stable isotope analyses allows me to separately investigate the effect of different sedge species on CH_4 production, transport and oxidation. These observations will help us to understand the impact that a shift in vegetation composition under a warming climate might have on greenhouse gas emissions from boreal wetlands.
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P-122

Recent developments in soil carbon accounting methodologies to support climate policies in Australia

Dr Senani Karunaratne, Dr Jeff Baldock, Dr Di He

Under the Australian Government domestic climate change policies, sequestration of carbon in soils through the adoption of improved land management activities has been incentivised through the Emissions Reduction Fund (ERF). Where a soil carbon sequestration project has demonstrated a positive change in soil carbon stock in response to new or materially different land management activities, Australian Carbon Credit Units (ACCUs) can be issued. The ACCUs obtained can be sold to the Australian Government, sold within a secondary market or retained for future use. Currently, there are two approaches/methods available for new soil carbon projects within the ERF: (a) model-based /default values approach (2015 soil carbon default approach) and (b) direct measurement approach (2018 soil carbon measurement approach). There has been no adoption under the 2015 soil carbon default approach as default sequestration rates are low and eligible land management activities are restricted. While there has been significant adoption (16 % of all ERF projects) of the 2018 soil carbon measurement approach, the costs associated with the measurement method are a barrier to greater uptake. Hence the study presents key aspects related to the new method's development designed to overcome these limitations, including (a) accounting for the impacts of soil carbon change with discrete layers vs soil profile as a whole; (b) assessment of the potential over or under issuance of ACCUs due to different change detection methodologies. This work informed the development of the 2021 soil carbon method.

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Soil-Landscape and Land use signatures on SOC stock spatial distribution with depth

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Within the context of global climate change, identifying methods to maintain and sequester carbon dioxide (CO2) is one of the most important environmental considerations. An important part to maintain and sequester atmospheric CO2 is the assessment of soil organic carbon (SOC) stocks and their spatial distribution with depth and stability. About 70% of the SOC stock variability, especially for the surface layers can be linked to soil landscape and land use. Reynolda Garden at Wake Forest University comprises of three major land uses (restored prairie, managed lawns, and forest) that occur on various slope position (summits, backslope and toe slopes). Soil samples based on genetic horizons were collected from the major land uses and slope positions and analyzed for organic carbon. Soil bulk density was also determined for a subset of soil sampling sites. The soil landscape signature for the SOC stock was better expressed for the subsurface genetic horizons. The SOC stock of surface horizons was highly variable especially between and within land use types.

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Shift from perennial to annual crops: the fate of the sequestered soil carbon in a long-term experiment.

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Perennial crops for energy use have a high soil organic carbon (SOC) sequestration potential thanks to their deep-rooted system and the reduction of soil disturbance. However, the fate of the SOC sequestered by perennial crops when land management changes to annual crops is poorly studied.
A field experiment located in Northern Italy was investigated. The experiment started in 2001 with a shift in vegetation (C3/C4) -from wheat (Triticum aestivum L.) to miscanthus (Miscanthus sinensis Anderss.)-, and in agricultural management -from tillage to no-tillage-. At the end of miscanthus life cycle (2014), the amount of total SOC and the miscanthus-derived C was measured in three soil layers up to a depth of 0.60 m. After miscanthus had been explanted, wheat was again introduced with a new shift in vegetation (C4/C3) and the introduction of tillage. Since then, soil samples have been yearly collected in order to follow the fate of the SOC previously accumulated.
During the 12 years of miscanthus the SOC content has increased significantly. Then, the tillage (i.e. plowing) caused, in the first year, a sharp increase in total SOC due to the incorporation into depth of miscanthus root system. In the following samplings a decrease but also a redistribution of the miscanthus-derived C was observed with the loss of SOC in the surface layer, and an increase and stabilization of the miscanthus-derived C in depth.
In conclusion, long-term experiments are crucial to study the real C dynamics and stabilization after changes in agricultural practices.

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P-125

Validity of Andic Soil Properties for Estimating the Intensity of Anthropogenic Impacts on Soil Organic Carbon and Phosphorus Accumulation

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Soil organic carbon (SOC) and phosphorus (SOP) play an important role in the global C and P dynamics and in the fertility of agricultural and forest soils. In the present study, regulating factors for forest soil organic C and P storage in a regional scale of areas influenced by volcanic ash in the cool temperate zone were investigated from the following aspects i) the relationship between the stocks of SOC & SOP and the stocks of various soil constituents derived from volcanic ash materials, such as Al and Fe constituents extracted by acid oxalate and/or pyrophosphate, and ii) the effects of locational condition, such as altitude, slope gradient, and vegetation management on the stocks of various soil constituents derived from volcanic ash materials. Sixty pedons were selected in Japanese forest soils with steep topography in the cool temperate zone in Saitama prefecture; 25, 32, and 3 were classified as Andosols, Cambisols, and Leptosols, respectively. The stocks of SOC and SOP in the mineral soil horizon were significantly correlated with the stocks of oxalate-extractable Al plus 1/2 Fe (Alo+1/2Feo). Furthermore, the stock levels of such soil constituents are closely related to the topographic characteristics, altitude, and vegetation management of the area. Stocks of Alo+1/2Feo in the artificial conifer forest, particularly Japanese cedar were low in places where slope gradient was steep and altitude was low. The degree of the load by human activities on the land was thought to be a particularly important factor for the erodibility of andic soils.

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P-126

Soil Organic Carbon Stocks in Western Himalayan Region of India and Drivers of their Degradation.

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With growing concern of international community towards adverse effects of climate change and its initiatives in sustainable development, global interest has shifted in promoting mitigation and adaptation in agriculture, forests and other land-use sectors. Being critical to achieving Sustainable Development Goals of the United Nations, firm understanding of the properties and processes of soil at national and regional scales is imperative. Himalayan region is fragile and vulnerable to soil erosion and any degradation in

soil has a potential to impact the lower regions. Soil Organic Carbon (SOC) stock is a strong indicator of land and soil degradation. SOC stock is estimated for six forest types namely, Sub Tropical Pine Forest, Himalayan Moist temperate Forest, Himalayan Dry Temperate Forest, Sub-Alpine Forest, Moist-Alpine Forest and Dry-Alpine Forest in Rohru Forest Division lying in the western Himalayan region of Indian Himalayas and drivers of SOC stock are identified. It was found that natural vegetation in these forest types contributes to the soil quality and maintains the SOC stock. Forest fire, grazing, recent changes in the agricultural practices (involving use of chemical fertilizers) and encroachment of forest land were the direct drivers while collection of fuelwood, fodder and non-timber forest produces were the indirect drivers of SOC degradation. A holistic approach is used to investigate the value of SOC stock as a keystone, influencing multiple ecosystem services and achieving effective soil carbon sequestration.
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P-127

Spatio-temporal dynamics of soil organic carbon in intensively cultivated sandy soils

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The goal of this project was to accurately map soil organic carbon (SOC) stocks across a 1,080-ha farm in the Central Sands Region of Wisconsin. The soils range from sandy loam to loamy sand, are excessively drained, somewhat excessively drained, or well drained, and developed on flat topography. Previous work has shown that irrigation and fertilization have increased the carbon stock of sandy soils under intensive agriculture. One hundred sampling locations were selected by conditioned Latin Hypercube sampling to cover variation of soil and landscape across the farm. Soil samples were collected from the A horizon to determine SOC concentration, and bulk density measurements were taken from the center of the A horizon. A horizon thickness was measured in the field. These were used to calculate organic carbon stocks. Environmental covariates used for prediction included LIDAR derived topographic parameters and legacy soil survey maps. Additionally, the land use history of the fields was inspected using historic aerial photographs to explore how the time since cultivation may impact organic carbon concentration and stocks. Adjacent forested land without a history of cultivation and forest converted from agricultural use were used as a reference of carbon stocks and an example of legacy effects from agriculture, respectively. This project provided critical information regarding soil carbon to the farmer as well as investigated how sandy soils respond to land use and management.
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Impact of continuous teak rotation on soil organic carbon pools and their thermal stability in laterite soils of Western Ghats

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Objective of the study was to assess the carbon pools and analyze the CO2 efflux at different temperature; from the soils under continuous teak rotations in the laterite soils of Kerala Western Ghats.
In general, the carbon content was found to decrease depth wise with rotation. However, in plantations without felling organic carbon was found distributed equally in all the layers which may be due to the unhindered transportation and translocation of humic materials with time in these plantations. The active carbon fraction responsible for the ecosystem health and sustainability of food webs was found to decrease with continuous teak planting. On the other hand, the passive fractions increased with rotation indicating a large conversion of the active carbon pools to passive thereby seriously impairing the ecosystem health and productivity.
Maximum CO2 evolution was observed in the age group 80-110 representing third rotation plantations. The lower depletion of passive carbon in the third rotation indicates that there is no supplementation of passive carbon to active and slow pool in these soils and the former fraction is relatively inert to decomposition. Carbon pool analysis at different temperature indicated that more carbon was oxidized at 40oC than 25oC indicating the release of even recalcitrant compounds for enzyme action from the organic materials at higher temperature. The study concludes that continuous teak rotation destabilizes carbon in soil and shows the potential of these managed forest systems to revert to a carbon source than sink if continuous rotations are taken without sustainable management strategies.

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P-129

Potential for soil carbon stock accumulation in agricultural areas in Brazil

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Soil plays an essential role in the climate regulation as a carbon sink (C) through plant growth. In this sense, agriculture represents a promising greenhouse gases (GHG) mitigation strategy. This strategy is essential for Brazil to achieve its goals assumed in the Nationally Determined Contribution (NDC-Paris Agreement). However, for the best use of this resource, it is necessary to know the potential of soil C stock accumulation for different uses and management practices established in the main agricultural regions. Thus, the present study aimed to determine the potential of C stock accumulation in agricultural areas in Brazil through comparison with native vegetation preserved areas. The effects of agricultural intensification levels on soil C stock rates were also evaluated. For this, a systematic review was carried out (1986 to2022), from which soil C stock data were extracted from native vegetation and agricultural areas under different biomes and management practices. A comparison of these values was evaluated using statistical methods. The Amazon biome had higher agricultural soil C stocks than native vegetation in two layers (0–10 and 0–30 cm), while the Cerrado biome only at 0–30 cm. For the other biomes, soil C stock values of native vegetation were higher than for agriculture. Regarding the level of intensification, the highest soil C stock values were observed in systems with three or more cultures. It is expected that these results will help the national program of low carbon agriculture (ABC+) with strategic actions, aiming to support the national carbon market.

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P-129A

Exploring macroscopic properties of soil organic matter using modeling and molecular simulations

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Soil Organic Matter (SOM) is composed of a complex and heterogeneous mixture of organic compounds. It is of great importance to understand its molecular structure, the conformations and water accessibility, as well as the interfaces and reactivity of SOM with its surrounding. SOM extracts permitted for decades a systematic way of studying SOM via the use of standardized samples. We used such standardized samples of the International Humic Substances Society (IHSS) to computationally explore the properties of SOM.

We used the Vienna Soil Organic Matter Modeler 2 (VSOMM2; Escalona et al. (2021); https://somm.boku.ac.at/) to produce representative, condensed-phase, atomistic models of IHSS samples. This online tool ensures greater chemical diversity of the models and reproduces the carbon distribution or organic composition estimated by NMR. Generated models were subjected to molecular dynamics simulations. We characterized these systems in order to observe differences in their structure and dynamics.

Our results indicate the importance of carboxyl and aromatic groups in the molecular interactions, specifically for their interactions with cations and indirectly for their aggregation properties. We also investigated the sorption properties of these systems by calculating the free energy of absorption of inserting a water molecule to the system, which values were affected by the water content, compaction, and phases of the organic matter.

These investigations help improve our understanding of properties and behavior of soil organic matter at a molecular level that is not attainable to experiments. We hope that such studies will have a great impact on basic research involving SOM.

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Soil organic carbon sequestration and dynamics in two fluvial terraces along a chronosequence

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Mechanisms of soil organic carbon (SOC) sequestration as a function of time and depth are investigated. Two fluvial terraces, showing the same land use, have been selected along a chronosequence (T1, 125 m a.s.l., ca. 125,000 years BP; T2, 15 m a.s.l., early Holocene). From each site, soil samples have been collected (1 profile and 2 cores) by horizon, and each horizon sub-sampled by depth. Five-cm thick sub-samples have been characterized for pH, EC, total organic C, total N, major/trace elements, SOC stability and texture, and particulate organic matter (POM) and mineral-associated organic matter (MAOM) have been isolated.
The average organic C content in topsoil (20 cm) is quite constant in both sites (27.4 mg/g), whereas the average total N concentration ranges between 2.7-2.9 mg/g. SOC stock in topsoil is 50% higher in T1 (72±3 MgC/ha) than in T2 (49±5 MgC/ha). Although SOC accumulation decreases with depth, the two sites recorded a similar average C stock at 35 cm (89±9 and 76±8 MgC/ha, respectively). The average content of the MAOM pool is constant along the T2 profile (52%), while increases with depth in T1. Thermal analysis (TGA-DSC) suggests a general increase of the stability of MAOM and POM with depth in both sites, with T1 showing a largest increase of MAOM recalcitrance in deep soil respect to T2.
While most of the studies on SOC sequestration and stabilization focuses on topsoils (0-20 cm), our preliminary data show that a significant stock of more recalcitrant organic C in the deeper layers.
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P-131

The stimulating effect of increasing N availability on the priming effect on soil organic matter in different layers of topsoil

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It remains unclear how N supply affects the decomposition of native soil organic C induced by labile C input (priming effect, Kuzyakov, 200). This study aimed at examining whether the magnitude and direction of the priming effect depended on N additon rates and how this interacts with soil layers differing in SOC content. Nitrogen was supplied at 0 to 160 mg N kg-1 as Ca(NO3)2, and 13C-glucose was supplied weekly to induce the priming effect. The priming effect increased with increasing N addition up to 20 mg kg-1, and then plateaued when N addition further increased to 140 mg kg-1. In the upper soil layer (0-5 cm), the priming effect decreased by 16% from the peak at a further N supply at 160 mg kg-1 but was still higher than that in the nil-N control. The effect of N addition on increasing priming effect lasted for four weeks during which soil mineral N concentrations decreased and microbial biomass C:N ratio maintained over time. By Week 6, N addition stimulated the priming effect to the greatest extent likely due to enhanced microbial turnover. This N effect was greater in the upper than deep soil layer (5-10 cm) (52% vs. 27%) in the first four weeks but similar afterwards. Our results suggest that the supply of N, over a wide range with continuous labile-C input, to N-poor soils stimulates the loss of native soil organic C irrespective of soil layers differing in SOC quantity and quality.

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P-132

Plant residues decomposition: Contribution to an active soil organic matter pool and carbon dioxide emission from the soil

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In a laboratory experiment under constant temperature (22°C) and moisture (25 wt %) conditions, the decomposition and mineralization of various plant residues were investigated by the quantitative measurement of produced C-CO2 and detected by gas chromatography. Organic samples were incubated with gray forest soil collected from forest, meadow, and cultivated soil. During one year of incubation, 25-67% of the Corg present in plant residues was mineralized. Oak leaves, aboveground mass of meadow grasses and clover were characterized by a three-pool structure of organic matter with a medium (0.1 > k1 > 0.01 day-1), slow (0.01 > k2 > 0.001 day-1), and very slow (k3 < 0.001 day-1) mineralization rate, while the other types of plant residues had only a two-pool structure with the slowest mineralization rates. Poorly decomposable plant residues (<30% of Corg) were the main source of particulate organic matter in the soil, and highly decomposable ones (>50% of Corg) were the main source of microbial biomass . The specific annual values of C-CO2 production by decomposable plant residues varied from 106 to 290 g/kg dry weight, whereas the samples of cultivated and gray forest soil, from 1.1 to 1.9 g/kg dry weight. Plant residues produced 69-264 times more C-CO2 than soil organic matter. To predict the mineralization losses of carbon in plant residues, it is important to consider the decomposition and mineralization rates at the early and late stages of transformation.

The study was carried out within the framework of state assignment No. 0191-2019-0045.

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Effects of long-term application of mineral and organic fertilizers on the total and biologically active organic matter in the soil

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In a long-term microfield experiment, the annual changes in total (Corg) and biologically active organic matter (C0) in cultivated gray forest soil in response to the annual application of increasing doses of mineral (N90-360P75-300K75-300 kg/ha) and organic (25-100 t/ha of fresh cattle manure) fertilizers were investigated. The systematic application of mineral fertilizers led to a gradual increase of Corg with an average annual increase of 0.04% by soil mass. Organic fertilizers, in doses equivalent to mineral fertilizers in nitrogen, resulted in higher annual increase in soil Corg from 0.08 to 0.20% by soil mass. At doses of 25 and 50 t/ha a fairly uniform increase of Corg was observed over seven years, but at doses of 75 and 100 t/ha (500-700 t/ha for 7 years) of manure, an organic carbon soil saturation at the level of 2.11 ± 0.25% was observed. The content of C0 in the cultivated gray forest soil increased in 1.2 times without a clear dose dependence of mineral fertilizers, and in 1.6-3.0 times with a distinctive dose increase of organic fertilizers. The average annual increase in C0 in the soil was 17 times higher due to the annual application of increasing doses of fresh manure than to mineral fertilizers. The increased input of organic fertilizers led to organic carbon soil saturation and did not show a cumulative increase in active organic matter.

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Soil Organic Carbon Stocks in the lower parts of Mountain Vukan Catena, East–Central Serbia

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The lower parts of Catena's often present areas with high variation of soil characteristics at which is quite difficult to predict soil properties accurately. This paper presents the differences in soil organic carbon (SOC) stocks at the contact of Jurassic limestones, and fluviatile-colluvial deposits, located on the foot and toeslopes of Mt. Vukan, over an area of 168 ha. SOC stocks at the depth of 0.3 m are determined after soil survey encoutering excavation of 42 soil profiles. The results indicate that SOC stocks are closely related to reference soil groups (RSG's) in the area. The highest average SOC stocks are found in 12 profiles of Leptic Phaeozems, 90.6±16.5 t ha–1, followed by eight profiles of Chernozems, 87.1±9.9 t ha–1. Seventeen profiles of Cambic Phaeozems have average SOC stocks of 68.2±10.4 t ha–1, whereas values in two profiles of Eutric Cambisols and Fluvisols are 52.1±2.6 and 75.5±3.1 t ha–1, respectively. An average value from 42 soil profiles is 78.1±16.3 t ha–1, in a range between 50.2–110.6 t ha–1. SOC stocks range extracted from Soilgrids is between 65–72 t ha–1, with an average value of 67.0 t ha–1. Values in Chernozems and Leptic Phaeozems are for 30–35% higher than modeled. Around 15% difference was found between measured and estimated average values, and SOC stocks modeling in this area might be prone to errors due to the effects of landscape position, parent material, and land use.

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Challenging the exploitation of Lunar and Martian regolith simulants as plant growth media

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Space farming based on in situ resource exploitation is a promising strategy for food production on extra-terrestrial habitats, as it can allow water recycling, organic waste composting, and oxygen production or CO2 consumption. Using the local regolith as “soil” for plant growth would be a viable way to grow food, even though “extra-terrestrial soil” is very different from vital and fertile “terrestrial soil”. Since Lunar and Martian regolith are not available on Earth, space research studies are commonly carried out on regolith simulants, which tend to replicate the physical and chemical properties of extra-terrestrial regoliths, assessed during the past manned missions to Moon or by rover and robotic spacecrafts landed on Mars. This work intends to provide a brief overview of the physicochemical properties and mineralogical composition of Lunar and Martian regolith simulants, currently produced and available on the market. Then, it aims to describe possible strategies and sustainable practices for creating regolith simulants akin to terrestrial soil, including amendment with composted organic wastes, which can turn nutrient-poor and alkaline crashed rocks into efficient life-sustaining substrates equipped with enhanced physical, hydraulic, and chemical properties. In this regard, we present main results from our recent scientific works focusing on exploitation of regolith simulant-based substrates as plant growth media and carried out within the Italian Space Agency project "In-situ REsource Bio-Utilization for life Support system" (ReBUS). Discussion will identify the main critical aspects and future challenges related to the in situ agricultural use of Lunar and Martian soil.
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Identifying Genes and Traits for Tolerance to Marginal Soils in Ancient Barley Landraces: Supporting Emerging Value Chains

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Micronutrient deficiency in cereals severely reduces yield and quality in marginal soils on a global scale. Ancient landraces represent a unique reservoir of genes and traits, selected over millennia, for adaptation to marginal soils. As part of a range of interdisciplinary studies bringing together soil science, plant physiology, genetics and value chain assessment, we screened extant Scottish barley (Hordeum vulgare) landraces (Bere) for their ability to cope with manganese (Mn) deficiency in hydroponics, mesocosms and field trials. Genetically the Scottish landraces were found to cluster according to their island of origin, and those adapted to soils with reduced fertility, had larger manganese (Mn), but also zinc (Zn) and copper (Cu) concentrations in the shoot. Strikingly, when grown in marginal soils in Orkney, these adapted landraces demonstrated an exceptional ability to translocate Mn to leaves, maintain photosynthesis and generate robust yield, while modern elite varieties failed to complete their lifecycle. We will present the latest results of research attempting to unravel the molecular and physiological mechanisms involved in this unique tolerance and how this information on sustainability, along with information on barley landrace heritage, is being used as a foundation supporting the evolving value chain surrounding Bere barley. This work demonstrates that ancient Scottish landraces contain untapped genetic diversity which could underpin future agricultural sustainability and support novel products for high value markets.

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P-137

Reducing cadmium transfer from soil to cacao (Theobroma cacao, L.) crop: evaluation of soil treatments in different field conditions

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Cacao (Theobroma cacao, L.) beans (seeds) are the mainstay in the production of chocolate. Elevated cadmium (Cd) levels in chocolate have raised concerns thus several regulatory agencies have imposed maximum limits in consumed produces. Cadmium is directly linked to cacao beans. The cacao plant accumulates Cd in aboveground tissue and is affected by Cd concentration in soils and key soil properties i.e., soil pH and organic matter. To ameliorate Cd uptake in cacao plantations, these properties must be modified. A set of treatments were applied in contrasting edaphic-climatic conditions, e.g. acid, neutral and alkaline soil pH. Treatments consisted in the application of agricultural lime, gypsum, compost and biochar. Soil and plant samples were collected systematically to assess the treatment effects. All soil properties were successfully modified after one year of application. Soil pH was increased ($p < 0.05$) when lime was applied at 4.8 kg plant-1 in all farms whereas soil organic matter (SOM) was 2-fold higher when compost was applied at 50 Mg ha-1, compared to control. Both treatments significantly reduced ($p < 0.05$) phytoavailable soil Cd. On average, tissue Cd (leaves or beans) was reduced up to 50% as compared to control. Contradictory, this difference was not statistically significant ($p > 0.05$) due mainly to high natural variation among blocks (Coefficient of variation > 40% among blocks). Lime and compost were effective in altering soil properties and reducing phytoavailable soil Cd but no plant Cd. Longer evaluation time is needed to determine which amendment/rate would lower plant Cd.
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Construction of functional and fertile Technosols from materials, waste and by-products for use in biointensive micro-gardening

Ms Pénélope Cheval

Soil is a limited resource subject to multiple pressures. Soil degradation sometimes leads to the loss of its functions, which is an irreversible process on a lifetime scale. The area covered by fertile soil decreases as it is exposed to anthropogenic activities. To meet the demand for the reconnection to food production in cities, it appears interesting to conceive functional Technosols using materials, waste, and by-products instead of extracting and transporting natural fertile soils. Technosols are soils with at least 20% of artifacts, a geomembrane or a technic hard rock. In the present work, two Technosols were designed and tested in a greenhouse experiment for a bio-intensive micro-gardening use. Their conception was based on the physico-chemical characteristics of soils known for their high agronomic potential for vegetable growing, as well as on the selection of available materials whose characteristics met the expectations.
For one year, three aspects were studied to assess the ability of Technosols to support the production of food biomass. These include the pedological component by measuring the physico-chemical parameters of the Technosols; the biological component comprising several bio-indicator organisms of the soil fauna as well as ecophysiological indicators of the crops (photosynthetic and nitrogenous status) and their development; and the ecological engineering component by studying the ability of an ecosystem engineers to improve the fertility of the Technosols.
After a few months, some pedogenetic processes were initiated and the indicators selected to evaluate the fertility of the constructed Technosols showed a good potential to support vegetable crops.

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Policy development for soil conservation: a case-study of CAP Agri-environmental-climate payment supporting No Till adoption in Italy.

Dr Luana Circelli, Dr. Danilo Marandola

Soil restoration and conservation fall within the main environmental objectives of the Common agricultural policy (CAP). According to the new EU Soil Strategy for 2030, the 2023-2027 reform must enhance CAP's contribution to maintaining and enhancing soil health in EU. This is to be achieved by adopting ambitious CAP national strategic plans containing targeted interventions under the green architecture. Among these, a major role towards the conservation of agricultural soil can be played by the Agri-environmental-climate (AEC) interventions that can be adopted in the frame of the EU Rural Development Programme (RDP) supported by the European agricultural fund for rural development (EAFRD). These are payments granted to support farmers for the economic disadvantages due to the adoption of voluntary farming practices that are considered beneficial for the soil.

In view to help policy development for soil conservation in the forthcoming CAP reform, this contribution aims to present and analyze the case study of an AEC measure aiming at promoting the adoption of Conservation agriculture (CA) practices such as No Tillage. The proposed AEC has been implemented in the 2014-2020 period in the frame of the RDP of Apulia region, a drought-prone area of southern Italy affected by severe problems of desertification.

The contribution provides an overview of AEC measure concerned, together with a description of results in terms of farmers' participation and distribution in the region. Finally, preliminary results of a qualitative analysis on farmers' perceptions on factors hampering CA adoption in that region are also presented.

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Overview and expert evaluation of European guidelines and best practice examples of soil protection in road construction

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Road construction has significant negative impacts on soils through land consumption, soil sealing and soil compaction. Therefore, soil protection measures are of high relevance for road construction projects. They are addressed in the RoadSoil project, which is an international collaboration of the research institutes of NIBIO in Norway, SLU in Sweden and WSL in Switzerland, funded by the Conference of European Directors of Roads CEDR. As part of this project we investigated regulations, guidelines and best practice examples to avoid, mitigate and compensate for the negative impacts on soils in the planning and construction phase of road construction projects in selected European countries. We compared the availability and strategy of regulations and guidelines in the different countries. Experts from the fields of soil sciences and road construction evaluated the best practice examples according to their feasibility and effectiveness. Our results show that many basic principles on soil protection are already known, but that there is a lack of proper implementation. The availability of documents differed from countries which mainly refer to publications of the EU and others that provide their own national and regional regulations and guidelines. A good example to ensure correct implementation of soil protection measures is the introduction of specially trained experts in Switzerland, known as "soil protection experts for construction supervision". The findings of the RoadSoil project will contribute to contemporary guidelines and decision support tools for future road construction projects in Europe.

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Beyond climate change mitigation: The hidden economic co-benefits of soil carbon sequestration

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Soil delivers multiple benefits to society through the provision of ecosystem services, and many are directly consumed by economic agents (people and businesses). Many studies have valued ecosystem services identifiable with soils as a whole, yet there are no published valuations for the service flows from specific components of soil, such as soil carbon, despite it regularly being cited as the primary indicator for soil health. We applied economic tools to approach this challenge and overcome significant data limitations. We used a Total Economic Value (TEV) approach, commonly used in the valuation of ecosystem services and widely accepted in a policy-making context to calculate financial benefit of soil carbon to ecosystem services. We supplemented a literature-based Benefits Transfer approach with a stakeholder elicitation to gain ranked information on the contribution of soil carbon to ecosystem services. Using these rankings, values were applied to each ecosystem service based on the TEV valuation and a price applied to soil carbon based on the ecosystem service directly derived from it. For every £1 of climate regulation benefit derived by society from the sequestration of carbon in soils, an additional £86 of co-benefits are derived from other soil ecosystem services. Based on the areas of soil and land use combinations, the total ecosystem service value derived from soil carbon in England and Wales, adjusted for C stock, was £50.8 billion (0-30 cm) and £59.7 billion (0-100cm).

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Reducing Bioavailability of Lead in Urban Residential Neighborhood Soils

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Research is lacking in the quantification of bioaccessibility and health risk reductions, especially for urban soils. The targeted community health study designed to measure the effectiveness of in situ stabilization treatments at reducing lead bioaccessibility in urban soils has begun recently. Study objectives include: 1) identify improved, cost-effective protocols to manage commonly elevated urban soil lead; 2) determine efficacy of mitigation; and, 3) build community capacity to target these protocols where they are most needed to prevent childhood lead poisoning. Partners include City of Kansas City, Missouri; U.S. Environmental Protection Agency; and Children's Mercy Hospital. The target population is young children in Kansas City's urban core, where some lead poisoning rates exceed 9x the U.S.A. average. Nearly 50% of parcels tested exceed EPA's play area lead threshold (400 mg kg-1), likely causing intransigent elevated blood lead levels, according to the Kansas City health department. In situ stabilization using soil amendments (e.g., phosphorus, iron, and exceptional quality biosolids) proven to reduce soil health risk by inducing biogeochemical reactions converting lead to forms with low bioaccessibility are being used. The results from the first part of the study will be discussed. This project anticipates producing verifiable risk reduction data critical to developing affordable strategies to mitigate lead in urban soils, and correlate child blood lead levels data with treated areas to identify potential health protection benefits.

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Physico-chemical soil properties affected by invasive plant colonization in southwest Germany (Rhineland-Palatinate) – A screening study

Jellian Jamin

The invasive plant Impatiens glandulifera, has been introduced to the Europe and is now found especially in riparian environments. Physico-chemical soil properties can be affected by invasive plants in terms of soil quality, carbon turnover dynamics and water retention resulting into a threat to native plant communities like Urtica diocia. To understand the effect of invasive I. glandulifera on soil and additional modulation by growth of the native plant U.dioca, soil samples were collected in the palatine forest near the river Queich, with either no (control) or a high population density of I. glandulifera and U. dioca. Various investigation for soil physico-chemical characteristics, including basic soil parameters (soil texture, pH, EC, CEC) and pore-size distribution, carbon content, organic matter fractions and soil mechanical stability were tested on these samples. The results indicate that I. glandulifera significantly affects most soil parameters different than U. dioca, which mainly results from its different root architectures and growth patterns. The tapered and lignified roots of the annual I. glandulifera ought to modify the soil matrix especially in terms of mechanical stability and soil organic matter content than the fine roots of the perennial growing U. dioca. Interestingly, soil mechanical stability was higher for soil rooted by U. dioca in certain soil depths, linked to the fine, strongly interconnecting root system. All in all, this screening study already indicates that both root systems significantly differ in their effect on the soil system which in turn might affect their own growth and competition dynamics.

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P-144

Metagenomic analysis of soil prokaryotic communities treated with carbon foam amendments

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Soil contamination is a widespread problem that has led to the development of amendments for stabilisation of contaminants and reduction of their bioavailability. While some of those amendments were proven to be effective, they could also have a negative impact on soil microbiota or not be suitable for some types of soils. Carbon foams are novel amendments deemed to be effective at reducing bioavailability of some elemental contaminants in soils. In this study, we applied two types of carbon foams (bare and impregnated with goethite nanoneedles), in an environmentally realistic dose, to a soil severely contaminated with arsenic to investigate their effects on autochthonous prokaryotic communities in a microcosm experiment. Both Automated Ribosomal Intergenic Spacer Analysis and 16S rRNA gene amplicon sequencing were applied. Furthermore, PICRUSt functional metagenomic prediction was performed. Bioavailability of arsenic was also monitored using TCLP method. Results indicated not only significant changes in the mobility of arsenic, but also shifts in the composition of microbial communities, as well as changes in alpha diversity and predicted metabolism depending on the applied amendment. This study emphasises further need to analyse specific interactions and possible cytotoxicity of these new amendments for them to be effectively applied in contaminated soils.

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Phosphorus reference conditions assessment by a survey of old forests sediments, in the lowland region of Belgium

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Elevated phosphate (PO4) concentrations can harm the ecological status in water by eutrophication. In most surface waters in lowland regions, the PO4 levels exceed the environmental limits. Some limits lack a scientific basis, highlighting the need to underpin the current P-limits to align with the European regulations. By surveying pristine areas in Flanders, the surface water reference P concentrations was investigated. Sampling both water and sediment allowed quantifying sediment P release and describing sediment sorption characteristics. This study reports the distribution of P levels in the most pristine surface waters and sediments found in Flanders. Furthermore, the effect of anaerobic conditions on sediment P release was investigated. At last, the relation between sediment P and surface water P was modelled.

Sediment and water from 141 reference locations in old forests were sampled and analysed on their P content. With an incubation trial, the anaerobic P release from those sediments was measured. Finally, a sorption model was applied to predict surface water P levels based on a sediment analysis. The 90th percentile of the reference surface water samples was 211 µg TP L-1, which is 50% larger than the prevailing nutrient limits. For pristine sediment samples, P release was 30% larger in anaerobic compared to aerobic conditions. Thus, the P limits were already exceeded in pristine areas in Flanders, which puts the utility of the limits into question, as they might be unrealistic to attain within a reasonable timeframe.

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Impact of water regimes and soil amendments on solid phase speciation of Arsenic in paddy soil

Mr Supriya Majumder, Dr Pabitra Banik

Water regimes combined with soil amendments were shown to change in the partitioning of Arsenic (As) in different soil fractions relevant to rice cultivation where reducing the risk of rice grain As uptake were taken into account. Field trials were consecutively conducted at the farmer's plot during monsoon and post-monsoon seasons, combining water regimes variation (waterlogged vs aerobic) and soil amendments addition (NPK, organic manure, silicon and iron). Modified sequential extraction procedure showed that aerobic practice significantly decreased the release of As from exchangeable fraction (F1) as compared to waterlogged practice ($p < 0.05$), which may indicate potential environmental benefit for rice consumers. This result was similarly translated into significantly reduced As accumulation in rice grain for monsoon and post-monsoon cultivars under aerobic conditions compared to waterlogged soils. Paddy soils under aerobic conditions retained significantly higher proportion of As in specifically sorbed (F2), amorphous Fe oxides (F3) and crystalline Fe oxides (F4) phase ($p < 0.05$), resulting restricted mobilisation of As in soils. Linear regression models demonstrated that rice grain As concentrations were positively correlated with As concentrations in F1 and negatively correlated with F2, F3 and F4, with satisfactory level of variation being explained ($p < 0.001$). The results conclude that F1, F2, F3, and F4 fractions critically contributed to As bioavailability in rice, and the aerobic practice led to less risk of As availability in soil. Such exhaustive information may be useful to adopting certain management practices for rice grown in As contaminated soil concerning the environmental issues in particular.
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P-147

Environmental and biological specificities of the lowland alluvial soils in Central Serbia

Dr Zaklina Marjanovic, Prof. Dr. Dragan Manojlovic, Dr Elmira Saljikov, MSc Slobodan Stefanovic, Dr Ali Nawaz, Dr Tesfaye Wubet, Dr Gilberto Bragato

Lowlands of Central Serbia are mostly covered by alluvial soils, while the natural vegetation types are various alluvial forests differentiated by the distance from the river bad (dynamics of soil water potential regimes) and gradients of soil structure, nutrient availability and soil pH (Marjanovic et al 2020). These forests have been heavily exploited for timber throughout the human history, but what has remained still represent significant hotspots of above and belowground biodiversity. The rare specificity of these ecosystems is the high diversity of truffles, fungi producing belowground fruiting bodies, among which the most prised white Piedmont truffle holds a special attention (Bragato and Marjanovic, 2016).
In order to describe these special habitats of Balkan Peninsula, we have conducted various experiments, mostly concentrated on soils that support the fructification of this ecologically and economically important species. In this contribution we will summarize results on soil structure, soil water content dynamics, nutrient availability, seasonality of soil processes as well as seasonality of root associated mycobiomes of selected alluvial forests. We focus on connecting the fructification of white truffle to different soil factors (Marjanovic et al 2015), as well as on defining the differentiation factors that have been shaping root associated mycobiomes (Marjanovic et al 2020). The contribution was set to uncover as many soil traits as possible to reveal the answer to the question of what are the ideal conditions of soil/vegetation /climate combination that is suitable for such specific fungal communities.

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P-148

Effects of graphene oxide nanoflakes on biological and chemical properties of a polluted soil

Miss Verónica Peña-Álvarez, Mr Diego Bargaño, Mr Alexander Prosenkov, Mr José Luis Rodríguez Gallego, Miss Ana Isabel Peláez

Graphene oxide (nGOx) is a novel extremely oxidative form of graphene with known capacity to remove metals on water and aquatic environments. However, its effects on soil metals and metalloids have not been well studied yet. Likewise, there are only few studies describing the effect of nGOx on soil microorganisms. To assess the effect of nGOx on biological and chemical properties of a polluted soil several assays were performed. Four microcosms experiments with metal and As contaminated soil were designed (control, addition of nGOx, addition of nutrients, and combined addition of nutrients and nGOx). Metal(oid)s availably and changes on microbial communities were monitored for 90 days. Metal(loid)s leachability was measured by TCLP method and water soluble fraction was determinate by water extraction. Changes on microbial communities were monitored analysing ARISA profiles. Results showed that nGOx was able to mobilize water soluble fraction of As and Zn and immobilize Cu and Hg, meanwhile other metals were not affected.Soil pH and EC were also modified by nGOx. Regarding microbiology, nGOx have a negative effect on microbial diversity 7 days after the addition, although it returned to values similar to those at the beginning of the experiment. However, these effects were mitigated when nutrients were also added. A divergent specialisation was also observed in bacterial communities in the combined treatment of nGOx and nutrients. This study has sought to delve into the unknown mechanism of interaction between nGOx and soil.

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P-149

Station for measuring climate and air quality impacts of northern agriculture

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Agriculture has a huge potential to combat and adapt to climate change, however, changing climate and strong weather variability threaten the capacity of these ecosystems to mitigate climate change. A new SMEAR-station (Station for Measuring Ecosystem-Atmosphere Relations), SMEAR-Agri, is a platform to quantify climate and air quality impacts and mitigation potential of northern agriculture. The station is part of an INAR RI Agriculture network, the first long-term integrated infrastructure network in Finland focusing on agriculture, and it links to the European Strategy Forum on Research Infrastructures (ESFRIs) Analysis and Experimentation on Ecosystems (AnaEE) and Integrated Carbon Observation System (ICOS). SMEAR-Agri substations (Viikki and Haltiala) are built on mineral soils cultivated with grass silage and various crops offering international top-level platform for research activities. The stations provide continuous GHG (H_2O, CO_2, CH_4, N_2O) flux measurements by eddy covariance and chambers, automated soil, vegetation and atmospheric measurements, reactive gas concentrations and fluxes, and aerosols and their precursors. The SMEAR-Agri Viikki station will also be equipped with automated or semi-automated sampling of surface runoff and subsurface drainage water to study aqueous loss of carbon and nutrients. All the measurements are conducted year-round over multiple years to decades. In this presentation, the first GHG flux data is presented as an example of future initiatives. Continuous data will be openly accessible with multiple utilization and co-operation possibilities, and the station will be used for teaching and citizen involvement. The station has open doors for visiting researchers, and can be equipped adequately according to their needs.

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Cold Region Ecosystems under Current and Future Climates: Winter Soil Processes in Transition

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Surface air temperature in high latitude cold regions, including permafrost, is increasing two to six times faster than the global average. Climate models project this rate of warming will continue through the 21st century, with the greatest warming occurring during the fall, winter, and spring (i.e., non-growing season; NGS). Winter processes affect both the hydrology of cold region's catchments (e.g., wetland, peatland, permafrost, agricultural) and the associated biogeochemical functions, including the cycling of carbon and nutrients. Consequently, elucidating how changing winter conditions affect soil biogeochemical processes and fluxes is essential for predicting nutrient availability and impacts on downstream water quality. Identifying the biogeochemical drivers on winter microbial community composition, functions and dynamics is therefore critical to establishing a mechanistic understanding of winter biogeochemical cycles. In this presentation, we present a process-based understanding of processes governing carbon and nutrient transformations in soil of cold climate regions and how soil and water resources will respond to future climate warming. We will present how the soil geochemical activities are influenced by a combination of changes in temperature and oxygen availability and the recurrent development of a physical ice barrier preventing the exchanges during freezing conditions, where the removal of this barrier during thaw conditions increases the rates of carbon and nutrients leaching and production. Our process-based understanding of the winter soil geochemical cycling advances the predictive understanding changes in carbon and nutrient stocks, speciation and fluxes driven by variations in snow cover and freeze-thaw cycles in soils of cold regions during the NGS.

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P-152

Manufactured soils resilience and recovery under extreme weather conditions

Dr Kate Schofield, Dr Naofel Aljafar, Mrs Angela Harrop, Dr George Littlejohn, Professor Mark Fitzsimons

Soil degradation is occurring globally and at a rapid rate. The uptake of more sustainable soil management practices is necessary for our continued reliance on soil functions and services. Alongside a shift towards sustainable management practices, the production of manufactured soils represents a potential means of increasing soil stocks. Manufactured soils comprise a mix of waste materials and recycled displaced soils, providing the opportunity to reduce some of the strain on natural soil stock, whilst contributing towards a strengthened circular economy [1]. They also offer the potential to increase our capacity to sequester carbon by incorporating stable carbon forms such as biochar.

One consequence of climate change is the increasing frequency, magnitude and duration of extreme weather events such as high temperature, drought, flooding and extreme rainfall [2]. For manufactured soils to provide valuable ecosystem functions, they must demonstrate resilience under such conditions.

A manufactured soil was prepared from composted green waste, composted bark, lignite clay and sand, and packed into mesocosms, half were amended with biochar (upper 5 cm at 2 kg/m), and all were planted with an amenity grass seed mix. The impact of flood and drought conditions on the ability of the soil to provide key functions and the potential for biochar to boost resilience and shorten recovery time was assessed in terms of plant health (fluorescence imaging, molecular techniques, and below-ground architecture) and soil biogeochemical properties (nutrient availability, carbon flux, microbial activity and population composition).

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P-153

A citizen-science based investigation of the link between heavy metal contamination and antibiotic resistance in urban soils

Dr Rachel Schwartz-Narbonne, Ms Alecia Hogan, Ms. Sarah Kershaw, Mr Olanrewaju Oladapo, Mr Abdul Haseeb Rahim, Ms. Sheila Torres Sanz, Dr Naomi Holmes, Dr Katherine Rawlinson, Dr Melissa Lacey

Sheffield (UK) has a history of industrial activity dating to the Industrial Revolution. Steelworks and mining have contributed to previous work finding heavy metals contamination in Sheffield urban soils (Weber et al., 2019). Sheffield soils are additionally contaminated by iron-rich ochre from coal mine drainage water (Banks et al., 1997). These inorganic pollutants can cause direct health risks. They can also impact the soil microorganisms, which respond to toxic levels of heavy metals by selecting for heavy metal resistance (Pal et al., 2017). This co-selects for resistance to antibiotics, potentially leading to increased antibiotic resistance in soil bacteria. We co-designed a citizen-science based research project with secondary school teachers and students, collecting and measuring Yorkshire-area soils for total heavy metals, bioavailable heavy metals, and antibiotic resistance in the soil bacteria. Sites contaminated with coal mine water had higher total levels of some heavy metals (iron and manganese) than background sites. However, they had similar levels of antibiotic resistance, suggesting the bioavailability of these metals limited in their impact on the ecosystem.

This interdisciplinary project helped link the history of the region to the ecology of the microbes and the health of the people living there, highlighting the importance of environmental science to lived experiences. Additionally, it enabled school students to see their progression, as scientists, from primary school, through secondary school and into higher education, with undergraduate researchers leading the project within the schools, helping to promote equality, diversity and inclusion within scientific research.

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P-154

The economic and soil sustainability evidence for the valorisation of cocoa pod husk (CPH) in Indonesia

Prof. Liz Shaw, Dr Geoff Warren, Dr Fiorella Picchioni, Dr Smilja Lambert, Prof. Kelvin Balcombe, Dr Steve Robinson, Prof. Chittur Srinivasan, Prof. Dimitris Charalampopoulos

Cocoa pod husks (CPH), generated when beans are removed from pods at harvest, are often recycled on farm as fertilizer, forming part of the internal cycle of nutrients that maintains soil fertility in agroforests. However, CPH is potentially a valuable feedstock for innovative production of healthier food ingredients. This offers the possibility for additional income for smallholder farmers seeking to diversify through sale of CPH to the food industry. Yet, the contribution that CPH makes to soil fertility maintenance is uncertain, as are the costs to the farmer for modification of production processes to supply CPH for new uses. Using case study in Sulawesi, we assessed the: (i) impacts of off-farm removal of CPH on soil properties and nutrient budgets; (ii) financial feasibility of innovative processes directed to CPH.

Through nutrient budget analysis, we conclude that CPH removal would reduce the external balances for C and N by 15.6 and 19.6%, respectively, leading to depletion of SOM in the long-term. The amounts of K, Zn and Cu recycled annually via CPH greatly exceeded the soil available stocks and CPH removal could increase requirements for K fertilizer in particular. Discrete choice experiments suggested that a high proportion of farmers require levels of compensation to collect or process CPH that may challenge economic feasibility of CPH use in the food industry. Additional income from the sale of by-products, such as CPH, is desirable for smallholder farmers, but is offset by both labour costs and potential impacts on the sustainability of soil fertility.

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P-155

Investigation of factors influencing the sorption behaviour of PhACs in soil

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The study was conducted on the sorption of nine Pharmaceutically Active Compounds (PhACs) on goethite and five soils that are formed under different redox conditions: an Arenosol with fully aerobic conditions, two Gleysol samples with suboxic and anoxic conditions and two Histosols with mostly anoxic conditions. The objectives of the study were to investigate how (i) the soil properties, (ii) the quality of soil organic matter and (iii) the physico-chemical properties of the pharmaceuticals modify the adsorption of the PhAC molecules. The soils were characterized on the basis of total organic carbon (TOC), specific surface area (SSA) and the Fourier transform infrared spectra of the humic acid and humin fractions (the soil remaining after alkali extraction) of the soil. The sorption of PhACs was described using Freundlich, Langmuir and Dubinin-Radushkevich models and the relationship between the chemical structures of the compounds and the parameters of the adsorption was evaluated using redundancy analysis (RDA). Due to different composition and structures of the soils, various mechanisms and intermolecular interactions are involved in the sorption processes. The main controlling factor for ionic compounds, such as diclofenac sodium, tramadol or lidocaine, is the fraction of PhACs present as charged species, revealing the importance of Coulomb forces. Strong correlations were found between the amount of aromatic and phenolic compounds in the organic matter and the sorption of hydropobic molecules, indicating that π-π interaction and H-bonding are the dominant sorption mechanisms.

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P-156

Sorption processes of Fluoroquinolone antibiotics on long and short term soil organic carbon pools

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Antibiotics are chemical compounds that are designed to inhibit certain mechanisms of a specified bacteria, and widely used for the treatment of several bacterial infections in humans and animals. Due to their mechanism of action, antibiotics released into the environment with domestic and industrial wastewater have a strong impact on microbiological activity. In soil systems the microbiological degradation of organic matter is the main force of the carbon cycle, hence antibiotic pollution can have a particularly large (indirect) impact on soil CO_2 emissions. Soil organic matter is not a homogenous system, it can be divided into different fractions by their residence time. The fraction to which antibiotics adsorbs better, will affect the short- or long-term release of soil CO_2. The adsorption of three fluoroquinolone antibiotics (ciprofloxacin, norfloxacin, ofloxacin) were studied by batch and kinetic experiments on three Luvisol samples with different land use (arable, grassland, forest). The SOM fractionation was based on the Zimmermann procedure, and the batch and kinetic experiments have also been carried out on the fractions. The soil fractions were analysed by TOC, XRD, XRF, BET, FTIR during the adsorption. Langmuir and Freundlich models were applied on the equilibrium data. The kinetics data were analysed by pseudo first and second order kinetics models. This study investigated whether long-term or short-term carbon storage systems are more affected by antibiotic contamination of soils.

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P-157

Can soil mineralogy predict radiocaesium bioavailability?

Miss Margot Vanheukelom

Following the Chernobyl accident, mathematical models have been developed to predict soil-to-plant transfer of radiocaesium (^{137}Cs) from readily available parameters such as soil clay content and exchangeable potassium. However, most existing ^{137}Cs transfer models perform poorly on a worldwide scale partially because they use clay with average properties, disregarding the clay mineralogy. We hypothesise that prediction of ^{137}Cs soil-to-plant transfer can be improved by including soil mineralogy in soil-plant transfer models. We conducted a ryegrass pot experiment on eighteen different soils sampled globally from nine soil classes. Soils were artificially contaminated with ^{137}Cs. Soil clay mineralogy was quantified using X-ray diffraction. The radiocaesium interception potential (RIP), which quantifies ^{137}Cs retention in soil varied two orders of magnitude among soils and, more importantly, three orders of magnitude when expressed per unit clay in soil. The soil RIP is positively related to the 2:1 type clay mineral fraction (R^2 = 0.81, N = 14). This study suggests that clay mineralogy may improve the predictions of the soil-plant transfer of ^{137}Cs beyond models that use mean clay properties. The soil-plant relationships will be presented at the conference.

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P-158

Landscapes under Climate Change - Influence of management and climate change on interactions of terrestrial and aquatic ecosystems

Prof. Dr. Jörg Völkel, Dr. Sigrid van Grinsven, Dr. Michael Dannenmann, Prof. Dr. Jürgen Geist, Prof. Dr. Ingrid Kögel-Knabner, Prof. Dr. Michael Schloter

Climate change influences the (nutrient) matter balance in the near subsurface, and therefore the interaction patterns between terrestrial and aquatic ecosystems. In this study, we quantify these changes in relation to different landuse, focusing ecological and economic functions and ecosystem services. C, N, P compounds play a prominent role in the search for mitigation and adaptation strategies. Changes in the metabolic balance of soils and soil-borne sediments are closely linked to changes in the microbiome. The complex interaction patterns in the near subsurface (critical zone) of terrestrial ecosystems are directly linked to aquatic ecosystems via substance inputs to water bodies, whose biodiversity is particularly at risk. In cultural landscapes, the form of land use is of utmost importance, especially grassland and its management. In search of suitable mitigation strategies, the project investigates these changes in the sink and source function of the C, N, P reservoirs along a climatic gradient in the Bavarian Forest from the montane to the colline stage within the same natural unit. Quasi-natural grassland sites without current and previous soil management form the reference conditions. They are contrasted with long-term intensively used sites. The interactions between landscape and climate will be illuminated and management strategies will be developed with the aim of maintaining soil functions under climate change conditions and reducing undesirable inputs from terrestrial to aquatic systems. In addition to cultural landscape genesis, the structure of the near-surface subsurface with material stocks, layer structure, weathering phenomena, pedogenesis and slope water flow is of fundamental importance.

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P-159

When the going gets tough – Enabling geoarchaeological soil phosphorus prospection for use in heterogeneous environments with multiple occupation phases

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Since the 1930s, geoarchaeologists have used soil phosphorus (P) contents to draw conclusions about past land use. Such geoarchaeological soil P prospection can provide information that is inaccessible to observation. Therefore, soil P is a valuable data layer in geoarchaeological research. The method is relatively straightforward in homogeneous study areas, but there are no systematic strategies for heterogeneous environments characterized by different bedrocks/substrata, vegetation, surface morphology, land use. This is a challenge when studying some site classes (e.g., large settlements) and in some areas (e.g., the German Middle Mountain Range) where P-relevant factors can change significantly over short distances. In this talk, I propose a strategy for the systematic evaluation of a soil P prospection in a heterogeneous study area, exemplified by the case study of the Iron Age hillfort on the Altenburg (near Niedenstein) in Hesse, Germany. Using the newly developed methodology, we were able to show that this settlement was originally 80 ha larger than previously thought. Because the site was occupied twice (during the Neolithic and Iron Age), we also developed a strategy to distinguish multiple occupation layers in soils, which has long been a limitation of soil P prospection. Using this method, we found out that the Neolithic settlement was scattered as individual patches across the study area, but encompassed larger area than previously thought.
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Phthalate pollution and migration in soil-air-vegetable systems in typical plastic agricultural greenhouses in China

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Plastic greenhouse (PG) agricultural production systems are important to satisfy daily food consumption nowadays. Phthalate pollution in PGs has aroused concerns. However, the mechanism and impact factors of phthalate migration and accumulation between soil-air-vegetables are unclear in the production system. To fill the gap, 19 typical PGs in northwestern China were selected to explore this issue. 35 soil, 48 air, and 26 vegetable samples were collected, and 7 types of phthalates were measured using GC-MSMS. $\sum_7$PAE concentrations in PG environmental media in winter were higher than summer. Sum concentrations of DEHP and DnBP accounted for 76.8% and 82.3% of the $\sum_7$ PAEs in soil and VPGs. DnBP and DEHP concentrations in VPGs were significantly correlated to those in air and soil, with correlation coefficients (R) of 0.89 and 0.96 to air and 0.68 and 0.59 to soil. Log-transformed soil-air partition coefficient (log KSA) and fugacity fraction (log ff) of DnBP decreased while log KSA and log ff of DEHP increased from winter to summer, though DnBP in soil volatilized to air while DEHP in air sank to soil within the year. The reasons have been discussed. Furthermore, DnBP concentrations in VPGs were positively correlated to KSA values of DnBP (R = 0.87) while those of DEHP were negative (R = -0.82). Therefore, VPGs could uptake more phthalates from air than from soil, especially for edible parts of leafy and fruiting vegetables. Applying phthalates free agricultural films and precision management in PGs could be considered to ensure the vegetable safety.

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P-161

The common mycorrhizal network originated from Urochloa brizantha suppresses the growth of native tree seedlings in southern Brazil.

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The common mycorrhizal network (CMN) interconnects plant roots, promoting nutrient and water exchange, in addition to working as a way of competition. The aim of this study was to evaluate the influence of CMN originated from the adult invasive grass Urochloa brizantha on the development of native tree seedlings Heliocarpus popayanensis (early-successional) and Cariniana estrellensis (late-successional). The plants were grown in high fertility soil in the presence of native arbuscular mycorrhizal fungi propagules. Four treatments were performed: 1) H. popayanensis and C. estrellensis seedlings grown under the influence of CMN for 225 days; 2) After 90 and 270 days of CMN influence, U. brizantha was pruned; 3) After 90 days of CMN influence, CMN was weekly severed; 4) Control treatment with ten seedlings of each species grown isolated without contact with CMN. The main results showed that the CMN originated from the adult invasive grass U. brizantha suppressed the growth of native tree seedlings. The severed CMN eliminated suppressive effects completely, while the pruning of U. brizantha adult reduced negative effects on the seedlings, however due to regrowth, suppression returned. Seedlings of H. popayanensis connected to CMN died, while the C. estrellensis survived, although totally suppressed. It is possible that the reciprocal reward mechanism, acting in the CMN, was responsible for directing the flow of mineral nutrients to the adult U. brizantha, which contributes with a greater amount of carbon to the network, resulting in suppression of tree seedlings growth.

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P-162

Mass balances of carbon and nutrients in the treatment of biowaste by methanogenic anaerobic digestion, composting and fermentation

M Sc. Vania Scarlet Chavez Rico, Dr. Paul Bodelier, Dr. Ir. Miriam van Eekert, Dr. Ir. Valentina Sechi, Dr. Ir. Adrie Veeken, Prof. Dr. Ir. Cees Buisman

Preserving carbon content while increasing its quality during the production of organic amendments (OAs) might be key to maximizing stable-soil-organic matter (SSOM) and reducing GHG emissions. During composting ~50-67% of C and ~20-77% of N of the initial substrate (IS) are lost to the environment. Contrarily, unwanted losses are minimal during digestate and Bokashi-like ferments production. These technologies offer different redox and pH environments that influence the final availability of C, N, and P which subsequently could increase microbial-biomass formation enhancing SSOM. We aimed to assess the influence of technologies on C preservation and OAs quality after production. Using mass balances over C, N, and P during composting (COM), methanogenic anaerobic digestion (AD), and lactic-acid fermentation (LAF), we compared the chemical changes of end-products. A biowaste-resembling model substrate was used to produce the mentioned OAs under laboratory conditions. Results showed that LAF and AD preserved better C, N, and P content than COM (LAF:99%, AD:64%, COM:25% of C of dry-IS; AD:100%, LAF:93%, COM:38% of N; AD:100%, LAF:90%, COM:68% of P). AD had the highest concentrations of C, N, and P in the water-soluble phase, making them more easily available for microorganisms. LAF had one order of magnitude lower concentrations while COM reported the lowest. Our results show that under reducing conditions (AD and LAF) unwanted losses of C, N, P can be decreased while increasing OAs quality in terms of sources for soil-microbial development demonstrating the potential of this approach to get information to improve OAs quality and resource management.
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P-163

Comparison of the effect of compost and Bokashi-like ferment on soil carbon pools and soil aggregates

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Recent studies on soil organic matter (SOM) stabilization show that high-quality organic amendments (OAs), should improve microbial-substrate-use efficiency and build-up of microbial biomass. Compost has abundant biochemically recalcitrant compounds that are energetically expensive to use for microbial biomass formation. In contrast, products of fermentation preserve better readily available nutrients providing resources for microbial growth. Yet, more insights are needed to assess the effect of these OAs on the C pools influenced by microbial activity. In our study, we compared the effects of compost and Bokashi-like ferments (from acid-lactic fermentation), made from both road-grass and model-bio-waste, on soil carbon pools and aggregates after 3 months of incubation in a lysimeter. A model soil without aggregates and low C content was used to amplify the effect of OAs. The treatments were: road-grass-based fermented product (GF) and compost (GC), bio-waste-based fermented product (BF), and compost (BC), and control without OA (C). The results showed that all OAs increased aggregate size and carbon content despite the priming effect. BC showed the best aggregation (3.3% w/w large macroaggregates >2 mm) followed by GC with 2.8% w/w. Furthermore, BF and BC reported the highest C content in soils which were stored inside <2 mm fraction of aggregates. BF and GF induced higher microbial activity and had the highest fractions of free-POM. Our work demonstrated that initial substrate composition and the technology used in the production of OAs can independently influence soil aggregation characteristics and the carbon fate into different soil carbon pools.

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P-164

Explore the transformation of chromium species on ferrihydrite in an oxidation flow reactor

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High chromium (Cr) concentration in the soil is primly due to anthropogenic sources. Ferrihydrite, a widespread and abundant mineral, can uptake Cr in the environment. When Cr is adsorbed on ferrihydrite and exposed to the air, undergoing atmospheric oxidations could lead to the transformation of Cr species, and even the formation of hexavalent chromium Cr(VI), a well-known carcinogen to humans. In this study, an oxidation flow reactor (OFR) is used to explore the transformation of Cr species in air and nitrogen conditions. The mercury lamps emitting 185/254nm generate hydroxyl radicals (·OH) by the photolysis of ozone and water, and it can simulate days to weeks oxidation environment within minutes in an OFR. Under ·OH exposure, Cr(III) is oxidized to Cr(VI) both in air and nitrogen conditions, and the Cr(VI) formation is higher in the air. Ozone and water are the major sources of ·OH in the air, however, the UV light seems to activate Fe species and generate ·OH, which interacts with Cr(III) and leads to the formation of Cr(VI) in nitrogen condition. We still need more studies to understand the transformation mechanisms of Cr on ferrihydrite. If the oxidation of Cr is taking place in a real atmospheric environment, it will increase the concern of air pollution and human health. This research may help further studies on air pollution, especially the oxidation mechanisms of heavy metals in the atmosphere.

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P-165

The contribution of atmospheric cadmium deposition on the soil-rice (Oryza sativa L.) system near a large copper smelter

Ruizhi Xia

Identification and quantification of the sources of heavy metals in soils and crops are critical important for reduction of regional environmental risks. Atmospheric deposition was the major source of soil trace metals near a large copper smelter in Eastern China. However, knowledge about bioavailability and fate of the newly deposited Cd in the soil/atmosphere-plant system is limited. We performed a fully factorial soil and atmospheric exposure experiment using customized chambers in this field to distinguish the impacts of the new wet and dry deposited Cd on the soil and crop Cd accumulation. Our experiment can effectively distinguish the newly atmospheric wet and dry deposited Cd accumulation in rice through soil and foliar exposure. Results showed that foliar uptake was an important pathways of Cd accumulation in rice plant, which can take up atmospheric Cd and then translocate within rice plant to other tissues, and the foliar uptake and translocation were higher than those of root under the same exposure amount. Foliar Cd uptake contributed 52-55% of Cd in brown rice, while the contribution rate by root exposure was 31-47%. The cadmium isotope composition in soil, atmospheric deposition and plant also verified our observations, showing that large potential to apply Cd isotopes as a new geochemical tool to distinguish and quantify the contribution from atmospheric wet and dry deposition via root and foliar Cd uptake. These findings highlight a preferential uptake of bioaccumulation of newly deposited Cd in rice and suggest a high potential of environmental risks under high atmospheric deposition.

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P-166

Soil-plant-water system changes due to soil redistribution processes in vineyards

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This study aimed to do a complex examination of the soil–plant–water system at vineyard sites (Vitis vinifera) with no-tillage (NT) and with annual tillage soil management between rows. The NT site has grass strips present, while the T site had no vegetation in 2020 and cover crops in 2021 sowed between rows. The sites are located on 8% slopes, where soil moisture and spectral reflectance sensor sets are placed at the upper and lower parts of the slopes. During two consecutive vegetation periods we investigated the changes in (i) grapevine response to soil physical and chemical parameters and plant growth using spectral reflectance sensors, (ii) soil water and temperature at different depths, and (iii) analyzed the soil water, soil chemistry, and plant interactions. T treatment showed 17% higher overall soil moisture and 4% higher soil temperature values compared to NT. Catch crops resulted in an accelerated soil moisture deficit during a 2-month long drought event in 2021. Higher soil moistures corresponded to a denser plant biomass production. The slope position greatly influenced plant growth and the soil chemical and hydrological properties. The most notable difference in the NDVI values was observed for NT, where the plants at the top of the slope showed much lower NDVI values compared to the ones at the bottom of the slope. The differences in the PRI values suggest that plants at the bottom of the slope have either better nutrient usage or less stress under drought conditions.
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Effects of Mixed Fermented Organic Fertilizer on Yield of Chinese Cabbage and the Soil Properties

Nan-Hee An, Sang-Min Lee, Cho-Rong Lee, Hyun-Young Hwang

In organic agriculture in which chemical fertilizers are not used, it is essential to provide organically sourced nutrients, such as livestock manure compost, organic fertilizer, or organic matter accumulated in the soil. This study analyses the effects of mixed fermented organic fertilizer (FA and FB) on chinese cabbage growth and soil properties in order to investigate the nutritional effects of organic fertilizers Results revealed that the growth and yield of chinese cabbage increased as more fermented organic fertilizer was used. However, while there were no significant differences in growth characteristics between treatments of 100% rate of mixed fermented organic fertilizer and 100% rate of MEC, the impacts on yields resulted similar. The nitrogen use efficiency (NUE) of Chinese cabbage was measured a range of 20-31% depending on the response to treatment. Regarding soil properties after cultivation, there were no significant differences among the effects of fertilizers in pH, EC, soil organic matter, and available phosphate. However, the content of exchangeable cations was higher in areas treated with mixed fermented organic fertilizer than in untreated areas. Furthermore, the bacterial population density in the soil was higher in areas treated with mixed fermented organic fertilizer than in untreated areas and increased as more mixed fermented organic fertilizer was used. These results also show that FA, as an alternative organic fertilizer for imported castor oil cake, has similar nutritional effects as that of MEC. Therefore, further research the appropriate amounts of fertilizer is required to achieve economical and eco-friendly nutrient management.
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P-168

Linking root traits and N2O emissions from grassland soils

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Grasslands, as one of the main global ecosystems, are under pressure by global changes and anthropogenic activities due to the increased demand for food production, and to deliver concomitant ecosystem services via sustainable management intensification. These ecosystems have been a source of greenhouse gas emissions especially nitrous oxide (N2O), a potent ozone-depleting gas. It is, therefore, crucial to identify ways to mitigate N2O emissions from intensive grasslands without compromising high-quality food supply. Studies have shown that specific plant species combinations with high trait dissimilarity were particularly effective at reducing N2O emissions, and the effect of individual species could be linked to specific traits related to the plant's nutrient acquisition strategy. We explored spatial root complementarity effects on N2O production-consumption throughout the soil profile and on plant N retention dynamics in two grasses, two legumes, and two forbs, and a six-species mixture. We measured soil N2O concentrations at depth using a unique diffusion probe that can be installed near flux sampling points at depth (5, 10, 20, and 30 cm) with minimum disturbance of the soil profile. Soil samples were taken weekly for soil biogeochemical analyses, leaf samples were taken at the beginning and at the end of the experiment to measure leaf traits, and roots were collected at the end of the experiment to measure root biomass and traits at two different depths. The results are still being analysed, but the preliminary results already show differences in N2O in the profile.

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P-169

Integrating the use of bio-organic amendments in salinity stress amelioration: A sustainable way of reclaiming salt-affected soils

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Salinity remains a global impediment to the attainment of food security and requires continuous attention from all stakeholders including, scientists, extension agents, policy makers and farmers. Given that salinity negatively impacts the productivity of soils by reducing its capability for food production, agricultural inputs that could reverse such negativity are required in ameliorating salt–affected soils (SAS). Bio-organic amendments which connote the integrated use of beneficial microorganisms (BM), and organic materials have a great potential in mitigating salinity stress effects on food production. Through improved soil properties, such as soil structure, permeability, root proliferation, nutrient availability, organic matter and biodiversity, bio-organic amendments application increases crops' tolerance to salinity stress. While organic materials act as substrate and food source for the growth of microbes in the rhizosphere, microbes (e.g., Trichoderma), in turn, breakdown organic materials (e.g., compost) into nutrients and organic compounds which improve soil properties. Salinity tolerance aided by BM is also enhanced by the production of metabolites, such as hormones and organic solutes like glycine betaine, and regulation of Na+ transporter genes. Bio-organic amendments improve soil processes such as nutrient cycling, hydraulic conductivity, respiration, organic matter turnover and microbial diversity. The use of bio-organic amendments on SAS has the potential to reduce soil salinity and increase carbon sequestration, thereby, improving soil fertility and mitigating global climate changes. It is suggested that the holistic deployment of bio-organic amendments could help in maintaining and improving the ecosystem functions of SAS and reduce the negative impacts of SAS on agricultural productivity.

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P-171

Evidence review of the use of vigorous rooting green crops to rectify soil structural damage

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Vigorous rooting green crops (cover and catch crops, green manures, and short-term herbal leys) are often promoted as a strategy to improve soil structure. However, evidence for this approach is unclear and there is a lack of guidance on the most appropriate crop species and how crops should be managed for optimal soil benefit.
This review summarises evidence of the ability of different green crops to remediate soil structural damage, focusing on recent studies (published ≥2010) in temperate climate systems which quantify effects on indicators of soil structure (soil bulk density, penetration resistance and visual evaluation of soil structure).
The results highlight the lack of evidence of a clear and consistent effect of vigorous rooting green crops on soil structure. Some evidence suggests that vigorous rooting crops can benefit topsoil structure when integrated into reduced or no till cropping systems for multiple years. However, there is a lack of longer terms studies (>1.5 years) and studies which quantify changes to soil structure at depths >30 cm. Other studies show that tap-rooted species are most suited to improving soil structure in compacted soils, however further evidence is required to determine which species or species mixtures are most effective, the levels and depths of soil compaction that can be remediated and timescales for these changes to occur.
Improved understanding of the benefits and limitations of using vigorous rooting green crops for remediating soil structure is required to guide best practice so that optimal agronomic and environmental benefits may be achieved.

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Effect of soil fertilization on the long-term assessment of Rare Earth-Element contents in red vineyard soils of semi-arid Mediterranean areas

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Nowadays, there is a growing interest in the knowledge of REE concentrations in vineyard soils, since agricultural practices could favour accumulation in soils and plants, which could reach toxic levels.
The research was carried out in red vineyards soils of La Mancha, an extensive wine-growing region in central Spain with a large number of Mediterranean red soils. The aim of this study was evaluating the long-term effect, after repeated fertilizations, the concentration of La, Ce, N, Sc and Y in 83 soil samples and 83 leaves of red vineyard soils were determined by X-ray Fluorescence. The results show that the average contents of these elements are 42.0, 79.5, 37.2, 13.4 and 24.1 mg/kg, respectively. The bioaccumulation coefficient (BAC, plant/soil total concentration of REE ratio) is low; specifically, La 0.07, Ce 0.07, Nd 0.11, Sc 0.27 and Y 0.13, which suggests that vine leaves only take up rare earth elements in small amounts. The content of REEs in the soil, especially Ce and Nd, increases with the levels of phosphate fertilization. Since approximately the 1960s, REEs have been used, (probably without the farmer's knowledge) as REE-based fertilizers into phosphorus fertilizer, in such a way that while improving the quality and yield of vineyards, there has been an enrichment in the soils with REEs.
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P-173

Root decomposition alters soil hydraulic properties

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Increased water infiltration in the presence of vegetation has been reported in the literature for both woody and herbaceous plants (Leung et al. 2018). However, there is a lack of experimental data on channels development after root decomposition, and consequent alteration of soil hydraulic properties.
In this study, individual D. carota plants were grown in columns (50 mm diameter; 315 mm height) with sandy loam soil packed at 1.4 Mg/m^3. Following seven-months of plant-establishment, columns were split in five sections (60 mm each) and saturated hydraulic conductivity (Ks) was tested in each section (i.e., down soil depth). Fallow soil was also tested as the control. Following the Ks tests, all sections were buried in soil and left for decomposition in a controlled environment. After seven months, sections were excavated and tested for Ks and soil water retention curves. Representative samples were CT-imaged.
Saturated hydraulic conductivity after plant establishment did not differ notably from that of control soil. However, an abrupt 25-fold increase of Ks was measured after decay in the vegetated soil (e.g., from 3.1e-6 ± 7.78e-7 to 7.6e-5 ± 2.9e-5). The effect of root decay on Ks decreased with soil depth (e.g., + 7.3e-5 at 3 – 63 mm depth; + 2.2e-6 at 255 – 315 mm depth). Soil water retention curves and CT-images will also be presented to interpret Ks data. Our findings show that it is possible to engineer soil hydraulic conductivity using herbaceous tap-root species. Practical applications will be considered in the context of flood mitigation.

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Understanding the Rhizosheath: Opportunities for Manipulating the Soil Root Interface

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Cereals produce a rhizosheath, a discrete structure at the root-soil interface consisting of soil particles, root hairs, microorganisms and mucilage. The trait was first noted on desert species over 100 years ago and thought to be limited to grass species in the Poales order until recently, when its presence was demonstrated in many orders of flowering plants. Rhizosheath weight can be screened easily and rapidly and has been shown to be related to the ability of plants to tolerate abiotic stresses.
We have demonstrated genotypic variation in rhizosheath in a range of crop species, specifically populations of barley. A range of QTLs and candidate genes associated with rhizosheath formation were identified using a population of elite genotypes. We will present validation in other populations of barley including recombinant chromosome substitution lines and a population of landrace barleys from the highlands and islands of Scotland.
We have also investigated the role of root hair length and mucilage production on rhizosheath formation. We have generated novel insight into the physical conditions at the root soil interface using high resolution synchrotron X-ray tomography. Understanding the biophysical nature of the rhizosheath is the first step to engineering the root soil interface and improving our ability to manipulate the function of the rhizosphere. Breeding cereal genotypes for beneficial rhizosheath characteristics is achievable and we have identified potential to do this in many other crop species. Enhancing this trait could contribute to agricultural sustainability in future environments where nutrient availability and water relations may be compromised.

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Vegetation survey to support digital soil mapping in mountainous grasslands – a case study in the Swiss Jura mountains

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Several Swiss regional administrations are currently working on soil mapping of their territory to acquire information on soil fertility and land use management. The recent change in climatic conditions has led to various problems impacting agricultural practices, especially in mountain areas. Development of an effective method to acquire soil information to evaluate relevant properties like water storage is essential.

Digital soil mapping is a useful tool to increase soil mapping efficiency. However, auger samples are hampered by large rock contents. In addition, the inaccuracy of geological maps means that terrain attributes need to be supplemented with additional information. This work aims therefore to assess the potential of using vegetation as explanatory variables for digital soil mapping in mountainous areas.

We sampled 150 soil descriptions (manual auger), each complemented by a phytosociological survey and a description of the surface use. For each point, soil responses were derived, and we calculated multiple ecological indicators for the whole area. We used the latter together with terrain attributes to predict soil organic matter, texture, and soil depth with random forest.

Analysis of the random forest models showed large variable importance for the vegetation indices compared to the other variables.

We have demonstrated the potential of vegetation surveys to adapt current soil mapping methods to facilitate them in mountainous areas. Although this requires botanical expertise, it reduces laborious soil sampling, allowing to increase mapping efficiency and consequently reducing the costs of soil mapping of landscapes that remain to date relatively poorly observed.

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P-176

NUTRITIONAL STATUS OF BARU (Dipteyx alata VOG.) IN PRODUCTION UNDER AGROFORESTRY SYSTEM MANAGEMENT

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Baru trees (Dipteyx alata) in Agroforestry Systems (SAF) are an alternative for valuing products from the brazilian cerrado biome, and increasing the income of farmers through the commercialization of fresh or processed nuts. This work aims to understand the dynamics of baru production and its leaf nutrientes status in trees under SAF, analyzing four treatments with different light conditions and systems of cultivation. The study was performed in Goiânia, Goiás State, between trees with 15 years old, under an intercropping system, with maize, cover crops and banana for the last 6 years. Four trees areas were chosen: trees in an area without intercropping; intercropped trees; intercropping edge trees under the sun and shaded trees intercropping edge. The variables measured were plant growth between 2019 and 2020, nut yield between 2019 and 2021, leaf essential nutrients (except for Ni and Cl) and chlorophyll content in 2020, both before fruit harvesting. The data statistical procedure used analysis of variance and T test using the AgroEstat software. Height and diameter of trees did not vary between the treatments. Nuts production did not vary statistically but were 60% higher in the intercropped trees than outside and trees with shadow. The most productive treatments were not those with higher nutrient leaf contents. There was a trend of biannuality for nut production. Trees under sun and with intercropping had more chlorophyll than outside intercropping. Baru confirm to be an strategical tree for agroforestry systems mantaining grow, nut production and nutrient levels even with intercropping.
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P-177

DO Eucalyptus globulus LABILL WITH Urochloa spp IN A SILVIPASTORIL SYSTEM AFFECT FORAGE QUALITY AND SOIL FERTILITY?

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Among the silvopastural systems (SS) found in Brazilian Savannah, the most common uses eucalyptus associated with brachiaria (Urochloa spp), where trees probably influences the development of forage. The aim of this work was to generate data about the soil fertility and leaf nutrients of brachiaria of sites cultivated with SS and monoculture. The sampling location was ZUF Florestas, in the municipality of Ipameri, sowtheast of Goias State, in different sites with Eucalyptus forest of 2nd and 3rd year associated with pasture formation of Urochloa brizantha and U. Decumbens. Soil was collected in depths of 0-20 cm and 20-40 cm. Leaves above soil of Urochloa were taken for nutrient analysis from the SS and pasture area. In the 0-20 cm layer when comparing time of sampling (rainy and dry season), exchangeable Al were lower in the rainy season. In the layer 20-40 cm, there were difference in most of soil parameters except pH, P, Mg and K. Native savannah and eucaliptus in monoculture presented the worst chemical parameters, but in the layer 20-40 cm, SS presented low Ca, pH and high H+Al levels. Leaf content of Boron were higher in the rainy period. The leaf levels of N, P, K, Mg and Mn were higher in the silvopastural system. Despite no difference between leaf nutrientes, Urochloa leaves were closer standard leaves for animal nutrition in SS than in monoculture. This SS studied until now were not able to improve soil chemical fertility despite reasonable nutritional leaf levels.

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P-178

Organic fertilization for potassium and nitrogen fertilization of coffee (Coffea arabica L.) in an agroforestry system

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Coffee (Coffea arabica spp.) can be managed in intercropped systems and appears as a possible option for agroforestry systems in the brazilian cerrado. The objective of this research is to reduce N and K fertilization of coffee (Coffea arabica L.) shaded and intercropped with banana (Musa ssp) and baru (Dipteryx alata L.), using organic fertilizer (cattle manure, chicken litter and SAF's own litter). It is expected improvement on soil chemical fertility at the end of the second year of coffee implantation. The experiment was conducted at University of Goiás, Goiânia, Goiás, (16°36'1.42"S and 49°16'47.58"W) with average altitude of 741m. Seven treatments were used, five increasing levels of organic fertilizer using organic compost, one agroflorestry litter and a mineral NPK fertilizer. Height increase of the coffee plants did not differ between treatments for 9 month of measurements. Plants canopy diameter increase were higher with agroflorestry litter and lower levels of organic fertilization. After 8 month of organic fertilizer amendment, soil chemical analisys showed better fertility for treatments with intermediate levels of fertilization except K levels. Side areas out of agroforestry were considerably lower in soil fertility than area under study. Higher levels of organic fertilizer could improve fertility in 10-20 cm soil depth. Leaf macronutrients did not vary between the treatments except for S, much lower in litter and NPK treatments. Chlorophyll level SPAD were similar between NPK and higher levels of orgânica fertilization. All data confirm that organic fertilization and litter were successful in replacing N and K fertilizers.
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P-179

Basalt quarry fines for sugarcane production in tropical soils

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The crushing of rocks produces a relatively fine material that has an uncertain destination and can generate negative socio-environmental impacts. In the soil, weathering of minerals present in these quarry fines can release plant nutrients and other elements, neutralise the soil acidity and increase plant growth, but the time that these processes take and the extent of the changes they cause are unknown and dependent on soil, plant and rock factors. To assess the extent of these changes and their effects on plant growth, we carried out a greenhouse experiment with two tropical soils of different textures (43% and 17% of clay), two sugarcane vari-eties and four doses of basalt fines (0, 10, 25 and 50 tons per hectare). Soils were fertilised with macro and micronutrients and sugarcane was cultivated for 85 days in pots of four cubic decimetres. We used conventional laboratory analyses for soil and plant and gamma spectrometry for soil K, U, and Th. The original values of the soil variables acidity and concentration of Si, K, U and Th of the two soils were not altered by basalt doses and sugarcane varieties. Plant growth was affected by soils and varieties, but not by basalt doses. Leaf Si concentration was significantly affected by the interaction among the three factors, with higher Si concentrations in higher basalt doses in some combinations of factors. Other soil and plant characteristics are being measured to increase our understanding of the potential and possible limitations of using mining residues in agricultural soils.

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Using ecosystem services to ensure the sustainability of the tropical agrosystems and overcome environmental subordination of Amazonian rural communities

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The principal challenge to avoid the unsustainability of the land use in tropical agro-systems is to overcome the harmful association between climate forces, which accelerates the decomposition of soil organic matter (SOM), decreases the content of base cations and increases soil erosion. We hypothesized that, in soil enriched with Ca, the use of biomass from legume trees would increase SOM and the sum of base cations (SBC) to avoid soil degradation. We aimed to evaluate the capacity of the biomass of legume trees to prevent soil degradation and ensure sustainable maize (Zea mays L.) productivity. The experiment was performed using a modified alley cropping system with the following legume trees in four areas: acacia (Acacia mangium), sombrero (Clitoria fairchildiana) (both with low-quality residue), leucaena (Leucaena leucocephala), and gliricidia (Gliricidia sepium) (both with high-quality residue). A fifth area was maintained only with Guinea grass (Megathyrsus maximus), and the sixth area was composed of secondary forest. Our results showed that the use of high-quality biomass of legume trees and gypsum can avoid soil degradation, ensuring sustainable maize grain yield, as the biomass of gliricidia and leucaena increased soil organic carbon (SOC) and SBC even after six years of soil use. Improvements in physical and chemical properties of soil caused by interactions between Ca and high-quality biomass enhanced soil fertility and increased maize grain yield. The spatial association between Ca, SOC, and maize grain yield suggests that gypsum and legume biomass must be part of the strategy to use structurally fragile tropical soils.

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P-181

Linking adsorption desorption characteristics with grain Zn concentrations by teff, wheat and maize in different landscape positions in Ethiopia

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The retention and release potential of soils do affect Zn availability and subsequent uptake by the crop. It is associated with soil parameters that differ along the landscape positions. Therefore, this study aimed at linking this with grain Zn concentrations of crops grown in a toposequence and to identify factors influencing its uptake. Adsorption-desorption characteristics from a previous study were used to estimate the amount of net Zn potentially available for crop uptakes. These were compared with grain Zn concentrations of crops in three different soil applied Zn treatments in on-farm trials. Landscape positions possessing higher soil pH, SOC and high clay content tended to adsorb more Zinc. This affected the net Zinc in the soil available for crop uptake and resulted in lower grain Zn concentrations as compared to landscape positions with lower values. Together, these three factors explained between 37 to 49% of the observed variation in grain Zn concentration. We also found significant correlations of the grain Zn concentration with Cu and Mg in soils and Cu and Ca in the grain, possibly related to the Zn uptake from the soil and its translocation to the grain. In landscape positions where Zn adsorption is high, application to the soil has little effect whereas in positions with low adsorption it is feasible to increase Zn uptake with applications to the soil. Therefore, knowledge of soil properties and crop characteristics can help to determine where basal Zn application can be effective and when foliar applications are the better approach.
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P-182

From Roots to Pollinators: How above- and below-ground organisms interact through plants

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With a growing global population, and increasing concerns around environmental degradation and climate change, we need to find sustainable solutions for food production. While the value of biodiversity to agriculture is being increasingly recognised, such as the role of below-ground organisms to healthy soils, and the contribution of insect pollination to crops. There is increasing recognition that what happens below-ground can have impacts on how plants respond above-ground and vice versa. However, we do not yet fully understand how below-ground soil animal communities might be affecting above-ground pollinator communities by altering floral rewards/traits and how these might be affected by agricultural management such as the use of pesticides in crop protection. This has important implications not only for the maintenance of biodiversity, but also for the healthy functioning of agricultural systems.
The purpose of this research is to investigate how below-ground interactions (soil biodiversity and plant roots) might alter floral traits and in turn affect pollinator behaviour, and how these interactions may be affected by pesticide use. The uses a manipulation experiment to create a soil biodiversity gradient (sterile to field realistic communities) and test its effects on floral traits such as colour, shape, size, nectar and pollen chemistry. A pollinator choice experiment is carried out to investigate the preference of a key group of pollinators, bumblebees, for one plant over another.
This study is the first to investigate soil-plant-pollinator interactions (i) in a multispecies setting, (ii) incorporate the plant root system and (iii) in a pesticide contamination context.

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Combined application of biochar with nitrogen and phosphorus supplements improve soil biochemical properties, nutrient utilization efficiency and soybean growth

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Numerous studies reported the positive effect of soil amendment with biochar on soil chemical, biological properties, and plant development (Lehmann et al. 2011). However, relatively few studies on biochar and its interrelation with nitrogen (N) and phosphorus (P) additions and their impact on soil properties, and plant growth have been reported. In our study, greenhouse experiments were carried out to understand the interactive effect of N, P supply, and biochar amendment on the soil enzyme activities, soil N,P content, soybean (Glycine max L.) growth, and nutrition. The biochar was produced from maize by heating at 600oC for 30 min, and used for pot experiments at concentrations of 2 %. Plants were fertilized with different concentrations of P (KH2PO4) and N (NH4NO3). Under low N (LN) and P (LP) supply, reduced plant dry biomass was observed in soil without biochar, whereas significant differences were found in soil amended with biochar. The N concentrations in soil under HNLP and HNHP without inoculation were higher at 23 and 27% compared to LNLP and LNHP, respectively. The soil P concentration showed a strong positive correlation with plant P concentration. Comprehensively, interaction analysis showed the biochar effect on the soil enzyme activities involved in N and P cycle depends on the N and P concentration and the biochar effect. Overall, these results contribute a further understanding of the interrelationship between biochar and mineral nutrients (N and P), and to the responses of soil biochemical properties, and plant growth to different N and P application rates.

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P-184

Plant nitrogen preference and alteration of soil nitrogen cycling may provide a route to breed for agricultural sustainability in Barley.

Mr Luke Fountain

Nitrogen is crucial for plant survival and is commonly applied in conventional agriculture as a synthetic fertiliser in the form of NH_4NO_3. However, crops typically display low Nitrogen Use Efficiency with only c30-40% of applied nitrogen captured by the crop. The remaining nitrogen is lost either through NO_3 leaching, gaseous emissions of NH_3, N_2O or N_2, or remains in the soil. The nitrogen cycle is predominantly biological, with two main processes in arable agricultural production. Nitrification sees the conversion of NH_4 to NO_3, producing the substrate for denitrification, where NO_3 is reduced to gaseous N products. N_2O is a potent greenhouse gas released as a by-product of nitrification and through incomplete denitrification, and agriculture accounts for c75% of all anthropogenic N_2O sources (Kanter et al. 2013). Both processes reduce plant NUE and increase costs to the farmer. There is a clear need to address these issues to improve sustainability. Plants generate bespoke rhizosphere microbiomes with downstream effects on function. We have observed variation in nitrogen cycling rates between different barley cultivars, the 2nd largest UK arable crop. We performed a screen of 200 cultivars, under different conditions, to determine if variation in nitrification and denitrification is significant and have assessed if this is linked to the N form preference of cultivars, which we have previously shown is variable between cultivars. Downstream these results will be used to assess if breeding for altered nitrogen form preference or manipulation of nitrification and/or denitrification represent routes to improve the sustainability of conventional agriculture.

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P-185

Plants control soil gas exchanges possibly via mucilage

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Gaseous matter exchanges in soil are determined by the connectivity of the pore system which is easily clogged by fresh root exudates. However, it remains unclear how a hydrogel (e.g. mucilage) affects soil pore tortuosity when drying. The aim of this study is to obtain a better understanding of gas diffusion processes in the rhizosphere by explaining patterns formed by drying mucilage.

We measured oxygen diffusion through a soil-mucilage mixture after drying using a diffusion chamber experiment. Therefore we mixed soil with various mean particle sizes with various amounts of mucilage. Afterwards we saturated the soil and measured the gas diffusion coefficient during drying.

We found that mucilage decreases gas diffusion coefficient in dry soil without significantly altering bulk density and porosity. Electron microscopy indicate that during drying mucilage forms filaments and interconnected structures throughout the pore space. Exudation of mucilage may be a plant possibility to actively alter gas diffusion in soil.
Haupenthal, A., Brax, M., Bentz, J., Jungkunst, H.F., Schützenmeister, K. and Kroener, E. (2021), Plants control soil gas exchanges possibly via mucilage . J. Plant Nutr. Soil Sci., 184: 320-328. https://doi.org/10.1002/jpln.202000496

P-186

Evaluation of polyhalite fertilizer for soybean using a novel root phenotyping system

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Polyhalite, $K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$, is a naturally occurring mineral which is certified as a organic fertilizer. It has a gradual dissolution thus having a prolonged release of nutrients to the crop.

The objective of this study was to test the efficiency of polyhalite as a fertilizer for soybean, to evaluate its capability to supply nutrients to the crop and its residual effect. The relative efficiency of polyhalite was compared a commercial fertilizer supplying the S, K, Mg and Ca nutrients. A novel root phenotyping system was utilized to monitor soybean root development under the tested fertilizers. This new phenotyping technology developed for soil-grown roots, keeps the root system architecture (RSA) in its natural form.

Two fully replicated pot experiments were conducted in a greenhouse: (1) fresh applications of both fertilizers at standard agronomic recommended doses, (2) plants were grown on a soil from a previous experiment with polyhalite in order to check its residual effect.

The results showed that the polyhalite is as efficient as the commercial fertilizer. Polyhalite showed higher accumulation of shoot biomass that the commercial fertilizer, thus enhancing the vegetative growth of the soybean plants. The polyhalite showed a better residual effect than the commercial fertilizer, as revealed in the higher shoot biomass.

RSA characteristics such as root length, root surface area, and root network area were significantly higher in both polyhalite and commercial fertilizer treatments than the control. The new phenotyping technique was successful in detecting mineral deficiency, as was observable in the fine root diameter frequency.

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P-188

Ancient and modern wheat varieties: a trade-off between CO2 emissions and yield?

Phd Student Rouch Laly, Pr Stéphane Follain, Mr Eric Pimet, Mr Florian Bizouard, Pr Olivier Mathieu, Mme Elodie Cognard, Pr Manuel Blouin

Despite the possible mitigation of carbon emissions by favoring carbon transfer to terrestrial carbon sinks, little is known about the capacity of different crop genotypes to enhance soil carbon sequestration. We hypothesize that carbon sequestration potential linked to old wheat varieties (released before 1960) is higher than the one linked to modern ones while old varieties are known to develop bigger and deeper root systems (Subira et al., 2016). Moreover, soil parameters can also have an influence on mineralization. We conducted a field experiment by cultivating four modern and four old wheat varieties, on four sites with specific physico-chemical soil conditions and various depths (Calcosoil Redoxisoil, Brunisoil, Rendosoil Fersialsoil). To assess the capacity of our genotype to store carbon in various soil conditions we set up incubations. For each of the 24 plots of each site we incubated soil and roots, from two to four depths (depending on the site), for 60 days. The gaseous phases of the microcosms were sampled six times for measurement of the CO2 concentration. We also set up "cross" incubations by incubating soil from ancient varieties with roots from modern ones (and vice versa). The goal of these "cross" incubations is to understand where the results we observe come from (soil microbial community or roots traits). Our first results suggest that mineralization rate depend on the experiment site. The effect of depth and breeding on mineralization rate are site-dependent.

Subira J, Ammar K, Alvaro F, et al (2016) Changes in durum wheat root and aerial biomass caused by the introduction of the Rht-B1b dwarfing allele and their effects on yield formation. PLANT AND SOIL 403:291–304. https://doi.org/10.1007/s11104-015-2781-1

P-188

Soil organic carbon storage capacity of old and modern wheat varieties

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Despite the possible mitigation of carbon emissions by favoring carbon transfer to terrestrial carbon sinks, little is known about the capacity of different crop genotypes to enhance soil carbon sequestration. We hypothesize that carbon sequestration potential linked to old wheat varieties (released before 1960) is higher than the one linked to modern ones while old varieties are known to develop bigger and deeper root systems (Subira et al., 2016). Moreover, modern varieties are often cultivated using synthetic chemical inputs known to modify soil carbon dynamics. We conducted a field experiment by cultivating four modern and four old wheat varieties, with and without chemical inputs (nitrogen, herbicide and fungicide), in Calcaric Cambisol conditions. After root and soil sampling, root morphology was assessed by image analysis, whereas potential catabolic activities by soil microbial communities was assessed by MicroResp ™ measurements. Additionally, CO2 emissions measurements were done by incubating soil and roots from each agronomic modality. Results suggest that the genotype (old versus modern varieties) did not affect root traits nor substrates respiration, but the soil from old variety modalities released 6% more CO2 than the one from modern ones. Application of inputs did not affect root traits, but increased soil microbial respiration by 11%. Inputs also increased the respiration of citric acid by 19.1%, while it decreased respiration of fructose and alanine by 8.84% and 16.79%, respectively. Taken together, our results invalidate the hypothesis that old varieties could be more performant than modern ones in storing carbon in this specific soil.

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P-189

Understanding the terrestrial diversity, distribution, and ecology of the aquatic fungus Tetracladium in oilseed rape farms

Ms Anna Lazar, Dr. Ryan M. Mushinski, Professor Gary D. Bending

The genus Tetracladium is best known as a decomposer of organic matter in freshwater. However, species of Tetracladium have been found in the soil and as endobionts of plants worldwide. It is unclear how these strains are related to each other, and little is known about the dual ecology of these fungi. In this study, we have looked at landscape scale data collected from 25 oilseed rape farms in the UK to better understand its distribution, diversity, and ecology. We have analysed Tetracladium diversity and distribution across the samples and have related crop management practices to relative abundance. We have found 12 OTUs representing the genus to be common parts of the oilseed rape microbiome with varying richness across the three sampled compartments (roots, rhizosphere, bulk soil). The highest abundance OTUs were T. maxilliforme and T. furcatum while lower abundance OTUs clustered together in an undefined group on the phylogenetic tree. There was a strong root preference with 5 of the OTUs including the highest abundance ones while the remaining preferred the other compartments or were equally present in all. The highest abundance OTUs had a positive correlation with oilseed rape yield increase in the roots. We have found a strong effect of these two OTUs on each other's relative abundance. While there seems to be an effect of crop rotation practices, oilseed rape genotype and pH, the presence of the other high abundance Tetracladium OTU overwhelms the response.

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P-190

Coupling of dynamic root architecture models with axisymmetric rhizosphere models

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Plant productivity is directly influenced by root system water and nutrient uptake. Therefore, an accurate description of the governing rhizosphere processes in functional-structural root models will enable better agricultural management strategies. In the following we will present a framework of model coupling generalising the ideas presented by Mai et al. (2019) and De Bauw et al. (2020).

Within a 3D soil, water movement and solute transport are described under realistic pedoclimatic conditions using Richards equation and advection diffusion equations (e.g. Koch et al. 2021). Water and nutrient movement within the growing and branching root system is simulated as flow and transport in a network of root segments, following Kirchhoff's law. The exchange of water and nutrients between the roots and the soil is realised with a sink term that depends on the rhizosphere water potential and nutrient concentration at the root-soil interface.

The multiscale problem of a macroscopic soil with microscopic rhizosphere gradients is solved by representing the rhizosphere of each individual root segment by a cylindrical model, which is defined by a coupled system of 1D radially symmetric equations (e.g. Schnepf et al. 2012). These equations can describe water movement, solute transport, ad- and desorption processes as well as chemical reactions between the compounds. At the inner boundary condition the rhizosphere interacts with the segment's root surface, at the outer boundary condition with the bulk soil.

We will discuss different choices of model coupling and its impact on actual plant transpiration in realistic pedoclimatic scenarios.

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P-192

Black box sorghum: belowground trait hunt

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Nutrient and water deficiency are besides pests the main cause for yield losses in smallholder farming systems. Particularly in semi-arid regions the range of crops which can be cultivated is limited and food production becomes difficult to maintain. Sorghum (Sorghum bicolor L. Moench) is a crop which shows adaptation mechanisms to nutrient limitations and drought. An experiment with five sorghum cultivars (two African and three Indian) was conducted to identify stress adaptation traits. Plants were cultivated in a P depleted (100 mg P kg-1 soil) or P enriched (320 mg P kg-1) Alfisol with a well-watered (WW) or water-stressed (WS) treatment combined with organic (cowpea root residues) and mineral 15N inputs. The trial was carried out in a lysimetric phenotyping system (ICRISAT, India) during the post rainy season irrespective of pre-crop treatment.

Under WW conditions sorghum genotypes showed different transpiration rates irrespectively of the P supply, whereas transpiration rates were significantly reduced at WS without a genotype effect.

Biomass and yield production were positively affected by P amendment and pre-crop residues under WW conditions, whereas under WS only the African cultivars produced yield. Belowground trait analysis indicated that mycorrhization rates to be relevant in early growth stages under low P supply, while from anthesis on key mechanisms triggering yield were less clear to be distinguished. Lower translocation rates of nutrients and assimilates might be a major issue for yield losses during drought, suggesting plant-soil interactions to be of major importance for future food security facing the challenges of climate change.

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Root-soil interactions in agricultural multi-species grasslands

Ms Katie Martin, Dr Fiona Brennan, Dr Olaf Schmidt, Dr Saoirse Tracy

Multi-species grasslands have shown potential for productive grass-based agricultural systems whilst providing the benefit of lower resource inputs and greater resilience to global change. These systems could play an important role in reducing fertiliser inputs and meeting sustainability targets. It is becoming evident that belowground interactions in multi-species grasslands are vital to their resource use efficiency, with the diverse root systems each providing different benefits.

In this research we aim to understand how increasing grassland diversity will impact plant-soil microbiome interactions, root architecture, and soil and microbiome structure. Combining the use of molecular techniques and X-ray computed tomography on samples taken from monoculture, two-species and six-species grasslands allows us to study the interactions between contrasting plant root systems, soil microbial communities and soil macrofauna. Despite the six-species mixture having a lower root mass than the grass monoculture there was no difference in root length density, suggesting that these communities maintain production of acquisitive fine roots. Non-destructive 3D imaging of the rhizosphere allows visualisation of root architecture and how roots and soil macrofauna can affect the soil structure and form biopores. There were trends towards higher soil porosity in the two- and six-species mixtures than grass monocultures, potentially due to the presence of tap-rooted species. Through integration of molecular techniques the microbiome structure and functional roles in nutrient cycling in diverse grassland communities will be assessed.

Understanding how multi-species grassland communities interact with soil and soil biota will aid in assessing their potential in sustainable grassland agriculture and best management practices.

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P-194

Alleviating Deep-Seated Compaction in Asparagus (Asparagus officinalis) Interrows (UK)

Lucie Maskova, Dr Rob Simmons, Dr Lynda Deeks, Dr Sarah De Baets

Conventional UK asparagus production includes annual re-ridging and intensive foot and vehicular trafficking. This leads to severe compaction in interrow wheelings which restricts root growth, increases runoff and erosion risk. Annual ridging damages roots promoting crown and root rot, which leads to a decline in asparagus productivity and stand longevity. This project investigated a suite of alternative management options applied annually from 2016-2020 to prevent or remediate soil compaction as alternatives to conventional practice. Alternative management options investigated included (1) companion crops - Rye (Secale cereale L.), Mustard (Sinapis alba L.), (2) interrow surface mulch applications (straw mulch and PAS 100 compost in combination with shallow soil disturbance (SSD)), (3) modifications of the conventional tillage practice by re-ridging (R) or not ridging (NR) and by applying shallow soil disturbance (SSD) or not, including zero-tillage. Application and straw mulch or PAS 100 compost in combination with SSD significantly reduced surface and deep-seated (>0.45 m) soil compaction of the interrows which is beyond the working depth of the subsoiler (0.25 m). In addition, the zero-tillage management option was also associated with significantly reduced interrow compaction as compared to conventional practice. These findings show that the extremely high levels of deep-seated compaction in interrows, associated with re-ridging, foot and vehicular traffic can be alleviated by adopting alternative management options.

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P-195

Exploring subsoil root-soil interactions to enhance agricultural productivity in wheat

Dr Tinashe Mawodza, Dr Hu Zhou, Dr William. R Whalley, Dr Malcolm. J Hawkesford, Dr Rhys. W Ashton, Dr Brian Atkinson, Dr Jonathan. A Atkinson, Dr Craig J. Sturrock, Prof Malcom. J Bennett, Prof Sacha. J Mooney

Water stress and nutrient limitations are two of the major challenges affecting crop production globally. Strategies that improve plant access to nutrients and water stored in the subsoil are paramount to improving global agricultural productivity as they can unlock often unexplored soil resources that are predominately wasted in modern agricultural systems. These strategies are important especially in the face of dwindling natural resources as their use could ensure the sustainability of crop production systems. To better understand plant-soil interactions in wheat plants, we used high resolution X-ray Computed Tomography on 100cm soil cores to answer critical questions about plant growth such as root macropore interactions. We examined the rooting depths of different genotypes in variable field conditions over several years to determine if genotypic variation affects subsoil exploration. Different nitrogen fertilisation regimes were also applied to determine if they have an effect on rooting depths. We also examined the pore structure of soil throughout each core to understand if these interact with roots growth at each depth. Our results revealed minimal impact of genotype on rooting depth whilst root density was largely reduced in the subsoil possibly due to high subsoil compaction. Nitrogen had an effect on root growth although limited to shallower soil depths (<30cm) and not in the subsoil. To better understand hydraulic dynamics in field conditions, our future work will involve modelling of water movement within the rhizosphere and bulk soil at different rooting depths in the soil, relating it to how it affects plant growth.
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P-196

Can increased plant diversity restore soil-associated ecosystem services in agroecosystems experiencing variable rainfall patterns?

Ms Cristina McBride-Serrano, Prof John Quinton, Prof Ian Dodd, Dr Ali Karley, Dr Tim George

Agricultural intensification has simplified landscapes thereby reducing biodiversity, depleting natural resources, and threatening ecosystem services. Resilience to abiotic stress is therefore decreasing, creating uncertainty about effects of climate change and the associated extreme weather events on agricultural production and environmental degradation. While much research has focused on the direct benefits of increased plant diversity for crop productivity, quantifying the effects on soil water availability and soil-associated agroecosystem services regulated by root systems has been relatively ignored. How cover crops bind soil (rhizosheath development) has attracted little attention even though they can decrease soil erodibility.

A mesocosm trial investigated cover crop rhizosheath development in droughted and well-watered soil. Four species (Secale cereale, Lolium westerwoldicum, Raphanus sativus, Brassica juncea) were chosen for their suitability to NW England environmental conditions. The fibrous rooting system of grasses developed more rhizosheath than the tap root system of brassicas. Although soil drying was greater in brassicas than grasses, drought did not affect rhizosheath formation. Sequential harvests demonstrated that younger roots formed more rhizosheath per unit root mass. Having established that species development stage and structural differences in rooting systems affect rhizosheath formation, further trials will combine species to determine if effects are additive or interact.

By providing scientific evidence for increased plant diversity effects on agroecosystem function, this work will inform land managers of cropping practices to conserve soil stocks and function and aid in delivering environmental policy targets for agriculture.

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P-197

The role of soil potassium fertility and application strategy in improving nitrogen use efficiency: a simulated grazing grassland study

Mr Thomas. P McCarthy, Dr Patrick. J Forrestal, Dr Imelda. A Casey, Dr James Humphreys, Dr David. P Wall

Nitrogen (N) fertiliser inputs associated with intensive agricultural production have become cause for heightened concern towards anthropogenic pollution. Nitrate-N (NO3-) losses from agriculture are linked to water quality degradation, while nitrous oxide (N2O) emissions from agricultural systems contribute to greenhouse gas emissions. Chemical N fertilisers play an important contributory role. Other soil macronutrients, particularly potassium (K) are intrinsically linked to plant assimilation and utilisation of N. An experiment was carried out to assess if adequate soil K fertility can provide an avenue towards increasing the nitrogen use efficiency (NUE) of grassland-based agriculture in an Irish context.
A simulated grassland grazing field-plot experiment was established in Johnstown Castle, Wexford, Ireland in 2020. The sward is perennial ryegrass dominated. The experimental design is a randomised block split plot. The main plot factor is soil K level (indices 1-3), the split plot factor is sward K application strategy and timing. Chemical and organic sources of K and a range of timings of K throughout the season are used. K treatments include treatments to mimic common K-containing compound fertilisers used on Irish swards. The trial is harvested monthly, with yield, sward N&K uptake recorded. Apparent %N recovery is calculated. The trial hypotheses are: 1) increasing soil K level will increase grassland NUE and yield, 2) K application strategy will effect herbage quality, yield and NUE.
The experiment is ongoing, however observations from 2021 data show optimal sward K supply increases apparent sward NUE. These provisional results will be presented and discussed at the conference.

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Effects of Liming on Micronutrient Uptake by Oil Palm on Tropical Peatland

Mr Nicodemus Ujih Michael Brenden, Ms. Amelia Jackob, Mr Kevin Dinggun, Dr. Faustina Sangok, Dr. Auldry Chaddy, Ms. Nur Azima Busman, Dr. Lulie Melling

Highly acidic tropical peat soils are greatly influenced by humified soil organic matter (SOM). High SOM content contributes to the high pH buffering capacity of peat soils which leads to low nutrient availability and consequently low soil fertility. Liming is a standard practice used to alleviate soil acidity and improve soil fertility. Thus, finding suitable liming rates is required to increase soil pH, and improve peat soil fertility for optimizing uptake of micronutrients by oil palm. We conducted a four-year (2017 – 2020) field experiment in an oil palm plantation established on tropical peatland in Sarawak, Malaysia. The objective of this study was to evaluate the effects of different liming rates on soil micronutrients availability for young oil palms. We evaluated four different liming rates of calcium carbonate ($CaCO_3$): 0 t/ha (T0), 3 t/ha (T1), 6 t/ha (T2), and 12 t/ha (T3). Foliar samples and peat soil samples of 0 – 25 cm depth were collected for total and available micronutrients analysis. The results showed that the highest liming rate (T3) significantly increased with available copper (Cu) and zinc (Zn) content in the soil ($p<0.05$). There was no significant difference in the availability of soil boron (B) among the liming rates ($p>0.05$). Total Cu, Zn, and B content in foliar for the liming rate of T2 and T3 were significantly higher than T0. This study highlights the importance of liming on the availability of micronutrients in soil and its uptake in oil palm cultivated in tropical peatland.

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P-199

Soil and rhizosphere microbiome structure under different field agricultural managements. Systematic review and meta-analysis

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The use of amplicon sequencing tools allows exploring the structure of the microbiome. The structure of the microbiome is recognized as an essential parameter for soil health. It is known that the microbiome structure can be modified by geographic area, climatic conditions, crops and agricultural management. In this sense, after a decade of development of amplicon sequencing, we analyzed the state of the art of this technology in agricultural soils.

Agricultural research using amplicon sequencing tools have achieved sometimes contradictory results. For example, fertilization modified the structure of the microbiome in some cases but not in others. Consequently, the objective of the meta-analysis was to examine the effect of agricultural management on the structure of the microbiome using the research available on a global scale. We proposed that conventional practices would have a detrimental effect on the structure of the soil microbiome, while environmentally friendly practices would have no effect or would be beneficial. To deep in this hypothesis, we are analyzing the structure of the microbiome and the taxonomic biodiversity at family level, and potential functional biodiversity. The general question of this research is: Do “environmental-friendly” agricultural management improve the diversity (taxonomic and functional) of the soil microbiome?

Currently, we are finishing the meta-analysis. I hope we can submit this research on december, 2021.

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P-200

FERRONICKEL MINING SLAG ON SUBSTRATES FOR PRODUCTION OF PRE-SPROUTED SUGARCANE SEEDLINGS

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The mining industry generates a gigantic amount of solid and liquid waste and is accumulated causing great socio-environmental impact. The state of Goiás is the third state with the highest production of ores in Brazil, behind Minas Gerais and Pará, and is the main nickel producer in Brazil. The main residue of ferronickel mining is slag, a solid residue of low solubility and rich in magnesium silicate. The agricultural use of industrial waste is still unusual in Brazil, although it presents high availability of materials. For sugarcane crop, which has grown the use of pre-sprouted seedlings for subsequent planting in the field, the use of quality substrates, which provide physical and chemical conditions for the development of these seedlings, is fundamental for good development. The objective of this work was to evaluate the potential of the use of mining excorive in substrates for the production of pre-crushed sugarcane seedlings. For this, a trial was carried out at the Jalles Machado Plant, during a period of 46 days. The use of agro-industrial waste is an alternative for the production of pre-sprouted sugarcane seedlings. The substrate with 1:2 proportion of mining slag and commercial substrate presented similar results to the commercial substrate commonly used by sugar and energy plants. The use of substrates with higher slag contents reduce the initial development of sugarcane seedlings.
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P-201

Identifying and transferring resistanceinducing microbes from ley soils

Miss Nancy Muringai, Prof. Stephen Rolfe, Prof Jurriaan Ton

Soil is a critical natural resource that is facing many threats due to activities such as intensive agriculture. Soil health is currently in the spotlight as an important feature for combating soil degradation and climate change. A ‘healthy’ soil determines how plants grow and respond to diseases owing to a diverse and active beneficial microbiome. Soil microbes play a crucial role in maintaining soil health by activities such as decomposition of organic matter, nitrogen fixation, and disease suppression. However, there is limited understanding of the influence of soil microbial activity on disease suppressiveness in farm soils. The main objective of this research is to investigate the influence of soils under different farm management practices on plant growth and disease response in tomato plants. We physicochemically and biologically characterised soils that were identified as ‘healthy’ or ‘poor’ soils by soil experts and farmers, and assessed how their designation into the different categories had an impact on tomato growth and response to bacterial speck disease. Tomato plants grown on ley soils were consistently smaller and disease resistant compared to arable soils. We conducted soil microbial wash transfer experiments to extract the microbiome fraction of the soil and transplanted these microbiomes to washed arable and ley soils. Microbial fractions from ley soil induced disease resistance in tomato plants in both washed arable and ley soils. The transference ratios and constituent make-up were confirmed using qRTPCR, 16SrRNA and ITS sequencing for bacteria and fungi.

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P-202

Impacts of domestication on fine root trait variation and effects on rhizospheric conditions

Ms Victoria Nimmo, Dr Marney Isaac, Dr Gurcharn Brar

While selecting crops that express certain leaf traits has formed detectable, albeit diverse, crop domestication syndromes, shifts in root functional traits throughout domestication have largely been overlooked. Yet, understanding the consequences of variations in fine root traits of crops can provide insight into critical agroecosystem processes, especially when comparing crop traits under conventional versus organic agriculture. One would expect that highly domesticated crops exhibit modified resource acquisition strategies and differential effects on rhizosphere conditions, as compared to their wild progenitors. Using varietals of Triticum aestivum along a domestication gradient, its ancestor Aegilops tauschii and a Watkins landrace, we measured a suite of leaf (specific leaf area, leaf N, photosynthesis, water use efficiency) and root (specific root length, root diameter, root N) functional traits, as well as microbial communities, AM colonization, and root exudate metrics. We applied two irrigation regimes (sufficient and limited water) and two amendment treatments (conventional fertilizer and organic worm castings). We show significant impacts of amendment on root functional trait expression across the domestication gradient. We also found both bivariate and multivariate relationship between root functional traits and rhizosphere chemical and biological properties. These shifts in crop functional traits and rhizosphere conditions have important consequences for nutrient uptake and nutrient loss in agricultural soils, and underscore the need to consider root functional traits in breeding for organic agroecosystems.
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P-203

Understanding how legume mulch may affect soil improvement, nitrogen uptake, maize productivity and sustainable land use in the Amazonian periphery

Jessica De Freitas Nunes, Emanoel Gomes de Moura, Sacha Mooney

The dynamics and responses to mulch management processes that ensure sustainability in agroecosystems in Amazonian periphery remain poorly understood. This study aimed to evaluate the short-and long- term effects of mulching on SOM accumulation, SBC retention, and physical improvement of a cohesive tropical soil enriched with 1.15 Mg ha-1 of calcium. We also assess the contribution of mulching and synthetic N (Ns) to the uptake of N and maize yield. The experiment had the treatments: Long-term mulching (LTM), LTM plus nitrogen, short-term mulching (STM), STM plus nitrogen, LTM plus STM, LTM plus STM plus nitrogen , bare soil with nitrogen (N), and a control. LTM consisting of dry biomass of Gliricidia sepium applied at a rate of 12 Mg ha-1 year -1 during six years, (2013 up to 2018), planting without mulch in 2019. STM, planting without mulch during six years and with mulch in 2019. The interaction between biomass, calcium and Ns was more intense in LTM areas, resulting in higher carbon content, base cations, enhanced soil rootability, increased nitrogen uptake. STM maintained soil moisture, decreasing penetration resistance, and, when paired with LTM, providing enough biological nitrogen to replace Ns. The effects of STM and LTM on their own were cumulative with N uptake 54% higher, accumulated N 163% higher and maize grain yield 125% higher (4.77 to 10.78 Mg ha-1) compared to control. The continuous use of mulch has benefits for both the sustainability and feasibility of Amazonian agro-ecosystems, preventing land degradation and avoiding shifting cultivation and deforestation.

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P-204

Understanding Nitrogen cycle dynamics in in paddy soil – opportunities for improving the sustainability of rice production through microbial manipulation

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Nitrogen use efficiency in paddy rice production is estimated to be as low as 40%. The remaining added Nitrogen is lost through leaching or gaseous loss, including the potent greenhouse gas nitrous oxide (N2O). 15.9–17.7 TgN of N2O is added with an increasing rate of 0.25% into global N2O emission budget annually. Agriculture is responsible for approximately two-thirds of these emissions driven by intensive nitrogen fertilisation. Microbial processes dominate Nitrogen transformations in soil. In contrast to dry agriculture there are four key processes in paddy systems: nitrification, denitrification, Dissimilatory Nitrate Reduction to Ammonium (DNRA) and anammox. The dominance of each of these pathways depends on substrate availability, soil conditions and, critically, interaction with the crop plant. Rice plays a vital role manipulating the soil ecology of its rhizosphere through, for example, Nitrogen assimilation, respiration and root exudation that together shape the rhizosphere community. The abundance and activity of different Nitrogen cycling bacterial and archaeal communities in paddy soils control the Nitrogen cycle and the fate of its end products. These Nitrogen cycling-associated communities in the rhizosphere and surrounding bulk soil react differently to the effect of rice plants especially in the rhizosphere. Using a microcosm system we have estimated the relative contribution of these Nitrogen cycling processes by measuring process rates, functional community dynamics and specific marker gene expression. This allow us screening methodology to assess the potential of plant breeding to reduce the detrimental impacts of agriculture increasing agriculture sustainability.

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P-205

Influence of polyhalite on turmeric rhizome yield (Curcurma longa) grown in Inceptisols of Tamil Nadu, India.

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Turmeric (curcurma longa) is a very important auspicious plant cultivated in large area in South India .Turmeric is grown for its aromatic rhizomes which are used for culinary , medicinal properties to fight covid 19 viruses ,and used for culinary and cosmetic purposes since antiquity. Turmeric is grown as a tropical rhizomatous crop . Turmeric has a high demand for plant nutrients especially potassium and responds well to increased soil fertility (karthikeyan et al 2009).
Polyhalite is a natural mineral which is rich in plant nutrients such as potassium, calcium , magnesium , and Sulphur. It's mined from under the sea bed in north sea in the UK and is now distributed in India as a natural fertilizer. In order to study the effect of different levels of Polyhalite on Turmeric rhizome yield under adequate conditions of nitrogen and phosphorous a pot experiment was conducted on Irugur soil series in the western zone of Tamil Nadu, South India.the results of the pot experiment concludes the fact that application of potassium 150 percent (50 percent MOP + 100 percent as K20 as poly halite which is about 750 kg ha-1) as polyhalite recorded the highest fresh yield turmeric rhizome which weighed about 454 gms.and cured yield of 91.1 percent and further curcumin content of 3.79 percent. It was 134 , 148 and 73 percent increase above the treatment which received zero percentage of potassium.The significant increase in yield was attributed to the application of fertilizer Polyhalite.

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P-206

Exploiting roots to understand grassland community-led mechanisms of root influence on soil structure

Mrs Annette Raffan, Professor Paul Hallett, Dr Kenneth Loades, Professor Mark Emmerson

Grasslands, including shorter term 'leys,' have beneficial effects on soil health and biodiversity. In the context of global change, it is imperative that they are optimised to improve soil and other ecosystem functions. Species choice is an under-utilised tool with the potential to improve soil structure through not only direct species impacts but also through enhanced community effects which occur when certain species are grown together.

Grassland species composition was investigated to determine how species mix contributed to soil surface physical properties. After year three, plot composition (timothy, perennial rye or mix of the two) had no significant effect on infiltration, saturated hydraulic conductivity, water sorptivity and repellency. In winter, grass roots had similar root properties overall, though timothy had more finer roots (<200µm). Because pore structure and porosity were similar even within the mix, it questions whether grasses with similar root traits and growth strategies, can be categorised as having similar effects on soil physical properties at the field scale and hence be used for targeted soil management in leys.

The next step will analyse whether contrasting root traits demonstrate enhanced benefits for soil structure through root complementarity. This investigates how interspecific root competition can be manipulated for targeted soil management, beyond that of diversity or richness effects. By using complementary experimental techniques like buried cores, 3D X-ray CT and microscale analysis techniques under controlled conditions to the field scale, it is hoped that new insights into community-led soil structural dynamics will optimise ley soil function.

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P-207

Geochemical fingerprinting for provenance traceability of vesuvian PDO “Pomodorino del Piennolo” tomato

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The vesuvian “Pomodorino del Piennolo” tomato (Lycopersicon esculentum Mill.) is a traditional variety grown in the Campania region (Italy) on the slopes of the Somma-Vesuvius volcano. It is generally sold in bunches assembled by hand and is characterized by long shelf-life. It has been awarded by Protect Designation Origin (PDO). Local "custodian farmers" play an important role in conserving traditional cultivation management and biodiversity, as well as organoleptic properties deriving from the environment of the Vesuvius area. Due to the high typicity and selling value, this product is susceptible to origin fraud. Thus, Tomato Trace 4.0 project (financed by Rural Development Programme – Campania Region 2014-2020) aims to valorise “Pomodorino del Piennolo” strengthening the traceability system. A way to achieve this is to link the tomato to the soil characteristics by multielemental fingerprinting. In 2021, seven farms (five inside and two outside the PDO area) were samples for tomato and relative cultivation soil. The exploratory PCA analysis of soil characteristics evidenced a natural grouping among the five representative PDO farms. The mineral fingerprinting of soils (total, bioavailable and readily available elements) and related tomato fruits from the five farms inside the PDO cultivation area was correlated and compared to those from the two farms outside PDO. Results evidenced a potential discrimination by mineral characteristics of PDO soils transferred in tomato fruits. The soil characterization, including physical and chemical analyses, as well as the features of cultivation environments were discussed as discriminant variables in applied chemometric models for origin traceability.

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P-208

Recycled iron phosphates are not effective phosphorus fertilizers in the short term on lowland rice grown in strongly P-fixing soils

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The high input of phosphorus (P) in agricultural areas in the last decades resulted in declining quantity of good-quality phosphate rock and a poor status of surface waters. To address both issues, P can be recovered from P-rich sources (eg., wastewaters), e.g. as vivianite ($Fe3(PO4)2 \cdot 8H2O$) or P-loaded Fe(III) oxides, and be applied as alternative P source for crops. The poor solubility of these materials, however, can strongly limit the plant availability of recovered P, particularly under aerobic conditions. Therefore, we hypothesized that under reducing conditions of flooded soils, the P mobility and availability can be possibly enhanced, rendering FeP materials as source of plant available P.
A pot experiment was set up to assess the performance of recycled FeP products as P fertilizer compared to that of triple superphosphate (TSP), using rice grown in three soils of contrasting properties under flooded and nonflooded conditions.
The recycled FeP products performed poorly compared to TSP and did not significantly differ with the control in terms of dry weight, P shoot and P uptake of rice across three soils. Plant parameters were not also improved by flooding.
Thus, recycled FeP materials are not suitable as P fertilizers in their current form, even under reduced condition. Different strategies (e.g., longer growth period, changing the fertilizer form) may be employed to enhance the effectivity as P fertilizer of recycled FeP products. Finally, recycled FeP can be also considered as potential raw material for P recovery which may be use for P recycling with chemical approaches.

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P-209

The influence of erosion processes on glomalin, a product of mycorrhizal fungi, as an important component of the soil-plant system

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Soil erosion is a global problem which affects soil properties, non-productive functions, and crop yield. In order to evaluate the influence of erosion on soil properties, we looked beyond the traditional parameters, and also focused on biological parameters including glomalin as a product of mycorrhizal fungi, which are an integral part of the complex soil-plant system. Mycorrhizal fungi are important in plant nutrition, and also protect against pathogen attack. In addition, glomalin is an important compound in SOM, representing a significant global store of fixed organic C and N. The research aimed to verify the sensitivity of this parameter within the soil, how it correlates with other properties, and how useful it is for indicating changes in soil, e.g. due to degradation. The research was carried out on 48 sites with the erosion-threatened chernozem soils of Southern Moravia, CZ. Erosional, depositional, and control sites located on different slopes were selected using erosion-deposition models. The most statistically significant differences were recorded between erosional and depositional sites with higher values of glomalin and of characteristics relating to quantity and quality of soil organic matter (SOM) and content of nutrients. Moreover, we also found statistically significant differences in the presence of arbuscular mycorrhizal fungi (AMF) spores. The results show many strong correlations between glomalin content and other soil characteristics, and we present the possibility of using glomalin as a indicator of soil properties during degradation processes. The
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P-210

Effect of differing pasture species on soil surface water infiltration rates and the potential underlying mechanisms

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The focus of land management has shifted from solely the agricultural product towards a broader range of environmental objectives. In this context, there has been much interest in how agricultural practices exacerbate or mitigate flood risk. This interest has concentrated on managing soil compaction by machinery and by high animal stocking rates for soil water retention. However, the use of alternative forages to the widespread perennial ryegrass (Lolium perenne) and ryegrass/white clover (Trifolium repens) swards is of interest in this respect. In a series of field experiments we compared these common swards with others, including red clover (Trifolium pratensis), plantain (Plantago lanceolata) and chicory (Cichorium intybus). Plots were sown with single or mixed species. Over the course of these experiments we measured surface infiltration every month; rooting and earthworm populations were recorded on several occasions during the experiments. Compared with perennial ryegrass most alternative forages gave higher infiltration rates and earthworm populations. Higher infiltration rates were associated with increased earthworm abundance for white clover but not for red clover. So differences in the earthworm abundance only partially explained the variations in infiltration observed. Forages independently differed in rooting patterns and impacts on soil physical conditions with consequences for soil hydrological function. The differing mechanisms driving variations in infiltration and their potential implications for local flood risk will be considered.

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Irrigation with brackish water: impact on the distribution of plant mineral nutrition

Dr. Manoj Shukla, Dr Hui Yang

With surface water increasingly getting scarce in arid/ semiarid regions, brackish water irrigation is threatening nutritional imbalances. We conducted experiments to compare underlying concentrations and distributions of macronutrients including, sodium, calcium, potassium, magnesium, nitrogen, sulfur, phosphorus and chlorine, and micronutrients including boron, copper, iron, zinc, manganese, and aluminum within tomato tissues irrigated with brackish waters. Irrigation waters had electrical conductivities (EC) of 0.6, 2, 3, 4, and 6 dS/m. The higher concentrations of $Na+$, $Mg2+$, $Ca2+$, $K+$, and $Cl-$ in soil and irrigation water resulted in increased $Na+$ and $Mg2+$ but decreased $K+$ and $Ca2+$ concentrations in plant root, stem, leaf and fruit. Chloride decreased in leaf but increased in root, stem and fruit with increasing salinity. Salinity also decreased S, P and N in the whole plant. The Fe, Mn, Cu, B and Al decreased with increasing salinity levels, and the concentrations for each micronutrient in tomato leaves was less than the reported critical leaf concentrations for toxicity, and salt stress did not reduce tomato growth and yield due to the toxicity of metal elements in plant leaves. Salinity slightly increased the uptake of Zn. K, N, and P accounted for as much as 50% of whole plant accumulation in tomato fruits, but their distributions in fruits decreased with increasing salinity. In contrast, the proportions of Ca, Fe, Mn and Na in tomato fruits increased with increasing salinity levels. Research provides insights to managing macro- and micro-nutritional elements of tomato, and breeding future crops under saline conditions.

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P-212

Effects of the placement of acidified biogas fiber on the P uptake and biomass of ten horticulture crops

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The placement of P fertilizers close to the seed and the acidification of biogas fibers (BGF) can increase maize P uptake. Thus, this study aimed to assess the effects of the placement of acidified BGF (aBGF) on the P uptake and biomass of ten horticulture crops: bean, broccoli, carrot, cucumber, fennel, onion, pea, squash, tomato, and zucchini. The following treatments were tested in a low-P soil: no P fertilization, and TSP, BGF, and aBGF were applied mixed and placed in the soil. The placement of aBGF significantly increased the P uptake of the bean, fennel, onion, carrot, and squash when compared to the TSP and BGF mixed treatments. However, the increase in P uptake de to the placement of aBGF did not always lead to a significant increase in shoots biomass. For onion and fennel, the placement of aBGF led to a greater shoots biomass when compared to the TSP and BGF mixed, respectively. These results indicate that: i) the placement of P-rich fertilizers may imply an opportunity cost to the plant on exploring the soil resources, and ii) the opportunity loss due to the placement may be a crop-dependent variant. Therefore, the acidification and placement of BGF can lead to a P use efficiency greater than P mineral fertilizers. More studies are still needed: i) to elucidate physical, chemical, and biological interactions in the placement area; and ii) to compensate the opportunity loss due to the placement and overcome it.

P-213

Impacts of long-term biomass management and nitrogen inputs on soil organic matter and nitrogen in a temperate grassland

Ms Sireetorn Siriwong

Retention of soil organic carbon (organic matter) and nitrogen play an important role in maintaining and improving the integrity and function of grassland ecosystems. This is influenced by a combination of factors that include plant biomass cycling and nitrogen fertiliser inputs. Soil to 50cm depth was sampled from replicated grassland field plots that had been maintained for 25 years with harvested biomass either retained or removed, with and without inputs of urea fertiliser (50kg nitrogen ha-1 per annum). Results revealed that at all depths concentrations and quantities of soil organic carbon and total nitrogen were significantly greater under biomass retention compared with removal. These differences amounted to increases of 21% for organic carbon (122 vs 101mg ha-1) and 29% for total nitrogen (1125 vs 875kg ha-1) in soil to 50cm. Lower soil organic matter and nitrogen under biomass removal reflected reduced plant production over 25 years, which was mainly attributed to the continued removal of nitrogen, phosphorus, and potassium. Annual inputs of nitrogen fertiliser increased plant production under both biomass management regimen, but this had no significant impact on concentrations and quantities of organic carbon and total nitrogen in the soil profile after 25 years. The findings of this field study confirmed that enhanced retention of plant biomass can increase soil organic carbon and total nitrogen, and the fact that additional nitrogen inputs had no significant impact on total nitrogen in the soil profile may reflect increased nitrogen removal in drainage (leaching) and by volatilisation (denitrification).

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Use of polyhalite to improve fertility in subsurface of acidic soils with coffee plantations in Brazil

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The cultivation of coffee has great value for the economy of Brazil. As a perennial crop, the fertility of the subsurface soil is difficult to be managed. In acidic soils, liming is the main source of calcium and magnesium. However, due to the low mobility of the corrective its action is restricted to the most superficial layer. The aim of the trial was to evaluate the mineral fertilizer Polyhalite as a source of potash, calcium, magnesium and sulfur for coffee and its effect in the improvement of fertility in subsurface layers of acidic soils in Brazil. The trial was conducted at Carmo da Cachoeira, Minas Gerais state, Brazil, in a field planted with coffee variety Acaiá 474/19. Experimental design in randomized blocks with 6 treatments and 4 replications. Treatments were blends of KCl and Polyhalite, relative to the weight of fertilizers, to provide 390 kg ha-1 of K2O, thus described: 1 - 100% KCl; 2 - 50% KCl/50% Polyhalite; 3 - 30% KCl/70% Polyhalite; 4 - 20% KCl/80% Polyhalite; 5 - 10% KCl / 90% Polyhalite; 6 - 100% Polyhalite. After harvesting the coffee, the soil was analyzed at three depths, 0-20 cm, 20-40 cm and 40-60 cm. Polyhalite significantly increased the contents of K, Ca, Mg and S at all depths, thus increasing base saturation (V%) and pH, and reducing the aluminum concentration in the soil profile, proving to be an option for use in partial or total replacement of KCl in acidic and base-poor soils in depth.

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P-215

Nitrogen but not phosphorus addition affects legume biomass and N2 fixation in global grasslands

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The total amount of nitrogen (N) derived from symbiotic N_2 fixation of legumes in grasslands depends on soil N and phosphorus (P) availability. Both elements can affect legume biomass and the proportion of legume N derived from the atmosphere (%Ndfa) through symbiotic N_2 fixation. We evaluated symbiotic N_2 fixation in 17 grasslands which are part of a coordinated global experiment with a fully factorial design comprising four treatments: N addition (N), P addition (P), their combined application (NP), and no element addition (control). Across all sites, application of N and NP reduced biomass of legumes by 65% and 45%, respectively, compared to the control. In contrast, P addition alone had no significant impact on legume biomass compared to the control. Elemental addition had no significant effect on %Ndfa of legume biomass. Due to the lower legume biomass in the N and NP addition treatments, the amount of N fixed annually per grassland area was less than half in the N addition treatments (1.39 and 2.13 kg N ha^{-1} yr^{-1}, respectively) compared to control and P addition (3.50 and 3.71 kg N ha^{-1} yr^{-1}, respectively). Our results from a global scale experiment reveal that N addition mainly impacts symbiotic N_2 fixation via reduced biomass of legumes in grasslands rather than changes in the %Ndfa. Therefore, soil N enrichment by anthropogenic activities can significantly reduce N_2 fixation in the world's grasslands, which may change their ecological functioning as well as grassland above and belowground biodiversity and provision of ecosystem services.
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P-216

On the importance of biological soil crusts to protect areas under sandization processes in southern Brazil

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Biological soil crusts (biocrusts) are a key factor in the protection of arid and semiarid ecosystems and, therefore, playing a major role to combat against desertification. Biocrusts are also of profound importance in sand dune areas, as they are recognized as the first colonizers after environmental disturbances and can help to prevent sediment remobilization. Moreover, biocrusts have shown to be of importance in soil protection against erosion, but also nutrient cycling in the Pampa biome in Brazil. Here, natural geomorphological processes and soil misuse led to the expansion of sediment remobilization areas, generating a severe problem - the difficulty of fixing field vegetation and crops. This study aims to characterize the types of biocrusts from areas that suffer sandization processes in the Brazilian Pampa biome and to verify their relationship with soils and organisms. We analyzed biocrusts in three successional stages. Starting with a taxonomic exploration of crust components, proceeding to its characterization, and finally determining its importance, we further investigated two study sites. In the form of black to dark green spotty communities on the soil surface, they play an important role in particle aggregation, which can be granulated or show macroscopic forms. Biocrusts occurring on slopes can be classified as pinacular, rough or smooth crusts. We found that the presence of these crusts as an element of nutrient source and balance generator leads to a reduction of soil erosion and is thus of importance for the restoration of this biome balance.

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P-217

Impacts of Cropping Systems on Soil Health of Deforested Upland Soils in Cambodia

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Agricultural development and logging in Cambodia has resulted in extensive deforestation. Some agricultural systems being imposed have less deleterious effect on soil health than others. Identifying which agriculturally systems are sustainable may improve soil health of deforested agriculture lands. The purpose of this study was to compare effects of cropping system selection on soil health parameters of deforested agricultural (DA) soil with forested soils. The study consisted of nine sampling locations at recently developed agricultural areas in the Cambodia Uplands. Forested and DA sites were identified at each location. Soil samples were taken from 0 - 15 cm depth and analyzed for electrical conductivity, consistency, pH, CO2 respiration, and organic C (SOC). Comparison of forested versus DA soils showed forest soils had higher SOC and CO2 respiration (2.8% and 127.7 mg CO2, respectively) than the DA soils (1.9% and 64.5 mg CO2, respectively). The forest soils had lower soil consistency than the DA soils suggesting lower bulk density. A comparison of cropping systems showed that forest soils had higher SOC and soil respiration than the soils under mono- (1.9% and 66.2 mg CO2, respectively) or poly-cropping systems (2.0% and 62.1 mg CO2, respectively). Cropping systems that included trees had similar soil consistency to forested soils but lower SOC and soil respiration. These data showed that deforestation of Cambodia Uplands soils has had a negative impact on soil health regardless of mono- or poly-cropping systems, but incorporation of trees in cropping systems may improve some soil health parameters.

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Rhizobium inoculation improved the rhizosphere soil P dynamics and plant P uptake in strongly weathered soil under P fertilized condition

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Plant productivity is generally limited by low phosphorus (P) availability in strongly weathered soil, with high P-fixation capacity due to the high iron and aluminum oxides. This study aimed to evaluate the effects of rhizobium inoculation(+I/-I) on plant growth, rhizosphere soil P dynamics, and plant root P acquisition with or without P fertilizer (50SSP: 50 kg P ha-1 / 0P). We conducted a 70-day pot experiment with P-deficient Ultisols. We analyzed the plant P uptake, fractionated P of rhizosphere and bulk soils, using the Hedley-fractionation method, and the amount of root exudation (organic acid and acid phosphatase) as plant P acquisition capacity. We found that: (1) plant P uptake in the 50SSP+I was larger than that in the 50SSP-I by 41%, (2) the amount of labile and less labile inorganic P (NaHCO3-Pi and NaOH-Pi) was significantly larger in the rhizosphere soil compared to the bulk soil by 44-55%, while such difference wasn't observed in the 50SSP-I, and (3) the amount of organic acid was larger in the 50SSP+I than that in the 50SSP-I by 132%. In 0P treatment, there was no clear difference between the +I and -I. These results indicate that rhizobium inoculation enhances the amount of organic acid from the root, causing the solubilization and accumulation of applied P in rhizosphere soil, resulting in the better plant P uptake and its growth, in strongly weathered soil only in P fertilized condition but not in P-deficient condition.

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P-219

The research progress of microalgae in application in agricultural production and its environmental benefits

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Microalgae are the general name for single/multicellular small algae invisible to the naked eye, and they are the producers at the bottom of the food chain, pioneering creatures on Earth and playing a key role in building the balance and diversity of soil microbial ecosystems. Microalgae can fix carbon, nitrogen, release oxygen, secrete natural biostimulants, microalgae into biofertilizers used in agriculture in line with the theme of green sustainable agriculture. This paper expounds the progress of research on soil physical and chemical characteristics, microbial abundance and diversity, crop growth and greenhouse gas emissions in the application of microalgae to agricultural production, and discusses the future research direction of microalgae biofertilizer, with a view to providing theoretical basis and scientific guidance for the rational utilization and sustainable development of microalgae in agricultural production.
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P-220

Monitoring uptake of root-derived carbon into the soil carbon pool using stable isotope probing volatile organic compound (SIP-VOC) analysis

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Root decomposition derived compounds are believed to constitute a significant source of soil organic matter [1]. Compared to living or senescing roots, little is known about the carbon entering the soil from dead/dying roots, specifically, when the root carbon begins to decompose and how the root carbon decomposes.

Living roots can produce a range of volatile organic compounds (VOCs), especially when the roots are damaged [2]. Here we use VOCs to indicate changes to metabolic activity and degradation of easily degradable organic carbon from roots after shoot excision.

We are particularly interested in how the root metabolite profiles shift with time after shoot excision, what volatiles are released from root degradation, and how the form of root death affects subsequent root carbon turnover.

To answer these questions, we are using stable isotopic measurements to track the fate of root-derived carbon into soil carbon pools and the microbial community. By labelling plant roots with 13CO2 and transferring labelled roots into natural abundance soil for incubation/degradation, all of the isotopic VOCs collected should be released from roots directly or from the microbial community utilising root derived carbon. Hence, the degradation process will be tracked by monitoring the shift in VOC profiles.

Preliminary data suggest roots under different treatment show distinct VOC profiles, which could be used to identify the nature of root death. Furthermore, preliminary work demonstrates that VOCs enable sensitive differentiation of soil receiving root amendments, indicating that it is possible to use VOCs as indicators of root decomposition into soil.

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P-220A

Impact of reduced tillage and rotations on root:soil relations in medium and long term UK field trials

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Farming systems are under increasing pressure to adapt to climate change, and policy frameworks are needed that address long-term sustainability of the food system environment. Changes in field management such as reduced tillage and more diverse crop rotations have a significant impact on soil physical structure and nutrient distribution within the profile, impacting root:soil interactions with consequential effects on yield, and soil/plant ecosystem function. Medium and long-term field trials are required as effects of tillage and rotations occur in the immediate – long-term timescale. Using data from multiple trials that include reduced tillage treatments, we assessed changes in soil structure and chemical distribution and the impact of these on soil as a medium for root growth and crop yield. Significant changes in soil pore structure occurred between tillage methods, between cropping years within rotations, and as a result of previous crop, as quantified using soil physical measurements and image analysis of soil cores. These soil structural changes were shown to impact on the status of the soil as a medium conducive to root elongation. Further, cereal varieties were found to differ in their yields between the traditional plough rotations and the reduced-tillage rotations. These differences are likely to be linked to differences in the root responses of the cereal varieties to changes in the soil physical and biological status of these rotations. These combinations of variety traits and their responses to reduced disturbance and cropping history can contribute to the design of more sustainable cropping systems in the future.
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P-220B

The impact of drought-induced root and root hair shrinkage on root-soil contact and water uptake

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Root hairs increase the contact area between roots and soil, are expected to facilitate nutrient and root water uptake and have been proposed as a “cost effective” root trait that potentially improves climate resilience of crops. Despite their role in nutrient uptake has been demonstrated, the contribution of root hairs to root water uptake remains controversial. Furthermore, there is a lack of knowledge regarding root hair responses to drought, in particular regarding the effect of soil drying on root hair shrinkage and loss of root-soil contact.

The objectives of our study were: 1) to quantify morphological responses of roots and root hairs to soil drying and to quantify the corresponding impact on the root-soil contact area; and 2) to estimate the effect on root water uptake by means of image-based modelling.

We scanned root compartments of 8 days old maize plants (Zea mays L.) using synchrotron radiation CT. The segmented images were utilized to quantify the root soil contact area and to extract the geometries for image-based simulations of water flow through soil and roots. The data show a progressive loss of contact between roots and soil during soil drying. Root hairs shrink at relatively high soil matric potentials (between -310kPa and -30kPa), while the main root shrinks at more negative soil matric potentials (below -1000kPa). The image-based model shows the importance of root hairs and their shrinkage for root water uptake.

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P-221

Biomass and Carbon Sequestration Potential of Winter Wheat and Barley agroecosystems in continental Croatia

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One of the most significant questions of the world that struggles with how to address climate change is how to reduce increasing levels of carbon dioxide (CO_2) in the atmosphere. One of the strategies for climate change mitigation is carbon sequestration i.e. storing of atmospheric carbon (C) into the plant/soil pool. This accomplishes not only the aim of reducing levels of atmospheric CO_2 but it is also improving soil health, leading to higher yields, nutrient contents and other agroecological benefits. The relationship between carbon sequestration and plant/soil carbon input is complex and depends on many elements like land use types i.e. crop type and cultivar, soil properties, agrotechnical measures, etc. Therefore, the aim of this study is to determine the biomass yields and carbon sequestration potentials of two arable crops (winter wheat and winter barley) and their four different cultivars. In order to determine biomass yields, biomass carbon contents and sequestration potentials, four different cultivars of winter wheat (Srpanjka, Renata, El Nino, Kraljica) and winter barley (Rex, Lord, Barun, Panonac) were destructively harvested at three randomly chosen 1 m^2 of each cultivar in continental part of Croatia at 2021 harvest. In this study, the above-ground (grain and straw: stems + leaves + chaff) and below-ground (roots + stubble) biomass yields, the allocation of atmospheric carbon within biomass and sequestration potentials of each cultivar will be presented.
This research was funded by European union from Operational Program Competitiveness and cohesion of European Regional Development Fund via project “Production of food, biocomposites and biofuels from cereals in the circular bioeconomy” (grant number KK.05.1.1.02.0016).

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Effect of a Biostimulant on the physicochemical properties of soils with different texture and salinity levels

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Several studies try to evaluate the effect of organic products as bio stimulants in crops and with less emphasis on soils, although it is in this environment where they are applied and therefore come into contact with plants by root system. For this reason, the research aims to determine the effect of a root biostimulant on the physical and chemical properties of different soils. The experimental design consisted of a multivariate design composed of 3 textural classes (clay loam, loam, and sand), 3 salinity levels (not saline, saline, and very saline), 3 biostimulant doses (0 L / ha, 2 L / ha, and 4 L / ha), and 2 periods of measurements (30 and 60 days respectively). The main outcomes showed that the application of biostimulant (dose of 4 L / ha) reflected a significant improve on aggregates stability in the non-saline clay loam soils, and therefore counteracted the effect of soil salinization. Despite the fact that the evaluated biostimulant is mainly directed to the root system of the crops (since it is an inducer of tolerance to metabolic stress in the plant), the results showed several improvements in the physical-chemical properties when the product was added on soil. However, the experience did not obtain a statistical significant differences between doses of 2 L / ha and 4 L / ha.
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P-223

Implications of root mucilage on the rhizosheaths formation

Mrs. Riffat Rahim, Prof. Dr. Eva Kroener

Root exudates stimulate microbial activity and function as binding and adhesive agent that increases aggregate stability in the rhizosphere. The exudates produced from plant roots and microorganisms in rhizosphere play a significant role in the formation of rhizosheath. Rhizosheath is defined as the soil attached to plant roots when excavated from soil upon gentle shaking. The standard and robust method to monitor and quantify rhizosheath formation remains unclear. To address this question, in this study we experimentally studied rhizosheath formation in response to various concentrations of chia seed mucilage coupled with 1D simulations using a partial differential equation. Here, we compared rhizosheath development in two different soils under five different concentrations of mucilage. We investigated rhizosheath development by using artificial roots made of flax cord to mimic plant roots under various chia seed mucilage concentrations. We found that (i) at low chia seed mucilage concentrations, the development & formation of rhizosheaths were smaller, (ii) at intermediate concentrations of chia seed mucilage, the formation of rhizosheaths were greater and more coherent while on the other hand (iii) at high chia seed mucilage concentrations, the development of rhizosheaths was again smaller. This study represents how rhizosheaths formation is controlled by the concentrations of chia seed mucilage with the interaction of soil moisture, drying & wetting cycles, and soil compaction. It is still challenging to monitor rhizosheath formation together with other soil mechanical properties in a realistic and quantitative way.

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P-224

Effects of low soil pH on nodulation, symbiosis, and N-fixing capacity of wild Cicer species

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Wild Cicer may be a source of acid tolerance traits to improve the adaptation of cultivated chickpea to acid soils. A soil experiment was carried out to determine whether a soil pHCaCl2 of <5.0 hampered the growth of wild Cicer species and their symbiosis with Mesorhizobium. Three levels of initial pHCaCl2 (4.0, 4.5, and 5.6), three different inoculum treatments: Mesorhizobium inoculated, N-treated and uninoculated (and without N), and two wild Cicer: C. reticulatum (C. reti) and C. echinospermum (C. echi) were used in this experiment. At the lowest pHCaCl2 of 4.0, plant biomass was decreased similarly for both genotypes and under all inoculum treatments. All the inoculum treatments had similar plant biomass at pHCaCl2 4.5 whereas Mesorhizobium inoculated wild Cicer had higher plant biomass at pHCaCl2 5.6 compared to N-treated plants. Only inoculated plants formed root nodules and there was no significant difference in nodule number and nodule dry weight between the two species. At 3 weeks, no nodules were found on plants grown at pHCaCl2 4.0 whereas, at 8 weeks, plants grown at pHCaCl2 5.6 had a greater number and dry weight of nodules. Moreover, at all pH levels, inoculated plants had lower total shoot N concentration, but at pHCaCl2 5.6 both inoculated, and N-treated plants contained a similar amount of shoot N. Therefore, both genotypes at moderately acidic pHCaCl2 5.6 produced effective symbiosis with Mesorhizobium as they formed higher number and dry weight of nodules and fix adequate amount of shoot N.

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P-224A

Study of inter-tillage weeding in paddy field without agricultural chemical and fertilizer: 1. Rice growth and yield.

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Inter-tillage was usually conducted to remove weeds without chemicals. In natural farming, it was succeeded to get a high yield in paddy fields by introducing multiple inter-tillage without agrochemicals and fertilizers in Japan. This study is to clarify the influence of multiple inter-tillage weeding on rice yield and growth in Hokkaido. The measurements lasted for 4 years (2018-2021) under four different treatments: no inter-tillage (0T), twice inter-tillage (2T), five times inter-tillage (5T), and modern conventional cultivation (CF). In 2018, the yields of inter-tillage plots (531 ~ 566 g/m²) were all higher than that of the regional average of conventional rice cultivation (497 g/m²). In 2019, the yields of inter-tillage plots (220 ~ 272 g/m²) were all smaller than that of the regional average (547 g/m²). In both 2018 and 2019, there was no significant difference ($P < 0.05$) in yield among the three inter-tillage plots. However, in the third and fourth year, although the yields of inter-tillage plots were still lower than the regional average (561 g/m²), the yield of 5T was significantly higher than the other two inter-tillage plots and the order was 5T (354 g/m² in 2020, 308 g/m² in 2021) > 2T (209 g/m² in 2020, 218 g/m² in 2021) > 0T (173 g/m² in 2020, 153 g/m² in 2021). Meanwhile, plant weight, number of tillering, plant height, and most of the yield components increased with higher inter-tillage frequency. The difference among the three inter-tillage plots became significant which proved multiple inter-tillage could improve rice growth.
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P-225

Impact of legume cover crops on soil microbial indicators in a bi-annual cereal rotation system

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Legumes are used as cover crops/intercrops to reduce the environmental impact on farming systems and improve their sustainability. Here, we evaluated several soil health parameters affected by the introduction of legume covers crops (LCC) in an irrigated maize-wheat rotation, particularly, the abundance of the main groups of microorganisms and their activity. The trial was established in 2018 in Central Spain with the following treatments: control maize-fallow-wheat-fallow-maize (R0); autumn LCC+barley mixture between wheat and maize (R1); a combination of vetch interseeded into maize before wheat plus LCC+barley between wheat and maize (R2). The treatments were established with two types of tillage, traditional (TT) and minimum (MT), leading to six combinatory treatments: R0TT, R1TT, R2TT, R0MT, R1MT and R2MT. Abundances of bacteria (16S), fungi (ITS) and archaea (16S), genes related to fungal (FGH3) and bacterial (BGH3) β-glucosidase activities, and eco-physiological parameters of the soil microbiota (qMIC, qCO2/TOC) were quantified. The different LCC management modulated the abundance and activity of the major groups of microorganisms. qMIC showed its highest values at R1TT, R2TT, R1MT and R2MT, indicating that legume cover favoured the establishment and energetic metabolism of the microorganisms. These results concurred with the highest abundance of fungi (R1TT), bacteria (R2MT) and archaea (R1MT). But the lowest values of qCO2/TOC showed the highest efficiency in terms of carbon use and quality when the legume cover coincided with MT (R1MT and R2MT). The integration of molecular analyses and eco-physiological parameters of soil microbiota allowed us to deduce which treatments improve soil health.

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Increasing legume input into rotations through interseeding cover crops: Effects on soil and crop as affected by tillage system

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Legumes in rotations, either as a main crop or as a cover crop (CC), provide important nutritional and environmental benefits in agroecosystems. Interseeding CC into maize shortens the establishment time and allows an additional legume CC in the short winter window after maize. However, CC management could modify the expected benefits of legume entry in rotations. In a field trial established in 2018 in Central Spain, we evaluated the impacts on soil and maize variables of increasing legume input in an irrigated maize-wheat rotation with different tillage systems. We tested three legume input levels: i) rotation maize-wheat with bare fallow (RO); ii) autumn CC mixture (barley-vetch) between wheat and maize (R1); iii) vetch interseeded into maize before wheat, in addition to the autumn CC mixture between wheat and maize (R2). These levels were applied under traditional or minimum tillage, with CC residues incorporated or left on the surface (crimper rolled), respectively. The level and form in which the CCs were managed influenced total and mineral soil N, microbial biomass C, mycorrhizal colonization, hyphal length, and maize chlorophyll. The soil bulk density reduced the most in R2, which had a particular interest under minimum tillage. In general, the addition of vetch interseeded into maize (R2) did not provide a notable advantage compared to R1 for most of the variables studied. Since the tillage system and the resulting residue management can greatly modify the effects on soil health of increasing legume inputs in rotations, they.are key when designing more sustainable cropping systems.

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P-227

Effects of Rice-Green Manure Rotation on Soil Fertility under an Environmentally-Friendly Farming System

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Due to its acidic Andisol and long-term rice monocropping system, Guandu Plain has faced some problems, such as low availability of phosphorus and unbalanced nutrition status in soil, gradually building barriers to local agricultural development. The aim of this three-year study was to increase soil fertility on Guandu Plain via an environmentally-friendly farming system with rice-green manure rotation, so that swapping soil redox status between paddy field and upland cropping on a regular basis. Green manure (a combination of Asteraceae, Leguminosea and Polygonaceae) was planted after the harvest of first season rice (Oryza sativa) and plowed into the soil at the end of its flowering period with the intention of increasing soil organic matter after decomposition. To evaluate changes in soil fertility and compare with a conventional farming system, soil sampling was conducted once every year from September 2018 until January 2021. Soil samples were analyzed on pH, electricity conductivity (EC), organic matter (OM), total nitrogen (TN), ammonium (NH4+-N), nitrate (NO3--N), total phosphorus (TP), available phosphorus (AP), total potassium (TK), and available potassium (AK). The results showed that TN and AP were significantly increased during the three years, while EC and NH4+-N were decreased ($p<0.05$). In addition, AP increased more than two times (from 12.0 to 37.4 mg/kg) throughout the experimental period. In conclusion, the method of environmentally-friendly farming with rice-green manure rotation applied on the paddy field of Guandu Plain may increase available nutrients in soil, especially phosphorus, with the potential of increasing both quality and quantity of rice.

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Pore-scale Simulation of Mucilage Drainage

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Plant roots exudate mucilage – a polymeric substance – which affects a thin layer of soil around the plant roots. This thin layer, rhizosphere, has different properties comparing to the bulk soil. For example, during drying, rhizosphere will remain wetter than bulk soil because of slow response to changes of water potential. Then presence of mucilage will change pore distribution of liquid and gas phases and hydrodynamic process in soil-root interactions.
Overview of the literature and previous models show the lack of a pore-scale dynamic model for a better understanding of the connectivity between different phases over drainage and irrigation cycles. A major challenge is that mucilage shows a complex behavior which covers phase transitions upon drying from a rather Newtonian liquid at very low concentrations, to a shear-thinning non-Newtonian fluid, a hydrogel of viscoelastic properties and finally to a dry solid.
In this study a pore-scale model based on the Lattice Spring method is introduced and employed to simulate the drainage of mucilage within the pore space. It is capable of reproducing spider-web like structures that are specific for mucilage and will be qualitatively validated by comparing simulation results and ESEM images of dry mucilage between glass beads.
The proposed model may provide us not only with a new perspective on hydrodynamic pore scale processes in the rhizosphere, but it may also help to advance models of further rhizosphere processes that depend on water dynamics, i.e. solute transport, gas diffusion, soil mechanics and microbial activity.
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Fragment size and diversity of mulches affect their decomposition, nutrient dynamics, and soil microbiology

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Plant-based mulch is a sustainable way of maintaining agricultural soil fertility. However, the factors affecting its decomposition, and their effect on crop yield are largely unknown. We investigated how mulch quality, proxied by the constituent plant species diversity, and mulch size drive mulch decomposition, crop nutrition, and yield.
A rhizotron experiment was set up with barley as a model crop, with the addition of mulch of two particle sizes (1.5 and 30 cm) and four different plant residue mixes (17, 12, 6, and 1 species) in a fully factorial design. Soil nutrient dynamics were measured throughout the experiment, together with residue quality, arbuscular mycorrhizal fungal (AMF) colonization of barley, and crop yield.
Dry mass loss of plant residues was significantly affected by residue diversity. Long residues (30 cm) retained significantly higher C and N content, and C:N ratio, compared to short residues (1.5 cm). Crop yield was not affected by residue diversity or size. Long residues supported higher rates of barley height at the stage of rapid stem elongation than short residues, influencing seed protein content. Soil available K was significantly increased by residues with a higher initial C:N ratio and recalcitrance. Short residues resulted in higher soil Zn. Residues of higher diversity demonstrated higher AMF root colonization.
Generally, long-residue mulches protect soil and maintain soil fertility for longer period than short-residue mulches without a deleterious effect on crop yield. Further investigation should evaluate the long-term effect of continuous application of long-residue mulches on soil fertility, and microbial populations.

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P-230

PREVIOUS CROP AND NITROGEN FERTILIZATION EFFECTS ON SOIL HEALTH INDICATORS IN WHEAT

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Soil microbiome plays an essential role in biogeochemical cycles and ecosystem services provision. The rotation of grasses with legumes may stimulate symbiosis with beneficial soil microorganisms as well as microbial activity. The reduction of nitrogen fertilization after legume introduction can enhance mycorrhization with potential benefits in crop nutrition. Our aim was to evaluate the effects of the previous crop (legume vs grass) and nitrogen fertilization on several soil microbial parameters in the subsequent wheat crop as part of a larger experiment. The trial was established in a Calcic Haploxeralf of Central Spain with barley and pea as previous crops; O and 75 kg N ha-1 were selected as fertilization levels. Wheat was sampled (0-15 cm) at the flowering stage. Mycorrhizal colonization was reduced by 31% in fertilized wheat compared to unfertilized one, being this reduction greater after pea than after barley. The hyphal length in wheat after barley increased by 27% compared to wheat after pea, without N dose effect. Basal respiration followed a similar trend as hyphal length, whereas the preceding pea and the N fertilization increased the microbial biomass carbon. So, pea reduced the metabolic coefficient (qCO_2) by 32% and, at the same time, increased ($p < 0.1$) the microbial coefficient (qMic) in wheat. This study found that barley improved mycorrhization parameters in the subsequent wheat more than pea did. But, in general, there was a positive effect of the previous pea by providing conditions that enhance more efficient use of carbon and greater stimulation of microbial populations.
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P-231

Raiders of the lost trait: screening historic wheat landraces for root traits linked to soil microbiome functions in the rhizosphere

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Nitrogen (N) fertilisers applied to crop systems supports half
of the worlds food production. However, approximately 50% of this N worldwide is transformed by soil microbes (through
nitrification/denitrification) and lost to the environment by leaching/gaseous emissions. Biological nitrification inhibitors
(BNIs) exuded from the roots of certain varieties of plants can reduce loss of N-fertilizer [1]. Particularly, some historic
landraces of bread wheat (Triticum aestivum L.) have shown evidence of BNI activity in their root exudates [2]. However, this effect was only tested for one specie of nitrifying bacteria.
To explore the effect of growing different wheat genotypes in the rhizosphere microbiome, we have performed 16S amplicon based sequencing for rhizosphere soil collected from 86 wheat genotypes grown in an agricultural field. We have identified two genotypes with contrasting impact on the microbiome composition and functionality [3]. This effect was confirmed with shotgun metagenomics sequencing of the same rhizosphere soil. Then, we have sequenced (16S) rhizosphere soil from 88 recombinant inbred lines derived from the wheat parentals with contrasting capacity to control nitrification in the rhizosphere. We have identified genomic regions in the wheat genome significantly linked to the abundance of nitrifying communities and nitrogen cycle functions in the rhizosphere soil. This knowledge will allow to introduce this agronomic trait into modern cultivars [4]. The benefits for soil health will be the improvement of N cycling in soil and the reduction of N loses to the environment. In addition, this trait will increase the efficiency of use of N-fertilizer by crops.

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Root traits for improving soil ecosystem services with intercrops

Ms Zohralyn Homulle, Dr Alison J. Karley, Dr Mariya Ptashnyk, Dr Timothy S. George

Intercropping is a means of diversifying crops and improving the sustainability of agricultural systems. Intercropping, where two or more crops are grown in close proximity, can lead to greater plant productivity and improved ecosystem services, including more efficient nutrient and water use, weed, pest and disease suppression, and greater resilience. Diversity benefits are thought to result from mechanisms of complementarity that minimise competition (niche differentiation) and/or promote facilitation[1]. Many of these outcomes depend on positive plant-plant interactions belowground, but a comprehensive understanding is lacking regarding the underlying mechanisms and how intercrop root trait combinations can be selected to maximise the benefits[2]. We illustrate this complexity with a model of interacting roots developed to characterise the relative importance of different rhizosphere exudation traits for maximising root complementarity through improved phosphate availability and uptake[3].

In addition, based on a synthesis of the literature[4] and our recent research, we summarise evidence for root traits that promote complementarity in intercrops through mechanisms of niche differentiation and facilitation. We explain how these traits might underpin soil ecosystem services through improved soil exploration, conserving soil nutrients, encouraging beneficial soil microbes, and regulating soil-borne pathogens and pests. We propose a framework for selecting root trait ideotypes to improve specific intercropping outcomes, highlighting the importance of agronomic decisions for maximising root trait effects and their contribution to agricultural sustainability.

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P-233

Testing the causal relationships involved in a plant-soil system using a multi-scale approach

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In a context of agroecological transition, studies on plant-soil interactions are essential to promote sustainable crops in agriculture. However, rhizosphere studies modeling networks of interactions are facing difficulties to link rhizosphere functions to plant performances. Therefore, research should explore new methodological approaches and statistical tools able to model the complexity of the rhizosphere.
In this study, we studied winter wheat (Triticum aestivum) and collected two independent datasets in a controled lab experiment and on the field. Variables of interest from different components of the plant-soil system were measured : soil microbial communities and chemical properties, root functional traits and aboveground plant performances.
Structural equation modeling (SEM) was used to explore complex ecological interactions in a holistic approach by the identification of causal relationships between latent variables of interest. The aim of this study was to consider the robustness of causal relationships in order to determine if a multi-scale approach may help to understand plant-soil interactions.
Our models explained the functioning of the plant-soil system in a holistic approach, directly or indirectly linking rhizosphere and plant processes. Some of the causal relationships identified using data collected in the lab were maintained on the field, thus extending the results from the lab to the field.
Our conclusions elucidated SEM as a promising modelisation tool to study complex plant-soil systems. We also provided a methodological framework to describe plant-soil interactions on the field.

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Effects of root growth of a winter cover-crop on physicochemical properties of soil profiles in a Japanese Andosol

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The root systems of cover crops have been reported to reduce soil erosion and N loss. We examined the effects of winter cover crop of wild oat (WO) on the soil profile physicochemical properties and subsequent crop (SC) yields (Brassica rapa var. perviridis) in comparison with conventional farming (CF) systems as controls in Andosols, Japan. Vertical root distribution, physical properties (bulk density, compactness, three-phase distribution, and porosity), and chemical properties (NO_3^--N concentration, exchangeable cations, and available P) at 0–100-cm depths were determined. In WO field, which exhibited a large number of cover-crop roots, bulk density and compactness were reduced in top and subsurface horizons, exchangeable K+ concentration was reduced in deeper horizons, and NO_3^--N and exchangeable K+ concentrations were increased in topsoil. These results suggested the WO roots improved the soil physical properties in subsurface horizons and reduced N and K loss. Furthermore, incorporating WO residues enhanced the topsoil physical properties and supplied it with N and K. The fresh SC yields in the WO field were higher than those in the CF field. In addition, the soil horizons with a large number of SC roots expanded to a 0–30-cm depth in the WO field, and was thinner in the CF field. These results suggested that the improvement of physical properties and N and K concentrations in the soils at 0–30-cm depth by WO introduction contributed to the increased SC yields.

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Relating Soil-Microbial-Biomass with Simulated Nitrogen-Use-Efficiency and Soil-Organic-Carbon for Soil-Health Improvement in Winter-Wheat Systems on Acid Sandy-Loam Soils in Humid Subtropics

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Soil-health management practices (SHMPs) are guaranteed to produce resilient ways to revive nature and sustain agroecosystems. Increasing temperatures has deteriorated SH as it accelerated the mineralization of soil organic carbon (SOC) ubiquitously, but the impacts on soil microbial biomass (SMB) remains unexplained. Preservation of SMB pools is important as it controls soil-nutrient cycles, while preservation of SOC pools is also necessary to bring sustainability and mitigate climate change effects. However, the trade-offs under different organic-enriching SHMPs to recarbonize agroecosystems, and changes in the relationships of SMB with nitrogen-use-efficiency (NUE), SOC pool and biomass are still very intricate. We aimed to simulate the impacts of SHMPs and relate the variables with SMB. Our experimental soil is low-fertile acid sandy loam situated under humid subtropical-climate zone. SHMPs were cover-crops followed by 100% residue addition with 100% fertilizer, 100% manure and 50-50 manure +fertilizer (50-50MF) for a winter-wheat system. Seasonal soil-samples were collected for four years and analyzed for SOC, N, SMB. Data were used to simulate the system and find 1) soil-specific SHMPs that improve C sequestration, NUE and yield sustainability, and 2) establish empirical relationships of SMB with SOC. We noticed a specific seasonal-pattern in SMB in the surface-soil layer. While long-term simulated trends revealed that 50-50MF could be the best SHMP for resiliency. Relationships of simulated N-uptake, SOC and biomass also clarified how increased temperatures and soil-moisture loss would affect the accelerated loss of SOC. While our empirical relationships of SMB with SOC helped select SHMPs that support climate-resilient agroecosystems.

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P-236

Comparative evaluation of different types of composts for nutrients, humic acid and growth response of Amaranthus spp. var. Mohini

Ms Faniya Toby, Dr Sujatha M.P.

Application of organic amendments to the soil has become an utmost priority in tropical soils in the context of soil degradation, healthy crop production and threatening climate change scenario. So in this study we compared three different types of composts madeout of coirpith, urban wastes and weeds to evaluate the quality with respect to the content of nutrients, humic acids and the growth response of Amaranthus spp. var. Mohini. A farm derived inoculum namely jeevamrutham was used to produce composts from weeds and urban wastes. The study was carried out through a pot trial using two different types of soils belonging to the orders vertisol and ultisol. The results of the study revealed that content of humic acid were highest in weed compost (24.42gkg-1), while the coir pith compost (4.84gkg-1) was extremely poor in their content. Similarly content of macro nutrients were highest in weed compost compare to other two compost. Weed compost was also superior in increasing the growth of Amaranthus spp. to a large extent than urban manure and coirpith compost. Application of weed compost to the soils significantly improved the soil properties also. It was also inferred that fulvic acid from weed compost had high degree of polymerization, high molecular weight, high carbon content, and low oxygen content and low exchangeable acidity while that from coirpith compost has less degree of polymerization, low molecular weight, low carbon content, high oxygen content and high exchangeable acidity.

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Root growth interaction with soil physical properties on long-term tillage systems with cover crop management in Endocalcari – Epihypogleyic Cambisol

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Soil and crop management practices such as tillage and cover cropping are important factor for soil physical and hydraulic properties like the bulk density, water content, pore size distribution and it usually impacts plant root growth. The objective of this study was to gain insight in to the influence of tillage and cover crop management on soil physical properties and root growth and their association with spring barley water availability.
Research was conducted in long-term soil tillage experiments (1956), established in the field of Lithuanian Research Centre for Agriculture and Forestry (55°23'50``N and 23°51'40``E). The soil of the experimental site is on Endocalcari-Epihypogleyic Cambisol of a loam texture (IUSS Working Group WRB, 2015). The field experiment was a split-plot design in four replications with two factors. Tillage systems - deep ploughing (DP), shallow harrowing (SH) and direct drilling (DD) were the main plots and cover crop (white mustard Sinapis alba L.) were as sub-plot in a particular crop sequence.
White mustard significantly decreased soil bulk density, at the soil surface, for DP and DD technologies and tended to reduce soil bulk density at 10-20 cm for all tillage technologies. Total porosity tended to increase at the arable layer, as influenced by the white mustard for all tillage technologies. Roots were concentrated in the 0-10 cm soil layer all tillage technologies and their volume were higher than in the 10-20 cm soil depth. Roots volume increased total porosity in SH and DD technologies within the entire 0-20 cm soil depth.

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P-238

Rehabilitation of degraded soils with teak and fodder regenerative agriculture concept in Cherating, Pahang, West Malaysia

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The current need to empower farmers with skills to manage their unproductive land has initiated the utilization of degraded and marginal soils for the establishment of agroforestry. One such area that needs enrichment is BRIS (Beach Ridges Interspersed with Swales) soil (Amir Husni & Mona, 1991). BRIS is well known to be sandy, very low in fertility due to the absence of clay, somewhat excessively drained, having low cation exchange capacity (CEC) and base saturation. Thus, we administered 3 treatments, T1: Standard fertilization (full rate) with no gypsum; T2: Standard fertilization (half rate) + gypsum and finally T3: Standard fertilization (full rate) + gypsum. Our results show that gypsum (T2 and T3) was able to significantly increase mean basal diameter of teak (1.5 to 2 folds) at 6, 9 and 12 months after planting (MAP) compared to control (T1). Similarly, T2 and T3 were 1.8 to 2.5 folds signfiicantly higher for seedling heights of teak at 6, 9 and 12 MAP compared to control. The continued application of gypsum may enhance the growth of teak and fodder and provide a sustainable income for farmers (Liu et al., 1997).

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Soil composition and grape enological characteristics of Aglianico cv: a possible relationship in Irpinia land (southern Italy).

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Investigations on environmental peculiarities, which define the uniqueness of a specific production area and its products (Terroir concept by OIV, 2010), play a key role for viti-vinicultural zoning and precision viticulture. In this framework, a research work in the Avellino province (Campania Region), the earth of the Taurasi DOCG macroarea, aims to understand the possible relationship between soil properties and grape enological quality.

In selected vineyards, soil geochemical composition was preliminary measured by a pXRF Olympus on soils sampled by hand auger at 3 soil depths. Maps of the spatial variability of selected elements (such as Ca, K, Fe, Mn, Zn, Th, Rb) were obtained using the IDW implemented in QGIS. In the identified homogeneous areas (HZs), grapes were collected at harvesting (October 2019 and 2020). ANOVA Multivariata test shows significant differences among the HZs in terms of chemical and physical properties (granulometry, pH, organic matter, CEC, available P), as well as in terms of bioavailability of elements (such, as Ca, K, Mg, Na, B, Cu and Mn), enological characteristics of grapes (total acidity and pH, color index, total anthocyanins, etc.) and grapes elemental composition (content of B, Ca, Cu, Mg, Mn, Na, Li, Sr). PCA shows that the HZs separate on the base of soil properties and chemical composition, and these differences correspond to variations on composition of the related grapes. Soil bioavailability of Ca, K, Cu correlates negatively with anthocyanins, while Mg positively. Vintage effect and intra-varietal variability were also evaluated.

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P-240

An approach for the 3D characterization of crop water use in agronomic experimentation

Dr Dongxue Zhao

An approach for the 3D characterization of crop water use in agronomic experimentation
The complexity of the root system and the opaque nature of the soil have mainly limited the root phenotyping and crop water use to growing plants in chambers, pots, or intact soil to monitor water use and root expansion over time. These systems will introduce difficult to control side effects that alter the growing conditions of roots and shoots. Recent, advances in electromagnetic induction (EMI), offer potential to infer root activity within the soil profile at spatial resolutions down to several meters in the field, because it provides measures of soil apparent electrical conductivity (ECa) which is related to soil moisture.

Therefore, this study aims to i) answer whether EMI and inversion modelling can provide an approach for 3D characterizations of sorghum root and function, and (ii) research whether combining 3D soil moisture dynamics mapping, satellite imagery and simple crop-eco-physiological principles could be used to untangle complex GxExM interactions to inform optimum combinations of cultivars and agronomic managements in sorghum.

The results indicated that EMI can be used to rapidly and cheaply characterise water use and ET across large field experiments and is able to capture known GxExM interactions. Measurement errors are small as the sensed volume of soils is enormous. A root activity factor was derived to represent the presence of active roots at different layers in the soil profile. There is potential for the deployment of the solution through Digital Ag service providers

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P-241

Study of inter-tillage weeding in paddy field without agricultural chemical and fertilizer: 2. Nitrogen dynamics

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Inter-tillage weeding was a traditional weeding method in Japan, which performed from the time of transplanting to panicle initiation. Repetitive inter-tillage weeding gained high yield in a fertilizer-free, agrochemical-free paddy field. However, the nitrogen dynamics are unknown. The objective of this research is to clarify how inter-tillage weeding affects nitrogen dynamics in fertilizer-free and agrochemical-free field in Hokkaido.

To study the impact, nitrogen nutrient concentrations in soil solution and soil were measured in fertilizer-free and agrochemical-free inter-tillage fields (0T: no inter-tillage weeding field, 2T: twice inter-tillage weeding field, 5T: five time's inter-tillage field) and conventional field (CF) from 2018 to 2021.

The positive effects of repetitive inter-tillage on rice yield and growth were observed. When compared to conventional fields, the low concentrations of ammonium and total nitrogen in inter-tillage fields were maintained without significant differences throughout the growing season.

In soil solutions at 5 cm deep, the average concentration of early growth stage in 5T was greater than 2T and 0T, with the sequence 5T>2T>0T in 2018 (1.12ppm>0.72ppm>0.50ppm), 2019 (0.53ppm>0.36ppm>0.28ppm), and 2021 (0.48ppm>0.39ppm>0.25ppm). However, the 5T value in 2020 was 0.22ppm, while the 2T and 0T values were the same (0.18ppm). Due to the consumption of initial fertile nitrogen, the concentration fell until 2020. No significant differences of total nitrogen, available nitrogen, exchangeable ammonium and biomass nitrogen were discovered in soil and soil solution, while nitrogen absorption in 5T rice plants was significantly ($P < 0.05$) higher than that in 0T plants. We continue to study how the nitrogen condition will change.

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Investigating the Effect of Tillage and Cover-Cropping on Wet Aggregate Stability in Texas Wheat Systems

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Managing for soil health through conservation practices is key to sustainably increase the production of global agriculture. In Texas, there are low adoption rates of soil conservation practices by producers indicating a need for more localized soil health information. Wet aggregate stability (WAS) is an important physical indicator that measures how resistant soil is to disassociation in water. WAS plays a role in important soil functions and characteristics. Macroaggregates (>250 µm) are especially sensitive to soil use and management practices. The objectives of this study were to assess the impacts of tillage intensity, summer cover-cropping, and double-cropping on macroaggregate WAS and wheat yield. This research was conducted for three years in two Texas locations on different soil series (Parrita sandy clay loam and Burleson clay). Soil samples were manually wet sieved for WAS. The impacts of these practices on WAS and wheat yield were variable across both locations. Both locations experienced a minimal effect of tillage on WAS while double-crop sorghum did increase WAS in only one location. We further investigated the relationship between WAS, wheat yield, and soil organic carbon. A correlation exists between WAS and wheat yield with weak fits, but sorghum has the best fit ($R^2 = 0.78$, P-value = <.0001). These results are a step toward understanding how well WAS can be used as an indicator of soil functions. With only three years of study, a longitudinal study would better identify when the benefits of these practices are observed on WAS in these Texas soil types.

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Pre-application treatment of elemental sulphur and cow manure and their joint effect on soil pH and biological properties

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Elemental sulphur (S^o) is used as a fertilizer, beneficial for both, plants, and soil microorganisms, and as a pH-regulator in the composting process. Composting of elemental sulphur and organic amendment helps to increase its solubility and enables its oxidation by soil bacteria which transfer it to utilizable form for plant nutrition. Elemental sulphur was used for pre-application treatment of cow manure. Control and three experimental variants: manure (40 t/ha), manure + S^o (100 kg/ha) manure + S^o (150 kg/ha), were tested in a small-scale plot trial with canola, the plant with high sulphur demand, established in 2019. Chemical and biological properties of soil were determined after harvest.

Despite the reported acidifying effect of elemental sulphur on the amended soil, there were no differences among the pH values of all variants. Elemental sulphur availability and benefit to amount and activity of soil microorganisms was improved by manure-mediated composting pre-application modification. Both variants with S^o-enriched manure showed significantly higher microbial biomass carbon (MBC), glucose-induced soil respiration, β-glucosidase, and urease soil activities as compared to the control and soil treated with unamended manure. The enrichment of manure with 150 kg of S^o/ha led to the significantly highest MBC, lysine-induced respiration, N-acetyl-β-D-glucosaminidase, and phosphatase.

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Different digestate application on permanent grassland and its effect on selected soil properties

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The effect of different digestate application to permanent grassland on hay yield and soil microbial properties was studied in the field experiment. The digestate was applied after the 1st and the 2nd mowing under the soil surface in following doses: 80+0 m^3/ha; 40+0 m^3/ha; 40+40 m^3/ha; 20+20 m^3/ha; 0+40 m^3/ha; 0+80 m^3/ha; or conventionally on the soil surface in dose 20+20 m^3/ha. Soil samples were taken after the 3rd mowing.
All variants with digestate increased annual hay yield by 3% (40+0 m^3/ha) to 11% (40+40 m^3/ha) as compared to untreated control. Variant 40+40 m^3/ha showed the highest dehydrogenase activity (DHA), increased by 58%. The basal respiration was the highest after application of 40+0 m^3/ha and 40+40 m^3/ha, increased by 145% and 95%, respectively. All variants applied under the soil surface increased urease activity by 27% (0+80 m^3/ha) to 84% (20+20 m^3/ha). On the other hand, conventional application of digestate on soil surface showed worse basal respiration (-13 %) and urease activity (-7%) than the control.
In this study, a repeated application of digestate under the soil surface in higher dose (40+40 m^3/ha) is the most suitable for high and balanced hay production. Same variant showed the highest microbial activity (DHA) and the second highest basal respiration. In conclusion, the digestate application under the soil surface is more efficient than the conventional approach, both in terms of hay yield and the health of the soil microbiome.
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Cover Crops and Limited Grazing for Regenerative Agriculture

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Cover crops protect the soil in which they are grown by covering the soil surface, retaining nutrients, and improving soil structure, yet cover crop implementation remains low throughout the US. Lack of economic return and potential harm to subsequent crops are two of the primary reasons given for not implementing cover crops. However, growing cover crops that also provide forage can reduce the cost of animal feed, provide the benefits of cover corps, and reintegrate animal and row crop production. This study investigated the influence of added cover crop mixes to improve soil health and provide economic return through short-term grazing as a regenerative agricultural practice. A wide range of cover crops were evaluated in a small trial, while selected covers were evaluated with short-term grazing and subsequent impact of cattle to soil. The combined benefits of biomass, soil coverage, and forage quality made small grain and legume mixes that included oat, cereal rye, winter pea and vetch the top performing treatment for soil health and potential to graze. Subsequent crops were not negatively affected by additions of cover crop.

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Crop Diversification and Soil Health in Dryland Wheat-Based Agroecosystems in the Inland Pacific Northwest USA

Jodi Johnson-Maynard, Sanford Eigenbrode, Kendall Kahl, Dane Elmquist, Subodh Adhikari, Saugat Baskota, Kurtis Schroeder, Daniel Nessly, Jessica Kalin, Shelley Pressley, Eric Russell, Clark Seavert, Zhongming Gao, Erin Brooks

Crop diversification is a key component of regenerative agriculture and may lead to enhanced resiliency of dryland agroecosystems in the inland Pacific Northwest (iPNW), USA. Impacts of diversification on soil health and profitability, however, have not been widely reported. The goal of this 4-year study is to assess two alternative systems (winter pea and forage crop), relative to the business-as-usual rotation in two agroclimatic zones (annual and transition). Fallow is common in the transition zone, but restricted to wet springs that preclude the timely seeding of spring crops in the annual zone. Biological indicators (earthworms and Solvita-CO_2) were similar between the two sites, despite differences in precipitation. Predatory soil arthropod communities differed among crops, largely driven by high predator abundances in forage crops and winter pea. The Haney Soil Health test ranged from 9 to 12.5 across sites and years and does not appear to reflect treatments. Water lost under fallow in the transition site was about half that used by winter pea and wheat. Winter wheat yields were similar for each rotation in the annual zone, but were reduced when winter wheat followed winter pea or cover crop in the transition zone. Carbon uptake (assessed by flux towers) was generally positive, except for fallow (-105 g C/m^2) at the transition site. Additional data collection and determination of economic profitability are underway and will be discussed. The data set will allow a comprehensive assessment of the impacts of diversification and aid farmers in making management decisions related to regenerative agriculture.

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P-247

Impact of agriculture practices on the abundance and diversity of Myriapoda and Acari

Phd Annely Kuu, Prof. Mari Ivask, M.Sc Kaarel Sammet, M.Sc Marian Põldmets, M.Sc Merit Sutri, PhD Kaire Loit, PhD Merrit Shanskiy

Soil is vital to global function and soil quality is the capacity of a soil to function within ecosystem and land-use boundaries to sustain biological productivity. With an annual increase of world population the pressure to use more land for food production and the pressure to use existing farmland more intensively is inevitable. Our ability to estimate the health of soils has become a major issue for food producers and for land managers throughout the world. Soil biota is a vital force which serves to maintain the health of soils and soil biodiversity should be protected because of their functional properties. Mites are an integral part of the soil food web, playing an important role in decomposition, nutrient cycling, and aiding soil fertility. The diversity of centipedes have been used in habitat quality indication. The aim of this study was to assess how the abundance and diversity of soil biota (Myriapoda, Acari) are affected by the agrotechnologies applied in the fields. Twenty sample areas all over Estonia were selected in 2019. In conventional fields, soils were more acidic than in organic fields. The phosphorus and potassium content of the soil was higher in conventional fields. The abundance of Oribatida was the highest in the organically managed fields, the abundance of Prostigmata was the highest in the conventionally managed fields. Diplopoda were more represented in the conventionally managed fields, the most common species being Cylindroiulus caeruleocinctus. This work was supported by the H2020 program through the SoildiverAgro-project grant agreement 817819.

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P-248

A new agro-ecological paradigm : the triple green revolution or maximisation system. Concept and methodology

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A new ecological paradigm based on traditional and innovating inter/alley/mosaic/cropping systems is presented. It operates simultaneously on two time scales.
In the short time the protection and resilience of agro-ecosystems is foreseen with organo-mineral fertilisation (biochar, RCW, burning, bonechar, compost, mulch, lime, PK..) and bio-physical techniques for run-off control and agro-ecological management of the run-on (filtering with stone barriers, ridges, hedges, tree/herbaceous lines, Zaï, half-moon, fascines, ridges, mounds...).
In the long term the fight against greenhouse gases is based on the restoration of forests and tree/shrub fallows together with the preservation of Serrer parkland inter/mixed/alley/mosaic/cropping systems. Moreover crop association (multi-stage, multi-species associations) provide higher yields (Land Equivalent Ratio>1), effective disease/insect control, economical use of water (Water use Equivalent Ratio>1) and sunlight (Radiation Equivalent Ratio>1), and higher earnings (Income Equivalent Ratio>1) provided per unit area.

Transition from "positivism" to "constructivism" can avoid the ecological, economic, health and ontological chaos that the Double Green Revolution or Conservation system will only insufficiently resolve. This Triply Green Revolution or maximisation system, which uses environmental protection, increased CO_2 sequestration, soil resilience and biodiversity, thanks to the use of traditional and innovative empirical local knowledge reinforced by the analytical and predictive knowledge of researchers, may help will give farmers their ecological, economic, food and social sovereignty.

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P-249

Impact of Soil Health Practices in an Irrigated Sugarbeet Cropping System, Western USA.

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Producers in intensively cropped irrigated agroecosystems are encouraged to adopt reduced tillage, cover cropping, diversified rotations, and other regenerative soil health practices. However, impacts under challenging agronomic conditions with short growing seasons, low soil organic matter contents, and root-crop production are not well documented (Hurisso et al., 2015). To evaluate effects of soil health practices within a common three-year crop rotation, we initiated a long-term study in 2014 at the University of Wyoming Powell Research & Extension Center. The dry bean-barley-sugarbeet rotation was grown under conventional and soil health management under full and deficit irrigation. Soil health management included strip-tilling before planting sugarbeets and beans, no-till planting barley into bean stubble, allowing barley regrowth to act as a fall/winter cover crop, and direct harvesting dry beans. Results indicate that by 2020, after two full rotations, the upper 15 cm of soil under the soil health management system contained 18.3 Mg per ha of organic carbon compared with 11.5 Mg per ha under the conventional system. Organic carbon contents were similar across irrigation levels and current crops, but crop yields were lower in deficit- than fully-irrigated plots. However, barley yields where higher under soil health than conventional management at both irrigation levels. The yield gap between deficit-irrigated minimum-till barley and full-irrigated conventional till barley was narrower than between other treatments, suggesting that improved soil health is improving water use efficiency. Results suggest that regenerative farming practices improve soil health and water use efficiency even without drastically changing cropping systems.
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P-250

Organic and biological resources in Senegalese agroecological systems to biofortify local foods with iron and zinc

Mr Emmanuel Noumsi Foamouhoue, Asst. Prof. Aboubacry Kane, Dr. Frédéric Feder, Dr. Paula Fernandes, Dr. Samuel Legros, Mr. Jean-Michel Médoc

More than 500 million people in Africa, mainly mother-child pairs, suffer from iron and zinc deficiencies. These deficiencies result from low iron and zinc levels in crop products. The low availability of these micronutrients in Senegalese soils contribute to this problem. Agronomic biofortification is defined as increasing the levels of micronutrients in crop products with agroecological practices. The agroecological practice tested in this study is the combination of organic residual products (ORP) application with beneficial microorganisms (BM) to fertilize cowpea and orange-fleshed sweet potato. Our objective is to evaluate agronomic, nutritional, and environmental impacts of this practice at the field level. Two ORP and one BM were selected for the field trials with a 30 days laboratory scale incubation experiment of soil-ORP-BM mixtures under controlled conditions. ORP were selected according to their iron and zinc content, and their mineralization dynamics. The BM was selected according to his capacity to mineralize carbon and nitrogen and to solubilize iron and zinc from the ORP. Poultry litter and sewage sludge, selected ORP, and fermented forest litter from the south groundnut basin of Senegal mixed with groundnut shells, selected BM, were tested in a split-plot design, considering local agricultural practices. Crops fertilized with poultry litter and the BM present the highest yields. As nutrient yield, iron and zinc contents of the crop products and soil will be determined by ICP-MS. PLFA analysis will determine the impact of established systems on soil microbial communities.

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P-251

The influence of conservation agriculture on soil biophysical properties, crop growth and yield in the UK

Ms Bethany O'sullivan

The practice of conservation agriculture requires farmers to reduce soil disturbance, provide soil cover, and rotate crops. These methods have the potential to improve soil quality, reduce greenhouse gas emissions, and improve crop water use while also reducing the level of input needed to manage the crops. While these benefits have been demonstrated in semi-arid regions of the world, much less work has been done in temperate regions. This project investigates the effects of conservation agriculture on soil structure, soil biological activity, crop growth, development and yield, with a particular focus on the changes in these factors over eight years of implementation. Using x-ray CT scans of the undisturbed soil, along with more conventional methods of soil structure assessment: penetration resistance, bulk density, soil moisture content, and infiltration rates, links have been investigated between changes to the soil and changes to the crop growth and development. The soil organic matter saw a significant increase under conservation tillage practices ($P<0.001$) which has then appeared to result in an increase in crop biomass production (r2=0.67) and establishment rate (r2=0.62). Similarly, the surface soil water content saw a significant increase under conservation tillage practices ($P<0.001$) which also correlated with an increase in biomass (r2=0.66) and with grain weight (r2=0.52). Thus, when the causal factors of crop changes can be identified, use of farming technology can be targeted to modify the soil in the most impactful ways.

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P-252

Quantifying the true costs of farming systems

Miss Bethany Roberts

UK agriculture is at a point of major reform with the new environmental land management scheme (ELMS) due to be rolled out by the end of 2024. The ethos of ELMS is public money for public goods; spending public money on things that have public value but are not sufficiently provided for by the market. For example, soil health is essential to food production and serves public goods however, is not currently valued in conventional agricultural systems with soil erosion and compaction from agriculture estimated to impose an external cost in England and Wales of £305M in 2010. The government have recognised the urgent need to protect these natural assets and ensure that food production today does not come at the expense of food production tomorrow. Therefore, within ELMS will be a sustainable farming incentive available to farmers, awarding payments such as for improved soil health.

However, there is currently no standardised metric for assessing the sustainability of farming systems and there is little empirical evidence whether and under what conditions a transition to more sustainable systems, like regenerative agriculture, can be more profitable.

Utilising a large-scale field experiment with gradients of crop rotations, soil disturbance, crop protection strategies and nutrition amendments we have developed practical methods for monitoring natural capital and built a sustainability metric which incorporates and values both natural capital and conventional profitability. Thereby, allowing us to assess trade-offs and synergies directly to understand the interdependencies between agricultural land use and natural capital and ecosystem service delivery.

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P-253

Microbial abundance and activity as soil health indicators relating to long-term crop yield in a dryland cropping system experiment

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There is a need for including soil physical and biological properties along with chemical properties to accurately measure soil health and relate to crop yields. The objective of this study was to determine a suite of soil health indicators that were sensitive to cropping systems and N fertilization and relate to soil properties and dryland crop yield in a 14-yr-old cropping sequence and N fertilization study in eastern Montana, USA. Treatments were conventional till barley/spring wheat-fallow (CTWF), no-till continuous barley/spring wheat (NTCW), no-till barley/spring wheat-fallow (NTWF), and no-till barley/spring wheat-pea (NTWP), each with two N fertilization rates [0 (N0) and 80/100 kg N ha-1 (N1)] applied to barley and spring wheat. The NTCW increased aggregate stability, wet aggregate stability index, average slake aggregate, P concentration, KMNO4-extractable C, CO2 flush (1 d incubation), potentially mineralizable N, and N-acetyl β-glucosaminidase (NAG), but reduced NO3-N concentration compared to other treatments. Water-stable aggregation, macro-porosity, volumetric water content at water saturation, and Mg concentration were greater with N0, but water-extractable total N and NO3-N concentration were greater with N1. Mean crop (barley/spring wheat) yield from 2006 to 2019 were greater in NTCW with N1 than other treatments. Multivariate analysis showed that phospholipid-derived fatty acid (PLFA) and CO2 flush at 4-d incubation were negatively related to Ca and Al concentrations, but positively to crop yield. Microbial abundance and activity can be used as important soil health indicators that were enhanced by no-tillage with increased cropping intensity and related to crop yield.

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P-254

Does regenerative farming practice positively impact soil health properties and total glomalin in agricultural soils?

Miss Katy Jo Stanton

Soil degradation through intensive agriculture is a global issue, with the UK facing net loss of soil from land that now exceeds new soil formation rates, resulting in major costs from the impacts of agricultural run-off and diffuse water pollution. Regenerative agriculture aims to reduce intensity through sustainable farming systems that rebuild soil organic matter and restore degraded soil biodiversity. Low-tillage, cover crops, and mob-grazing are techniques designed to reduce disturbance and promote soil aggregation. Glomalin related soil proteins (GRSP) are produced by arbuscular mycorrhizal fungi in plant mycelial networks, and act as a biological 'glue' improving soil aggregate stability, reducing erosion, and improving nutrient cycling and carbon sequestration. This research aimed to contribute to the available knowledge for GRSP detection methods and assess the impact that regenerative farming practice has on GRSP concentration in soils. Soil samples were taken across four blocks at a farm in Cornwall, UK, comparing pasture age, tillage, cover crops, mob-grazing, and outwintering bale management with soil properties and GRSP concentrations. Total glomalin related soil protein (T-GRSP) and easily extractable glomalin related soil protein (EE-GRSP) concentrations were highest in woodland and undisturbed areas, with no difference in GRSP concentrations found between bale line and grazing strips, suggesting regenerative mob-grazing has no negative impact on GRSP concentrations. GRSP concentrations were highest in the oldest pasture blocks that are zero-till, confirming GRSP concentrations are positively impacted by reduced soil disturbance. Limitations to GRSP detection methods were found and alternative methods investigated, to make recommendations for future research.
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P-255

Evaluation of soil ecosystem services and sustainable soil management in some Hungarian conventional, organic and permaculture horticultural farms

Alfréd János Szilágyi, Dr. Eszter Tormáné Kovács, Dr. Csaba Centeri

Soil is one of the most important natural resources, as it is a non-renewable resource on a human life scale. Numerous ecosystem services (ESs) are linked to soil, the most important is related to food production capacity and soil organic matter storage. Sustainable farm management should focus on soil characteristics as well. In the present study, we carry out a complex evaluation of different soil data that we gathered during 2020 in the field and link them to the ES and sustainability concepts. We measured soil compaction, soil moisture and decomposition ability of soils. Besides analyzing 14 soil physical and chemical parameters we also assessed soil life diversity, namely earthworms, nematodes and soil surface fauna. The field study was complemented with farmer interviews collecting data on farm management and understanding their attitude towards soil management and other environmental themes. Based on all the collected information, we evaluate five soil-related ecosystem services which are prevalent in these agro-ecosystems. For that, we apply the so-called cascade model, which describes the flow of services from eco-systems to human systems. We interpret the data from a sustainable management perspective as well. For that, we apply the relevant FAO-SAFA sustainability subthemes and indicators. Our hypothesis is that soil ES provision of permaculture and organic farms is higher than that of conventional ones because of having more sustainable soil management.

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P-257

FixOurFood: The impact of regenerative farming on soils in Yorkshire

Dr Ruth Wade, Dr Gesa Reiss, Professor Pippa Chapman, Professor Steven Banwart, Professor Lisa Collins

There is urgent need to transform the UK's food system to meet the demand of our growing human population whilst adapting to and mitigating climate change. Current food production that supplies UK diets is unsuitable: 33% of UK soils are assessed as degraded where 3 m tonnes of topsoil eroded each year, with intensive agricultural practises associated with the loss of 60% of soil carbon. Furthermore agriculture is responsible for 10% of UK's greenhouse gas emissions as well as over half the UK's methane emissions and ¾ of N_2O emissions. Regenerative farming seeks to address the historic global decline in soil stocks and fertility, C and N sequestration, terrestrial biodiversity and water quality, as well as offer increased agricultural productivity with social benefits. Working with a network of growers in Yorkshire, we present exemplars of regenerative farming in the local area and compare gas emissions, soil stocks and structure in fields using regenerative practises, with fields using conventional practises. Practice-based options such as mixed crop cover, novel livestock-crop rotations, greater crop diversity and reduced tillage, will be trialled at the University of Leeds farm and at local farms to quantifying the impacts of the regenerative farming practices on soil quality, crop production and greenhouse gas emissions. This work aims to determine the impact of regenerative farming changes on whole-life cycle GHG emissions, long-term profitability and environmental sustainability.

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P-258

Evaluating the natural flood management potential of soil use and management strategies

Miss Emily Trill, Professor Joanna M Clark, Dr James Blake, Peter Scarlett, John Robotham, Dr Ponnambalam Rameshwaran, Dr Gareth Old, Elinor Sherlock, Bel Whitwam, Adrian Hares, Amanda Ingham, Timothy Clarke, Helen Theobald, Dr Russell Frost, Richard Gantlett, Julian Gold, Professor John P Hammond, Professor Martin Lukac, Dr Tom Nisbet, Samantha Broadmeadow, Tom Ormesher, Professor Anne Verhoef, Louise Webb, Becky Willson

Soil use and management as a form of Natural Flood Management (NFM) has potential to increase infiltration and soil water storage above and below ground. As a result, it can slow the flow of water and reduce flooding caused by surface run-off, rivers and groundwater. Here, we report findings from the LANDWISE project (Landwise, 2021), which examined the potential of land use and management in lowland groundwater-fed catchments in the River Thames Basin, England. We focused on five soil classes within two geology types: shallow permeable soils on carbonate geology (Limestone and Chalk) and deep clay soils on mudstone geology; across agricultural land, grassland and woodland. We compared different farming systems, including conventional, regenerative and organic agriculture. We gathered empirical evidence of within and between field variation for different soil use and management strategies, through a broad survey of 160+ fields and an in-depth survey of 7 sites. We show that both land use and soil type are significant in affecting bulk density. We also show correlation between organic matter and bulk density, which is important for NFM as organic matter content can be controlled by land use and management practices. We adopted a co-production research approach, to deliver usable impacts for farmers who will ultimately deliver NFM through land use change and management. This work will inform policy and design and delivery of agri-environment schemes; such as the soil survey scheme, a key part of the DEFRA soil action plan. It will help co-deliver NFM alongside other ecosystem services.

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P-259A

Beyond environmental benefit: designing a framework for economic and social benefits of regenerative farming systems

Prof Thomas Baumgartl[1], Dr Jess Reeves[1], Dr Sarina Kilham[2], Dr Sosheel Godfrey[2], Mr James Diack[3], Dr Richards Culas[2], Prof Karl Behrendt[4], A/Prof Tom Nordblom[2]
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Although we know some of environmental benefits of regenerative agriculture, this is often only motivation for some farmers. The key elements to decision making around on farm practice are economic and social. In our study we investigate the capacity of regenerative agriculture to improve ecological function toward improving soil health and achieving desired and beneficial outcomes in agriculture. Despite a large number of examples and application of regenerative and conservation agricultural practices, there is still lack of certainty in empirical data to quantify the effect of regenerative agriculture. Further, the economic, environmental and social benefits of regenerative agriculture have not been holistically defined yet.
Our contribution will present those principles contributing to the structure of a framework and distinguish long-term societal goals against individual short-term goals. The framework incorporates natural capital into resource and land use decisions and the interconnections are modelled using known ecosystem services modelling techniques.
The presented pathway shows the conceptual design of models that take into account economic and financial risks inherent to agriculture and combine them with framework(s) that capture aspects of natural, human and social capital, and ecosystem services and that are currently poorly represented in agricultural decision support tools. Representative biophysical parameters will be presented as comparative and quantifiable indicators for the anticipated increase in soil health as a consequence of the transition to or already practiced regenerative agriculture.
The presentation will explain and discuss the concept of the framework and the approach taken to consider and incorporate social and economical benefits.

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P-260

Avocado regenerative agriculture. The case of Uruapan, Michoacan, Mexico.

PhD(c) Alma Barajas-Alcala[1,2]
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Worldwide, agriculture-related issues seem to have similar origins: monocultures, losses of water, and soil degradation. Furthermore, the multifunctional capacity of soils depends on their health. The aim of this research was to integrate a soil-detailed description with local perspectives for designing regenerative agriculture in central-western Mexico (Uruapan, Michoacan). To diagnose the soils, experimental farmland was selected based on: landscape and management. In this way, three profiles were described, analyzed, and classified (WRB 2015): two in avocado orchards and one in the forest. The soils were classified as Andosol, Luvisol, and Leptosol. The macronutrients have similar content and behavior; while the micronutrient content is related to the management of the orchards. At least 75% of those surveyed consider it important to maintain or increase productivity to cover the financial capital of sustainability. However, natural capital was more relevant, due to its relationship with the incidence of pests and diseases. We conclude that the regenerative agriculture basis are more related to soil biology and pedo-transfer properties than the presence of Trichoderma sp.

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P-261

Digital Regenerative Agriculture

Mr Thomas O'Donoghue

Regenerative agriculture has ridden a groundswell of follower and promotor support to international attention, generating new consumer markets and institutions in its wake. However, the jury is still out on the efficacy, contextuality, and feasibility of Regenerative Practices. The movement's associations with Agroecology, Permaculture, Syntropics, etc acknowledges the need for adaptive practice, an idea that does not easily fit with how "sustainable agricultures" have been promoted over the last 40 years. As a result, outcomes and goals have come to dominate discussions on direction but contextuality and natural limits present roadblocks.

The classification of landscapes and quantification of improvement will not only resolve issues of contextuality and efficacy, it will also, through farmer-to-farmer collaboration, provide land managers with contextually relevant advice and help decode the knowledge barrier to entry.

Digital Regenerative Agriculture will monitor, Crop, Soil, Water, Biology, and Human parameters. The Soil Security framework will guide natural limit benchmarking, as will landscape change mapping. The outcome will deliver farming systems optimised to feasibly achieve a set of intentions across contexts, farmers will be equipped with the tools to quantify the ecosystem services they provide, and consumer products through digital supply chains will be ready to take advantage of decommoditised markets.

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P-262A

Shifting to regenerative agriculture improves maize yield and soil quality in a conventionally driven farming system in Mauritius

Mr Vagish Ramborun, Professor Sunita Facknath, Professor Bhanooduth Lalljee

Agriculture in Mauritius is practiced at a high cost of synthetic inputs of inorganic fertilisers, pesticides, water, and fossil fuel based energy. Such an environmentally unsustainable approach has come into criticism in recent years, encouraging farmers to adopt more ecologically based, health and sustainable ways of food production. This study investigated a package of regenerative farming practices composed of mulching, no till and no fertiliser on maize growth, grain yield, and plant biomass in three successive crop cycles in the region of Vacoas, Mauritius. Four treatments: Regenerative Practices (R), Mulch (M), Fertilizer (F), Tillage (T), were tested at 2 levels each, and replicated 3 times. The 2 levels were mulch-no mulch, fertilizer-no fertilizer and tillage-no tillage. The present study revealed that No-till × No-mulch × Fertilizer and No-till × Mulch × Fertilizer were both possible options to replace Tillage × no-mulch × fertilizer (conventional method) not only for their ability to produce higher yield but also for their potential to conserve soil nutrients and buffer pH. The study further revealed that No-till × mulch × no-fertilizer had the potential of reducing CO2 emission over time. Soil Quality Index (SQIw) of each of the eight treatments were calculated and compared. The SQI ranged between 0.269 and 0.387. The present study revealed that the package of regenerative agriculture tested outperformed the conventional systems used presently, and can be used to replace the latter without loss of crop yield and farmer income, while being beneficial to the soil and the farming system.

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Surface spray application of PAM on leafy greens: effects on soil and crop metrics

Mrs Silvia Arpano, Dr Robert W. Simmons, Dr Lynda K. Deeks

The tillage intensity employed in the production of leafy greens, prevents the development of the natural-occurring soil structure, exposing the soil surface to soil splash, capping and sealing, with consequential impact on crop yield and quality[1]. Polyacrylamides (PAMs) are long-chained organic polymers. Despite their efficacy being well documented since the 70s, due to their extreme viscosity when mixed with water, their use in precision agriculture has been limited by the high amount of water required to deliver an effective dose of PAM[2].

This study presents the results of novel field application of PAMs using dual-fluid nozzles applied at 0, 40, 80 and 120 kg ha^-1 using 110-150 litres of water ha-1, alone or combined with Calcium Nitrate (1mol of Ca:1mol of acrylamide) to PAM at 80 kg ha^-1. PAM's effect on metrics of soil-crust formation on seedling emergence and stand establishment of coriander (Coriandrum sativum) and spinach (Spinacia oleracea) were quantified. Results showed a 24, 41 and 59% decrease in splashed soil or plots treated with 40, 80 and 120 kg ha^-1 PAM respectively. Emergence occurred significantly earlier and faster for plots treated with 80 and 120 kg ha^-1 PAM, but there was no statistical difference in hydraulic conductivity in Coriander. For Spinach, adding Calcium Nitrate reduced soil splash by 58% for PAM+Ca treated as compared with Control plots, and increased yield. Finally, PAMs associated with 50% less irrigation pre-emergence did not significantly impact hydraulic conductivity, emergence or soil splash, in respect to a commercially irrigated Control

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Soil surface roughness effect on slope hydrology and soil erosion processes

Ms Sophia Bahddou, Prof Wilfred Otten, Prof Jane Rickson, Dr Richard Whalley, Dr Ho-Chul Shin, Dr Mohamed El Gharous

Soil erosion is a result of detachment of particles or small aggregates from the soil surface followed by transport of the detached material. One factor that affects surface runoff and soil erosion is the soil surface roughness (SSR). Prior research reports that increasing roughness reduces generation of runoff and soil loss. In addition to that, it is widely found that across-slope oriented roughness best controls soil and water losses. However, to date there have been no studies into the effect of both magnitude and orientation of SSR on runoff, infiltration and soil erosion (i.e. by raindrop splash, overland flow and wind), occurring simultaneously. In this study, we compared the effects of up-down-slope oriented roughness, across-slope oriented roughness and random roughness, along with a smooth surface. We used a moderate slope gradient of 10%, a simulated rainfall intensity of 90 mm hr-1 and storm durations of 15 and 30 minutes. SSR was measured using the chain method before and after the rainfall event. Images of the soil surface were taken using a hand-held laser scanner to monitor the effect of rainfall and overland flow on the morphology. The outcome of this study shows that rainfall erosivity decreases SSR. In the random roughness treatment, this decrease was 64% of the pre-rainfall condition. This treatment generated significantly more runoff and soil loss and less infiltration than the other treatments ($p < 0.001$). Contrary to expectations, the across-slope oriented roughness did not always reduce runoff and soil erosion compared to the up-down-slope orientation.

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The impact of digestates on the structural stability of agricultural soils – a first typology

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Aggregate stability is a key indicator of erosion risk and of particular importance in areas dominated by loamy silt soils under conventional agriculture. Digestates, by-products from the growing biogas sector, are increasingly being used in agriculture as a combined organic amendment and fertilizer, though their impact on soil physical properties is poorly understood (Möller, 2015; Nkoa, 2014). The objective of our research is to assess how differences in digestate biochemical properties may influence soil aggregate stability dynamics following spreading.

A panel of 17 digestates representing the diversity of those commonly produced from operational anaerobic digesters were collected and characterized. Digestates were mixed at a dose of 6 gC/kg soil with aggregates of an agricultural silt soil and incubated under controlled laboratory conditions. Samples were taken after 0, 7, 14, 41, 98 and 183 days, and the soil aggregate stability analysed using the standard method (Le Bissonnais, 1996). Carbon and nitrogen mineralization and soil properties involved in aggregate stabilization were also monitored during the experiment.

The results showed four contrasting types of aggregate stability dynamic which differ in immediate effect, magnitude of effect and time to maximum effect. Using multivariate statistical analysis, these observed aggregate stability dynamics were compared to the characteristics of the digestate, as well as the parameters of anaerobic digestion and post treatment, to generate a typology of impact. This highlights promising pathways towards better management of different digestates in agriculture, as well as possibilities for optimizing digestate properties to better suit its use as a soil amendment.

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Increasing the fertility of arenosols in Nyírség in reforestations

Istvan Attila Kocsis, Zoltan Laszlo, Zsolt Sandor

The effects of climate change are increasing in Hungary, especially in areas with poor production conditions, such as the arenosols of Nyírség (NE Hungary). Carrying out reforestation here is a difficult task for professionals. The area is characterized by sand with poor humus content with an unfavorable water and nutrient supply. In the forest parts affected by reforestation, stump removal is done after the end-use logging. This is followed by depositing the stumps in tidy rows, which is most often done by unloading. In this phase of the work, the richest in organic matter layer (upper 5-10 cm) is also removed by moving the stumps and roots. This loss of organic matter is extremely unfavorable for the subsequent development of reforestation. Reducing weed competition in the initial period is key task for seedling growth and afforestation. To this end, deep plowing (70 cm) is carried out, loosening the compacted upper soil layers, and bringing the colloidal particles accumulated at deeper levels close to the surface while rotating the roots of the herbaceous vegetation. As a result, the amount of organic matter close to the soil surface is significantly reduced based on our research. Due to the loss of organic matter content of around 30%, the water and nutrient supply capacity of the soil deteriorates. According to the study, part of the organic matter content favorable for the development of the seedlings entered the stump rows, while the remainder appeared at a depth of 50 cm because of the deep rotation.

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Quantification of soil erosion using meteoric 10Be in volcanic soils of SE Iceland

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Icelandic Andosols are relatively young soils developed at the end of the Pleistocene and during the Holocene from airborne volcanic ejecta. Due to their specific physical properties, e.g., extremely high water retention and thixotropy, they are strongly susceptible to slope failures when disturbed, which is often evidenced in the landscape as e.g., landslides or rofabards (cliff escarpments). In Iceland, the soil erosion was mostly measured based on the sediment accumulation rates (SeAR) (questionable due to possible hiatuses not included in the calculations). Moreover, the Andosols are also considered as soils receiving large rates of aeolian deposition (a rate of 0,1-1 mm/year) which suggests a high rate of soil development in a long-time perspective.
The high geomorphodynamics of Iceland have led us to the following hypothesis: the erosion rates of Icelandic Andosols outbalance accumulation rates owing to the intense natural disturbances and human-driven changes. As a consequence, the evolutionary trajectories of the Andosols are modified, and phases of soil development are strongly affected. To check this hypothesis we calculated long-term soil erosion rates based on meteoric beryllium (10Be) which is a new approach in a volcanic environment. The research was conducted in SE Iceland nearby the Vatnajökull ice cap. The chosen area represents a sequence of volcanic sediments and well-developed Andosols subjected to transformations of various scales due to ongoing erosional and depositional processes.

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Development of badlands on brine substratum in the Jijia Hills from Eastern Romania

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Land degradation is one of the most important environmental threat on the agricultural hilly lands from eastern Romania. Of special interest is the occurrence on large scale of badlands as effect of soil and gully erosion on brine substratum in the Jijia Rolling Hills. Under these circumstances, based on field campaigns and using modern GIS techniques such as remote sensing and photogrammetry aided by with UAV surveys processed through SfM techniques, we managed to inventory the areas occupied by such extremely degraded lands. Also, we established that the pipping is the main triggering process downstream of alignments with coastal springs. Generally, the denudation rates are low, but in the long run such processes and landforms are distinctly inscribed in the local landscape.
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Gully head-cut inventory within the Moldavian Plateau from eastern Romania using classical and modern research techniques

PhD. Lilian Niacsu, Ionut Costel Codru, PhD. Andrei Enea

Gully erosion represents one major environmental threat within the agricultural hilly area of Moldavian Plateau, eastern Romania (~22.000km2). Among the triggering factor that influenced gully head retreat the most important are related to the landform features, favorable lithology, specific climacteric conditions and land cover changes on the background of improper human impact.
Under these circumstances, the main objective of our study was to achieve an up-to-date gully inventory at regional level. Till now, such a goal has been elusive and difficult to attain on the whole scale region due to traditional field methods that are time, financial and human resource consuming. Our approach follows modern research methods based on GIS techniques such as remote sensing and photogrammetry aided by with UAV surveys processed through SfM techniques.
The only existing gully inventory for the entire region of Moldavian Plateau between Siret and Prut rivers counts over 9000 gullies (Radoane et al, 1995). They mapped two main areas of severe gully erosion and estimated an average gully density of 0.1-1.0 km/km2, with maximum values >3 km/km2. Our results show that there are over 43.000 gully headcuts all over the region with an average density of 1.95 gully headcuts/km2. The maximum values arrive to 119 gully headcuts/km2.
All these findings prove that our case study area has one of the biggest densities of gullies in Europe. Consequently, based on such extremely degraded agricultural lands, this hilly region in the European Far East remains one of the poorest regions in the EU.
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Organic side streams from pulp and paper industry decrease soil erodibility

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The pulp and paper industry produces large quantities of organic side streams. In a circular economy, these valuable materials could be used in new value chains creating jobs and environmental benefits. In a 5-yr field trial, we made a single application of organic sludges (an input of ~8 Mg ha−1 C) and studied their effects on cereal yield, soil C content, and fungal and bacterial composition. In laboratory rainfall simulations, we also studied the effects of the soil amendments on susceptibility to erosion of a clay-textured soil. We measured the quality of percolation water passing through intact soil monoliths taken in each spring over five consecutive years after application.

Organic soil amendments reduced suspended solids (SS) and total phosphorus (TP) concentrations in percolation water over the 5-yr study period. The amendments had only minor effects on the soil C content after 5 yr, likely because of fast microbe-mediated turnover. The fungal and bacterial community composition was clearly changed due to amendments. We attributed the lower tendency for particle detachment in rain simulations to direct interactions of soil minerals with the added particulate organic matter and microbe-derived compounds that stabilize soil aggregates. This 5-yr field-scale experiment indicated that organic soil amendments can be used to mitigate adverse effects of food production to the quality of discharge waters. Especially in soils with low organic matter content, pulp and paper industry by-products can be a viable measure for erosion mitigation.

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P-270A

Did Palaeolithic Technosols exist? Palaeopedological study at the Upper Palaeolithic sites Kostenki 14 and 17, Central Russian Plain

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Technosols are believed to be formed only after the Neolithic revolution when humans began to alter soil properties owing to the onset of agricultural activities. New palaeopedological research at the Upper Palaeolithic sites Kostenki 14 and 17 proposes that Technosols already existed in the Palaeolithic period. Cultural layers at the archaeological sites of the Kostenki-Borshchevo region are often found with paleosol horizons. Despite the weak development of these paleosols, their "soil memory" contains significant palaeoecological information, whose interpretation is not yet clear.

One of the most debatable issues is pedogenesis of paleosols of so-called Upper Humic Bed (UHB) investigated at Kostenki 14 and 17. UHB (32-36 ka cal BP) consists of several polygenetic paleosols: Bg-Ah-BCk. Several interpretations of the first soil formation phase (Ah-BCk) have been proposed: hydromorphic, steppe cryoarid pedogenesis, and soil formation of rendzina.

Here we suggest an alternative version: anthropogenic alternation of humic horizons of UHB paleosols. Firstly, the abundance of microartefacts was observed in micromorphological thin sections. According to our hypothesis, dark material is represented not solely by soil humus but largely by black carbon. The presence of black carbon is confirmed by the analysis of the IR spectra of organic material. Thus, magnetic susceptibility peaks might be interpreted not by the presence of pedogenic magnetic minerals but by their pyrogenic synthesis. This will be confirmed by the magnetic characteristics' ratio: XARM/Xfd to XARM/Xlf. The analysis of organic biomarkers is also planned.

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P-271

Comparing effects of biocrusts on erodibility and nutrient allocation along a climatic gradient in the Chilean Coastal Range

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Erosion is one of the main soil degradation problems worldwide, water-driven erosion being especially significant due to its severity and widespread distribution. Biota play a fundamental role in stabilization of soils against erosion, with plants and microorganisms being widely studied in past years. Currently, more attention is also given to biological soil crusts (biocrusts), mainly due to their dominant role in arid environments, where limited water availability hinders the growth of vascular plants. Biocrusts are communities of poikilohydric organisms that mostly grow in the top few centimetres of soil. However, biocrusts also play an important role in soil surface stability and nutrient allocation in non-arid ecosystems. Here, they are often relegated to open spaces between vegetation or zones of disturbances.

In our study we seek to answer how biocrusts affect soil erodibility and related processes such as water and nutrients transportation in and on the soil along a 1500 km climatic gradient in Chile. We expect that as vegetation vigour and cover increase, soil erodibility decreases, with biocrusts being protagonists of this stabilization under low pedological development conditions. This effect will increase along the climatic gradient as edaphic and climatic conditions disfavour plant colonization.

This study will help to better understand the role of biocrusts in soil erosion control and will clarify its influence on soil losses under different climatic conditions.

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The impact of tramlines on water erosion in agricultural catchments

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Process-based soil erosion models have long been used as a well-suited tool to estimate soil erosion and predict the effectiveness of conservation measures. Despite a large number of scientific articles that emphasize the role of compacted tramlines for soil erosion and surficial nutrient transport, no study exists that integrates these artificial structures into process-based modelling at catchment scales. Our study aims to quantify the effects of tramline compaction on soil erosion dynamics within a catchment. For this reason, high-resolution spatial data (1x1 m) have been incorporated into the model EROSION 3D, which was employed, calibrated and tested for an erosive soil erosion event. Furthermore, we assessed the impact of the tramline direction to the slope (contour-efficiency) on soil erosion and runoff processes. The results reveal that (i) the parameterization of tramlines improved model outcomes, (ii) tramlines significantly contribute to overall soil loss and sediment entrance into the channel network, (iii) the bulk density of tramlines is an important driver of increases in soil erosion and runoff and (iv) soil loss and runoff depend on the angle of tramlines to the slope. Moreover, our investigation suggest that the impact of compacted tramlines have long been underestimated in soil erosion modelling and can assist in the assessment of surficial flow path connectivity. Thus, the integration of tramlines into soil erosion modelling is important for the implementation of adequate soil conservation and water protection measures.
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The impact of accelerating erosion of chernozem soils, in terms of agricultural production and food security

Prof. Bořivoj Šarapatka, Dr. Marek Bednář

Not only does erosion have an impact on soil properties and the non-productive functions of soil, but it also significantly affects crop yield. Research usually relates soil erosion to yield on a local scale, depending on the reduction in the depth of overlying horizons, nutrient loss, etc. There is, however, a limited amount of quantitative information on the effect of erosion on agricultural productivity at a regional level. Therefore we focus on the influence of erosion on crop yield in the intensively farmed chernozem region of South Moravia (CZ). Erosional and depositional areas show significant differences in soil properties, which are also reflected in total crop yield. For research in localities with the most widespread winter wheat crop, the Enhanced Vegetation Index (EVI) was used, which turned out to be the best correlate for yield. For the identification of erosion-affected areas, we made use of the specific method based on spectral NDVI and NBR indices derived from Sentinel-2. The relationship between yield and erosion was expressed through Pearson correlation, and the results showed a statistically significant linear reduction in yield depending on the level of degradation. An average EVI value was assigned to each of the three reclassified levels of degradation, which enabled us to specify the rate of decrease in yield when comparing degraded and non-degraded sites. A comparison of different farming approaches, with and without site-specific crop management, will also be presented. The research was supported by a project by the Czech agencies NAZV QK1810233 and TAČR SS02030018.

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New aspects on improving reliability of the method using rare earth elements as soil erosion tracers

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Agricultural soil erosion is widespread and serious environmental problem, destroying croplands' productivity, generating non-point source pollution, inducing significant carbon and greenhouse gas emission.
Being essential natural resource providing food, severe and still increasing degradation of soil aggravated by increasing demand for its provisions is a pressing problem. Deeper understanding of the processes endangering and destroying it leading to solutions of protection and prevention are essential.
Though soil erosion studies have long tradition, knowledge on the origin of eroded sediment is still limited resulting in gaps in controlling soil loss and associated nutrient and pollutant transport, and in developing appropriate watershed management tools. Tracing methods can provide spatially distributed erosion data filling this gap.
Using several rare earth elements (REEs) as tracers marking different parts of the study area helps tracking soil redistribution and identifying the place of origin of eroded sediment. Former experiments using REEs as tracers assumed that concentration of the tracer in bulk soil is equal to that in eroded sediment. Selectivity in REEs binding to soil aggregates of different sizes was investigated and reported stating that different adsorption characteristics can be observed in soils of different texture, but differences among REEs in mobility during erosion was not considered. This study aims to draw attention to the importance of the finding that different REEs are hosted in soils by various phases showing different erodibility, thus they may show various mobility due to erosion, which is a feature essential to know for reliable data evaluation in REE tracer studies.

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P-275

Fundamental change of the soilscape by the first cultivators in the Altsiedelland along the Danube in Lower Bavaria

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In Central Europe, from the Preboreal to the Atlantic, black earths formed in the loess-covered lowlands outside the glaciation areas of the Wuermian. North of the low mountain threshold they occurred in wide distribution in the so called Börden. As sites of high edaphic favor, they were specifically sought out by the crop farmers migrating to Central Europe (Linear Pottery Culture) and intensively used for agriculture. South of the Central German uplands black earths are documented only sporadically. We report a novel finding of a extensively preserved black earth, developed on the loess-covered rift terrace of the Danube near the city of Straubing, Lower Bavaria and preserved by a colluvium from prehistorical times. The pedological investigations go hand in hand with an extensive archaeological excavation, which documents the early settlement history and the development of agriculture from the immigration of the Linear Pottery Culture to the Bronze Age. Traces of agriculture from the time of the Linear Pottery are still preserved today and allow conclusions to be drawn about the intensity of use. The black earth itself, as well as the fill of Linear Pottery pits used as granaries, are 14C-dated, both in the form of bulk samples and on remains like plant macrofossils and charcoals. The colluvial cover of the black earth is dated with OSL. Further analyses are concerned with the nature of the carbon and address the question of what influence Neolithic soil management had on humus quality.

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Use of 137Cs and 210Pbex fallout radionuclides for soil erosion assessment on Ulleung island, Korea

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Most of the agricultural areas on Ulleung island in Republic of Korea are known to be vulnerable to soil erosion due to its steep slope. Estimation of soil erosion in Ulleung island is necessary to make plans for soil-conservation measures. However, it is difficult to apply USLE methods to Ulleung island due to the characteristics of volcanic ash soil and region-specific agricultural activities. Unlike the USLE, the fallout radionuclides (FRNs) would enable to estimate soil erosion through measurement of radioactivity in the soil sampling only. This study measured the site-specific concentrations of ^{137}Cs and ^{210}Pbex on both upland sites and a reference site to estimate soil redistribution (erosion and sedimentation). The average result of soil erosion assessment was 19.8 ton/ha/yr for using ^{137}Cs and 24.4 ton/ha/yr for ^{210}Pbex. The result of a flat area (Nari Basin) was -3.5 ton/ha/yr for using ^{137}Cs and -2.1 ton/ha/yr for using ^{210}Pbex, confirming that sedimentation (negative value) occurred due to the topographical factors of the basin. And there was a difference in the results of soil erosion at steep slope sampling sites depending on the fallout radionuclides, and there was no significant correlation between ^{137}Cs and ^{210}Pbex. The reason is considered to be that the half-lives of radionuclides are different and, unlike ^{137}Cs, ^{210}Pbex is continuously generated in soil and fallout by rain. We conclude that the FRN method can be used to assess soil erosion and redistribution in volcanic ash soil and steeply sloping agricultural areas on Ulleung island.

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Long-term effect of biochar on interrill erodibility of agricultural soils with different textures at pre-industrial kiln sites in Wallonia (Belgium)

Mr. Martin Zanutel, Mr. Adrien Lefebvre, Ms. Sarah Garré, Mr. Charles Bielders

Whereas the short-term effects (<5 years) of biochar on soil erodibility have been documented to some extent for a variety of agro-pedological conditions, the long-term effects remain unknown. These effects are nevertheless important to study given biochar's long-term persistency in soils. Therefore, soil aggregate stability and soil interrill erodibility were measured using topsoil (0-10cm) samples from a silt loam, loam and sandy loam cultivated soil on three kiln sites per site enriched with charcoal for more than 150 years in Belgium. Aggregate stability was determined according to Le Bissonnais (1996). Erodibility was derived using the equation proposed by Kinnell (1993) based on 90 min. rainfall simulations at 84 mm/h on 75 cm x 50 cm plots.

Century-old charcoal concentrations ranged from 0 (control) to 0.5-1.9% depending on the site. The presence of historical charcoal from kiln sites did not affect soil aggregate stability, irrespective of charcoal content or soil type. Overall, steady state runoff and sediment flow rate tended to decrease with increasing charcoal content. Because runoff and sediment flow rate decreased to a similar extent, interrill erodibility was not affected by the presence of century-old charcoal. Consequently, the charcoal does not appear to have a long-term impact on these soil mechanical properties, but rather an effect on runoff. This effect is independent of soil texture for the range of textures covered by our experiments. Further research may be needed to confirm the observed trends over a wider range of soil types.

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Emulator Construction and Sensitivity Analysis of WEPP model using GEM-SA

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Water Erosion Prediction Project (WEPP) 1)Model developed by USDA uses many parameters in its application. Though the data base of US is prepared, users of other areas have to decide these parameters by themself. Because it is difficult to measure all parameters of the objective area, it is important to examine which parameters are sensitive to the application. However, it is not realistic to run WEPP model many times on GUI in the sensitive analysis, because the CPU time becomes too long. Therefore, we tried to apply Gaussian Emulation Machine for Sensitivity Analysis (GEM-SA) 2)which was the R package to simulation results of WEPP with changing soil parameters (particle distribution, organic matter, CEC, albedo, initial water content and soil layer depth) and to construct the emulator using these results. Then, we conducted global sensitivity analysis of soil parameters. As a result, it was confirmed that the accuracy of the emulator constructed using soil parameters was not so high and parameters of the organic matter, sand and clay are sensitive.

1) USDA ARS National Soil Erosion Research Lab:
WEPP Model Documentation, USDA, 1995 http://www.ars.usda.gov/Research/docs.htm?docid=18073
2)The GEM Software http://www.tonyohagan.co.uk/academic/GEM/

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A soil improver to reduce runoff rate and soil losses in hydrophobic Mediterranean soils

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The high temperatures that soil reaches due to forest fires can make it more erodible. In many cases, soil shows an increase of soil hydrophobicity, promoting water erosion. This situation is very common in semi-arid Mediterranean areas and for this reason; this study aims to assess the effectiveness of the soil improver Aereo-ReGen on water erosion produced by rainfall simulations under laboratory conditions.
The experimental design consists in 15 soil trays distributed in five treatments: control, hydrophobized soil, hydrophobized soil + Aereo-ReGen, hydrophobic soil with ash and hydrophobic soil with ash + Aereo-ReGen. Three repetitions were prepared for each treatment and the trays were subjected to two rainfall events (separated by 30 days). Soil loss, runoff, porosity and microaggregate stability were determined according international methodologies.
The main outcome showed that Aero-Regen application reduced soil losses by 67.05 % when soil presented ash on the surface (more specifically, soil losses ranged from 11.31 g/L in hydrophobic ash soil to 2.15 g/L in hydrophobic ash soil + Aereo-ReGen). In reference to the runoff rate, it decreased 20.23% when the improver was applied (17.65 mm/h in hydrophobic soil with ash versus 14.08 mm/h in hydrophobic soil with ash and Aero-Regen). In the case of applying the improver on soils without ash, soil losses were reduced by 25.77%. For this reason, the best way to apply Aero-ReGen is right after the fire, when the soil surface has the highest amount of ash.

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P-279

Contribution of Cesium-rich microparticle to Cs-137 concentration of suspended solid in Oguni and Takase River at Fukushima

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A lot of Radioactive cesium (Cs-137) was released around the Fukushima prefecture, Japan, after Fukushima Daiichi Nuclear Power Plant accident. Most of Cs-137 remained in the forest surface soil layer, and could enter into the river via soil erosion during rainfall event (Tsuji et al., 2016; Osawa et a., 2018). Cesium-rich microparticle (CsMP) such as Cs-bearing microparticle and Cs-sorbing clay mineral might cause locally high levels of radioactive contamination (Miura et al., 2018). In this study, we investigated contribution of CsMP to the Cs-137 concentration of suspended solid (suspended Cs-137) in the river water.
We investigated at two study sites, the Takase River and the Oguni River at Fukushima Prefecture Japan, where the soil contamination conditions by Cs was several times different. When the river water level increased due to rainfall, 1 L of water was sampled every 20-minute intervals for 24 bottles at each rainfall event using an automatic sampler. For each 1L of water sample, the ratio of Cs-137 concentration derived from CsMP to the suspended Cs-137 varied widely as follows; 0-72% in the Oguni River and 0-80% in the Takase River. However, the ratio of CsMP to suspended Cs-137 for each rainfall event was approximately 10% in both rivers. It is considered that CsMP might locally increase the concentration of suspended Cs-137 in the river, but did not affect significantly Cs runoff in the river through the rainfall event.
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Temporal dynamics of soil erosion in coffee (Coffea arabica), Llano Brenes, Costa Rica

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Introduction. Water erosion is a natural phenomenon accelerated mainly by human activity. This contributes to soil degradation and is an environmental problem mainly due to the transport of sediments to other areas. Objective. Quantify the surface runoff and the rate of soil erosion at the plot scale under natural precipitation events in a shaded coffee plantation and determine the temporal dynamics and the influence of the main factors associated with this process at the plot scale. Materials and methods. The study was developed in Llano Brenes, Alajuela, Costa Rica. Nine plots were installed, each with a runoff meter and a container to collect sediment samples. Three time domain reflectometry sensors were installed to measure superficial soil moisture content. The data analysis was carried out on a monthly-annual scale, inter-event and intra-event (the infiltration model of Diskin & Nazimov, 1995 was applied). Results. The total annual runoff was 90.99 mm in 2018 and 102.66 mm in 2019. The sediment concentration was 2.14 g l-1 during 2018 and 1.88 g l-1 in 2019. In 2018 the loss soil was 1612 g m-2 and in 2019 it was 1692 g m-2; In general, the highest soil loss values were obtained in October of each year; The intra-event analysis allowed to explain the runoff generation based on the initial moisture content and precipitation. Conclusion. Total precipitation event, rain intensity, and superficial soil moisture content at beginning of rainfall event played an important role in the generation of runoff and soil loss.

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Proteinaceous Extracellular Polymeric Substances Increased the Streambank Fluvial Erosion Resistance of Root-Permeated Soil

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Plant roots add organic fibers to the soil environment that physically bind soil particles and biologically interact with microorganisms. To reduce streambank erosion rates, it is important to understand which root mechanism (physical vs biological) plays the dominant role in protecting soil from fluvial erosion. Therefore, the goal of this experiment was to quantify the impact of organic matter (OM), synthetic (inert) roots, and living roots on the fluvial erosion rates of streambank soil. To do this, six replicates of six silt loam soil treatments were created: 1) no roots (NR, control); 2) no roots, amended soil (NR-A); 3) synthetic roots (SR); 4) synthetic roots, amended soil (SR-A); 5) live roots (LR); and 6) live roots, amended soil (LR-A). Amended soil treatments were included to enhance microbial activity by adding 1 g dried and < 1 cm pulverized grass per 100 g soil. The samples matured in a greenhouse prior to flume erosion testing. Following erosion testing, soil samples were collected for analysis of extracellular polymeric substances (EPS). Preliminary results show that EPS-carbohydrates were significantly lower while EPS-proteins were significantly higher in OM-amended treatments compared to the unamended treatments. Root type did not have an impact on EPS. A significant negative trend was also found between EPS-proteins and fluvial erosion rates. Lastly, all OM-amended and LR soil treatments significantly reduced erosion rates compared to the control. Results of this study demonstrate that decreases in fluvial erosion due to roots may be the result of root-microbial interactions that stimulate microbial activity.

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Structural condition of agricultural soils in the UK

Dr Anne Bhogal, Dr Paul Newell Price, Dr Joanna Cloy, Dr Paul Hargreaves, Dr Lizzie Sagoo, Mr John Williams

The maintenance of good soil structure is central to the delivery of resilient, sustainable and economically productive cropping systems. Soil structure, consistence and porosity influence crop root proliferation (and hence water and nutrient use efficiency) and the movement of air and water through soils. Consequently, poorly structured and compacted soils are often associated with lower crop yields, higher inputs (nutrients, energy) and an increased risk of flooding, run-off and erosion, leading to soil and diffuse pollution to watercourses.

Regular monitoring of soil structural condition is vital at the field level to inform soil management decisions. The most effective and practical method for determining soil structure is the direct visual and physical examination of the soil profile. This paper considers the importance of soil structure to crop productivity and nutrient use efficiency and looks at the use of visual soil evaluation techniques for assessing soil structural condition. We report on the current condition of agricultural soils in UK, summarising the key issues identified by recent surveys of arable, horticultural and grassland soils. These surveys not only give a snapshot of the current condition of soils in the UK but also enable the identification of those soil types, regions and practices that are most vulnerable or at risk to degradation, and to which efforts to protect or improve soils can be targeted.

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Application of organic materials on land - Sustainable use in Scotland

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Recycling organic materials to agricultural land allows beneficial re-use of nutrients and can help to increase soil organic matter content. This supports crop growth, reduces farmer dependency on manufactured fertilisers and reduces waste disposal.

The diversity of soil types and agriculture in Scotland presents both challenges and opportunities for recycling organic materials, such as animal manures and slurries, anaerobic digestates, distillery/brewery wastes, composts and sewage sludge, to land.

The Scottish Environment Protection Agency (SEPA) aims to regulate organic material spreading to ensure that the right amount of the right material is spread at the right time and in the right place.

Some problems with spreading organic materials to land in Scotland are applicable globally, for example imbalances between nutrient release, crop requirements and available soil nutrient levels, while others are more specifically Scottish, such as copper build up in soil from repeated application of distillery waste.

As knowledge surrounding persistent organic pollutants in organic materials spread to land in Scotland is limited, we carried out a preliminary investigation of this. Results from this study (Stutt et al. 2019) will be presented. Similar investigations of other emerging contaminants (e.g. microplastics), are ongoing.

SEPA aims to ensure that organic materials continue to be spread safely and beneficially to land in Scotland and that spread materials and receiving soils are adequately characterised to realise these benefits. A mixture of monitoring, policy and guidance improvement, research and stakeholder engagement is required to achieve this.
Stutt E, Wilson I and Merrington G (2019). The assessment of organic contaminants in materials spread on land. Report for SEPA.
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Legislative tools to enhance the use of natural water retention measures in agricultural and water management sectors in Hungary

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Our study analyses the implementation of natural/small water retention measures (NSWRM) in the Hungarian legislation, especially from a soil and nutrient management point of view. NSWRMs enhance the adaptation of agricultural production to the extreme events of climate change. Despite a comprehensive set of techniques available to increase water retention on both catchment and farm levels, only a few of them are defined as legislative components in Hungary so far. We observed low acceptance and application of the measures by the end-users and a lack of knowledge on their effectiveness and optimal combinations. The Ministry of Interior and the General Directorate of Water Management are the main legislating actors from the water sector. The law enforcement actors are the regional water directorates, although they have less potential to influence farmers in applying NSWRMs. While the water sector authorities operate at the regional level, the Ministry of Agriculture and Hungarian Paying Agency are acting country-wide and have a significant impact on the application of NSWRMs by financial support or through potential fines.
Based on the results of interviews with the Multi-Actor Reference Groups (www.optain.eu), we can state that stakeholders have a growing interest in promoting and applying NSWRMs. However, the implementation of the NSWRMs is hampered by the 1) lack of coordinated cooperation between several actors, 2) the opinion that the measures decrease land for agriculture production, 3) that the investment will often pay off in the long term, and 4) the lack of general and expert knowledge about the measures.

OPtimal strategies to retAIN and re-use water and nutrients in small agricultural catchments across different soil-climatic regions in Europe, (2020) OPTAIN H2020 project (No. 862756). https://www.optain.eu/

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Evaluation of Two Rates of Legume Winter Cover Crop on Soil Function in the Central Valley of California, USA

Ms Sarah Light, Dr William Horwath, Geoffrey Koch, Dr Jeffrey Mitchell, Veronica Suarez Romero, Dr Amber Vinchesi-Vahl

Cover cropping, which can increase soil organic matter and soil health, is not widely adopted in annual cropping systems in California due to water limitations and short intervals between highly lucrative cash crops. This two-year research project evaluated two seeding rates of vetch (Vicia americana) compared to a winter fallow on soil function both from the perspective of farmers in the region and society at large. Both rates of vetch had the immediate benefit of out competing weeds and reducing bare soil. In one year, both seeding rates produced cover crop biomass with significantly more total nitrogen and carbon than the resident vegetation biomass in the fallow plots. Despite this, no significant differences in total carbon or nitrogen were measured in either annual, or end of project, soil samples. However, soil nitrate (NO_3) , which is readily taken up by plants, was consistently higher in cover crop treatments. Wet soil aggregate stability was insignificant by treatment at project end. Despite concerns that using a legume cover crop would increase N_2O emissions, there were no differences in greenhouse gas emissions (CO_2 or N_2O) between treatments. Grower perspectives on cover crop management will be shared. It appears that a lower rate of vetch seed (39 kg/hc) is sufficient to achieve benefits to soil function and the reduced cost of seed may increase adoption. Total bulk carbon in soil increases very slowly and studies longer than two years are required to measure changes in soil carbon and soil function.

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Digital Agronomy Tools in the Next Generation Farming: Energy Management and Precision Agriculture

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Agricultural research has made significant progress from the early days of plant physiology research to the invention of fertilizers and understanding their role in increasing crop productivity. Modern agricultural operations have become digital by using variety of spectral signatures to monitor crop performance and yield. Combining basic plant research advancements with advanced tools is highly essential to bring the benefits to the growers while mitigating the negative environmental effects. Over the past decade, as technology became a part of our farm input decision management tools, it is very important to understand their roles and impacts on plant response and crop yields. It really matters to understand how plant responds to the external drivers of inputs and their managements in order to benefit from them. Our current research is focused on understanding and increasing the efficiency of plant energy assimilation (ATP) process at the cellular level amid technology driven farming. It is necessary to understand how to make plant respond positively to the energy management technologies to increase profit margins while reducing environmental damages and overcome yield stagnation. In this presentation, we will see research findings on plant energy metabolism, non-conventional fertilizers and the digital agronomy tools like Variable Rate techniques that could help growers to overcome the yield barriers in different farming situations.

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Securing multiple soil functions in European grasslands – does mechanical loosening help or hinder?

Dr Paul Newell Price, Mr Steven Hadden, Dr Caroline Rhymer, Dr Richard Franksen, Dr Rachel Thorman, Mr James Dowers, Professor Mark J Whittingham, Mr John R Williams

Well-managed grassland soils can deliver a range of goods and services, including storing carbon, supporting habitat, regulating water flows and providing food and clean water. However, when grassland soils are compacted, many of these services can be compromised. Mechanical loosening of grassland soils through spike aeration or 'sward lifting' is often promoted as a means of improving soil structure and function and improving multiple ecosystem services. This paper present results from a recent study on the effects of mechanical loosening on grass yields and water infiltration and discusses the results in the context of similar research carried out over the past decade. Several studies have demonstrated that mechanical loosening of 'moderately compacted' soil can have significant (4- to 10-fold) increases in water infiltration rate and can result in improved grass yield. However, the implications for surface runoff and flooding risk are unclear and overall grass yield effects appear to vary by site, year and season. Furthermore, one study has indicated short-term negative impacts on soil earthworm populations and no long-term effect on nitrous oxide emissions. This paper discusses the pros and cons of mechanical loosening within grassland systems and proposes guidance to help farmers and advisers in their decision making.

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University/Institution-wide Collaboration for Interdisciplinary Sustainable Soils (CISS) Project

Ms Cairo Robb[1,2,3]
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The need for soil literacy among today's and future decision-makers has never been greater. The imperatives of the climate and biodiversity crises, and food and water security are urgent, with transformative action required within the decade.

Relevant decision-makers are current students, postgraduates, faculty members and alumni of Universities and institutions. Their institution's educational and operational environment now will set the tone for their appreciation of soil during the coming decade.

Their decisions regarding soil resource use and management, land use choices, academic research, funding, investment and legacy will have imminent consequences for our success in operationalising the soil security agenda.

While progress is being made in soil education in schools, and traditionally strong soil science University faculties are vocalising concerns about the declining availability of soil science courses, there appears to be a gap in-between.

There is a critical need to embed the relevance of soil and soil science within the minds and curricula of all current and future decision-makers, and to foster interdisciplinary approaches spanning science, policy and practice.

This requires action now in Universities and institutions at undergraduate, postgraduate, faculty, operations and estates management, investment and alumni level. It requires collaborations within Universities and institutions and between them.

Based on a proposal entered into the Cambridge Carbon Challenge 2020, the Collaboration for Interdisciplinary Sustainable Soils (CISS) project presents a framework for Universities/institutions to implement a Work Programme to integrate consideration of soils across teaching, research and operations. It also envisages a CISS Fellowship Programme within and between Universities/institutions.

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P-289

Controlled burns as forest management tools in the South of Spain: alteration in soil physical-chemical and biological properties

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In the last few years, the use of fire to manage forest ecosystems has become more frequent in Europe. Fire has a great impact on soil, and it is necessary to assess how controlled burns affect it. This study assesses the alterations in soil physical, chemical and biological indicators after a high-intensity controlled burn. A grid of 12 points was established on a hillside in Sierra Morena (South of Spain) and thermal sensors were placed. Soil samples were collected before burning, immediately after burning and one year later (recovery), at two depths (0 - 2 and 2 - 5 cm). Soil pH, electrical conductivity, magnetic susceptibility, colour, nutrient content and / or availability and their spatial and time variations were analysed. Soil pH was substantially increased in the first centimetres of the soil (0 - 2 cm) immediately after burning, up to > 2 units, and the increase was maintained one year after the burn. The magnitude of the alterations in soil indicators was spatially explained by the behaviour of fire. In addition, the high-intensity burn had a positive short-term effect on some of the soil properties, such as nutrient availability for plants (P, N), which was considerably increased. Microorganisms of soil were also affected by fire, directly by the raise in temperatures and indirectly by the alteration of other soil properties. In conclusion, the possible immediate and short to medium term effects of burning on soil should be considered for a more holistic management of fire in forest ecosystems.

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P-290

A synthesis of evidence: management practices, to minimise diffuse pollution from maize cropped land in England

Dr Kate Smith, Miss Hannah Priest, Mr Ryan Hickinbotham, Mr John Williams

In 2019 the area of maize grown in England was estimated at over 200,000 hectares (Defra, 2020) this is a 20% increase from around 160,000 ha in 2012, and further increases are likely. Maize is established in the spring and typically harvested between late September and mid November, when soils can be 'wet', which increases the risks, of soil compaction by harvest machinery and the potential for surface runoff and sediment loss to surface water systems. Also as the ground is virtually bare over-winter nitrate leaching losses can be elevated.

This paper will report results from field experiments & demonstrations funded by Defra and water companies carried out over the last 10-years in England to investigate management practices to reduce the environmental impacts of maize production without compromising crop yields. The paper will consider methods for establishing cover crops and cultivation techniques, and report available results for the impacts on nitrate leaching losses, phosphorus and sediment losses to water as well as impacts on maize yields. The information has been used by stakeholders to promote sustainable maize production.

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P-290A

Artificial intelligence for good soil governance : assessing national institutional and legal environments to ensure global soil security

Miss Julie Itey, Mr Jean Tampon

Achieving effective soil organic carbon sequestration (SOC) is believed to be an indicator of good soil governance. It implies taking all soil security dimensions into consideration, especially the codification one which support the others. In recent years, the number of national and global initiatives investigating the SOC biophysical potential has dramatically increased. However, this information is still not effectively packaged into tools and guidelines for decision-makers, who develop and implement policies, laws, markets, and incentive schemes to promote soil carbon sequestration. As such, the development of more effective tools enabling domestic and international policymakers to accurately assess the SOC socio-environmental potential and to efficiently target interventions for best effect has become urgently needed. Indeed, poor soil governance undermines efforts to sustainably manage soils and mitigate climate change because the soil's role as the major terrestrial carbon sink is not optimised. Ambition therefore needs to be scaled up to a global systematic assessment in order to quantify the current codification potential for the on-the-ground implementation of SOC SSM practices at the national level. Artificial intelligence is believed to bring the necessary tools for research and data analysis towards good soil governance. It allows for the automatic processing of a large number of texts and can thus be used to assess whether there is a friendly institutional and legal environment at the global scale to implement the SOC biophysical potential at its fullest while promoting soils sustainable management to ensure soil security worldwide.

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Transitioning towards peat-free gardens: What does it take?

Dr Nazli Koseoglu

Peat provides extensive services for planetary and human functioning, best known for carbon storage, but also supports extensive biodiversity and iconic landscapes. Peat degradation, however, remains significant, and removal of peat for use in horticulture a leading threat. Reducing the demand for peat extraction by horticulture is therefore essential to ensure the security of global peatlands as natural capital assets. In our research we investigate economic, technical, and social aspects of the demand for peat in amateur horticulture. The research aims to inform the design of holistic policy interventions to end peat extraction for amateur horticulture within the peat supply chain by considering bottlenecks for different stakeholders simultaneously.

In the first phase of our research, we held interviews with the key stakeholders in the growing media supply chain and surveyed amateur gardeners as the end-users of growing media to understand existing knowledge of, and barriers to, shifting to peat-free growing media. In the second phase, we interviewed supply side stakeholders, as well as representatives from NGOs and policy organisations, to understand how these barriers may be overcome.

The findings indicate that while awareness of the harm caused by peat extraction is high among the hobby gardeners, the perceived ineffectiveness of peat-free materials for plant growth, inconsistency of the alternative material content and unavailability of peat-free products in local outlets, hinders behavioural change. Similarly, producers are aware of the need for change; however, the lack of reliable alternative material supply and policy signals slows the pace of transition to peat-free alternatives.

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P-292

Beyond Soil Health to a Theory of Soil

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The term ‘soil health’ has captured the interest of government, and land managers, whilst the global academic community has struggled to rationalise its use and wider benefit. It has proved a powerful tool in conveying best practice to a lay audience. However, the widespread adoption of the ‘metaphor’ has resulted in calls by many public bodies for tools that facilitate the measurement of soil health, preferably quantitatively, and often as a single figure, for ease of use/communication and cost of monitoring. The insurmountable problem is that soil health is neither a readily quantifiable nor measurable object. Only organisms can have ‘health’, which manifests as characteristics of a living system - true of complex systems exhibiting ‘emergent’ properties such as resilience in the face of perturbation.

We pose the key question: is soil really a system capable of exhibiting ‘health’, or any other property emerging from a complex, connected, self-regulating system? We argue that if you cannot detect emergent properties, you are i) Looking at the wrong dynamic parameter; ii) focusing on the wrong scale and not seeing the entire system; or iii) not looking at a system. We suggest that it will be more fruitful to look for the relationships between components, complexity, and function.

This framework will allow us to assemble and align disparate threads of soil science research on a cogent and coherent ‘theory of soil’, which is an essential and practical step forward for the sustainable management of global soil resources, across all land uses.

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P-293

Connecting people to soil: the role of Food-Landscape Networks in promoting improved care of the soil resource.

Ms Julie Gillespie, Dr Carol Margaret Smith, Dr. Sarah Edwards, Dr Dione Payne, Dr Jo Cavanagh

While many people understand the connection between soil and human health through the conduit of food in terms of nutrient supply and growth of crops, the connection back to the soil is not as strong. There is a growing disconnect between people and the soil and this disconnect is more noticeable in urban populations. If people can see the positive health benefits of the connection between food and soil and hence the benefits of caring for soil, then they are more likely to manage and understand the soil resource in a better way (Brevik et al, 2018).
Recently, there has been a noticeable momentum building in Aotearoa New Zealand around the potential for more 'holistic' farm systems; and central to this is enhancing food and environmental quality through enhancing soil health. "Te Mahi Oneone Hua Parakore" perspectives on Māori soil sovereignty and wellbeing (Hutchings and Smith, 2020), outlines that a paradigm shift is needed to encourage care for the soil resource. In te ao Māori, soil is part of a wider whakapapa that connects in this context: whenua, takata whenua and mahika kai to hauora.
Our research posits that there are 7 factors that influence Food-Landscape Networks. We use mahika kai and terroir frameworks, plus conceptual frameworks of soil health and well-being to inform ways to reconnect people with the soil. Our specific transdisciplinary research question is how does a better understanding of Food-Landscape Networks enable soil-food-human connections to be understood and potentially enhanced?

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P-294

The Soils of Japan at glance

Professor Ryusuke Hatano, PhD Hitoshi Shinjo, PhD Yusuke Takata

On behalf of 165 soil scientists in Japan, who contributed to the book “The Soils of Japan” (2021), we, the book editors present their work on the pedogenesis and properties of land use in Japan following these variations in climate, landscapes and geology, as well as human activity and other factors. The major part of Japanese agriculture has been rice farming due to the presence of a monsoon climate in all regions except part of Hokkaido. Although most Japanese islands are affected by a monsoon climate, they still have various climate zones, which range from subarctic to subtropical climates. The islands also have various landscapes, from mountain terrain to alluvial plains within a single region. The soils of Japan are affected not only by these various climates and landscapes, but also by fresh volcanic tephra, which has a significant impact. According to these variations in climate, landscapes and soils, Japan’s cultural regions are divided into six regions. Each of these regions has developed its own agricultural management practices. Chapter 1 overviews natural environments including soils and land use of Japan. Chapter 2 explains factors in soil formation in Japan, and Chap. 3 describes soil classification system of Japan and distribution of soils in Japan. In Chap. 4, the general physical and chemical properties of the major soil types in Japan are explained. From Chaps. 5–10, each chapter describes the characteristics of soil management in each of the aforementioned six cultural regions of Japan.

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P-295

Integration of grass leys to arable rotations to improve soil health

Dr Lizzie Sagoo, Dr Anne Bhogal, Mr John Williams

Integration of grass/herbal leys and livestock into arable rotations has the potential to provide benefits to both arable and livestock farming systems. Continuous arable cropping with annual soil cultivations and little or no inputs of organic materials have led to reductions in organic matter content in many arable soils. Temporary grass/herbal leys have the potential to enhance soil organic matter levels, leading to increased moisture retention, increased nutrient cycling and reduced risk of soil erosion.
In September 2017, six long term arable (>10 years) fields were sown to grass/clover or herbal grass/clover leys at Norwood Farm in Somerset, UK. Detailed baseline assessments of soil physical, chemical and biological quality were carried out in autumn 2017 prior to the leys being sown. These assessments were repeated in autumn 2020 and showed a significant improvement in soil quality after there years of a grass ley. Topsoil soil organic matter increased by an average of 0.3 percentage points (from 7.9% in 2017 to 8.3% in 2020), equivalent to an increase of 6 t/ha organic matter in the top 15cm of soil. Earthworm numbers increased by 60% between 2017 and 2020 (from 158 to 253 worms/m2), and total earthworm biomass increased three-fold from 46 to 137 g/m2. This data provides clear evidence of the soil quality benefits of integrating temporary grass leys into arable rotations.

None

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Forgotten soils: Soil properties across a transect from the mountains to the plains of Nepal. Implications for sustainable land-use

Dr. Keshav Adhikari

Soil acidity and erosion have long been considered two of the primary management challenges facing the mountain soils of Nepal. Other factors contributing to soil productivity, including soil organic matter and major plant nutrients in soils, are poorly documented in this region. The present paper examines the spatial distribution of soil acidity, soil organic matter and the major nutrients (nitrogen, phosphorus, potassium) of the surface soils along the 174-km long north-south transect connecting Solukhumbu district in the north (territory of world's highest peak Mt. Everest) and Saptari district in the south (the lowest elevation, <100m amsl). The aim of this transect was to include the soil samples from full range of elevation where agriculture is practiced. The results of the study were based on laboratory analysis of 528 soil samples collected from the transect. Sampling intensity decreased with decreasing area of cultivation from south to north (1 to 18 km2/sample) in the transect. Analysis of coefficient of determination (R2) showed that elevation alone explained 92% of variation in the amounts of organic matter, 77% in total nitrogen, 63% in available potassium and only 13% in available phosphorus in soil. It showed a negative relationship with soil pH (r = -0.24) which means that other soil-forming factors masked the effect of elevation. The results indicate that greater emphasis should be given to the soil management practices on the southern hills and plains of the transect where appropriate technologies can improve the condition of these soil properties for sustainable land-use.

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The Nature and Properties of Soils, Ray R. Weil and Nyle C. Brady; 15th Ed., Pearson Education Limited, 2017, USA

P-297

Long-term study of soil water dynamics under different land uses

Tibor Zsigmond, Dr. Zsófia Bakacsi, Imre Zagyva, Dr. Ágota Horel

The aim of the study was to assess soil moisture content data of different land use types over six consecutive years. The present study was carried out in Upper-Balaton, Hungary between 2015 and 2021. Soil water content (SWC) dynamics were investigated under different land use types (cropland, vineyard, grassland, and forest) at three depths (15, 40, and 70 cm). Meteorological data were collected on site. A continuous decrease in cumulative precipitation amounts was observed (average 26% less from 2016 to 2020), while air temperatures were similar between the investigated years at the sites. Grassland showed the highest (12.3℃) and forest soil had the lowest average soil temperatures (10.6℃). Significant differences in SWC were observed between annual and seasonal changes within a given land use ($p < 0.05$). The lowest SWC was observed for grassland (11.7%) and the highest for the vineyard (28.3%) among land use sites. Clear trends of decreasing SWCs were observed with 13.4%, 37.7%, and 29.3% lower overall SWC for the grassland, forest, and vineyard sites, respectively, from 2016 to 2020 (upper 15cm). At the cropland, the type of vegetation further influenced soil moisture regime, and choosing the right crop might be critical for water retention measures. Our study further highlights the sensitivity of grapevine to drought conditions, which is being more frequent on this site. Grassland had the most days when the SWC was below the wilting point, while the forest had the most overall days when the SWCs were optimal for the plants.
This material is based upon work supported by the Hungarian National Research Fund (OTKA/NKFI) project OTKA FK-131792.
This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No. 862756 (OPTAiN).

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Circular Buffer Strips of Native Perennial Grasses to Improve Multiple Ecosystem Services

Dr. Sangamesh Angadi, Mr. Paramveer Singh, Mr. Sundar Sapkota, Dr. Sultan Begna, Dr. Rajan Ghimire, Dr. John Idowu, Dr. Dave Dubois, Ms. Mickie Wilkinson

The US Great Plains is facing multiple challenges including extreme wind and water erosion, increasing climate extremes, decreasing soil health, declining biodiversity and low water use efficiency. Partial pivots (part of circular system irrigated) created by declining well outputs are used to develop 'Circular Buffer Strip (CBS)' concept, where dryland portion is rearranged into circles of buffer strips of native cool and warm season perennial grass mixtures alternating with crop strips to enhance multiple ecosystem services. A long term, landscape study was started at Clovis in 2016 to assess temporal and spatial distribution of benefits from single and multiple buffers. Grain corn was planted in strips alternating with grass strips and in control. Observations include microclimate, soil moisture, wind erosion, soil health, greenhouse gas dynamics and corn yield and yield components. The system was more (18 to 25%) efficient in conserving large rainfall events (≈ 50mm). This improved water extraction from the soil profile, reduced water stress and improved biomass production in CBS corn in the short term. In addition, wind moderation effect by grass strips conserved 3 and 26% higher moisture at 5 cm depth in 2019 and 2020, respectively. Improved water conservation and efficient use improved corn yield by 10 to 15% and benefits extended to 72 m from outer edge. As a result, corn water use efficiency in CBS was 18% higher than CT over two years. Large scale adoption of CBS can sustain Ogallala aquifer and improve resiliency of irrigated cropping system in the region.

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Sk Musfiq-Us- Salehin, R. Ghimire, S. Angadi, O. J. Idowu. 2020. Grass Buffer Strips Improve Soil Health and Mitigate Greenhouse Gas Emissions in Center Pivot Irrigated Cropping Systems. Sustainability 12(15), 6014.

P-299

Germination and early growth assessment of three different species by phytotoxicity tests in vineyard soils with high Cu contents.

Ms Raquel Vázquez Blanco[1], Ms Rocío González Feijoo[1], Dr. Daniel Arenas Lago[1], Professor Manuel Arias Estévez[1], Dr. David Fernández Calviño[1]

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The use of Cu-based fungicides in vineyard soils is a common practice to eradicate diseases in the vineyard (Droz et al., 2021). The accumulation of high contents of this metal in the soil can cause problems of environmental contamination and toxicity in other organisms. In this study, 43 soils from 34 different vineyards with different Cu contents (16 and 293 mg/kg) were sampled in NW of the Iberian Peninsula. Three different species (Sinapis alba L., Lepidium sativum L., and Sorghum saccharatum L.) were selected to carry out phytotoxicity tests and analyze their germination and early growth in the different vineyard soils. The germination percentage and the length of the roots and the aerial part were determined during a 3-day trial in a climatic chamber (25 ºC). The results obtained indicate that, in general, the three species germinated and developed despite high concentrations of Cu in the soils (germination: L. sativum > 96%, S.alba > 93%, and S. saccharatum > 83%). Sinapis alba showed a high Cu tolerance and a stimulating growth effect. In general, L. sativum did not show toxicity signs, although in some soils an inhibitory grow effect was observed. Finally, S. saccharatum showed an inhibitory effect in most soils, being the species with the greatest signs of toxicity.

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P-300

Copper availability assessment in vineyard soils using different simple extractions

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Since fungal diseases appeared in vineyards, winegrowers have been forced to use Cu-based fungicides. In most vineyard soils, this continuous use of fungicides has caused the average total contents of Cu to exceed thresholds considered toxic of 100 mg/kg (Kabata-Pendias, 2010). However, total Cu content in the soil is not a good predictor of metal toxicity in plants, so it is important to determine which Cu fraction is bioavailable (Mahieu et al., 2013). In this study, 43 soils were selected from 34 different vineyards in the NW of the Iberian Peninsula. The available Cu contents were analyzed using five different extractants: deionized water, $CaCl_2$, NH_4OAc, NH_4Cl, and EDTA. The extraction efficiency (EfEx) was calculated to know the Cu percentage released with each extractant. The extractants with the lowest efficiency were deionized water and $CaCl_2$ (EfEx max 2.4% and 6.6%), while NH_4OAc and NH_4Cl showed intermedium values (EfEx max 14,9% and 29.5%) and, being EDTA the most efficient extractant (EfEx max 84.3%). The high contents of Cu extracted with EDTA are related to its ability to form organometallic complexes. Thus, this extractant reflects more total content than is available. The high variability shown by ammonium extractants does not make them a reliable measure either, while distilled water and $CaCl_2$ underestimate the available Cu values. Therefore, currently, the greatest option to have a more complete and precise view of Cu availability in vineyard soils is to use several extractants.

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Mahieu, S., Soussou, S., Cleyet-Marel, J.C., Brunel, B., Mauré, L., Lefèbvre, C., Escarré, J., 2013. Local adaptation of metallicolous and non-metallicolous Anthyllis vulneraria populations: Their utilization in soil restoration. Restor. Ecol. https://doi.org/10.1111/j.1526-100X.2012.00927.x

P-301

EVALUATION OF THE APPLICATION TO THE SOIL OF BREWERY BY-PRODUCTS UNDER CONTROLLED CONDITIONS

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The management and final disposal of agro-industrial waste is increasingly relevant. One of the used alternatives is land disposal. The objective of the work was to evaluate the nutrient availability of two residues of the brewing industry: sludge and diatomaceous earth from beer filtering in order to estimate their potential as organic fertilizers for crops and effects on soil properties. Due to their high content of P, sludge could replace phosphate fertilization in crops and pastures. Diatomaceous earth contributes mostly to soil C, therefore they could be used as organic amendments promoting microbial growth and improving the physical, chemical, and biological properties of soils. The mineralization and nutrient release potential of the materials was evaluated with different doses mixed with the soil under controlled laboratory conditions through periodical soil sampling and analysis. The soil was taken from a farm nearby the brewery industry, where by-products are intended to be used as soil amendments.. The treatments were: sludge, diatomaceous earths, a mixture of both by-products (for having complementary properties), a control with similar N and P doses from synthetic fertilizers, and a control without the addition of materials. Although difference was observed between the doses, a low release of nutrients, especially N and P was observed when the different materials were separately tested. However, the combination of sludge and diatomaceous earth presented a release of nutrients similar to those released by the chemical fertilizer, so it is presented as a promising option for the final disposal of these type of residues.

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P-302

Natural Farming Systems Model for Livelihood Security of Farmers in North Eastern Hill Region of India

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Natural ecosystems and industrial agro-ecosystems are very different. It is the task of research to determine how close an agroecosystem needs to be for the benchmark values to be sustainable (Gliessman 2001). Considering the above, a natural farming system (NFS) site in Lambrang village under Umling block of Ri Bhoi district of Meghalaya was selected during 2020-2021 for studying soil types, species available in the area and possible intervention to check degradation of the system through human intervention and making the systems economically viable by introducing few important crops suitable for the agro-climatic situations. Efforts were made to improve the NFS by introducing few important crops and increasing the population of existing crops depending on marketing opportunity and natural resources of the site. The farmer is willing to spend 300,000 for the 6.0 ha (15 acres) farm area and can arrange to engage 600 man-days in a year, if system can be managed/improved to make it economically viable. Optimised models were developed for NFS using Lingo software (www.lingo.com) under single objective framework to maximise net income under a set of constraints (Behera et al. 2014). Various strategies were developed by combining various crops suitable for the farm and already adapted to the agro-climatic situations. This study indicated that performance of a natural systems can be improved and proved potential to provide economic as well as ecological benefits at par with a conventional system. Suitable blending of the NFS with modern scientific approach is needed to promote NFS in the region.

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Black gram (Vigna mungo L) is a viable option for Rice-Fallow situations in Eastern India

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A field experiment was conducted during rabi season of 2019-2020 at Chatabara village, Odisha to study the effect of different integrated nutrient management (INM) practices on productivity, profitability and nutrient acquisition by black gram. The experiment was laid out in randomized block design (RBD) with three replications. Eight INM treatments viz., T1: 100 % RDF, T2: T1+FYM, T3: T1+ Nutri priming with Mo and P, T4: T1+FYM +Nutri priming with Mo and P, T5: 75 % RDF, T6: T5+FYM, T7: T5+ Nutri priming with Mo and P, T8: T5+FYM + Nutri priming with Mo and P. The fertilizer nutrient was supplied through urea, diammonium phosphate (DAP) and muriate of potash (MOP). Black gram variety (PU30) was sown in 30 cm x10 cm crop geometry apart during first week of November with the seed rate of 25 kg/ha. Based on the finding of present study it can be concluded that INM with 100% RDF+ FYM (5 t/ha) + Nutri-priming with Mo and P (Ammonium molybdate 0.1% and 1% P solution of SSP) can be the best practice for the cultivation of black gram under rabi season with a yield level of 741 kg/ha and net returns of 39.2 x 103 ₹/ha. However, for farmers convenience point of view, INM with RDF+ 5.0 t/ha of FYM can be the 2nd best practice for the cultivation of black gram under rabi season with a yield level of 687 kg/ha and net returns of 35.2 x 103 ₹/ha.

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P-304

Sequestering soil carbon by planting hedgerows

Professor of Biogeochemistry Pippa Chapman, Dr Sofia Biffi, Dr Richard Grayson, Professor Guy Ziv

Carbon sequestration by vegetation and soil plays an essential role in addressing climate change. In the UK, the Climate Change Committee has proposed a 40% increase in hedgerow length as a key contribution to net-zero targets. However, the contribution of hedgerow planting to net-zero targets remains unclear due to a lack of data on the rate at which carbon dioxide (CO2) is taken up and stored in their biomass and the soil beneath them. In our study, twenty-six hedgerows in Cumbria, England, were classified into four age categories and soil organic carbon (SOC) stocks were quantified for the top 50 cm of soil beneath hedgerows and in adjacent grassland fields. SOC stocks were higher beneath hedgerows than in adjacent fields; this difference increased with hedgerow age although sequestration rate decreased over time. We used a 37-year-old SOC sequestration rate to show that if England were to reach its goal of a 40% increase in hedgerow length, 6.3 Tg of CO2 will be taken up and stored in the soil over 40 years. However, it will take ~200 years to reach this target with current rates of planting in agri-environment schemes. In contrast, if we upscale rates of planting achieved in a private-supply chain scheme in Cumbria this 40% increase in hedgerow length could be achieved by 2050.

CCC (Committee on Climate Change), 2020. Land use policies for a net zero UK

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Soil Fragility: definition and future perspectives

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On the scale of human generations, the soil is a non-renewable natural resource that provides fundamental ecosystem services for life on earth, therefore, it is necessary to develop tools that allow to recover and maintain soil functions under sustainable conditions for both, agricultural and undisturbed ecosystems. In this context, the regulation of land use to sustain the potential productivity of agroecosystems becomes essential. Until now, the assessment of the sustainability of soil resources based on their fragility had not been sufficiently studied. We hypothesize that soils have a fragility threshold, which is defined by two boundary conditions: i) soil fragility where resilience is not possible and any anthropic intervention generates a significant decrease in one or several soil functions, e.g. through sealing, resulting in a "point of no return" and the system becomes unstable, and ii) soil fragility where resilience is possible to any anthropic intervention e.g. intensive compaction, and its return to the productive potential reached will be progressively lower and the system will stabilize once soil functions are balanced. Furthermore, an approach on how to manage soil resources to avoid their degradation over time needs quantifiable tools that are made available to farmers, researchers, and institutions. We believe that it is critical to develop a soil fragility index for individual agricultural and undisturbed ecosystems because those indices, applied to the agricultural sector, would allow regulating the sustainable use of soils based on their functions within ecosystems.

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P-306

Carbon sequestration in hedgerows – quantification of soil and biomass carbon stocks

Ms Sophie Drexler, PD Dr. Axel Don

Agriculture is a key sector that generates greenhouse gas emissions and contributes to biodiversity loss, but also offers solutions to combat these crises. Establishing hedgerows is an option to sequester carbon (C) in agriculture to mitigate climate change while also enhancing biodiversity. To quantify the C storage potential of hedgerows, we conducted a meta-analysis on soil organic carbon (SOC) data from 83 hedgerows and adjacent agricultural fields, plus biomass data from 64 hedgerows. On average, 104 Mg C ha-1 were additionally stored in hedgerows compared to adjacent croplands. Establishment of hedgerows on cropland did increase SOC storage by 32 ± 22%. No significant differences in SOC storage were found between hedgerows and grasslands. Biomass C stocks were estimated to be 92 ± 40 Mg C ha-1. However, only one study reported measured root biomass data under hedgerows with a mean root:shoot ratio of 0.94:1 ± 0.26. This literature-based estimate was therefore refined by our own measurements of below-ground C stocks at nine hedgerow sites in northern Germany. Preliminary results indicate even higher C stocks: Below-ground biomass and rootstocks of the sampled hedgerows stored on average 70 ± 29 Mg C ha-1, with fine roots contributing 9 %, coarse roots 58 %, and rootstocks 33 % to this amount. We discuss how planting hedgerows can be an effective option for C sequestration.

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P-307

Soil, carbon dynamics and biodiversity in pasture areas of Southern Italy

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Natural pastures, valuable carbon stock, results from the combined influence of climate and soil properties together with centuries of managed livestock grazing. With the aim to investigate the soil properties and botanical composition linked with the grazing population, two Apennine pasture areas of Southern Italy, Frosolone (41°36’N 14°27’E) and Montenero Val Cocchiara (41°43’N 14°04’E) recognized by UNESCO and Natura 2000 network, were selected. During 2019-2020 grazing period (May-July), three sampling sites for both areas were identified according to WRB soil classification. Biomass production evaluation and phytosociological investigation though vegetal transepts (n=36, 0.5 m2) were studied. Grazing animal data were collected for Frosolone. Furthermore, soils and vegetation were also analysed through Vis-NIR spectroscopy and Sentinel-2, respectively. Frosolone soil profiles, Cambic Chernic Phaeozems, were characterized by low calcium carbonate and high organic carbon contents. Cambic Protostagnic Endocalcic Someric Phaeozems soils of Montenero Val Cocchiara derived from degraded ancient peat bog. In both areas vegetal density showed a prevalence of grass plants, and the average turf composition reached maximum values of 4.3 t/ha and 5.0 t/ha, respectively for Frosolone and Montenero Val Cocchiara. However, a decrease of goat, horses, and donkeys was observed. Carbon dynamics in grassland soils suggested high capacity for long-term carbon storage. Nevertheless, the investigated traits advice the need of policy reform for these strategic pasture areas, as source of ecosystem services, that could boost sustainable development, use, and protection of fragile inner areas of Southern Italy threatened by soil degradation and land abandonment.
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P-308

Harnessing Plant-Soil-Microbe Interactions to Promote Sustainable Bioenergy Agroecosystems on Historically Mined Lands across Appalachia, USA.

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Globally, 57,000 km² of land has been scarred by surface mining. Encouraging environmentally and economically sustainable post-mining land uses are key to securing the future viability of these mine-impacted regions. One such promising land use is the production of bioproduct (e.g., bioenergy) crops, which can provide feedstock to meet the demands of an increasing bioproduct economy, as well as support regenerative ecosystem services (e.g., soil C sequestration, hosting biodiversity). For this reason, developing best practices to produce quality feedstocks while improving ecosystem services on lands with degraded soils is imperative. We hypothesized that the soil microbiome can be indirectly (i.e., through soil amendments) and directly (i.e., through microbial inocula) manipulated to improve keystone microbially-mediated ecosystem functions like carbon use efficiency, nitrogen fixation, and soil organic matter (SOM) production and stabilization in bioproduct agroecosystems on previously mined land. To test this hypothesis, parallel field and greenhouse experiments were established with mine-impacted soils in the Appalachian region, USA, whereby plots of bioproduct crops (i.e., Miscanthus, switchgrass) were developed and treatments were imposed. After two years, SOM content and mycorrhizal fungal abundance increased with amendments at the highest quality site. Microbial carbon use efficiency correlated with SOM content and was not altered by amendments. Microbial inocula led to increased root biomass and did not alter overall microbial activity. These results suggest that bioproduct crop establishment on previously mined land is more dependent on initial soil quality than amendment strategy and that SOM content, microbial activity and mycorrhizal abundance are sensitive to amendment strategy.
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P-309

Conservation Systems to Improve Soil Health in the Southeastern United States

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Many soils in the southeastern United States are severely degraded due to the humid climate, coarse soil texture, and intensive row cropping systems used in the region. Conservation systems which combine high-residue cover crops with conservation tillage can improve soil health by increasing SOC storage, alleviating compaction, improving soil fertility, and enhancing soil water infiltration. The majority of cover crop research in the southeastern United States has focused on high-residue small grain cover crops, particularly cereal rye, for improving soil health, but there is a growing interest in using cover crop mixtures to provide diverse benefits. Studies were conducted from 2017 to 2021 on two soil types: a kaolinitic, thermic Typic Paleudult and a loamy, kaolinitic, thermic Arenic Kandiudult to examine the impact of cover crops on dynamic soil health indicators. Treatments including fallow, along with monocultures and combinations of cereal rye (Secale cereale L.), crimson clover (Trifolium incarnatum L.), and Daikon radish (Raphanus sativus L.) were arranged in a randomized complete block design in cotton (Gossypium hirsutum L.)–legume cash crop rotations. Soil health indicators measured included SOC, permanganate oxidizable C (POXC), water stable aggregates, and soil strength. Rye and clover cover crops often improved SOC, POXC, and soil strength in upper soil depths, but mixtures did not develop higher biomass or SOC than rye and clover monocultures in most site-years.

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P-310

Agronomic performance of pea-barley intercrops compared to sole crops without and with 100 kg nitrogen per hectare

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Intercropping is re-emerging as a beneficial practice in agricultural intensification that can increase nutrient use efficiency, reduce nitrogen (N) fertilizer requirements,
and improve crop yields and yield stability. The objective was to assess agronomic performance of pea-barley intercrop (IC) compared to pea sole and barley sole crops (SC) with 0 (0 N) and 100 kg N per hectare (100N) in Denmark. A split plot field design was established with cropping systems (pea-barley intercrops, pea and barley sole crops) as main plots and N rate of 0 and 100 N as split plots. 15N stable isotope was used to determine N accumulation from the soil, fertilizer and N2 fixation. The land equivalent ratio revealed that the IC
had a 20% advantage over the corresponding sole crops on the basis of N accumulation, 14% for grain yield, and 15% for N in grain. The IC produced 4.59 t·ha-1 of grains compared to 5.97 t·ha-1 in pea SC and 3.25 t·ha-1 in barley SC. Barley as a component of IC took up approximately twice as much N from fertilizer than pea. Advantages of IC over SC were found in the grain yields and grain quality for both component crops, demonstrating the benefits of IC in the production of high quality fodder or grain yields while reducing nitrogen fertilizer requirements in barley sole. The study showed that pea-barley intercrop increased N uptake and use efficiency by exploiting the available soil, fertilizer and N fixation, reducing the need for fossil-based nitrogen fertilizer for crop production

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P-311

Micronutrient content in agricultural soils under different types of land use

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The type of land use and agricultural practices established by farmers essentially determines the number of micronutrients in soils, which contributes to soil fertility and directly affects plant nutrition. The study aimed to assess key micronutrients in agricultural soils affected by different land uses in the Eastern part of Georgia under similar soil-climatic conditions and determine the factors affecting their availability. In particular, copper, zinc, manganese and iron. The study showed a high dependency of micronutrients content and their mobility in soil on crop types and peculiarities of agricultural practices and irrigation patterns. Micronutrient contents in soil were greatly affected by a legacy of agricultural plots, which was identified using old land use maps from the last century. The study showed that historical land use patterns together with the quality of irrigation water were conditioned soil nutrient composition.

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P-312

Soil organic carbon storage potential under lowland British hedgerows

Dr Ian Grange, Dr Matthew Axe

Hedgerows were originally formed as boundaries to contain livestock, but have several related ecosystem benefits, including wildlife and habitat connectivity, soil conservation and runoff mitigation, fuel wood production and carbon sequestration (Montgomery et al. 2020). Hedgerow soil organic carbon (SOC) is the focus of this study.

Hedgerows now feature in national Net Zero targets, yet few empirical studies have investigated hedgerow SOC stocks (Gregg et al. 2021) with much of the evidence being derived from long term studies of secondary woodland succession (Poulton et al. 2003) and modelling (Falloon et al. 2004). Three replicated sets of incremental soil samples, to 1m depth, were extracted from three hedgerows, adjacent grass margins and arable crops on two soil types in SW England. These sample hedges were well established (>170 years) and mainly comprised of Hawthorn (Crataegus Monogyna). Cumulative SOC stocks showed significant differences, for both 0-30cm and 0-100cm, respectively, between each of the ranked land uses: Hedgerow (98.7±3.15 and 133.5±7.63tC/ha)> margin (85.1±2.86 and 120.6±15.98tC/ha)> arable (73.4±4.71 and 73.0±10.44tC/ha) ($H=15.14$ $p<0.01$ and $H=13.98$ $p<0.001$, respectively).

Extrapolating the hedge SOC stocks to typical arable (209.5ha, 15.9km hedge) and livestock farms (123.3ha, 12.2km hedge) (RBR, 2015) showed there to be 234.8 and 180.1tSOC for 0-30cm and 317.6 and 243.6tSOC for 0-100cm, on each farm type, respectively. Despite, these hedge carbon amounts comparing favourably to other empirical and modelled results, further work is needed to better understand the relationships between hedge types and management, particularly with soil types, to better address the variability.

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P-313

Long-term impact of farmyard manure on copper and zinc concentrations in Swiss grassland soils

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Farmyard manure (FYM) plays an important role in nutrient cycling but also contains potential soil contaminants such as copper (Cu) and zinc (Zn) (Alloway 2012, Spiess 2011). Both trace elements are indispensable micronutrients for plant and animal life, but may also accumulate in the soil (Keller and Schulin 2003, Cagnarini et al. 2021). Because accumulation occurs over decades, we need studies at that time-scale to detect trends and underlying drivers. Here, we capitalize on three decades of soil and management data for eleven independently managed grassland sites in Switzerland to study the temporal evolution of Cu and Zn concentrations in the topsoil (0-20 cm depth) from 1988-2017. We compare measured concentrations against modelled concentrations from soil surface balances and forecast the future evolution for different scenarios. Results show a slow but steady accumulation on two out of five high-intensity grassland sites for Cu, and on all high-intensity grassland sites for Zn. Low-intensity grassland sites showed no accumulation. Measured concentrations were mostly within ±1 standard deviation of the modelled concentrations, indicating that soil surface balances are reasonably accurate to estimate trends of Cu and Zn in the soil. Modelling the future evolution under different scenarios revealed that reducing Cu and Zn concentrations in animal feeds and improved manure management could reduce the probability of reaching Swiss soil guide values. Our results underscore the need for soil and management data on the plot scale over long periods to detect trends, identify drivers of change and estimate effects of measures to reduce accumulation.
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Impact of land use change on the ecosystem functionality in soils derived from volcanic ash in southern Chile.

Belen Henriquez Caurapan, Prof. Dr. Yakov Kuzyakov, Franz Zehetner, Susana Valle

Changes in land cover and land use are considered the first cause of soil disturbance, can deeply affect the ecosystem's functionality. In southern Chile, the volcanic ash soils cover about 60% of the arable land in the country and have been affected by the changes in use. The main objective of this study was to define the impact of the land-use change on the ecosystem functionality in three soils derived from volcanic ash. We analysed published data on land-use change in Volcanic ash soils in southern Chile. It was assessed the change in the SOC content under different agricultural, forestry, and native forest management for a Duric Histic Placaquand, Andic Palehumults, and Typic Hapludands. A Sensitivity or the resistance of soil properties to the decrease of SOC content approach was used. The results indicate a general trend, in which SOC was reduced due land-use change a at the first 20 cm (Duric Histic Placaquand = -19.2%; Andic Palehumults = -46.3%; and Typic Hapludands= -4.1%). Experimental applications of the approach allowed separation of the sensitive and resistant soil properties to the decrease of SOC content, showing that some properties such as bulk density had a different response depending on the type of soil. The application of the sensitivity and resistance approach showed a clear response in the properties assessed. Finally, it is proposed that this approach can be used to assess the soil functionality, since reflect how strongly or weakly the individual parameters change with the change and intensity of use.

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P-316

Reduction in manganese toxicity by immobilization using iron oxides in chromium contaminated soil

Ms Jee Hyokyung

Manganese exists in various oxidation states in soil. Mn(Ⅱ) is toxic to plant limiting its growth because of high mobility. Mn(IV) in soil can be reduced by Cr(III) contamination, which increases Mn toxicity in soil. Therefore, objective of the study was to reduce Mn toxicity by immobilization in Cr(III) contaminated soil. Various iron oxides were used to reduce manganese toxicity. The iron oxides synthesized were goethite, schwertmannite, ferrihydrite and hematite. The synthesized iron oxide was identified by X-ray diffraction. To examine Mn(Ⅱ) oxidation and immobilization by iron oxides, 0.2 g iron oxides were reacted with 25 mL Mn(Ⅱ) solution. Goetite was the most effective in Mn adsorption compared to ferrihydrite, schwertmannite, and hematite. It was found that Mn(Ⅱ) is adsorbed by electrostatic attraction by iron oxide. Furthermore, a study was conducted to evaluate the toxicity of manganese in chromium contaminated soil using various soil amendments. Soils were spiked with Cr(Ⅲ) and bioavailable Mn concentration increased in the soil. The soils were treated with CaSO4, CaCO3, CaNO3 and garlic stalk for 1 year. CaCO3 treatment reduced bioavailable Mn concentration in soil, which can be attributed to Mn oxidation as evidenced by X-ray absorption spectrocopy (XAS) analysis.

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P-316A

Can local knowledge of “Panal” soils (Loess) in Catalonia lead to sustainable land management in vineyards?

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The soils of the Ebro Valley present a high risk of erosion, which can be aggravated by climate change (CC) (Alcañiz et al, 2016). Recent aeolian deposits (Loess) have been reported, which are vertically stable and are commonly called “Panal” (honeycomb) due to the presence of insect holes that give the appearance of wasp nests (Boixadera et al, 2015). According to local producers, “panal” are easy to cultivate, have high-water retention, and are mostly covered by vineyards to produce wine with Appéllation d’Origine (DO-Terra Alta and DO-Montsant). Our research aims to assess whether the cultivation practices incorporated by local soil knowledge (LSK) are capable of producing in a sustainable and environmental-friendly way high-quality wine, also in the frame of future CC scenarios. We sent a questionnaire about the characteristics and management of "panal" to producers from the two DOs; made field trips to make an inventory of soil management practices; compared the information from the LSK with the technical soil knowledge (TSK) (ICGC, 2021); and evaluated the suitability of the practices according to the FAO-ITPS (2020) and European Commission (2019). Our results indicate that LSK can identify and explain the physical parameters of “panal” that allow high productivity of vineyards and that are consistent with TSK. They show a high CRAD that makes them highly resilient soils, even under CC scenarios, although they need careful management to avoid erosion. Most producers incorporate sustainable land management practices (62%) which offers a wide opportunity to be within the Farm to Fork strategy.
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Dynamics of Peat Surface Fluctuation in a Bornean Peat Swamp Forest

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Tropical peatland is a complex and globally important wetland ecosystem, storing an enormous amount of the Earth's terrestrial carbon from centuries of organic material accumulation. In this ecosystem, peat swamp forests developed over an ombrogenous peat where hydrology influences its physico-chemical properties, one of which is fluctuation of the peat surface. While several studies of tropical peatland surface fluctuation have been reported, most are based on relatively short measurement periods or focused on drained areas. Here we present, to our knowledge, the first study of dynamics of peat surface fluctuation from an undrained peat swamp forest over a decadal period (2011-2020). In this study, peat surface level, water table, and rainfall were measured monthly at three experimental sites in a peat swamp forest in Sarawak, Malaysia. The sites were different in soil structure and vegetation community; namely Mixed Peat Swamp, Alan Batu, and Alan Bunga forests. Throughout the measurement period the peat surface in all three sites exhibited consistent oscillating movement that generally follow the fluctuation of water table, with swelling and subsidence occurring after high rainfall and dry spells respectively. Positive linear relationships were also found between peat surface level and water table ($p < 0.05$). Both the surface level and water table at all sites fell to their lowest during an intense dry period in 2019. Surface fluctuation at the Alan Batu site was most affected by seasonal changes in water table, which may be due to presence of vacant zones in the peat profile.

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Concomitant Immobilization of Oxyanions and Heavy Metals using Iron Phosphate Compounds

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Arsenic (As) is a highly toxic metalloid that can be absorbed by crops due to soil contamination of agricultural land by mines and smelters, which is a problem. Antimony (Sb) is an element involved in the same column of periodic table as arsenic, which is expected to be behave similar to As. Agricultural soil around the abandoned mine is contaminated not only with As and Sb but also with heavy metals such as lead (Pb) and cadmium (Cd). However, arsenic and Sb exist in nature in the form of oxyanions, it is difficult to control them at the same time as other heavy metals that exist as cations. Since the oxyanions are stabilized by binding to the iron oxide and the heavy metal is stabilized with phosphate, it is suggested that iron phosphate can stabilize both the oxide anion and heavy metals. Therefore, the purpose of this study is to evaluate the possibility of simultaneous stabilization of oxyanions and heavy metals with iron phosphate. Iron phosphate adsorbed As, Sb, and Pb at the same time, and Pb removal rate was 100%, and As and Sb adsorption followed a Freundlich isotherm. In addition, the adsorption of oxyanions and heavy metals was affected by pH. As a result of incubation experiment of contaminated soil with iron phosphate, Pb concentration decreased as the amount of iron phosphate increased, but bioavailable As concentration increased because of competition with phosphate. Therefore, appropriate amount of iron phosphate should be applied in mixed contaminated soils.

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P-319

Integrating Soil Fertility Management Practices and Remote Sensing in Maize Yield Forecasting at Field Scales in Kenya.

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Crop yield forecasts are fundamental in agricultural planning, management, and adaptation to climate change, especially when conducted before harvest. To capture spatial heterogeneity in soil and management practices and create a timely and site-specific prediction of crop yield, this study evaluated 20 fields within a 36 km2 region in Kwanza district, Kenya.
Site-specific practices, including residues and fallow management, and fertilizer rates were analyzed for each field, and crop growth was monitored on the site. Soil samples were collected and analyzed to determine the soil texture, PH, organic carbon, and total nitrogen. Soil attributes and remote sensing indices, including normalized difference vegetation index, normalized difference moisture index, and canopy chlorophyll content index, were used to forecast maize yields at vegetative and reproductive stages. Feature selection was done by quantifying the relative contribution of each variable towards yield performance. Geostatistical analysis was used to infer attributes at unsampled locations. Multiple linear regression was used to fit the model, and determine the interaction effects of the soil and land management.
Our results show that fields left fallow and those with residues had significantly higher soil organic carbon (1.61-3.20%). Moreover, soil organic carbon, total nitrogen, and the normalized difference vegetation index at the vegetative stage were the best predictors of maize yield. The linear regression evaluation metrics (R2, RMSE, and IOA) were 0.65, 0.1 MT/ha, and 0.78, respectively. Based on these findings, we conclude that both soil fertility enhancement practices and high-resolution satellite information can sufficiently provide yield forecasts at field scales.

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P-320

Impact of controlled bush thinning on the carbon sequestration potential of Namibian soils affected by bush encroachment

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Rangelands in Namibia have experienced a shift from herbaceous to woody plant dominance which has reduced indigenous plant biodiversity, altering ecosystem function, and threatening subsistence pastoralism. Due to the thorny nature of encroaching bush, feeding grounds become inaccessible to wildlife. The high root density in the affected area decreases soil moisture leading to premature leaf drop in early winter, which then decreases animal feedstock for browsers during the dry winter months. A common approach to reduce this negative impact is bush thinning (1). In the EU funded project "SteamBioAfrica" (Innovative Large-Scale Production of Affordable Clean Burning Solid Biofuel and Water in Southern Africa: transforming bush encroachment from a problem into a secure and sustainable energy source) we seek to introduce an innovative continuous Superheated Steam process as an approach to turn the harvested bush into clean burning solid biofuel and water. In order to evaluate the impact of this approach on soil properties and its carbon sequestration potential, a cronosequence of soils with up to 15 years after bush thinning are studied with respect to soil nutrient status as well as to quantity and quality of its soil organic matter. Their carbon sequestration potential is evaluated by determination of CO2 production during 3 to 6 months in controlled microcosm studies.

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P-321

Comparison and validation of different soil survey techniques to support a precision agricultural system

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The data need of precision agriculture has resulted in an intensive increase in the number of modern soil survey equipment and methods available for farmers and consultants. In many cases these are based on simple measuring methods such as EC or NIR reflectance measurements, and in many cases not providing accurate data under the environment conditions. In this study several different survey techniques are compared on a very heterogeneous 36 hectare research field, including different soil scanners, standard survey methods, and a very detailed mapping of soil diagnostic units.
The usability of these methods is validated on the soil map, and with the use of several years of harvester based yield maps. We have found that although all the methods have identified certain features on the field, many of these had no or minimal effect on the yield potential of the field, thus the usage of these tools or techniques have no or negative effect on the cropping system and on the environment. Although the WRB diagnostic units are rarely used for the purpose of precision agriculture planning, the information provided by the maps of these units are in a high correlation with yield potential, through its aggregated information content. Since precision agriculture is an intensively expanding market and is supposed to be one of the main tools for sustainable agriculture a broad validation of these tools should be performed to identify the soil and climatic conditions where these can be safely used with providing the required precision and reliability.

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"Black soils" in the Russian Soil Classification system, the US Soil Taxonomy and the WRB: Quantitative correlation and implications for pedodiversity assessment
CATENA 196 Paper: 104824 , 11 p. (2021)

Dobos, Endre ; Vadnai, Péter ; Kovács, Károly ; Láng, Vince ; Fuchs, Márta ; Michéli, Erika
A novel approach for mapping WRB soil units – A methodology for a global SOTER coverage
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Milics, G ; Zsebő, S ; Szabó, Sz ; Bűdi, K ; Takács, A ; Láng, V
Increasing corn (Zea mays L.) profitability by site-specific seed and nutrient management in Igmand-Kisber Basin, Hungary
In: 14th International Conference on Precision Agriculture
(2018) pp. 1-7. , 7 p.

Vince, Láng ; Márta, Fuchs ; Tamás, Szegi ; Ádám, Csorba ; Erika, Michéli
Deriving World Reference Base Reference Soil Groups from the prospective Global Soil Map product - A case study on major soil types of Africa
GEODERMA 263 pp. 226-233. , 8 p. (2016)

Csenki, Sándor ; LÁng, Vince
Soil sampling and prescription planning, using simple geostatistical methods (In Hungarian)
MEZŐHÍR: ORSZÁGOS AGRÁRINFORMÁCIÓS SZAKLAP 2020/8 pp. 64-66. , 3 p. (2020)

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Effect of green manuring on soil moisture content

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Conventional farming causes a gradual degradation of soil conditions. Soil compaction caused by heavy machinery, intensive ploughing-based tillage, and the lack of or inadequate organic matter recharge all contribute to soil degradation and soil fertility. Under the reformed Common Agricultural Policy (CAP), EU decision-makers have recognised that if farmers cannot be expected to exercise restraint, they must be forced to produce sustainably in the long term through legislation, financial incentives and sanctions. In Hungary, the majority of farmers designate areas of ecological importance (EFA) with ecologically significant secondary seeding, which is intended to increase biodiversity in agroecosystems and mitigate the environmental damage caused by intensive agricultural cultivation. Unfortunately, these green maunures may have some disadvantages, in particular their soil drying effect. The aim of my research was to investigate the effect of 21 plant species of ecological importance on soil moisture after harvesting winter wheat. In order to maximise biodiversity, we selected a wide range of species, including Fabaceaes, Brassicales and other plant species. Our experiments were carried out under field conditions, in triplicate. Based on our results, we concluded that soil moisture values decreased as a result of the green manuring, i.e. a drier soil condition was available as a result of the green manure. Our studies have demonstrated once again how fragile and vulnerable the ecologically important second sowing, which is the largest area of designated ecological importance in our country, is to weather, especially precipitation.

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Soil Characterization and Hydrogeological Modelling for Natural Resource Sustainability in Tropical Catchments of the Panama Dry Arc

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The Panama Dry-Arc is a Pacific coastal region with seasonally dry climate where groundwater hydrogeology and soil characterization data are scarce. Climate change has altered rainfall patterns, increasing drought occurrence[1], and consequently reducing groundwater recharge. Soil resources in tropical catchments contribute to important ecosystem services such as provision of crop nutrients, water infiltration, and climate regulation, among many others[2]. We characterized the dominant soils in the Zaratí River Subbasin (ZRS, 163.8 km^2) to promote soil and water conservation and sustainable land use based upon the main soil forming factors: geology, geomorphology, life zones, climate, and formation time[3]. A detailed soil morphological description was conducted through physical and chemical analysis for USDA Soil Taxonomy classification[4]. In the ZRS lower elevations (<350 m) we found that old, clayey, low fertility Ultisols dominated a landscape over low-permeability ignimbritic tuffs and plinthite that have accelerated surface water runoff and caused severe erosion gullies. Higher elevations in the ZRS (350-800 m) were dominated by recently developed soils on steep slopes (Entisols and Inceptisols), formed over pyroclastic deposits from an extinct volcanic caldera at Antón Valley, where soil characterization data showed that these are critical for groundwater recharge due to their coarse texture, forest cover and higher precipitation regimes. Our study showed that soil and water conservation practices should be implemented to increase organic matter contents (promoting C sequestration), improve soil aggregate stability, infiltration rates and overall resilience to runoff erosion, while at the same time increase primary productivity for forestry, agriculture, and groundwater resource conservation.

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Comparing net ecosystem production of bioenergy maize produced on mineral and organic soils

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The agricultural sector makes a significant contribution to climate change, emitting around one-third of global greenhouse gas (GHG) emissions (1). The sector is vulnerable to climate change, but effective land management practices that enhance soil carbon storage whilst contributing to decarbonisation of the energy sector provide an opportunity to reduce GHG emissions and contribute to the net-zero ambition (2, 3). The use of maize for bioenergy has increased rapidly since the 1970s, and in 2019 represented 70% of all energy crops grown in the UK (4). The use of maize for bioenergy is controversial as the productive land could otherwise be used to grow food crops. There is another possible conflict surrounding the growth of bioenergy crops, particularly on peat soils, as intensive agriculture can accelerate soil organic matter decomposition and carbon loss, potentially outweighing any emissions reduction from the use of bioenergy in other sectors (5). To better understand the influence of environmental conditions, including soil type and climate, on the carbon balance of maize, the net ecosystem productivity (NEP) was quantified for two maize crops in the UK using the eddy covariance technique - one on mineral soil and one on peat soil. The results of the study will help inform land managers and policymakers on where, and how, to best grow maize for the sustainable provision of renewable energy.

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P-325

Conservation practices and management for rangeland soil health: an economic modeling evaluation.

Ms Savannah Warwick, Ms. Jessica Windh, Dr. Kristie Maczko, Dr. John Tanaka

Soil health is a key factor in sustaining life, an important resource for sustainable production on rangelands (Bünemann et al., 2018). State and federal land management agencies in the United States have developed conservation management practices for land managers to implement to increase soil health. Within the United States, the state of California has 38 million acres of publicly and privately managed rangelands (Larson-Praplan, 2014). This study examines the economic implications of increasing forage production due to changes in soil health in three regions of California: the Coast, Sacramento Valley, and the San Joaquin Regions. Soil data from two sources is analyzed to determine relationships between soil characteristics and production. A recursive multi-period linear program is used to assess how increasing forage affects the value of a ranch over a 35-year period. Correlations were found between Soil Organic Carbon and Organic Matter and forage production. The Coast region increased herd size by 23 brood cows and Net Present Value increased an average of $695 lb ac of additional forage. The Sacramento Valley region increased herd size by 35 brood cows and Net Present Value increased an average of $988 lb ac of additional forage. The San Joaquin Valley region increased herd size by 36 brood cows and Net Present Value increased an average of $877 lb ac of additional forage. Improving soil health supports increases in livestock production, simultaneously enhancing ecological and economic rangeland sustainability, as well as benefiting resource dependent communities in each region.

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Existing R&I knowledge on sustainable soil and land management: a comprehensive overview

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The Soil Mission Support (SMS) project aims at improving the coordination of research and innovation (R&I) on soil and land management in support of the Horizon Europe Mission "Soil deal for Europe". Therefore, current R&I knowledge and stakeholder needs are compared to identify knowledge gaps. Here, we present a quantitative and qualitative analysis of scientific literature, in order to provide a comprehensive overview of existing R&I knowledge within sustainable soil and land management.

The structural basis for the literature analysis is a knowledge matrix that combines six major soil related societal challenges with eight different areas of knowledge as needed to ensure practical transition towards sustainable soil and land management. A keyword-based stocktaking of the existing literature was conducted. Searches included peer-reviewed scientific journal articles published in English on an online bibliographic database. 15,700 related articles were identified. A textual analysis using the digital platform CorTexT was undertaken to rapidly explore the identified literature. An overview of the themes addressed was obtained, as well as the relationships that exist between those themes.

It revealed that the societal challenges "reduction of soil degradation", "improve disaster control" and the knowledge area "assessment & modelling" have been studied extensively. Conversely, the societal challenges "mitigate land take" and "increase biodiversity" and the knowledge areas "science-based policy support" and "awareness, training & education" are rather little discussed.

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Evaluation of the effect of reduced tillage systems on soil organisms and ecosystem services

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Reduced tillage systems (including reduced soil disturbance, use of cover crops, long crop rotation, organic matter management) are expected to be good alternatives to conventional systems which have led to a decrease of soil biodiversity and multi-functionality. Many studies worldwide have analyzed the impact of tillage systems on different soil functions, but an integrated view of the impact of these systems is still lacking, especially in "real" life. SoilMan project (https://ecobiosoil.univ-rennes1.fr) proposes an interdisciplinary collaboration in order to evaluate the agro-environmental, economical and sociological sustainability of agroecological practices. The aim was to study how reduced-tillage systems impact on ecosystem services such as soil biodiversity conservation (earthworms, microorganisms), soil structure maintenance (aggregate stability) and water regulation and. Twelve fields managed by farmers and located in Brittany (France) were studied, allowing the comparison of direct seeding and conventional ploughing systems. The results highlight that direct seeding systems positively impact microbial biomass, abundance, diversity and earthworm biomass, anecic abundance, nitrogen and carbon rates in the first 10 centimeters of soil. It also improves soil aggregate stability, however, it doesn't affect water infiltration speed but disfavours hydraulic conductivities. The analyses of parameters interactions highlight positive impacts between biological (hypha, anecics microbial biomass) chemical and physical parameters. This being so, wheat yields obtained in direct seeding systems are not lower than those under conventional ploughing system. As a conclusion, agro-environmental soil quality is globally improved in direct seeding systems.

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Carbon sequestration of sustainable managed hazelnut orchards in central Italy

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The European hazelnut (Corylus avellana) cultivation is showing a rapid increase due to high global demand of hazelnuts from the confectionery industry, and Italy is the second largest producing country after Turkey (FAOSTAT, 2019). Like most of the tree crops, hazelnut tree plantation includes land preparation and frequent tillage operations during the first years to avoid weeds competition, whereas after 3-4 years soils are normally left permanently grass covered. Aim of this work is to develop a model of carbon sequestration based on hazelnut orchards age and type of orchards management. The results demonstrate that, with sustainable management of hazelnut orchards, SOC tends to decrease of 20-25% after the land use change from grassland. After about 5 years, SOC tends to increase quickly and to return around the levels of the grassland. After 35 years of orchard, SOC is always slightly higher than grassland, whereas after 50 years SOC is increased of about 25-30% respect to the grassland. In some cases, excessive nitrogen fertilization decreases C/N ratio and the soil carbon sequestration potential. In conclusion, land use change from grassland to hazelnut cultivation has a short-term negative impact in terms of SOC stock. In orchards with optimal fertilization and management, the SOC stock is recovered and strongly increased after about two decades, highlighting the high carbon sequestration potential offered by this type of tree crop cultivation. To date, very few studies about carbon sequestration potential of hazelnut tree cultivation are available (Oral et al., 2013; Zhang et al., 2021).

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SOIL ENZYME ACTIVITIES IN THE GROWING SEASON UNDER DIFFERENT TILLAGE SYSTEMS IN HUNGARY

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Long-term conservation tillage impact on soil enzyme activities has not been discussed in many studies in Hungary. A study to investigate the dehydrogenase, glucosidase, and phosphatase activities under different tillage management was conducted in Szentgyörgyvár, Hungary. A 16-year cornfield with conservation tillage (MT) and ploughing tillage (PT) was applied in this study. Enzyme activities were measured from the soil at 0-5;10-15 and 20-25 cm depths in the initial, mid, and end of the vegetative growth phase. Dehydrogenase activity was noticeably higher in MT in the whole stage at 0-5 cm depth. A gradual significant decrease of dehydrogenase activity occurred with the increase of soil depth in MT. Meanwhile, the inconsistent trend of dehydrogenase activity appeared in PT at whole stages. The difference in the tillage system did not induce glucosidase activity at all phases. Nevertheless, the soil depth was considerably inverse with the glucosidase activity only in the initial stage of growth in MT. Likewise, the phosphatase activity was not affected by the tillage system and the soil depth. The significantly highest activity of phosphatase was identified in the mid-phase of growth at a whole depth of both tillage systems ($p<0.05$). Our investigation revealed that the growth stage implied markedly on the dehydrogenase and phosphatase activity, particularly in the mid-phase. Change in soil water content was remarkably responsible for the change in dehydrogenase and phosphatase activity (Pearson correlation coefficients were -0.50 and -0.27). Similarly, SOM alteration in MT by 1.9% higher than PT (1.4%) influenced the activities of soil enzymes.

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P-330

Optimal Input Rates of Fertiliser and Organic Matter

Dr Thibaut Putelat, Prof. Andrew P. Whitmore

Sustainable management of agricultural land means optimising soil fertility to increase food production whilst maintaining environmental quality or vice versa or even improving both together. Like fertiliser, organic amendments can increase yield so they could partly replace artificial N. The use of chemical fertilisers may become restricted to reduce GHG emissions and improve water quality. Because amendments such as manure or compost can also be in short supply, we sought optimal means for how to apply N alongside annual applications of organic amendments that takes account of how quickly yields build up with amendment, how long these benefits persist, and how N fertiliser might be reduced in such a way as to increase nutrient use efficiency.

Using optimal control theory, we present a rational basis for combining applications of inorganic fertiliser and organic matter to a sequence of crops grown in consecutive seasons that ensures maximum profit from crop production, improves soil fertility and reduces the amount of N applied. The idea of a nutrient response curve was extended to include not only the effect of the nutrients themselves but also a long-lasting, yield-enhancing factor such as organic matter . Our methodology generalises a dynamic form of the well-known break-even ratio used in nitrogen fertiliser recommendations. We show how this methodology can be used to develop efficient N guidance that is both sustainable and optimal. We present examples of our method in action using datasets from long-term experiments in relation to N, organic matter and rotation.

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P-332

Impact of vegetation cover on soil loss in a mesocosm scale rainfall simulation

Ms Helena Ripley, Prof Carly Stevens, Prof John Quinton

High levels of soil erosion in Spanish hillside orchards, caused by the topography, semi-arid climate and sparse vegetation, result in loss of agricultural land and pollution of reservoirs. This soil loss is expected to worsen as increased heavy rainfall events, due to climate change, have been observed and are predicted to rise. However, ground cover between tree crops, traditionally removed, can protect soil from water erosion. This paper investigates the difference in runoff and soil loss between bare and vegetated plots.
Native Spanish species were used in a mesocosm experiment consisting of five treatments: Brachypodium distachyon, Medicago sativa, Silene vulgaris, mixed vegetation and bare plots. Rainfall simulation was carried out for approximately 25 minutes on each plot with subsamples of runoff collected every five minutes. The volume of the subsample was measured, the water left to evaporate, and the sediment weighed.
The bare plots had a significantly higher ($p < 0.05$) rate of soil loss than the other treatments. While there was high runoff from all the plots (857 ± 270 ml min-1), the bare plots had higher rate of soil loss (34.26 ± 19.85 g min-1) than the vegetated plots (6.13 ± 8.27 g s-1). This experiment demonstrates the importance of vegetation cover to reduce soil loss and its consequences to water courses.
This presentation will outline the methods used in this rainfall simulation experiment, give an overview of the findings and discuss how they validate the use of cover crops to reduce soil loss from Spanish orchards.

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P-333

Soil organic carbon fractions under different tillage and residue retention treatments in a rice-maize rotation in Bangladesh

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Soil Organic Carbon (SOC) fractions are influenced by soil properties, climate and management practices, and can be an indicator of soil health in agricultural systems. Little information is available on the distribution of SOC under tillage and residue incorporation practices in the rice-maize cropping systems in sub-tropical regions. We conducted a two-year (2020–2021) field experiment in Bangladesh to assess the distribution of SOC fractions under 0, 25 and 50 % crop residue retention rates conventional tillage (CT) and strip-tillage (ST). SOC concentration was measured in Dissolved Organic Matter (DOM), Light Particulate Organic Matter (POM), Heavy POM and Mineral-Associated Organic Matter (MAOM) by density fractionation, in two soil depths (0–10 and 10–20 cm). The largest increases in light POM compared to the control treatment (0% crop residue retention) were observed under ST (114% increase at 10-20 cm with 50% crop residue retention) and 24% at 0-10 cm in 25% crop residue retention. Heavy POM increased by 51% in CT, and 33% in ST at 10-20 cm under 25% crop residue retention. For MAOM, the highest changes were observed in CT by 35% at 10-20 cm and 26% under ST at 0-10 cm in the 25% crop residue retention. Similarly, the highest DOM was found under ST by 36% in a 25% crop residue and 28% under 50% crop residue at 10-20 cm compared to the control. The study reveals that all SOC fractions increased with crop residue retention under both ST and CT.
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Biochar as a potential strategy for sustainable land management in the dry tropical cropland of southern India

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Soil organic matter plays an important role in maintaining soil fertility and subsequent crop productivity, especially in the nutrient-poor tropics. Biochar application has potential not only to enhance soil organic carbon (SOC) stock and crop productivity but also to mitigate climate change. To assess the effective use of biochar in tropical alkaline soil, we conducted a 27-month field experiment including three-times cultivation experiments. We evaluated the effect of land management (biochar (B; 8.2 Mg C ha-1), manure (M; 1.1 Mg C ha-1 y-1; 100 kg N ha-1 y-1), chemical fertilizer (F; 100 kg N ha-1 y-1), and a mixture of them) on (1) soil C budget and microbial activity, and (2) soil N dynamics and crop productivity, with environmental factors in the cropland of southern India. Regarding (1), cumulative CO_2 flux were estimated as 2.7, 3.7, and 3.3 Mg C ha-1 in the B, B+M, and B+F applications, and these treatments increased SOC stock, creating positive C budgets. Regarding (2), B application improved soil water holding capacity, contributing to better crop N use efficiency and crop productivity in the B+F application, except for the dry year. In contrast, B or B+M applications didn't improve soil N dynamics and hence crop productivity. These results suggest that biochar application should be the sustainable land management for improving SOC stock, while another nutrient application such as fertilizer is also necessary simultaneously to improve the crop productivity in the dry tropical cropland of southern India.

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P-335

Changes of Escherichia coli retention, organic matter, and electrical conductivity under saline waters and irrigation management in cold seasons

Dr Nasrollah Sepehrnia

Global warming and drought have severely affected arid and semi-arid regions. The outcomes (desertification, fires, and torrential rains) have destroyed physical, chemical, and biological qualities of water and soil. Irrigation and manure management may help reclamation and utilization of these affected environments. Therefore, an area of 2000 m2 comprised 6 plots for flooding system and 24 plots for tape irrigation system with lateral distances of 60, 100 and 120 cm were prepared, and the study was performed in autumn and winter. The wheat was linearly cultured with a density of 500 plants per m2. The studied plots were treated once with cow manure (35 Ton ha-1) and irrigated with two water qualities (2 and 8 dS m-1) five times (twice in autumn and three times in winter). The results showed that electrical conductivity (EC) increased, and organic matter (OM) decreased in soil profile (0-80 cm) for the two irrigation systems. The lateral changes (between and in the lateral distances) showed an increase of EC, but a slight reduction of OM content. Escherichia coli concentration decreased within the soil profile, between and in the lateral distances particularly for 8 dS m-1. Tape irrigation system transported a higher bacteria concentration under 2 dS m-1 than 8 dS m-1 if compared to flooding. Escherichia coli survival was severely influenced in winter under tape irrigation.

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P-336

POLY4: a multi-nutrient source for enhancing the performance of rice-wheat cropping systems in North West alluvial plains in eastern India

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Imbalanced and low potassium (K) applications can significantly decrease crop yield and farm profitability (Majumdar et al., 2016, Singh et al., 2021). Common fertilizers used in India contain one or two nutrients and multi-nutrient deficiency in soils is increasing. POLY4 is a multi-nutrient fertiliser that could be a good option for improving crop yield and soil fertility. It is produced from the mineral polyhalite (K2SO4.MgSO4.CaSO4.2H2O) and contains 14% K2O, 19% S, 6% MgO and 17% CaO. A field experiment was conducted for two years (2019-2021) in alluvial soils with nine treatments which included two K sources i.e. POLY4 and muriate of potash (MOP; K2O 60%) in different ratios. The puddle-transplanted rice (cv. Rajendra Bhagwati) was grown during kharif (rainy) season and wheat (cv. HD-2733) was grown during rabi (winter) season. Rice equivalent yield (REY) and nutrient uptakes were increased significantly by application of K through POLY4 alone or in combinations with muriate of potash over unfertilized plots, plots which received only N and P, and plots which received all K from MOP. When half of K was supplied from POLY4 and half from MOP, a 16.6% increase in REY was measured compared to the treatment which supplied all K from MOP. A significant build up in available soil K post-harvest with POLY4 was also recorded compared to MOP. The findings indicate that the application of multi-nutrient source POLY4 in combination with MOP could be a good option for enhancing crop yield, nutrient use efficiency and fertility of soil.

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Recovery of Phosphorus by the Quick Wash Process: Agronomic Evaluation

MSc Virginia Takata, PhD Ariel Szogi, PhD Amabelia del Pino

The Quick Wash (QW) process was used to reduce the phosphorus (P) content of agro-industrial wastes and their potential environmental impact due to their land disposal. The QW consisted of three steps: 1) liquid extraction of P using mineral acid (H_2SO_4) with separation of a washed-solids byproduct; 2) P precipitation from the liquid extract under alkaline pH; and 3) enhanced P recovery as concentrated calcium phosphate (Ca-P) using an anionic polymer. The concentrated Ca-P can be used as a fertilizer and a more economical manner to transport P away from animal production sites. The objective was to evaluate the P extraction using the QW process from manure and the agronomic value of recovered Ca-P precipitates and washed solids as soil amendments. Three animal wastes were used: dairy, feedlot, and poultry manure. The mineralization of the different Ca-P precipitates and the respective washed solids applied to two sandy soils were evaluated under controlled laboratory conditions. We found that 72% of total P in dairy manure, 90% in feedlot manure and 38% in poultry manure was recovered as Ca-P with the QW. The recovered Ca-P and washed manure solids materials released different amounts of P in the two types of soils used in this study. In both soils treated with the washed solids or the P precipitates, plant available P was higher than in the soil control. Therefore, the QW process is applicable to recover P from animal wastes and the concentrated P product can be used as a fertilizer material.

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P-338

Redesigning a long-term field pH experiment - the rising of the pHoenix’

Dr Kairsty Topp, Dr Robin Walker, Prof Paul Hallett, Dr Rob Graham, Prof Christine Watson

Sixty years ago, the prime motivation for encouraging farmers to manage soil pH was yield. Today there is increasing interest in its impact on regulatory ecosystem service delivery; namely, carbon, nutrient cycling and nitrous oxide emissions. In 1961, a demonstration trial was established in North-East Scotland incorporating an 8-course ley-arable rotation with soil pH increasing along a gradient from 4.5 to 7.5, in 0.5-unit intervals. After 60 years, the soils at pH 5 tended to have the lowest soil carbon content. The available P status was c 9.4 mg/L (Modified Morgan’s method) at pH 6 and 6.5 and increased as the soils both became more acidic and alkaline. In contrast, the available K tended to increase with increasing pH. Due to urban development, we moved the topsoils from the pH trial to a new, nearby location on the same parent material in 2021. The new trial, the pHoenix, is part of the Aberdeen Cropping Experimental (ACE) platform, a joint initiative between SRUC and the University of Aberdeen. The move provided an opportunity to randomise the plots, making the trial more robust from a statistical viewpoint. We added additional plots from the new site where we will be able to monitor the impact of rapidly changing the pH on the soil microbiome, physical properties, nutrient cycling and greenhouse gas emissions. This provides a rare opportunity of being able to study soils maintained at a range of pHs in the field under the same management and climate conditions. We would welcome collaboration.
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Feedback on the evaluation of soil ecosystem services for decision support

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The concept of soil ecosystem services (SES) was initially developed to increase recognition of the multifunctional role of soils. From this broad idea gradually emerged a consolidated theoretical corpus and a set of methods of SES assessment, progressively integrated into complex decisions chains such as the appraisal of agricultural production systems, land management or territorial planning.
We developed a multidisciplinary research project in order to combine biophysical and socio-economic approaches to evaluate cultivated soil ecosystem services (SES) at different spatial scales and to analyse their consideration in the strategic choices of farmers and land managers. Soil ecosystem services were estimated by modelling on different territories from 12 to 1800 km² in northern France by adapting the evaluation model to the production system considered (annual crops or grasslands). The joint estimation of six to thirteen ecosystem services was obtained, according to a methodology that was homogeneous between sites, based on 30-year simulations of plant growth and element flows from dynamic models driven by climatic conditions, soil properties and agricultural practices.
Results of the project confirm the interest of an assessment of soil ecosystem services that goes beyond the classic evaluation of soil functions usually carried out, because it allows the current and future expectations of the beneficiaries of ecosystem services to be integrated into the approach. In this way, they participate in the development of farm and territorial management strategies that include a soil preservation objective.

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The Role of Soils in Cropland Transitions in California & Implications for Land Use Futures

Dr. Ariani Wartenberg, Dr Van Butsic, Dr Diana Moanga

The importance of agricultural land-use in the context of climate change and global ecological degradation, e.g., from excessive irrigation, pesticide application, soil degradation and habitat loss, is becoming increasingly clear. Given growing issues of land scarcity at global scales, one much debated strategy to reduce expansion of agriculture into remaining natural areas is the sustainable intensification of existing agricultural areas, which will need to build on healthy and resilient agroecosystems. Soils are at the heart of agricultural land management, and should therefore play a pivotal role in such sustainability transformations. To assess the role of soils in this dynamic, we focused on Kern County, California, a global hotspot of agricultural production. We examined historical and projected cropland transitions and examined their impacts on soils and other ecosystem parameters. We used observed parcel-level crop-type data to quantify historical land-use change between 2002 and 2018 and identify drivers of cropland transitions between 13 crop commodities. We then simulated future crop choices under three scenarios exploring consequences of climate change and policy response by 2050. Our results identify soil quality as an important driver of agricultural land-use change in our study region, and illustrates how soils may be impacted by future crop transitions, with likely socio-ecological consequences.

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P-342

Mechanical Soil compaction: An Important Agro-Environmental Management Practice on Tropical Peatland

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Tropical peatland is a globally important terrestrial ecosystem with thick deposits of organic matter mainly controlled by hydrological processes. Due to high organic matter content, tropical peat has low bulk density and high porosity. The bulk density regulates peatland hydrology by influencing soil moisture content. In 2013, an agro-environmental management practice of mechanical soil compaction had been introduced to improve soil bulk density. Under this practice, peat soil is mechanically compacted by heavy machinery to increase soil bulk density, to reduce soil porosity, to increase capillary rise effect, and thus increasing soil moisture content. To examine this practice, we evaluate the effect of mechanical compaction on soil bulk density and moisture content in tropical peatlands of Sarawak, Malaysia.

In this study, the soil bulk density, soil moisture content and water table were measured in an undrained peat swamp forest dan three oil palm plantations. Peat samples for bulk density were collected at depths of 0 – 25, 25 – 50 and 50 – 100cm depths using a peat auger. Soil moisture content was measured to 100cm depth using a Delta-T PR2/6 profile probe. Due to mechanical soil compaction, the soil bulk density in oil palm plantation was about three times higher than forest site. Soil moisture contents showed significant positive relationships with bulk density and oil palm yield. The results indicate that the mechanical soil compaction can increase soil bulk density and moisture content, thereby increase mass per volume of the soil, reduces nutrient leaching, enhance crop growth and productivity.

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Drivers of rangeland degradation in Namibian semi-arid savannas

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Savanna ecosystems continue to deteriorate due to prolonged droughts and unsustainable rangeland management, resulting in a loss of palatable grasses and bush encroachment. We aimed to reveal causes and triggers of rangeland degradation by comparing soil dynamics of two rangeland management systems: freehold farms with rotational grazing and bush control, and communal areas with continuous grazing and no bush control in a semi-arid Namibian savanna.
We established 16 transects in 4 freehold farms and 4 communal areas. We analyzed (i) texture as an intrinsic indicator, (ii) water holding capacity as an indicator for resilience against droughts, and (iii) soil organic carbon and nitrogen as the most prominent indicators for soil fertility. Complementary vegetation cover was estimated and differentiated into bare soil, herbaceous vegetation, and bushes.
Soils were predominantly sandy (89%) and classified as Arenosols, however, we found small but significant ($p<0.001$) differences between both management systems: Clay contents and water holding capacities were both higher in freehold farms than in communal lands. Soil organic carbon and nitrogen concentrations were respectively 19% and 32% higher in freehold farms. Additionally, above-ground dynamics revealed that communal rangelands had more bare soil exposed (+15.9%), fewer herbaceous plants (-24.9%), and denser shrubland (+8.4%) than freehold farms.
We conclude that communal lands face higher degradation than freehold farms. However, minor differences in soils caused overall less resilient baseline conditions in communal lands, where grazing without resting coupled with recent droughts triggered degradation in an already vulnerable agroecosystem.

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P-345

Natural mineral additives and industrial waste as a component for soil restoration

Mr. Marko Zupan, Mr. Matjaž Pirnat, Ms. Vesna Zupanc, Ms. Damijana Kastelec, Ms. Helena Grčman

Restoring degraded land (i.e., polluted and abandoned industrial or urban areas) is of high importance for sustainable land management, but creating technogenic soils also requires mineral- and humus-rich soil material. In order to protect fertile soils of agricultural land, mineral soil horizons can be used, which are a by-product of construction works. Mineral soil horizons are very often of low fertility; in addition to an unfavourable soil texture, an acid pH and a low cation exchange capacity also limit their use. The unfavourable properties can be improved by different amendments of natural or artificial origin.
The aim of this study was to test different natural additives (limestone, zeolite) and industrial wastes (autoclaved aerated concrete (AAC) and gypsum boards) to improve low fertile, highly acidic (pH=3.8) silty clay loam (SCL) soil material excavated during construction works. Additives were added at three dosages (3, 25, and 50 mass percent). In addition to the chemical and physical properties of the soil, the effect on plant growth was also tested using Chinese cabbage (Brassica rapa subsp. pekinensis L.). Soil acidity was significantly reduced by the addition of AAC and limestone. At a dose of 25%, the addition of gypsum board and AAC (silty loam) improved soil texture better than the addition of limestone and zeolite (clay loam). All types of additives had a positive effect on cabbage yield. For practical use, the addition of AAC would be recommended, but for extended use we suggest further investigations.

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P-346

Inventory of soil properties and soil tillage for three soil erosion study sites

Dr. Vesna Zupanc, dr. Matjaž Glavan, dr. Rok Mihelič, dr. Marko Zupan, Matic Noč, Urša Pečan, Davor Mrzlič, Katarina Kresnik, Slavko Krpič, Miha Curk, Luka Žvokelj, Jure Ferlin, Prof. dr. Marina Pintar

Agricultural land and freshwater are under severe pressure from intensive use, inappropriate land management and climate change, so conservation measures need to be taken. Case study sites in three agricultural catchments in Slovenia were selected for a study on small-scale water retention and soil erosion control measures. For each case study, 6 fields, 3 conventional and 3 no-till fields, were selected and an inventory of chemical (pH, base saturation, organic matter and nutrients) and physical (hydraulic properties, aggregate stability) soil properties and tillage practices over five years was conducted. In addition, soil water status was measured to evaluate water balance. The results of the soil properties show that the soils in the northeast of the study area are the most susceptible to erosion. The results of this study will help to assess the impact of climate change on the economic sustainability of water management in agricultural soils and land management practices.
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P-346A

BS3882: Does it Promote Soil Reuse?

Mr Steven Philp

I often get the opportunity to work on many housings development sites across England and with many different Environmental Consultancies. Something that continually comes is BS3882 – The British Standard for topsoil. In my experience, rarely do natural soils meet the full criteria for BS3882. This can (but not always) lead to both Environmental Consultancy's and Developers opting for manufactured topsoils rather than utilising natural topsoil. I propose we need to alter BS3882 to make it more accommodating for natural topsoil reuse as well as safeguarding the end-user of the soil. I would like to open this presentation to the floor for discussion.
NA

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Assessing Agricultural Landscape Dynamics through Landscape Agronomic Practices

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Farming on its own accounts for the majority of human land use with 25.8% and 11.8% accrued to pastures and crops respectively. This indicates that, one third of the land on the surface earth is managed as farmland. t. The dynamics of landscapes posed enormous difficulties to majority of agronomists in the area of agricultural landscapes management by majority of farmers across board despite the non inclusion of agronomy in most landscape research. Besides, this gap has not been subjected to sufficiently comprehensive monitoring and evaluations for agricultural sustainability. The paper argue why and how agronomy can contribute to landscape research with a conceptual model suggesting a new perspective on farming practices as a crucial driver in the pattern-process relationships. Broadly speaking, agronomy delivers operative knowledge to landscape managers, the farmers and their organizations. Therefore, to enhance landscape research concerning the design and management of sustainable agricultural landscapes, we argue the need for an effective interdisciplinary approach that includes agronomic knowledge and tools. The paper further posits the importance of landscape agronomy in expatiating the correlation existing between varying farming systems and the dynamics of agricultural landscapes. The article therefore presents agricultural landscape dynamics as germane concept that vividly illustrates agronomic contribution to landscape research as a discipline. This concept investigates the tripod relationship that exists amongst farming practices, landscape patterns and natural resources and helps in the understanding of the likely complexities in agricultural landscape dynamics and the integration of farming systems in landscape research.

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P-348

Soil Organic Matter: A Source to Sustainable Agriculture in Selected Geopolitical Zones of Nigeria

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Agricultural development strategy in the rural areas of third world countries are mostly geared towards increased productivity of agricultural lands at affordable cost with higher production efficiency at no cost to man and the environment. This research was carried out in the north-central geopolitical zone of Nigeria using a multistage sampling technique. Interview schedule was design and distributed to 250 smallholder farmers with a total acreage of 10ha each. The study revealed diverse organic agricultural farming systems which though have not been subjected to adequate monitoring and evaluations to enable their sustainability and impact to be better verified. Though most of the initiatives adopted are of diverse origins of 65.5% agro-forestry, 0.5% poultry, 4% composting and 20% green manure and crop residue respectively, to make significant impact still requires collaboration from relevant stakeholders. The plights of majority (93.8%) of organic farmers to effectively practice organic farming in this geopolitical zone of the country are in the areas of training (60%), extension (23%) and demonstration (10.8%) because the operation is knowledge intensive. The study further revealed that majority (89%) of the farmers affirmed that benefits from organic agriculture are not always immediate which therefore underscores the need for support/incentive in order to sustain the practice.

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P-349

Land use planning and soil conservation strategies in Costa Rica

Msc. Paola Brenes, Msc. Esteban Loria

Land use management and planning are presently being oriented to soil conservation due to the global soil degradation status. There are many public and private organizations globally that seek to create adequate policies to carry out soil management. However, they have faced limitations due to the decentralization and weak platforms to develop enhanced soil conservation efforts. Costa Rica is going through a process of urban expansion and intensification of their urban land use, a situation that has exposed the loss of the soil resource and degradation of it, putting soil resources for agriculture use in a state of vulnerability.

Costa Rica has a regulation norm called Reglamento de Fraccionamiento y Urbanizaciones that has recently been reformed and its framework integrates regulations for land subdivision planning in agriculture areas to protect agricultural soils. This new regulation unifies soil studies as part of the requirements to subdivide their land and it limits the use of the land for urban uses.

Due to Costa Rica´s successful case of natural resources conservation policies, there is huge progress being made on soil conservation, focusing on institutional partnership and legal frameworks. INTA, INVU, and ACCS have been working to ensure and enhance soil resources status in the country, focusing on land use planning, soils ecosystem services in urban and rural areas, and working on good strategies for carbon sequestration.

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P-349A

Correlation of soil macronutrients, organic fertilizer, and foliar macronutrients in the mint (Mentha piperita L.) crop in Minga Guazu, Paraguay

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Organic fertilizers application in medicinal plants crops is an alternative to the problems generated by the intensive use of chemical fertilizers. The aim of this work was to correlate the Nitrogen (N), Phosphorus (P) and Potassium (K) content present in the soil and in organic fertilizers with the content in mint leaves of the following three treatments: control (T1), chicken manure (2 Kg/m2) (T2) and bovine manure (1 Kg/Ha) (T3) in the mint crop in Minga Guazú, Paraguay. The foliar N, P, K content varied significantly ($p < 0.05$) between the treatments, with the chicken manure fertilization showing the highest values. The Pearson correlation analysis for the soil N levels showed a negative correlation with the foliar N content of T2. Soil P levels positively correlated with the foliar P of T1, and negatively correlated with the foliar P levels of T2 and T3. The chicken manure N correlated positively with the foliar N of T2. P correlated positively with foliar P of T1 and inversely with T2, whereas K positively correlated with foliar K for T1 and T3. The N of the bovine fertilizer correlated positively with the foliar N levels of T1 and T3. The P content showed a positive correlation with the foliar P of T1 and an inverse correlation with T2. The K showed a positive correlation with the foliar K of T1 and T3. Results showed that higher N, P, K levels in the chicken manure resulted in higher levels of these in the mints leaves.

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P-350

Plant-based amendment as a conservation strategy in cultivated peatland: from lab incubation to field study.

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Peatlands are known to perform essential economical, societal and regulating functions. Once they are drained to provide optimal crop growth conditions, a series of degradation processes is generated. To counteract degradation of these soils, the use of amendment, based on plant material (straw, wood chips, biochar) was proposed.

In this study, we assessed, throughout a six-month incubation experiment, the effect of four plant-based amendments namely, biochar, "forest mix", willow and miscanthus, on N kinetic parameters and N pools released (cumulative N data at the end of the incubation) from two contrasting histosols (Haplosaprist and Haplohemist). The amendments rate was 15 tons (dry weight)/ha.

Miscanthus and willow-based amendments reduced the most the N kinetic parameters (-19 to -82% decreased compared to control) and the N pools released (-13 to -74% decreased compared to control). The microbial biomass N and urease activity measured in the soil at the end of the incubation and the C:N ratio of the amendment all explained significantly the variability observed for both the N kinetics and N pools released data. A field study showed similar reduction in the availability of N and impacted negatively a lettuce crop growth.

The results of this study showed that the inputs of plant-based amendments in cultivated peatland decreased the availability of N pools, which could have beneficial impact for N sequestration but could restrict crop growth. Further research is needed to fully assess the impact for this soil conservation strategy on both N and carbon fluxes at the soil-plant-atmosphere.

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P-351

Risk of Soil Secondary Salinization under Mixed Irrigation using Brackish Water and Reclaimed Water

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The use of unconventional water resources is an effective way to alleviate the scarcity of freshwater resources, especially in areas where freshwater is scarce but reclaimed water is abundant. To explore the reasonable utilization of brackish water and reclaimed water, a pot experiment was carried out to study the risk of soil secondary salinization. The experiment set two salinity levels of brackish water, four mixed irrigation ratios of brackish water and reclaimed water, and fresh water irrigation as the control. The results showed that soil moisture content, salt content, pH, ESP, and SAR decreased with the increase in the proportion of reclaimed water in the mixture; Soil exchangeable Ca^{2+} content under mixed irrigation was higher than that of brackish water irrigation and reclaimed water irrigation, especially the content was significantly higher under the 1:2 mixed irrigation with brackish-reclaimed water. Based on ESP, ESP was less than 15% under fresh water irrigation, brackish (3 g/L)-reclaimed water 1:2 mixed irrigation, reclaimed water irrigation, indicating no risk of alkalization. But other treatments may cause soil alkalization; At 3 g/L of brackish water, there was salinization risk when the proportion of reclaimed water in the mixture was less than 1/2, but there was no salinization risk when the proportion was greater than 1/2. At 5 g/L of brackish water, there was salinization risk under mixed irrigation. Therefore, the mixed irrigation of brackish water and reclaimed water had the risk of soil secondary salinization, and the appropriate salinity and mixing ratio should be selected.

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P-351A

Changes in soil pH and organic matter across European wheat crops under conventional and organic management

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Soil pH and organic matter (OM) are essential to drive food crops and determine soil functions and health[1-4]. We evaluated 188 soils from wheat crops under two managements (conventional and organic) across nine pedoclimatic European regions. Our goal was to determine if soil management may affect pH and OM physicochemical properties. pH was determined in water (pHw), in KCl (pHk) and in $CaCl_2$ (pHc). OM was determined following the loss-on-ignition method. We found a wide range of pH across the nine pedoclimatic regions, varying between 5–9 for pHw and 3.8–8.2 for pHk and pHc. The lowest values were found at Lusitanean region and the highest at Mediterranean North and South regions. Differences between conventional and organic management were not found for any pH measurements among all data. However, significant differences were found at Mediterranean North region for pHw; at Continental, Lusitanean and Mediterranean North regions for pHk; and at Continental and Mediterranean South regions for pHc when applying different managements, resulting in a pH increase in acidic soils whereas a decrease in neutral to alkaline soils when organic management is applied. OM ranged between 1.6-19.1% among all regions. The lowest OM contents were found at Mediterranean South and the highest at Boreal regions. Regarding management, significant differences were found at Lusitanean and Mediterranean North regions: OM increased at Lusitanean region under organic management while it decreased at Mediterranean North region compared to conventional. In conclusion, management did not affect overall results, but they did particularly per region.

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P-352

Evaluation of spatial variation of soil quality based on crop rotation pattern for sustainable land use

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Crop rotation is the practice of growing a series of crops on the same land, which causes huge impacts on soil quality[1]. The spatial-temporal crop rotation information provides a basis for understanding differences in soil quality[2]. Characterizing the spatial variation of soil quality based on crop rotation permits improving soil quality by spatial optimization of crop rotation, and thus contribute to sustainable land use. Focusing on Guangdong in southern China where the agricultural landscapes are largely fragmented, we proposed a classification of crop rotation. According to the classification, we produced 10-m crop rotation system map in 2020, using Sentinel-1/2 satellite data and a decision-rule-based model. Then we established the correlation between crop rotation systems and soil quality by spatial analysis, literature review, field survey, farmer interview and expert knowledge. Based on the generated crop rotation map and the established correlation, the spatial variation of soil quality was analyzed at different scales. In general, soil quality is generally higher for paddy rotation systems due to lower fertilizer input, less soil disturbance, and long-term water surface, while it is generally lower for vegetable and orchard systems due to higher fertilizer input. The overall soil quality is medium, mainly characterized by the third class. Spatially, soil quality is higher in the north and lower in the south. The produced maps provide detailed spatial pattern of soil quality, which clearly reflect the spatial variation of crop rotation management. Thus, crop rotations could be spatially adapted to improve soil quality for sustainable land use.

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P-352A

Macro- and micronutrients content across European wheat crops under conventional and organic management

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Soil macro- and micronutrients such as C, N, P, K, Ca, Mg, Cu, Zn, Fe and Mn are essential for plant development[1-3]. Their availability will be key to determine crop yield and food quality. We analysed 188 soils from wheat crops under two managements (conventional and organic) across nine pedoclimatic European regions. Our goal was to determine if agricultural management may affect available soil macro- and micronutrients soil. Carbon (TOC) was determined as total minus inorganic carbon; N was determined by Elemental analysis; P was determined by Olsen method; K, Ca and Mg were determined as exchangeable bases; and Cu, Zn, Fe and Mg were determined in DTPA extractions. Management significantly affected C, N, P, Mg availability among all regions, resulting in higher values of C, N and P while lower of Mg under organic compared to conventional management. However, the effect of management per region showed significant differences in Lusitanean and Mediterranean North regions for C; in Atlantic Central, Lusitanean and Mediterranean North regions for N; Lusitanean, Mediterranean North and South and Nemoral regions for P; in Atlantic North and Nemoral for K; Lusitanean, Mediterranean South and Nemoral regions for Ca; in Atlantic North, Lusitanean and Nemoral for Mg; in Lusitanean for Cu; in Continental and Lusitanean for Zn; and in Lusitanean, Mediterranean North and South, Nemoral and Panonian regions for Fe. Finally, macronutrients availability is most affected by the European region but when considering the data per region, almost all nutrients availability is affected by management.

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Soil quality indexes as tools for the evaluation of sustainable soil managements at local scale

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Soil management is a central point for sustainable land use in terms of carbon conservation, soil quality and ecosystem services. Organic management aims to maintain/enhance soil quality with the adoption of organic fertilizers, cover crops and reduced tillage.
The MOnsampolo VEgetable organic long-term field experiment (Central Italy), where conventional (Conv) and organic (Org1 -with compost- and Org2 -intercropping with Vicia faba-) managements are compared since 2001, was studied with the goal to understand whether there are differences in soil quality between the different management strategies using simple soil quality indicators and a complex soil quality index (SQI) calculated via selection, scoring and integration of single indicators.
Simple soil indicators highlighted that Conv and Org1 managements enhanced the available fraction of nutrient content. Instead, simple and complex indexes indicated that with the Org2 the microbial activity is mainly focused on faba residues degradation, however not impacting the organic carbon content or the microbial efficiency. Both the Org managements enhanced the soil quality even if with different processes as suggested by the different results obtained from the soil quality indexes, which, could effectively be considered valid tools for soil quality evaluation. The determination of a unique SQI could resume all the detailed information concerning soil processes thus being a valid support for the valorization of the most sustainable agronomic practices for soil quality improvement and for sustainable land uses polices implementation.

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Effects of combined agricultural and ecological vermicompost as organic amendment to improve soil and plant health in agricultural ecosystem

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The improper management of livestock manure are becoming a new major issue for both terrestrial and aquatic ecosystems, the ditches and wetland plants have known to be a widely used technology for waste management. However, recycling of these nutrient-rich plants and manure is usually overlooked and less studied. In this study, we tested the vermicomposting technology by reusing ecological (wetland plants) and agricultural (maize residues and manure) and evaluated the soil fertility and plant growth after vermicompost amendments. A soil column experiment with a fully factorial design was conducted to investigate the effects of different vermicompost made by four species of wetland plants [Canna indica (CiV), Cyperus alternifollius (CaV), Acorus calamus (AcV), and Hydrocotyle vulgaris (HvV)] on maize growth across the growing season. Concomitantly, we compared the vermicompost effects with the conventional synthetic fertilizers (NPK) as well as the control treatment without any fertilizer (CK). Our results demonstrated that significant positive effects with wetland plants vermicompost on soil fertility and plant growth. Among the four species, combined Cyperus alternifollius (CaV) Hydrocotyle vulgaris (HvV) wetland plant-vermicompost as an organic fertilizer showed the higher values in plant total nitrogen (TN), soil organic matter (SOM), and shoot biomass in comparison to NPK and CK. This study revealed that vermicomposting with combined effects of wetland plants can be used as organic amendments and offers a novel approach by reusing the ecological wastes to promote the transformation of nutrient-rich organic fertilizers and crop productivity while reducing the environmental risk.

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Relationship of phosphorus levels with physico-chemical parameters in different soil managements of Minga Guazú-Paraguay

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The soils in Minga Guazú, Paraguay, are classified as Oxisols with a clay texture, good plasticity and high moisture retention. The soils phosphorus level is low in this district and throughout the eastern region of Paraguay. The aim of this study was to analyze the relationship between phosphorus levels and physico-chemical parameters as texture, organic matter (O.M.), pH, calcium (Ca^2+), magnesium (Mg^2+), potassium, aluminum (Al^3+) in different soil managements and depths. A stratified random sampling was performed with an area of 489.5 km2 in four different managements: no-till direct seeding, forest land, conventional tillage, and pasture, analyzed in six depths: 0-5, 5-15, 15-30, 30-60, 60-100 y 100-150cm respectively, totaling 216 samples. The samples were submitted to the soil fertility analysis. The results were classified according to the soils management, depths, and the analyzed chemical elements, showing that as the depth of the soil increased the levels of phosphorus were higher. In addition, according to the Spearman's analysis, there was a direct relationship of the phosphorus level with the clay content. However, the Ca^2+, Mg^2+, K+ and $Al+^3$ elements presented a greater availability on the surface. The principal component analysis indicated a similar behavior between the conventional tillage to that of pastures as well as no-till direct seeding to those of forest lands. Negative relationships were observed between P, O.M., Ca^2+ and K+. Regardless of the soils management, most nutrients except P, were mostly concentrated on the surface.

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Morphogenesis of Naturally Formed Capillary Barrier in the Fluvial-Lacustrine Soils of Arid Oman: Novel-Technique towards Saving Water and Mitigating Salinity

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Unique morphogenesis of soils consisting of a sedimentary mosaic of silt blocks sandwiched by sand-filled horizontal and vertical fractures were discovered in naturally formed fluvial-lacustrine sediments-soils inside the reservoir bed of Al-Khoud dam in Oman. The peculiarity and "smartness" of this sedimentary 3-D blocks-cracks composite is attributed to the ability of cracks to conduct downwards the externally applied pulses of precipitation or irrigation water. The ensued evaporation during extreme heats of Omani summers is drastically reduced by the capillary barrier (CB) of the sand filling (proppant), which impedes the motion of the in-block moisture both to the atmosphere and deep percolation.
We imitated the smart soil structure by agro-engineering the rootzone of field crops and explored opportunities towards saving irrigation water and mitigating salinity pernicious for desert agriculture. Our novel smart soil technology saved 40-70 % of irrigation water. Our porous composites alleviate the deleterious secondary salinization in the smartly-engineered rootzones of date palms, lemon trees, tomatoes, and marigold. With certain initial investments, soil toiling, and supplying/transporting of certain quantities of sand-silt (to be imported to a crop field or park/garden zone), applying our CB to what is currently undervalued as "no hope badlands" due to their high sandy-gravelly texture and poor water-holding capacity (Torriorthents) in Oman may become a goldmine of agronomy.
Our results put forward a new paradigm: we do not consider the existing topsoil as a mechanically-static structure, a routine layered system, which deserves only a traditional irrigation/fertilization. We optimize the subsurface via soil engineering.

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Determination of Tetracyclines via electrochemistry, with a view to its application in adsorption on fine fraction (clay) of volcanic soils

Chemist Constanza Venegas, Doctor María Angélica Del Valle, Doctor Monica Antilen

The family of tetracycline are formed by: Doxicicline (DC), Tetracycline (TC), Oxitetracycline (OTC) and Chlortetracycline (CTC), and they are antibiotics that there used is in livestock industry as a growth agent and for treat infections. It has been reported that between 25 and 70% is excreted in its active form, that come to soil and groundwater. It's known that the inorganic fraction is the most reactive part of the soil, it confers the charge and is responsible for the cation exchange capacity (CEC). In this work, a new analytical method is developed, based on electrochemical techniques for the determination of antibiotics in an aqueous system, and evaluate the adsorption in the clay fraction of Osorno's soil (Andisol). The physicochemical characterization, pH, and electric conductivity, it was realized using recommended methods for Chilean soils. It has been used electroanalysis techniques for tetracyclines determination because soil it doesn't act like an interferent in the measurements. The determination of the antibiotics was carried out by using wave voltammetry square, at 10mVs-1 in which potassium dihydrogen phosphate (KH_2PO_4 0.005molL-1) was used as support electrolyte. Among the results obtained, a high adsorption of antibiotics in the clay is appreciated, due to the high specific surface. An equilibrium time of 90 min was obtained for the adsorption kinetics and the data were fitted to the pseudo first and pseudo second order model. Isotherms show us the type of adsorption between the antibiotic and the clay, and the data were fitted to Langmuir, Freundlich and Langmuir-Freundlich model.

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Quantitative X-ray diffraction analysis to identify mineral species for arable soils in Japan

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X-ray Powder Diffraction (XRPD) is an effective technique to identify type of minerals present in soil. Although several ways of quantitative analysis of XRPD data have been proposed, optimal one may differ depending on type and weathering degree of minerals, which reflect their pedogenic conditions. The objective of this study was to verify the accuracy of XRPD analyses for quantifying mineral compositions of arable soils in Japan.
Forty soil samples were collected from 0-15 cm of arable soils in Fukushima, Japan. Air dried, 2 mm sieved soils were mixed with corundum powder at a ratio of 4:1, finely ground, and arranged to a randomly oriented specimen, which were scanned in a range of 5-65 °2θ diffraction angles. The amounts of minerals were obtained from the XRPD data with two methods: mineral intensity factor (MIF) method and full pattern summation (FPS) method using an R package, powdR. The accuracy of these two methods were evaluated by comparing the amounts of minerals obtained with those by wet chemistry methods (WCM). The mean absolute error (εA) and correlation coefficient (r) between WCM and two methods (i.e., MIF, FPS) for the selected minerals were as follows: quartz (εA=-0.41 wt.%, 11.0; r=0.85***, 0.26), K-feldspar (εA=-2.8, -2.4; r=0.31*, 0.83***), plagioclase (εA=-7.4, -2.6; r=0.92***, 0.95***), mica (ε A=-3.8, -1.2; r=0.56***, 0.76***). Thus, FPS was more accurate for most of the minerals whereas MIF was better for quartz, indicating that combinational use of FPS and MIF is recommended to determine the mineral quantities for arable soils in Japan.

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Investigation of hydrophobic organic chemical (HOC)–mineral interactions by miniaturized adsorption experiments

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Hydrophobic organic chemicals (HOCs), such as halogenated aromatic hydrocarbons, may be highly persistent in the environment and cause harmful effects on humans and biota. Sorption processes are highly relevant for the assessment of their environmental fate and risk arising from them. In this context, especially HOC–organic matter interactions are intensively studied, whereas knowledge of HOC adsorption to minerals is comparatively limited. In the present work, adsorption of halogenated benzenes (as HOC representatives) to smectite rich bentonites (as mineral phases) was determined. Laboratory experiments were performed with a miniaturized batch adsorption method combined with solventless HOC extraction by automated solid-phase microextraction coupled to GC–MS for straightforward determination of adsorption isotherms. Presented are results for various halogenated benzenes to multiple mineral phases that highlight the varying influences of HOC hydrophobicity and mineral composition on the extent of adsorption. Experimental results on adsorption will be compared with results from molecular modeling calculations. The in-depth studies on HOC adsorption to minerals are part of the "ClayHOC" project, in which laboratory adsorption experiments and molecular modeling methods are combined to further elucidate mechanisms of HOC–mineral interactions.

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Predicting soil nitrogen supply using ion-exchange resin membranes.

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Nitrogenous fertilisers are commonly applied at a uniform rate across fields calculated on volume per area basis. However, soil nitrogen (N) supply to the plant is not a homogenous process and varies significantly. The use of ion exchange resins to determine the availability of nitrate and ammonium in agricultural soils provide an opportunity to monitor the release of N from mineralisation and key transfers of N through the soil and provide a more accurate means of assessing soil to crop N supply compared to traditional spot sampling and mineral extraction was investigated.
In a field pot experiment, resins were placed in six winter wheat treatments covering three crop yield potentials and three carbon contents and removed after 4 weeks at mid-stem extension. All pots received a basal ammonium nitrate application equivalent to 80 kg N/ha. Control pots received a further application equivalent to 100 kg N/ha mimicking standard application of 180 kg N/ha. Treatment pots (ResinN) received an adjusted N application rate that accounted for the quantity of N already available in the soil indicated by the resin strips. Results indicated to less post-harvest residual-N in the plots receiving adjusted N applications. Adjusting N application based on measured N content had no significant influence on harvested wheat, however more precise N application may result in lower surplus N that may be lost through leaching or nitrous oxide emissions, demonstrating a benefit of the resinN application with no significant consequences on yield or crop quality

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Natural TiO_2-nanoparticles in soils: a review on current and potential extraction methods

Mr Daniel Armando Campos

The monitoring of anthropogenic TiO_2-nanoparticles in soils is challenged by the knowledge gap on the characteristics of the large natural TiO_2-nanoparticle pool. Currently, no efficient method is available for characterizing natural TiO_2-nanoparticles in soils without an extraction procedure. Considering the reported diversity of extraction methods, the review and discussion of such in the context of TiO_2 from soils are necessary, focusing on the selectivity and the applicability to complex samples. Therefore, the presented work encompasses a literature review, which also proposes tentative methodological criteria. First, it is imperative to develop a preparative step reducing analytical interferences and producing a stable colloidal dispersion. We suggested that an oxidative treatment followed by alkaline conditioning and the application of dispersive agents achieve such a task. Thus, this enables further separation and characterization through size or surface-based separation (i.e. hydrodynamic fractionation methods, filtration, or sequential centrifugation). Meanwhile, cloud point extraction, gel electrophoresis, and electrophoretic deposition have been studied on various nanoparticles but not on TiO_2-nanoparticles. Furthermore, industrially-applied methods in, for example, kaolin processing (flotation and flocculation) are interesting but require further improvements in terms of selectivity and applicability to soil samples. Our review concluded that none of the current extraction methods is sufficient for TiO_2; however, further optimization or a combination of orthogonal techniques could help reach a fair selectivity towards TiO_2. Lastly, this presentation will include, in addition to the review, an experimental pilot approach towards a method developed in this context.
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Soil heterotrophic respiration assessment using minimally disturbed soil microcosm cores

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Ex-situ measurement of soil respiration is usually done with highly disturbed samples that may confound the interpretation and extrapolation of results. We have developed a lab respiration assessment method that better simulates field conditions and allows efflux estimations based on soil surface area. First, intact soil cores are extracted in the field and transferred to the lab. Next, soil moisture content and bulk density are assessed in each soil core. Immediately following this the soil cores are gently broken, pooled per treatment (or plot) and the root systems removed. Subsequently the field moist, non-sieved soils are repacked into microcosm cores at their respective bulk densities. Moisture in the microcosms is adjusted to desired levels by adding drops of deionized water or by air drying for several hours. After moisture adjustment, the cores are pre-incubated at 25C for two weeks. Afterwards, the microcosms are further incubated in the dark at the desired temperatures in airtight containers. At 0_24_48_96hours, 20ml of gas sample is collected from each container and then injected into pre-evacuated exetainers for CO2 determination using a gas chromatograph or an infrared gas analyzer. Finally, soil efflux is estimated based on the rate of linear CO2 increase in the container headspace. One of the advantages of this method is that results can be presented per unit of mass (e.g. mg CO2-C g soil-1 day-1) or area (e.g. g CO2-C m2 day-1). These soil microcosms can also be used to simultaneously assess
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Is the promotion of soil health only important as a concept in intensively managed agricultural systems?

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Soil quality and soil health have been used frequently and interchangeably within the scientific literature, however the definition is often ambiguous and different depending on the stakeholder. The concept of soil health is mainly used within an agricultural context or when the soil is likely to have been degraded. Earthworms are often used as the emblem of soil health, having a large effect on the physical soil environment – through burrowing, bioturbation mixing litter and soil, as well as being referred to as ecosystem engineers. Therefore, monitoring earthworm abundance and diversity could be a useful indicator of soil health and transcends different farming systems. This talk will focus on a range of studies recently completed that evaluate the soil health of different farming systems. Firstly, a limestone grassland that is extensively grazed but the management focus is to provide habitat for the rare large blue butterfly (Phengaris arion), compared with a range of direct drill trials and long-term management trial. Assessments of soil health have been made using soil biology, physics and chemistry measures. Measurements include earthworm abundance and diversity analysis, soil structure (VESS and penetration resistance) and pH, organic matter and micronutrient content. Results will be discussed in relation to the standard soil health metrics used within agriculture and whether the soil health concept is viable across all systems.
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Developing rapid infrared spectroscopic tools for assessment of novel soil health tests and identification of spectra patterns in Ontario soils

Mr Andrew Hector, Dr Laura Van Eerd, Dr Kari Dunfield, Dr Asim Biswas, Dr Adam Gillespie

Producers, industry organizations and governments are increasingly asking for soil health assessments to track the effects of land use on soil properties. Currently, these tests are time consuming and expensive, hampering the uptake by producers and limiting how soil health data is interpreted and evaluated. Soil health testing is a crucial tool for evaluating best management practice effect on soils as it allows stakeholders to make informed soil health decisions based on multiple information sources. In this study, we used infrared spectroscopy, a proven tool, which is rapid and inexpensive to fill this data gap (1). We intend to demonstrate the ability of infrared spectroscopy to predict novel-lab based soil health tests on Ontario soils and identify spectral patterns in soils under similar management.

Soils were sampled from four long-term research sites across the province of Ontario, Canada. Treatments reflect an array of local best management practices primarily focusing on tillage and crop rotations. These soils were subjected to four soil health tests: Soil organic carbon, total nitrogen, active carbon, and ACE protein. These same soils were analyzed using mid and near-infrared spectroscopy and a relationship between the spectra and soil health test values was established to build a prediction model using multivariate statistics and machine learning techniques. Further, spectral patterns were correlated with soil properties to determine spectra similarities in soils under similar management. This research is expected to alleviate time and costs associated with soil health assessments and bring greater understanding of soil health dynamics regarding local practices.

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P-365

Use of measured water levels as a water management indicator for reducing rice grain arsenic and cadmium concentrations

Dr Toshimitsu Honma, Dr Ken Nakamura, Dr Hidetaka Katou, Professor Tomoyuki Makino

High levels of inorganic arsenic (iAs) and cadmium (Cd) in rice grains are a public concern for human health. High correlations have been found between iAs and Cd concentrations in grains and soil Eh during three weeks after heading. However, since soil Eh is not easily measurable by farmers, a simpler indicator for water management is required. In this study, we looked at the water level, as measured with perforated PVC pipes, as an alternative indicator for soil redox conditions. We conducted field experiments in which different water managements, including continuous flooding, intermittent irrigation and rainfed, were practiced. We investigated the relationships among the measured water levels, the number of days with specified water levels, soil Eh, and grain iAs and Cd concentrations.

In the absence of rainfall, the water levels in the intermittent irrigation plots dropped to below −15 cm within 2–3 days after drainage. Across different water managements, soil Eh was negatively correlated with the water level averaged over 2–3 days preceding the measurement. The grain iAs concentration was positively correlated with the number of flooded days during the 3 weeks before heading, whereas the grain Cd concentration was highly positively correlated with the number of days with water level below −10 cm during the 3 weeks after heading. These results suggest that the water levels may be used by farmers as a simple indicator for water managements aiming at simultaneous reduction of iAs and Cd in rice grains.

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P-366

Detection of agriculturally relevant lime concentrations in soil using mid-infrared spectroscopy

Ms Ruby Hume

Globally, surface and subsurface soil acidity pose a serious threat to crop production and require effective management to prevent yield losses. The application of lime (calcium carbonate, $CaCO_3$) is a well-recognised remediation technique for surface soil acidity. However, for subsurface acidity, improved application and detection methods are required to manage acidity due to the stratification of acidic layers. Mid infrared (MIR) spectroscopy has potential as a rapid, cost effective and accurate method of $CaCO_3$ detection in soils. However, for this technology to be valuable in an agricultural context, there is a need to develop MIR spectroscopy methods for the detection of $CaCO_3$ at agriculturally relevant concentrations of <1%, which was the aim of this study. MIR Partial Least Square Regression (PLSR) carbonate prediction models were developed using carbonate-specific spectral regions to predict $CaCO_3$ concentrations in soil. Prediction models using specific carbonate peak regions were established and compared with models using the entire MIR spectrum to assess the model performance. Models built using a single peak range at 2560-2460 cm^{-1} gave the best results (highest R^2 values and lowest RMSE values) followed by the single peak range at 1840-1760cm^{-1}. The MIR method enabled accurate prediction of carbonate concentrations and had a detection limit of 0.05% $CaCO_3$, similar to what can be achieved using a pressure calcimeter. Findings suggest that MIR spectroscopy measurements of agriculturally applied $CaCO_3$ in soils may provide valuable insights into monitoring the movement and efficacy of lime treatments and will enable more informed lime applications in the future.

Hume, R., Marschner, P., Schilling, R., Mason, S., Mosley, L., (in press), Detection of agriculturally relevant lime concentrations in soil using mid-infrared spectroscopy, Geoderma

P-367

Advanced analytical methods for linking phosphorus sources and transformation in soils and waters

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Understanding processes involved in phosphorus (P) cycling in the soil-water continuum requires novel techniques that can that go beyond operationally defined methods and can connect sources, chemical reactivity, and pathways of transformation. Here we present a series of recent research efforts aimed to address P processes using HPIC, HPLC-MS, NMR, NanoSIMS, Bayesian modeling, and stable isotope methods in an agriculture runoff dominated catchment. Our data show dynamic variability of P speciation, influenced primarily by runoff and tides, with phytate being the dominant organic P. Distinct sets of isomers and isotopically identical phosphate moieties in phytate attest that the IRMS is a reliable tool to track the sources of phytate. Isotope composition of P pools and fingerprinting element modeling together allow tracking sources of P in the downstream water. The relative abundance of bacteria capable of phytate degradation and expression of phytate genes indicate that the presence of phytate promotes the proliferation of phytate-degrading microorganisms. Similarly, measurements of isotopes using nanoSIMS on relatively P-rich and pure minerals and Orbitrap methods on dissolved phosphate ions are likely to new frontiers in methodological developments. While scrutiny is needed to connect results from different techniques, new analytical methods have enabled an improved understanding of the micro- to macro-level P processes in soils and waters.
none

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J-DISTAS: a new tool to predict field readiness to ensure efficiency of field operations and avoid soil compaction.

Mrs Marine Lacoste, Philippe Billa, Hocine Bourennane, Isabelle Cousin, Annie Duparque, Rémy Duval, Mathieu Lamandé, Emilie Nivelle, Carolina Ugarte Nano, Pascale Métais

Sustainable crop production implies high efficiency of field operations and protection of the soil as a natural resource. Soil physical fertility is threatened by compaction, especially deep soil horizons for which remediation is more critical (Schjonning et al., 2015). To avoid soil compaction and ensure field operations efficiency, including satisfactory crop production in a cost-effective way, the prediction of field readiness, defined as the combination of soil workability and soil trafficability, is of prime interest (Edwards et al., 2016).

The currently available tools are generally focused on only one part of the problem (either soil compaction risk in deep soil horizon or possibility of efficient field operation), and are usually built for a specific pedoclimatic context, which raises question of their application in a broader context. They also need to be upgraded to consider agricultural equipment evolution.

The J-DISTAS project (2019-2022) aims at creating a prototype of interoperable tool to predict field readiness. This tool will combine: (i) the evaluation of the soil compaction risk using the Terranimo® model (terranimo.dk) and the CHN crop model, and (ii) expert models estimating soil water potential and soil workability (Ugarte Nano et al., 2021). This decision support tool will allow strategic decisions based on field readiness consideration such as definition of cropping systems in the context of global changes, optimization of the use of agricultural machinery, etc.

We will present i) the J-Distas tool's ability to predict field readiness, ii) its sensitivity to input data, and iii) an example of its use.

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P-369

Using hyperspectral imaging and image processing for assessing soil coverage by crop residues.

Mrs Noémie Lafouge, Dr. Eric Perrin, Dr. Brigitte Chabbert, Mr Pascal Thiébeau, Mr. Gonzague Alavoine, Dr Frédéric Baret, Dr Alban Goupil, Dr Sylvie Recous

Currently, increasing research is being dedicated to improving the management of the period between two cash crops. The management of crop residues is one issue of this theme. Crop residues are either left as mulch or partially incorporated after harvest. Therefore, they impact exchanges of water and heat between the atmosphere and the soil, with consequences on biogeochemical cycles[4]. Depending on the nature, quantity and management method of crop residues, soil coverage and decomposition dynamics[3] are different, as are their consequences[4]. However, the characterization of crop residues is difficult to measure and predict. New agroecological systems involving crop mixtures are notably concerned in this context. Thus, the aim is to determine, depending on the crop, the rate of soil covered by crop residues and their evolution during the post-harvest period.
Hyperspectral images[2;5] at low altitude[1] and with a pixel size of a few mm^2 have been acquired in control (light, temperature, humidity) and field conditions, for wheat and rapeseed straw. In control conditions, hyperspectral images of several amount of biomass corresponding to several rates of soil covered , were taken. In field conditions, images were taken at different dates after the harvest. At the same times, residue biomass amount and moisture and soil surface moisture were implemented to relate spectral information to field reality.
Controlled conditions' images were processed using the k-means clustering, a classical unsupervised classification method. It separates wheat straw from soil and allows to obtain a relation linking the rate of residues cover and the biomass amount.

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P-370

Low energy and cost moisture sensor technology: characterisation in a controlled environment

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Efficient water use is a must for sustainable agriculture, driving the need for affordable soil moisture sensors to guide irrigation timing. Sensors are limited by cost, maintenance and the need for wires for data capture and charging. We are developing low-cost, long-life, wireless in-situ soil sensing networks, which can potentially enable a much higher sensor density for large farmland or intense research plot monitoring. This custom soil sensor is made from off-the-shelf electronics and consumes approximately 10x less energy per measurement, compared to commercially available sensors. Here we evaluate our new sensor technology in a series of controlled environment experiments over a range of soil conditions, investigating the correlation between the output of this sensor and soil water content. The repeatability and accuracy of the sensor is also compared to that of commercially available soil moisture sensors. The final application of the custom soil moisture sensor is an underground in-situ sensing network, which will be enabled through wireless powering and telemetry systems implemented on autonomous vehicles, both ground and aerial.
Delta-T Devices Ltd., "User Manual for the ML3 ThetaProbe," Datasheet ML3 ThetaProbe, 2017.

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Impact of soil amendments on soil moisture sensor readingspo

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The ability of soil to retain water under drought and the efficient use of water through irrigation timing are key to the sustainability of food production systems. Soil amendments are often used to improve soil water retention capacity, while soil moisture sensors are being deployed for scheduled irrigation timing. However, there is a lack of data on the impact of these amendments on the sensor output values. Here we evaluate soil moisture sensor readings taken in sandy soil, with added biochar (2.5% w/w), compost (5% w/w), hydrogel (0.6% w/w) and water treatment residues (5% w/w). The samples were saturated and then subjected to wetting and drying cycles. Measurements were taken continuously using multiple commercial sensors, along with a newly developed low-cost, long-life moisture sensor. Preliminary data show consistent underestimation of soil water content by commercially available sensors in the presence of amendments in comparison to unamended soils. The interactions between amendments and water content readings taken by soil moisture sensors will be discussed in detail, along with their repeatability and accuracy.
Delta-T Devices Ltd., ”User Manual for the ML3 ThetaProbe,” Datasheet ML3 ThetaProbe, 2017.
Delta-T Devices Ltd., ”User Manual for the SM150T soil moisture sensor,” Datasheet SM150T, 2016.

P-372

Making Soil Science Accessible: Low-cost soil analysis using digital image colorimetry (DIC)

Dr Michael Muir

Access to precise and accurate chemical analysis techniques is vital in a broad range of soil science settings globally, such as in agriculture, in the investigation of soil degradation by pollution or salinization, in researching the ways soils respond to a changing climate, and in education. The recent rapid improvement and widespread accessibility of smartphones with high quality digital cameras provides an exciting opportunity for the development of low-cost methods that have the benefits of instrumental analysis, such as reproducibility, accuracy and precision, without the requirement for specialist instrumentation. Smartphone digital cameras can replace traditional detectors in colorimetric analysis techniques through an approach called digital image colorimetry (DIC). Benefits of DIC include removing the need for specialist colorimeters or spectrophotometers, ease of use in the field, and improved precision and accuracy over test-strip or test-kit techniques which require users to compare colours formed in chemical reactions to printed calibration cards by eye. Digital image colorimetry can also be applied to a broad range of pre-existing colorimetric methods. Three examples of applying DIC to soil analysis are introduced: 1) The analysis of nitrate using test strips in agricultural topsoil, 2) The analysis of chloride using test strips in coastal soils, and 3) Measuring CO_2 in laboratory incubations of soils from different locations. The application of DIC enables widespread access to robust soil chemical analysis in the field and in areas where access to analytical instrumentation is limited.

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P-373

Fitting laboratory methods to "on-the-go" soil analysis in the fields

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In the research project „soil2data" a mobile field-laboratory will be developed for "on-the-go" soil preparation and major nutrients analysis.
The aim of this project is to make soil analysis results available to the farmer without delay. In the process, the fresh soil samples are prepared and extracted, and multiple parameters are measured simultaneously on site in a short time. An ISFET sensor (ion-selective field effect transistors with specially developed membranes) measures NO3-, pH value, H2PO4- and K+ in the extract. Because of different requirements for rapid soil preparation the common standard extraction methods must be adapted.
The new rapid "soil2data" method presents a good relationship with the standard extractions in the laboratory (Germany, VDLUFA), with the coefficient of determination for the pH value of $R^2 = 0.91$ and for nitrate contents of $R^2 = 0.95$. It provides a better correlation to standard extraction for potassium and phosphorus when soil groups are considered separately according to the requirements of the Lower Saxony guideline on basic fertilization. The segmentation for potassium is classified as follows: (group 1 (sandy soils): $R^2 = 0.90$; group 2 (sand-silty soils): $R^2 = 0.96$; group 3 (loam-silty soils): $R^2 = 0.75$; group 4 (loamy soils): $R^2 = 0.55$). In the case of phosphorus, a distinction is made between sandy soils and other soil types, which results in an R^2 of 0.71 and 0.66, respectively.
The field-laboratory could be included in autonomous and nonautonomous carrier platform.

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P-374

Quantification of anthropogenic TiO2 nanoparticles in soils and sediments combining size fractionation and trace element ratio

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Soils and sediments are the most important sinks for anthropogenic TiO2 nanoparticles which are used in diverse commercial products such as paints, personal care products, and food. Therefore, it is important to assess their environmental impact and monitor their concentration in this media. Since these matrices contain a high level of natural TiO2, including a colloidal fraction, the detection limit for anthropogenic TiO2 nanoparticles depends mostly on the level and heterogeneity of this background, which can be particularly high. In order to tackle this challenge, we explored the potential of combining colloidal extraction and natural background correction using element ratio (Ti/Nb and Ti/V) to lower the limit of detection at environmentally relevant levels. For that, we spiked soils and sediment samples with P25 TiO2 nanoparticles and used them to test the performance of each step of the procedure. Our results show that sample homogenization through grinding, using Nb as a proxy for natural TiO2, and matrix specific recovery correction using standard addition result in limits of detection close to 10 µg(TiO2)/g. Repeating the extraction step and combining the extracts can improve the low recoveries for the extraction step. Interestingly, the natural Ti/Nb ratio is not uniform over the size distribution. This may have implications for the choice and the treatment of the control sample. Overall our results represent a significant step towards the detection of anthropogenic TiO2 in soils and sediments at realistic concentrations which is required for their long-term monitoring and the evaluation of their impact.

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P-375

Soils in silico – process-based modeling of dynamic structures at the pore scale

Dr. Alexander Prechtel, Simon Zech, Dr. Nadja Ray, PhD Alice Lieu, Dr. Raphael Schulz

Key functions of soils are determined by structures at the microaggregate scale (< 250 µm).
Although advanced imaging techniques now allow snapshots even down to the nanoscale, the evolution of elemental distributions, liquid phases and dynamic microbial processes still cannot always be assessed experimentally. Consequently mechanistic models operating at the pore scale facilitate the study and understanding of such phenomena.
We present a versatile hybrid discrete continuum modeling approach combining cellular automata and partial differential equations which integrates the complex coupling of biological, chemical, and physical processes. Dynamic liquid and gas phases, diffusive processes for solutes, mobile bacteria transforming into immobile biomass, and ions are prescribed by means of partial differential equations. Furthermore the solid phase is dynamic, e.g. through aggregation of soil particles, growth of biofilms or the distribution of particulate organic matter in the system [1, 2, 3, 4].
Finally mathematical homogenization techniques are used to show a way to incorporate information as the diffusivity from the pore scale to macroscale models [1,5].
Applications include structure formation of clay minerals [4], the interplay of liquid phase connectivity, substrate supply and organic matter turnover [3], or the quantification of the effective diffusivity by upscaling on 3D geometries from CT scans of a loamy and a sandy soil.

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P-376

Glucose Imaging, a new developed method for in situ visualization of glucose release in soil

Mr Mehdi Rashtbari, Dr. Bahar S. Razavi

A significant portion of photosynthetically fixed carbon (1%–30%) is deposited in the rhizosphere (Bamji and Corbitt, 2017) which are the major source of carbon for the microbial populations in the soil. Sugars such as glucose dominate root exudates. It is vital to identify the localities of high glucose release to identify microbial hotspots in the soil (Jones and Darrah, 1996). In the previous studies, glucose was detected using a gel-based, enzyme-coupled, fluorometric assay. In this study, we further modified method from McLaughlin and Boyer (2004) and developed a membrane-based enzyme-coupled colorimetric and fluorometric assay instead of the gel-based approach, to image glucose in situ and used this assay in combination with enzyme assay to show that there is spatial variability in glucose release from plant roots and how this dynamicity affects rhizosphere enzymatic activity. For this purpose, we saturated membrane in reaction solution (containing glucose oxidase, peroxidase and Ampliflu Red) and attached to the soil in the rhizobox. After 20 min, we took photos under UV light and the photos were calibrated with different glucose concentrations. Our results showed that wheat root had heterogeneous glucose release and had the highest glucose exudation rate in young roots and root tips. Also, rhizosphere soil had the highest enzyme activity. We concluded that localities of high glucose release stimulated microbial activity, induced high enzyme activity. The developed method successfully localized glucose exudation rate from wheat root in the rhizosphere and soil matrix and can be coupled with enzyme measurements to localize hotspots.

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P-377

Localising Soil Organic Matter via staining with OsO4: Changing the scale to microaggregates

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Fine pores are suggested to play a major role in long-term carbon (C) storage in soils due to physical occlusion of soil organic matter (SOM) and reduced mineralisation because of limited O2 diffusion. Recently, models have been developed that describe the relation between soil architecture and SOM turnover, modeling C dynamics in a spatially explicit way. In order to generate realistic inputs for these models, it is important to describe the architecture of soil aggregates quantitatively as well as to localize the contained SOM. A well-established way is to stain the SOM with osmium tetroxide (OsO4) to increase its contrast for µCT imaging. This method has already been applied to soil macroaggregates but not yet to microaggregates, despite their proposed higher importance in long-term SOM storage.

We treated 12 microaggregates (200–250 µm) from two soils (Cambisols) with contrasting clay contents (19 and 34 %) with OsO4 vapour to stain the included organic matter. The samples were then scanned with synchrotron radiation-based x-ray µCT at a spatial resolution ~1 µm, shortly below and above the L3 absorption edge of osmium. The subtraction of one scan from the other reveals regions with high concentrations of OsO4 and hence SOM.

We expect any particulate organic matter (POM) to give a clear OsO4 signal. Based on previous research on samples from the same site, we further expect high-clay aggregates to contain more POM than the low-clay soil. Implications for long-term C storage will be discussed, as well as limitations of the results.

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P-378

National scale test of a soil structural stability measurement by image analysis via a mobile phone application (Slakes).

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Soil aggregate stability is a useful indicator of soil physical health and can be used to monitor condition through time. Many methods for measuring structural stability have been proposed, and one of them has been standardized after work carried out in France. The University of Sydney has recently proposed a new method to measure structural stability, using a dynamic image recognition algorithm that they have implemented in a cell phone software: Slakes. This application is available on the google store. Its protocol is simple and accessible to the general public.

The objective of this study is to evaluate the reliability of this new method in an agro-pedological and climatic context broader than its initial test framework (Australia), by comparing it on a consistent set of sites to measurements of structural stability according to the standardized method, entitled "NF-ISO10930-2012. Soil quality - Measurement of the stability of soil aggregates subjected to water action". We also looked for statistical links between the measurement of structural stability according to the two methods and soil properties. Finally, we proposed a national map from a large number of measurements carried out on soils collected at different scales: national with the soils of the Réseau de Mesures de la Qualité des Sols (Soil Quality Measurement Network), regional with the soils of the Sols de Bretagne project and finally local with the soils collected within a catchment area.

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P-379

Mineralogical differences and iron isotope variations in ferromanganese nodules in soils with different hydromorphic conditions

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The strong differentiation for the fabric and chemistry within the ferromanganese nodules is a well-known phenomenon. We aimed to study whether this differentiation can be related to the Fe mineralogy and isotopic composition of the nodules. Six soil profiles under different conditions of hydromorphism were studied by geochemical (EPMA, MC-ICP-MS) and mineralogical (XRD, micro-XRD) analyses.
Different conditions of hydromorphism resulted in the same nodule types and their similar vertical distribution in the soils. Although the observation of assumed differentiation of hydrous Fe oxides failed within the nodules, soils with different conditions of hydromorphism could be characterized by different Fe-oxyhydroxide mineralogy, at least in the progression of their crystallization process. Differences in the nodules' geochemistry and mineralogy could be related to differences in intensity of water oscillation and the duration of redox periods in the soils.
An enrichment of light Fe isotopes up to 1.28‰ in δ^{56}Fe was found in the nodules when compared to the bulk soils with a similar vertical distribution pattern for both of them. No clear relationship between the degree of hydromorphism (based on nodules' characteristics) and changes in Fe isotope values was observed, although often less negative values were found within the layers of highest hydromorphism.
Periodic redox cycles result in spectacular differences for iron formation among and within the soils, which is often accompanied by only slight mineralogical and geochemical changes. However, revealing such slight differences may supply important knowledge on the genesis of soil components.

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P-381

GeoPhenomics; predicting crop fertiliser uptake from soil mid-infrared analysis

Cathy Thomas, Javier Hernandez-Allica, Dr Keith Shepherd, Steve P. McGrath, Dr Stephan M. Haefele

Fertiliser recommendations rely on costly, time consuming and often unreliable tests of soil extractable nutrients. Instead, spectral analysis of soils could provide multi-nutrient, cheap and rapid recommendations. Wheat was grown in a glasshouse in 30 diverse Kenyan soils under full fertiliser and minus P, K, S and Zn fertiliser treatments. Predictions of plant nutrient concentration from soil mid-infrared (MIR) analysis were compared to those from a comprehensive set of soil wet chemistry analyses.
Under the full fertiliser treatment, the spectral models gave predictions as good as the wet chemistry models of plant P (CVR2 = 0.70 and 0.65, respectively) and Mn uptake (CVR2 = 0.72 and 0.75, respectively), but not of plant K uptake (CVR2 = 0.29 and 0.85, respectively). This was due a big crop uptake response to P but not K fertiliser, and P but not K fertiliser reacting strongly with the soil. Conversely, under the minus fertiliser treatments, MIR gave a reasonable prediction of plant K uptake (CVR2 = 0.65) but not of plant P uptake (CVR2 = 0.11), because predictions of indigenous extractable soil K were reasonable (CVR2 = 0.57) but of indigenous extractable P were poor (CVR2 = 0.22). Spectral features indicated that organic substances e.g. organic acids were the main determinants of nutrient uptake, and oxides, clay and sand were also positive predictors varying with the nutrient.
Many of the soil components determining plant nutrient availability are IR-active, so IR modelling with larger field-scale datasets could make reliable fertiliser uptake and yield response predictions.

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P-383

A new technique placing white painted water-filled polyethylene bottles on soil surface beside plant bases to reduce soil temperature damages

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Under the hot weather condition, high soil temperature retard the plant water absorption even soil water sufficient to plant growth. To reduce soil temperature damages, we developed a new technique to place white painted and water-filled polyethylene (PET) bottles beside the plant bases. Experiments were conducted in greenhouse in Japan International Research Centre for Agricultural Sciences in Ishigaki Island, Okinawa, Japan.

In the first experiment, effects of vertical burying and horizontal placing water-filled PET bottles on soil temperature were evaluated. Soil temperature reduction at 10 cm depth in horizontal placing water-filled PET bottles was highest (1.5˚C) at mid day. Soil temperature reduction at 10 cm depth in vertical burying watered PET bottle was 0.5˚C around 15:00 which is less than horizontal placing. In the second experiment, effects of water-filled PET bottles horizontal placing beside the plant bases of chilli and cucumber with drip irrigation were evaluated. The PET bottle placing increased the leaf growth of chilli and the yield of cucumber, 30% and 40%, respectively. The technique named water bottle technique (WBT) is effective especially for developing countries due to no energy and less capital cost.

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P-383A

Data fusion of proximal and remote sensors improves mapping of soil physical and geochemical properties at the farm-scale

Dr Yakun Zhang, Dr Alfred Hartemink, Dr Jingyi Huang, Dr Philip Townsend

In this study, we evaluated the data fusion of proximal sensors (visible near-infrared (vis-NIR) and X-ray fluorescence (XRF) spectroscopy) and remote sensors (airborne hyperspectral data and space-borne data – LiDAR DEM and Sentinel-1) to map soil properties in a heterogenous landscape and investigate the contributions of the different sensor data to the mapping accuracy. The study was conducted on a 330-ha farm in south-central Wisconsin, USA, where soils are relatively young and soil variation is high. One hundred sampling locations were selected to collect soil samples from 0 to 90 cm deep at every 10-cm depth interval. All the soil samples were scanned using both proximal sensors in the laboratory, whereas selected subsamples were analyzed for physical and chemical properties. In the first step, different combinations of vis-NIR and XRF sensor data through principal component analysis were evaluated to predict soil properties for the whole dataset. In the second step, different combinations of airborne and space-borne remote sensing data were evaluated for mapping clay, silt, sand, Al, Fe, and Si for the 0–10 cm depth of bare field. The partial least square regression (PLSR) model was used for establishing relationships between soil properties and proximal or remote sensing data. It was found that combining vis-NIR and XRF spectra, and hyperspectral data with DEM and Sentinel-1 improved model performance for mapping a range of soil properties. In a highly heterogeneous landscape, surface soil properties can be accurately mapped combining proximal and remote sensing data.

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P-384

Coupling non-invasive imaging and reactive transport modeling to investigate oxygen and soil moisture dynamics in the root zone

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Plant roots influence physical and biogeochemical soil properties, e.g. through respiration, growth, and water uptake. Observed gradients and patterns in the rhizosphere feature pronounced spatiotemporal variability, and mathematical models contribute to our understanding of the underlying dynamic processes. This study aims to bridge the gap between experimental measurement of small-scale gradients in the rhizosphere and modeling of overarching transport and uptake processes to explain observed patterns with a focus on oxygen and soil moisture dynamics, as being closely linked.
We measured O2 concentration (via optode imaging), soil moisture (via neutron radiography) and root system architecture (neutron laminography) during a drying-rewetting experiment with plants grown in slab-shaped rhizotrons. Based on this experimental dataset, we constructed a 2D model of the rooted soil domain (0.12m x 0.11m) using the reactive transport code MIN3P-THCm. Roots are represented in the model in terms of local root surface density based directly on the neutron imaging results. By combining high-resolution, coupled imaging with numerical simulations, we
(1) identify the most important processes that must be considered when constructing a reactive transport model that characterizes oxygen and moisture dynamics in a complex root-soil system and
(2) test to which extent “inhomogeneities” observed in the experimental system, e.g. cracks or local bulk density variations need to be included in the model to match observed O2 concentration patterns.
We will assess shortcomings and benefits of the direct combination of imaging experiments and reactive transport modeling on the single plant scale and outline the potential for the method’s future application.

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P-384A

Resolving the distinct arrangement of soil organic matter and interactions with mineral particles at the microscale based on NanoSIMS analysis

Dr. Steffen Schweizer, Dr. Thiago Inagaki, Dr. Itamar Shabtai, Dr. Tara Webster, Dr. Roland Wilhelm, Dr. Carmen Hoeschen

Advanced spectromicroscopic analyses such as NanoSIMS can reveal the functioning of organic matter (OM) dynamics at the microscale in soil. By resolving at scales that capture individual organic and mineral components, NanoSIMS can locate hotspots of OM turnover and storage and investigate the relationships between OM and fine mineral particles. This research composites several studies that provide a broader perspective into how the spatial arrangement is driving OM dynamics in soil. We traced isotopically labeled substances to quantify the proportion of added OM that interacts with mineral- and OM-dominated particle surfaces. A comparison of soils with different properties demonstrated that Fe and Al oxides can be co-localized and form increased associations with N-rich OM. Distinct organo-mineral arrangements are highlighted by spatial interactions of OM-dominated regions with the distribution of Ca and Al. Here, we review various study results and hypothesize that the OM dynamics in soils do not equal the sum of individual mineral or OM properties, but are governed by their distinct spatial arrangement at the microscale. Taken together, these findings provide a new perspective of spatially resolved interactions that determine the fate of OM locally at the soil microscale.

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P-385

Soil liming requirement method analysis in Scotland: optimum resource use for management of agricultural emissionss

Ms Rose Boyko, Dr Gareth Norton, Dr Robin Walker, Professor Graeme Paton, Professor Christine Watson

Scottish agricultural climate policies aim to reduce emissions by 9% by 2032. This target relies on precision fertilizer use via soil pH management. Liming requirement (LR) methods are used to determine the volume of lime needed to reach a soil target pH value. Analyses of methods have been performed in a number of countries but not in Scotland to date. This research aims to provide analysis of the accuracy of main LR methodologies and to find the soil factors that contribute to LR values. Methods analyzed included SAC's model, Rothlime model, Modified Mehlich, SMP and Sikora buffers, and $Ca(OH)_2$ titration. Forty-one soils representing 48% of Scottish agricultural land were used. Soils incubated with lime for a period of time is a common method to determine the true pH change in soil. Incubated soils had the highest correlation to the Sikora ($r^2 = 0.82$) and SMP ($r^2 = 0.77$) buffers, both overestimating LR values. Incubated soils yielded moderate correlation to SAC ($r^2 = 0.66$) and Rothlime models ($r^2 = 0.58$) with greater accuracy in values. Soil factors most correlated to liming capacity included organic matter ($r^2 = 0.62$), CEC ($r^2 = 0.61$), clay ($r^2 = 0.46$) and sand particles ($r^2 = -0.42$). The $Ca(OH)_2$ titration method was recommended as an alternative to current lab-based methods due to its accuracy, minimal environmental impact and price. Where greater soil pH precision is required, analyses beyond common models should be explored. Improving accuracy in future methods should include soil texture, CEC and OM content.

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P-386

Correlative neutron and X-ray imaging of soil-plant systems

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Neutrons form a highly penetrating radiation passing through matter without damaging or structurally modifying it, a property that makes them the ideal tool for many kinds of complementary material investigations. Neutron imaging is one of the experimental techniques in which captured or scattered neutrons provide important information about the inner structure and indirectly about the composition of a sample considering the fact that different materials attenuate neutrons to a greater or lesser extent. The strong interaction of neutrons with hydrogen and their ability to distinguish between hydrogen and deuterium with no radiation damage make neutrons a good probe for imaging biological specimens. This talk aims to present the recent developments in combined neutron and x-ray imaging techniques and their applications to soil-plant systems based on the latest results acquired from the research done at the Rutherford Appleton Laboratory in collaboration with academic partners. [1-5]

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P-387

On the nature of interactions between hydrophobic organic compounds and clay minerals - a molecular modelling approach

Dr Peter Grančič, Dr Leonard Böhm, Prof Daniel Tunega, Prof Martin H. Gerzabek

Risk assessment and management of soils and sediments is inevitably connected to the biological availability and accessibility of contained pollutants. Particularly, our understanding of the medium- and long-term behaviour of hydrophobic organic compounds (HOCs) in the environment is highly relevant, especially when substances are persistent, bioaccumulative, and toxic. HOC sorption and desorption processes in soils and sediments are of vital importance in this context. In the present work, interactions between HOCs (represented by halogenated benzene derivates) and smectite clay minerals (represented by montmorillonite clay with varying number of isomorphic substitutions) are investigated via series of density functional theory calculations. Based on the calculated electron densities, conclusions are drawn revealing the nature of their mutual interactions, the related stability of such complexes as well as possible molecular arrangements. A number of the calculated properties can be directly compared with experimental findings. These systematic studies aim to contribute to a better mechanistic understanding of the interactions of hydrophobic organic compounds and reactive mineral soil surfaces. The combination of molecular modelling methods and laboratory adsorption experiments will be executed within the framework of "ClayHOC" project.

smectite clay, hydrophobic compounds, polyaromatic hydrocarbons, density functional theory

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Prediction of different organic matter fractions in forest soils by thermogravimetry

M. Eng. Ina Krahl

Soils are an important storage of organic carbon and this soil function is strongly influenced by environmental factors and land use. Predicting the potential for soil organic carbon (SOC) sequestration is challenging due to the diversity of its composition and the wide variation in the biological stability of the different fractions.
A new approach considers water binding as functionally important property of SOC investigated by thermogravimetric fingerprinting of natural and used soils. The study deals with validation of indicators derived from this approach for managed forest soils. The used sample set comprises major soil types of Bavarian forests, sandy soils from pine forests in Brandenburg, organic litter and wood residues. Thermogravimetric indictors of SOC were compared with results of density fractionation, soil respiration and biodegradation of organic residues gained from laboratory incubation experiments.
We found significant correlations between selected density fractions of soil organic matter (SOM) and dynamics of thermal mass losses (TML). Further results indicated the potential applicability of TML to assess biological degradation independent from soil use (agriculture, grassland, forestry). The biological degradation showed a dependency of wood residue on humus condition, sampling depth, temperature, and moisture. The SOC content of mineral horizons and the organic layer of forest soils could be determined via TMLs in 10°C temperature increase steps what offers opportunities for indirect SOM assessment.
We conclude about the potential of thermogravimetry for simple quantification of soil organic carbon in forest soils although there is a lack of information on causal factors for the relationships used.

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P-389

Simple method for estimating the content of nonexchangeable potassium in paddy soil using extraction with sodium tetraphenylborate

Dr Naoki Moritsuka, Mr Kosuke Baba, Mr Hiroomi Horiuchi, Dr Hiroki Saito, Dr Ryosuke Tajima, Prof Yukitsugu Takahashi, Prof Hideaki Hirai, Dr Kaori Matsuoka, Dr Daisei Ueno

Nonexchangeable potassium (K) in soil plays a key role in maintaining K availability for a long term, although its determination is more laborious than exchangeable K. Sodium tetraphenylborate (NaBPh4) facilitates the release of nonexchangeable K by precipitation of K+ as KBPh4. Based on the idea that the volume of KBPh4 would reflect the amount of K extracted from soil, we developed a simple method for estimating nonexchangeable K in soil. By referring to Cox et al. (1996), 1 g of air-dried, 2-mm sieved soil and 0.41 g NaBPh4 were placed into a 15-mL Falcon centrifuge tube, and 6 mL of 1.7 mol L-1 NaCl containing 0.01 mol L-1 EDTA-2Na was added. The suspension in the tube was mixed and left undisturbed at 25°C to allow the soil to settle. After 6, 24, 48, 72, and 96 hours, soil volume was measured visually using the granulated lines on the tube. The tube without addition of NaBPh4 was also prepared. By using 190 paddy soil samples collected from 6 farms, we evaluated whether the concentration of NaBPh4-extractable K can be estimated from the difference of soil volume between the tubes with or without NaBPh4. During the settlement period, the difference of soil volume increased until 48 hours and remained almost constant thereafter. The increase of soil volume after 48 hours could predict the concentration of NaBPh4-extractable K with the R2 value of 0.78. However, the proposed method was not sensitive enough to detect the small within-farm variations of NaBPh4-extractable K in soil.

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P-390

Applying geostatistics to quantify the 2D surface roughness of crusted soil surfaces under different cover crops

Dr Mary Thornbush, Prof. Richard J. Heck, Dr Adam Gillespie, Dr Laura Van Eerd

Soil crusting typically involves a changing in surface roughness, which can be diagnostic of topsoil characteristics and local processes. Given that agricultural management practices, which promote soil cover, can influence crust formation, the main objective of this study was to compare the soil crust surface characteristics under selected management practices. This was carried out by applying geostatistics at the microscale using directional semivariance analysis to examine the surface. High-resolution (40 µm) digital elevation models were extracted from 3-D x-ray µCT imagery of cores extracted from fields with long-term cover crop plots, for four different treatments of cover crop (radish, rye, oats, and a combination of radish/rye mixture) and no cover (control) groups. Semivariance analysis was conducted using a Java script algorithm executed in ImageJ. The results indicated that surface roughness was affected by cover crop type, with rougher surfaces evident in the mixed treatment of a radish/rye cover crop. Conversely, using a radish cover crop produced the smoothest surfaces, indicating a lack of surface cover sufficient enough to reduce crust formation due to exposure. Generally, planting cover crops later in the summer led to smoother surfaces, suggesting that the lack of cover enhanced soil crusting. There are notable implications of this study, including the promotion of management practices that reduce surface roughness as structural crusts develop.

Keywords: Semivariance; ImageJ; x-ray µCT; µDEM
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P-390A

Subsurface biofilm community assembly in porous environments driven by microbial interaction via spatial niche partitioning

Dr Yichao Wu, Dr Peng Cai, Dr Qiaoyun Huang

Biofilm is a central microbial living strategy in subsurface porous environments. Due to the inherent microscale spatial heterogeneity of microbial communities and activities, the role of microbial interactions and the underlying mechanisms that shape biofilm community structure are poorly understood. Here, we employ a microfluidic chip to show that microbial interactions between free-living and biofilm-forming bacteria drive deterministic community assembly through spatial niche partitioning in porous environments. In contrast to current knowledge, we find that a positive interaction taking place during initial colonization improves the fitness of both biofilm and planktonic populations and thereby promotes their respective dominance in segregated niches. The initial niche preemption exerts a priority effect to determine the subsequent community structure. Through exometabolomics and pairwise interaction analyses, we show that free-living Arthrobacter enhances biofilm fitness by scavenging the biofilm inhibitor, D-amino acids. Collectively, our results reveal how microbial interactions impose selective forces on microbial community assembly and provide a roadmap towards understanding the intricate microbial interactions at biologically relevant scales.

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P-391

Contribution of soil properties to the biotic and abiotic degradation processes of aflatoxin B1

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Aflatoxins (AFs) are toxic fungal secondary metabolites that are commonly detected in food commodities. It is a common practice to incorporate contaminated crop residues that can no longer be commercialized into the soil. AFB1 is known to be degraded via selected enzymes and also via light exposure. These processes do also occur in soils. Nevertheless, soil has been largely overlooked as a potential source and sink of AFs and as a matrix in which these degradation processes take place. Therefore, we conducted a study to investigate the degradation processes contributing to the dissipation of AFB1 in soil. AFB1 contaminated soils were incubated for 28 days under three conditions: unsterile soil incubation in dark (biodegradation, BD), sterile soil incubation in dark (dark abiotic degradation, DAD) and sterile soil incubation under UV-light (photodegradation, PD). AFB1 concentration decreased in all degradation scenarios. Initial results indicate that the rate of degradation decreased in the following order: BD > PD > DAD. In addition, considerably slower degradation was observed in the more humic and clayey soil under all degradation regimes. This may be explained by the strong immobilization of AFB1 due to sorption to clay minerals and soil organic matter, lowering the bioavailability for degrading microorganisms. In addition, the presence of organic ions may served as an energy acceptor for the photoexcited AFB1 molecule, returning it to its ground state and thus protecting it from photodegradation. These findings may contribute to a better understanding of the fate and relevance of AFs as environmental micropollutants.

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P-392

Urban sources of microplastics – The Coimbra city case-study

MSc Inês Amorim Leitão, Dr. Loes van Schaik, Dr. António José Dinis Ferreira, Dr. Violette Geissen

Microplastics are an increasing subject of concern worldwide, since they contribute to the environmental pollution in water, air and soil. In urban environment, sources of microplastics pollution are identified as wastewater, landfills, industrial production, roads, etc. However, little is known about microplastics contamination of urban soils. This study investigates the spatial distribution of microplastics in soils of six land-use systems in the urban area of Coimbra city (Portugal). Three composed samples of the topsoil (10 cm) were taken from nine urban agriculture, industry, construction and parking spaces, and from two dumps and landfills. All the 120 samples are currently quantitatively and qualitatively analysed on their microplastic content (MPs < 2 mm). The flotation method is being used to extract microplastics and the microscope and the FTIR for visualize and identify them. The present work clarifies the degree of microplastics pollution in the soil of urban spaces and, specifically, which land-uses and associated activities may lead to higher levels of contamination. The different microplastics potential sources will be discussed. First results show high levels of microplastics at different locations in the city of Coimbra. It is expected that the dumps and landfills present the highest values. For better understanding of the fate of microplastics in urban areas, more knowledge on the connection between the sources and sinks of microplastics and pathways of transport is necessary.

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P-393

Effects of the addition of organic amendments on physicochemical and biological properties of mine tailings: a worldwide meta-analysis

Dr Humberto Aponte, Mr Hendrik Sulbarán, Dr Jorge Medina, Dr Claudia Rojas

Mine tailings (MTs) are characterised by high metal(loid) contents, acidic pH, poor physical structure, among others (Sun et al., 2018), which hinders the plant establishment. However, the addition of organic amendments (OAs) can improve initial substrate properties for further biological management such as phytostabilization. This meta-analysis evaluated the effects of several OAs on the physicochemical and biological properties of MTs. A bibliographic search was performed in the Thomas Reuter Web of Science and Scopus using "mine tailing*" and "organic amendment*" as keywords. A total of 496 scientific articles were obtained, from which 16 were processed (November 2021) to extract the required data. Observations of each physicochemical and biological variables were classified for 1) MT without OAs, and 2) MT with OAs. Moderators of the effect of OAs on MTs were registered (e.g., type of OA, MT acidity, and others). The current data comprises 1594 observations partitioned on 30 and 12 physicochemical and biological properties respectively, from which the log response-ratio was calculated in R statistic 4.1.0. Results show an increase in pH, electrical conductivity, available and total carbon content, as well as decreasing in bulk density and most of available metals contents after the addition of OAs (especially compost and biochar). Higher biological activity and abundance was registered in MTs by the addition of OAs. These results varied by the type of OA, the acidity of MTs, among others. Thus, general positive effects of the addition of OAs on MTs have been registered, which can allow plant establishment and development.

Sun, W., Ji, B., Khoso, S.A., Tang, H., Liu, R., Wang, L., Hu, Y. (2018). An extensive review on restoration technologies for mining tailings. Environmental Science and Pollution Research 25, 33911–33925. doi:10.1007/s11356-018-3423-y

P-394

Ex situ soil bioremediation – how environmentally sustainable can we make it?

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Ex situ bioremediation is generally viewed as a sustainable remediation approach over landfill disposal for hydrocarbon contaminated soils.
The shift from generic total petroleum hydrocarbon (TPH) to risk based speciated TPH fraction targets has certainly increased the opportunities for application in the UK. As a result, ex situ bioremediation is now potentially applicable for a wider range of hydrocarbon contaminated scenarios aside from the most heavily contaminated soils and/or recalcitrant hydrocarbons.
In recent years there has been increased attention in the UK and other countries in comparing the sustainability of remediation approaches for projects/sites. However, these sustainability assessments are 'high level' and largely qualitative.
This presentation looks at factors that influence the environmental sustainability of ex situ bioremediation as a remediation technique for hydrocarbon contaminated soils; specifically looking at environmental sustainability from a remediation contractor perspective and drawing on commercial application, and applied research, on ex situ bioremediation in a temperate climate. Moving forward, considering these factors and through their assessment, our aim is to help ensure ex situ soil bioremediation projects are run as environmentally sustainably as possible.

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Amoxicillin adsorption onto bioadsorbent materials

Msc Raquel Cela-Dablanca, Dr Ana Barreiro, Msc Lucía Rodríguez-López, Professor Manuel Arias-Estévez, Dr María Josefa Fernández-Sanjurjo, Dr Avelino Núñez-Delgado, Professor Esperanza Álvarez-Rodríguez

Amoxicillin is one of the antibiotics most used in the treatment of infectious diseases, both in veterinary and human medicine. Due to its high consumption and the fact that more than 80% of it is excreted through feces and urine, this antimicrobial agent reaches wastewater and can end up entering the soil, causing serious environmental problems. This research is focused on the adsorption and desorption of amoxicillin onto/from five by-products of the forestry and food industries (eucalyptus leaf, pine bark, pine needles, biomass ash, and mussel shell). For this, batch type experiments were carried out, adding increasing concentrations of the antibiotic (0, 2.5, 5, 10, 20, 30, 40 and 50 µmol/L) to samples of 0.5 g of bio-adsorbent. Eucalyptus leaf, pine needles and biomass ash showed high adsorption scores, which were higher than 80%, similarly to Putra et al. (2009) results with bentonite. Regarding pine bark and mussel shell adsorption scores reached 39% and 48%, respectively. Similarly, Conde-Cid et al. (2019) found that mussel shell was not adequate for tetracycline adsorption, meanwhile, pine bark was described as a good bioadsorbent for this antibiotic. When adjusting the results to adsorption models, pine bark, wood ash and mussel shell fitted well to the Freundlich and Linear equations, while the pine needle and eucalyptus leaf do not fit well to any of the models. Regarding desorption, it was 5% or lower for all the bio-adsorbents. All the materials studied in this work performed well as adsorbents for amoxicillin, except pine bark.

Conde-Cid, M., Ferreira-Coelho, G., Arias-Estévez, M., Álvarez-Esmorís, C., Nóvoa-Muñoz, J.C., Núñez-Delgado, A., Fernández-Sanjurjo, M.J., Álvarez-Rodríguez, E. 2019. Competitive adsorption/desorption of tetracycline, oxytetracycline and chlortetracycline on pine bark, oak ash and mussel shell. Journal of Environmental Management 250, 109509-109519.
Putra, E.K., Pranowo, R., Sunarso, J., Indraswati, N., Ismadji, S. 2009. Perfomance of activates carbon and bentonite for adsorption of amoxicillin from wastewater: Mechanisms, isotherms, isotherms and kinetics. Water Research 43, 2419-2430.

P-396

Partitioning and fate of (ultra)trace elements along a steep redox gradient in mesoscale laboratory lysimeter experiments

M.Sc. Marcus Böhm, Dr. Daniel Jara Heredia, Dr. Arno Märten, Dr. Francesca Quinto, Prof. Dr. Thorsten Schäfer

The potential far-field transport of radionuclides from a deep geological repository for high-level radioactive waste into the biosphere and e.g. the food chain must be considered. A mesoscale laboratory lysimeter experiment with four different natural agricultural top-soil substrates was set up to investigate the upward transport of long-lived radionuclides and their homologues from groundwater through the unsaturated zone.

Packed lysimeters were placed in a climate chamber at 10.5°C. Grimsel-Test-Site groundwater carrying actinide tracers ^{233}U, ^{237}Np, ^{242}Pu and ^{243}Am at ≤ ppq levels (Quinto et al., 2015, Quinto et al., 2017) was continuously fed for over 750 days to the subsoil and maintained at a constant level in the evaporation driven systems. After about 200 days, the formation of a redox interface at the capillary fringe was observed by in-situ Eh probes and with sub-mm resolution using chemical optical sensor foils (VisiSens TD). After 500 days an injection of conservative tracers (Br, Cl) and homologues of radionuclides such as SeO_4^{2-} and I- was performed. Along the physicochemical gradient in the lysimeters with Eh differences of 500-700 mV in a 7cm soil section, a change in porewater water composition was detectable. Conservative tracers and I- showed a recovery of >80% in the anoxic zone, whereas e.g. I- showed significant lower recoveries in the oxidized zone. A partitioning of monitored elements was observed to different colloidal size fractions and to the dissolved fraction as demonstrated by 1kDa filtration and ultracentrifugation. AMS measurements and solid phase analysis will be discussed in the presentation.

Quinto et al. (2015), Anal Chem, 87, 5766-73
Quinto et al. (2017), Anal Chem, 89, 7182-89

P-397

From overburden to soil: can we create functioning soils by recycling mine spoil?

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Soil degradation, resulting in the loss of fertile and functioning soil, is one major challenge for humanity. Mining, cement and aggregate industries do not only require an extensive land usage, but also produce an excessive amount of overburden material that is challenging to recycle. However, some of these mine spoils have the potential to deliver beneficial nutrients to plants and may therefore be mixed with soils and valorized as manufactured soils for rehabilitation of degraded landscapes.
We conducted a 10-week mesocosm experiment with sunflowers (Helianthus annuus L.) to characterize the performance of various rock spoil (basalt, augite, and greywacke) and soil mixtures, resembling Cambisols of either clayey or sandy texture. In order to test the performance under challenging environmental conditions, we tested a severe drought treatment in addition to the regular watering treatment and compared both treatments to natural soils as a control.
Our results show that, regarding plant growth, initial soil texture and drought had a higher impact than the rock spoils. Regarding soil structure however, the rock spoils increased the amount of microaggregates in the soils by up to +70%. We also highlight a re-distribution of organic carbon (OC) into the finer fractions of the soil (up to +32% OC in <250µm fractions), regardless of the soil texture, which is promising for long-term OC persistence.
Based on this work, the tested mine spoils have the potential to be recycled as component in manufactured soils providing suitable soil-like functions and maintaining plant growth.
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AMOXICILLIN ADSORPTION ONTO SOILS COMBINED WITH BIOADSORBENT MATERIALS

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The antibiotic amoxicillin may appear as an emerging contaminant in different environmental compartments, because between 80-90% of the dose administered is excreted, due to its poor absorption by living organisms (Kidak and Doğan, 2018), and this, together with its low degradation rate, favor its presence in wastewater, and also in soils due to the use of sewage sludge as fertilizer. This work aims to determine the adsorption and desorption of amoxicillin on/from soils combined with different by-products that can act as bio-adsorbents (eucalyptus leaf, wood ash, pine bark, and mussel shell), comparing with the adsorption capacity of the soils alone. These bio-adsorbent materials were mixed with the soils at doses of 12 and 48 t/ha. To carry out the study, batch-type experiments were performed, in which increasing concentrations of amoxicillin were added to 2 g of mixtures consisting of soil + bio-adsorbent. The dose of 12 t/ha of bio-adsorbent was not enough to produce substantial changes, while the dose of 48 t/ha increased the adsorption capacity of the soils for all the bio-adsorbents, with pine bark being the most effective, reaching values of practically 100% adsorption for amoxicillin. When adjusting the adsorption data to different models, the best fitting corresponded to the Freundlich's equation. As for desorption, it decreased when the bio-sorbents were added to the soil, with desorption percentages never exceeding 5%. The four materials performed well as bio-adsorbents for amoxicillin when mixed with soils, since they increased their adsorption capacity and decreased the desorption of this antibiotic.

Kidak, R., Doğan, Ş., 2018. Medium-high frequency ultrasound and ozone based advanced oxidation for amoxicillin removal in water. Ultrasonics Sonochemistry. 40, 131-139.

P-399

Adsorption of amoxicillin in forest and crop soils

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In this work, the adsorption and desorption of the antibiotic amoxicillin (AMX), is studied for 17 different soils. Batch-type tests were carried out, adding increasing concentrations (0, 2.5, 5, 10, 20, 30, 40, and 50 µmol L-1) of the antibiotic to the soils. The adsorption values ranged from 90.97 to 102.54 µmol kg-1 (74.21-82.41% of the amounts of antibiotic added) for forest soils when the highest concentration (50 µmol L-1) was added, while the range was between 69.96 and 94.87 µmol kg-1 (68.31-92.56%) for maize soils, and between 52.72 and 85.40 µmol kg-1 (50.96-82.55%) for vineyard soils. Among all soils, the highest adsorption was shown by those being more acidic and having high organic matter and non-crystalline minerals contents. The best fitting to adsorption models corresponded to Freundlich's, similar to the results obtained by Kim. et al (2012). Regarding AMX desorption, it was generally <10%, similar results were obtained in previous studies for cefuroxime antibiotic (Cela-Dablanca., 2021). These results can be considered relevant for agricultural and forest soils as regards risks of pollution due to an antibiotic that, reaching the environment, can be a hazard for human and environmental health.
Cela-Dablanca, R., Nebot, C., Rodríguez-López, L., Fernández-Calviño, D., Arias-Estévez, M., Núñez-Delgado, A., Álvarez-Rodríguez, E., Fernández-Sanjurjo, M.J. 2021. Retention of the antibiotic cefuroxime onto agricultural and forest soils. Applied Sciences 11, 4663. https://doi.org/10.3390/app11104663.

Kim, Y., Lim, S., Han, M., Cho, J. 2012. Sorption characteristics of oxytetracycline, amoxicillin, and sulfathiazole in two different soil types. Geoderma 185-186, 97-101. https://doi.org/10.1016/j.geoderma.2012.03.016.

P-400

Arsenic Detoxification by Extremophilic Cyanidiales

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The extremophilic Cyanidiales could subsist in high temperature (up to 56℃) and acidic habitats. The tolerance of Cyanidiales for stressing high-salt, drought as well as heavy metals conditions are application for metal retaining and cycling. Particularly, the extensively applicable genes such as arsenic methyltransferase genes have been revealed in Cyanidiales. Therefore, it is the first attempt to develop the detoxification of arsenic(III) [As(III)] in Cyanidiales [Galdieria partita (Gp), Cyanidioschyzon merolae (Cm), and Cyanidium caldarium (Cc)] at the acidic condition. To determine the spatial distribution, speciation, and interaction of As on Cyanidiales, the Transmission X-ray microscopy (TXM) and As K-edge X-ray absorption spectroscopy (XAS) accompanied by linear combination fitting (LCF), as well as the synchrotron-based Fourier-transform infrared spectroscopy (SR-FTIR) to investigate changes in functional groups and protein secondary structure (PSS) of Cyanidiales were used. The As accumulated in Cyanidiales was regulated in consort with three mechanisms. A part of As(III) ions were oxidized to As(V) by Cyanidiales. Then, the As(III) and/or As(V) ions were complexed with polysaccharides on surface of Cyanidiales, wherein the sucrose on polysaccharides were mainly participated in the reaction. Simultaneously, the As(III) ions were transported in vivo of Cyanidiales and complexed with the cysteine which makes it promoted the sorption capacity of Cyanidiales for As. All mechanisms for resisting As were discovered in Cyanidiales, however, responses for defensing As were depended on different Cyanidiales species. Collectively, the Cyanidiales could be an innovative green technology for applying to remediate variously contaminated sites, especially in acidic environments.

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(3) Qin, J., Lehr, C. R., Yuan, C., Le, X. C., McDermott, T. R., & Rosen, B. P. (2009). Biotransformation of arsenic by a Yellowstone thermoacidophilic eukaryotic alga. Proceedings of the National Academy of Sciences, 106(13), 5213-5217.

P-401

Phytomanagement solutions for Cd-Pb contaminated garden soils: results of field and pot experiments

Ms Sibylle Comeliau, Gilles Colinet

Central Belgium has a rich industrial history that has left a heavy heritage of contaminated sites. Food safety has become a prominent public concern when transfers of metals from soil to vegetables were measured in private and market gardens, even in areas with slight to moderate contaminations. Associating high biomass crops to target vegetables may be a promising approach since it allows food production to continue while remediating soil.
Field and pots trials were conducted to investigate the combination of Swiss chard with accumulator crop species, Helianthus annuus or Brassica juncea, and the effects of intercropping on growth performance and metal uptake by the involved plants. The experiments were performed on Cd-Pb contaminated soil. The impacts of organic amendments, biochar and green waste compost, on the phytoremediation efficiency and soil properties were also assessed.
Compared with Swiss chard monoculture, intercropping with high biomass crops significantly reduced chard biomass production and did not significantly decrease chard shoot concentration. The labile metal fraction and soil pH were not significantly different between amended and unamended treatments. However, the application of green waste compost has limited the Zn and Cd uptake by chard.
Our results do not show evidence of benefit in terms of metal uptake by chards from intercropping and that a longer time period may be needed to determine the effects of organic amendments addition on soil properties. Further studies are still needed to identify remediation strategies allowing a safe production of vegetables in areas impacted by small atmospheric contaminations.

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P-402

Soil constraints to crop production

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Soil constraints, which are responsible for significant yield losses globally, can be defined as any soil characteristic that limits crop growth and negatively impacts agricultural production. For example, in Australia, ~76% soils have single or multiple constraints and cost farmers $2 billion/annum in forfeited grain yield. Soil constraints can be naturally occurring or induced by inappropriate agricultural management and can either be physical, chemical and/or biological. Soil constraints may occur singly or in combination and tend to vary spatially across the landscape and within soil profiles, occurring in both topsoil and subsoils. This variability increases management complexity and improvements in our ability to identify what constraints and where in soil profile they occur are required to effectively target management. Constraint management approaches can generally be grouped into three broad categories: a) amelioration, which focuses on the removal of constraints or reduction in their severity; b) agronomic management, which uses techniques to maintain crop production despite the presence of constraints; and c) land use change, which is used when amelioration or agronomic management are not logistically/economically feasible. This paper provides a brief overview of the different types of constraints affecting cropping systems, the importance of accurate constraint diagnosis, and management options available to improve farm productivity and profitability. It also introduces a new book entitled 'Soil Constraints to Crop Production' due for publication in early-2022, which provides a comprehensive outline of the major soil constraints and includes detailed regional case studies outlining approaches to soil constraint management in major world regions.
Dang, Y.P, Menzies, N.W and Dalal, R.C. (2022) Soil Constraints to Crop Production. Cambridge Scholar (due for publication in early 2022)

P-403

Identification, extraction, and analysis of microplastics in agricultural soil: protocol development and optimisation.

Miss Grace Davies, Professor Iseult Lynch, Professor Stefan Krause, Dr Samantha Marshall, Dr Massimiliano Mascelloni

Microplastics (particles <5mm) are emerging contaminants of the terrestrial environment. Whilst the impacts of microplastics on soil are not fully known, it is possible that they will compromise soil health and functions. Soils act as a sink for microplastics, which typically enter the soil through the widespread use of plastic in agriculture, with the agricultural industry representing 3.4% of global plastic demand (Plastics Europe, 2020). Other common entry pathways include the application of microplastic-containing sewage sludge as fertiliser, and the direct application of microplastics via the polymer encapsulation of pesticides and seeds.

We urgently need to understand how microplastics of different compositions and sources affect soil ecosystems, but research progress is hindered due to the lack of standardised protocols for the identification, extraction, and analysis of microplastics in the complex soil environment.

This talk presents our research to optimise the extraction and analysis of microplastics from soil samples, following a generalised framework of sieving, density separation, organic digestion, and spectroscopic analysis. It outlines the effectiveness of each step in the soil matrix and its applicability for both biodegradable and non-biodegradable microplastics. It compares the effect of commonly used digestion solutions (e.g., Fenton’s reagent, hydrogen peroxide, intended to remove the organic particles) on the polymers, by using Raman spectroscopy and Scanning Electron Microscopy to characterise the plastics before and after treatment, and thus to assess chemical and physical changes arising from the sample processing. Based on the findings, recommended workflows for different microplastic polymer types are presented.

Plastics Europe. (2020). Plastic the Facts -2020. https://plasticseurope.org/knowledge-hub/plastics-the-facts-2020/

P-404

Can Pongamia pinnata be an effective phytoremediation tool in the Copperbelt of Zambia?

Dr Erika Degani, Dr Benjamim Warr, Dr Rodica Pena, Dr Amin Soltangheisi, Dr Ihsan Ullah, Prof. Mark Tibbett

Contaminated land surrounds numerous mining towns in the Copperbelt of Zambia. As mining activities decline communities are left heavily impacted by the negative environmental and social conditions surrounding them. The challenge is to understand and promote an effective revegetation approach that is economically productive, providing employment, and diversification. Pongamia pinnata (L.) Pierre, a tree member of the Fabaceae family, has generated interest as a potential sustainable biofuel feedstock. It produces seeds with high oil content and can be cultivated in marginal land, therefore removing the issue of competition for land with edible crops. Additionally, the phytoremediation potential of Pongamia is also being explored and the use of crops with high bioenergy potential for the phytoremediation of contaminated soils can potentially provide both economic and ecological benefits. Our study aims to gain fundamental understanding of the potential of P. Pinnata as a phytoremediation tool. We are assessing how P. Pinnata has modified the soils around it and how the plant has responded to the high levels of copper (Cu) in tailings (up to 6000ppm) using a randomised complete block design field trial established in Cu mine wastes, with control plots established both in natural soils and untouched mining tailings. This is being done through: (i) Rhizosphere soil, root, and leaf analyses to determine Cu content; (ii) monitoring of chlorophyll content; (iii) root assessment of mycorrhizal colonisation and rhizobium nodulation; and (vi) DNA metabarcoding to assess soil microbial and invertebrate diversity and composition.

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P-405

Mining subproducts and compost as amendments for the remediation of a multi-element polluted soil

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Soil pollution by metal(loid)s is a worldwide environmental issue. The study of nature-based solutions to remediate this contamination is urgent and mandatory. The use of soil amendments to reduce the mobility of the pollutants, providing at the same time nutrients and the organic matter needed for plant development, is an innovative technique of increasing interest. The objective of this experiment was to test the capacity of mining subproducts and compost to restore a soil polluted with As, Cu, Pb and Zn, and this scope fits in the objectives of circular economy. To perform the experiment, pots containing polluted soil amended with the mining subproduct (rich in magnesium silicates), compost or/a blend of both, were controlled during 42 days in the greenhouse. These amendments were combined with Eupatorium Cannabinum L (a plant with phytoremediation capabilities). The evolution of soil properties, metal(loid)s availability, microbial activity, and vegetation (photosynthetic efficiency, pigments content, oxidative stress or stem and roots length) was examined. In general terms, the amendments reduced the availability of the contaminants after 42 days, especially when the two amendments were combined. Nevertheless, the use of compost implied an increase in As availability (slightly smoothed with concurrent dunite addition) together with a biomass increase, that revealed plant resistance to this metalloid. Consistently, the concentration of pigments in the plant, the physiological factors related to plant stress, and the microbial populations showed better behavior with the addition of the compost.
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P-406

Transfer and ecotoxicity of wood treatment residues in soil and water

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New methods of modifying wood such as furfurylation have appeared in recent decades. The polymerization of furfurylic alcohol with cellulose and lignin improves the resistance to wood decaying fungi (Sejati et al., 2017). Nevertheless, environment behavior evaluation of furfurylic residues is poorly documented (Dong et al., 2020) with a few studies on the ecotoxicity of leachates from furfurylated wood (Lande et al., 2004; Pilgård et al., 2010). Thus, effects of furfuryl wood treatment residues on the environment was followed during 2 years using outdoor lysimeters filled with three representative soils of Lorraine. Samples of beech wood (20 x 2 x 0.5 cm) untreated, or treated with tanalith or furfurylic alcohol have been planted in soil columns. In addition, ecotoxicity tests were performed in different ways of exposure: aquatic organisms were exposed to leachates and terrestrial organisms were exposed to lysimeter soils. Whatever the soil, the wood degradation was faster for the control compared to tanalith or furfuryl treatments. The levels of treatment residues in percolates are below the LOQs for azoles and furfuryl alcohol, and reached up to 30 µ/L for copper. No effect of percolates was observed on rotifers and daphnids. A lower effect on growth of algae was observed with furfurylated wood compared to tanalith. In soils, the levels of treatment residues are lower than the LOQs for azoles and furfuryl alcohol. Copper contents reached 47 mg/kg in the 0-5 cm topsoil. Rapeseed and oat were grown on lysimeter soils: no effect of wood treatment was observed.

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P-407

Role of metallothoneins in conferring tolerance to cadmium and copper in plants

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The problem of soil contamination with heavy metals is a global problem that affects the cultivation of several crops. Metallothioneins are a class of proteins that bind to heavy metals and have an important role in controlling the level of such metals within living tissue of plants and animals. We have isolated the genes from poplar and the tropical species Pongamia that encode one specific metallothionein, introduced these genes into a cup2 mutant strain of yeast, and shown significantly improved resistance to normally toxic levels of copper and cadmium. For example, the transgenic strain was able to grow on 1000 µM, ten times the normally toxic level. Similar results were obtained with cadmium. We have now generated transgenic lines of Arabidopsis, the model plant used in such studies, and will describe the response of these lines to growth in copper and cadmium.
It is hoped that such information can be used in the future to help in the reclamation of contaminated land in Africa and Asia.

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P-408

Minerals associated organic carbon induce distinct priming effects on stable soil organic carbon decomposition in Mollisol

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The decomposition of soil organic carbon (SOC), affecting climate feedbacks and global carbon cycling depend on microbial activities driven by substrate types and bioavailability. However, it remains unclear how mineral associated organic carbon may influence the decomposition of SOC. In this study, to investigate the effects of added oxalic acid (13C-labeled and unlabeled oxalic acid) bound to vermiculite and montmorillonite on the decomposition of SOC from topsoil, a series of laboratories incubations were conducted. We mixed 5 g of vermiculite and montmorillonite separately with 35 ml of different concentrations of oxalic acid (0.125 and 0.75 Mol L-1) to ensure the sorption of oxalic acid into minerals. Thereafter apart from control, we added each mineral-oxalic acid complex (3g) into mollisol (20g) to obtain the following treatments: Mollisol+Vermiculite-oxalic acid0.125 (Vm0.125); Mollisol+Vermiculite-oxalic acid0.75 (Vm0.75); Mollisol+Montmoriollinite-oxalic acid0.125 (Mt0.125); Mollisol+Montmorillonite-oxalic acid0.75 (Mt0.75) and incubate for 21 days. The results show change on the XRD spectra and in the isotherm curves after mineral-organic interaction, confirming the sorption of oxalic acid onto minerals. The variation of priming effects occurred for all treatments: The positive priming effect appears in all treatments during the first period (1-7 days); a pulse of negative priming effect appears in the second period (7-21 days). After 21 days of incubation, the NMR results demonstrated that chemical composition of SOC change depending on the associated mineral types. These findings emphasis the key role of mineral associated organic carbon in regulating the stock of soil carbon in Mollisol

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P-409

Geochemical patterns and contamination aspects of rare earth elements (REEs) in soils of Northwestern Italy

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REEs have acquired much interest in the last decades due to their ever-growing demand in modern technology. Nevertheless, their presence and distribution in the environment is still underreported, since only in recent years REE have been considered as emerging contaminants.
In urban areas, the concentration of anthropic activities makes soils a possible primary sink for REE and, in turn, a potential source through leaching and through dispersion of particles by erosion. This is particularly relevant considering the proximity of these soils to humans.
This study reports soil REEs contents in different urban and natural areas in an attempt to establish natural background and possible anthropogenic enrichments of REE in the Piedmont region. Soils were sampled in urban and peri-urban sites around a heavily industrialized area, in mining areas were high REEs backgrounds were expected and in uncontaminated areas.
Pseudo-total REEs concentrations were determined using ICP-MS after a microwave-assisted aqua regia-hydrogen peroxide digestion. The dissolution method was optimized testing different acid attacks, extracting conditions and soil:solution ratios on certified reference soils with diverse characteristics. The method with the highest REEs recovery was selected.
To investigate REEs distribution, enrichment factors (EF) REE-normalized patterns, REE fractionation indices (LaN/YbN, LaN/SmN, SmN/YbN, and LREEN/HREEN ratios) and geochemical anomalies ratios (δCe and δEu) were assessed Accordingly, the binary cross-correlation plots of the selected indices and ratios were used to discriminate the natural variations of REE concentrations from anthropogenic sources which would influence REE levels.

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P-410

Soil pollution risks for agricultural lands of Georgia

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One of the main reasons for degradation of the soils in Georgia is considered contamination with heavy metals and radioactive isotopes. In south-east Georgia, on Mashavera river valley, soils with high potential of agricultural productivity and well-maintained irrigation system, Meadow cinnamonic (Kastanozems) soils are being polluted with heavy metals coming from irrigation water and dust from open mine pit sites extracting gold and cooper.

Heavy metals such as (cooper, zinc, cadmium, etc.) are critically polluting soils on agricultural areas. Their concentration exceeds maximum allowed norms and the reason for that is irrigation water coming from Mashavera river. Contamination of soils carry high risk of entering heavy metals in food chains and creates threat for plants, animals and human health. In Imereti region, Zestaponi ferromanganese plant causes contamination of Brown forest (Dystric Cambisols), Yellow brown forest (Chromic Cambisoils and Stagnic Alisols), Raw carbonate (Rendzic Leptosols) and Alluvial (Fluvisols) soils by increasing concentrations of cooper, manganese and lead, which exceeds maximum permissible concentrations on some agricultural lands.

After 29-30 years from accident on Chernobyl atomic station, radioactive contamination of the soils of Georgia is still problematic. According to the newest research in west Georgia (in vicinity of village Jvari) Yellow podzolic soils in 0-20 cm and 20-40 cm layers are polluted by 137Cs.

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P-411

Occurrence of pesticide residues in agricultural soils in northern climate

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Globally, around 3 million tons of pesticides are applied annually. In EU, there are almost 500 active substances approved, with annual sales of 374,000 tons of pesticides. Although the use of chemicals is regulated and controlled by wide ranging legislation, the risk of pesticide contamination to agricultural ecosystems is evident. Mixtures of multiple pesticide residues have been shown to commonly persist in agricultural soils of EU. Specific concern is related to northern ecosystems, where pesticides might persist longer because of prevalent soil types and climatic conditions.

In Finland selected soil element concentrations have been monitored over decades (the national soil monitoring program of Finnish agricultural soils Valse). Instead, information on pesticide remains in the soil and their risks for northern soil environment is almost totally lacking.

PesResValse -project (2021-2023) produces novel and comprehensive information on the occurrence of pesticide residues in agricultural soils across Finland. Specific aim is to compare soil contamination levels between various production systems (organic vs. conventional, dominating crop species) and soil types. The aim is also to investigate whether there is a connection between soil pesticide remains and soil biodiversity.

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P-412

Quarternary alkylammonium disinfectants in soils

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Quaternary alkyl ammonium compounds (QAACs) are a group of cationic disinfectants and surfactants with numerous industrial and agricultural applications that are frequently released into the environment. Against this background, this contribution aims to increase the understanding of the occurrence and behaviour of QAAC in soils. We developed a method to analyze QAACs concentrations in soils and investigated the long-term accumulation of QAACs in Mexican soils that were irrigated with wastewater for different times (0, 1, 3, 6, 8, 13.5, 35, 85 years).
The most abundant QAAC homologues in wastewater-irrigated soils were Benzylalkyl Compounds (BACs) > Alkyltimethyl Compounds (ATMACs) > Dialkyldimethyl Compounds (DADMACs). Concentrations of QAACs increased linearly and slowly in the first years of irrigation (∑ QAACs: 2 - 23 µg kg-1), but after 40 years of wastewater irrigation, an exponential increase in QAAC concentrations (up to 155 µg kg-1) was observed. In contrast to pharmaceuticals, no apparent steady state of concentrations in soils was reached after decades of wastewater irrigation. Our results demonstrate that continuous input of QAACs with wastewater used for irrigation, but likely also with organic fertilizers, sewage sludge or pesticides, can cause a long-term accumulation of these compounds in soils.
Considering the intensive use of QAACs in general and during the COVID-19 pandemic in particular as well as the potential co-selection of antibiotic-resistant bacteria by QAACs, our findings on the accumulation of QAACs in soils highlight the need for further research addressing the bioaccesibility and effects of these compounds on microorganisms in the environment.

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P-413

Assessment of vanadium mobility in two contrasting soils from tropical and temperate regions with nano titanium oxide amendments

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Vanadium (V) is a re-emerging potentially toxic element. Its mobility depends significantly on soil physicochemical properties. Due to high sorption capacity nanoparticles can be used as amendments to immobilize V in contaminated soils. The mobility of V in the presence of titanium nano-oxides (TiNO) has not been investigated for contrastingly different soils. We evaluated the mobility of V in two soils in the presence of TiNO using a tropical Ultisol from the wet-zone of Sri Lanka (Paleudult) and a temperate Mollisol from the prairie region of Canada (Calciudoll). Soils were characterized for mineralogical signatures using FTIR, and charge density using surface titrations. A pH-adsorption edge study of V was conducted on soils alone and mixed with TiNO (1% w/w) in the pH range from 4 to 10. The pH of Paleudult and Calciudoll were 5.4 and 8.3, respectively. The FTIR revealed predominant clay minerals for Calciudoll as montmorillonite and for Paleudult as kaolinite. Surface charge density in Calciudoll was positive and decreased with increasing pH while in Paleudults it was negative, and negative charges increased with increasing pH from 5 to 9. The pH-adsorption edge for V in Calciudoll was located in the pH range of 5.4 to 7.2. Vanadium adsorption declined after pH 7.2 indicating greater mobility of V in soils with pH > 7.2. The addition of 1% TiNO increased V adsorption capacity by 11% and extended the pH-adsorption edge to 7.8. Understanding factors controlling V mobility in soils is important in controlling its release to the environment.

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P-414

Would amendments used to immobilize phosphorus change the mobility of potentially toxic elements during snowmelt flooding?

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Soil amendments applied to reduce phosphorus losses from agricultural soils has the potential to change geochemical properties of soils altering the mobility of potentially toxic elements (PTE). Changes of PTEs (As, Cu, Ni, Se, V, and Zn) with snowmelt flooding due to the addition of amendments in the previous fall season were rarely investigated. This experiment was conducted (a) to evaluate the release of PTE loadings to spring snowmelt and (b) to compare PTE loadings in snowmelt of unamended, gypsum-, MgSO4- and alum-amended soils. In the fall of 2020, field plots were laid out in a randomized complete block design in two agricultural fields (manured and non-manured), and amendments were surface applied at a rate of 2.5 Mg ha-1. Runoff boxes were installed at the edge of plots during the winter to collect snow. In the spring of 2021, snowmelt in each box was pumped out, and volume was recorded until the end of the snowmelt period. The PTE, other cations, and pH were measured using a subsample. The measured PTE loadings in the manured field were higher than in the non-manured field. Selenium, V, Ni, Zn, and As loadings in MgSO4-amended treatment in the manured field were significantly less (58% to 83%) than the un-amended treatment. All PTE loadings in the non-manured field and Cu loading in the manured field had nonsignificant treatment effects. Our results with one season show that the effect of amendments on PTE loadings varied depending on the amendment, metal, and soil conditions.

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P-415

Alkaline Metalliferous Mine Remediation: Issues of Incorporating Organic Amendments for Phytostabilisation Goals

Dr Andrew Innes

Ecologically driven remediation of abandoned mining sites remains an attractive target, by allowing natural processes to stabilise and reduce the potentially harmful legacy effects of these contaminated landscapes.

Over the years organic amendments have been widely applied to abandoned mines, with varying success, however alkaline mine tailings present unique challenges to remediation since the incorporation of organic amendments can elicit the increased mobility of potentially toxic elements (PTEs) from the site, therefore impacting the success of revegetation projects.

Mine tailings from an abandoned Pb-Zn mine were studied in column leaching experiments under various application rates of common organic amendments (Manures, composts and coffee wastes), with the observations of increased mobility of PTEs, leaching of nutrients and acidification of tailing substrates. Further in-situ field studies indicated that plant revegetation efforts are challenging to achieve on these sites, immobilising plant nutrients and only providing limited decreases in the uptake and translocation of PTEs to plant systems.

The challenges of balancing ideal soil conditions for plant development and the risks of increasing PTE release from these sites are clear, and a careful selection of organic amendments to suit the environmental and geological nature of the sites is essential for successful rehabilitation projects.

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P-416

Ubiquitous occurrence of disinfectant quaternary ammonium compounds in soils of Hesse, Germany

Msc Kai Jansen, Christian Mohr, Dr. Christian Heller, Katrin Luegger, Prof. Dr. Jan Siemens, Dr. Ines Mulder

Quaternary ammonium compounds (QACs) are cationic organic substances with amphiphilic properties that are widely used as surfactants and disinfectants in industry, households and agriculture. Several studies suggest that exposure to QACs co-selects for antibiotic resistant microorganisms and thus may contribute to antibiotic resistance formation in the environment. Although often detected in sewage sludge, sediments and surface waters, data on the occurrence in soils is scarce and limited to soils that are prone to exposure with QACs. Therefore, we conducted a comprehensive screening for QACs in soils of Hesse, federal state of Germany, covering an area of 21,115 km².

64 soil samples from agricultural, grassland, forest and vineyard sites were provided by the Hessian Agency for Nature Conservation, Environment and Geology and are part of the Hessian continuous soil monitoring program. Five gram of each air-dried sample was extracted ultrasonically with an extraction solution consisting of 99.9% acetonitrile and 0.1% HCl (v/v) and subsequently analysed via HPLC-MS/MS.

In 51 of all samples, QACs were detected above the limit of quantification, most frequently dialkyldimethylammonium (DADMACs), benzylaklydimethylammonium and alkyltrimethylammonium compounds. The highest total QAC concentration was 5.4 mg kg-1 for a grassland soil influenced by riverine suspended particle loads during floodings with DADMAC-C16 and -C18 as dominant QAC homologues.

Our work highlights the ubiquitous occurrence of QACs in soils of Hesse and the need for more research concerning their impact on antibiotic resistant microorganisms in soils.

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P-417

Occurrence of mycotoxins in soil under different tillage systems on German croplands

Mrs. Lena Juraschek

Mycotoxins are secondary metabolites produced by certain fungi that have harmful effects on animals and humans. They are either produced on growing plants and can accumulate during storage, or remain on plant residues that stay on the field after harvest and are exposed to the soil environment for varying lengths of time through subsequent tillage practices. To prevent erosion, conservation soil management practices such as no tillage or mulch seeding have been adopted in recent decades. Among many benefits of conservation tillage, it also carries risks: harmful fungi can survive on the mulch layer and produce mycotoxins, which may accumulate in the soil. Currently, over 300 different mycotoxins have been identified. Deoxynivalenol (DON) and zearalenone (ZEA), in particular, are common mycotoxins in agriculture that often co-occur and are suitable indicator compounds and should therefore serve as target compounds for monitoring changes in soil quality. However, current monitoring efforts focus mainly on the accumulation of these mycotoxins in cereals and crops, while the dynamics of their formation, accumulation, and sorption in soil have received little attention. Therefore, our aim was to investigate the occurrence of DON and ZEA in soil under different tillage systems. To achieve this, we first established an LC-MS/MS method in our lab and analyzed soil samples from German croplands from long-term (20 years) trials, varying by plow, mulch, and no-till systems. The first results showed that the amount of mycotoxins DON and ZEA is higher in soil samples without tillage than in plowed soil samples.

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P-418

A simplified approach to the assessment of environmental risk caused by soil contamination with potentially toxic elements – case studies

Prof. Anna Karczewska

The problem of soil pollution with potentially toxic elements (PTEs) in Poland and Europe concerns basically only the sites contaminated in the past, where the contaminants have been subject to aging processes or to remediation measures. If the contamination occurs in a large area, the attempts to apply technical decontamination would not be reasonable. Remediation measures over the large, slightly or moderately polluted areas may be aimed at slow removal of relatively mobile elements, such as Cd and Zn, for instance by phytoextraction. In the case of elements that are poorly soluble and poorly taken up by plants, the only reasonable remediation method is phytostabilization followed by a regular control of environmental risk. Various factors, however, can cause PTEs to be remobilized in soils thus increasing the associated risk. This contribution will present various examples of factors, such as soil pH or redox potential, or the introduction of organic matter, that may increase the solubility and ecotoxicity of PTEs. A discussion will be commenced on the possibility of using a simplified methodology of environmental risk assessment, based on the results of extraction with selected extraction agents. The development of such a methodology would provide a valuable monitoring tool for (phyto)stabilized areas without the need for complex and largely discretionary methods of health risk assessment implemented in different countries. For various kinds of contaminated sites, polluted with multi-PTEs, the assessment obtained on the basis of soil extraction will be compared with the results of ecotoxicological bioassays.

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P-419

Diffuse soil contamination is a ‘sleeping giant’ problem needing more attention

Professor Mark Kibblewhite

Diffuse soil contamination (DSC) arises from historic and current sources that may be local or distant. Here the need for a stronger focus on DSC is presented. The public health implications of DSC are clear: exposure pathways may be direct, for example via soil ingestion and dust inhalation, or indirect, for example via contamination of water supplies or uptake into the food chain. New ‘signals of harm’ from DSC may soon be observed, supported by epidemiological studies employing more powerful methods of spatial data analysis and access to better health statistics. And there is a growing awareness of emergent diffuse pollutants. Continuing and poorly monitored sources of DSC in the urban and peri-urban environments include unabated combustion of solid fuels, vehicle emissions, construction activities and informal disposal of wastes. Natural background levels of some soil contaminants sometimes exceed risk-based guidelines for human health protection. More commonly, however, the natural background is negligible compared to DSC from anthropogenic sources. Historic DSC can be re-mobilised and dispersed in dust and by flooding, extending its spatial distribution, but the processes and extent of this re-mobilisation are poorly understood and awareness of them is limited. Characterising and attributing risk from sources of DSC is complex, requiring identification and analysis of multiple sources, pathways, and receptors, all of which vary in type, number, and in their temporal and spatial configuration. Nonetheless, there is a growing imperative to better describe and assess DSC to inform environmental and public health policies.

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P-420

The effect of drainage on the physicochemical and microbial characteristics of peat: an investigation on three UK blanket bogs

Mr Ezra Kitson, Dr. Nicholle Bell

Over the last century we have acquired substantial evidence that water table regime is a fundamental determinant of peatland health. Peatland health refers to the ability of a peatland to perform essential ecosystem functions for humanity, including but not limited to, carbon sequestration, water filtration, flooding prevention and sustenance of high biodiversity. Undrained peatlands perform these services better than drained peatlands. The question is, why?

Peatland drainage affects the physicochemical and microbial characteristics of peat. These characteristics are linked and likely interact through feedback mechanisms, although the precise nature of these interactions are not known. The result of these changes is to create peat that no longer performs the ecosystem functions listed above. The consequences for humanity are serious: carbon release driving global warming, flooding, fresh water pollution and loss of biodiversity.

The primary aim of this work is to develop a better deterministic understanding of how peatland drainage changes the physicochemical and microbial characteristics of peat, and in turn how these changes result in loss of ecosystem functions. Secondary aims are to identify individual variables that can be used as robust proxies for peatland health and to assess the success of current peatland restoration efforts using statistical models based on these variables. To this end, metabolomic characterisation through FT-ICR mass spectrometry, microbial characterisation using 16S RNA and DNA sequencing and a variety of physicochemical analyses were performed on peat cores taken from drained, undrained, and rewetted regions at three UK blanket bogs. This presentation explores findings from these datasets.

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P-421

Effects of Tourism Activities on Grassland Degradation in Hulunbuir Grassland, Inner Mongolia, China

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The recent increase in the number of tourists has raised serious concerns about grassland degradation by tourism activities in Inner Mongolia. Thus, we evaluated the effects of tourism activities on the vegetation and soil in Hulunbuir grassland. We identified all the plant species, measured the number and height of plants and plant coverage rate, calculated species diversity, and estimated above-ground biomass in the used plot and the non-use plot. We also examined soil hardness, and soil physical and chemical properties in both plots. The obtained results were as follows: a) the height of the dominant plants, plant coverage rate, species diversity, and above-ground biomass in the used plot were significantly lower than those in the non-use plot, b) Carex duriuscula C.A.Mey., indicator plant for soil degradation, was dominant in the used plot, c) OC, TN, LFC, LFN and CEC in the topsoil were lower in the used plot than the non-use plot possibly because of the decrease in plant residue input, and d) soil hardness was significantly higher in the used plot than in the non-use plot and spatial dependence of soil hardness was only found in the used plot (range was 111 m). On the basis of the results, we concluded that the tourism activities can be another major cause of the grassland degradation in Inner Mongolia and that when tourism facilities are moved to avoid further land degradation by tourism activities, they should be moved more than 111 m away from the original location.

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P-422

Exchangeability of radiocesium and potassium in decontaminated agricultural soils from different parent materials in Fukushima, Japan

Mr. Kohei Kurokawa, Ms. Ikumi Asano, Dr. Atsushi Nakao, Dr. Yuzo Mampuku, Dr. Junta Yanai

Decontamination of agricultural fields after the Fukushima accident in 2011 reduced radiocesium (^{137}Cs) content in the surface soil. However, few studies elucidated ^{137}Cs transfer risk of decontaminated soils from different parent materials. Therefore, the objective of this study was to determine total and exchangeable ^{137}Cs as well as phytoavailable potassium (K) content, controlling factors of ^{137}Cs transfer, of decontaminated agricultural soils from different parent materials.

Soil samples (0–15 cm depth) were collected from decontaminated agricultural fields in sedimentary rock area (S soils, n = 173) in Tomioka town in 2016, and granitic area (G soils, n = 18) in Iitate village in 2019. Exchangeable K (Ex-K) in soils was extracted with 1 M CH_3COONH_4, whereas phytoavailable K with 1 M HNO_3. Nonexchangeable K (Nex-K) content was obtained by subtracting Ex-K content from phytoavailable K content. Total and exchangeable ^{137}Cs (Ex-^{137}Cs) in soils were determined by γ-ray spectrometry.

Total ^{137}Cs content were on average 1.2×10^3 Bq/kg for both S and G soils, and the Ex-^{137}Cs ratio were 8.1% and 10%, respectively. Decontamination activities effectively reduced the total ^{137}Cs to about one-fifth of those before decontamination with keeping low mobility of this nuclide. Average Nex-K content for G soils (218 mg K_2O/100g) was higher than S soils (55 mg K_2O/100g), mainly because of higher K-bearing mineral contents in G soils and sediments used for decontamination. In conclusion, geological background behind soils and sediments largely controls ^{137}Cs transfer risk in decontaminated fields.

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P-423

LONG TERM EFFECTS OF GLYPHOSATE APPLICATION IN A CORN-SOYBEAN ROTATION ON SOIL RHIZOSPHERE MICROORGANISMS

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The herbicide glyphosate (N-(phosphonomethyl) glycine) was first introduced in 1974 as a non-selective, broad spectrum, post-emergent agrochemical (trade name Roundup®) to control weed populations in agricultural farming. The effect of glyphosate on the environment, and specifically on soil microbial populations is still controversial and debated. Much of the research has been on short-term glyphosate effects which might differ compared to long-term effects. Therefore, a greenhouse study was conducted with a repeated application of glyphosate (eight soybean/corn growth periods in rotation) to determine long-term effects. Long-term glyphosate applications increased the abundance of gram-negative soil microorganisms relative to a single application as detected by phospholipid fatty acids (PLFAs). 13C labeled Glyphosate revealed insights into glyphosate decomposition and priming effects. DNA-Microbiome analysis via LOOP-Genetics indicated long-term glyphosate application shifted the balance between soil beneficial and non-beneficial microorganisms, with evidence that glyphosate stimulates the fungal Fusarium species that can produce mycotoxicity, causing plant disease.
In addition, Next-Generation Sequencing (NGS) analysis of the rhizosphere bacterial community after medium-term glyphosate exposure (4 growth periods) revealed that the relative abundance of Acidobacteria decreased in response to glyphosate exposure. Furthermore, glyphosate increased protein metabolism, decreased amino acid synthesis, and the central carbon metabolism by bacteria was downregulated under glyphosate exposure.

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P-424

Storage and Dynamics of Organic Pollutants (Polycyclic Aromatic Hydrocarbons) in Alpine Soils

Miss Lise Marchal, Dr. David Gateuille, Pr. Jérôme Poulenard, Pr. Emmanuel Naffrechoux, Dr. Noelia Garcia-Franco, Dr. Martin Wiesmeier

Mountainous soils from Central Europe provide various ecosystem services and they are very important as biological hotspots. However, these soils are affected by the deposition of high amounts of toxic organic pollutants (such as Polycyclic Aromatic Hydrocarbons, PAH), which are strongly bound to soil organic matter. In addition, climate change may lead to PAH remobilization from soils to rivers. Currently, there is only limited information on the role of different soil organic matter pools on the potential remobilization of PAH in mountainous soils. Our study focused on the potential remobilization of PAH in several French alpine toposequences and chronosequences. On more than 40 plots (~ 320 samples), pollutant contents were investigated in relationship with external (distance to cities or to roads, altitude) and soil factors (organic matter content or quality, texture and aggregate characteristics) in order to identify the main drivers of the constitution of PAH stocks and to gain insights into how changes in soil properties may lead to pollutant remobilization.

Our results showed that all studied soils were polluted with PAH and that soils are relevant archives for industrial activities, particulalry in alpine valleys. Moreover, our results suggest that a change in the quality and/or the quantity of organic matter can change the storage capacity of PAHs in soils.

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P-425

Bacterial community tolerance to Zn depending on how the metal is added to soil (single or multiple applications)

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Zn may reach soils from different sources, and depending on the source, may vary from one high pollution event to a continuous pollution with low Zn concentrations. In this work, Pollution Induced Community Tolerance (PICT) methodology [1] was applied to assess the effect of pollution event type on soil bacteria. For this aim, a soil with geochemical baseline concentration of heavy metals (pH 6.4; OM 17%; Zntotal = 203 mg·kg-1) was spiked with five Zn concentrations (0, 250, 500, 1000 and 2000 mg·kg-1) using two different procedures: a single Zn application followed by a 1 year of incubation, and multiple Zn applications for 1 year. After incubation period, bacterial community tolerance to Zn was measured [2,3] for all added Zn concentrations and spiking procedures. Results showed that bacterial community tolerance to Zn increased as added Zn to soil increased [4], regardless of the type of application. However, the magnitude of bacterial community tolerance to Zn was higher when Zn was added in a single application than when was added in multiple applications. Thus, bacterial communities were more negatively affected when Zn reach the soil in a single pollution event than when soil is polluted in multiple events with the same total amount of Zn.

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P-425A

Risk of Cu leaching in vineyard soils and its dependence on soil properties.

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The use of Cu based fungicides caused high Cu accumulation in vineyards[1], posing a high risk for surrounding environment if Cu is transferred to subsurface and ground waters. Cu leaching in soils depends on its adsorption/desorption, which are highly dependent on soil properties and Cu concentrations[2]. Therefore, to assess the potential impacts of Cu accumulation, leaching experiments in vineyard soils are needed. In this work, 10 soils with variable soil properties were spiked in the laboratory with 6 Cu concentrations (0, 50, 200, 400, 800 and 1600 mg/kg using Bordeaux mixture. Just after soil spiking, leaching experiments were performed using soil columns. Deionized water was passed through soil columns, output solutions collected, and Cu determined via atomic absorption spectroscopy. Mean Cu concentrations in the output solutions were highly variable as function of soil and Cu concentration. Mean Cu vary between 0.04 and 40.40 mg/L for different soils. When Cu was spiked with 1600 mg/kg, leaching was minimum in soils with soil pH >7.0 (0.19 and 0.49 mg/L), maximum in the soil with pH <5.0 (40.40 mg/L) and intermediate for soils with pH values between 5.0 and 7.0 (1.52-7.46 mg/L). In summary, some of the soils, depending on its pH, were more vulnerable for a high mobility of Cu to the aqueous phase of soil, posing a greater risk to soil biota in general and to the quality of aquatic resources. Thus, pH control in vineyard soils is a key management practice to prevent Cu pollution in vineyards surrounding waters.
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P-426

Herbaceous flora of sand dune and its soil characters

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Soil nutrients in natural ecosystems are spatially discrete at the macro, meso and micro aspects but in coastal dunes, the distribution of nutrients are not uniform and create a patchy environment with specific plants. The organic matter and other elemental concentration are observed low which leads to develop specific herbaceous flora under stress. Keeping this in view, an attempt has been made to document the herbaceous flora of seven selected sites of eastern coastal areas of Odisha, India along with their soil characters and other biotic and abiotic association during August 2020 to August 2021. The plant samples were collected and identified in the Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Cuttack, Odisha. The soil characters were analyzed and pH of carnivorous plants were noted down. The passport data form (PDF) was used to gather information from local communities. The results revealed that 25 herbaceous flora was common in all selected seven sites along with two carnivorous plants (one terrestrial on dune and one in seasonal brackish water) having pH less than 6. Low organic matter and less nutrients were noted in the soil of all selected sites. The PDF analysis showed that the soil characters and vegetation is decreasing every year and in last 10 years, it was fast declination. The present study highlighted the importance of soil characters in the balancing of sand dune ecosystem and conservation of sand dune herbaceous flora which will be helpful in balancing food chain and ecology of microbes to higher taxa.

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P-427

Microbiome structure and functioning in field-contaminated soils by a copper smelter

Dr Pedro Mondaca, BSc Marlene Manzano, Dr Dinka Mandakovic, Dr Sebastian Abades, Dr Juan Luis Celis-Diez

Anthropogenic activities have affected the ecosystems leading to the loss of biodiversity. This is the case of coastal shrublands affected by emissions of a copper smelter in the Puchuncaví valley. We hypothesized that soil contamination reduced the soil microbiome biodiversity in the Puchuncaví valley. Vegetation loss has been reported in the Puchuncaví valley. However, the shrub Baccharis linearis has survived this impact. Thus, we also hypothesized that soil microbiome biodiversity is not reduced in the rhizosphere of Baccharis linearis? We assessed the soil microbiome structure in three contamination levels (uncontaminated, semicontaminated, and contaminated). At each contamination level, we collected soil and soil surrounding roots (SSR) samples. We extracted the DNA of these samples to sequence 16s and ITS regions to study bacteria and fungal populations, respectively.
We found a reduction of taxonomic biodiversity of bacteria and fungi in soil samples but not in RSS. Similarly, beta diversity showed that the soil microbiome differed among the three contamination levels only in the soil samples. However, the rhizosphere of Baccharis linearis would mitigate the effect of contamination.

Currently, we are finishing soil chemical analysis to contrast quantitively the effect of trace element concentration in soils with taxonomic and functional diversity indicators.

We will finish this work on december.

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P-428

Effect of soil mineral balance on soybean Cs uptake mechanism

Effect Of Soil Mineral Balance On Soybean Cs Uptake Mechanism Kazuki Murashima, Effect of soil mineral balance on soybean Cs uptake mechanism Hayato Maruyama, Effect of soil mineral balance on soybean Cs uptake mechanism Toshihiro Watanabe, Effect of soil mineral balance on soybean Cs uptake mechanism Takuro Shinano

After TEPCO's Fukushima Dai-ichi Nuclear Power Plant accident, radioactive cesium (Cs) has been widely studied in its dynamics in soil and transfer to plants. As potassium (K) acts as an antagonist to Cs, increasing K concentration in the soil solution suppresses radioactive Cs transfer. Cs uptake is mainly mediated by K transporters, but other minerals are expected to influence the Cs uptake mechanism, such as sodium and/or rubidium. It is important if we consider the uptake mechanism in the soil condition because the difference among soil types, growth stages, etc. may easily change the mineral balance in the soil solution. Therefore, it is necessary to evaluate Cs uptake in terms of "soil mineral balance".

Soybean (Glycine max (L.) Merr.) was grown in long-term fertilize field at Hokkaido University (June-September 2021). We set six treatments (without one of nitrogen, phosphorus, potassium, sulfur fertilizers, without any fertilizer, and with all fertilizers), and analyzed soil and plant mineral contents. There were significant differences among each treatment in growth at each growth stage. Regarding the dynamics of exchangeable cations in the rhizosphere soil, Cs and K were negatively correlated ($R = -0.84$, $P < 0.05$) and Cs and Na ($R = 0.65$, $P < 0.05$), Rb ($R = 0.75$, $P < 0.05$) were positively correlated. Thus, it is important to include these minerals to consider the countermeasure to mitigate Cs uptake in the field. We are currently investigating soybean and soil mineral contents for comprehensive mineral balance evaluation in several fields including Fukushima.

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P-430

Artificial soils to boost bioremediation in lindane-polluted soils

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There are different technologies to decontaminate soils polluted by lindane and its isomers, but most of them have some drawbacks. For example, physico-chemical technologies are not sustainable because they are expensive and create highly toxic compounds during the degradation process. Currently, the most profitable and ecological strategy is the use of microorganisms that have the capacity to transform this pesticide into non-toxic components. However, degraded soils limit the growth of these microorganisms. The main aim of the BtoGsoils project is to demonstrate that is sustainable and economically viable to remove lindane from industrial soils by using nature-based technologies.
The target soil is located in a brownfield polluted by lindane. Prior to the pilot experiment in the field, we have carried out a pot experiment under controlled conditions. First, consortium bacteria were acclimated for 90 days under aerobic conditions, using a mineral medium containing lindane as sole carbon source. Second, two artificial soils (Technosols) were designed to promote the growth of the selected bacteria. These soils were elaborated with organic wastes and biochar. Then, pots were filled with the polluted soil, with and without artificial soils, and with and without bacteria consortium. Lollium perenne seeds were planted in all pots. In parallel, landfarming microcosms were carried out in order to simulate an alternative treatment. All treatments were kept for 60 days. Physic-chemical and biological monitoring of soils was performed to optimize future real-scale treatments.

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P-431

FAO International Network of Salt-Affected Soils: joining efforts to manage salt-affected soils sustainably

Prof. Rosa M Poch

Soil salinization and sodification are major threats to global food security and to the achievement of the Sustainable Development Goals (SDGs) as identified in the Status of the World Soil Resources report (FAO and ITPS, 2015).
According to available data, salt-affected soils occupy more than 8.7% of land surface (FAO GSASmap, 2021). They are widespread in arid, semi-arid and coastal regions that pose a great challenge for farmers living on these soils, since they evolve very fast under changing environments.
To manage salt-affected soils sustainably, an integrated approach is required that converges soil, water, plant and climate knowledge with practical solutions through joint actions of scientists, international organizations, farmer associations, policymakers, and governments. To address this need, the International Network of Salt-Affected Soils (INSAS) was established under the umbrella of Global Soil Partnership (https://www.fao.org/global-soil-partnership/insas).
The main goal of INSAS is to address and facilitate the sustainable and productive management of salt-affected soils for current and future generations, also in the frame of adaptation to climate change
INSAS has four working groups of experts addressing the issues of salt-affected soils through four major themes: (1) SAS&Assessment: Mapping, assessing and monitoring of salt-affected soils; (2) SAS&SSM: Sustainable management of salt-affected soils (practices, policy); (3) SAS&Crops: Halophyte agriculture and salt-tolerant crops; (4) SAS&Water: Integrated soil and water management under saline/sodic conditions.
The presentation will cover the main achievements of INSAS in developing the harmonized methodologies of analysis, monitoring and mapping; collecting good practices and other important activities.
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P-432

Combined bioaugmentation and biostimulation techniques in bioremediation of pentachlorophenol contaminated forest soil

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Pentachlorophenol (PCP) is quite persistent in the environment and severely affects different ecosystems including forest soil. The main objective of this work was to study different bioremediation processes of artificially PCP (100 mg kg-1) contaminated forest soil (Sc). In fact, we used bioaugmentation by adding two different bacterial consortia B1 and B2, biostimulation procedures by applying amendments, such as forest compost (FC), municipal solid waste compost (MC), sewage sludge (SS), and phosphate, and the combined treatments. Soil physical and chemical properties, residual PCP, microbial biomass carbon and respiration and some enzymatic activities at zero time and after 30 d-incubation were evaluated. A net reduction of PCP after 30 d-incubation occurred in the sample Sc+B1+FC, as the best performance among all treatments, due to natural attenuation, immobilization of PCP molecules in the forest soil through organic amendments, and the action of the exogenous microbial consortium B1. The single application of FC or B1 led to a depletion of PCP concentration. Soil microbial biomass carbon decreased in PCP contaminated soil but it increased when organic amendment also in combination with microbial consortia was carried out as bioremediation action. Soil respiration underwent no changes in contaminated soil and increased under FC based bioremediation treatment. These results demonstrate that the combined treatments of biostimulation and bioaugmentation might be a promising process for remediation of PCP contaminated soil but further efforts should focus on expanding the research regarding soil-microbe-amendment-contaminant interactions to understand better the capability of indigenous and exogenous microorganisms under different environmental conditions.

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P-433

Assessing trace element contents in surface soils across Switzerland

Dr Jolanda Reusser, Prof Dr Lenny Winkel, Prof Dr Ruben Kretzschmar, Daniel Wächter, Dr Reto Meuli

Soils are the main source of most essential elements. However, some trace elements in soils, such as Cd, can threaten human and animal health already at low concentrations. Others, such as Se, are essential for organisms, but can become toxic at elevated concentrations. The aim of this study was to assess the trace elemental composition of soils in Switzerland in order to define regions of potential deficiencies or contaminations.

Between 2011 and 2015, 4'270 samples of the topsoils (0-20 cm) have been collected at 1'153 sampling sites along a regular 6 by 4 km grid covering whole Switzerland in the framework of a biodiversity monitoring program (Meuli et al., 2017). The dried soil samples were sieved at <2 mm with subsequent measurement of pH ($CaCl_2$) as well as total N and C contents (dry combustion). Elemental concentrations were then analysed in aqua regia digests of milled samples using ICP-MS. Our ultimate goal is the development of a geochemical soil atlas of Switzerland showing the spatial distribution of 22 elements in surface soils.

First results on Se indicate that the majority of soil samples (75th percentile = 0.5 mg Se/kg soil) fall within the concentration range of potentially Se deficient soils (Lyons et al., 2003). On a spatial scale, these soils are located in areas important for agricultural production. In contrast, elevated concentrations of As, Cd and Cr were detected in more than 25 % of sampling sites located in northwestern Switzerland.

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P-434

Azithromycin degradation under simulated sunlight and in the dark

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In this work, the degradation of the antibiotic Azithromycin (AZ) present in aqueous media was studied at three different pH values (4.0, 5.5 and 7.0), both under simulated sunlight (using a Suntest equipment) and in the dark, similarly to that previously carried out by Rodríguez-López et al. (2021). The experiment was performed at different times, from 30 min to 192 h. The results showed that the antibiotic concentration was reduced by 15% at 192 h in the case of the experiments in the dark, while AZ concentration decreased by 41% after 192 h under simulated sunlight. It was observed that changes in the pH value have a clear effect on degradation, giving that the higher the pH, the lower the degradation of the antibiotic. The data resulting from the experiments under simulated sunlight fitted well to an exponential decay equation, with R2 values always higher than 0.913. The half-lives of the antibiotic in the presence of similated sunlight ranged between 250 h at pH 4.0 and 455 h at pH 7.0, similarly to that reported in previous studies, such as the one by Mathon et al. (2021).

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P-435

Adsorption/desorption and release of Ciprofloxacin onto/from bio-adsorbent materials from the wood industry

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This research is focused on the study of the adsorption/desorption of the antibiotic Cirpofloxacin (CIP) onto two by-products derived from the wood industry used as bio-adsorbents (pine bark and cork oak bark), which was performed through batch-type experiments, as well as on the release of the antibiotic at different pH values (3.0, 5.0, and 8.0), by means of the stirred flow chamber technology. The results showed that CIP has high affinity for both bio-adsorbents, with KFA (Freundlich adsorption coefficient) values reaching 64.01 and 2066.8 Ln µmol1-n kg-1 for cork oak bark and pine bark, respectively, and with values of 3527.23 and 20104 Ln µmol1-n kg-1 for the Freundlich desorption coefficient (KFD), which indicates that a hysteresis is affecting the overall process, also reflected in desorption percentages below 5.5%. These values are similar to those previously obtained in studies such as that by Movasaghi et al. (2019). Regarding the results of the release experiments, they were below 35% for both bio-adsorbents, with most of the release from cork oak bark taking place at pH 8.0, while it took place at pH 3.0 in the case of pine bark. Therefore, both by-products performed well as bio-adsorbents, and can be recommended for soil remediation in cases of specific antibiotic pollution.

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P-436

Bacterial community tolerance to tetracycline antibiotics induced by As polluted soils.

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The presence of As in soils is increasingly abundant as a result of natural processes (parents rocks, volcanic activities, forest fire…) and anthropogenic activities (mining, pesticides, fertilizers…); and therefore, soil bacterial communities had to adapt to the presence of this contaminant. In the current research, a laboratory experiment was carried out to assess the co-selection of the bacterial community tolerance to As and tetracycline antibiotics (tetracycline, oxytetracycline and chlortetracycline) on 3 agricultural soils contaminated with 6 concentrations of As (1000, 750, 500, 250, 125 and 0 mg kg-1). The induced tolerance of bacterial communities (PICT) to As and tetracyclines was estimated following Bååth (1992) and Díaz-Raviña et al. (1994), using the leucine incorporation technique to estimated bacterial community growth (Bååth, 1994; Bååth et al., 2001). Tolerance was estimated as log IC50, the logarithm of the concentration of As or antibiotic that resulted in 50% bacterial community growth inhibition. In As polluted soils, Log IC_{50} values showed increases on bacterial community tolerance to As, but also to the three tetracycline antibiotics. The magnitude of these increases depends on added As dose and the type of studied soil. The study of bacterial community tolerance to antibiotics in agricultural soils is of vital importance since the appearance of antibiotic resistance genes in soil bacteria could be transmitted to human pathogens and therefore pose a risk to human health.

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P-437

From land to water: controls on microplastic movement in overland flow

Ms. Emilee Severe, Dr. Ben Surridge, Professor John Quinton

In 2019, farms in the EU used approximately 708 kilotons of plastic to grow and store their crops. Once added to the soil, removing this agricultural plastic is challenging as exposure to sunlight and other environmental elements fragment the plastics into macro- and microscopic pieces. Additionally agricultural soils are being unintentionally injected with microplastics from a myriad of sources e.g., biosoilds input, runoff from roads and atmospheric deposition. Several studies claim 80% of plastics currently present in oceans originate from the land but there is little empirical evidence behind this statistic. Soils are usually thought of as sinks for plastic waste but growing literature suggests mismanaged agricultural soils could be significant sources of plastics to aquatic environments. In this study, we investigated the process of microplastic movement in response to rainfall and overland flow. We compared the movement of two types of plastic (linear low-density polyethylene and acrylic) in two size fractions with sand particles in rainfall simulation experiments. We examine the extent to which plastic particles are preferentially eroded compared to fine sand particles, alongside the relative importance of particle size and polymer type for controlling the erosion of plastics from soil.

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P-438

Effects of microplastics on physical and physicochemical properties of loess soils

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Environmental contamination with microplastic (MP, 0.1 µm – 5 mm diameter) increasingly threatens soil functions, plant health, microbial activities and other biota. However, little is known so far on the effects on soil physical and physiochemical properties. The current study evaluated the potential effects of MP on soil physical parameters (saturated hydraulic conductivity, water retention, and water repellency) at typical MP concentrations found in farmlands (up to 2 % w/w). Polyethylene (PET) and polystyrene (PS) were used and three size ranges (between approx. 0.5- and 3-mm diameter) were produced and mixed with the soil at concentrations from 0.5 to 2 %(w/w). All plastic treatments (all sizes and contents) decreased saturated hydraulic conductivity (ksat) compared to the control soil without MP, irrespective of MP type. The highest reduction of ksat was found for the highest concentration (2 %) and the largest size of MP (approx. 3 mm diameter). Air capacity and permanent wilting point were mainly affected by the size of MP for both types. Total porosity, field capacity, plant available water and permanent wilting point decreased compared to the control from 0.5 to 2 % MP. Soil water repellency (contact angles) increased at a concentration of 2 % and for MP sizes > 1 mm, while no hydrophobic effect was observed for lower concentrations and smaller MP sizes. In conclusion, MP features (e.g., type, size, and content) had a discernible impact on soil physical parameters, which potentially may have an impact on plant growth.
Keywords; Microplastics,water retention, hydraulic conductivity, hydrophobicity
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P-439

Effect of mycorrhizal symbiosis on the partitioning of copper in Populus trichocarpa

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Fast-growing trees such as poplars may have potential in phytoremediation schemes. Their symbiosis with arbuscular mycorrhizal can alter element uptake, distribution and toxicity (De Oliveira et al., 2020). We assessed accumulation of copper (Cu) in Populus trichocarpa. Poplars were grown in sandy substrate under different Cu applications of 0, 729 and 6561 mg kg-1, with and without Rhizophagus irregularis and Paraglomus laccatum. Cu contents in roots and shoots were determined. Both AMFs did not influence root Cu concentrations and its transport to shoots. Cu accumulated mainly in roots (up to 52.2 g kg-1 Cu). Shoot Cu concentrations were 0.04, 2.20, and 17.75 g kg-1 under 0, 729, and 6561 mg Cu kg-1 soil, respectively, while they were 0.69, 18.92, and 52.24 g kg-1, respectively, in roots. Cu uptake by shoots was only influenced by different Cu concentrations applied to the soil. It increased with increasing Cu application rate being 1.7, 1028, and 8941 µg plant-1 under 0, 729, and 6561 mg Cu kg-1 soil. Cu uptake by roots was influenced by the interaction of mycorrhizae and Cu levels. When Cu was not applied, non-mycorrhizal treatments had the highest root Cu uptake. With Cu application, mycorrhizal plants showed higher root Cu uptake compared to non-mycorrhizal plants. Plants colonized with Rhizophagus irregularis had the highest root Cu uptake, being significantly higher than non-mycorrhizal plants and those with Paraglomus laccatum colonization.

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P-440

Rock dust application as a restoration measure for acidified forest soils: from mineral to helicopter

Mister Robrecht Van Der Bauwhede

Large parts of the world's forests suffer from soil acidification and nutrient depletion. Counteracting this soil degradation, exacerbated by atmospheric nitrogen pollution, is necessary for augmenting stress tolerance and safeguarding primary production in a context of climate change. As a potential solution, several soil restoration experiments with rock dust (RD) have been set-up in Europe. RDs are by-products from the mining industry, they are slow release multi-nutrient powders with soil liming traits. There is a large range of RDs on the market, however, there is neither a proper assessment of these products for forest vitality restoration, nor a clear physicochemical quality control on the products. As a result, forest managers are reluctant to apply them, remaining uninformed to what extent RDs are truly effective.

A wide and contrasting set of RDs were evaluated based on rapid laboratory assays that determine weathering rates at different temperatures and pH. This framework is linked back to the mineralogical composition of the RD. These assays are indicating RD's acid neutralizing and fertilizing potential which is compared to their functioning in the soil in a mesocosm pot trial. Lastly in new and old (35 years) field experiments we are showing and linking RD's short- and long-term ecosystem restoration effectiveness with reference to liming and mineral fertilizers.

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P-441

Changes in soil physical properties after the abandonment of vineyards

Associate professor Cristian Vasilică Secu, Associate professor Dan Cristian Lesenciuc, Lecturer Ionuț Vasiliniuc, Researcher Gabi Zaldea, Researcher Ancuța Nechita, Researcher Cătălin Alexandru

The study compares the variability in soil physical properties - penetration resistance (PR), moisture (θg), porosity (P) and bulk density (BD), in three closely related areas including active and abandoned vineyards and natural, forested vegetation. The study area located in Eastern Romania is characterized by plateaus covered by cambic Chernozems (WRB, 2014), while vineyards soils, due to the deep tillage and fertilization, have been classified as terric Anthrosols. The sampling implied a grid of 75 x 75 m for the vineyard soils and random sampling for forest. Soil parameters have been determined through classic methods for the topsoil, between and on each wheel track in the vineyards and close to each sampling point in the forested area. On the overall 196 determination were made. Total porosity registered decreasing values in the order forest (56.5) - abandoned vineyard (52-54) - active vineyard (44-55). Except for the abandoned vineyard, in all cases smaller values are characteristic for the wheel tracks, similar to the BD (mean minimum for wheel tracks of 1.12, respectively 1.50 g/cm3 for the space between). Higher values were also measured in the active vineyard. Soil humidity registers higher values in the abandoned vineyard and smaller on the wheel tracks, while RP has high values especially on the wheel tracks from the active vineyard. Some higher values determined in the forest need to be re-evaluated. All findings indicate, besides the well-known compaction on wheel tracks, that after the abandonment of the vineyards the soil starts to recover quite quickly.
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P-442

Comparison of green manures and farmyard manure effects on phytoremediation performance of contaminated waste soil using Salix Viminalis hybrid

Miss Yu Wang

Waste soil has been one of the top three categories of landfilled waste in Scotland for many years, but future policy changes will require alternative practices to be adopted. This study will assess the potential to phyto-remediate contaminated soil using Salix Viminalis hybrid as a bioenergy crop. This combination of soil phytoremediation and bioenergy production (e.g. willow short rotation coppices) will support soil recycling and so be more financially sustainable and more easily accepted by landowners of vacant or derelict land. A pot experiment has been designed to test Salix Viminalis hybrid biomass yields and remediation capability for a spiked contaminated soil. Addition of three green manures (Vicia sativa, Trifolium incarnatum, Trifolium resupinatum) and farmyard manure will be compared to measure changes in soil nutrients and Salix Viminalis hybrid performance. Contaminated soil was spiked with 5 g/kg lead nitrate, 7 mg/kg Benzo(a)pyrene, 10 mg/kg Benzo(b)fluoranthene, and 2 mg/kg Dibenz(a,h)anthracene. The contamination levels were based on an exemplar contaminated soil collected from a site in north England, where the topsoil layer was destined for landfill. Chlorophyll fluorescence analysis, numbers of branches or leaves (morphological / growth changes), and oven-dried biomass weight will be recorded for plant health and biomass yields analysis. Soil pH, EC, nutrient contents (NPK) will be measured to review soil condition with treatment. Trace element concentrations (ICP-OES) in soil and plant samples will be used to calculate phytoremediation efficiency, Translocation Factor (TF) and Bioaccumulation Factor (BAF). GC-MS will be used to determine PAH concentrations in soil samples.

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P-443

The mitigation on cadmium and arsenic in rice plants by successive application of various silicate materials produced in Japan

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ICodex Commission has instituted the maximum level of arsenic (As) and cadmium (Cd) in rice, requiring reduction them simultaneously. While silica materials can be concerned for the answer, the comprehensive research on a variety of the materials is insufficient. The purposes of this study are to analyze elution characteristics of the commercially available materials and to elucidate the relationship between the elution characteristics and As, and Cd concentrations in rice plant. The amount of available Silica in 31 materials was determined by an extraction method, followed by the selection of 14 materials, covering different levels of the available silica, for pot cultivation test under continuous flooding condition. The amount of Silica leached from the materials was found to have a certain relationship with the specific surface area. The concentrations of Silica, As and Cd in solution, and those in rice plant were analyzed by ICP-OES and/or ICP-MS.
The Silica concentration in soil solution positively correlated with the available silica of materials. The Silica concentration in shoots was positively correlated with that in soil solution, suggesting that the eluted silica was effectively taken into the plant. The total As concentration in shoots significantly decreased along with the increase of Silica concentration in soil solution. On the other hand, Cd concentration in brown rice was at low level sufficiently, probably due to the flooding condition. With the successive application of the materials, the amount of Silica leached into the soil solution increased and the As of rice plants tended to be reduced.

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P-444

Off-site phytoremediation of trace element contaminated soils: The role of plant selection

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Heavy metals and metalloids (trace elements, TEs) are major inorganic contaminants in soils, and originate mainly from different anthropogenic sources, like former industrial and mining activities, but also to inadequate agricultural practices (e.g., the use of low quality P fertilisers and irrigation waters). An off-site remediation experiment was established for two soils with high TE concentrations: a mining soil (96, 2100 and 14080 mg kg-1 of As, Pb and Zn, respectively) and an agricultural soil, which received low quality fertilisers and irrigation for several years (52, 2560 and 1570 mg kg-1 of As, Pb and Zn, respectively). The experiment was run outdoors, in containers of 1.2 m2 and 0.46 m depth (6 per soil type). The mining soil was amended with pig manure compost to increase the organic matter content from 0.94 to 5.4 % and soil pH from 5.4 to 6.0. Agricultural soil was not amended (OM 5.7 % and pH 7.3); both soils had high electrical conductivity (6.7 and 7.7 dS m-1 for the agricultural and mining soils, respectively). The phytoremediation strategies were: environmental restoration with locally adapted species (Atriplex halimus and Nicotiana glauca in the agricultural soil; Retama sphaerocarpa and Rosmarinus officinalis in the mining soil), and active remediation (Brassica juncea and Cynarara cardunculus for the agricultural soil; B. juncea and Dittrichia viscosa for the mining soil). Plant production and TE concentration were determined in the first crop. The effect of plants on soil extractable-TE and on soil biological indicators were determined after the first harvest.

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P-445

Humic acid extract and citric acid enhanced the heavy metals phytoextraction potential of lemongrass in Cu-Ni Mine Tailings

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The enhancement of phytoextraction potential of lemongrass as affected by chelating agents EDTA, citric acid, and humus extract was assessed utilizing a pot culture experiment in Cu-NI mine tailings. Chelates were applied on four-month-old plants and the heavy metal (HM) availability in tailings, HM uptake, and the physiological response of lemongrass was monitored within 16 days from chelate application. Plants treated with EDTA and citric acid have higher toxicity scores and low photosynthetic rates, evapotranspiration, and stomal conductance compared to the control and those treated with humus extract. EDTA also reduced the chlorophyll a and the content of the total pigment but increased the chlorophyll b content. Accumulation of heavy metals in the leaves of lemongrass was highest in EDTA treated plants and the spike was observed 4 days after chelate application (DACA). On the other hand, citric acid and humus also increased the HM uptake but the spike occurred at 8-12 DACA. The concentration of available HM was highest in tailings treated with EDTA while citric acid treatment had the lowest. The essential oil yield was not affected by the chelating agents and the HM contents were within acceptable limits. Based on the results, citric acid and humus extract are potential chelating agents to HM phytoextraction by lemongrass especially in continuous cropping and ratooning due to its low toxicity on plants and fast recovery after chelating treatments and harvest of shoots.

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P-446

DETERMINATION OF EMERGING CONTAMINANTS IN A CALCAREOUS SOIL AFTER 26 YEARS OF AMENDMENTS WITH SEWAGE SLUDGE

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Although urban sewage sludge (SS) can be used as an organic amendment, its use is not exempt of risks, as it may contain chemicals of emerging concern (CECs) derived from the use of pharmaceuticals and other chemicals in urban environments (Urra et al., 2019).
To determine to which extent CECs were present in soil after 26 years of SS amendments at different doses and rates, samples from a long-term trial conducted between 1992 and 2018 in Arazuri, (Navarra, Spain) on a calcareous soil were studied. The SS came from the local urban wastewater treatment plant (run by the local Commonwealth (MCP)). For this study, soil samples from the control, mineral fertilized and the treatments receiving 80 t SS/ha every year and every 4 years, were used (n=4).
An LC-MS grade acetonitrile (ACN) extraction followed by clean up in a preconditioned SPE HLB cartridge was performed on samples from the tilled depth (0-30 cm) of the treatments, plus pure SS. Subsequent analysis was performed by HPLC coupled to mass spectrometry (HPLC-TOF-MS) for a series of CECs previously found in other organically-amended soils.
Of the 18 CECs analysed in soil extracts, five were detected in some of the treatments, including the control treatment (Estrone, α-Estradiol, β-Estradiol, Sulfamethoxazole and Sulfadimethoxine). Moreover, α-Estradiol and β-Estradiol were detected in the SS. In all cases, the concentrations detected were below the limits of quantification, which indicates no relevant accumulation of any of these compounds after 26 years, but suggests that ongoing monitoring would be advisable.

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P-447

Influence of fly ash and compost on the temporal dynamics of heavy metals in three mine tailings in Botswana

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The heavy metal migration in a column filled with mine tailings from BCL mine (BCL), Mupane Gold mine (MuG), and Monarch gold (MoG) amended with fly ash and compost were assessed. The HM concentration in the soil solution (SS) was withdrawn from 15cm, 30cm, and 60cm down the surface using a Rhizon® sampler at a 4-week interval for 12 months. Results showed that FA and compost had variable influences on the soil solution pH and EC which could have influenced the heavy metal solubility and movement in the column. The concentrations of As, Cu, Ni, Mn, and Cr in the SS had increased down the profile during the experiments without amendments. Fly ash and compost increased the concentration of Cr, Mn, and Ni at the initial stage of the experiment but reduced the concentration of As, Ni, Mn, and Cr after four months of sampling in MuG. For MGM tailings, FA increased the concentration of Cr, Cu, and As while compost reduced the Mn, Ni, and As in the soil solution extracted at the surface layer. Overall, these results had demonstrated that FA and compost amendments could influence the availability of different heavy metals not only at the surface where the amendments were applied but its influence could be manifested down the soil column.

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P-448

Contamination by polycyclic aromatic hydrocarbons in urban soils: Valencian municipalities's case study.

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Soil is a non-renewable natural resource, therefore any damage to its functions poses a serious threat to the maintenance of environmental quality. In urban contexts, quality of the soil directly indicates the quality level of the surroundings, so its study is an important challenge in environmental research and public health since they are subject to a continuous accumulation of pollutants. This study was carried out in order to evaluate the level of contamination by polycyclic aromatic hydrocarbons (PAHs), a kind of carcinogenic organic subproducts derived from anthropic activities, in soils of urban parks of the city of Valencia and surrounding areas of socioeconomic interest. It was determined the concentration and evaluated the degree of contamination of soil samples from 31 selected sites, as well as the risk of exposure associated with the presence of these pollutants. The samples were analyzed carring out a liquid phase extraction following the QuEChERS procedure; quantification of 13 PAHs was performed by GC-MS/MS with a limit of quantification of 5 µg/kg. The most frequently detected compound was chrysen (0.02 ± 0.02 mg/kg). Inden-(1,2,3-cd)-pyrene was detected in areas with high urban and industrial density. The value of ΣHAPs indicated 3 contaminated sites (ΣHAPs ≥ 0.2 mg/kg). Almost entirely, vehicular traffic was recognized as the main source of pollution. The equivalent toxicity index (TEQBaP) identified different areas with potential risk of exposure. Therefore, it is considered necessary to monitor the levels of these pollutants to identify their origin, control the level of contamination and prevent health hazards.

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P-449

Brick kiln operation impact on soil microbial activity

Dr Nasrin Chowdhury

Heavy metal emission from brick kiln operations in developing countries is one of the major sources of environmental pollution. The present study evaluated the intensity of Cd and Pb pollution and its impact on soil microbial activity in agricultural soils in the vicinity of the brick kiln cluster in Hathazari, Bangladesh. Soil samples were collected from 21 sites covering 7 locations, including the reference sites for the assessment of the toxic impact on soil biota related to crop productivity. The metal concentrations in the soils indicate that the anthropogenic input was in the range of 0.27 to 1.07 mgkg-1 of Cd and 19.07 to 52.07 mgkg-1 of Pb. The contamination factor demonstrated that the soils were contaminated to a moderate to considerable level. Exponential curves revealed a significant positive correlation between heavy metal and microbial metabolic quotient (qCO_2), indicating metal stress and decreased microbial biomass and enzyme activity. A significantly high correlation was observed for Cd and Pb ($r = 0.89$, $p \leq 0.001$). It suggests the same source of contamination from the aerial deposits of metal-enriched fumes from brick kiln operations. From correlation studies and PCA analysis, a significant negative impact of Cd and Pb on soil microbial and enzyme activities was also evident. The study is important in eco-toxicological and biomonitoring aspects as the data on heavy metal toxicity to the soil environment can act as guidelines for the continuation of brick kiln operations and the sustainable utilization of natural resources.

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P-450

ASSESSMENT SOIL CONTAMINATION OF URBAN AREAS IN VALENCIA (SPAIN)

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The study of potentially toxic elements contamination, such as heavy metals, in parks and gardens in urban and industrial areas is of great interest, as these environments are considered indicators of the environmental quality of these zones. To assess the level and risks associated with the presence of this pollutants in the city of Valencia and neighbouring municipalities (an area of great socio-economic interest subject to high anthropic pressure), a field campaign was carried out using random sampling of soil samples taken from parks and gardens of recreational and industrial areas. The fundamental properties of the soil were analysed, and the Cd, Co, Cr, Cu, Mn, Ni, Pb and Zn concentration was determined by acid digestion in a microwave oven and quantified by EAA or ICP-OES. The contamination factor (CF), potential contamination index (PLI) and ecological risk (IR) were calculated to assess the contamination and health risk. Results showed significant variations in the content and distribution of Cd, Cu, Cr, Ni, Pb and Zn which were associated to traffic and population density. According to the CF, the soils were moderately to heavily contaminated, while according to the PLI, more than 50% of the sampled sites were considered contaminated (PLI > 1); however, the RI indicated a low potential ecological risk. This work highlights the need for monitoring actions to control the level of pollution in urban areas and to prevent health risks.
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P-451

PHYTOREMEDIATION OF ARTISANAL GOLD MINES IN COLOMBIA: SELECTION OF PLANTS AND BIOFERTILIZERS.

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Artisanal or informal gold mining here refers to small-scale mining, carried out by individuals without formal title, which use mercury for ore concentration. Mining wastes with high trace elements concentrations are left behind, posing a threat to people and ecosystems. The objective of this study was to select autochthonous plants, tolerant to high trace elements concentration, to be used for phytoremediation of these contaminated areas. Amendment with vermicompost rose the pH from 2.4 to values above 4.4. The study was carried in microcosms outdoors, using mine tailings, vermicompost and biofertilizers. Three local plants were selected for the study: Chrysopogon Zizanioides, Enterolobium Cyclocarpum and Brachiaria Decumbens. The effect of vermicompost and two commercial biofertilizers, one based on mycorrhiza and another on nitrogen fixing bacteria was investigated. In the absence of organic matter amendment, Brachiaria Decumbens was unable to grow, even in the presence of biofertilizers. On the contrary, Enterolobium did grow well with and without inoculants. In the case of Vetiveria Zizanioides addition of inoculants promoted growth. On the other hand, addition of vermicompost allowed plant growth in all treatments, although biomass did not improve when pots were inoculated with mycorrhizas or a mixture of mycorrhizas and bacteria. Interaction of vermicompost and microbial inoculants was observed.

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P-452

Impact of conventional and biodegradable mulch film on crop and soil health

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The use of plastic mulch film in an agricultural context has been actively encouraged in many regions of the world, improving water and nutrient use efficiency, crop yields and food security. However, plastic mulch film is extremely difficult to remove from the soil, which results in the plastic films being ploughed back into the soil, leading to an accumulation of legacy plastic in agricultural fields. The majority of short- and long-term effects and fate of conventional and biodegradable plastic films in soil are still undetermined. We conducted a field experiment, comparing the effects of conventional LDPE and biodegradable PLA/PBAT-based mulch film on soil and crop health, whilst also looking at the degradation of the plastic films and the potential microplastic contamination of the soil. Maize (Zea mays L.) was grown to harvest under both films and without any film for a duration of four months. To determine the effect of plastic mulch film usage on nitrogen use efficiency, 15N fertiliser was applied at the beginning of the experiment. The key measurements taken include soil moisture content and temperature, microbial diversity (16S/ITS), plastic contamination, 15N recovery and uptake, plant biomass and chlorophyll and nutrient content. The degradation of the films was determined by monthly visual assessment and the use of Hyperspectral Camera and FTIR. We found a difference in plant growth dynamics and some soil properties (moisture content) between the treatments, which equates to a difference in overall plant biomass.

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P-453

Does size matter? Assessing the role of the coarse fraction to overall pollution of anthropized soils

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Should the soil coarse fraction be considered a key element in the functioning of highly anthropized soils, especially regarding risk associated to contaminants? Soil quality diagnosis systematically dismiss it as inert for not contributing to the soil's nutritional potential or contaminants in the short term. However, in forest context, it can contribute significantly to the assimilation of essential nutrients by plants. Yet, insufficient research has been done to understand its influence in terms of physicochemical fertility and contribution to toxicity in the context of highly anthropized soils. In these contexts, coarse materials are found in various quantities and natures and can constitute in some cases the main source of pedogenetic evolution of these systems. This raises the questions of the evolution of the properties of the soil coarse fraction constituents as a function of their size, and the intensity of their contribution to the fertility and toxicity of highly anthropized soils.
In an original approach, the nature, the typology, and the reactivity of a brownfield soil coarse constituents are determined, and their fertile and toxic properties qualified. The results of this study confirm the high level of reactivity of the soil fine fraction and highlight the contribution of the coarse fraction to the provision of fertile and toxic elements. The coarse fraction loses its inert nature to the benefit of a reactivity, admittedly not intense, but still present that should be taken into account for risk assessment purposes.

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P-454

Is it enough to seek and find? How to tackle (micro-)plastic contamination in soils using a spatio-temporal approach

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(Micro-)plastics have been identified as potential contaminants in soils. After half a decade of research, qualitative evidence in soils worldwide, emission pathways or biogeochemical impacts posed by (micro)-plastics on soils could be discovered.
However, few studies have addressed microplastic pollution of soils so far. Hence, many questions remain unanswered, like where and why (micro)-plastics end up in the soilscape anyways. Currently, the scientific community appears to jump rapidly into modelling to approach those issues. One might ask, however, on what on which data basis representative in spatial and temporal dimensions?
Opposed to the popular seek and find approaches, the contribution intends to present an alternative to create a reliable, spatially representative and temporally resolved database in order to record the spatial distribution and duration of (micro)-plastic contaminations in soils. Based on conceptual considerations and quantitative results from two field studies conducted in a fluvial and agricultural soilscape, insights into a spatio-temporal approach to (micro-)plastics distribution in soils will be presented. Different natural and anthropogenic influences on (micro-)plastic distribution could be determined through the application of spatially representative sampling concepts, depth sampling and consideration of polymer ages. These examples are intended to highlight how the spatio-temporal approach can be applied, what advantages and practical pitfalls it has, and which further improvements are conceivable.
Nevertheless, the approach requires that plastic as a soil contaminant be understood for what it is: An artificial, polymeric, solid and insoluble material which has a much more heterogeneous spatio-temporal distribution in soils than previously assumed.

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Water Relations and Cadmium Uptake of Wheat Grown in Soil with Microplastics

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Microplastics contaminate the terrestrial environment, yet no information exists concerning the water-relations of plants grown in soil with them. Therefore, the first objective of this experiment was to determine the growth, stomatal resistance, and evapotranspiration rate of wheat grown in soil with microplastics. Because microplastics can be a vector for toxic trace-element uptake, the second objective of this experiment was to determine the uptake of cadmium (Cd) to see if they enhanced its uptake. Wheat was grown in pots with a commercial potting soil. The microplastic was polyethylene glycol (called PEG 8000). At the beginning of the experiment, pots were divided into three sets: pots with soil that received no PEG 8000 (no-PEG treatment); pots with soil into which dry PEG 8000 was mixed at a rate of 2% on a dry-weight basis (dry-PEG treatment); and pots with soil that received PEG 8000 via irrigation of a 2% solution of PEG 8000 (wet-PEG treatment). The three sets of pots were divided in half, and, during the experiment, half of the pots were irrigated with a 100 µg/mL Cd solution. Both with and without Cd, plants in the wet-PEG treatment were shorter, had a lower evapotranspiration rate, and had a higher stomatal resistance than plants in the no-PEG treatment. Plants grown in the wet-PEG treatment with Cd had a Cd concentration that was 1.6 times more than plants grown without Cd. The results showed that PEG 8000 was a potent vector for the transport of Cd to wheat leaves.

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P-456

Anthropogenic impact on soil functioning in the Arctic environment (South tundra, Taimyr Peninsula)

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The interest of scientists to the Arctic has been increasing, especially in the aspects of environmental contamination and functioning to improve understanding of soil ecosystems. This study assessed the health and functioning of soils in terms of contamination with heavy metals and petroleum products (TPH) as well as sulfur. We studied contaminated soils and uncontaminated analogues of South tundra, Taimyr Peninsula. The soils were characterized by active permafrost effect, low biological activity, low degree of soil aggregation, low resistance to anthropogenic stress. Main characteristics of soils were: pH 4.5 – 6.0, high moistening and content of soil organic matter (SOM) (7-70%). Studied soils were rich in manganese and iron (0.15-0.20 and 9.4-15.0% respectively) and at overwetting conditions, their status turned to redox forms that explained the contaminated soil pH values (6.0-8.0). The presence of sulfur was caused by pyrite ore and also air pollution. Sulfur detected mostly in sulfate form in soils, likely evoked alkalinization at the presence of high SOM content and microbiological reduction of sulfates. The high level of nickel and copper was due to regional geochemical area as well as anthropogenic load. Trace metals were mostly found in insoluble forms. Adding ameliorants increased the microbiological activity and TPH biodegradation. We assessed the changes in soil functioning that could be useful for risk analysis and regulation of human activities and ensure the sustainable development in the Arctic.

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P-457

Complexation of gallium and indium on humic acid-ferrihydrite

Mr. Wei-lin Liu, Mr. Shan-Li Wang

Recent development of semiconductors and energy industries results in the release of trace elements such as gallium (Ga) and indium (In) into the environment. In soil environments, humic acid and ferrihydrite play an important role in the fate of metals in the soil environment. In this study, humic acid, ferrihydrite, and ferrihydrite-humic acid co-precipitates were investigated for the retention mechanisms of gallium and indium in aqueous solution.

The complexation of gallium and humic acid tends to be stable along with the reaction time at pH4, whereas the proportion of gallium in the aqueous phase gradually decreased at pH9. The proportion of gallium in the solution was shown to be reduced after the addition of ferrihydrite (including co-precipitation). Ferrihydrite influenced the external charge of gallium humate. As the external charge of gallium was influenced by ferrihydrite, gallium is suggested to react with ferrihydrite by surface complexation or adsorption.

Similarly, the complexation of indium and humic acid was shown to be stable at pH4. However, the complexation of humic acid with gallium or indium varied in neutral and alkaline conditions. Indium was suggested to react with humic acid in the form of In(OH)3 with or without the presence of ferrihydrite (including co-precipitation) according to EXAFS results. Further studies are needed to elucidate the effect of the structure and functional group of humic acid on the complexation mechanisms of gallium and indium with humic acid for understanding the fates and potential risks of gallium and indium in the environment.

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P-458

Enhanced degradation of strobilurin fungicides residues in soil by ozonation treatment

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Strobilurin fungicides are systemic substances globally used in agriculture to manage fungal diseases in numerous crops. Their mode of action is related to the inhibition of electron transfer in fungus mitochondria, disrupting respiration and eventually causing the pathogens death[1]. Due to their widespread application as agrochemicals, residual levels have been found in soils, surface and groundwaters, being able to affect adversely other living organisms and becoming a highly significant environmental issue. The aim of this work was to assess the usefulness of the ozonation technique for degrading residues of strobilurin fungicides (azoxystrobin, pyraclostrobin and trifloxystrobin) in soil. Soil treatments were performed over soils previously watered and covered with polyethylene film. Ozonation treatments were conducted using an Osmaqua ozone generator joined with an BMT 964 analyzer and an ozone destructor. Preliminary essays were performed at controlled conditions with pots inside a greenhouse. Field-scale experiments were carried out in parcels located in a greenhouse during winter 2020. In both stages, polluted soils were subjeted to different treatments for testing the influence of ozone application mode on pesticides degradation (S: film placement, SOS: film + surface ozone application, SOD: film + deep application, SOSD: film + dual application, and C: without any treatment). Ozonation effect on soil physical-chemical characteristics was also evaluated. The greater degradations obtained for ozonized soils (SOS, SOD and SOSD) in comparison with the control soil (untreated) show that this technology could be proposed as an alternative remediation tool for soils polluted with these fungicides at field scale.

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P-459

Assessment of Mobilization Potential of Per- and Polyfluoroalkyl Substances for Soil Remediation

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Efforts to design technologies to remediate soils contaminated by per- and polyfluoroalkyl substances (PFASs) due to the legacy use of aqueous phase film-forming foams (AFFFs) have rapidly increased. The aim of this study was to investigate the mobilization behaviour of a wide range of PFASs present in AFFF in water-saturated soils with a view to assessing the feasibility for their remediation by soil washing. Column studies were carried out (using a 1-D miscible displacement approach) on a broad range of PFASs. The role of both sorption equilibrium and nonequilibrium of PFASs and factors that affect these processes during adsorption, desorption and transport in water-saturated soils were discerned. Results showed that most of the shorter carbon-chain PFASs ($C \leq 6$) reached more than 99 % sorption capacity/desorption rapidly - after approximately two pore volumes. This indicates that shorter chain PFASs will be readily removed by soil washing technologies. The mobilisation of those shorter chain PFASs was well predicted by an equilibrium transport model using Freundlich parameters. The equilibrium model failed to predict the mobilisation of longer chain PFASs ($C \geq 7$). The time taken to attain 99 % sorption/desorption was up to five times longer than predicted by the equilibrium model indicating greater effort would be required to effectively remove those PFASs through soil washing. The mobilisation of those longer chains PFASs was limited by non-equilibrium sorption/desorption. Hydrophobic interactions are suggested to be the main driving force leading to the non-equilibrium processes during mobilisation of longer chain PFASs in soils.
Not applicable

P-460

BIOREMEDIATION OF PETROLEUM CONTAMINATED SOILS USING BARLEY STRAW FOR OPTIMIZED LAND FARMING

Dr. Ufuomaefe Stephen Oghoje, Dr Chris Ejeomo, Associate Professor Justina E. Ukpebor, Dr Philip O Oviasogie, Professor Esther U Ikhouria, Professor Emmanuel E Ukpebor

The effects of green compost pulverized barley straws (PBS), Hordeumvulgare on the water retention capacity (WRC) of diesel polluted soils and the leaching potential of diesel range organics (DROs) from soils was investigated. Determination of the levels of DROs was carried out according to standard methods and analysis done using gas chromatography-mass spectrometry (GC-MS). Results obtained revealed that 5, 10 and 15 % diesel contamination reduced the WRC of the soils by ~ 6, 11 and 26 % respectively. On composting 15 % diesel polluted soils with various amount of PBS (1, 2.5, 5, and 10 %), the WRC of the soils was found to increase by ~ 18, 31, 53 and 75 % respectively. It was also observed that 2.5, 5, and 10 % PBS significantly reduced the leaching of the DROs from the diesel polluted soils by 34, 75, and 100 % respectively. The study revealed that, composting of diesel or similar oil contaminated soils with green composts - barley straws increases the WRC of such soils and also prevent or reduce the leaching of oil pollutants from the top soils thereby enhancing bioremediation of such soils during land farming.
Keywords: Barley straws, water retention capacity, Diesel range organics, Bioremediation, Leaching.

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P-461

GREEN COMPOST FOR THE ENHANCEMENT OF SOIL PROPERTIES AND MICROBIAL ACCESSIBILTY TO HYDROCARBON POLLUTANTS IN SOILS

Dr. Ufuomaefe Stephen Oghoje, Associate Professor Justina Ebehirieme Ukpebor, Professor Emmanuel Ehiabhi Ukpebor

The impact of green composting using pulverized broad leave lime tree (Tiliaplaty phyllosee) leaf-mulch (PBL) on the water retention capacity (WRC) of diesel polluted soils and the reduction on leaching of Diesel Range Organics (DROs) from the spiked soils was studied. Results obtained showed that 5, 10, and 15 % diesel contamination reduced the WRC of the soils by ~5, 12 and 28 % respectively. Result from the effect of various amount of PBL (1, 2.5, 5, and 10 %) on the most contaminated soil (15 % contamination) revealed an increase in the WRC of the soils to ~30, 32, 37 and 41 % respectively. It was also observed that 2.5, 5, and 10 % PBL significantly reduced the leaching of the DROs from 20 % diesel polluted soil by 61, 91, and 100 % respectively. This study has revealed that composting of diesel or similar oil contaminated soils with PBL would be a good and effective enhancement of bioremediation of hydrocarbon pollutants in soils.
Keywords: Green composts, Hydrocarbon contamination, soil properties, microbial accessibility.

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P-462

Two Forms of Organic Stimulation for Enhanced Landfarming of Heavily Petroleum Polluted Soils

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The removal of petroleum hydrocarbons from heavily oil polluted soils using two forms of chicken manures for biostimulation was investigated. Soil samples were spiked with petroleum hydrocarbon products mixture (PHM) comprising of diesel, benzene, toluene, ethyl benzene, xylene and naphthalene. The spiked soils were treated with three levels (0, 10 and 20 %) of composted chicken manure (CCM) and chicken manure digestate (CMD). Samples were collected at day 1, 14, 28, 56, 84, 168 and 336. And chemical analyses were carried out according to standard methods. The results showed that 20 % biostimulation with the organic manures gave higher arithmetic values of TPH degradation in the samples. But, in most of these values, the 20 % treatments showed no significance differences and less bioremediation efficiency (BE) with their 10 % treatments counterparts. For instance, the 10 % treatments with CCM or CMD gave BE ranges of 3.84 – 7.64 and 4.02 – 6.42 respectively as against that of 1.66 – 4.47 and 1.77 – 4.05 for their 20 % treatments counterpart respectively, at the remediation period of 56 - 336 days. Generally the use of the CMD had greater BE particularly at short remediation periods. The need to repeat application of CMD supplement for a prolonged bioremediation was established. Furthermore, the study revealed that the use of CMD (and by extension all bio-digestates), for Land farming of heavily petroleum polluted soils, to be feasible and cost effective.
Key words: Organic stimulation, Land farming, Highly Petroleum Polluted soils, Remediation efficiency.

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P-463

Effects of Bioremediation of Petroleum Hydrocarbons Pollution on Soil Physicochemical Properties and Metals Bioavailability in Southern Nigeria.

Dr. Ufuomaefe Stephen Oghoje, Associate Professor Justina Ebehirieme Ukpebor, Dr. Chris Ejeomo, Associate Professor Onoriode Onos Emoyan, Professor Augustine Asiagwu

The purpose of this study was to determine the effects bioremediation on soil physicochemical properties and heavy metals bioavailability in the Southern geopolitical zone of Nigeria. The levels of total petroleum hydrocarbon (TPH) pollution and remediation, metal bioavailability and eutrophication status of the bioremediated soils were examined on 40 composite oil polluted and remediated soils including the control sites. The results revealed remediation levels with a range of about 95 to 97% in all the sites examined. However, a general drop in the soils' pH with average reduction in pH values of 2.20 in the bioremediated sites was observed. Also, the bioavailability of heavy metals increased with average values of 4.86, 12.29, 15.78 and 14.31 % for Cr, Pb, Cd and As respectively. Similarly, the percentage increase in bioavailability for Ba, Cu, Ni and Zn were 9.67, 11.54, 17.47 and 21.62 % respectively. The increment in the metal bioavailability corresponded to the drop in the pH of the sites during the remediation protocols. Furthermore, the concentration of available phosphorus in the leachate from the sites ranged 0.03 – 0.64 mg/kg and was above the recommended values of the element for industrial effluents and waste waters. The study has revealed the need for soil conditioning to follow bioremediation of oil polluted soils. Also, the need to monitor and prevent the leachates from bioremediated sites getting into surface waters in order to prevent or reduce their eutrophication was buttressed.
Key Words: Post bioremediation, eutrophication potentials, Petroleum hydrocarbon polluted soils, Heavy metals bioavailability

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P-464

Investigating the dynamics of water content and metal pollutants in the surface layer of urban soils

Dr Marco Peli, Dr. Martina Siena, Prof. Stefano Barontini, Prof. Monica Riva, Prof. Roberto Ranzi

Aiming at identifying the long-time effects of water content dynamics on the distribution of metal pollutants in the surface layer of urban soils, this work focuses on the role of the zero-flux-plane (ZFP), the “static zone” (Richards, 1954) which onsets between upward (evaporation) and downward (drainage) water fluxes occurring simultaneously in a thoroughly wetted soil.

Field activity was conducted in Bagnolo Mella (Northern Italy), where a ferroalloy industry operated from 1974 to 2015. Metal(loid) concentration (As, Cu, Fe, Mn, Ni, Pb, Zn) and soil physico-chemical and hydrological properties were measured in four sites. Despite rather homogeneous soil properties, remarkably higher metal concentrations were detected downwind and closer to the plant, within the top soil layer, and exceeded background levels, especially for Mn. Laboratory analyses highlighted the presence, larger in the more enriched sites, of Mn-substituted magnetite, a ferroalloy production byproduct possibly water-transported within the soil (Peli et al., 2021).

Numerical simulations with HYDRUS 1D were performed to model the time evolution of both ZFP and solute content in the investigated sites, accounting for grain-size stratification, eventually considering root uptake and estimating surface recharge and evapotranspiration from meteorological data. Normally the ZFP reached shallower depths in presence of a developed root system, except after long periods without rain when a shallower ZFP occurred in the domain without roots. In both cases the ZFP position mostly stayed between the ground surface and a maximum depth of about 20 cm, consistent with the vertical range where peak concentrations of metal(loid)s were found.

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P-465

Can the zinc-smelter effluent-contaminated soil be reclaimed in relation to heavy metal content using chemical amendments?

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Effectiveness of lime, single-super-phosphate (SSP), fly ash and conjoint use of rock-phosphate (RP) with Sesbania rostrata leaf in immobilization of Zn, Cd and Pb in Zn-smelter effluent-irrigated soil was evaluated in a greenhouse pot experiment using Indian spinach (Beta vulgaris L. var. all green) as a test crop. One bulk surface soil (0-15 cm) sample was collected from a location near Debari, Udaipur, Rajasthan, India which had a history of receiving irrigation with Zn-smelter effluent since last five decades. Metal solubility (assessed by Baker soil test) and phytoavailability in soil as affected by the amendments were evaluated. Lime and fly ash were effective in reducing free-ion activity (solubility) of metals in experimental soil. The lowest free-ion activities of Zn2+ (pZn2+ =10.194), Cd2+ (pCd2+ =12.365) and Pb2+ (pPb2+ =11.875) were obtained with lime application at the rate of 50 g kg-1, which was associated with the reduction in phytoavailability of Zn, Cd and Pb by more than 41, 59 and 41%, respectively over control. Metals were significantly redistributed from exchangeable-water soluble and organically bound pools to carbonate, oxide and residual pools due to application of lime and fly ash in soil. Human health risk assessment based on computation of hazard quotient (HQ) for intake of metals through consumption of test crop indicated that health risk could be minimized using lime and fly ash even in intensively polluted smelter effluent-irrigated soil.

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P-466

Application of drainage centrifugation method under reduced condition – a batch incubation experiment

Bs.c Shatabdi Saha, Bs.c Kumi Watanabe, Dr. Tomoyuki Makino, Dr. Hitoshi Kanno, Dr. Kazuhiko Kimura, Dr. Shin-ichi Yamasaki

Efficient separation of solid and liquid phases of soil under reductive conditions is of utmost importance to study the soil solid and liquid chemistry as well as to predict the mobility and bioavailability of nutrients and toxic pollutants in waterlogged reduced soils (WRS). However, no study has been done to separate the solid and liquid phases of WRS while maintaining the reductive conditions. This study aimed to verify the applicability of a simple centrifugal filtration method (CFM) for the efficient separation of soil and liquid phases of a sandy loam WRS and studied the CFM-extracted soil solution to confirm that the reductive condition was maintained during the solid-liquid separation process. Incubation experiments were performed with or without ethanol/molasses as additional organic matter (OM) under reductive conditions and soil solution was collected by both suction method and CFM at different rotation speeds (700, 2760, and 11000 rpm) and time (1-7 min). The addition of ethanol or molasses enhanced the reductive conditions in the initial days of experiments. The solute (As, Fe(II), Mn, Cr, and Co) concentrations in soil solution extracted by CFM were close to the solute concentrations in soil solution collected by suction method, confirming that the reductive condition was maintained during the solid-liquid separation by CFM. Centrifugation speed rather than time showed maximum recovery of the soil solution. This study concludes that CFM is a simple and highly effective technique to efficiently separate the solid and liquid phases of sandy loam WRS while maintaining the reductive conditions.
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P-467

Application of proximal sensors and soil survey for the spatial variability assessment of soil contamination in a skeet shooting range

Prof. Simona Vingiani, Dr Annalise Guarino, Dr Roberto De Mascellis, Prof. Massimo Fagnano, Dr Carlo Perreca, Prof. Stefano Albanese

Outdoor shooting ranges (OSRs) represent a recreational facility involving several millions of people in the world. However, environmental effects can arise from continued use of the areas and management of plant activity, due to the leaving of expended lead bullets and uncollected shots on the fields. The area of an OSR at Acerra (South of Italy) has been investigated due to an extensive long term soil contamination associated with Pb, Sb, PAHs, dioxins, PCBs and C>12 hydrocarbon.

A field survey was focused to identify different zones in terms of soil physical properties, using several proximal sensors, including EMI, Gamma Ray spectroscopy, ultrasonic penetrometry for the evaluation of soil compaction and occurrence of hardened layers. Direct investigations were performed by hand auger for soil preliminary characterization and sampling. The soil geochemical composition was measured by pXRF at different soil depths, while PAHs compounds on topsoils.

A Robust PCA based on compositional (As, Pb, Sb, V, Zn, total PAHs) and non-compositional (electrical conductivity at different depths, travertine layer depth, total radioactivity) variables was performed to explore hidden potential relationships among involved parameters. On the first component, responsible of almost 80% of the overall variability, positive scores are associated to PAHs while negative ones mostly depend on Pb and Sb contents of soils and electrical conductivity pattern at shallow depths. On the second component, electrical conductivity at higher depth shows a good correspondence with the variation of a travertine layer depth and the increase of total radioactivity with the increase of soil volumes.

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P-468

Bioremediation for the soils contaminated with chloroethenes - Microbial reductive dechlorination in the suspensions with urban soils

Miho Yoshikawa, Dr. Kawabe Yoshishige Kawabe, Dr. Zhang Ming Zhang

Soil contamination with carcinogenic chloroethenes typically occurs at the areas used for dry-cleaning and metal processing. Bioremediation using reductive dechlorinating bacteria such as Dehalococcoides maccartyi is a promising technique due to its cost-effectiveness and sustainability (Zhang & Yoshikawa 2016; Yoshikawa et al. 2017). Most of the laboratory studies on reductive dechlorination have been conducted only using liquid culture, though solid particles (e.g., Fe precipitation) affect the reductive dechlorination (Yoshikawa et al. 2021). To understand the biological process and for achieving complete bioremediation of chloroethenes in contaminated soils, dechlorinating tests with practical soil particles were carried out.

We collected urban soils from chloroethene contaminated sites, and measured the characteristics of test soils such as particle size, specific surface area, pH, TOC, and concentrations of organic acids. For the dechlorinating tests, we suspended the air dried soils sterilized with gamma radiation in the solution of enrichment culture stably dechlorinated chloroethenes over several years in test vials under reductive conditions. The headspace of vials was replaced with N2, and electron donors and 10 mg/L of tetrachloroethene (PCE) were added. All vials were incubated in the dark at 20 ℃, and concentrations of PCE and its byproducts in the headspace of vials were periodically analyzed.

The dechlorination rates varied among test soils. When the soils with low concentrations of organic acids were used, partial dechlorination and accumulation of cis-DCE occurred. When the soils with high concentrations of organic acids were used, complete dechlorination of PCE to harmless ethene and ethane were achieved.

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P-469

Removal pathway quantification and co-metabolic mechanism evaluation of alkylphenols by phenolic root exudates in the rhizosphere of Phragmites australis

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Phenolic root exudates (PREs) released from wetland plants are potentially effective for accelerating the biodegradation of alkylphenols, yet the inherent behavior is still unclear. In this study, two representative root exudates (REs), namely p-coumaric acid (PREs) and oxalic acid (non-PREs) were exogenously added as specific and non-specific co-metabolic substrates, respectively, to elucidate the quantification of each removal pathway and degradation mechanism of co-metabolism for alkylphenols (i.e. p-tert-butylphenol (PTBP)) from synthetic wastewater. The results showed that soil adsorption (31–37%), microbial degradation (27–37%), and plant uptake (16–41%) are the main removal pathways of PTBP by PREs in the Phragmites australis rhizosphere. Both REs enriched anaerobic functional community (anaerobic ammonium oxidation bacteria and denitrifying bacteria) and promoted the usage of PTBP as carbon source and/or electron donor. The activity of non-specific enzyme (polyphenol oxidase) was enhanced by RE which owning a significant positive correlation with bacterial abundance, whereas only PREs strengthened the activity of specific enzyme (monophenol oxidase) catalyzing the phenolic ring hydroxylation of PTBP followed by a dehydrogenation route. Moreover, exogenous PREs significantly improved the growth of degrading-related bacteria (Sphingomonas and Gemmatimonas), especially in unplanted soils with high activity of dioxygenase catalyzing the cleavage pathway of PTBP, instead of plant presence.

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P-470

Characterization of biocalcifications in loess-paleosol sequences from the Ebro Valley, Spain and its potential use as palaeoenvironmental proxies

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A special type of biocalcifications, named "queras" (Herrero et al., 1992), are complex pedofeatures formed in soils under semi-arid conditions (xeric soil moisture regime and dry climate), with or without gypsum accumulations. They consist of a channel with a dense infilling of a mosaic of grains of biosparite (quesparite), 1 to 2 mm wide and <2 cm in length; and a decarbonated hypocoating. Despite they have been widely reported in many environments, their study is limited to their morphological descriptions and setting hypothesis on their genesis, mainly fungal or plant root origin (Burford et al., 2003). These bioaccumulations, as a specific type of secondary carbonates can be used for paleoenvironmental reconstructions (Gázquez et al., 2020). The objective of this research is to study the queras in sequences of Loess-paleosols dated with OSL in the Ebro Valley to propose a pedogenetic model in the area and its possible use as paleoenvironmental proxies. For this, we compare the morphologies, 14C ages, mineralogy, isotopic composition of oxygen (16O, 18O) and carbon (12C, 13C), in queras within different soil horizons. We also explore the possibility to isolate any DNA for its purification and amplification. The morphology of the queras varies according to the age of formation and the horizon of the soil in which they were formed. Their isotopic composition has the potential to indicate the climatic variation at the time of the queras' formation, which together with the radiocarbon dating allows making correlations regarding the palaeoenvironmental conditions during their formation.

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P-471

Digital mapping and testing of relevant soil classification diagnostics units to support Precision Agriculture

Mr. Sándor Csenki, Dr. Endre Dobos, Dr. Vince Láng

Precision agriculture just like any other major development in technologies in the last decade relies on large precise datasets. Recently many survey tools have been developed to increase the speed of data collection, to feed these systems, but in many cases the quick data collection provides poor basic data for the decision making process. Although modern digital soil mapping and soil classification systems enable fast and accurate thematic mapping it is often neglected in PA systems. We have identified the major WRB diagnostic units applicable in a PA system under Hungarian soil and climatic conditions. Pilot fields were used to validate the applicability and information content of these classification units and to create digital soil mapping algorithms. The pilot fields of different soil and environmental conditions were intensively surveyed using soil scanning , traditional soil survey, UAVs, yield mapping and high accuracy elevation modeling among others. Diagnostic units of the WRB and the proposed Hungarian Soil Classification System have been mapped with high density to support the soil mapping process and to enable a thorough validation. The results show that the diagnostic units, which are aggregating soil chemical, physical and morphological conditions, are well representing the in field variability and correlate with the yield maps, and the yield potential of different management zones. With the development of these mapping tools and corresponding sampling schemes these soil survey methods are less time consuming and provide significantly more information for the PA system than the 'modern' survey methods.

Csenki, Sándor ; Láng, Vince
Soil sampling and prescription planning, using simple geostatistical methods (In Hungarian)
MEZŐHÍR: ORSZÁGOS AGRÁRINFORMÁCIÓS SZAKLAP 2020/8 pp. 64-66. , 3 p. (2020)

P-472

Impacts of historical land-use changes on soil properties in hemiboreal biome

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Based on the studies of historical maps and the current composition and age of the forest stand, six sampling sites, located on outwashed glacial till deposits, were chosen to conduct the research. Forest ecosystems, long-term cultivated agricultural lands and grassland ecosystems were selected to clarify the impact of land-use change history and succession on soil pedogenesis, morphology and properties in catena. Thus far, most studies have attempted to elucidate the effects of land-use change, however, there is a lack of studies assessing the effects of sequential land-use change on soil formation.
Charcoal was found in all soil profiles. The dating of the age of the soil charcoal showed that the forest was burned several times in the study area. It was determined that agricultural soils with loamy sand were abandoned and afforested earlier than soils with sandy loam. Due to the natural succession dominated by deciduous trees, our studied soil profiles had a poorly developed O horizon even after more than 100 years of formation. A thick A horizon has formed in all soil profiles, which shows that in areas that have historically been used as shrubland, as a result of soil cultivation, the humus horizon is thicker than in naturally developed forest soils. For this reason, morphological identification of the E horizon was weak, however, chemical analyses indicated secondary podzolization.
Significant differences, connected to soil nutrient content, was found between the soil profiles in the short distance, indicating the wide influence of land-use change on postagrogenic soils.
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P-473

Where are the iron colloids in an Albic Podzol? Insights from Flow Field-Flow Fractionation analysis

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Iron (Fe) colloids dominate the soil solution and are important vectors for the migration of nutrients and contaminants in soil. The question remains whether depth gradients in soil chemical characteristics or rather physical processes such as straining and adsorption, cause vertical mobilization and immobilization of Fe colloids. Using Flow Field-Flow Fractionation (FlFFF-UV-ICP-MS) analysis, we addressed this question by characterizing the vertical changes in size and composition of Fe colloids in an Albic Podzol (Panto-Arenic). Soil samples were taken from 8 different horizons within a depth of 110 cm. Pore-water was obtained by centrifugation of field moist samples. The pore-water Fe concentration first increased with depth and peaked at 66 µM in the E horizon just above the Bh horizon beyond which it sharply decreased to only 9 µM. The Fe colloids (<100 nm) consisted mainly of mineral Fe oxyhydroxide colloids coated with organic matter and to a lesser extent of Fe-OC complexes. Fe occurs in a mobile form in the E horizon, whereas it is much less mobile in the Bh and Bs horizons where it accumulates in the soil. In the sandy texture, physical filtration or straining is not considered to be an important retention mechanism for the Fe-rich colloids because the size of the mobile Fe fraction is much smaller than the actual soil pore size. This research shows that Flow Field-Flow Fractionation analysis offers a novel technique to gain insights into active pedogenetic processes.

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P-475

Mineral materials implemented - from tunnels to vegetated infrastructures - valorisation and development of soils

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Soil is a basic component of green infrastructure, playing key roles in supporting plant growth, infiltration, and biological activity, that all contribute to the preservation of air and water quality. However, urban soils are often physically, chemically, or biologically unsuitable for green infrastructure. Engineered soil produced from mixture of organic and mineral wastes, implemented as horizons, is a man-made soil designed to meet specific requirements and has great potential in some green infrastructures. The objective of the project MMOTIVVES is to provide owners and developers with a solution for reusing excavated materials in an urban and peri-urban application. We follow as a common thread the mastery of the sharing coefficients of water, energy, and carbon, at the atmosphere/urban interface that constitutes the urban soil. The feasibility of recovering these materials and urban biomass in the form of a new soil has already been proven on simple design cases. Here, we propose a non-trivial association of mineral materials with organic waste (compost, biochar). Through experimentation, we verify that it leads to a gradual transformation of the by-products from plant production to the formation of fertile soil, then to living soil. The precise methods of implementing the initial composite material are being developed to ensure ecosystem functions appropriate to the expected uses of these soils, such as green buffers for controlling rainwater runoff. This solution allows to outline a distribution scenario on the scale of a territory ranging from Geneva to a larger circle that may include the Lyon metropolis in France.

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P-476

Spatial variability of Brunic Arenosols affected by historic charcoal production

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In situ production of charcoal was common practice in European forests in the past. Results of the previous studies showed strong environmental effects of that process. However this issue is still poorly explored in the context of soil science. The purpose of this work was to evaluate effects of historical charcoal production on Brunic Arenosols developed from fluvioglacial sands in young-glacial landscape of West Pomerania (Northern Poland). The studies covered three stands (charcoal hearths) located near the Nicemino Lake in 90 years-old pine forest. Three soil profiles were done at each location (central part of charcoal hearth, ditch and control profile). Soils were described, sampled and analyzed using the standard procedures. A considerable differences between charcoal hearths and control soils were observed in morphology, physical and chemical properties. Typical for soils of charcoal hearths was 20-33 cm surface layer of dark-colored anthropogenic material constituting mixture of redeposited A and B-horizons, ash and charcoal particles. A-horizons of buried soil strongly transformed by high temperatures occurred under that layer. Original sequence of horizons in the soils of ditches was destroyed by removal and mixing of original soil. In ditch soils admixtures of ash, charcoals and tar usually occurred. Charcoal hearths and control soils strongly differed in advancement of podzolization (higher in control soils), vertical distribution of various elements and their forms and sorption characteristics. Results of our study highlight importance of historical charcoal production as a factor of soil heterogeneity.

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P-477

Soil development in the Central Spanish Pyrenees

Prof. Dr. Thomas Raab, Dr. Florian Hirsch

Field and laboratory methods have been used to study Late Quaternary soil development in two adjacent valleys in the Spanish Central Pyrenees (headwaters of the Aragón and Gállego rivers). Both valleys were shaped by glacial advances during the Last Glacial Maximum (LGM), so that not only glacigenic sediments, but especially post-LGM overprinting by periglacial processes (mainly cryoturbation, geli-solifluction, aeolian input) played an important role for soil development. In the partially carbonate-free substrates, recent pedogenesis is characterized by brunification, lessivage and rubefaction. Thin section and grain size analyses prove that mainly fine clay is displaced during clay illuviation. Reddish soil colors (2.5YR and 5YR) indicate hematite and can be proved micromorphologically. Rubefied soils are developed primarily in loess; rubefaction decreases with increasing site elevation. Due to high amounts of $CaCO_3$ in parent materials, the soils are usually decalcified only in the uppermost decimeters or contain diverse calcite crystals despite advanced brunification or rubefaction. Calcite crusts on the underside of stones are associated with cryogenically induced precipitation of calcite. On the other hand, rhizoliths, calcified root cells, and acicular calcite indicate biogenic carbonate dynamics. Crystals of calcium oxalate in living and dead fine roots also provide evidence for biotic processes and, with the illites and vermiculites found by X-ray diffraction, point to plant-soil interactions responsible for carbonate dynamics (= abiogenic-descending vs. biogenic-ascending displacement). Initial soils on primary carbonate-rich substrates with shallow A horizons and missing subsoils associated with colluvia on lower slopes provide evidence of widespread erosion disturbing natural soil development.
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P-479

Soil water repellency when volcanic ash interacts with organic matter: persistence and effects on soil hydraulic conductivity

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Ash deposition from a volcanic eruption disrupts soil functions. Soil water repellency (SWR) hampers soil infiltration, enhances erosion and causes drought stress. SWR responds to abiotic (ash characteristics, soil texture, moisture, pH, and heat exposure) and biotic (organic matter, microorganisms) factors. Thus, SWR can vary among land-use systems (vegetation) and soil characteristics. The interactions between volcanic ash and organic matter in inducing SWR and its consequences on soil hydraulic conductivity have, to our knowledge, been rarely investigated.

We investigated SWR induction when volcanic ash from the 2014 Mt. Kelud eruption was combined with litter of low, medium, high, and mixed quality, (pine, durian, coffee, and mixed litter, respectively). SWR as a function of incubation time (0-16 weeks) and soil water content (θ, g g-1) after mixing was quantified by Water Drop Penetration Time (Log WDPT) and Contact Angle (CA, o). The consequence of SWR on soil hydraulic conductivity (ksat, cm hour-1) was also studied for 5 cm litter and ash layers on top of an soil column. Simple linear correlation analysis tested relations between SWR-metrics and litter lipid content (%) and pH.

Addition of OM was found to induce SWR in volcanic ash, correlated to lipid content and pH. SWR declined with incubation time for all litter treatments, but mixed litter had the most persistent effect. As expected, SWR was negatively related to θ and entirely disappeared at θ >9%. Adding litter and ash layer resulted in 54 - 75% lower average ksat compared to control soils.

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P-480

Pedogenesis and Inorganic Carbon in Southeastern U.S. Blackland Prairie Vertisols

Dr. Joey Shaw, Dr. Thorsten Knappenberger, Cassi Savage, Dr. Beth Guertal, Dr. Eve Brantley

Vertisols with carbonates in the solum occur in the Alabama and Mississippi Blackland Prairie of the southeastern U.S (17,000 sq. km). These soils largely form from Cretaceous chalks and are acid or alkaline in the upper solum and calcareous in the lower solum. Pedogenic carbonates are anomalous for humid regions (approx. 1400 mm precipitation) and the characterization of secondary versus lithogenic carbonates in these soils is of interest for understanding carbon cycling and inorganic carbon sequestration. In addition, questions exist on soil formation pathways and parent material uniformity within these systems. We have utilized isotopic analyses, micromorphology, and rare earth elements in order to better understand these soil systems. Elemental ratios suggest lithologic discontinuities exist in these soils that have an acidic upper solum. Micro- and macromorphology indicate two distinct secondary carbonate forms (nodular vs soft accumulations), and isotopic analyses suggest a more relict formation pathway for cemented nodular forms and more contemporary formation of soft accumulations. Our study coupled with data from a USDA-NRCS National Cooperative Soil Survey study in the region have increased our understanding of Vertisol development in humid regions, soil inorganic carbon sequestration, and will facilitate inventory and interpretation of these soil resources.

not applicable

P-482

Effect of Two Liming Regimes on Soil Profile Characteristics of a Mollisol in Iowa

Dr. Nicola Louise Timbas, Dr. Lee Burras, Mr. Ken Pecinovsky

Lime is an important soil amendment because it decreases soil acidification by increasing soil pH. The effect of lime on soil pH can influence several soil processes, resulting in changes in soil properties. In this study, we hypothesized that a single application of a high rate of lime could cause pedologically significant changes throughout the soil profile. We collected pedons from plots applied with 17 Mg ECCE ha-1 in 1984 (HL) and those not applied with lime (UL). We compared the selected soil properties of HL and UL pedons. Effervescence is only present in UL pedons. Redoximorphic features are found deeper in HL. Soil pH of HL is significantly higher throughout the profile. Aggregate stability is higher in HL than UL. Fine clay to coarse clay ratio of UL pedons is higher than HL. Both HL and UL pedons are classified as Pachic Argiudolls. Quartz dominates the sand and silt fractions, with calcite, dolomite, albite, and kaolinite present in both pedons. Kaolinite is the dominant phyllosilicate in clay fractions.
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P-483

Influence of long-term application of fertilizers on selected soil properties of Mollisols in Iowa

Dr. Nicola Louise Timbas, Dr. Lee Burras, Dr. Antonio Mallarino, Mr. Francis Akitwine

Pedologists believe that soil changes that are pedologically significant occur after hundreds and thousands of years. However, recent studies showed that anthropogenic activities can accelerate soil processes that cause these changes. We hypothesized that decades of applying high rates of fertilizers can promote soil changes beyond the surface layer. We tested this hypothesis by sampling pedons from long-term fertility plots applied with P and/or K fertilizers for more than 40 years in Iowa. Pedons applied with high rates of fertilizers have a shallower depth to effervescence and depth to redox features, higher soil pH at the 15-60 cm depth, and higher extractable K+. Higher fine clay to clay ratio is observed in pedons that were not applied with P and/or K fertilizers for decades. Changes in classification at different hierarchal categories are observed in both pedons. Peak height ratios of sand and silt mineralogy decrease with depth in both pedons. Higher kaolinite and lower illite are present in pedons not applied with fertilizers. Our results indicate that after decades of long-term cropping, the addition or removal of materials in the soil causes it to change.

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P-484

Geochemistry of clay-rich Luvisols formed over limestones in a humid temperate climate

Mr. Rok Turniški, Ms. Nina Zupančič, Ms. Helena Grčman

In environments with high precipitation rates, eluvial-illuvial processes play a key role in pedogenesis. The most evident process is the vertical translocation of clay, leading to the formation of an argic horizon. Such soils are found in areas of global importance on different rocks and different climatic environments. At the European scale, Retisols predominate (15%), followed by Luvisols (6%), while others account for less than 1%. Modern studies mainly address clay-illuvial soils developed on loess in northern Europe, while there is a lack of studies on the pedogenesis of clay-rich Luvisols on limestone in humid temperate climates. The aim of our research was to identify geochemical indicators of eluvial-illuvial processes in clay-rich soils on limestone and to clarify their origin in terms of aeolian contribution. Morphological, geochemical and mineralogical analyses of bulk samples were carried out on ten representative profiles of Luvisols from the Dinaric Karst region. The particle size distribution supported by morphological features indicates the clay illuviation and accumulation. The illuviation is evident in the downward increase in Al_2O_3, Fe_2O_3, MgO, K_2O, Ba, Co, Cr, Ga, Ni, Sc, Th, U, V, Y and REE. The chemical trend is supported by the increase in illite, chlorite, kaolinite, gibbsite and hematite content in the Bt horizons. The results show that the textural differentiation of the Luvisols is most likely due to clay illuviation, although a contribution of allochthonous material cannot be excluded. The results contribute to the understanding of soil pedogenesis on limestone.

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P-485

Formation of placic horizons in temperate climate – the interplay of lithology and pedogenesis (Stołowe Mts, SW Poland)

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Placic horizon is a thin layer cemented or indurated by a combination of organic matter, Fe, Mn and/or Al. The placic horizon is a hard, laterally continuous impermeable and impenetrable layer, that retards vertical leaching of water and inhibits the growth of roots. Placic could develop under different climates and in various ways, still however we do not fully understand interactions between lithology and pedogenesis that might promote or inhibits their formation. Applied multiproxy approach (ERT measurements, XRD, Mössbauer spectroscopy, geochemistry, soil micromorphology and 14C dating) in sandstone–mudstone dominated lithology helped to shed light on that matter. The ERT inversion models and soil survey emphasize clear lithic discontinuities in three studied profiles (Podzol, Planosol and Stagnosol), however soil micromorphology fully confirmed that placic formed slightly below this abrupt line. Obtained calibrated radiocarbon ages spanning between 2.0 and 4.8 ka, which indicate their formation as early as Subboreal. Dates suggested more humid conditions that would be favorable for placic formation, that stand in line with mineralogy – dominance of ferrihydrite and lepidocrocite at the expense of goethite. Micromorphology evidenced that after placic formation phase of clay migration have occurred, while later podzolisation was the main soil-forming process. This sequence of 'events' proofed that thin iron pans developed independently of other processes and exists (at least some of them) before spodic horizon development.

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P-486

Calcium and magnesium ratios linking to potentially mobile chromium and nickel in ultramafic soils of Asia-Pacific region

Ms. Chia-yu Yang, Mr. Dinh Quoc Nguyen, Mrs. Huong Thi Thuy Ngo, Mr. Ian A. Navarrete, Mr. Atsushi Nakao, Mr. Shiuh-Tsuen Huang, Mr. Zeng-Yei Hseu

Serpentinites are characterized by low Ca/Mg ratio and extremely high Cr and Ni concentrations. This study evaluated the hypothesis that total Ca/Mg and exchangeable Ca/Mg ratios increase with soil development, resulting in the release of Cr and Ni from parent materials. Thirty-five soil horizon samples of eight pedons from Japan, Taiwan, Philippines, and Vietnam were collected, and the total and fractional concentrations of Ca, Mg, Cr, and Ni were measured. According to the principal component analysis based on the total contents of Si, Al, Fe, K, Ca, Mg, Mn, Cr, and Ni, the first and the second principal components indicated significant variations in soil samples from different countries, verifying the diverse origins of parent materials. Elemental mappings with electron probe microanalysis indicated that silicate minerals, including serpentines, were the predominant sources of Cr and Mg. During pedogenesis, the Cr released from parent materials was mainly associated with organic matter and Fe/Mn oxides as potentially mobile fractions (PMFs), along with the increase in Ca/Mg ratios because of the leaching of Mg with soil development. Moreover, the PMF of Cr was predicted by a function of total Ca/Mg and exchangeable Ca/Mg ratios, clay, and organic carbon using multivariate linear regression analysis. As for Ni, the PMF of Ni was predicted by total Ca/Mg and exchangeable Ca/Mg ratios, total Ni, and dithionite-citrate-bicarbonate extractable Fe.
Empty.

P-486A

Element mobility during weathering of gneisses and amphibolites in Cauvery catchment, South India

Dr. Deepika Pandey

Cauvery (Kaveri) river flows from west to east in the southern part of the Indian subcontinent. Along with its tributaries, the river traverses three states and it is a major source of irrigation in the area. A study of weathering profiles of Gneisses and Amphibolites was conducted in the catchment area in the upper course of the Cauvery river. Amphibolite bearing Gneisses prominently constitute the geology of this region (Mehta and Malviya, 2021) and bulk elemental study of their weathering is the significant factor in determining the geochemistry of the area. As weathering is the basic geochemical process that leads to the formation of soil, the information on element mobility with weathering profile is vital in understanding the soil genesis. The weathering profiles of Ambhibolites and Gneisses were chosen under different climatic regions of the study area and the distribution of 15 elements was studied in 7 defined fractions. The elements were analyzed for their occurrence in defined fractions in the successive weathered samples of a weathering profile (Pandey, 2007). The sequential extraction method (Leleyter and Probst, 1999) was applied to study element speciation in the samples of progressive weathering stages to understand their behaviour and mobility pattern. It is probable that the soil formed in the catchment area is a function of weathering pattern of these parent rocks of the region.

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P-487

Molecular scale view at organo-mineral aggregates

Dr. Edgar Galicia-Andrés, Prof. Dr. Chris Oostenbrink, Prof. Dr. Martin H. Gerzabek, Prof. Dr. Daniel Tunega

During pedogenesis, soil materials are bound by various physicochemical and biological processes forming microaggregates. Microaggregates can be described as organo-mineral structures formed mainly by soil organic matter (SOM), clay minerals and oxihydroxides linked to soil properties and functions, forming a hierarchy of aggregates with varying structural and compositional complexity. Microaggregates are related to the protection and resilience of SOM against degrading processes by either microorganisms or chemical attacks.

Over the last few decades, molecular modeling (MM) contributed to the molecular description of soil components. The CLAYFF force field (Cygan 2004) describes structural and physicochemical properties of minerals. More recently, the Vienna soil-organic-matter modeler (VSOMM) (Escalona 2021; Sündermann 2015; Vienna Soil Organic Matter Modeler 2) generates realistic models of humic substances (HS) diverse in composition and 3D-structure reproducing SOM thermodynamic properties.

Our results exhibit that MM simulations of HS and clay models generate models of organo-mineral aggregates providing deep insight on the formation and dominant interactions of microaggregates with water and cations content taken into account. HS adsorption is driven by the electrostatic environment, mainly influenced by the exposed mineral surface, promoting HS dispersion over the surface developing the electric double layer. HS adsorb on the mineral surface due to hydrogen bonding with cation bridges and hydrophobic interactions stabilizing HS aggregates. These aggregates form patches competing with the repulsion between negatively charged HS molecules. These new findings promise to explain phenomena of interest such as carbon sequestration as well as the fate of pollutants and nutrients in soils.

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P-488

Fractionation of rare earth elements as pedogenic tracers along a chronosequence

Professor Zeng-Yei Hseu, Mr. Wen-An Liao, Miss Cho-Yin Wu

Rare earth elements (REEs) are a group of seventeen elements and are commonly classified as light REEs (LREEs; La, Ce, Pr, Nd, Pm, Sm, Eu, and Gd) and heavy REEs (HREEs; Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, and Y) according to their atomic weight. The REEs display decreasing atom radii with the increase of atomic numbers. This phenomenon is known as lanthanide contraction, making chemical behaviors of LREEs and HREEs different to be fractionated in the environment. The fractionations between LREEs and HREEs are further quantified by (La/Yb)N, (La/Sm)N and (Gd/Yb)N. The different processes of fractionating REEs can be used as tracers of pedogenetic processes by abovementioned indices. Six soil profiles classified as Inceptisols, Ultisols, and Oxisols were collected from a chronosequence with known dating on aged fluvial terraces in Central Taiwan. The soil profiles in descending order are HS (400 ka), PJ (350 ka), SBK (322ka), GS (200 ka), CS (105 ka), and DJ (28 ka). The highest total REEs content, ranging from 184 to 232 mg/kg, was found in the DJ profile. However, the lowest REEs content was in the PJ profile (155-170 mg/kg). The (La/Yb)N value increased as the soil depth decreased, indicating the clear fractionation between LREE and HREE during pedogenesis. Furthermore, a significant and linear correlation ($n = 47$, $p < 0.01$) exhibited between ratio of iron crystallinity and (La/Sm)N. Hence, consideration of (La/Sm) N with the chemical forms of pedogenic Fe oxides are valuable to interpolate the soil age in the chronosequence.
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P-490

Lithological controls on soil geochemistry and clay mineralogy across Spodosols in the coastal temperate rainforest of southeast Alaska

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The formation of Spodosols on contrasting lithologies is driven by fast podzolization rates in the temperate rainforests of southeast Alaska. Yet, the role of lithology on chemical weathering, base depletion, and mineral transformation remains elusive. We established a lithosequence comprised of tonalite, phyllite, slate, and metavolcanic rocks to test the hypothesis that lithological influences in soil geochemistry and mineralogy can be detected in similar soils. We evaluated physico-chemical properties, clay mineralogy, Fe oxides, weathering degree, and elemental mass balance on 11 Spodosols. We also propose a new weathering index to evaluate weathering degree of soils with Al mobility and base-rich parent materials. The pedons expressed similar physico-chemical properties, with a predominance of andic properties, thick spodic horizons, and thin E horizons. Podzolization imposed similar mineral transformation trends, mainly mica to interstratified mica-vermiculite, and smectite on E horizons. The Fe oxides concentration was higher on slate, followed by metavolcanic, phyllite, and tonalite but with similar depth distribution and predominance of organometallic complexes. The weathering trends were similar, driven by Mg, K, and Ca depletion. Yet, slate pedons were the most weathered, followed by phyllite, tonalite, and metavolcanic. Differences in the weathering degree were dictated by geochemical and mineralogical rock composition. Our results demonstrated that lithology controlled elemental depletion intensity, Fe oxide concentration, and partially the clay fraction mineralogy in addition to podzolization acting as a dominant pedogenic process. These findings advance our understanding of the role of lithology on mineralogy/geochemistry that impacts soil functions, such as carbon cycle and elemental fluxes.
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P-491

Rare earth elements fixed by pedogenic iron oxides in humid and tropical soils

Ms Cho-Yin Wu, Assistant Professor Mei-Fei Chu, Assistant Research Fellow Kuo-Fang Huang, Professor Zeng-Yei Hseu

Rare earth elements (REEs) from parent materials are easily trapped in highly weathered soils such as tropical and humid soils. However, few studies have regarded REEs fractionation by Fe oxides during pedogenesis. Therefore, this study determined REEs partitioned in pedogenic Fe oxides of four pedons developed from schist, andesite, shale, and ultramafic rocks in Eastern Taiwan by using the dithionite-citrate-bicarbonate (DCB) extraction with bulk soil samples and microspectroscopic methods on thin sections. The DCB extraction was applied to pedogenic Fe oxides (Fed) and to assess the potential mobility of REEs through the dissolution of Fed. The spatial distribution of REEs in Fe nodules and surrounding soil matrix was achieved by using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) and electron probe microanalysis (EPMA). Total REEs were fractionated during pedogenesis; thus, the ratio of light REEs (LREEs) to heavy REEs (HREEs) varied substantially among pedons. However, the DCB-extractable REE content significantly increased when the Fed content increased, indicating the high affinity of pedogenic Fe oxides for REEs. Moreover, the Fe oxides exhibited an association preference for HREEs over LREEs although the DCB-extractable concentrations of LREEs were higher than those of HREEs in the soils. Additionally, the association of REEs with Fe oxides caused HREEs condensation in the Fe nodules identified through LA-ICP-MS and EPMA.
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P-492

Evaluation of soils of the Edina catena for crop production: A key to food security

Dr Eunice Agyarko-mintah, Professor Daniel Okae-Anti, Dr Caleb Melenya Ocansey, Dr Isaac Danso

Rice and maize are major staple food in Ghana. Of all the cereals produced in Ghana rice is second to maize in the level of per capita consumption. An assessment of land suitability for maize and rice production was performed on the Edina catena at School of Agriculture Teaching and Research farm of University of Cape Coast. Five profile pits were dug along the Edina catenaries sequence. Profiles were sampled by genetic horizons and detailed profile descriptions were carried out. Classification of the soils was carried out according to the World Reference Base (WRB,2006), where the upper, middle, lower, toe and valley bottom series were classified as Haplic Regosol, Plinthic Lixisol, Haplic Lixisol, Stagnic Lixisol, Eutric Gleysol and ethnopedologically as Edina, Atabadze, Bronyibima, Benya and Udu series respectively. Haplic Lixisol, is a new soil series discovered at the lower slope of the toposequence which may be due to pedogenic processes. FAO,(1983) Simple limitation method was used for the evaluation. The upper slope soil series was moderately suitable (S2ce) for maize production with climate and erosion as limiting factors. The middle and lower slope were rated as moderately suitable (S2f) for maize cultivation with fertility as the limitation factors. The valley bottom series was rated as marginally suitable (S3fct) for low land rice production with fertility (f), climate(c) and topography as the main limitation factors. The suitability of the five soil series for the cultivation of both crops could be improved by the management of these physico- chemical limitations.

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P-493

Contemporary Soils of ultra-continental cold steppes as analogues of the Late Pleistocene steppe periglacial paleosols in Europe and Beringia

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Extensive steppe-tundra biotopes were widely described basing on paleobotanical, paleozoological, and paleosol data as a typical periglacial landscapes of the interstadials within the latest Pleistocene glaciation and the terminal deglaciation in Eurasia and Beringia (Morozova, 1981; Hopkins et al., 1, 1982; Sanborn et al., 2006, Sycheva et al., 2015; Sycheva et al., 2020 and many others). From the very beginning of micromorphological studies in paleosols of mentioned period T.D. Morozova (for Bryansk (MIS-3) paleosol) and later other researchers mentioned a combination of frost action features (microgranular (ooid), lenticular microstructure, imvolutions, frost sorting of soil matrix), and features common for steppe soils (biogenic aggregation, features related to processes carbonate accumulation and redistributions) as typical for MIS-3, MIS-2 paleosols. Some of these soils are poor in organic matter, others in the opposite have very dark humus horizons, well developed zoogenic microstructure and other signs of soil fauna activities.
There was a rare attempt to classify these soils (Sycheva et al., 2016). Three soil in a MIS-2, MIS-3 sequence were attributed to three different groups according to WRB: Cambisols, Leptosols, and Chernozems. This clearly testify on a considerable difference both in their genesis and environmental background.
Possible contemporary analogues for the earlier described MIS-3 and MIS-2 paleosols of periglacial steppe environments will be discussed in the presentation with a special concern to soil micromorphology. Ones were found among permafrost-affected and seasonally frozen soils of ultra-continental cold steppes in Central and East Siberia.

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P-496

Multi-proxy analysis of colluvial deposits for iron-age settlement and land use dynamics in Hochdorf (Enz), SW Germany

M. Sc. Judith Koschorke, M. A. Anne Jerosch, Dr. Susanne Lindauer, Prof. Dr. Ellen Kandeler, Dr Christian Poll, Prof. Dr. Thomas Knopf, Prof. Dr. Thomas Scholten, Dr. Peter Kühn

Colluvial deposits are the result of human-induced soil erosion. Various pedological and biogeochemical properties of colluvial deposits can be used as proxies for human activities, even allowing the reconstruction of past land use practices.

This study focuses on the transition from the Late Hallstatt/Early Latène Period to the Middle Latène Period in the area of Hochdorf (Enz), SW Germany, where the period of the highest population density was followed by a migration phase accompanied by a massive population decline around 400 BCE at the beginning of a cold climatic phase. Beside the climatic change, social pressure (e.g. overpopulation, 'Realteilung'), overuse and impoverishment of the soils were also discussed as triggers for migration. In this context, we focus on the following research questions:

Was the migration caused by intensive agriculture, high erosion rates and negative effects on soil yield?

What prehistoric land use practices can be deduced from the biogeochemical proxies of the colluvial deposits?

Has there been a spatial restructuring of land use between eroded sites and sites covered by colluvial deposits?

To answer these questions, optically stimulated luminescence (OSL) and AMS 14C dating of charcoals will be used to establish a chronostratigraphy of the colluvial deposits. Urease activity is used to identify the input of excrements and faecal biomarkers such as sterols, stanols and stanones allow the differentiation of herbivorous and omnivorous digestive residues. Phytoliths, charcoal spectra, heavy metal and phosphate contents and PAHs serve as further land use proxies.

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P-501

Mineralogy, geochemistry, micromorphology and WRB classification of a soil-sedimentary sequence on limestone in Monte Coronichi (Istria, Croatia)

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The aim of this work was to analyze a soil-sedimentary sequence in a vineyard on the Istrian peninsula in order to relate its properties to climatic conditions and to classify it according to WRB. Regional climate is moderately warm with hot summers (Csa). The profile consists of recent Terra rossa overlying two red palaeosols on limestone of Lower Eocene age. The designations and depths (in cm) of the horizons are: Ap (0-30), Ap/Bt1 (30-70), Bt1 (70-110), Bt2 (110-170), 2Btb1 (170-200), 2Btb2 (200-230), 3Btb3 (230-260), 3Btb4 (260-300), R (>300). Its (micro)morphology (color, structure, clay coatings, Fe/Mn nodules) indicates long and intense weathering and pedogenesis (interrupted by erosion/sedimentation cycles). Accordingly, pHKCl values are lower than 4.2. The soil is (heavy) clay, with clay content increasing with depth. However, this increase is interrupted in 2Btb1 and 3Btb3 horizons, which contain less clay than the horizons immediately above. Nevertheless, both 2Btb1 and 3Btb3 have abundant illuvial clay. Along the profile, CEC increases with increasing clay content, and its values indicate low-activity clays. The main soil minerals are kaolinites and illitic material, with significant amounts of quartz and hematite. Distribution of the three most abundant oxides reflects weathering intensity: SiO2 decreases with depth, while Al2O3 and Fe2O3 increase. The whole sequence is named Rhodic Lixisol (Clayic, Cutanic, Hypereutric, Profondic). Considering that Lixisols are soils of seasonally dry (sub)tropical regions, and in agreement with the results presented here, one can conclude that the studied profile developed in a climate different from the present one.

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P-504

Soil characterization and classification as the first step to evaluate the impact of WWTP effluent

Edgar Tena, Laura Escarmena, PhD Núria Roca, PhD Tere Sauras-Yera, PhD Francesc Sabater, PhD Santi Sabaté

Intermittent streams located in the Mediterranean region are particularly vulnerable to human pressure because they tend to have low discharge or are dry during certain periods of the year. This phenomenon is especially relevant in streams that receive effluents with high nutrients contents from wastewater treatment plants (WWTP). The aim of this contribution is to characterize and classify the riparian soils as a first step to the understanding of potential role of those riparian soils to recycle part of nutrient loads received from WWTP. The studied soils have a dominant alluvial calcareous substratum and receive the WWTP's effluent of the municipality of Caldes de Montbui (Catalonia, Spain). Seven soil profiles were described and analyzed for each horizon: pH, EC, OC, particle size and CEC. Soils were classified with WRB 2014. They include: Calcaric Katofluvic Cambisol (Arenic, Geobruptic, Humic, Raptic), Calcaric Fluvic Cambisol (Humic, Loamic, Amphiraptic), Calcaric Endoleptic Fluvisol (Arenic), Calcaric Pantofluvic Fluvisol (Loamic Humic), Calcaric Leptic Orthofluvic Fluvisol (Loamic, Humic), Calcàric Protic Regosl (Fluvic, Geoabruptic, Humic, Loamic, Raptic) and Calcaric Protic Leptic Regosol (Humic, Loamic). The soils have an abrupt difference in particle-size distribution, a difference of ≥25% in the ratio coarse sand to fine sand and a difference of ≥5% in the content of coarse sand and fine sand. Most soils have more than 1% of OC in the fine earth fraction as a weighted average to a depth of 50 cm. These soils properties could explain the specific drainage of the WWTP's effluent and the retention of nutrients.

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P-506

NOVEL INSIGHTS INTO PALEOVEGETATION RECONSTRUCTION OF THE BEERBERG PEAT SEQUENCE (THURINGIA, GERMANY) THROUGH THE USE OF MULTIPLE PROXIES

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Reconstruction of paleovegetation composition over time can provide an increased understanding of environmental changes in the past as well as insight into how future changes will affect vegetation and local conditions. There are multiple proxies preserved in archives such as soil or sediments that may be used for reconstructing paleovegetation including pollen, macrofossils, and biomarkers. Each proxy has its own advantages and disadvantages that can be mitigated when used in combination with the others. A sequence from the Beerberg peatland in Thuringia, Germany covering approximately the last 2500 years was investigated using pollen, macrofossils, and lipid biomarkers, specifically free extractable lipids including n-alkanes, n-alcohols, and n-fatty acids. The biomarker data will be implemented in the VERHIB (Vegetation Reconstruction with the Help of Inverse Modelling and Biomarkers) model to enable a more systematic and quantitative approach to reconstruction with biomarkers. The VERHIB model allows multiple compound classes of biomarkers to be considered simultaneously, providing a more complete interpretation of vegetation development over time (Jansen et al., 2010, Jansen et al., 2013). The overall aim of the project is to compare the results from the modeled reconstruction to that of the pollen and macrofossil analysis to determine potential improvements for future iterations of the VERHIB model. Preliminary results from the macrofossil and pollen data indicate a possible fen to bog transition around 2400 years BP as well as other slight vegetation shifts through time. We expect that these results will be echoed in the biomarker signatures and the modeled paleovegetation reconstruction.

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P-507

Soil-sedimentary sequence paleosols at the Khotylevo I archaeological site during the last cryochrone

Ms Maria Korkka, Ms Tatiana Romanis, Mr Sergey Sedov, Mr Alexander Otcherednoy, Ms Larisa Savelieva

Khotylevo I, one of the largest Middle Paleolithic sites in Eastern Europe, is located in Bryansk Oblast', 400 km southwest of Moscow, in the upper course of the Desna River. The site includes a complex of areas of different ages which vary in the extent of preservation of cultural deposits, their cultural appurtenance (most of them deal with Micoquian/Keilmessergruppe), and human habitation intensity (The Institute of Archaeology…, 2019).
The soil-sedimentary sequence of the right bank of the Desna is presented by deposits of the last macro-cycle MIS5-MIS1 (according to OSL, AMS dating). Paleosols of varying degrees of preservation have matching pedofeatures and stratigraphic patterns throughout the extent of site.
In the bottom part of the sections, soils MIS5 a-c contain Middle Paleolithic cultural layers. The MIS3 soil series presents as several levels of soil formation. One of the soils has a full set of genetic horizons undisturbed by cryogenesis (similar paleosols are described in Germany and Austria (Terhorst et al., 2015)), AO-El-Bm(t)-Bca(g)-C, the closest contemporary analogue of which is the Cambic Cryosols of Yakutia. The formation of these soils occurs in extracontinental semi-arid climate conditions on the territory of the middle taiga zone. Within the thickness of interstadial deposits the nature of soil formation inherits the change in climate: from Cambic Cryosols to Gleysols. Owing to high deposition rates and the development of weak earthslide slope processes, a detailed paleosol chronicle reflecting short-term climatic fluctuations has survived in Khotylevo I sections.

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P-508

Magnetic mineralogy and micromorphology in paleosols of the crater of the Alberca de Teremendo volcano (México) Late Pleistocene-Holocene environmental implications.

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Several studies have established the relationships between the magnetic mineralogy of soils and paleosols and changes in Quaternary environmental conditions. Climate is an important factor that affects the mineralogical and chemical composition of this type of environmental archive. In this research, three soil profiles were analyzed in different positions of the Alberca de Teremendo maar volcano crater (TER1, TER 2, and TER 3). Magnetic concentration and mineralogy analysis were complemented and compared by studies of the physical (color, texture) and micromorphological characteristics of the soil horizons. The results of the research show that there is a differentiation between the magnetic properties of soils and their degree of pedogenesis. It was observed in TER 3 they have a higher concentration of larger magnetic minerals while in TER 2 and TER 1 they have low concentrations of magnetic minerals dominated by fine particles. Regarding the micromorphology in TER 3, in all horizons, a high abundance of iron nodules and manganese mottling and clay coating is observed, which are not observable in TER 1 and TER 2 where the presence of organic matter is more predominant. The analysis of these Pleistocene paleosols (~ 22.4 ka BP) suggests that their development is related to a humid environment, coinciding with several regional records for this period.
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P-508A

Semi-supervised learning for predicting soil properties at a national scale of Germany

Dr Ruhollah Taghizadeh Mehrjardi, Prof. Dr. Thomas Scholten

The basis of digital soil mapping (DSM) techniques is the relationship between the geospatial environmental covariates with any soil properties. Based on such relationships, DSM can produce and quantify spatial soil functions by implementing different machine learning (ML) algorithms. Although the supervised ML algorithms are routinely applied throughout the world for mapping of soil properties at all manner of spatial scales and extents, there are still some unresolved issues for the application of supervised ML algorithms in DSM when it comes to mapping soil information at the national scale with limited field data (i.e., labeled data). To overcome this drawback, semi-supervised learning has been applied in different environmental sciences. Semi-supervised learning is a branch of ML that aims to save human labor costs for collecting a large amount of soil data and improve learning performance by using unlabeled data in addition to labeled data. In the current work, we applied supervised and semi-supervised ML algorithms to correlate soil properties (2000 soil observations) and a wide range of environmental covariates (170 raster layers) in order to create soil maps at a national scale of Germany. The results indicated the higher performances of semi-supervised compared to supervised ML. This is particularly true when we used a small number of labeled data (25, 50, 75, and 100%) for training the ML algorithms. Generally, the semi-supervised ML can be a promising approach for mapping soil properties in areas with few soil samples.

Machine learning, digital soil mapping, spatial prediction, remote sensing

P-509

Comparing sequential Gaussian simulation and turning bands algorithms for modelling spatial uncertainty of organic carbon in forest soils.

Dr. Gabriele Buttafuoco, Dr. Massimo Conforti

Soil organic carbon (SOC) provides multiple functions and the main soil ecosystem services are associated with its content. Mapping SOC spatial distribution and modelling its spatial uncertainty are critical research issues. Geostatistical simulation is largely used for the assessment of spatial uncertainty generating a set of alternative maps (possible realities or realizations) of SOC that honour sample information but also attempt to reproduce its spatial variability (Deutsch and Journel, 1998; Heuvelink, 2018). However, there are several geostatistical simulation algorithms and each of them requires specific assumptions and simplifications with different advantages and disadvantages. Therefore, choosing the most appropriate simulation algorithm for the case under study is neither trivial nor simple. Consequently, it is essential to validate the quality of the simulation algorithms. Within this perspective, the study was aimed to evaluate the performance of sequential Gaussian simulation and turning bands algorithms for modelling the spatial uncertainty of soil organic carbon in a forest catchment in southern Italy. The study area is a 139 ha catchment on granitic parent material and subordinately alluvial deposits, where soils are classified as Typic Xerumbrepts and Ultic Haploxeralf crop out. Soils samples were collected at 135 locations (up to a depth of 0.20 m) and the sample design was developed using a spatial simulated annealing algorithm. In the laboratory, SOC concentration was measured using a Shimadzu TOC-L analyzer with a SSM-5000A solid sample module. Statistical testing and graphical validation were applied to check for the two algorithms, the reproduction of data, summary statistics, and variogram.

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P-510

Mapping soil apparent electrical conductivity using machine learning and high resolution data to predict soil organic carbon stocks in peatlands

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Peatlands ecosystem is one the largest terrestrial carbon pools worldwide. This emphasises the significance of mapping the soil organic carbon stocks (SOCstocks) in peatlands. However, mapping SOCstocks is a tough task for scientific community. Proximal sensing and high resolution remote sensing data can support digital mapping of SOCstocks. The soil apparent electrical conductivity (ECa) has been a useful tool to estimate not only peat thickness but, SOCstocks. A few studies to date have attempted to use the digital soil mapping framework to map ECa data from EMI. This study evaluates the application of random forest algorithm through digital soil mapping framework to map ECa and its application as an environmental variable to map SOCstocks in peatlands. To test this hypothesis, we applied three different scenarios defined as: spectral indices calculated from (1) averaged multitemporal image; (2) non-averaged multitemporal images; and (3) non-averaged multitemporal images of RapidEye satellite collection with terrain derivatives from LiDAR sensor as environmental variables to map ECa. We evaluated the use of the best fitted model for ECa from those three scenarios using its predicted map as environmental variable to map SOCstocks. The scenario 3 outperformed the other two ones. Whilst, the scenario 2 presented better metrics than scenario 1. In this sense, adding the ECa information to improve predictive power of SOCstocks presented better accuracy then not adding that information. High resolution remote and proximal sensing data can assist to map ECa and SOCstocks in peatlands to unknown areas overcoming the limitations of geostatistics.

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P-510A

Estimating soil organic carbon stock change at regional scales: Challenges and possible solutions

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Many national and international initiatives rely on spatially explicit information on soil organic carbon (SOC) stock change to support policies aiming at climate change mitigation, water security, food security and land degradation neutrality. In the past few years we have made efforts to predict SOC stock and its change and quantify the uncertainty associated with these predictions for Hungary using advanced digital soil mapping (DSM) techniques. In doing so we faced a number of challenges. For example, uncertainty quantification approaches that assume normality and homoscedasticity of the error distribution may yield inaccurate uncertainty quantifications as data on SOC stock are frequently found to be positively skewed and have a positive relation between prediction uncertainty and predicted value. We also experienced that prediction uncertainty of spatial averages is strongly dependent on the spatial correlation of prediction errors. Even if we find a DSM technique that is accurate in both the spatial prediction and uncertainty quantification, uncertainty of predictions at small supports may be too large to detect statistically significant SOC stock changes. Furthermore, prediction errors for different years may be correlated, which should be taken into account in order to reliably characterize the uncertainty of SOC stock change. Using the example of Hungary, our aim is to illustrate these challenges and present some possible solutions (see references) and discuss them in a broader context. This may help not just to yield accurate and reliable predictions of SOC stock change but also to better understand its spatio-temporal variability.

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P-511

Calibration Set Optimization for Soil Carbon Estimation Using Mid-Infrared Spectroscopy

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Mid-infrared spectroscopy is an efficient technique for soil carbon analysis. Efforts to measure and monitor carbon through mid-infrared spectroscopy require the development of soil spectral libraries. These libraries are used for the construction of calibration models which relate soil carbon measurements to spectra. The optimization of these models is an important process for the accurate and resource-efficient estimation of soil carbon. This study demonstrates the optimization of calibration models for soil carbon estimation through subsetting techniques. Various subsetting criteria are tested across landscapes in the United States. Results of this study are presented in the context of the development of new soil spectral libraries.
Dorantes, M. J., Fuentes, B. A., Miller, D. M. (2021). Calibration set optimization and library transfer for soil carbon estimation using soil spectroscopy – A review [Manuscript submitted for publication].

P-512

Spatial prediction of soil type maps with Convolutional Neural Networks including quantification of model uncertainty

Mrs Kerstin Rau, Mr Thomas Gläßle, Prof. Dr. Philipp Hennig, Prof. Dr. Thomas Scholten

Convolutional Neural Networks (ConvNets) originated in image recognition but are increasingly used in the Geosciences. Since they consider the local neighbourhoods of pixels and thus the surrounding landscape, ConvNets are well suited for the prediction of geographical variables. In their basic form, however, deep-learning algorithms do not provide interpretable predictive uncertainty. Therefore, we implement in our explorative study on soil classification a Bayesian deep learning approach (i.e. a method to add uncertainty to deep networks) known as last layer Laplace approximation.
Our target variable soil type provides us with a variety of information about soil processes and properties, which is a great advantage given the effort required to sample all these. In our study area around Tübingen in South Germany we have 39 different soil types, which we consider for the prediction individually but also combine into higher categories with similar properties. As a test case, we then include the Swabian Jura, which exhibits quite different soil types, as a prediction area. In addition to point soil samples, remotely sense-able variables such as satellite imagery, a digital elevation model and its derivatives, climate data, and existing soil maps are incorporated as input into the model.
Our goal is to enrich soil type maps with structured uncertainty, which is expected to be high around the area of the Swabian Jura. This will help to better understand about the causality of machine learning models in soil science and their transferability to regions other than the training and validation area.
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P-512

Effect of uncertain calibration and validation data on the prediction accuracy of pedotransfer functions

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Soil properties that are considered difficult to measure are frequently determined through pedotransfer functions (PTF). Calibration and validation wet chemistry datasets are needed to construct PTFs. However, these data are imperfect due to measurement error. Until now, the uncertainty of calibration and validation data has been ignored when deriving PTFs, and uncertainty quantification remains limited to propagation of model input, parameter and structural uncertainty. In this contribution, we to take uncertainty analysis one step further by studying how measurement error in wet chemistry calibration and validation soil data affects PTF predictions and associated prediction uncertainty. We focused on PTFs to predict cation-exchange capacity (CEC), which is an important indicator of soil fertility and nutrient retention capacity. To predict CEC, clay, organic matter content and pH are commonly included in PTFs. We aimed to study the effect of measurement error in CEC data on the accuracy of partial least squares regression and random forest models. PTFs were developed for the entire USA, subdivided per soil taxonomic order. Here, wet chemistry data from the National Cooperative Soil Survey's (NCSS) Soil Characterization Database were used. The PTFs were fitted with and without including measurement error. However, the majority of the NCSS Soil Characterization data did not have duplicate measurements, which were needed to quantify measurement error. For this, we used data from the Wageningen Evaluating Programmes for Analytical Laboratories (WEPAL). Comparison of PTFs with and without measurement error showed significant differences in model accuracy metrics.

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P-514

Spatial disaggregation of a legacy soil map to support digital soil and land evaluation assessments in Scotland

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Digital Soil Mapping (DSM) techniques are widely used to produce maps of soil properties and functions at regional to global scales. These can then be used operationally by decision and policy makers to support the sustainable management of environmental systems and the provision of multiple benefits to societies. Spatial disaggregation can harness the valuable knowledge about relations between soil classes and underlying environmental conditions embedded in legacy soil maps and transform them to spatially-explicit biophysical tools that can improve land evaluation assessments. We developed a 50m grid spatially-disaggregated map at the taxonomic level of soil series (class) that, when linked with the Scottish Soils Database, can produce nationwide digital soil property maps as inputs to digital environmental assessments. We divided Scotland into nine areas of similar landscape and soil characteristics and randomly selected virtual samples within the single and complex soil polygons of the 1:250,000 scale National Soil Map using areal-proportion sampling. We predicted probabilities of soil series occurrence by training a Random Forest at each land division using values of standard environmental covariates at sample locations and algorithm fine-tuning. Prediction accuracy was assessed at 1,925 profile locations and ranged from 32% to 59%, when the most- and 3rd most-probable series were considered, respectively. We demonstrate the utility of the disaggregated map for environmental assessments by translating the map to soil hydrological classes and combining with remotely-sensed habitats to map hydrological wetland types and assess wetland health and functioning, and their capacity for moderating hydrological extremes of flooding and drought.
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P-515

Soil salinity mapping in Lajas Valley, Southwestern, Puerto Rico

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The average economic impact caused by excess salts in crop yields was calculated at $441 per ha in losses, for a total of $ 27.3 billion worldwide, this considering that only 20% of the 310 Mha of the global irrigated area classified as soils affected by salts (Qadir et al., 2014).
The soils of the Lajas Valley, located in the southwest of Puerto Rico, present saline and / or sodium conditions, a condition that increases in magnitude at greater depths (Bonnet and Brenes, 1958). After more than 60 years, the salinity and sodicity of the valley's soils continue to be a concern among farmers in the area due to the lack of recent research to determine the status of this resource. The study hypothesis was to demonstrate changes in the magnitude and spatial distribution of the salinity and sodicity of soils at a local and regional scale for the year 2020. A protocol was developed to evaluate the magnitude and spatial distribution of the salinity and sodicity of soils, at field and regional scale using soil parameters, apparent electrical conductivity (ECa) measurements, laboratory analysis of saturated pastes and soil / water solutions at 1: 5 proportions and satellite images. Results demonstrated that field-scale ECe and SAR measurements can be extrapolated to a regional scale by analyzing satellite images obtained from Sentinel 2A, Landsat L8, and environmental variables. Neural network algorithms were used to extrapolate the salinity and sodic maps to a regional scale.

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P-515A

New Digital Soil Map of Russia: Progress and Challenges

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Soil Map of the Russian Federation (1 : 2.5 M, 1988) vectorized in the 1990s is the main source of geographic information on Russian soils. This map contains 25711 polygons, and its legend includes 295 names of soils, soil complexes, and nonsoil bodies. Polygons may include from one to four soils or soil complexes. The map displays natural soil cover and reflects information and genetic concepts developed by the 1980s. Since then, new soil data, genetic concepts and classification decisions, and digital soil mapping technologies have appeared. In many regions, native soils are transformed by humans and require their adequate representation. A project on the creation of a universal digital model of the soil cover of Russia with a 500-m resolution was launched by the Dokuchaev Soil Science Institute. First, attribute information to the map of 1988 was updated: soils of each polygon were reclassified according to the new Russian soil classification, information on agrogenic and technogenic disturbances of native soils (Aric soils, Technosols, etc.) was added. The updated legend includes 729 names of soils, soil complexes, and nonsoil bodies. Their correlation with global soil reference bases (WRB, Soil Taxonomy) is being performed. Second, this updated information was used to generate digital soil map via imitation of traditional mapping with the help of globally optimal decision trees. Satellite images, CHELSA climate data set, GMTED2010 elevation model, and digital vegetation map were the main sources of supporting information. Expert verification of the first iteration of digital map is now in progress.

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Zhogolev, A, & Savin, I. (2020). Soil Mapping Based on Globally Optimal Decision Trees and Digital Imitations of Traditional Approaches. SPRS Int. J. Geo-Inf. 2020, 9(11), 664

P-516

Using UAV to identify plant patterns in arable fields: a spatio-temporal analyses to detect soil compaction

M.sc. Frauke Lindenstruth, Dr. Michael Kuhwald, Prof. Dr. Rainer Duttmann

Field traffic under unfavorable soil conditions result in soil compaction and increase bulk density (Bd), reduce soil hydraulic conductivity (Ks) and hinder plant growth. As a consequence, plant stress occurs and may result in decreased yield. To detect areas of compacted soil, however, is challenging, as further environmental effects influence plant growth.

The objective of this study was to identify patterns of soil compaction using multispectral UAV imagery and distinguish them from naturally occurring patterns in field vegetation. Therefore, imagery of five fields with winter wheat, winter barley and silage maize in three different growing stages were captured in 2019, 2020 and 2021 to analyze the crop signals. Clusters of crop productivity were developed from plant height models and NDVI to detect spatial-temporal patterns using the k-means algorithm. Detected plant patterns were validated by collecting field samples of soil texture, Bd, air conductivity (Ka), Ks, and yield.

Results showed that (1) plant patterns can be distinguished by their geometry and orientation, (2) linear plant patterns running parallel to the tramlines indicate soil compaction and showed an increase in Bd, while Ks, Ka and yield decreased, (3) planar plant patterns in the headland exhibit similar trends for grain fields but weather dependent yield variability for silage maize, (4) rounded plant patterns of low crop productivity display changes in topography and soil texture.

Thus, using UAV enables to detect plant patterns caused by soil compaction. Furthermore, plant patterns caused by differences in geomorphological conditions can also be identified.

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P-517

Terrain attributes correlating with soil organic matter stocks at different depths in Alpine grasslands, investigations in Lungau, Austria

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Alpine landscapes are known for different topographical and geological features. These are introduced as major controlling factors for soil development and therefore control soil organic carbon (SOC) stocks, but knowledge for their influence in subsoil is limited. The current study investigates the effects of topographic features and parent material on SOC and total TN stocks in permanent grasslands of the Lungau region, Austria. Grassland soils from fifteen organic farms were sampled down to a depth of one metre. These soils developed from two parent materials (moraine and alluvial-colluvial deposits) under various slope aspects. The mean SOC stock in the region was 23.4 kg m-2, ranging from 11.4 to 38.8 kg m-2. Soil developed on alluvial-colluvial deposits had higher SOC and TN stocks than soil found on moraine. For both soils, SOC and TN stocks were higher in soils collected in south and south-west aspects (shady aspects), than those in west and east aspects. Most of SOC stocks were found in topsoil (51% of total SOC stocks in 0-20 cm), compared to upper-subsoil (27% of total SOC stocks in 20-40 cm) and subsoil (22% of total SOC stocks in 40-100 cm). The topographic wetness index (TWI), which indicates soil moisture gradients, was identified as the main topographic feature related to SOC and TN stocks (R2=0.5-0.7), particularly in the subsoil. Our results indicate that subsoil OC stocks in the alpine grasslands correlated to topography, particularly slope-aspect, and parent materials.
Zhu, M., Feng, Q., Zhang, M. et al. Effects of topography on soil organic carbon stocks in grasslands of a semiarid alpine region, northwestern China. J Soils Sediments 19, 1640–1650 (2019). https://doi.org/10.1007/s11368-018-2203-0

Lozano-García B, Parras-Alcantára L (2014) Variation in soil organic carbon and nitrogen stocks along a toposequence in a traditional Mediterranean olive grove. Land Degrad Dev 25:297–304

P-518

Efficacy of reflectance spectroscopy to evaluate remediation of arsenic and metals polluted soils

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The potential of vis–NIR spectroscopy in order to monitor the remediation efficacy of a polluted soil is addressed. To this scope, 12 soil plots were monitored (7.5m2 each) using both reflectance spectroscopy and classic geochemical analyses. Organic and/or inorganic amendments had been previously applied in each plot to immobilize arsenic and metals derived from extractive mining activities. Three composite soil samples for each plot were taken in four different times (0 -before amending-, 15, 100, and 200 days), totalling 144 samples.

For geochemical characterization, soil samples were sieved, through 2-mm mesh to remove large particles, then split into two parts: one for availability calculation by means of Toxicity Characteristic Leaching Procedure (TCLP) procedure, and the other to determine total concentrations (ICP-MS) after aqua regia digestion (grounding below 100 µm was done). In turn, spectral reflectance was recorded at 1-nm intervals from 350 to 2500 nm using an ASD FieldSpec 4 Portable Spectroradiometer. These data were obtained for three groups of subsamples with different levels of soil processing: (i) no processing; (ii) material finer than 2 mm; and (iii) material below 2 mm and ground finer than 100 µm. This procedure allows evaluating particle size influence in spectral studies.

The complete matrix of geochemical and spectral data was treated by means of different machine learning algorithms: Random Forest; Support Vector Machine; and Generalized Boosted Models. This approach was used to select the best model to adjust the geochemical behaviour of each element (dependent variable) with respect to spectral data (independent variables).

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P-519

Soil cover and soil map of Smolenskoe Poozerye National Park (Russia)

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The soil cover of the Smolenskoe Poozerye National Park is heterogeneous owing to the unique combination of different glacial landforms and sediments of the WÜrm glaciation marginal zone with diverse plant communities. Among sediments, sands and loamy sands serve as most common parent materials, and soils were plowed since the 17th century. Mapping in the tradition of the factor-genetic approach is still relevant for such territories with poor information on soils. We studied the soil cover patterns, and created the first soil map based on the new Russian soil classification system. The map legend has 22 soil units, some of them display polyecomorphism. The territory was subdivided into soil-landscape areas: (1) (Albic) Podzols with Moder humus + Cambisols on sandy materials, and Retisols on loams under coniferous forests; (2) Umbric (Albic) Podzols under mixed and broad-leaved forests; (3) Dystric/Eutric/Ombric/Rheic Histosols (4) fine-contour catenas on Eskers and Kames; (5) Umbric/Dystric Fluvisols of river and lake floodplains; (6) (post)agrogenic soils of various degrees of cultivation and texture; (7) local areas of Hortic Anthrosols of abandoned ancient settlements. As a result of our study, the area of (Albic) Podzols was expanded. compared to previous Area Studies. The occurrence of Folic (Moder humus) Cambisols under pine forests on Eskers and Kames was recorded. For the first time in the National Park, we described Umbric Cambisols on watersheds, peat mesotrophic soils (Hemic Histosols), Hortic Anthrosols of abandoned ancient hill-forts, and post-agrogenic soils.

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P-520

Using NDVI for assessing soil constraints under different climate scenarios

Miss Fathiyya Ulfa, Dr Thomas Orton, Dr Yash Dang, Prof Neal Menzies

In rainfed agricultural systems, the impact of yield limiting soil constraints often depends on climate. In dry years, soil constraints that limit plant water uptake are potentially important drivers of spatial variation in crop growth. In wet years, soil constraints related to waterlogging can play an important role. In years with adequate rainfall, we might expect limited impact of soil constraints. To investigate the relationship between climate and soil constraint impact, time-series yield data are crucial. However, it is rare to have historical yield monitor data. Therefore, to represent the yield spatial variation, we used remote sensing data (Landsat) to calculate an average NDVI (normalised difference vegetation index) from around the peak of each growing season from 1999 to 2019 at four fields in eastern Australia. We then analysed the correlations between soil characteristics and remote-sensing data in different rainfall years. The results showed that the average NDVI was most significantly correlated with soil constraints in wet years. This was somewhat surprising, as the subsoil salinity at the study sites was expected to be more limiting to plant water uptake in dry years. Possible explanations are that waterlogging associated with sodicity more severely affected plant growth in wet years, or that the imageries used for the average NDVI were not representative of soil constraint impacts. This study highlights the usefulness of remote sensing to provide historical data to identify spatial variability in crop growth and demonstrates how soil and climate data can be integrated to better diagnose soil constraint impacts.
NDVI, soil constraint, in-crop rainfall, yield, spatial variation in crop growth

P-521

Aerial Estimation of Soil Properties Using UAV Images: Implementation of Machine Learning with Data Augmentation

Mizuki Morishita, Naoki Ishitsuka

Precision agriculture requires a detailed understanding of the distribution of soil properties in a field. For this purpose, high-resolution aerial images observed by UAV (Unmanned Aerial Vehicle) are expected to be utilized. Recently, machine learning of soil properties using UAV images has also been attracting attention. However, machine learning requires big data, and it is difficult to obtain sufficient data size from analysis values obtained from soil samples.

Therefore, in this study, we attempted to augment the analysis data from soil samples using UAV images in order to enable machine learning for spatial estimation from limited soil sample sizes. Specifically, assuming that the soil properties are homogeneous within a certain range of sampling points, the soil analysis data was augmented with corresponding pixel values of the UAV images contained within the range. Using this augmented data, machine learning with random forest regression was performed on the relationship between soil properties and UAV images.

As a result, the above data augmentation enabled a highly accurate estimation of soil distribution by machine learning. The estimation accuracy of random forest regression (R^2 for test data: 0.54-0.85) was higher than that of a multiple regression model (R^2: 0.19-0.49, without data augmentation). Besides, in case of this study, it was suggested that the highest performance was obtained when the range of data augmentation was set to 1m to 1.5m.

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P-521A

Comparison of global versus soil-order models for soil properties estimation from Vis-NIR Laboratory spectral data of Northern Karnataka (India)

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14 Division 1 Commission 1.2: Soil geography: basic science and new technologies:
Chairperson: Professor Thomas Scholten, Lomond Auditorium, August 1, 2022, 17:30 - 19:30

Rapidity of Visible Near Infrared (Vis-NIR) spectroscopic soil properties prediction takes advantage over the cumbersome laboratory estimation specially in the regions where the soil information is scarce. The objectives of this study are to 1) identify the soil properties which can be predicted from Vis-NIR laboratory spectral data over the northern Karnataka plateau and 2) compare a global model (built over the entire database) with soil-order models (built over each specific soil order). Spectral reflectance of 482 soil samples of 139 soil profiles belonging to four soil orders (Alfisols (217), Vertisols (82), Inceptisols (153) and Entisols (31)) were used to predict the soil properties. This work highlighted that 1) only soil properties characterized by a large range of values (e.g., clay) and either spectral response due to physico-chemical responses (e.g., clay) or having correlations to one property (e.g., sand, silt, pH and CEC correlated to clay) were successfully predicted at global scale by global models, 2) prediction performances obtained with global models at local scale differed from those obtained at global scale, depending on the soil properties range at soil-order scale and 3) no recommendation to choose between a global or soil-order model may be given for estimating soil properties at soil-order scale. So this work highlighted the risk to overestimate prediction accuracy at soil-order scale when figures of merit are based on a validation dataset built at global scale and can assist in the building of holistic and updated spectral libraries of vast and diverse soil resources of India.

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P-522

Soil microstructure development in West-Mediterranean loess-paleosol sequences

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Soil formation processes on loess in the Ebro River Valley (NE Iberia) mainly consist of structure development, besides carbonate and gypsum redistribution in the most recent sequences (Boixadera et al., 2015). The objective of our research is to determine and quantify the structural and porosity changes in loess from its initial deposition to the first stages of soil development using a micromorphometrical approach. The microporosity of thin sections of loess profiles of different ages was obtained through 2D image analysis at two scales. The textural porosity was studied through high-resolution scanning of the whole sections, and the structural porosity by high-resolution mosaics following Gutiérrez-Castorena et al. (2017). Pores were classified as biopores, packing pores, and fissures according to size and shape indices (Sauzet et al., 2017). These results, together with physical and chemical parameters, were related to the age of deposition obtained through luminescence dating, from 11 to about 280 ka. They indicate that the main factor leading to structure development was the bioturbation due to the activity of earthworms and root growth. A clear relationship is observed between the number and area of biopores and the stadial (cold, less porosity) and interstadial (warm, higher porosity) periods described in the literature, regarding the Quaternary paleoclimatic evolution in the western Mediterranean and the Ebro River Basin (Cacho et al. 2002). Our results stress the importance of the porosity development in these loess-paleosol sequences as part of the loessification processes and the paleoclimatic conditions of the area.

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P-523

Vegetative Buffer Effects on Soil Structure Assessed Using Water Infiltration and Tomography in Selected Landscapes

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Soils used for grain crop production and managed with perennial vegetive buffer management systems that increase water infiltration and improve soil structure may help mitigate consequences of climate change. The objective of this study was to evaluate the effects of vegetative grass buffer and perennial vegetation systems on water infiltration as compared to continuous corn (Zea mays L.)-soybean [Glycine max (L.) Merr.] rotation on deep loess (Monona silt loam; Typic Hapludolls) and claypan (Mexico silt loam; Vertic Epiaqualfs) soils. The study sites were located at Treynor, Iowa, USA and University South Farm at Columbia, Missouri, USA. Infiltration rates were monitored during two years at each site for each management treatment. The two parameter Green and Ampt infiltration equation was fit to the infiltration data for each treatment at the two sites with improved infiltration rates shown under perennial vegetative management. Undisturbed soil cores imaged using X-ray computed tomography illustrated the benefits of perennial vegetative management on increased soil macropore development (pores > 1.0 mm) resulting in enhanced infiltration. Results for selected 24-hour mean frequency (11.8, 14.2, and 16.2 cm) storms showed that grass buffer and perennial vegetation systems enhanced estimated water infiltration, reduced estimated runoff, and decreased estimated time from water ponding to end of ponding compared with row crop management. Overall, these findings highlight benefits of perennial buffer systems for the potential to increase water infiltration and enhance pore structures within soil landscapes.

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P-524

Particle size distribution as affected by soil properties and analytical method

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Particle size distribution (PSD) is a fundamental soil physical characteristic, which strongly influences many other soil properties. PSD can be determined in several ways, in different disciplines and laboratories. Currently, despite all its known flaws, the sieve-pipette sedimentation method (SPM) is accepted as the standard soil physical method.
In this study, we presented the experience of using laser diffractometry method (LDM) for measuring PSD. PSD results obtained with SPM and LDM methods were compared on a national (HunSSD) database (samples examined in great detail from about 60 soil profiles with ca. 250 different horizons that are representative of the Hungarian soil conditions at country scale). The LDM PSD data of the samples were measured using Malvern Mastersizer 3000 (Hydro LV dispersion unit) and the SPM PSD data were determined by the Hungarian sedimentation (sieve-pipette) standard. With statistical analysis we determined the conversion possibilites of the PSD determination methods.
Data mining methods were used to investigate the effect of individual soil properties on conversion errors. Based on our experience, differences in the soil PSD data are highly dependent on the soil structure (primarily on aggregate stability), which is also dependent on other soil properties such as organic matter quality and quantity, calcium carbonate and sesquioxide content, base saturation etc.
This study was supported by the Hungarian National Research, Development and Innovation Office (K 119475), and by a common grant from the Hungarian and Polish Academy of Sciences (Grant No. NKM 2019-17).

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P-525

Comparative analysis of aggregate stability indices of typical Hungarian soil types

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Research on soil structure has great importance, since structure influences, among other things, the movement of water, air, nutrients or pollutants through the soil. Soil structure can be characterised by shape, size and stability, using categorical variables or by constructing various indices.
In the course of our research work, we explored about 60 soil profiles that are representative of the Hungarian soil conditions at country scale, and sampled the different genetic horizons of the profiles (about 250). In addition to the basic soil properties, the soil structure was investigated using the following methods. a) Macroaggregate stability (MaAS) was determined by wet sieving method (Eijkelkamp device). b) Microaggregate stability (MiAS) was measured by laser diffractometric method (LDM), with Malvern Mastersizer 3000 device, as the ratio of dispersed to non-dispersed clay content. c) Aggregate stability was also assessed by comparing water retention of soils with non-polar liquid retention. The organic non-polar model fluid was an aromatics free petroleum distillation product. d) The pore size distributions were calculated from the liquid retention results and the aggregate stability was characterized by the rate of macropores.
We compared the relationship of the four aggregate stability indices with each other and with various soil properties. It was shown that each aggregate stability index characterise the soil structural stability in their own way, and their dependence on soil properties is different.
This study was supported by the NKFIH (K 119475), and by a common grant from the Hungarian and Polish Academy of Sciences (Grant No. NKM 2019-17).

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P-526

Soil salinization in the valley of the river Werra (Germany)

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The salinization of surface water bodies is a key factor driving soil salinization. Although soil salinization is mainly widespread in arid and semi-arid areas, it can also occur outside of these climatic areas. The subjects of our research are the soils of the Werra River valley. As floodplain soils they are in exchange with the water body of the river Werra via multiple and highly dynamic pathways. Due to the discharge of saline wastewater from the potash industry, the river Werra is highly salt-affected. In order to record the effects of the river water on the floodplain soils, soil samples were taken from five depths along different transects with increasing distance to the Werra River and examined with regard to their salinity level. The ECs reached up to 12 dS/m. The accumulation of salts did not only depend on the distance to the river, but also on important standard soil parameters. In order to evaluate the influence of high exchangeable Na+ and Mg2+ percentages on the structural stability of the soils, both the saturated hydraulic conductivity on undisturbed cylinder samples and the percolation rate on disturbed soil samples were determined. So far, several soil samples have shown low hydraulic conductivities. The net dispersive charge also assumed positive values, which supports the assumption of soil structural deterioration.
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P-527

Extension of the Visual Evaluation of Soil Structure scoring system for assessing agronomic suitability of soils for crop growth

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Better understanding of soil quality and crop productivity relationships are needed to help identify any necessary improvements in soil quality and required improvements in soil management. The potential for VESS to do this is by (1) improving the diagnosis of VESS scores according to local land conditions or (2) using the relationship between VESS and crop and soil conditions (including field measurements) to allow specification of appropriate thresholds for agronomic soil qualities that are optimal for crop growth. Examples are taken from organic farming, intensive grass silage production, no-till soybean production and extensive mob grazing of grass. The method of specifying an extended VESS system called 'AgriVESS' is presented and is shown to be well-suited to the holistic assessment of soil health by including residues, surface conditions and porosity of compacted layers. The relevance to crop production is shown from comparisons with crop yields and indicators of crop performance. The method is particularly suited to assessing the value of conservation and regenerative agricultural practices in sustaining soil health, along with improvements from baseline assessments.
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P-528

Changes of soil mechanical strength as a consequence of grazing and short-term irrigation management in pastures over volcanic ash soil

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Pastures under grazing in southern Chile are very important since them constitute the principal part of animal feeding during whole year. The growing competence between farmers and effects of climate change force them to increase pasture yield by the implementation of irrigation, which has potential negative effects on soil structure. Therefore, this study analyzed the impact of pasture defoliation (mowing and grazing) and short-term irrigation (< 2 years) on soil mechanical strength of a volcanic ash soil. For this, soil water content (ϴ0-10cm) and penetration resistance profiles (PR0-80cm) were measured in the field as well as the precompression stress (Pc0-3cm) and compression index (Cn) through repeated loading events over undisturbed soil samples were determined. When the loads were higher than Pc (under grazing), the plastic deformation, and changes in macropore volume and air permeability were observed. Pc increased after the first grazing, but not after mowing. The impact of animal trampling were observed in PR Profiles highlighting the footprint formation after 8 grazing events. These implies that if these conditions do not change, probably a significant soil deformation and a progressive increase in soil mechanical strength near the soil surface can be expected.

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P-529

Short-term effects of compaction on soil structure dependent properties of an Andosol under grazing

Dr. José Dörner, Sebastian Bravo, Marte Stoorvogel, Dr. Dorota Dec, Dr. Susana Valle, Dr. John Clunes, Prof. Dr. Rainer Horn, Dr. Daniel Uteau, Dr. Ole Wendroth, Dr. Lorena Lagos, Dr. Felipe Zúñiga

Several studies on soil physical quality relate soil structural properties to bulk density, proposing values for critical limits of soil compaction status. These values are not applicable to Andosols due to their abnormally low bulk density (< 0.9 Mg m-3). We aimed to evaluate the short-term effects of soil compaction on the soil physical quality of an Andosol. Soil samples were collected from the soil surface and field measurements were conducted to monitor changes in soil physical quality after compaction events during tillage and pasture establishment. The soil was compacted using rollers of 1 Mg to reach three bulk densities (T0: 0.65, T1: 0.75 and T2: 0.85 Mg m-3). Soil compaction during tillage induced an increase in soil bulk density that resulted in an increase in mechanical strength and caused a decrease in the volume of macropores (e.g. T0: 22%, T2: 11%) responsible for water infiltration. The latter provoked an increase in the volumetric water content in the upper 10 cm of the soil, which decreased the air conductivity. The bulk density also increased due to wetting and drying cycles, showing the effect of the natural rearrangement of soil particles/aggregates, which occurred most in the soil with the lowest bulk density. When the bulk density of the tilled soil increased to values over 0.8 Mgm-3, soil pore functions related to soil aeration reached critical values concerning soil compaction, while the soil precompression stress and plant available water remained within a safe range.

No references

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Effect of Long-Term Manure Application on Soil Physical Properties under Different Climate, Soil and Crop Types

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Manure application and crop rotation are common agricultural practices, which can alter soil structure and impact soil functions[1]. In this study, we assessed the effect of long-term manure fertilization and crop rotation on soil structure and pore network. Samples were collected from seven long-term experiments (LTEs) located in Sweden, Denmark, Germany, Spain and the United Kingdom. The LTEs were selected along a climate gradient and covered various soil textures (loamy sand to silty clay), manure fertilization rates and crop rotations (spring barley, winter wheat, maize and grass/clover mixture). Soil structural and hydraulic properties including soil bulk density, water retention, gas transport, aggregate stability, saturated hydraulic conductivity, and pore-network structure (by X ray-CT) were measured/visualized. Several indexes for key soil functions, including percolation thresholds for gas transport and air-filled porosity for the optimum aerobic microbial activity, and their relationships with soil organic carbon content will be presented and discussed. The results from this study will contribute to the understanding of soil management in different climate zones, which is beneficial to improving soil resilience and carbon stabilization.

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P-531

Grassland soil resilience loss due to compaction during extreme moisture regimes

Mrs Emanuela Lepore, Professor Olaf Schmidt, Professor Owen Fenton, Dr Giulia Bondi, Dr Saoirse Tracy, Dr David Wall

Soil moisture significantly affects the level of soil compaction caused by machine trafficking. Although soil compaction is the primary threat to soil degradation in Europe, data on the extent and severity of soil compaction in soils are limited in many countries. This study aims to understand soil's inherent resilience to compaction at three (dry, field capacity and waterlogged) moisture levels.
A field study on moderately drained plots at Johnstown Castle Dairy Farm (Wexford, Ireland) investigated how soil porosity and bulk density changed with and without machinery trafficking (tractor with a fully loaded slurry tanker) at soil moisture deficit (SMD) 10, 0 and - 10 mm. Compaction events simulated four passes across one year of grassland management in April, June, October, and January. Cores were excavated at three depths (0-10, 10-20 and 20-30 cm) and three locations (edge, centre and outside) for each SMD event.
Preliminary results showed that trafficking at SMD 0 mm leads to major compaction, which significantly increased ($p<0.05$) than trafficking at SMD 10 mm. The most severe degradation occurred in the central mark sampling point for the 0-20 cm depth.
Early results indicate that moisture content has a more significant impact on soil vulnerability to compaction than the number of compaction events it receives, and forecasting soil moisture will be valuable in predicting optimal times for operations such as slurry spreading.

Keywords: grasslands, soil moisture, soil compaction, traffic, soil bulk density

P-532

Image-Based Analysis of Soil Slaking: Sensitivity to Management and Inter-User Variability

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Aggregate stability is a particularly effective indicator of soil health due to its sensitivity to management changes (e.g., reduced tillage or adoption of cover crops) and relationship to multiple soil functions (e.g., resistance to erosion, water retention, and carbon sequestration). However, the time and equipment required for lab-based aggregate stability measurements have hindered widespread application of this indicator. Soil slaking, the disaggregation of soil peds upon wetting, may provide a more accessible indicator of aggregate stability. Here, we quantified the aggregate stability of a set of soils from the South Central USA with a slaking test using consumer-grade electronics and a simple image recognition algorithm. We evaluated the method in terms of its (1) sensitivity to management, (2) covariation with other soil health indicators, and (3) reliability across users. Aggregate stability inferred from slaking was greater under perennial vegetation than row crops and in soils with lower clay contents. The size and statistical significance of these effects (as well as relationships between aggregate stability and organic carbon concentration, potential carbon mineralization, and water-holding capacity) varied by geographic region and, to a lesser degree, by user. Modifications to the image-based slaking test improved sample throughput (12-18 samples per hour per user) and yielded acceptable agreement among users (intraclass correlation=0.7, median sample-wise coefficient of variation=15%). These features make image-based slaking measurements a promising means of evaluating soil structural responses to management change at scale.

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P-533

The effect of plant mucilage, water content, soil compaction, and root tip geometry on root penetration forces in the rhizosphere.

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Soil mechanical properties and plant root exudates (mucilage) affect root penetration resistance significantly. Our study aims to understand the effect of water content and density of the soil on the penetration resistance to root growth. Fine-grained soil (passing 600µm sieve) was compacted using mini-compaction apparatus to obtain the compaction curve. Based on the compaction curve the experiments were designed for 15%, 20%, 25%, and 30% water contents and respective densities. Needles with 30° and 60° apex angles were selected to represent the roots with various root tip geometry. To understand the effect of mucilage, experiments were conducted without adding mucilage and then adding mucilage with concentrations of 0.1%, 0.3%, and 0.5%.

Results show that dry soil with high density will increase the penetration resistance. The effect of mucilage is significant in altering the penetration resistance. Mucilage at low concentrations (0.1% and 0.3%) reduces the penetration resistance compared to the case without mucilage application. At 0.5% concentration, mucilage increases the stability of the soil resulting in an increase in penetration resistance. Results also show the root tip geometry affects penetration resistance significantly.

Furthermore, numerical simulations are performed based on the discrete element method. Yade software is used for the simulations. Parameterization results of particle bond strength, friction, and density show that higher bond strength and low friction angle increases the penetration resistance.

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P-534

Thermal alteration of soils belonging to highly diverse forest ecosystems: what's behind the non-univocal aggregate stability and water repellency response?

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Climate change drawbacks have recently induced major variations in fire regimes, and projections for future years forecast even more frequent and disruptive events [1]. As wildfires impose deep modifications on soil organic matter (OM) and mineral phase [2,3], soil water repellency (WR) and aggregate stability (AS) can be heavily affected, with fallouts on fertility and erosion. Yet, the extent of these alterations may vary according to soil type and development degree.

Thirty topsoils representative of a wide variety of forest ecosystems across the globe (from savannah to tropical, Mediterranean, temperate and boreal forests) were subjected to laboratory heating at temperatures of 200° and 300°C (for 30 minutes) and characterized for WR, AS, and main drivers of organo-mineral interactions, such as pH, texture, organic C (OC) and total N content, and abundance of Fe oxyhydroxides. Selected samples were also analyzed by FT-IR, GC/MS, TGA-DSC and XRD.

Water repellency, despite being highly variable among the samples, was always drastically lost when samples were exposed to temperatures>200°C. After separation into macro (2–0.250 mm) and micro (<0.250 mm) aggregate size classes, determination of macro-aggregate stability revealed that, upon growing temperatures, OM-rich high-elevation soils (from temperate and boreal forests) were far more subjected to AS loss than highly-developed Mediterranean and savannah soils, where aggregation is possibly ruled mostly by clay and heat induced Fe-Al oxyhydroxides re-crystallization phenomena [4].

In tight interlink with ecosystem resilience, the present study clearly evidenced the vulnerability of certain biomes towards thermal-induced soil degradation.

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P-535

The impact of disruption of soil structure on microbial communities and degradation of crop protection products

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Reduction in land available for agriculture and increasing populations are resulting in a growing demand for higher yields from agricultural land than ever before. A component of this is a continuing need for modern, safe agro-chemicals available to reduce losses due to weeds, pests, and diseases. Improving our understanding of the link between degradation of crop protection products in laboratory test systems and the environment they will be utilised within is crucial for the safe development of new products. Addressing this requires the best possible understanding of their behaviour in agricultural ecosystems

Field and laboratory testing under the current regulatory framework fall short on delivering this understanding as they are conducted under controlled conditions that deviate from natural field conditions. The testing protocol OECD 307 specifies that soil should be sieved prior to incubation studies. The resulting disintegration of structure influences the size, activity, and composition of microbial communities through several mechanisms. As examples, this can cause the dehydration of cells, the disruption of macro-aggregate-binding fungal hyphae the altering of microbial substrates bio-availability, such as soil organic carbon, and the spatial reorganisation of microbial populations.

This research looks to quantify the impact such disruption has on microbial communities and aims to enhance in the predictability of crop protection product degradation. The findings will deepen the knowledge of the role of soil structure and microbial diversity on the degradation rates of crop protection products whilst forming a greater understanding of the shortcomings of current testing systems.

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P-536

Soil Structural Stability and Extracellular Polymeric Substances (EPS): transient bonding agents affected by land-use

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Soil structural stability is thought to be maintained through the action of 'biological binding agents', including temporary binding agents (fungi, roots), transient bonding agents (EPS), and persistent bonding agents (old 'ambiguous' organic molecules). Increasing total SOC can be challenging, and managements that enhance concentrations of more influential carbon fractions may be a more feasible approach.

To investigate this we sampled soils from the Highfield long-term field trial (Rothamsted, UK), comprising previous grassland, arable, and fallow managements subdivided into more recent reversions to all 3 land-uses (total = 9 treatments; Redmile-Gordon et al., 2020). We quantified soil organic carbon (SOC), EPS (extracellular protein and polysaccharide; Redmile-Gordon et al., 2014), and mean weight diameters (MWD) of water stable aggregates (Le Bissonnais, 1996).

EPS and aggregate stability (MWD) were found to be correlated, and strongly influenced by the current land-use (managements implemented 2.5 years before sampling), but not by the longer-term preceding land-uses (initiated > 50 years before sampling). Polysaccharide EPS was significantly correlated to the soil's structural stability ($p = 0.027$), as was proteinaceous EPS ($p = 0.002$).

Total soil organic carbon (SOC), being primarily driven by previous land-use, indicated that structural contributions from (relatively) stable organic matter were surpassed by the contributions of temporary binding and transient bonding agents from the current land-uses. This is cause for optimism, as it suggests the physical quality of soils can be improved by short-term application of managements that favour the production of binding agents and microbial exudates (EPS).

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P-537

Development of mechanical soil stability in an initial homogeneous loamy and sandy soil under in situ field conditions

Msc Ulla Rosskopf, Dr Daniel Uteau, Prof. Dr. Stephan Peth

Purpose
Soil structure evolving from physical and biological conditions and texture are closely related to soil mechanical characteristics. A soil plot experiment in Bad Lauchstädt, Germany, with two homogeneous substrates, a loam and a sand, allowed us to study the initial development of mechanical traits and how mechanical energies required for root penetration change over the course of two years.
Methods
Plots were planted with two maize genotypes (wild type (WT) and rth3 mutant) with contrasting root hair attributes. Undisturbed soil cores were taken at BBCH83 in 2019 and 2020 at 14 and 34 cm depth. Confined uniaxial compression tests were performed to determine pre-compression stress (σpc), compressibility (Cc and Cs) and elasticity index (EI) and mechanical energy was calculated based on penetration resistance tests with a penetrometer needle resembling root geometries.
Results
σpc, Cc and Cs were significantly higher in loam as compared to sand, whereas the factor genotype proved to be negligible. Over time, σpc increased and Cc decreased in loam from 2019 to 2020 and Cs declined in both substrates. A tendency to higher energy values could be observed in loam compared to sand and in WT as opposed to rth3. Required energy was higher at 14 cm compared to 34 cm depth and decreased from 2019 to 2020.
Conclusion
For the development of the mechanical traits examined texture proved to be the driving factor and changes in soil stability could be observed within a short period of time.

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P-538

The vulnerability and resilience of soil post volcanic ash deposition: vegetation effect on soil organic carbon and soil structure

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During volcanic eruption, soils were exposed to ash depositions which have direct negative impacts on soil. The severity impacts, indeed, depends on the intensity metrics (ash thickness, particle-size distribution) and frequency (return period). However, the vulnerability and subsequent recovery (resilience) of the plant-soil system depends on vegetation and soil management.
We investigated the resilience of four different land-use systems (LUS) of remnant forests, complex agroforestry, simple agroforestry, and annual crops during short- and medium-term post volcanic ash deposition. Plots were established 17 years after the preceding (1990) eruption of Mt. Kelud (Indonesia) and resampled 3 and 6 years after 2014 eruption. Each LUS was monitored in three landscape replicates. Data collection included canopy cover, volcanic ash thickness, litter thickness, texture, soil organic carbon (Corg) and carbon stocks, bulk density, macroporosity, aggregate stability and soil infiltration.
We found that preserved ash thickness, as an indicator of LUS vulnerability, was varied between LUS and strongly affected by the slope position of plots rather than canopy cover. In short-term, ash depositions homogenized 30cm of topsoil properties across LUS. Litter thickness, aggregate stability and infiltration were changing rapidly. Soil surface showed low aggregate stability and limited water infiltration demonstrating hydrophobicity. However, six years after the eruption, different LUS resulted in a different recovery trajectory of soil properties. Complex and simple agroforestry recovered more quickly than open-field agriculture in terms of soil carbon stocks and soil infiltration, but also received less ash than forests and annual crops systems on other parts of the slope.

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P-539

Zero tillage has important consequences for soil pore architecture and hydraulic transport

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Following the adoption of zero-tillage (ZT) from conventional tillage (CT), the soil pore network undergoes immediate and significant changes. As soil remains undisturbed for an extended period, a soil structure emerges that is primarily generated and stabilised by both biotic and abiotic processes. There is limited understanding concerning how the adoption of ZT influences the soil porous architecture and associated soil hydraulic properties, and specifically over what timeframe these changes occur. It has been shown that ZT can influence porosity depending on soil texture, pore size class, depth and time, and also influence important agrochemical transport mechanisms. Our investigation reveals the value of a prospective examination of an evolving ZT pore network both visually and functionally across scales of time and space. We also highlight the necessity for standardised methodology to aid in future data compatibility and quantitative analysis. Our experimental work is aiming to elucidate the effect of ZT on the pore network and associated hydraulic functionality of soil in comparison with CT. As ZT becomes more popular, a greater understanding of the impact it has on soil structure and subsequently hydraulic performance will be required.

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P-539A

Link between macroscale and microscale soil descriptors of urban soils

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Soil supports many ecosystem services crucial to humanity. Changes to soil biodiversity following environmental modification alter the soil capability to deliver these services (Pereira et a., 2018). Knowledge gaps around the links between soil environment characteristics, biodiversity, and delivery of ecosystem services is particularly acute for urban environments, which comprise 10-15% of UK's Landover and support around 85% of its human population. Hydrological properties of urban soils are impacted by alternative urban soil uses and are essential to understand the impact of urbanisation on the functions supporting many of these ecosystem services such as water storage or filtration. In this contribution, we measure the infiltration rate of major gradients of urbanisation in SE England and use modelling and X-ray Computed Tomography image analysis to study obtain several microscopic descriptors of urban soils. Correlation among macroscopic (infiltration rate) and microscopic descriptors obtained from urban soils are studied using statistical methods. Overall, this contribution provides further insights about the links between macroscopic and microscopic soil descriptors than can be routinely measured.
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P-540

Microplastics change high-energy moisture characteristics of soil

Dr Nasrollah Sepehrnia

Microplastics have a large impact on a range of processes in soils, but physical aspects are only beginning to be investigated. This study was conducted on two microplastics-treated soils to explore the effects of microplastics' content (0, 0.5, 1, and 2 w/w%), size (1.6, 3, 5, and 12 mm), and aging (two- and six-months incubations) on structural stability quantified by high-energy moisture characteristics (HEMC). The experiments were performed under slow- and fast-wetting and a modified van Genuchten function was fitted for HEMC data (matric suctions 0 to 50 hPa). The relevant soil structural indices included volume of drainable pores (VDP), relative VDP (RVDP), VDP ratio (VDPR), modal suction (hmodal), relative hmodal (Rhmodal), stability index (SI), relative SI (RSI), stability ratio (SR), relative SR (RSR) were derived. The experiments are ongoing and the results will be presented by the time of meeting.
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P-541

A study of the effect of intercrop management practices on soil structural stability using the QuantiSlakeTest

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In Belgium, the soil is increasingly affected by extreme climatic events, especially intense rainfall. These can lead to erosion of soils with low structural stability.

We studied the influence of cultural practices applied by 18 Walloon farmers for the establishment and management of their intercrop cover. Soil structural stability was assessed with the QuantiSlakeTest approach (Vanwindekens et. al., 2020) three times between harvest (July 2020) and sowing of the following crop (March 2021).

Regarding tillage prior to cover crop establishment, the trials revealed that only plots that were revealed that only plots that were tilled had a negative effect on soil structural stability soil structural stability, even when a cover crop had been developed. No effect was found for other tillage operations.

The results of the comparison of the different methods of canopy destruction observed reveal that, in general, there is a loss of structural stability during the winter season, with the exception of plots where the canopy remained alive during the entire intercropping period, which retain their structural stability. The loss is even greater for plots where the soil has been worked to destroy the cover crop.

In our experiment, the farming system (organic, conventional, conservation) of the farmers did not show any effect on soil structural stability.

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P-542

Quantifying Agricultural Soil Compaction by Inflated and Deflated Tractor Tires using X-ray Computed Tomography

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The risk of soil compaction increases with the trend towards the use of massive farm machinery and presents a significant risk to food security. Two potential strategies to reduce wheel compaction, are to lower tire pressure or to use tracks, thereby distributing the same weight over a larger area. Emerging technologies now permit farmers to rapidly deflate and inflate tractors and implement tires. This research employed high-resolution x-ray CT scanning to quantify the impact of inflated and deflated tires, on the physical structure of medium-textured (loamy) soils. Intact soil cores were collected at three depths (5cm, 10cm, and 20cm) from the inflated and deflated tire tracks and the no traffic. CT scanning and image reconstruction were performed using Nikon XT-H225 ST system. Subsequent processing and analysis of the 3D imagery were conducted using open-source NIH ImageJ software, employing plugins designed for segmentation, morphometric (particle analyzer), and spatial (3D semi-variance) analysis. The soil cores were re-wetted to field capacity, then subjected to micro-penetrometer (ELE Digital Tritest 50) analysis, to characterize their penetration resistance profile. The measured Hounsfield Unit (HU) values allowed the visual assessment of the soil structural condition through 3D visualization of air-filled macropores, and the calculation of the mean dry bulk density and standard deviation of voxel-related HU values for each slice of soil cores. Soil compacted by tillage could be assessed by CT through quantification of decreased air-filled porosity, destroyed macropore connectivity, increased dry bulk density, and decreased standard deviation of HU values in horizontal slices.

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P-544

2-D image analysis of soil porosity to the achievement of pore area distribution, pore shape, and soil water retention capacity

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Purpose: The objectives of this study were to characterize the Soil Pore area Distribution (SPAD), and to estimate Soil Water Characteristic Curve (SWCC) using the 2D image analysis method.
Methods: Soil micromorphological and physical characteristics, including SWCC, were determined for undisturbed soil samples taken from soil profiles. Undisturbed samples were impregnated with a mixture of polyester resin plus fluorescent dye diluted with styrene. The serial sectioning and imaging of the hardened impregnated blocks were carried out at 50 µm intervals. To determine SPAD, the 2-D images were analyzed using the ImageJ software. Then, the Laplace equation was used to transform the estimated SPAD to SWCC.
Results: The estimated SWCC was compared to the SWCC that was measured using pressure plate/membrane apparatus. Results showed that the 2-D image analysis method is able to determine the quantity of the pore's water-retaining, in suctions lower than 1 bar. Considering the shape factor, the macro-pores were approximately circular while, the finer pores exhibited more elliptical shapes and less circularity. The feret diameter (R) and minimum feret diameter (r) factors of the pores were significantly different from the feret diameter of a circular cross-section.
Conclusion: The assumption of circularity of soil pores which links the SWCC to SPAD adds uncertainty to obtained results in particular at high matric suctions. To estimate the dry part of SWCC from SPAD, more accurate assessment and pore visibility techniques can help to better characterization of soil pores such as orientation, connectivity, and functioning.

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P-545

Effects of soil structure complexity to root growth of plants with contrasting root architecture

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Typically, when investigating physical constraints to root growth, a homogeneous soil is used, oversimplifying the natural environment. The aim of our study was to compare root and shoot growth under heterogenous and homogeneous soil conditions. Soil treatments used soil sieved to < 2mm, with conventional packing to create a homogenous structure. A heterogenous structure was created by compacting soil followed by disaggregation to simulate aggregates. H. vulgare L. cv Optic, P. sativum L. cv Kelvedon wonder, and A. thaliana ecotype Col-0 were grown under three compaction levels (1.25 g/cm3, 1.40 g/cm3, 1.55 g/cm3) and two soil structures (homogeneous and heterogeneous) for 10 days. Soil pore structure properties were measured from water retention characteristics and X-ray Computed Tomography (CT), showing heterogenous soil had 50% more macropores at 1.55 g/cm3 than homogenous soils. Penetration resistance increased from 0.4 MPa at 1.25 g/cm3 to 1.1 MPa at 1.55 g/cm3. Total root length, root volume, tip number, root weight, and average diameter were measured. Measurements of above-ground biomass included height, weight, chlorophyll, nitrogen, and flavonoid content. Pore structure complexity in the heterogenous structure proved beneficial for root growth of P. sativum and H. vulgare but not A. thaliana. Shoot biomass of P. sativum grown in heterogenous soil at 1.55 g/cm3 increased 65% when compared to homogenous soil, whereas H. vulgare and A. thaliana shoot biomass did not differ significantly in any treatments. Soil structure influenced many root properties and above-ground biomass, with impacts found to be species-dependent.

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P-546

Investigation into the cause of secondary swelling of clayey paddy soil: Verifying the importance of reduction of iron oxides

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Although swelling of clay soil is usually regarded as elastic expansion of soil fabric due to release of water suction, paddy soil keeps on swelling under submerged condition after the release of water suction ends. Because such "secondary swelling" can be controlled by lowering the temperature, biochemical reaction indued by wetting and submerging probably causes this phenomenon. This study aimed to investigate the major cause of the secondary swelling of paddy soil. Air dried clayey paddy soil was wetted and kneaded to make soil paste. The soil paste packed in the cylindrical samplers was dehydrated in the pressure chamber at 100kPa, to obtain consolidated clay column having a volume of 40 cm3. A half of the specimens were submerged in deionized water at 35℃ for 0, 1, 3, 7 and 14 days, and the other half were submerged in the solution of ascorbic acid having concentrations of 0, 1, 3, 6, 12 and 25mg/L at 3℃. The water content, total volume, and the content of ferrous iron in the soil solution were measured for each specimen. Although both treatments induced reduction of iron oxides, swelling was progressed less in the solution of ascorbic acid in low temperature than in the deionized water at high temperature. Comparison of the results showed that the contribution of suction decrease, iron reduction, and the change of other substances around soil particles were 53%, 10%, and 37%, respectively. Therefore, the effect of the reduction of iron oxides on the secondary swelling was unexpectedly small.

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P-547

Estimation of structural stability in tropical Andisols, Oxisols, and Vertisols soils testing different methodologies.

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Structure is a fundamental physical property of soil for its contribution to ecosystem services and is thoroughly used as an indicator of soil quality. Factors such as colloid content and type, pedogenetic processes and anthropogenic activities are widely known as well as their influence on aggregate stability, however, there is still no consensus on the most suitable determination method for each soil type according to its diagnostic characteristics. For this reason, the objective of this study was to estimate the structural stability in tropical Andisols, Oxisols, and Vertosols soils testing different methodologies.

The study was carried out in 2019, using diagnostic horizon samples from 3 soil orders (Andisol, Oxisol and Vertosols) under different land uses and edaphoclimatic conditions in the Andean, Amazon, Caribbean, and Orinoco regions of Colombia. Aggregate stability was calculated from two of the most commonly used methods: wet sieving with a single sieve, wet sieving with multiple sieves and a third method based on optical microscopy and laser diffractometry. For comparative analyses, mean weight diameter, water-stable soil aggregates, aggregate stability index and the structural stability index based on particle size distribution and organic carbon content were calculated.

The results showed the close relationship between the different soil cementing agents and the stability of aggregates, in all 3 methodologies, Vertosols proved to be the most susceptible to structural degradation, while Andisols and Oxisols shows a higher association between the sieving method used, the aggregate size distribution and the aggregate stability.

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P-547A

Soil structure stability in a humid region: effects of long-term land use and polymer application

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Enhancing soil structure is vital for sustainable land management. We evaluated the effects of long-term land use (no-till, NT; conventional-till, CT; grass, and forest), and that of adding polyacrylamide (PAM = 25, 50, 100 and 200 mg/L) to CT soil, on a silty loam soil quality indices, pore size distribution and structural stability (IN, USA). For that we used high energy moisture characteristics (0-50 hPa), which were described by a modified van Genuchten model that provides parameters α (location) and n (steepness), and soil structural index (SI). Land use and PAM treatments yielded significantly different shapes of the water retention curves (α, n), that occurred at different ranges of macro-pore sizes (> 250-300, 125-250, 60-125 µm). Increase in soil organic matter content (2.1–3.9%; CT< NT ≤ grass < forest) and PAM rate improved α and SI, and decreased n. Though CT soil yielded the lowest SI (~2-4 fold less than the other treatments), treating CT soil with low PAM rates (25-50 mg/L) gave SI comparable with the SI of NT or grass soils, whereas high PAM rates (100-200 mg/L) yielded greater SI (~2 fold) than that for NT or grass soil, and comparable with the SI of forest soil. Exponential relations existed between SI and α and n, and could be linked to the (i) effects of land use and amendments, on pore- and aggregate size distribution in the soils, and its resistance to slaking, and (ii) soil quality; such relations can assist in designing resilient C sequestration strategies.

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P-548

Examination of Nitrogen Fertilisers for Nitrous Oxide Emission: A Comparison Between Controlled-Release Fertiliser and Ammonium Sulphate

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In Okinawa, Japan, controlled-release N fertilisers (CRF) are promoted to reduce labour of fertilisation and to increase the fertiliser use efficiency. However, environmental impact of CRF have not been examined yet. Therefore, a laboratory experiment was conducted to compare N2O emissions between CRF and normal fertiliser: ammonium sulphate (AS) applied conditions for "Kunigami-mahji" (red yellow soil), a local soil in Okinawa. Soil samples were treated with CRF (linear type CRF with 41% N) and AS, applied at a rate of 725.8 µg N/g dry soil. Irrigation and ventilation were used to create soil moisture variation with the time. N2O emission was measured with 1 min interval for 20 mins followed by 70 mins of continuous ventilation to the atmosphere. Soil moisture, soil temperature, nitrate-N and ammonium-N in leached water were also analysed. Cumulative N2O emission due to CRF treatment (2079.8 mg-N2O-N/m2) was lower than AS treatment (3153.42 mg-N2O-N/m2) during frequent high soil moisture conditions prevailed at the initial stage after fertilisation. AS also caused for higher NO emission than CRF throughout the experiment. Highest N2O emission rates were recorded for both CRF and AS at the water filled pore spaces between 60-70%, indicating that nitrification was the dominant process of the N2O emission of the experimental soil. However, at the later stage with frequent low soil moisture conditions both fertilisers indicated less N2O emission. Our results highlighted that choosing the appropriate form of fertiliser and proper management of soil moisture content could effectively reduce N2O emissions.

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P-549

Quantification of available nitrogen in UK soils for the growth of baby leaf spinach (Spinacia oleracea).

Miss Ellie Barbrook

Increasing nitrogen use efficiency (NUE) of crop plants is a critical component of increasing the sustainability of agricultural production. Baby leaf Spinach (Spinacia oleracea) has a short growing period of ~40 days and a NUE of 40-60%. To avoid a large N surplus in crop lands without compromising yields, N fertilizer application should be adjusted to crop needs, taking in to account the amount of potentially available N in the soil. The most common method for measuring plant available-N is KCl extraction for subsequent analysis of soil NH3-N and NO3-N. However, KCl extraction estimates the N available at the start of the crop growth period, when samples are taken, but not the N that might become available via mineralization during growth.

Consequently, we aimed to evaluate the value of chemical methods (physical isolation of the free light fraction-N; chemical extraction of hydrolysable N and plant root simulators (PRS®) probes) and biological methods (anaerobic N mineralization assay) for prediction of soil nitrogen supply via mineralization to inform baby leaf spinach fertiliser recommendations. To do this, 15 UK soils were sampled, with varied N amendment history, from multiple yearly calcium ammonium nitrate applications to spent mushroom compost accompanied by legume cover crop. KCl extractions and pot-grown Spinach N content were used to benchmark the chemical and physical methods. Past research on increasing NUE has mainly focussed on cereals, however, the short growth cycle and multiple within-season harvests for baby leaf spinach has possible implications for adjusting the dynamics of soil N availability.

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P-550

Do Fall-Seeded Cover Crops Cycle Nitrogen to The Following Cash Crop?

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Fall-seeded cover crops (CCs) provide soil coverage, preventing soil erosion, and reducing NO3-N leaching. In addition, it is believed N accumulated in CCs biomass is available to the next crop, but this not always occurs. The main objective of this research was to determine if the N in the CC biomass provides N credit to the next crop of maize (Zea mays) and sugarbeet (Beta vulgaris). The experiments were conducted in in Hickson and Prosper, ND from 2017-2019. Maize grain yield and quality and sugarbeet root yield and chemical composition of the root were evaluated after fall-planted CCs. CC fall biomass production was higher in radish (Raphanus sativus) and oat (Avena sativa) than the other CCs evaluated. Likewise, in the sugarbeet experiment, check plots (no CCs) had higher soil NO3-N compared with all other CCs. Winter-hardy CCs lowered gravimetric water content in the soil profile in the spring in comparison with winter-killed CCs and the check treatment with no CCs. Winter camelina (Camelina sativa) and winter rye (Secale cereale) reduced maize grain yield compared with the check (no CC) and other cover crop treatments. Winter camelina and winter wheat (Triticum aestivum) decreased sugarbeet establishment and root yield in Prosper and Hickson in 2018. Both crops yield increased with increased N rate, but the N accumulated in the cover crops biomass did not make a difference in grain or root yield of both maize and sugarbeet, indicating there was no N cycling to the following crop in either experiment.

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P-551

Can insect farming co-product (frass) be utilised as a sustainable soil improver contributing to net zero and circular bioeconomy goals?

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In recent years, there has been increasing interest in domestic protein production at a global level to reduce the reliance on imported protein and develop more sustainable sources. At the same time, more than 33% of the food we produce, is wasted. The use of insects as a protein source in animal feeds and oils can act as viable waste treatment for a number of organic wastes (e.g. food and distilling wastes). The production of insect faeces (frass) has the potential to be upcycled as a soil improver and fertiliser product and could contribute circular bioeconomy goals in food production.
However, to date little is known about the composition of frass, in particular the effect of insect dietary substrate source and implications of its potential use as a soil improver. A recent crop growth study was conducted using Black solider fly frass from three dietary sources with results showing both positive and negative implications for soil health and crop growth. In particular, soil mixed with frass derived from pre-commercial food-waste was shown to act as a slow-release fertiliser due to its ammonium content, performing better than the soil-only and soil-compost treatments in terms of crop production (unpublished). Ongoing experimental research will develop upon these findings investigating the range of frass composition, effectiveness as a biofertilizer and its potential contribution to net zero carbon and circular bioeconomy goals.

P-552

Smart N fertilizer designed to foster soil C sequestration

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In spite of the effort to sequester C in agriculture soils, adequate management of N and P input in agricultural systems are required to not promote a soil organic carbon mineralization, which is one the main factors for soil fertility. Diazotrophic bacteria has attracted attention as an alternative to develop smart fertilizer, due to being capable to convert N-atmospheric into ammonia, which can be used by plants. The aims of this study were to screened the biological N2-fixing (BNF) capacity in 5 Free-living diazotrophic bacteria for smart fertilizer development with C-rich carriers designed to foster terrestrial C sequestration and stabilization. The bacteria tested were Stenotrophomonas sp., Serratia sp., Enterobacter sp. strains, and Escherichia coli as negative control. BNF assay on N-free Burk's media was determined after 7 days incubation. Soil incubations were conducted for 8 weeks to evaluate the BNF capacity. Total N content was digested through sulfuric acid Kjeldahl method and determined by spectrophotometry at 425 nm using Nessler's reagent. To evaluate the C dynamic of C-rich carrier, soil decomposition experiments were conducted to determine C release and storage. Preliminary results showed that Serratia has the best performance as N2-fixing bacteria in Burk's media (108.1 ± 2.34 mgN L-1) reporting 23% over the other strains and 76% more than control. However, in the soil incubation experiments Stenotrophomonas was the best for BNF (12.9 ± 0.33 gN kg-1) ~35% more than other strains, able to fix ~5 gN kg-1 in an Andisol. Results suggest that for smart fertilizer design Stenotrophomonas could be a better alternative.

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P-553

Herb- and legume-rich multispecies leys alters lamb excreta composition but does not reduce soil nitrous oxide emissions

Miss Emily Cooledge, Dr Karina Marsden, Professor Jonathan Leake, Professor Dave Chadwick, Professor Davey Jones

Ruminants excrete most of the consumed nitrogen (N) in urine and dung, resulting in nitrous oxide (N_2O) “hotspots” within grazing pastures. Diet, water consumption, and animal physiology heavily influence the composition of excreta. Multispecies leys containing a diverse mix of grasses, legumes, and herbs with high levels of plant secondary metabolites offer a potential N_2O mitigation strategy through increasing the proportion of N in the dung fraction of excreta, which is less vulnerable to N losses than urine. Currently, no studies report either the excreta composition or excreta-patch N_2O emissions from sheep grazing multispecies swards. A 2-year 2-hectare field trial in North Wales, UK, aimed to develop a seasonal excreta-patch N_2O emission factor and quantify differences in excreta composition. Urine and dung were collected and analysed from Welsh mountain ram lambs in autumn 2020 and ewe lambs in spring 2021 grazing either a grass-clover diet (n = 6) control or a multispecies diet (n = 6) and reapplied to the soil. Soil (0-10 cm) and greenhouse gas measurements were made from static chambers and analysed for each treatment (urine, dung, fertiliser, or control). Urine N loading rate varied with season and lamb sex (autumn 2020: 555 kg N ha-1 grass-clover vs 1020 kg N ha-1 multispecies, spring 2021: 1484 kg N ha-1 grass-clover vs 1305 kg N ha-1 multispecies). There was no effect of sward type or treatment on N_2O emissions. The potential of sward, lamb sex, and seasonality to affect excreta composition and thus N_2O emissions requires more investigation.
N/A

P-554

Amending agricultural soils with crude glycerol, a biodiesel byproduct, to temporarily immobilize leachable nitrogen and then recycle immobilized nitrogen

Dr. Mriganka De, Dr. Marshall McDaniel, Dr. John Sawyer

Nitrogen (N) lost from agricultural fields can impair water quality and be an economic loss to farmers. Winter cover crops have shown promise as a remedy, but low adoption illustrates the need for alternatives. Here we tested whether adding crude glycerol (a biodiesel byproduct) can immobilize N, and then determined whether and when immobilized N would be released. We conducted a laboratory incubation with a full factorial combination of four glycerol rates (0, +117, +468, and +1872 mg C kg-1 soil), three supplemental nitrate-N (NO3-–N) rates (0, +10, and +40 mg N kg-1), and two soils (clay loam and loamy sand). Soil inorganic N and microbial biomass (MB) were measured at seven and three time points, respectively, across the 98-d incubation period. Across all treatments, glycerol increased MBN in both the short-term (7 d; 4–1137% compared to no glycerol addition) and long-term (98 d; 10–169%) and decreased NO3-–N with increasing rate of glycerol. Adding glycerol caused net N immobilization of 21–61% (+117 mg C kg-1) and ~100% (+468 and +1872 mg C kg-1 addition) compared to the control. Inorganic N was released from MB turnover, but timing and rate of release depended on the soil and added N rate. Overall, glycerol has the potential for use as a soil amendment to temporarily immobilize NO3-–N, and then make some of that N available after MB turnover.
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P-555

Use of controlled-release urea to improve grain yield and nitrogen use efficiency of maize

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Nitrogen (N) is usually the principal nutrient limiting crop production in many of the world's agricultural areas. Excessive N fertilizer input and inappropriate application methods lead to low N use efficiency and high N losses through leaching, denitrification, and/or volatilization. The use of controlled release urea (CRU) has been shown to be an alternative to conventional urea to improve the N use efficiency (NUE) and reduce the adverse environmental effects of conventional urea. However, more exhaustive information on the effect of CRU on the agronomic performance of crops, such as maize, and the synchronized relationships between N release of CRU and N plant requirements is needed. The objective of this work is to quantify and compare the effect of the CRU and conventional urea on grain yield, biomass, and NUE of maize. Four rates of CRU and conventional urea (0, 50, 100 and 150 kg N ha^{-1}) were applied at the sowing of maize. Soil and plant samples of all treatments were taken at six grown stages, where total N and NO_3 were determined in plant and soil samples, respectively; as well as grain yield. The information generated will be used by farmers and technicians for a better N management in productive systems.

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P-556

Effects of Desmanthus Legume Cultivation on Nitrogen Cycling in Pasture Soils

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The use of pasture legumes to supplement soil nitrogen (N) stocks and maintain pasture productivity is a widely used practice across East Australia grazing lands. Despite the growing popularity and cultivation of Desmanthus legume varieties, the effects of Desmanthus on soil N cycling and greenhouse gas emissions in the form of nitrous oxide (N_2O) remain largely unknown. This study investigates soil N cycling and N_2O emissions from Desmanthus and grass pastures at different sites in Southeast Queensland, Australia, using ^{15}N pulse labelling to determine gross N transformations and N_2O source partitioning in a soil microcosm approach. Preliminary results show higher total N and mineral N levels in Desmanthus soils compared to grass pastures. Emissions of N_2O from Desmanthus soils exceeded those from the grass pasture by a factor of 9.45 and 15.52 for the different sites, respectively, which is consistent with increased nitrate availability. These findings suggest increased substrate availability for denitrification as the main pathway of N_2O production in Desmanthus soils. Further ^{15}N analysis will test this hypothesis and identify potential shifts in gross N transformations in Desmanthus soils compared to grass pastures. Linking these results to in-situ quantification of leguminous N inputs and N_2O emissions will improve our understanding of N cycling and N_2O losses in legume pastures. Given that grazing pastures occupy 40% of Australia's land mass, establishing the impacts of legumes on the N status and resulting productivity of pastures is an important contribution to this agricultural industry.

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P-557

Nitrogen Management of Corn Under Different Tillage Systems

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No-tillage (NT) and cover crops (CC) significantly effect soil nutrient cycling that necessitates modified nutrient management to maximize crop yields. Two field experiments were conducted to evaluate N-sources UAN, urea, and urea+N-stabilizer (urea+stab) and N-split applications in a sandy loam soil and three CC wheat, vetch, and radish along with three N-rates (67, 135 and 202 kg N ha-1) in a silt loam soil on corn growth and yield in NT compared to conventional tillage (CT). Among N-sources urea+stab produced the highest corn growth and yield compared to UAN and urea under NT while no differences were observed in CT. Though N-split applications improved yield under both tillage-systems, response was higher under NT. Interactions of N-source and N-split applications showed urea+stab and UAN improved corn grain yield by both two-split and three-split applications while only by two-split for urea under NT. Under CT, N-split applications improved yield for urea+stab and UAN, but not for urea. Cover crop study showed that regardless of the tillage system, the vetch increased corn growth and yield, whereas wheat decreased yields. The decrease in corn yield from wheat CC was relatively lower in the NT than CT potentially due to slower decomposition of residue from poor soil contact. No-tillage had lower yields than CT under all CC treatments; however, the gap became insignificant at higher N-rate. High bulk density, surface residue, and weed pressure in NT than CT attributed to the differential corn response to N-source, N-split, and CC treatments between the tillage systems.

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P-558

Exploring the potential of beneficial viruses to improve rhizobia-based inoculants as nitrogen biofertilizers

Ms Mary Eliza, Dr Ellie Harrison

The soil microbiome and plant interactions are essential to processes such as nutrient provision and nutrient cycling that support the production of food. However, the soil microbiome is often neglected and replaced by practices such as inorganic fertilizer use. Fertilizer use negatively affects the microbiome-plant interactions leading to a loss of the soil microbiome and its functions. Soil microbiome techniques such as microbial inoculants – microbial preparations used as nutrients and plant growth stimulants – can be used as an alternative to inorganic fertilizer use to maintain the soil microbiome and ensure sustainable food production.

Rhizobia-legume interactions form the basis of rhizobia-based microbial inoculant functioning. Rhizobia are nitrogen-fixing bacteria that are found in the root organs called root nodules where they fix nitrogen for legumes in exchange for carbon. Yet, the current use of rhizobial inoculants has quite variable and usually sub-optimal results in the real world. Rhizobial inoculants are beneficial where naturally occurring rhizobia are ineffective. Yet, native rhizobia are typically very competitive and usually displace the introduced inoculants. Here, we investigate the role of two naturally occurring beneficial viruses which integrate into rhizobia and can potentially increase rhizobial competitiveness in vivo and in the rhizosphere of clover. We find that these viruses increased the competitiveness of rhizobia in rhizobia-rhizobia competition experiments by 13% and 7%, in vivo and in the clover rhizosphere, respectively. These findings suggest that beneficial viruses can be used to increase the competitiveness of rhizobial inoculants leading to more efficient and successful rhizobia-based nitrogen inoculants.

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P-559

Evaluation of Cotton Yield Response to Nitrogen Fertilizer Application across the US Cotton Belt

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Nitrogen (N) is an important and one of the costly input of cotton production. Therefore, it is important to find out if current nitrogen fertilizer guidelines for cotton production are still valid across soil type, environmental conditions, cropping systems, and management practices. A multi-state project was started in 2020 to improve our understanding of soil biophysical properties in predicting cotton yield and quality response to N application rate. Nitrogen rate response trials were established in LA, MO, MS, NC, OK, SC, TN, TX, and VT in Randomized Complete Block Design with have N rates and four replications. Rates and sites were selected by based on the local conditions and history of previous positive cotton yield response to N applications. At 9 sites out of 20, lint yield responded non-significantly to N applications. These sites had a large variation in lint yield with mean site yield varied from 315 to 1452 lbs/ac. At the other 11 sites, curvilinear response of lint yield to N applications was observed and
pro�t-maximizing N rate at these 11 sites varied from 37 to 150 lbs N/ac. Economic analysis showed that 7 out of 11 sites needed 20 to 123 lbs less N compared to recommended N application. The results from this study warrants that we should include information from soil biophysical properties in making N recommendations so do determine where to apply N and how much to apply. The revised N guidelines will help us to increase farm projets and environmental sustainability of cotton production.

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P-560

Evaluating the Right Nitrogen Time, Rate, Source, and Placement (4Rs) Management for Corn Production in the US Upper Midwest

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Urea has become the main nitrogen (N) source in Minnesota, USA. Fall urea is listed as an acceptable practice by University of Minnesota guidelines in western Minnesota. However, this practice needs re-evaluation due to changes in climate in this region. The objectives were to re-evaluate guidelines and quantify grain yield response in continuous corn, corn-wheat, and corn-soybean cropping systems with fall and spring applications of 1) N rate of urea, 2) N source, and 3) placement. The study was conducted at University of Minnesota's Southern, Southwest, West Central, and Northwest Research and Outreach Centers from 2016 to 2020. Treatments included six urea-N rates for fall and spring applications at 45 kg N/ha increments (0 to 225 kg N/ha) and an additional rate of 270 kg N/ha for continuous corn. Nitrogen source and placement included: anhydrous ammonia with the nitrification inhibitor N-Serve in the fall and without N-Serve in the spring; ESN broadcast and incorporated by tillage; and urea with or without the nitrification inhibitor Instinct broadcasted and incorporated by tillage or subsurface-banded. Measurements included plant N uptake, canopy sensing, grain yield, and soil inorganic N. All variables equal, spring applications produced more grain than fall applications. Anhydrous ammonia was superior to urea, especially in the fall. Subsurface-banded urea and ESN in the fall had limited advantage relative to broadcast and incorporated urea. Nitrification inhibitor produced no grain yield increase. Based on this study, university guidelines for fall urea will be adjusted to reflect change in climate.

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P-561

Holistic Nitrogen Management Strategies: Cover Crops and Living Mulches Effects on Irrigated Corn-Soybean Production Systems and the Environment

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The state of Minnesota, USA has over 240,000 ha of irrigated glacial outwash sands that are predominantly under corn and soybean cultivation. While highly productive and important to Minnesota's economy, these soils are highly vulnerable to nitrate leaching. Therefore, farmers are encouraged to go beyond a traditional production approach by implementing the use of sustainable cultural practices such as cover cropping. Nevertheless, there is limited research aiming to holistically understand their effect on N cycling (N availability, nitrate leaching, nitrous oxide emissions, and ammonia volatilization) and competition with corn and soybean for resources. This study was established in 2011 in an irrigated sandy loam soil at Westport, Minnesota. Three adjacent blocks of continuous corn (CC), corn-soybean (CSb) and soybean-corn (SbC) cropping systems were used. Treatments included N fertilizer rates of 0, 100, 200, 250 and 300 kg N ha-1 split-applied at V2, V6, and V10 development stages of the CC and CSb while no N was applied in the SbC. Each N rate had winter-rye (Secale cereale) and winter fallow. Kura clover (Trifolium ambiguum M. Bieb.) living mulch was present in the 0, 200 (CSb only) and 250 (CC only) kg N ha-1 rates. Preliminary results from the first year of this comprehensive assessment will include nitrate leaching concentrations and load, nitrous oxide and ammonia emissions, season-long soil N availability, crop N uptake, and grain yield. This study aims to discover an improved strategy in soil and crop nutrient management to optimize agronomic production while substantially minimizing agricultural environmental impact.

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P-562

Combined effects of bovine-urine application and freeze-thaw events on nitrous oxide emissions in a grazed pasture soil

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Nitrous oxide (N2O) emissions from soils applied with livestock excreta, such as urine, have been widely reported previously. High N2O emissions from soils are also often reported during thawing periods in cold regions where soil freezing is common. However, the combined effects of cow urine application and freeze-thaw events on N2O emissions are still unknown. Thus, we simulated a freeze-thaw event at −3 °C for 7 days, and then increased to 3 °C for 46 days using intact soil cores with and without cow urine (392 kg N ha−1) application. Dicyandiamide (DCD), an inhibitor of nitrification, was added to investigate the significance of nitrification on N2O emissions. N2O emission rates from the urine-applied soils peaked at approximately 1000 µg N2O-N m−2 h−1 immediately after the soils thawed. The soil freezing with urine application showed significantly higher cumulative N2O emissions (537 mg N2O-N m−2), compared to non-frozen soils with urine (247 mg N2O-N m−2). DCD did not reduce the magnitude of N2O peaks, suggesting a low contribution of the nitrification process to the N2O peaks during the thawing period. The soil freezing event decreased soil bulk density by 9% and then increased soil moisture content (water-filled pore space), stimulating N2O emissions. Additionally, urine application increased urease activity, while the freezing event decreased that activity. Denitrification was a critical process determining the magnitudes of N2O emissions during the thawing period, but the concentration of nitrate did not explain the magnitude of N2O peaks.
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P-563

Grassland Soil Compaction Alleviation Effects on Dry Matter Yields and Nitrous Oxide Emissions

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Temperate agricultural grasslands have increased compaction with 32% of European soils suffering from some form of soil structural damage (Horn and Fleige, 2009). Increased weight of farm machinery along with extended grazing across the season has contributed to soil compaction and potentially increased the emissions of the greenhouse gas nitrous oxide (N2O), because of reduced porosity and drainage (Palmer and Smith, 2013). Unless the grassland yields have become uneconomic other solutions can be employed to re-introduce soil structure other than ploughing. This work investigated the use of either a surface slitter or a sward lifter on two compacted soil types (sandy, free draining and silty clay loam, imperfectly drained) attempting to improve dry matter (DM) yields and assess N2O emissions. The two types of compaction were trampling by dairy heifers and by tractor; studied over three years. Both methods of alleviation were seen to decreased soil bulk density and this was confirmed with a visual assessment method (VESS), especially for the clay soil. The use of the sward lifter generally reduced DM yield for the clay soil because of use in the spring (De Boer et al., 2018). The N2O emissions were enhanced using either the sward lifter or slitter, up to 94% more than an uncompacted control soil as a result of moving from denitrification to nitrification conditions. Implications are the release of more N2O from grassland, up to 243 kg if soil structure is improved with a surface slitter on sandy soil, for a 150 ha dairy farm.

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P-564

Nitrogen use efficiency of crops in a newly arranged agricultural landscape: effects of field size, crop synergy and soil heterogeneity

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Nitrogen (N) is a major nutrient playing a vital role in crop production. However, over-application of N (fertilizer and manure) leads to environmental degradation via leaching as nitrate (NO3-) and gaseous emissions of nitrous oxide (N2O) or ammonia (NH3). A novel field experiment is designed to solve this problem by breaking down the characteristic large, sole cropped fields into site-specific patch-based multi-cropping landscapes in Brandenburg, Germany. The aim is to improve crop production while minimizing the loss of nutrients and enhancing biodiversity and ecosystem services. Our research question was what is the effect of field size, crop rotations, and soil properties on the N use efficiency (NUE) of crops.
A large 70 ha field was divided into smaller fields of ~0.5 ha (72m x 72m) by considering the small-scale soil heterogeneity, defined as patches. The “chess-board” shaped patches were cropped with six different crops within two studied cropping cycles (2020-21 and 2021-22), covering winter and summer crops. Soil and plants were sampled along a transect from the center of each patch to the edge to understand the spatio-temporal distribution and gradients of soil and crop N (NO3-, NH4+, total N of soil and plant). Other variables in use are soil texture, moisture, temperature, slopes, and crop normalized difference vegetation index (NDVI) from high-resolution remote sensing imagery. In this contribution, we will show the first results provided by statistical analysis and linear mixed models to reveal the spatial gradients and edge effects that emerged from crops synergy, rotation and soil heterogeneity.

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P-565

Comparison of Grass-legume Mixtures and Nitrogen Effects on Trace Gas Emission and Soil Microbial Biomass

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Grass-legume mixtures can reduce greenhouse gas emissions from soil. The two-year study compared nitrous oxide (N2O) and carbon dioxide (CO2) gas emissions, soil microbial biomass, and mineral-nitrogen for meadow bromegrass receiving three nitrogen rates (0, 56, and 112 kg ha-1), alfalfa monoculture, and 50-50% and 70-30% meadow bromegrass-alfalfa mixtures. Treatments affected (P=0.012) N2O fluxes. In the first year, N2O fluxes from alfalfa monocrop (150 µg nitrogen m-2 h-1) and 50-50% mixture of meadow bromegrass with alfalfa (125 µg nitrogen m-2 h-1) were highest. Meadow bromegrass (P<0.05) suppressed N2O fluxes in monocultures differentially fertilized with nitrogen (59 and 80 µg nitrogen m-2 h-1) and in 70-30% mixtures with alfalfa (92 µg nitrogen m-2 h-1). In the second year, the 50-50% mixture of meadow bromegrass with alfalfa (162 µg nitrogen m-2 h-1) and alfalfa monoculture (139 µg N m-2 h-1) had highest N2O fluxes. Lower (P<0.05) fluxes were recorded in the 70-30% mixture of meadow bromegrass with alfalfa (92 µg nitrogen m-2 h-1) and grass monocultures (59 to 80 µg nitrogen m-2 h-1). There were poor correlations between soil mineral-nitrogen and N2O flux (R2=0.3, P<0.05) in both years. Although there was no significant treatment effect, the range of CO2 flux (15 to 67 mg carbon m-2 h-1) were 10 times lower than those found in undisturbed forage crops. Treatments had similar soil microbial biomass in August and October of both years. Overall, mineral-nitrogen demand by grass underpins the suitability of meadow bromegrass-alfalfa mixtures in reducing greenhouse gas emissions and sustaining soil microbes.
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P-566

Impact of soil pH and liming rates on N2O fluxes and yields under grassland

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Agricultural soils are the largest anthropogenic source of the greenhouse gas nitrous oxide (N2O). Hence, there is much interest in a systematic evaluation of management options to minimize agricultural N2O emissions. There is evidence that an increase in soil pH will support the transformation of the potent greenhouse gas N2O to climate-neutral atmospheric nitrogen in soil (Simek and Cooper, 2002). Thus, increasing soil pH by lime application might be a way to reduce N2O emissions. Liming can also offer benefits in terms of increasing plant available phosphorus, increasing plant biomass production and enhancing carbon sequestration. The evidence of the pH effect on N2O emissions stems almost exclusively from laboratory experiments. Therefore, testing of liming strategies under realistic field conditions is needed. We conducted two separate liming experiments to investigate the influence of different liming rates on N2O fluxes and plant productivity; one on an intensively managed lowland grassland, cut for silage, (2017/2018) and one on a set stocked permanent pasture (2019/2020) in Scotland. The experiments were established in the most acidic area of the fields. Two liming strategies were compared, a conventional lime application based on the average soil pH of the field (2.5 t lime ha-1), the other based on precision liming to the individual square of the field (7.2 t lime ha-1), while control plots did not receive lime. N2O fluxes were measured weekly and more frequently after fertilizer events by chamber method, while soil and plant parameters were measured monthly. Results from both experiments will be presented.
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P-568

Trends Survey on Soil Quality Assessment Indicator

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Soil quality is the capacity of soil to function. Main function of agricultural soil has extended from crop productivity to environment quality and further biological diversity. In organic farming, it is more important to maintain biodiversity and to reduce environmental impact (such as climate change) as well as sustain crop productivity. The objectives of this study is to survey trends on soil quality indicators in worldwide to develop organic soil quality assessment in South Korea. Physical, chemical, and biological properties were collected in 18 frameworks in each other 12 countries; South Korea, USA, Canada, New Zealand, Australia, EU and China, Netherlands, Japan, India, Indonesia, and Brazil. In the results, total 14 physical properties, 28 chemical properties, and 15 biological properties were proposed in 18 frameworks. The number of minimum data set was minimum 4 to maximum 28. In physical indicators, bulk density (56%) and aggregate stability (56%) were most used, followed porosity (39%), water holding capacity (33%). In chemical indicators, pH (89%) was most used, followed organic matter (72%), phosphorus (67%), nitrogen (39%), potassium (39%), CEC (33%). In biological indicators, microbial biomass (39%) was most used, followed anaerobically mineralized nitrogen (33%), earthworm density (28%). Some frameworks suggest particulate organic matter, labile carbon, and PLFA as promising indicators for biodiversity and organic matter pool. These results show that common indicators for soil quality assessment are pH, organic matter, phosphorus, bulk density, and aggregate stability. Recently, organic agriculture is regarded as one of a promising mean for mitigating climate change. The further research on the selection of indicators related to carbon storage is suggested to be important.

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P-569

Are nitrification inhibitors effective in mitigating cattle-urine derived N2O emissions within livestock congregation areas?

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Cattle congregation areas (e.g. gateways) are soil nitrous oxide (N_2O) emission "hot-spots" due to elevated excretal loads, reduced vegetation and changes in soil compaction and moisture via treading. Nitrification inhibitors (NI's) are commonly proposed to reduce N_2O from "hot-spots", yet evidence of their efficacy in congregation areas is lacking. We hypothesised: i) N_2O-N emission factors (EF's) from urine would be higher in a gateway compared to standard pasture, and ii) NI's applied alongside urine would be less effective in reducing N_2O in the gateway than when compared to standard pasture, due to a lack of vegetation to acquire the excess N. Cattle urine (7.24 g N l^{-1}) was collected on a dairy farm in North Wales, and applied (434 kg N ha^{-1} loading rate) to a standard area of pasture and a gateway, with and without the NI DMPP (10 kg DMPP ha^{-1} loading rate). Automated greenhouse gas chambers were used to monitor N_2O fluxes at high temporal resolution. Mean ± SEM N_2O-N EF's (% of N applied) were 0.73 ± 0.33 (urine in standard pasture), 0.37 ± 0.33 (urine + DMPP in standard pasture), 1.42 ± 0.29 (urine in gateway) and 1.07 ± 0.15 (urine + DMPP in gateway). Mean urine-EF's in the gateway were almost double that of the standard pasture, while DMPP reduced urine EF's by 49% in the standard pasture, but only 24% in the gateway, supporting our hypotheses. We conclude NI's are less effective in mitigating N_2O from congregation areas compared to standard pasture areas.
No references were cited in the abstract.

P-570

Quantification of N2O fluxes and emission factors from grazed grasslands in hydro-hallomorphic soils in Argentinian Pampas.

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In Argentina, most sodium affected-soils are used for beef cattle raising. Even when 95% of N_2O emissions come from animal excreta deposited in soil, little information has been generated about N_2O emissions coming from grazed grasslands in a complete year in Argentina.
The objective of this study was to measure emissions of N_2O from grazed grassland in hallomorphic soils that can be used to add information and develop country-specific EFs for N_2O emissions from these soils in Argentinian pampas.
The experiment was carried out in Salado River Basin, Buenos Aires. N_2O emissions were measured in soils with the addition of bovine urine and dung. The urine and faeces were collected directly from the animals the same day of the application. Highly frequent N_2O samplings were done during approximately 45 days of experiment in each season.
Cumulative N_2O emissions per chamber were higher ($p<0.01$) in chambers with urine in all the seasons. The data showed that the annual emission factor for N_2O from urine and dung applied to grazed grassland hallomorphic soils were 0.65% and 0.007%, respectively. Measured EFs are slightly lower but quite close to the N_2O emission factors of the excreta deposited in grasslands proposed by the IPCC in the refinement of the guidelines published in 2019.

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P-571

Optimising N2O measures following the application of mineral and organic nitrogen fertiliser to sugarcane

Dr Daniel Poultney, Mr Charles Detaille, Dr Laurent Thuriès, Dr Frédéric Feder, Dr Antoine Versini

Agricultural soils are the most significant source of the major greenhouse gas N2O[1] with humid, tropical soils favouring the production of N2O[2]. Static chamber measurements remain the most common method of measuring N2O emissions, given that the materials are inexpensive and easy to use. For organic fertilisers, there is limited information with regards to optimising measures, which could greatly reduce the cost and time spent in sampling. The aim of this study was to determine the optimal sampling frequency and number of measures required at each sampling over the sugarcane growth-cycle, for a mineral fertiliser (urea) and two organic fertilisers (sewage sludge and pig slurry) at a highly monitored sugarcane experimental site in Réunion Island.

The number of measures needed for each sampling were tested using static chambers at various dates over the first 50 days after harvest. Automatic chambers enabled continuous measures to be taken over 3 years, and emission factors were established for each fertiliser treatment. This data was interpolated to compare different measurement scenarios over the sampling years to daily measures.

There was no significant difference ($p<0.01$) in emission values when 5, 4, 3 or 2 measures were taken over a 60-minute interval. Bi-weekly sampling over the entire growth-cycle was shown to capture sufficient variability over the sugarcane growth-cycles (<5 % difference from daily emissions measured with automatic chambers). This can be used to inform appropriate protocols to reduce cost and time spent in N2O measurements with static chambers, without reducing the accuracy of N2O emission results.

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P-572

Nitrogen budget and evaluation of mineral and organic fertiliser N losses from a soil-sugarcane agroecosystem

Dr Daniel Poultney, Dr Laurent Thuriès, Dr Antoine Versini

Nitrogen (N) is critical to sugarcane growth and productivity[1] but over-application has negative environmental consequences[2]. This study established a complete N budget for a soil-sugarcane agroecosystem and evaluated the N losses from mineral fertiliser (urea) and two organic fertilisers, pig slurry and sewage sludge, over two experimental years at a highly monitored experimental site in Réunion Island.

The major N outputs evaluated were: N uptake by the sugarcane using 15N isotopes, N in solution lost via leaching measured using porous cups, NH3 emissions using ammonia diffusion samplers, N2O emissions using automatic gas chambers, and N immobilisation by deduction from the established N budget.

Of the N applied with the urea fertiliser, 22 % was taken up by the sugarcane, 36 %, 1.4 % and 3 % lost via volatilisation, denitrification and leaching respectively, and 37 % immobilised in the soil. Of the pig slurry N, 7 % was taken up, 63 %, 3.6 % and 2 % lost via volatilisation, denitrification and leaching respectively, and 27 % immobilised. Of the sewage sludge N, 9 % was absorbed, 8 %, 0.7 % and 5 % lost via volatilisation, denitrification and leaching respectively, and 70 % immobilised.

The study showed a high proportion of mineral fertilisers were lost via volatilisation. There was a low level of N loss via leaching, likely due to the soil’s capacity to retain nitrates. There was a high level of immobilisation, in particular for the sewage sludge, due to its high organic N composition and slow-release properties.

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P-573

Climate smart farming and the role of biological nitrification inhibition

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Current estimates show that approximately 20 gigatons (GT) of negative greenhouse gas (GHG) emissions per year would be needed to limit the projected global temperature rise to below 2oC by 2100 (Pacala et al., 2019). Achieving this is possible only through implementation of innovative strategies to minimize GHG emissions. Nitrous oxide (N2O) is a major long-lived GHG and stratosphere ozone-depleting substance emitted primarily due to nitrogen fertilizer application in agriculture (Ravishankara et al., 2009). Substantial improvements in nitrogen use efficiency and reduction in N2O emissions are critical for improving sustainability of agriculture world-wide. An innovative climate-smart strategy that could play a key role in regulating soil nitrification and N2O production is biological nitrification inhibition (BNI) (Subbarao et al., 2021). BNI is the ability of some plants to extend the availability of nitrogen in soils as ammonium by releasing specific root exudates that inhibit soil nitrifier activity and production of nitrates in soils. As plants can utilize ammonium, inhibition of nitrification doesn’t lead to reduced yield. Sorghum (Sorghum bicolor L.), especially wild genotypes, are known for releasing BNI compounds in various amounts. In studies conducted at College Station, Texas, USA, we investigated the effect of sorghum BNI on nitrogen use efficiency, nitrate leaching, and N2O emissions. Results showed that high BNI sorghum genotypes significantly reduced soil nitrification, nitrifier population, and N2O emission. Additionally, BNI activity of sorghum decreased soil nitrifier population in the rhizosphere. Results from these studies will be presented at the conference.

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P-574

Global Sensitivity Analysis of Key Parameters in APSIM Next Generation Sugarcane Model for Nitrate Leaching Via Treed Gaussian Process

Ms Rathnappulige Himasha Kithmini Rathnappriya, Professor Sakai Kazuhito, Associate Professor Sho Kimura, Professor Tomokazu Haraguchi

Sugarcane industry supports the local economy of Okinawa, Japan by being a major crop cultivated in the region. However, nitrate leaching from chemical fertilisers from sugarcane fields is identified as a major source for the elevated nitrate levels in the groundwater of the area. Nitrate leaching must be influenced by many factors such as crop growth, soil hydraulic characteristics and fertilising conditions. APSIM Next Generation is a process-based crop model that has been efficiently used to explore the complex nature of plant-soil interactions under different environmental and management conditions. In the application of APSIM to observed data including parameter optimisation, it should be indicated what are the more sensitive parameters related to nitrate leaching. Thus, we conducted a global sensitivity analysis on the key parameters in APSIM Sugarcane model on nitrate leaching under conditions of different fertilisation levels: (i) BL (bare land), (ii) N-free (P and K fertilisation), and (iii) Urea application, via Treed gaussian process. Soil type of the experimental site is a local soil “Shimajiri-mahji” (dark red soil). Parameters related to rue (RUE3, RUE4), y_n_conc_crit_leaf (NCL4), y_n_conc_crit_cane (NCC4), tt_emerg_to_begcane and green_leaf_no were identified as highly influential parameters on nitrate leaching under Urea and N-free fertilisation conditions, while BL treatment was highly influenced by SWCON (whole soil profile drainage rate coefficient): parameters related to rate of flow of water under saturated conditions. Our findings can be used to improve the accuracy and efficiency of modeling and to identify the appropriate fertiliser management practices for sugarcane cultivation in Okinawa region.

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P-575

Effect of soil drying-rewetting cycle on the efficiency of nitrification inhibitors in sandy and silt loam soils

Mr Pablo Ribeiro, Dr. Asif Naeem, Dr. Karl Mühling

Nitrification inhibitors (NIs) can mitigate nitrous oxide (N2O) emission from agricultural lands and increase the nitrogen use efficiency. However, soil drying-rewetting cycles frequently occur in rainfed areas and may affect the efficiency of these compounds. Therefore, this study investigated the efficiency of two NIs viz. 3,4-dimethylpyrazole phosphate (DMPP) and PIADIN (active ingredients: 3.00-3.25% 1,2,4-triazole and 1.50-1.65% 3-methylpyrazole) in preventing N2O emissions from sandy and silt loam soils subjected to moisture levels of 40% water holding capacity (WHC), 80% WHC and to a drying-rewetting cycle. Cylindrical pots with 15 cm diameter and 33 cm height were soil fulfilled. Fertilization was performed by using ammonium sulphate at 0.25 mg NH4+-N kg-1 soil, applied with the inhibitors at 1% of applied N and incubated in a climatic chamber at 25 °C and 40% air humidity for 60 days. Total N2O-N total production during the incubation period was calculated based upon the daily N2O emission and nitrification process was monitored through periodic determination of NH4+-N and NO3--N contents in the soil. NIs, mainly DMPP, were more efficient in preventing N2O emissions from the sandy than the silt loam soil probably due to the enhanced oxygen availability, which lowered denitrification, and the reduced NIs adsorption to sand particles. Soil drying-rewetting cycle can lead to significant increase in N2O emission even in the presence of NIs, but it does not generate total N2O emission higher than in 80% WHC treatment.
No references to update.

P-576

Changes in soil health in response to cover crop and manure integration in the upper Midwest

Mr. Manuel Sabbagh, Dr. Melissa Wilson, Dr. Paulo Pagliari

In the upper midwestern United States, farmers oftentimes apply manure in the late fall following a cash crop and heading into winter when no active roots are present in the field. This leads to an increased risk of nutrient loss, primarily nitrogen and phosphorus, with the initial flush of available nutrients soon after manure application. A strategy to enhance nutrient retention may be to plant a cover crop (CC) prior to manure application so that it has time to grow and actively take up nutrients. Field trials were initiated in spring 2019 at two locations in the upper Midwest. The study was laid in a randomized complete block design with split plots utilizing two separate continuous maize (Zea mays) rotations. Cereal rye (CR; Secale cereale); oats (Avena sativa); and a 3-species mixture of CR, oats, and radish (Raphanus sativus L.) were no-till drill-seeded shortly after maize harvest. In a separate rotation, a mixture of CR and annual ryegrass (Lolium multiforum) was interseeded into maize near V5, R5, or shortly after harvest. To minimize soil disturbance, liquid manure was sweep-injected in the early fall, shortly after CC planting, and late fall when soil temperatures were at or below 10°C. A no CC and no manure control was also included. Soil and plant samples were taken throughout the CC and row-crop growing season. Preliminary data show later application of manure had better retention of inorganic nitrogen. Analyses measuring nutrient cycling, soil health, and agronomic responses are underway and will be reported.

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P-577

Nitrogen mineralization in pasture volcanic soils in Chile

Dr. Osvaldo Salazar, Dr. Francisco Nájera, Dra. Leah Renwick, Dr. Marco Pfeiffer, Dra. Yasna Tapia, Dr. Juan Pablo Fuentes, Ayleen Celedón, Prof. Manuel Casanova

Chile is a natural laboratory that offers a broad range of agroecosystems with diverse climate and soil types that enable research of local and global interest related to factors controlling soil nitrogen (N) dynamics. The main objective of this study was to evaluate net N mineralization (NNM) rates in pasture volcanic soils under mediterranean and temperate climate conditions. This study spans climate conditions and soil types along a 600-km north-south transect from 36° to 41° S. Four experimental sites (latitudes: 36°, 37°, 39° and 41° S) were evaluated with in situ NNM measurements and additional environmental parameters (i.e. soil moisture and temperature). To assess in situ NNM in each experimental site, six capped PVC cylinders were filled with topsoil (0-30cm depth) and placed in a 2 m x 1 m grid. This procedure started in autumn (April-2021) and repeated in spring 2021 (October). Each set of soil cores were removed from the field after six months and sent for laboratory analyses. All soil samples were analysed for inorganic N forms and total soil organic carbon (SOC). The cumulative NNM was determined as the difference between initial and final ammonium (NH_4^+) concentrations. This study will consist of two years of NNM measurements, between April 2021 and March 2023, of which the first year's results will be reported. Preliminar results show that while soil N, SOC and precipitation increase from north to south, soil temperature decreases, with more limited NNM rates in autumn-winter than in spring-summer.
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P-578

Photocatalytic power of soils, abiotic NOx gas fixation

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Gaseous nitrogen oxides (NOx) resulting from combustion of fossil fuels, volcanic eruptions or forest fires affect air quality. It is well known that other biological reactions in soils as oxidation (nitrification) and reduction (denitrification) also generate NOx emissions, but counterpart fixation has been scarcely studied. We provide evidence of gas fixation in soils through abiotic photocatalytic reactions under UV–Visible irradiation. A wide range of photocatalytic efficiencies in the NOx abatement, from close to zero for a sandy soil and poor in titanium to high values for ferralsols with high clay, iron oxides and titanium was found. These last soils with amounts of titanium below 5% showed a photocatalytic efficiency (near to 80%) comparable to pure TiO2 P25 benchmark product. Besides the content of these photocatalytic minerals other soil properties as the amount of iron oxides, organic matter and texture, influence this abiotic reaction. In addition, soil temperature, radiation intensity and gas concentration are other factors assessed here. This mechanism of N fixation provides a new insight into the nitrogen cycle and may inspire alternative strategies to reduce NO emissions from soils.
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P-579

Effect of micronutrients and S and N application on components of winter wheat yield across a range of European soils.

Ms Saoirse Sheehy Ariff, Saoirse Tracy, David Langton, Paul N.C. Murphy

Micronutrients and S can be limiting nutrients (crop yield and quality) in intensive arable cropping systems and the prevalence of such limitation is likely increasing due to a number of factors. Their effect will likely depend on crop N nutrition and soil type. It was hypothesised that micronutrient (Zn, Cu, Mn) and S application would affect winter wheat (Triticum aestivum; Graham variety) crop yield and quality and that their effects would interact with the effect of N application and soil type. To investigate this, a polytunnel pot experiment was carried out using six contrasting soils from across Europe that have been in long-term conventional arable production; a Chernozem, a Cambisol, a Luvisol, an Arenosol, a Rendzina and a Leptosol. The soils were collected from the top soil horizon (plough layer). Soil properties that might influence nutrient availability were measured (pH, organic matter, plant available nutrients, soil texture and cation exchange capacity). Treatments of control, S (25 kg/ha), Mn (20 kg/ha), Cu (20 kg/ha) and Zn (50 kg/ha) were applied in aqueous solution to the soil at GS12 in an incomplete factorial design with 5 replicates per treatment. N was applied in aqueous solution at three levels: 0, 150 and 300 kg/ha. Each N treatment was applied over GS30, GS31 and GS37, with the majority of N being applied at GS31. Three plants were grown per 3 l pot. At full maturity the straw and grain were separated, dried and mass measured. This poster presents initial results from one growing year.

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P-580

Influence of Compost Properties on Organo-Mineral Fertilizers Composition and Nutrient Release

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Organo-mineral fertilizers (OMFs) are made by combining an organic fraction (OF) with one or more mineral fertilizers to get a product that unites characteristics of inorganic and organic fertilizers (Smith et al., 2020). Depending on their structure, OMFs can provide a slower release of nutrients than mineral fertilizers alone (Sakurada et al., 2016) or change soil properties (Tejada et al., 2005). However, the type of raw materials, processing, or process time, provide a high variability in the organic fractions characteristics; that could be transferred to the OMF.

Sixteen OFs, grouped as green compost, mixed compost, vermicompost, biochar, and peat, will be characterized for organic C, humic C, NH4, NO3, total N, total S, total P, Ca, K, Mg, Fe, pH, and organic fibers. These variables will be used in a principal component analysis to find similarities and differences among the materials. The four most different OFs will be selected to create granular OMFs with ammonium sulfate, urea, and triple-superphosphate. The OMFs will be used to fertilize a sandy loam soil for an incubation looking at the nitrogen immobilization, in a test of nitrogen leaching in tubes of soil with water fluxes, and in a pot experiment with ryegrass looking at the nitrogen use efficiency.

The results of the three experiments will be correlated to the parameters of the compost to find the best predictor for the OMF quality. Finding desirable properties of OFs will be relevant for designing OMFs with lower N losses than conventional fertilizers.

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P-581

Temporal and spatial variability of soil pH from a sheep grazed grassland, and its impact on soil nitrous oxide emissions

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Intensively managed temperate grazed grassland soils tend to be acidic, caused by a combination of high rainfall/low evapotranspiration and acidifying nitrogen fertilisers. These conditions are conducive for N2O production. It has been suggested that increasing the soil pH could reduce soil N2O emissions. To investigate this potential mitigation strategy, we surveyed the soil pH in every 25m2 of a 10 ha grassland, located on an imperfectly drained Eutric Cambisol, SE Scotland. Twenty-four static chambers for N2O flux measurements were placed across a pHCaCl2 gradient (pH 5.4 – 6.9). Fluxes of N2O were measured during three urea fertilisation events, together with soil moisture, temperature, ammonium, nitrate, pH and dissolved organic carbon contents.

Spatial and temporal variation of N2O fluxes were typically high, but surprisingly this was also true for soil pH measurements. Nitrous oxide emissions were not significantly related to soil pH (p-value = 0.116 (n.s), n = 576). The lack of significant relationships highlights the need to investigate N2O production in the wider context of biotic processes and as part of a large N cycle. In global or regional N2O emission models, soil pH is a key parameter predicting grass production (Wang et al., 2018). We did not observe a correlation between grass N concentrations and soil pH. Our results question the ability to assess the effect of soil pH on N2O emissions and the ability to quantify the mitigation potential of increased liming.

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P-581A

Seasonal rainfall distribution drives Nitrogen Use Efficiency and losses in dryland summer sorghum

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Nitrogen (N) fertiliser inputs represent one of the largest variable costs in dryland cropping systems, and a key determinant of water-limited yield. Despite extensive research into microbial N losses via intermediate denitrification products such as N2O, limited research exists on total N losses, and the effect of increasing soil N surplus has on fertiliser use-efficiency is not clear. In this study, the fate of banded urea fertiliser N across crop uptake, soil residual N and N losses was determined using the 15N recovery technique over nine trials with four N rates (0, plus low, medium and high industry rates) across N responsive and non-N responsive sites over 3 years in dryland sorghum (Sorghum bicolor). On average, crop uptake efficiency ranged from 50% at the low and medium N rate (80 kg N ha-1) to <38% at the highest N rate, and was as low as 5%. Nitrogen losses averaged 26.5% across all rates and trials. At the medium N rate, losses exceeded 18% in all trials, despite relatively dry seasons, and in some trials exceeded 34%. Losses of N were driven by large cumulative rain events and high early-season rainfall. In dryland systems, the inability of crops to acquire banded N fertiliser can potentially leave fertiliser stranded in the topsoil, leaving it vulnerable to losses.

P-582

Organic amendments reducing fertilizer derived N_2O emissions dependent on climate conditions

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Cool-season vegetable crops, such as leafy greens, are particularly sensitive to environmental changes, making them vulnerable to global climate change. Complicating these outcomes is the reliance on high N fertilizer inputs, which in combination with increased crop stress could exacerbate N losses considerably. In these high-risk agricultural systems, the use of conservation management practices such as compost application is considered part of sustainable N management but the impact of compost application on applied N fertilizer is still poorly understood. The objective of this study was to evaluate the fate of fertilizer N under optimal (23°C and 60% WHC) and stressed (28° and 40% WHC) crop growth conditions when co-applied with agricultural-waste compost. Two soil types, sandy loam, and clay loam were chosen to represent major soil series, by area, of the Salinas Valley, California, USA - a globally relevant production region. After the application of ^{15}N urea fertilizer to microcosm pots, located at the UC Davis Controlled Environment Facility, total cumulative and fertilizer derived nitrous oxide (N_2O) emissions were measured alongside crop fertilizer use and soil fertilizer N retention. Results showed that compost application reduced fertilizer derived N_2O emissions, but this effect was minimized by soil moisture conditions, and surprisingly not by temperature or soil type. Under optimal conditions, cumulative N_2O was highest and applied N fertilizer contributed a larger portion of the total emissions than compost and soil. This work offers insight into how global change factors will influence crop N availability under conservation management in vulnerable cropping systems.

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P-583

Vermicompost: A potential amendment to improve soil health and reduce GHG in agricultural systems

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Vermicomposting offers important benefits for agriculture. The purpose of our research is to quantify how vermicompost application affects soil health and greenhouse gas emissions from soils in a walnut orchard and annual crops in Yolo County, California. Integrating vermicompost into standard agricultural practices has a high potential to improve soil health, mitigate climate change, and sustainably increase harvestable yield of crops. Vermicompost is nutrient-enriched, it benefits the microbial community, promotes plant growth, supports soil carbon sequestration, and suppresses soil and plant disease. As California moves to divert organic waste from landfills, vermicompost represents a competitive alternative soil amendment to green and food waste compost. Our aim is to develop guidelines for using vermicompost as a soil C and N amendment and could facilitate the development of vermicompost production in California to diversify soil amendment products available to agriculture.

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P-584

Interaction between soil and fertiliser nitrogen (N) drives plant N uptake and nitrous oxide (N2O) emissions in tropical sugarcane systems

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High nitrogen (N) fertiliser inputs in intensive sugarcane systems drive productivity but also significant emissions of nitrous oxide (N_2O). The effects of N fertiliser inputs on soil organic nitrogen (SON) availability for plant N uptake as well as N_2O emissions remain unknown, hindering efficient N management. This study therefore investigated the contribution of fertiliser and soil N and their interaction to plant N uptake and N_2O emissions in two intensive tropical sugarcane systems with different farming practices. High temporal resolution N_2O measurements were combined with ^{15}N recoveries across four N fertiliser rates, (100, 150, 200 and 250 kg N ha-^{1}) in soil, plant and N_2O emissions. Cumulative N_2O emissions ranged from 0.3 to 4.1 kg N ha-^{1}, corresponding to emission factors ranging from 0.7 to 2.4%. Fertiliser N addition increased the contribution of SON to N_2O emissions, which accounted for > 60% of cumulative N_2O emissions across N rates. Similarly, plant N uptake derived from SON accounted for > 60% of the total plant N uptake. These findings highlight the interaction between N fertiliser and SON, with the latter being the dominant source for N uptake and loss. Overall fertiliser ^{15}N loss responded exponentially to N rates, showing that up to 60% of applied N fertiliser were permanently lost. The predominance of SON in plant N uptake but also N_2O emissions indicates that SON loss exceeds fertiliser ^{15}N loss by far, driven by the interaction between N fertiliser and SON in intensive sugarcane systems.

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P-585

Nitrification and urease inhibitors as mitigation strategies for NH3 volatilization in sugarcane cultivation areas with addition of organic residues

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Nitrogen-enriched concentrated vinasse (CV) is a strategy to reduce Brazilian sugarcane fertilization costs. However, this strategy impacts ammonia volatilization (NH3). The efficiency of urease inhibitors (UI) and nitrification inhibitors (NI) efficiency is unknown under this combination. The aim of the present study was to evaluate the NH3 volatilization from the joint application of CV and urea in a sugarcane field with and without U/N-inhibitors. Three experiments were carried out in Piracicaba/SP, and NH3 volatilization was evaluated for 40 days in the two wet season (WS-I and WS-II) and for 79 days in the dry season (DS-I) experiments. The treatments applied were: 1) Control - C; 2) Urea - UR; 3) UR + UI; 4) UR + NI; 5) UR + UI + NI; 6) CV; 7) CV + UR; 8) CV + UR + UI; 9) CV + UR + NI; and 10) CV + UR + UI + NI. UI addition reduced NH3 volatilization by 20, 31 and 42% for WS-I, WS-II and DS-I, respectively, compared to UR. Conversely, the NI addition reduced NH3 volatilization in WS-I (13%) and WS-II (6%) and increased in DS-II (+25%). The joint fertilization with CV and UR decreased NH3 volatilization by three-fold compared to UR in the WS and by four-fold for the DS, indicating that the joint application of vinasse and UR can be considered an excellent strategy to reduce NH3 volatilization in soils cultivated with sugarcane, showing better results in reducing N losses even than the UI addition.
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P-586

Rice husk biochar mitigate global warming in barley field in Ehime, Southwestern Japan

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Two crops, rice and barley, were commonly cultivated in Southwestern Japan. In our study, rice husk biochar was applied for optimizing soil pH for barley cultivation to evaluate the biochar application on barley yield, carbon (C) budget, and greenhouse gas emission.
This study was conducted in Ehime University Farm in Japan. Three treatments, conventional (D, dolomite, 150 g/m2), biochar (B, 6 kg/m2) and biochar×2 (2B, 12 kg/m2), were set up in Nov. 5, 2020. 2B showed optimal soil pH at the pre-incubation experiment. Plant growth and yield were measured. Heterotrophic respiration (Rh), methane (CH4) and nitrous oxide (N2O) emissions were measured by closed-chamber technique. Carbon budget and net greenhouse gas emission (NGHGE), and yield scale NGHGE were calculated. Carbon input from barley were only calculated from root.
Carbon budget (kgC/m2) in 2B (5.8) was higher than B (4.8) and D (4.1), though there were no significant difference among the treatments. Because there were no significant differences in Rh, root C input, and CH4 emission among the treatment, increasing biochar C application increased C budget. The NGHGE in D, B, 2B were -15, -17, and -21 kgCO2eq/m2, respectively. Grain yield were higher in B and 2B compared to in D. Therefore, yield scale NGHGE in 2B (-4.6 kgCO2eq/m2) was lowest. Almost no effect of biochar application on Rh and greenhouse gases emission might be due to lower temperature during the experiment. This study demonstrated that biochar application is acceptable for cultivating barley and mitigating global warming.
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P-587

Impact of Increased Ammonia Dry Deposition on Nitrous Oxide Emissions from Forest Soils

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The use of nitrogen-based fertilisers increases emission of the greenhouse gas nitrous oxide (N_2O) from agricultural soils (Acton and Baggs, 2011). This fertiliser application likely has indirect effects on N_2O fluxes in natural systems through volatilisation and subsequent down-wind deposition of ammonia (NH_3) (Denier van der Gon and Bleeker, 2005; IPCC, 2019). The aim of this present study is to improve understanding of the importance of such indirect N_2O emissions in natural ecosystems and the mechanisms that underpin them. We investigated how increasing atmospheric ammonia NH_3 concentrations affects N_2O emissions from forest soils. We mimicked a point source of NH_3, such as a chicken farm, using an automated ammonia release system, coupled to meteorological measurements in Glencorse, Scotland (Leeson et al., 2017; Leith et al., 2005). Thirty-six static flux chambers were used to capture the spatial variability of N_2O fluxes. The spatial and temporal variability of NH_3 concentrations were measured using ALPHA® samplers and a cavity ringdown gas analyser, respectively. Extractable soil ammonium and nitrate were measured using colorimetry as a proxy for the availability of reactive nitrogen in the soil. Other key soil physicochemical properties were also measured such as soil moisture, bulk density, and pH. Inferential modelling was utilised to estimate NH_3 dry deposition. The findings from this study will help elucidate the proportion of atmospheric NH_3 deposition that may be re-emitted as N_2O, and thus help refine emission factors for indirect anthropogenic N_2O emissions from natural systems.

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P-588

Excellent excrement? The potential benefits and drawbacks of soil amendment with frass

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Insect rearing is a rapidly growing sector in Europe, with larval protein production projected to exceed 1 Mt in 2025. The by-product frass, a mix of larval faeces, exoskeletons and undigested substrate, has potential as a soil improver. We conducted incubation and pot trials to gauge the effects of soil amendment with frass of black soldier flies (Hermetia illucens, BSFF), mealworms (Tenebrio molitor, MWF) and buffalo worms (Alphitobius diaperinus, BWF) on microbial growth and processes, nutrient provision to plants, heavy metal bioavailability and greenhouse gas emissions.

All frass types induced microbial growth in contaminated soil due to nutrient provision and reduced metal bioavailability. All featured high nutrient levels, with variability caused by species and diet. Increased N2O emissions in BSFF-amended soils were associated with high nitrogen/carbon availability, particularly if larvae were mainly fed carbohydrates.

Frass promoted microbial growth, especially that of saprotrophic fungi. A substantial fraction of frass carbon was labile, therefore mineralised. Nitrification was also stimulated. However, MWF/BWF could induce soil nitrite increases, thought to be linked to higher archaeal gene copy numbers. Higher application rates of MWF/BWF inhibited ryegrass germination, possibly due to ammonia toxicity. At lower application rates, both were effective fertilisers. Concurrent nitrification inhibitor application reduced nitrogen loss, whereas urease inhibition retarded nitrogen release, potentially allowing frass use as a slow-release fertiliser.

While frass could be an effective ameliorant in metal-contaminated soils and benefit soil microbial biomass, widespread use as an organic fertiliser is not recommended until deleterious plant effects and greenhouse gas losses are minimised.

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P-589

Management of cover crops to reduce nitrogen leaching loss from cropland

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Nitrogen from cropland is a major water pollutant and a major driver of eutrophication in lakes and estuaries. Cover cropping is a tool for controlling the leaching loss of soluble nitrogen during the winter months in temperate regions. However, cover crop management is rarely optimized to reduce nitrogen leaching. Our research in Eastern USA over 10 years shows that aboveground cover crop nitrogen exceeds soil nitrogen reductions in 0-1 meter, and that large pools of soluble nitrogen remain after cash crop harvest with much of this deeper than 90 cm in the soil and very susceptible to winter leaching. We show that the time of cover crop establishment is critical to their being effective during the fall-winter-early spring leaching season. Our new model of cover crop nitrogen leaching reduction suggests the critical cover crop action is the early fall removal of soluble nitrogen from the deep soil profile, so when drainage water passes through the profile during winter and spring because of high rainfall and low ET it encounters little soluble nitrogen to dissolve and carry away. A few weeks' planting time difference in late summer can dramatically affect nitrate concentrations in drainage water from December through May. Inter-seeding into standing cash crops is one technique for getting cover crops planted early with significantly more growing degree days to develop root systems that capture deep nitrogen. Late-planted cover crops accomplished little more leaching reduction than winter weeds. Governments should incentivize early cover crop planting.

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P-590

Potential ammonia volatilization from 39 different novel biobased fertilizers applied to soil – A laboratory study using European soils

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Currently, the political focus on promoting a circular economy in the European Union drives a high interest in developing and using more biobased fertilizers (BBFs, waste or residue-derived). However, ammonia (NH3) volatilization from BBFs, apart from a few as e.g. manure, has not been well studied, even though NH3 volatilization from agriculture results in major environmental impacts. Ammonia volatilization poses a risk to the environment and human health when entering the atmosphere, causing pollution in natural ecosystems through re-deposition and contributing to formation of fine particulate matter (PMx). In addition, since NH3 volatilization results in removal of plant-available N from agricultural systems, it constitutes an economic loss for farmers. This study assessed the potential NH3 volatilization from 39 different BBFs commercially available on the European market. Moreover, the effect of incorporation, soil moisture content, soil type and application rate was tested. Results showed a great variation between BBFs in potential NH3 volatilization, both in terms of temporal pattern of volatilization and amount of NH3 volatilized. The potential NH3 volatilization varied from 0.03% (compost) of applied total N to 63.9% (digestate) of applied total N during a 27- or 44-day incubation period. Characteristics of BBFs (pH, NH4, NO3, DM and CN) could only poorly explain the variation in NH3 volatilization potential. Incorporation of BBFs into soil effectively reduced potential NH3 volatilization. Ammonia volatilization potential varied between five different soils (varying in clay and organic matter content) with the highest NH3 volatilization potential from a sandy soil.

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P-591

In-season application of swine manure to maize to improve nitrogen management

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In agricultural areas with cool climates, application of livestock manure for crop production can be challenging. For example, spring in the upper midwestern United States can be short and is increasingly wet due to climate change, making it difficult to apply manure and plant crops in a timely manner. This results in a significant amount of manure applied in the fall after the cash crop is harvested. The nitrogen in fall-applied manure has ample time to mineralize and leave the root zone before next season's crop can utilize the nutrients. This excess nitrogen outside of the growing season can end up in ground and surface waters. Applying manure to maize (Zea mays) during the growing season, referred to as sidedressing, could provide farmers with another window of opportunity to apply their manure, maximize nutrient uptake efficiency, and protect water quality. Replicated, on-farm studies were initiated in 2018 to evaluate sidedressing slurry swine manure to maize using tanker or drag hose application systems. Both systems were able to inject the manure between maize rows to reduce ammonia volatilization. In the first study using a drag hose applicator, liquid manure was compared to sidedressed anhydrous ammonia, 32% urea ammonium nitrate, and a no-sidedressed-nitrogen control. In the second study using the tanker applicator, manure application timing was the experimental factor. Manure was applied when the first, fourth, and seventh maize leaf collars had emerged. Results from these two experiments, including maize yield and residual soil nitrogen after harvest, will be discussed.
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P-592

Do cover crop species influence nitrous oxide emissions consistently across different management and environmental conditions?

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As a traditional approach used to improve soil quality and sustain cash crop productivity, cover cropping has been shown to improve soil aggregation, increase soil organic matter content, and reduce nitrate leaching. However, past site-specific studies and meta-analyses have shown that cover crops increase emissions of nitrous oxide (N2O), a potent greenhouse gas. Although cover crop species, agricultural environments, and other agricultural management factors are known to impact soil N2O emissions after incorporation, the relative dominance of these effects, and specifically the consistency of species influence, is not known. Here we undertook a meta-analysis of data from over 60 peer-reviewed field studies. Our results emphasise the effect of cover cropping on increasing N2O emissions compared to bare soil. Emissions from legume cover crops are greater than from non-legume cover crops which we explain on the basis of dominant traits including C:N ratio and lignin contents. In terms of environmental and management impacts, annual precipitation, soil texture, location (country) of the field experiments, tillage practices and fertilizer application (N, P, K) all affected the magnitude of emissions on short time scales up to 1 year. We provide the first multi-species, multi-environment analysis, and present evidence for the influence of environmental conditions and management on the relationship between cover crop traits and N2O emissions, This represents an essential step forward in the development of a predictive framework for N2O emissions from cover cropping systems, and enables us to determine the influence of climatic zones, soil type and management practices on species-emissions relationships.

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P-593

Can botanical nitrification inhibitors improve the yield of capsicum under tropical field conditions?

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Nitrification inhibitors (NI) can improve N-fertilizer use efficiency in cropping systems. The impact of dry-leaf powders (botanicals) of pepper (Piper nigram), karanda (Pongamia pinnata), neem (Azadirachta indica) and cinnamon (Cinnamomum verum), which have nitrification inhibition potential were tested for their impact on capsicum yield. Treatments (zero-urea, urea alone, urea+Dicynamide (DCD) and urea+botanical) were applied in triplicates in field experiments conducted at Horticultural Crop Research and Development Institute, Gannoruwa, Sri Lanka in two consecutive cropping seasons during 2018-2019. Botanicals and DCD were applied with urea [30% and 7.5% (w/w) of N applied, respectively] at each fertilization event. All four botanicals were tested in the first season and only karanda and cinnamon were tested in the second season. The treatments, urea alone, urea+DCD and urea+botanical, were repeated in triplicates in one farmer field at Marassana, Sri Lanka and as one replicate per farm in three farmer fields at Gampola, Sri Lanka. Yields were recorded in all plots. Crop showed significant response ($p<0.05$) to N-fertilizer application. In the first season, significantly highest ($p<0.05$) yield was observed under cinnamon+urea (11.7±2.67 MT/ha) followed by karanda+urea (11.0±2.24 MT/ha) compared to urea+DCD (8.4±1.50 MT/ha) and urea alone (6.6±2.84 MT/ha) treatments. In the second season, there were no significant effect of applying nitrification inhibitors with urea ($p>0.05$). In farm fields at Gampola, applying karanda with urea improved capsicum yield by 38%. In Marassana, the highest yield was recorded under cinnamon+urea. In conclusion, capsicum yield can be improved by applying dry-leaf powders of cinnamon and karanda with urea.

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Nitrous oxide (N2O) and dinitrogen (N2) fluxes from grazed pasture soil after simulated cow urine deposition at two different rates

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Ruminant cattle grazing pasture result in urine deposition at high nitrogen (N) rates that can impact the environment including via gaseous emissions[1]. There is limited information on the magnitude or fluxes of N_2 losses from grazed-pasture systems after urine deposition due to the method limitation[2]. We used the ^{15}N flux method in explore N_2 and N_2O fluxes over time after synthetic urine application at two rates (400 and 800 kg N/ha) on a New Zealand grazed pasture soil. The higher N rate significantly increased daily N_2O fluxes but has no significant effect on daily N_2 fluxes in our study compared with a lower rate. N_2 is the predominant gaseous N form lost from the applied urinary-N among two rates. Codenitrification and denitrification co-occurred in the pasture system, with denitrification being the predominant N_2 production pathway, contributing 97-98 % of total N_2 production. $N_2O/(N_2+N_2O)$ product ratio was generally lower than 0.2 when the soil relative gas diffusivity (Dp/Do) was lower than 0.02, which occurred on most days of our study. This study showed a clear temporal cascading pattern of soil mineral-N transformation and N_2O and N_2 fluxes after urine application and demonstrated the majority of N_2 was lost via denitrification when soil was relatively wet. This study suggested that mitigation practises which aim at reducing the urine-N rate could potentially reduce the N_2O emission by promoting N_2O reduction to N_2.

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P-595

Ammonia emissions from field applied fertilizers – comparing micromet and multi-plot approaches

M.Sc. Hannah Götze, Dr. Andreas Pacholski, M. Sc. Sina Kukowski

Ammonia (NH_3) emissions affect the environment, climate and human health. Additionally, they can reduce the nitrogen use efficiency of fertilizers. Due to uncertainties in the efficacy of NH_3 emission mitigation measures and in the derivation of emission factors emission data from internationally accepted standard methods and valid emission measurements from replicated small plots, are of particular urgency.

In the years 2020/2021, a comparison of methods for NH_3 emission measurement from field applied urea fertilizer was carried out on a luvisoil site near Braunschweig in winter wheat as part of the national cooperative project 'NH3-min '.

Circular large plots (1300m²) were used for micrometeorologial measurements and horizontal NH_3 fluxes were recorded with 'Leuning' and Alpha Samplers. The standard micrometeorological methods 'integrated horizontal flux method (IHF)', as well as the ZINST method and the 'backward Lagrangian stochastic dispersion technique (bLS)' were applied and showed close agreement for Leuning samplers.

In replicated square small plots (8 treatments, n=4, quadratic plots 81m²), two types of acid samplers (sulphuric acid traps and Alpha samplers) and the open dynamic chamber system of the 'Draeger-Tube-Method (DTM)' were tested. Alpha samplers were first used in such an experimental design. The Emissions from urea obtained by the two acid samplers and the DTM correlated strongly with the results of the micrometeorological methods. Alpha samplers were capable of significantly differentiating the NH_3 emissions, quantified by the bLS method ('Windtrax' software), between treatments in the chosen experimental design.

The paper will present a first overall evaluation of the measurement techniques used.

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P-596

Farmyard manure application and associated root proliferation improve the net greenhouse gas balance of Italian ryegrass – Maize double-cropping field

Dr Akinori Mori

The objective of this study was to compare the net greenhouse gas (GHG) balance (NGHGB) of Italian ryegrass – corn (maize) double-cropping fields receiving farmyard manure (FYM), slurry, or methane fermentation digestion liquid (MFDL). FYM, Slurry, MFDL, mineral fertilizer only (Fert.), and no-N control (Cont.) plots were set up in a randomized block design (n = 3). FYM, slurry, or MFDL was applied to meet the K requirement for forage production, and then mineral fertilizers were supplemented to meet the N and P requirements. From September 2017 to September 2020, C inputs as manure and crop residue, heterotrophic respiration (RH), and emissions of methane (CH_4) and nitrous oxide (N_2O) from soil were determined. The similarity of the total yields in FYM, Slurry, MFDL, and Fert. plots reflected judicious fertility management. However, the residue-C input of Italian ryegrass was 38% greater in FYM plots than in the other plots. Manure-C input decreased in the order of FYM > Slurry > MFDL plots. RH was greater in FYM and Slurry plots than in MFDL plots. Net ecosystem C balance (NECB) ([residue-C + manure-C] − [RH-C + CH_4-C]) decreased in the order of FYM > Slurry > MFDL plots. N_2O emission decreased in the order of Slurry > MFDL > FYM plots. Consequently, NGHGB ([CH_4 and N_2O emissions] − NECB) in terms of CO_2 equivalent decreased in the order of MFDL > Slurry > FYM plots, so FYM application contributed most to GHG mitigation.

Mori A (2021) Farmyard manure application and associated root proliferation improve the net greenhouse gas balance of Italian ryegrass – Maize double-cropping field in Nasu, Japan. Sci Total Environ 792: 148332

P-597

EFFECT OF TEMPERATURE AND SUBSTRATE CONCENTRATION ON SOIL L-GLUTAMINASE ACTIVITY

Mr. Manikyala Bhargava Narasimha Yadav, Dr. G. Padmaja, Dr. P. Chandrasekhar Rao

Incubation studies were directed to examine the effect of temperature and substrate concentration on soil L-Glutaminase (L-glutamine amido hydrolase E.C. 3.5.1.2) activity in three black soils and three red soils at Department of Soil Science and Agricultural Chemistry, PJTSAU, Telangana, India. Increase in temperature increased the L-glutaminase activity (µg of NH_4+ released/gram of soil/4h) from 10 to 50°C but decreased sharply with further increase in temperature. Temperature coefficient (Q_{10}) values were <1, as the temperature increased beyond 60°C indicating the deactivation of L-glutaminase. Ea varied from 28.72 to 40.17 with a mean 33.47 KJ/mol. The L-glutaminase activity increased as the substrate concentration increased 2 mM to 40 mM. With additional increment in substrate concentration negligible change in catalyst activity was noticed. At the concentration of 40 mM, L-glutaminase was saturated with L-glutamine and the reaction rate was followed Zero-Order kinetics. Maximum enzyme reaction velocity (Vmax) and Michaelis constant (Km) were determined by application of three linear transformations of the Michealis–Menten equation. The Vmax varied from 10.42 to 47.62 under Lineweaver-Burk transformation. Under Hanes-Wolf plot the values varied from 11.11 to 23.20. In Eadie-Hofstee transformation values varied from 9.55 to 23.31. Km values using Lineweaver-Burk transformation varied from 22.67 to 46.00 mM. Under Hanes-Wolf plot Km values varied from 13.85 to 22.59 mM. In Eadie-Hofstee transformation Km values varied from 15.41 to 22.60 mM. The Km and Vmax for black soils were high compared with red soils its due to presence of Montmorillonite clay mineral and more O.C %.

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P-598

Standardisation of assay of L-glutaminase activity in low organicmatter soils of arid and semi arid tropical soils of south India

Mr. Manikyala Bhargava Narasimha Yadav, Dr. G. Padmaja, Dr. P. Chandrasekhar Rao

L-glutaminase (L-glutamine amido hydrolase E.C. 3.5.1.2) is the soil enzyme that catalyzes the hydrolysis of L-glutamine and produces L-glutamic acid and ammonia. Thirty surface soil samples (10 Red soils and 20 Black soils) of varying physico-chemical properties representing, various cropping systems were collected from Rajendra nagar campus of Hyderabad. The procedure of modified indophenol blue method for assay of L-glutaminase activity in soils was standardized and compared with steam distillation. The activity of L-glutaminase by steam distillation varied from 3.13 to 23.41 µg of NH_4+ released/ gram of soil/ 4h and for modified Indophenol method the values varied from 3.25 to 23.50. Linear regression analysis (R^2 = 0.997) was carried out for activity of enzymes obtained by modified indophenol blue method against steam distillation. Correlation analysis between the soil properties of 30 surface soil samples (10 Red soils and 20 Black soils) and L-glutaminase activity indicated that L-glutaminase was significantly and positively correlated with organic carbon (r = 0.75*), total nitrogen (r = 0.78**), clay content (r = 0.664*) and available nitrogen (r = 0.664*) for Red soils. Similarly in Black soils these was positive and significant also, coefficient correlation with O.C (0.74**), total N (0.688**), clay content (0.475*) and available N (0.69**). For all the soils (Red and Black soils together) highly significant correlation was noticed with O.C (0.73**), total nitrogen (r = 0.686**), clay content (r = 0.514**) and available nitrogen (0.679**). However there was no significant correlation between L-glutaminase activity and pH, total soluble salt content.

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P-599

Quantification and mitigation of ammonia emissions from paddy fields in subtropical central China

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The new designed method for quantifying ammonia emissions can realize measuring ammonia emission at every five minutes automatically. The measured daily ammonia fluxes showed good correlation with solar radiation and air temperature. More than 50% of the ammonia emitted from paddy fields was reduced under treatments with reduced N application combined with deep application of basal fertilizer or urease inhibitor as compared with conventional treatments, while rice grain yield did not show significant difference among the treatments. Deep application of basal N fertilizer and using of urease inhibitor can be good measures to mitigate ammonia emissions from paddy fields.

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P-600

Maintaining of high crop yield and minimizing of nitrogen losses via integrated cropping residues incorporation and water-saving irrigation under sustainable intensified farming: Experiences from a 12-year long term experiment study

Ph.D candidate Xuan Yang, Ph.D candidate Xiuchun Xu, Ph.D candidate Wei Zhang, Ph.D candidate Bang Ni, Professor Wenliang Wu, Professor Fanqiao Meng

Recycling of crop straw and animal wastes, optimized fertilization and irrigation have already long been recognized as promising practices to promote agricultural sustainability, however, most of these studies are not undertaken under intensive agricultural condition. We report the findings from a 12-year experiment, which started in 2008 and was high intensively operated in the North China Plain (NCP). Three treatments were chosen for study, i.e., CK (no fertilizer N input), CON (600 kg N ha-1 yr-1, wheat straw incorporation and conventional irrigation), and OPT (optimized fertilization, inorganic fertilizer with organic fertilizer, wheat and maize straw incorporation and water saving irrigation). For the 12-year period, compared with CON treatment, the OPT treatment increased the N utilization efficiency by 20.7% and reduced the N losses by 43.4% (N leaching), 11.4% (ammonia volatilization) and 28.5% (N2O+NO+N2). Compared with CK, OPT achieved the carbon sequestration rate of 3.70 Mg C ha-1 yr-1 and soil TN increase by 139 kg N ha-1 yr-1 for 0-100 cm soil depth, higher than the CON treatment of 2.31 Mg C ha-1 yr-1 and 81 kg N ha-1 yr-1. The study highlighted that intensification agricultural practices help to tackle the current dilemma of grain supply and carbon neutrality.

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P-601

Large climate benefits could be achieved by reducing nitrous oxide emissions over small fraction of the world's croplands

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Mitigating soil nitrous oxide (N2O) emissions is essential for staying below a 2°C warming threshold. However, accurate assessments of mitigation potential are limited by uncertainty and variability in direct emission factors (EFs). To assess where and why EFs differ, we create high-resolution maps of crop-specific EFs based on 1,507 georeferenced field observations. Here, using a data-driven approach, we show that EFs vary by two orders of magnitude over space. At global and regional scales, such variation is primarily driven by climatic and edaphic factors rather than the well-recognized management practices. Combining spatially explicit EFs with N surplus information, we conclude that global mitigation potential without compromising crop production is 30% [95% CI: 17-53%] of direct soil emissions of N2O, equivalent to the entire direct soil emissions of China and the United States combined. Two thirds (65%) of mitigation potential could be achieved on one fifth of global harvested area, mainly located in humid subtropical climate and across gleysols and acrisols. These findings highlight the value of a targeted policy approach on global hotspots that could deliver large N2O mitigation as well as environmental and food co-benefits.
Cui, X., Zhou, F.*, Ciais, P. et al. Global mapping of crop-specific emission factors highlights hotspots of nitrous oxide mitigation. Nature Food (2021). https://doi.org/10.1038/s43016-021-00384-9

P-602

Key rhizosphere traits of wheat landraces to overcome P limitation in calcareous soils

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Wheat is a staple food crop in most of the developing countries, i.e., Afghanistan. Long-term climate fluctuations pose negative impact on the productivity of many modern commercial cultivars. Furthermore, wheat cultivation often on calcareous soil that tend to immobilize P due to high pH and the presence of bivalent cations. Therefore, rhizosphere traits circumventing this immobilization potentially hidden in Afghan wheat landraces are crucial to be identified. Therefore, this study aims i) to determine fertilizer P immobilization by limestones, and ii) to identify critical rhizosphere traits for remobilization and uptake of calcium-bound P.

In the first experiment, defined limestones were placed in rhizoboxes fertilized by liquid P fertilizer with 33P activity. Subsequently, the limestones' P immobilization was measured. The capacity of three Afghan wheat landraces for P mobilization was tested in the second experiment against a modern hybrid wheat variety. 33P enriched limestones were placed inside of an exclusion mesh barrier in order to separate the mobilization happening by hyphae only and root plus mycorrhizal hyphae.

It was found that a significant proportion of added fertilizer phosphate was being immobilized by the limestones, even inner limestone structures. The landrace KU-716 showed higher P assimilation than other genotypes. Mycorrhiza symbiosis alone does not promote mobilization of calcium-immobilized P. Therefore, breeders will have to look for alternate solutions promotion of root exudation or their composition, playing a potentially high role in Ca-bound P mobilization by roots.

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P-603

Phosphorus Retention and Release from Soils Impacted with Poultry Litter

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Phosphorus (P) loss from agricultural lands is the primary contributor for degradation of water quality and is a major environmental concern. Transport of P in soil depends on the P retention capacity of the soils. Phosphorus sorption isotherms are widely used to determine the soil P retention capacity. Additionally, the solubility, reactivity, and bioavailability of P depends extensively on the P species and hence plays a critical role in the environmental fate of P. Recently, P saturation ratio [PSR; molar ratio of P/(Fe+Al)] is used effectively to determine environmental P loss risk. The objectives of this study were to a) determine P sorption-desorption parameters of P impacted soils; b) evaluate the relationship between sorption-desorption parameters with soil P fractions and PSR. Soil samples were collected from highly weathered regions of Alabama with annual P applications in the form of poultry litter (PL) and were separated into four depths:0-5, 5-15, 15-30 and 30+ cm. The inorganic P (Pi) and organic P (Po) forms were determined using sequential Hedley fractionation. The P retention characteristics of the samples were determined using traditional Langmuir isotherms. The P saturated soils were then sequentially desorbed for seven cycles. Unlike the lower soil depths, desorption of P was almost complete for 0-5 cm soils after five successive 24-h extractions. Langmuir sorption maxima Smax was strongly positively related to the clay content and crystalline Fe and Al oxides and was negatively related to labile Pi forms, equilibrium P concentration (EPC), originally sorbed P (So) and soil PSR.

P-604

Deriving soil P indicators related to crop yield and runoff risks to assess long-term sustainable fertilizer P inputs

Ms Yu Gu, Dr. ir Gerardus Hendrik Ros, Dr Qichao Zhu, Prof. dr. Minggang Xu, Prof. dr. ir Wim De Vries

We assessed the impact of long-term P addition, with varying P fertilizer and manure types, on changes in different P pools in soil, and evaluated how crop yield and environmental risk respond to legacy P in wheat-maize rotation systems in China. The concentrations of soluble, fast reactive, slow reactive and total P pools (extracted with $CaCl_2$, $NaHCO_3$, oxalate and acid) under nine fertilization treatments were monitored over 30 years, together with crop yield and P uptake. Long-term surplus P inputs significantly increased the concentrations of the four P pools, with relative changes decreasing from more than 20 fold for $CaCl_2$, 10 fold for $NaHCO_3$, 5 fold for oxalate and 2.5 fold for total P at a P accumulation near 6000 kgP ha^{-1}. The redistribution of P inputs over the pools varied with the degree of P legacy, with Olsen P and oxalate P levels coming at a maximum (saturation) at a P accumulation near 3000 kgP ha^{-1}. Above a critical P-$CaCl_2$ level near 2 mg/kg, crop yield did not respond anymore. We found a strong relationship between the P-$CaCl_2$ concentration and the P saturation index, being the ratio Poxalate/(Al+Fe)oxalate. A tipping point of enhanced P-$CaCl_2$ levels was observed near a PSI of 0.2, known as an upper critical value for enhanced P runoff risk to surface water. The critical P-$CaCl_2$ level near 2 mg/kg was also reached near a PSI of 0.2. This implies that the target agronomic P level equals an upper critical value for enhanced P runoff risk.

P-605

Mobility of Easily Soluble Phosphorus in Sewage Sludge Compost and Their Supply to Leafy Vegetable

Takuro Matsumi, Akari Taguchi, Masahiko Katoh

Sewage sludge is expected to be used for agriculture. Coagulant during the sewage treatment process decreases the phosphorus(P) availability even if a sufficient P is contained. A column percolation and cultivation tests were conducted to clarify the supply of easily soluble and non-soluble P in five sewage sludge composts(SSC) with different P phases to Brassica rapa var. perviridis with a short cultivation period. Swine manure compost (SMC), chemical fertilizer(CF), and no-P were prepared as controls. Composts were applied to Gray Fluvic soil at 200 mg-P_2O_5/kg as total P. In the cultivation test, chemical fertilizer compensated for the lack of N and K derived from composts. Plant biomass and nutrient uptake was evaluated after 28 days cultivation period. The relationship between the available P in soil after cultivation and the P migration rate in percolation test was investigated. The plant biomass of four SSC was compatible or higher than that of SMC and CF except one type of SSC. Plant biomass and P uptake showed a strong positive linear relationship. P uptake didn't show a clear relationship with the P migration rate, but it showed a positive linear relationship with the available P in soil. On the basis of the relationship between the available P in soil and P phases in compost, the easily soluble P in SSC was supplied as available P. In some SSCs with a low Ca content, HCl extract P was also supplied as available P.

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P-606

Effect of poultry manure application on soil quality indicators to improve soil organic carbon storage and pasture production on degraded Andisols.

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Excessive inputs of inorganic phosphorus (P) fertilizers in pastures could negatively affect soil microorganism activity associated to P cycling thus, increasing organic P accumulation, particularly in the form of phytate which is hardly available for plant uptake. Several studies had pointed to poultry manure (PM) as an interesting option to enhance soil quality properties including soil organic carbon (SOC) storage as well as to increase pasture production. To evaluate the long-term effect of poultry manure and inorganic fertilizer application on the physicochemical soil quality indicators in pastures developed on Andisols under field conditions a total of 10 pastures sites fertilized with PM and inorganic fertilizers were sampled. Soil bulk density, SOC, exchangeable Al, Ca, K and Mg, and soil P availability were assessed as physicochemical quality indicators. In addition, dry matter production and P concentration in shoots and roots tissues were determined. Physicochemical indicators were enhanced in soils following PM amendment as compared to inorganic fertilizers. SOC ranged from 9.8 to 12.6% in soils amended with PM and from 8.7 to 10.9% in soils with inorganic fertilization. Available P and acid phosphatase were increased in some soils fertilized with PM while it was dependent of soil type. Moreover, P concentration and biomass production of shoots and roots was higher in soils amended with PM as compared to inorganic fertilization. The study of soil quality indicators is crucial to enhance pasture production in Andisols and contribute to ensure food security, considering the critical challenge of feeding the rising world population.
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P-607

Effect of Chemical Fertilizer Combined with Soil Conditioners on Phosphorus Leaching and Physicochemical Properties of Coarse-Textured Soil

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Coarse-textured soil is characterized as an infertile soil because low nutrients, cation exchangeable capacity (CEC), water retention and high nutrients leaching, including phosphorus (P). Appropriate soil conditioners could improve physicochemical properties and reduce P leaching from soil. This study was conducted to investigate the effect of soil conditioners (zeolite and pumice) on P leaching and physicochemical properties of coarse-textured soil. Soil column leaching experiment was arranged to investigate P leaching and field experiment was conducted to investigate physicochemical properties. Loamy sand texture was used in this study. Treatments were designed as follows: 1) control, 2) chemical fertilizer (CF), 3) CF + zeolite (CFZ), and CF + pumice (CFP). All treatments had equal nutrients, except control. The results from leaching experiment showed that leachate from CFZ contained soluble P and K significantly lower than CFP and CF. Soluble P in leachate of most treatments except CFZ was the highest at the beginning (1 or 7 days) and gradually decreased to the lowest at the end (21 days). Results from field experiment were supported with the leaching experiment because available P and CEC of CFZ were significantly higher than CF and control. For CFP, it showed that available water capacity (AWCA) was higher than CF and control. However, available P and AWCA between CFZ and CFP were not different. Overall, it suggests that soil conditioners could reduce P leaching and improve water retention based on its characteristics. Lastly, long-term studies are needed, based on the requirement of local people and socio-economic constraints.
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P-608

The beneficial role of silicon fertilization on physiological features and yield of barley cultivars grown at different phosphorus supply

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Low phosphorus (P) availability in soils is a limiting factor for crop production worldwide, and numerous studies have highlighted the role of silicon (Si) improving plant tolerance to P deficiency (Vance et al. 2003; Hu et al. 2021). We investigated the effect of Si fertilization on physiological features and yield of barley cultivars grown at different P supply. A field assay was conducted on Andisol using two barley cultivars with contrasting P deficiency tolerance (Traveler, sensitive; and Sebastian, tolerant). Two P doses (0 and 200 mg P kg-1 soil) in combination with three Si doses (0, 250, 500 mg Si kg-1 soil) were applied, and three different growth stages were evaluated. An enhancement of CO2 assimilation, stomatal conductance and transpiration rate, as well as a reduction of oxidative damage across the growth stages were observed as a consequence of Si application to both cultivars grown at 0 P. Silicon also improved the number of spikes/m2, number of grains/spike and grain yield of both cultivars irrespective of P supply. Interestingly, a clear separation among treatments was displayed by a Principal Component Analysis, which explained a 67.1% of the total variance. An overlapping between 200 P-0 Si and 0 P-250 Si treatments was observed denoting that Si could attenuate the oxidative stress induced by P limitation mainly in the sensitive cultivar. Moreover, when 200 mg P kg-1 were applied in combination with either 250 or 500 mg Si kg-1, a positive direction to photosynthetic and yield parameters was found, suggesting a synergistic effect between P and Si supply on barley.

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P-609

Stratification of phosphorus forms and its implication in soils with repeated poultry litter applications

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Poultry litter (PL) is an excellent source of plant nutrient and is mostly land applied as the primary waste management strategy. Since PL is bulky, long-distance transportation is economically limited. Repeated application of PL in localized area along with no-till practice results in soil phosphorus (P) stratification. There is a need to understand the distribution of P forms (highly reactive P, HRP; moderately reactive P, MRP; and non-reactive P (NRP) within the soil layers. Phosphorus saturation ratio (PSR, molar ratio of P/(Fe + Al)) is used as a tool to determine environmental P loss risk. The objective of this study was to understand the distribution of P forms within the soil profile and the relationship between various P forms and soil PSR. Soil samples from agricultural lands with long term PL application history were collected and separated into four depths: 0-5, 5-15, 15-30, and 30-45 cm. Phosphorus fractionation was performed using sequential Hedley fractionation method. The PSR of the soils were determined using oxalate extract. Results indicated that the soils were acidic, and the pH ranged from 4.9 to 7.0. The P forms were highly stratified within the soil layers, with reactive P (HRP + MRP) as the dominant P form for the surface 0-5 cm depth and NRP as the dominant form for the lower depths (15-30 and 30-45 cm). The PSR was significantly higher for the surface (0-5 and 5-15 cm) compared to the subsurface soils and was linearly related to HRP and MRP forms.

P-611

Soil characteristics and soil biological activity is key in P-supply of corn at cold early spring in Central-European soils

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Inorganic P-fertilizers are frequently applied to corn for enhanced early spring germination and growth in the temperate regions. Field experiment was designed to study the effect of starter P-fertilizers (5-, 30 kg P2O5 ha-1) at conventional agricultural practices with corn (Zea mays, FAO number is: 350) on siltic Luvisol (pH=4.91; SOM=1.64%; available P2O5=66 ppm) and on silty clay Gleysol (pH=6.75; SOM=2.53%; available P2O5=303 ppm). Height of plants, root and shoot biomass production, the yield at the end of the vegetation period, the phosphatase enzyme activity and the amount of labile carbon of the soils were assessed. Resulting the starter P-fertilizer, a better early biomass production (at 5-6 leaves-stage) was found at both soils. Finally, not a yield- increasing effect could be realised, even though the shoot and root biomass production were increased. Phosphatase enzyme activity and labile carbon decreased during the growing season due the decrease in soil moisture and microbial activity. The significant higher phosphatase enzyme activity and labil carbon in the Gleysols explained by the higher water holding capacity, higher soil organic matter and organic phosphorous content. Microbial inoculation by Pseudomonas putida, Azotobacter chroococcum, Bacillus circulans, Bacillus megaterium had no effect on the P-uptake of corn. We assume that at early spring with low soil temperature (10 oC) the starter P-fertilizer can improve corn growth and development. Cost of fertilizer however can be realised only ecologically during a short vegetation period at a dependence of the soil characteristics. Keywords: phosphorus starter fertilizer, biofertilizer, corn, soil types, soil biology

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P-612

Phosphorus management and the relationship between differing soils capacity to regulate P availability for plant uptake in Scotland

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A new and novel soil specific approach to P management has allowed better use of soil reserves to reduce P fertiliser by using differing soils capacity to regulate P availability for plant uptake and improve sustainability of food production. The approach is novel as it is the first to make use of high-resolution spatial data directly in nutrient use recommendations. This has been made possible due to easily available spatial information to farmers through web resources such as https://soils.environment.gov.scot/.
Adsorption of inorganic P derived from fertiliser is controlled by adsorption reactions on mineral surfaces that include (hydr)oxide type mineral surfaces and the variable charge edge sites of phyllosilicate clays. Data for 400 soils (Ap horizons) representing 38 soil associations (soil mapping unit based on parent material) were collated. P sorption categories were determined from that data set by ranking soils according to their oxalate Fe+Al extractable values. P sorption was assumed to be a linear function (Fe + Al) ox. The ranked values were then split into 3 categories of P sorption capacity (PSC) and mapped as index 1, 2 and 3 to reflect inherent soil PSC i.e., low, medium, and high PSC respectively.
Adjustments to P fertiliser recommendations have been made taking account of PSC indices to build-up or run-down to the target soil P tests.

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P-612

Phosphorus and potassium content changes in an acidic, humus-poor sandy soil and in ryegrass after application of different compost doses

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Every year gets more and more household-, food industry- and agricultural by-product in waste landfill, while large part of these wastes would be beneficial using as plant nutrient, because they contain high content of macro-elements, and this would be an excellent material to produce high quality composts. To clear the effects of different compost doses were mixed with acidic sandy soils low in humus content. The applied compost ratios were: 0, 5, 10, 20, 30, 40 and 50 %. The 2.5 kg pot experiment was set up in four repetitions in the greenhouse of our Institute. The experimental plant was perennial ryegrass (Lolium perenne L.). At the end of the vegetation time soil and plant samples were collected from each pots. The nutrient elements were measured in the dried plant tissues. After drying of soil samples their plant nutrient content were also analyzed. There were used a strong and a weak extractant: the ammonium lactate – acetic acid (AL) solution according to Egner et al. (1960) and the calcium chloride solution according to Houba et al. (1990).
It was concluded, that the by the compost provided plant nutrients (such as P and K) were extracted by the perennial ryegrass plants only in a small amount and especially in the case of higher compost doses the majority of nutrients were found remaining in the soils. This fact is predicting that using of plant origin compost treatments can be an advantageous solution for the enhancing the conditions of flying sandy soils too.

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P-614

Sustainable Soy and Sustainable Nutrient Management: The Critical Role of Phosphorus

Miss Hannah Walling, Professor Mariana Rufino, Professor Philip Haygarth

Phosphorus (P) can limit soybean growth and there are clear environmental risks associated with the accumulation of “legacy” phosphorus within soils. However, inefficient phosphorus fertilizer use is widespread amongst soybean cropping systems and studies of P stoichiometry in soybean are limited and the impact of P on soybean yield is not well documented, especially in the tropics. It is hypothesized that P limitation within soybean production has onward stoichiometric effects on nitrogen fixation rates and hence crop potential and crop yields (Bello, 2021). Inefficient P use through potential overfertilization within soybean cropping systems can lead to leakage to water and the consequential eutrophication of surface waters, alongside the accumulation of consequential quantities of “legacy” phosphorus. Soybean’s (Glycine max [L.] Merr) global significance as the 4th most important grain crop in terms of production, acting as a vital source of both protein and vegetable oil globally, means it is key that “legacy” phosphorus and phosphorus fertilisers are effectively utilised to sustain high soybean crop yields (Grassini et al., 2021). Here we present novel research which aims to improve phosphorus efficiency and the utilisation of P pools through the development of an improved, integrated crop modelling approach that incorporates phosphorus partitioning and can be applied to soybean cropping systems across a range of environments. Improved theoretical understanding will underpin further experimental work to derive critical parameters for modelling, which will be used to explore strategy for more efficient use of P in soybean systems.

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P-615

Deep phosphorus stocks in floodplain subsoils – New insights and implications for sustainable management

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Despite decades of management efforts, it has not been possible to effectively curb freshwater eutrophication in all affected ecosystems. This may be due to insufficient knowledge of the sources of phosphorus (P) input to surface waters. In the literature, P loss from soil to water is largely attributed to processes at the soil surface (e.g., erosion, runoff). However, the impacts of P in the subsoil have rarely been studied, which would be important for groundwater-affected soils. We investigated P distribution in floodplain soils in central Germany and found systematic enrichment of readily soluble P between an average depth of 87 and 200 cm. Water-soluble P in these "deep P stocks" was positively correlated with total P concentrations in adjacent surface waters, suggesting hydrological exchange between the two via the groundwater. Moreover, P concentrations in the deep P stocks differed between dry periods with low flow and moist periods with higher flow, indicating that more temporally resolved research strategies are needed to learn more about the dynamics of subsoil P loss. Deep P stocks can be considered a new source of diffuse P losses from soil to water. They should be considered in the development of best management practices to effectively control freshwater eutrophication.
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P-616

Plant nutrient and harmful heavy metal concentration in agricultural soils of the EU-28

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The EU's Farm-to-Fork strategy aims to reduce nutrient losses by 50%, which is expected to decrease the requirement for fertilisers by 20% by the year 2030. To reach these ambitious targets, it is of utmost important to know the nutrient status of agricultural soils to optimise fertilisation to reach optimal yields. Furthermore, substitution of mineral fertilisers with bio-based fertilisers (BBF) reduces the need for finite mineral phosphorus (P) sources and production of energy intensive mineral nitrogen (N) fertilisers.
Several soil testing methods, especially for P, exist in Europe for determining fertilisation requirement. This complicates comparisons of fertilisation schemes across Europe. Furthermore, soil heavy metal contents need to be considered to ensure food and feed safety.
In this study, a sub-set of soil samples from the LUCAS soil sample archive, collected in 2015 (https://publications.jrc.ec.europa.eu/repository/handle/JRC107926), were analysed for their soluble elemental composition. The selection of soil samples from the EU-28 countries was based on proportional allocation with the following criteria: soil pH, carbonate content, texture, organic carbon content, and Olsen-P values. A total of 1,661 soil samples from cropland (out of 9,246 samples) and 695 samples from grassland (out of 4,055 samples) were selected and soluble elemental concentrations were analysed with the electro-ultrafiltration (EUF) method.
Regional plant nutrient and harmful heavy metal concentrations are presented as choropleth maps for depicting regional fertiliser requirement across Europe. These maps will be further utilised for determining the quality requirement for BBFs, and thus technological requirements for their production for ensuring food and feed safety.

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P-616A

Fertilisation with composts: Effects on soil P legacy

Dr. Carmo Horta, Msc Marta Batista, Msc Abel Veloso

Composting is one of the priority processes to valorise livestock slurries as soil organic amendment, contributing to increase the carbon stock in the soil, and to the goals for the circular economy in agriculture. However, the content in nutrients of the composts, namely in nitrogen (N) and phosphorous (P) should also be considered in the fertilisation planning since they are in bioavailable forms. The objective of this work was to assess the effect on the soil P legacy when using a compost as source of organic matter and nitrogen (No) to crops. A field experiment was carried out with lettuce fertilised with compost (CP) or with N mineral fertilizer (Ni) in a completely randomized design. The treatments were: Control (CT) without any fertilization, N mineral fertilization (Ni) at a rate of 85 kgNi/ha (Ni85), compost application at a rate of 170 kgNo/ha (CP_No170), and compost plus Ni at a rate of 85 kgNo/ha and 42.5 kgNi/ha (CP_No85_Ni42.5). The soil used in the experiment had high P content. The N:P ratio of the compost was 4:1. The results showed significant ($p < 0.05$) increase in the SOM from 5.3% in CT, to 5.8% in CP_No170. Also, the Olsen P increased significantly ($p < 0.001$) in the CP treatments from 72mg kg-1 in CT, to 91 or 88mgkg-1 in CP_No170 and in CP_No85_Ni42.5. These results highlight the need for considering the N:P ratio of the composts used as soil organic amendments and apply composts at a rate that didn't exceed P crop needs.

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P-617

Soil Phosphorus Fractions under Different Land Uses in the Mid-Elevation Mountain Area, Taiwan

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Phosphorus (P) is essential for plant growth; however, labile P in soil is usually deficient and typically growth-limiting. Forest floor is the primary source of P in a forest, and it disappears once forests are converted into croplands. In this study, Japanese cedar (Cryptomeria japónica) and Taiwania (Taiwania cryptomerioides) forests with thick forest floor and abundant soil organic matter and the typical local economic croplands, tea tree (Camellia sinensis L.) and Moso bamboo (Phyllostachys pubescens) plantations in Xitou tract, the experimental Forest, National Taiwan University, were selected as the study sites. Soil physical and chemical properties were investigated, and the soil phosphorus sequential extraction method was used to assess the influence of land uses on the amounts, forms with different availability. The results showed that NaOH-Pi, NaOH-Po, and residue-P were the dominant fractions in all land use types, and tea and bamboo plantations showed significantly higher NaOH-Pi than in forests. Meanwhile, NaOH-Po and residue-P in the Japanese cedar and Taiwania forests were greater than in the tea and bamboo plantations. Except for the lowest NaHCO3-Po among all study sites, tea plantations showed the greatest amount in all P fractions. Compared to other land use types, the greater H2O-P and NaHCO3-Pi in the tea plantations indicated the available P increasing because of long-term chemical fertilization. Although Japanese cedar and Taiwania forests had the lower H2O-P and NaHNO3-Pi than two croplands, the higher NaHCO3-Po can still be provided for plan growth after mineralization.

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P-618

Is it possible to mitigate P runoff losses by amending soils with ferric chloride?

Is it possible to mitigate P runoff losses by amending soils with ferric chloride? Paula Codina[1], Is it possible to mitigate P runoff losses by amending soils with ferric chloride? Carlos Perdomo[1]
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In Uruguay, agriculture is responsible of 80% of phosphorus (P) input into freshwater courses. Particulate P (PP) and soluble P (PS) is transported mainly by surface runoff. Therefore, research focused on management measures aimed at reducing these contributions, are extremely necessary. In the recent years, application of chemical products (such as $FeCl_3$ and $AlCl_3$) with a high P soil retention potential, are being evaluated as a possible management strategy to reduce sites with high soil P levels.. The aim of this study was to quantify the amount of P removed from surface runoff as a result of soil amendment with ferric chloride ($FeCl_3$). Runoff was monitored in small microplots (0,5 m^2) under natural (UN) and simulated (SL) rainfall conditions. Contrasting situation were compared: 9 kgFeha-1 application vs. control (zero amendment). In SL treatments, Fe application resulted in a reduction of 66% and 60% in PS and PP losses respectively, while in UN treatment, reductions resulted comparable to those observed with SL treatment. This suggests that $FeCl_3$ may be able to retain PS and PP fractions, thereby reducing total P (PT) losses with superficial runoff. However, the overall result, will depend on specific conditions of each site (labile P concentration, use and management of ground).

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P-619

Long-term P fertilization and tillage effects on rhizosphere P dynamics of maize and soybean

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The processes that occur in the rhizosphere determine the dynamics and plant availability of soil nutrients. In this study, we evaluated the effects of long-term phosphorus (P) fertilizer application on the dynamics of P in the rhizosphere of juvenile maize (Zea mays L.) and soybean (Glycine max L. Merr). Undisturbed soil samples (3 x 9 x 33 cm) were collected from a 25-year, 2×2 factorial experiment of P fertilization (0 and 63 kg P ha-1 y-1) and tillage management [chisel plow (CP) and no-tillage (NT)]. The soil samples were placed in two-chamber rhizoboxes. Maize and soybean were grown for 14 days under controlled conditions. Soil solution was collected from the rhizosphere (< 3-mm from the root surface) and bulk soil (> 8-mm from the root) with micro-suction cup lysimeters and analyzed for PO_4-P via ion chromatography. Rhizosphere and bulk soil samples were also collected directly from the rhizoboxes to analyze phosphatase activity. Maize shoot dry matter production was higher in P-fertilized soil. Phosphorus-uptake efficiency from maize rhizosphere solution increased by 20% in NT soils compared to CP soils. Similar responses were not observed for soybean. In all treatments, the concentration of P in the soil solution was lower at the root surface than in the bulk soil. Unexpectedly, rhizosphere and bulk soil phosphatase activity did not differ; however, there were complex treatment effects that depended on the crop. In general, long-term P fertilization and tillage had complex, interactive effects on maize and soybean rhizosphere P dynamics.

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P-620

Effects of Phosphate-solubilizing Bacteria on Corn under an Environmentally-friendly Farming System in Andisols

Project Management Professional, PMP Ke-Chun Lin, Dr. Pi-Hui Suzi Chang, Mr. Cheng-Han Yang, Mr. Po-Hsien Sun, Mr. Wen-Chieh Lin, Professor Zueng-Sang Chen

The Andisol of Guandu Plain has faced the challenge of low phosphorus availability in volcanic soil under long-term conventional farming systems. The aim of this study was to increase soil phosphorus availability while cultivating corn (Zea mays L.) via an environmentally-friendly farming system and applying commercial phosphate-solubilizing bacteria (PSB, with Bacillus licheniformis) combined with different levels of compost (Comp) as top dressing. At the beginning of this study, the PSB activity was checked by a NBRIP medium, and clear zones were visually detected. Also, soil phosphatase activities were determined by a 14-day ex-situ incubation with treatments as control, Comp, PSB, and Comp+PSB. The results showed that Comp+PSB maintained the highest phosphatase activity during the incubation, which may deliver benefit to corn growth. A field experiment was conducted with the same level of basal compost, from 2020 until 2021, to evaluate the effects of different levels of compost combined with or without PSB as top dressing, treatments of no compost (only PSB and blank), half compost (0.5Comp+PSB and 0.5Comp), normal compost (Comp+PSB and Comp), and double compost (2Comp+PSB and 2Comp) were applied in the field. The results showed that the corn height, chlorophyll content and yield had a positive correlation with the level of compost. In contrast, the effect of PSB on corn growth was not obvious in the field experiment. In summary, a high level of compost as top dressing would be more helpful than commercial phosphate-solubilizing bacteria for corn growth in the Andisol of Guandu Plain.

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P-621

Mineralization and speciation of organic phosphorus in a cropped sandy soil under mineral P fertilization for 28 years

PhD Fellow Pablo Raguet, Barbara Cade-Menun, Alain Mollier, Dalel Abdi, Noura Ziadi, HDR Antoine Karam, Christian Morel

Soil organic phosphorus (SOP) mineralization should play a role in plant nutrition but its quantification is rarely reported and mineralization vs speciation linkage has not been studied (Haygarth et al., 2018). We determined SOP mineralization using time series data of a 29-years field experiment (1972-2000), cropped under maize, fertilized at 0, 44, and 96 kg P ha-1yr-1 (triple superphosphate). We calculated P in above- and below-ground residues using P harvest index and shoot-to-root ratio. The SOP stock in the ploughed layer was determined by ignition method (SOPSW) (Saunders & Williams, 1955). The soil P speciation were determined in 2000 using P-NMR in NaOH-EDTA extraction (Cade-Menun & Preston, 1996) Inorganic P stock strongly varied with years and fertilization whereas SOPSW increased by 1.5 (±1.0) kg P ha-1yr-1. The gross annual rate of mineralization (garm) was calculated using SOP dynamics modeling including initial stock (368 kg P ha-1) (Andriulo et al., 1999; Hénin & Dupuis, 1945), SOP gross mineralization coefficient (K), P in residues and their P humification coefficients. P in residues significantly differ across years and fertilization (overall mean of 17.1 kg P ha-1yr-1). The model calibration with time series of measured SOPSW, gave K=0.005 yr-1 and garm = 1.7 (±1.6) kg P ha-1yr-1. Orthophosphate monoesters (93%) and diesters (4%) did not differed significantly across P treatments. The garm value was explained by orthophosphate monoesters sorption, stabilizing them strongly. Further similar studies are required in other agroecosytems to confirm this minor role of SOPSW mineralization in plant nutrition.

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P-622

The biogeochemistry of sphagnum acid in northern peatlands

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Sphagnum-derived phenols have been clearly distinguished from lignin phenols in moss-dominated peat using thermally assisted hydrolysis and methylation (THM/GC-MS) (Abbott et al., 2013). These biologically active phenolics structurally support and mask cell wall polysaccharides, inhibiting microbial decay e.g. the recalcitrance of Sphagnum plant litter can be partially attributed to (E)-3-(4-hydroxyphenyl)pent-2-enedioic acid which is exclusive to the moss. The stability and fate of these compounds will be explored in this presentation.

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P-623

Forest conversion to plantations induce changes in soil chemistry and mineralogy

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Land-use intensification directly affects soil properties and functions. However, little is still known of the effect of LUI on soil mineralogy. Here we explore the impact of native forest conversion to plantations in the chemical and mineralogical composition of five contrasting soils.
The study considered five sites: two residual soils from Schist (SCH), Granite (GR), and tree transported derived from Recent Tephra (RA), Young Ash (YA), and Old Ash Deposit (OA). Deep soil profiles to a depth of 240 cm were fully described and sampled by genetic horizons. The clay mineralogy of each horizon was studied by XRD and quantified using NewMod® and selective dissolutions (CBD, Oxalate, Pyrophosphate). Other chemical parameters determined included pH-H2O, pH-KCl, CICE.
Overall, we found differences between NF and PL in pH, Feox/Fed and Alox/Ald ratios, and clay mineralogy. However, the extend of mineralogical alterations varied. Crystalline soils (SCH, GR, OA) under PL displayed a lower Feox/Fed ratio, suggesting that PL's drier conditions favor Fe-oxide crystallization. We also found that PL soils present greater SOM-Al complexation and loss of Al from Gibbsite and interlayered micas (GR and YA), enhanced weathering, and higher amorphous silica phases precipitation in the RA site. The Andosol (YA) under PL increased Halloysite and amorphous silicate precipitation but a decrease of gibbsite and cristobalite. These results highlight the profound alterations that the conversion of NF may have on soil systems and that the mineralogy of different soil types responded differently to forest use intensification.

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P-624

Historical effects on aggregate stability and SOC storage during forest succession

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Widespread loss of forests in Europe has radically reduced forest cover across the continent, with only 4% now considered undisturbed primary forest[1]. UK forest cover represents 13% of the total land area, slowly recovering from a record low of 5% at the start of the 20th century[2]. The reversal of forest cover loss is a key target for many governments, driven by the multiple benefits generated by forest ecosystem services, and the urgency for mitigation measures to combat climate change. However, little is known about the impact of woodland creation on soils, which act as irreplaceable multifunction mediators in the provision of numerous ecosystem services. Soil aggregate stability is an important physical indicator of soil health, quantifying its ability to resist degradation under disruptive pressures. Many studies have investigated the effects of land-use change on SOC and water-stable aggregates (WSA), but very few of these focused on forests and its succession[345] This study examines the links between aggregate stability and SOC storage in secondary temperate forests as they develop on previously farmed land. We use a space-for-time approach to select a chrono sequence of 30 secondary forest patch ages (10-160 years old) and to compare with 10 ancient woodlands (minimum age 250 years) and 5 areas of adjacent farmland. We seek the answer to three pressing questions: (1) what happens to soil aggregate distribution as forests mature; (2) how does SOC change over time; (3) and will SOC be gradually locked in smaller and more stable aggregate fractions over time.

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P-625

Which organic matter-rich fertilizers may increase Zn, but not Cd, in wheat grains?

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Zinc (Zn) is an essential micronutrient for humans and plants. Wheat grown in soil with low Zn bioavailability can exhibit Zn deficiency, which may limit biomass yields and decrease the nutritional value of resulting food products. Organic matter-rich fertilizers, such as green manure, farmyard manure, or compost, can increase plant-available Zn in the soil, either through direct addition of available Zn or by solubilizing Zn immobilized in the soil solid phase. However, an increase in available Zn can be associated with an increase in available cadmium (Cd), a toxic trace element with similar biological uptake pathways as Zn. The effect of the fertilizer on Zn/Cd availability will depend on the chemical properties of the treatment, such as total elemental content of C, N, S, Zn, Cd, and organic matter composition. To better understand the effects of organic matter application on Zn/Cd uptake by wheat, we must evaluate how the variety of organic matter-rich fertilizers available for use in agriculture may increase the bioavailability of soil Zn/Cd. We have performed a survey of thirty fertilizers of diverse compositions and have characterized organic matter composition (via pyrolysis GC/MS), total elemental composition, and Zn/Cd binding to high- and low-molecular weight organic compounds. As a next step, we will select three fertilizers with distinct organic matter composition and apply them in a pot experiment to evaluate their effect on Zn/Cd uptake in wheat.

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P-626

Effects of soil microbial inoculants on mineral leaching and nutrient bioavailability

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Most nutrients essential to plant growth and development originate from the mineral component of the soil and are made available to plants through interactions between soil microorganisms and colloids. The role of Clonostachys rosea, Bacillus subtilis and Paenibacillus polymyxa in enhancing soil fertility and plant performance and defence against pathogens has been well documented. However, their interaction with minerals in soil and impact on nutrient bioavailability have not been studied yet. The aim of this study is to test their impact on mineral weathering and the release of nutrients to the soil solution. Four soils from different countries with various structures, textures and compositions were inoculated with either C. rosea, B. subtilis or P. polymyxa. After six months of incubation in the dark, at 25° C, changes in soil mineralogy (X-ray diffraction), mineral composition at the nanoscale (SEM-EDS), phosphorous, potassium, iron and magnesium concentration in different soil fractions (ICP-AES) were assessed alongside the microbial community structure using 16S rRNA gene and ITS sequencing and activity based on MicroResp analyses. The outcomes provide new insight into soil processes associated with biogeochemical cycles of minerals key to plant health. The findings will help develop sustainable strategies for increasing soil fertility to meet global food demand.

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P-628

Percolating dissolved OM initiates water-stable soil structure formation in various soil textures

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The interactions between mineral particles and soil organic matter (SOM) are an important factor for soil structure formation. Percolating dissolved organic matter (DOM) from upper soil horizons is considered the main source of subsoil organic carbon (OC) in temperate soils. While DOM sorption processes have been extensively studied, the effect of DOM input on soil structure formation has rarely been looked at systematically. We conducted a short-term laboratory incubation experiment to investigate the processes of DOM-induced structure formation in artificial model soils with three contrasting textures (clay loam, loam, sandy loam).

The mixtures' texture defined the pore system and the flow characteristics, leading to a lower liquid retention and faster soil solution turnover in mixtures with a higher sand content. In contrast, the OC retention was unaffected by the texture, indicating that only the clay minerals and iron oxide, but not the texture-defining quartz grains contributed to the OC sorption.

The total microbial biomass, as well as the CO2-release were unaffected by the texture. In contrast, the microbial community composition showed a texture-dependent development with a higher proportion of fungi and gram-positive bacteria in the sand-rich mixtures. This suggests that texture-related architectural features shape the microbial community composition.

The biochemical processing of the added DOM solution induced the formation of large macroaggregates in all textures without the presence of physical OM nuclei. The water-stability of the formed aggregates could be established by very low OC concentrations, although those were not sufficient to provide any meaningful stability against mechanical load.

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P-629

Examining the soil carbon response to land use change through the lens of microbiome traits: the role of soil pH

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Soils are important terrestrial carbon stores whose management offers a potential solution to help mitigate climate change. Agricultural practices tend to reduce soil organic carbon (SOC), since soil disturbance and reduced resource availability can stress the soil microbiome, altering its physiology and ability to incorporate carbon into its biomass. In this study, we examined the impact of increased land use intensity (LUI) on the microbiome and carbon response of two soils with contrasting soil pH, since pH strongly influences microbial pathways of carbon processing. We integrated microbial taxonomic and functional data along with ecosystem measures by extracting microbial traits from soil molecular datasets and represented these traits as key life history strategies, which are microbial yield (Y), resource acquisition (A) and stress tolerance (S).

We describe how increased LUI in acidic soil leads to carbon loss through increased decomposition, as acid retardation of microbial growth (Y) is alleviated. Our more alkaline site lost carbon under increased LUI due to reductions in microbial biomass, related to trade-offs with stress alleviation (S) and resource acquisition (A). We conclude that less-intensive management at our more alkaline site could enhance SOC storage through increased microbial growth. We also present preliminary results from a laboratory study on these soils that aimed to explain whether edaphic properties, or the microbiome, drives the mechanisms that were observed in our field study. In conclusion, we highlight how a trait-based Y-A-S framework provides a valuable approach to explain soil microbiome impact on carbon cycling in response to environmental change.

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P-630

Nature and properties of iron-humic substance complexes in relation with the long residence times of soil organic matter

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Goethite, hematite, magnetite and ferrihydrite strongly interact with humic substance (HS) in soils creating nano-, micro-, and macro-aggregates with specific nature and stability. Long residence times of soil organic matter (SOM) have been attributed to iron-humic substance (Fe-HS) complexes due to physical isolation and chemical stabilization at the organic–mineral interface. Humic acids (HA) and fulvic acids (FA) contains versatile functional groups, such as carboxylic acid, phenol hydroxyl, alcohol hydroxyl, ketone, quinone and ester groups that interact with several possible mechanisms with Fe oxides. Because of the numerous interaction between Fe mineral and the natural SOM many research has led into a better identification and definition of HS. The iron interaction with HA and FA were considered totally diverse from the water soluble pools of organic matter or small organic molecules with high iron affinity (e.g. phenolics, and carboxylic acids). The surface properties of Fe oxides such as magnetite, maghemite, hematite, goethite and ferrihydrite react in different way with HS. The interaction of this minerals with HS can be efficiently characterized by X-ray diffraction (XRD), Fourier transform infrared (FTIR) spectroscopy, dynamic light scattering (DLS) and diffuse reflectance spectroscopies (DRS). The current state of knowledge regarding the adsorption/precipitation of HA onto iron mineral surfaces and its effects on aggregation and ion adsorption is still considered with high impact with several biogeochemical cycle: increase Fe bioavailability, improve carbon sequestration, reduce green-house gas emission, affect the fate, transport, and availability of persistent organic and inorganic pollutants.

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P-631

Effect of biogas digestate, winter crop and climatic determinants on dissolved organic carbon, nitrates and orthophosphates transfer to subsoil

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Transfer of dissolved organic carbon from surface to subsurface soil enhanced carbon (C) sequestration, but also increased losses of C to groundwater and transport of micropollutants (Achat et al., 2016). This study aims to evaluate the effect of climatic and agronomic determinants (organic wastes products and winter cover crops) on dissolved orthophosphate, organic C and nitrate dynamics in soil profile. EFELE is one of the experimental sites of the SOERE PRO network (https://www6.inra.fr/valor-pro) and allows the measurement of long-term evolution of agrosystems after seven years of fertilization with mineral as control, pig slurry and biogas digestate issued from this slurry. Two open lysimeters at two depths (40 and 90 cm) were monitored from 2014 to 2021, under a winter cover of wheat or mustard as catch crop. Nitrate leaching losses at 90 cm were extremely low under mustard (0.1 to 2 kg N.ha-1) and low under wheat (6 to 25 kgN.ha-1), whatever the treatment. Phosphate dynamics was complex to interpret and seemed to be partly coupled to C dynamics. C fluxes from topsoil to subsoil (40 cm) were not different between catch crop and wheat. Mean C fluxes for slurry amendment were 23.3 ±4.5 kg C.ha-1 identical to mineral although mean C fluxes for slurry digestate were significantly higher (50.7±1.7 kg C.ha-1). Fluxes to groundwater (90 cm) were not significantly different between treatments. A part of the C is sequestrated in subsoil.

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P-632

Importance of particles in the input-output budget of major elements in humus of a beech forest

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This study presents a complete budget of the input/output fluxes of major elements in the humus layer by considering dust inputs and, for the first time, particle output. Indeed, in a context where forest ecosystems usually develop on poor and unfertilised soils, nutrient cycles and input/output balances are key to determine the sustainability of forests. This is especially true for the humus compartment.
In this study, we studied mulls in beech ecosystems considering two contrasting soil types. Over a timespan of 7 years the inputs and outputs of elements, i.e. both particles (dust inputs and particles in the outgoing solution) and solutions, have been quantified.
The concentrations of the elements in the particles output were 3 or 16 times higher than those in dust, because some particles were produced in the humus. The input/output balances were in equilibrium for K, Na and S in both soils and for P, Si and Mg in one soil. These elements were transported in the humus mainly as a solution or in soluble form in plant tissues. The inputs were higher than the outputs for Ca and Mn in both soils and for P, Si and Mg in one soil, which are the elements found in biominerals. This indicates that other outputs were not taken into account in this budget, such as biomineral sedimentation or uptake by fungi. In conclusion this study highlights the importance of the humus particles in element cycles.

Dincher et al, 2020a
Dincher et al, 2020b

P-633

Invasive Fallopia japonica does not have affinity for ammonium

Johanna Girardi, Dr. Melanie Brunn, Dr. Katherine Muñoz, Prof. Dr. Hermann F. Jungkunst

Fallopia japonica, is an invasive species in Europe and North America, known to modify soil nitrogen processes to outcompete native plants. It was suggested that F. japonica inhibits nitrification to take advantage of its higher affinity to ammonium. However, the uptake of ammonium by F. japonica had not yet been studied experimentally. We hypothesized that F. japonica has a greater potential to take up ammonium, which is linked to rhizosphere activity, compared to a native species.

We performed combined ^{13}C and ^{15}N labelling on young F. japonica and native Urtica dioica plants. They were pulse labelled with $^{13}CO_2$ and fertilized with ^{15}N enriched nitrate or ammonium (44 mg N kg $^{-1}$ dry soil) . Atom excess of ^{15}N and ^{13}C, was measured after seven days in non-rooted soil, rhizosphere, fine roots, transport roots and shoots. Contrary to our hypothesis, F. japonica utilized less soil mineral N than U. dioica when fertilized with nitrate and similarly when fertilized with ammonium. Despite greater root activity of F. japonica (elevated root exudation, more investment of carbon and nitrogen into the transport roots), ^{15}N uptake was lower compared to U. dioica in both treatments, suggesting that the competition advantage of F. japonica may not solely be linked to root activity but also to greater nitrogen use efficiency.

Our data revealed that the mechanism of nitrification inhibition by F. japonica is not based on an affinity for ammonium. However, the identified strategy of F. japonica for using nitrogen presumably affects N-losses from riparian soil.

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P-634

Impacts of chemical weathering and incipient soil formation processes on the carbon cycle in proglacial areas

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The increase in global temperature and disruption of precipitation patterns is driving fast glacier retreat in many high elevation watersheds. As a result, extensive swathes of previously glaciated terrains are currently undergoing initial pedogenesis. Embryonic soil formation affects the biogeochemistry of carbon, as organic carbon begins to accumulate in the topmost soil layer, and chemical weathering rates increase under the influence of biological processes such as soil respiration and the exudation of organic acids. Chemical weathering leads to the production of dissolved inorganic C from the reaction of C dioxide and water with weatherable minerals, and is thus considered a C sink. While these fundamental processes are qualitatively well-established, we have very little empirical information on the link between pedogenesis, weathering processes and the C sink function of glacier forefields.
In this study, we aim to document early pedogenetic processes and weathering in the foreland of the Otemma glacier located in the western Swiss Alps. We collected soil and water data during the 2021 melt season. Weathering rates were estimated using water discharge and alkalinity data, while soil data provided mechanistic insight into chemical weathering processes. Early results show that pedogenesis was most active under mosses, lichens and cryptogamic crusts, with a significant accumulation of organic C and pedogenic iron and aluminium phases. This is likely attributable to the exudation of organic acids. Watershed weathering rates estimated from drainage water chemistry show that alpine proglacial areas may be an unaccounted for yet regionally significant C sink.

Proglacial freshwaters are significant and previously unrecognized sinks of atmospheric CO2
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P-635

Trace elements dynamics during decomposition of silver birch leaf litterfall at post-arable stands

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The studies on trace elements dynamics during decomposition of silver birch leaf litterfall have been conducted at 8 post-arable stands in Central Poland (mean annual temperature ~ 8.3°C; mean annual sum of precipitation ~ 538 mm). Four stands were located on Brunic Arenosols and four on Cambisols. Moreover, the stands varied in terms of age (15 - 61 years), density and tree size. Litterbag method was used in this study. 15 g of dry initial material was placed into bags, exposed in the field at 3 replicates per stand and sampled every 3 months. Then samples were dried, weighted and analyzed, including contents of Cu, Zn, Ni, Pb, V and Cr, using the ICP-OES (Avio 200, Perkin Elmer) after digestion in 65% nitric acid. Initial materials strongly varied in terms of chemical composition, however the effect of soil type was not clear for the studied elements. Contents of Cu, Ni, Pb and V were typically low for uncontaminated areas. Zn occurred at higher contents, however it is an effect of strong bioaccumulation of that element by birch. Intensity of leaves decomposition was moderate-fast. 38.0-75.1% of initial mass decomposed after 15 months of the experiment. Concentrations of all the studied elements showed increasing tendencies during decomposition. The trend lines were usually linear for Cu, linear or exponential for Zn, exponential or polynomial for Pb, Cr and V. Ni showed various tendencies depending on stand.

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P-636

Simultaneous minimization of arsenic mobilization and nitrous oxide emission under nitrogen fertilization in paddy soils

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Nitrogen fertilizers are commonly applied to paddy fields to increase rice yields, but they also stimulate microbial (de-)nitrification which leads to emissions of the potent greenhouse gas nitrous oxide (N_2O). Denitrification can be coupled to the oxidation of iron(II), both microbially and abiotically, forming iron(III) minerals, which are strong adsorbents for toxic metals and metalloids such as arsenic, potentially limiting the uptake of arsenic by rice plants. Currently, it is unknown how a balanced addition of nitrogen fertilizer can, at the same time, lower arsenic mobility while minimizing N_2O release. To investigate this gap in knowledge, we incubated paddy soil from Vercelli, Italy, in artificial irrigation water suspensions and applied potassium nitrate at three different concentrations (35, 100, 200 mg N/kg DW-soil) two times over a typical rice cultivation period of 129 days. We observed that nitrate reduction was coupled to the oxidation of dissolved and solid-phase iron(II) and inhibited microbial iron(III) reduction. Arsenic mobilization occurred due to microbially-mediated reductive dissolution of iron(III) minerals after nitrate depletion. Highest cumulative N_2O emissions and inhibition of methanogenesis were observed under the most extensive nitrate fertilization regime. However, the lowest nitrate fertilization regime accounted for the greatest global warming potential after 129 days of incubation. We further linked these geochemical observations to the abundance and activity of N- and Fe-metabolizing microorganisms. Our results indicate that high nitrate fertilization can minimize arsenic mobilization due to inhibition of microbial iron(III) reduction without having adverse effects on the climate relative to lower nitrate fertilizer additions.

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P-637

Pseudosand as biophysical reactor

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Most biogeochemical models and their integrated pedotransfer functions were developed for temperate zones. For the tropics, large discrepancies between field measurements and model predictions have been reported, for example, in regard to overestimated nitrous oxide (N_2O) emissions (Meurer et al., 2016). Tropical soils are characterized, among other features, by stable and water-insoluble microaggregates called pseudosand, which are perceived as sand in the field but measured as clay and silt in the laboratory. For biogeochemical models, pseudosand could simplistically be replaced with sand for calculation of features determined by soil texture. However, we pursue the hypothesis that, biogeochemically and physically, pseudosand does not re(act) like sand, due to i) their high internal surface and rough structure providing a wide variety of ecological niches for microorganisms and, ii) the swelling and shrinking behaviour of clay particles bound in the microaggregates changing the physical and hydraulic properties in dependence of the water content.

In a first experiment we analyzed the biogeochemical effect of pseudosand on microbial activities. Similar fraction sizes of different substrates (pseudosand, quartz sand, glass beads) were inoculated with the nosZ-deficient denitrifier Agrobacterium tumefaciens (with N_2O as final product of denitrification) at different oxygen levels. In a second experiment we will increase the level of complexity by additionally targeting the variable physical and hydraulic properties of pseudosand at different water contents. The long-term goal is to develop a pedotransfer function related to the properties of pseudosand to improve biogeochemical models for tropical soils.

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P-638

Nitrate Leaching Potential From Dairy Manure Composting Operations in California: Attenuation by Denitrification in the Vadose Zone

Mr. Geoffrey Koch, Mrs. Xia Zhu-Barker, Professor William R. Horwath

With composting of dairy manure expected to increase in California, the potential risk to groundwater from leached nitrate produced during composting is of significant concern to regulators as well as professional composters. Composting is ostensibly a beneficial practice as an alternative to other management regimes for solid dairy waste. However, the quantity, fate, and transport of mineralized nitrate in the composting leachate are not well understood. We hypothesize that denitrification is occurring in the Vadose Zone in layers that become water-saturated due to textural shifts creating perched water and anaerobic conditions promoting denitrification. Our work includes monitoring of nitrogen and carbon pools during the composting process; deep soil monitoring and nitrate stable isotope enrichment values (δ15N & δ18O); and potential denitrification assays in the lab as evidence of denitrification in the vadose zone. The former is to quantify when and how much nitrate is mineralized from composting operations. the latter to identify the mechanism and potentially the estimated rates of denitrification in this system. Initial results indicate that concentrations of nitrate decrease to background levels with depth paired with an increase in stable isotope enrichment values.

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P-639

Phosphorus burial in three boreal lake sediments in Finland

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Permanent phosphorus (P) burial as the ferrous iron (Fe(II))-P mineral vivianite in lake sediments has been a recent research theme among studies into lacustrine nutrient dynamics (Heinrich et al. 2021; Jilbert et al., 2020). Vivianite formation in eutrophic lakes may play an important role in reducing internal P loading (O’Connell et al., 2015). However, the conditions controlling vivianite formation are not well constrained, since porewater supersaturation alone does not guarantee the presence of vivianite (Rothe et al., 2016).

In this study we investigate the prevalence of natural vivianite formation in three contrasting lakes in SW Finland. Lake Köyliönjärvi and Lake Pyhäjärvi have history of nutrient loadings from agriculture and are eutrophic while Lake Vähäjärvi is oligotrophic, leading to potentially contrasting sediment biogeochemical dynamics. Sediment profiles (0-30 cm) and porewaters were studied by geochemical analyses and P speciation. Selected samples were taken to micro-XRF and SEM-EDX analyses.

Porewater profiles and sediment P data showed opposite gradients and contrasting P speciations between the oligotrophic vs. the mesotrophic/eutrophic systems. Reactive P is buried in all systems but the role of reducible oxides in diagenesis is greater in mesotrophic/eutrophic lakes. Despite evidence for coupled Fe-Mn-P cycling of micro-XRF analysis results, and theoretical conditions (porewater supersaturation, P speciation) favoring vivianite formation, vivianite was only observed in a single sample from mesotrophic Lake Pyhäjärvi at depth 28 cm. Therefore, P burial in eutrophic systems likely occurs mainly as Fe-oxide bound P that escapes reduction during sediment accumulation in sulphide-poor conditions.
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P-640

Distinct dynamics of microbial necromass and plant debris in arable soil manipulated by maize residue return

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Soil organic matter (SOM) is defined as a continuum from intact plant residues to highly oxidized microbial-carbon, which is necessarily associated with two distinct processes of microbial transformation and physical migration of plant fragments. Nevertheless, how organic carbon input influenced the relative contributions of microbial necromass and plant debris to soil organic carbon (SOC) sequestration in arable soil remain poorly understood. Therefore, amino sugars and lignin phenols were used as biomarkers to trace the dynamics of microbial necromass and plant debris under maize straw return in a 12-year no-till experiment in Northeast China. Temporally, the accumulation of amino sugars approached to a new steady-state equilibrium much earlier than lignin phenols because of the existence of "microbial carrying capacity". The ratios of amino sugars to lignin phenols continuously decreased with increasing amount of straw mulching, accompanied with a decreased degree of lignin side-chain oxidation, reflecting preferential accumulation of fresh lignin over microbial necromass with increasing organic carbon input. While the ratios of amino sugars to SOC decreased, the ratios of lignin phenols to SOC increased when the straw mulching doubled from half to full harvested yield, suggesting that the retention of plant-derived components may play a key role in promoting long-term SOC accumulation. This finding improved our understanding of the accrual pattern of plant- versus microbial-derived organic compounds, which is essential to predict the functions of SOC in conservation tillage practices.
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P-641

Cropping system rather than reclaimed wastewater irrigation exerts strong impact on antibiotic resistance gene assemblages in greenhouse soils

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The effects of reclaimed wastewater (RW) irrigation on spread of antibiotic resistance genes (ARGs) in soil is modulated by a myriad of biotic and abiotic factors and their relative significance remains vague. Given that change in physical and biogeochemical properties of soil, which mediate microbial activity and ARGs profile, after management practice change is a slow process and takes decades to reach new equilibria, and testing this needs long-term experiment. Hence, we compared the microbial communities, assemblages of genes resistant to antibiotics, biocides and metals, and insertion sequences (ISs) in soils following 16-year of irrigation with groundwater (GW), RW or alternate GW and RW in two greenhouses with different cropping systems, using shotgun metagenome sequencing. The results showed that it was the cropping system rather than the RW irrigation that impacted the profile of ISs and resistance genes more significantly, and the impact was most strongly associated with concentrations of copper, mercury and perfloxacin in the soils. There was no significant difference in the soil ARGs profile between continuous RW irrigation and alternate GW and RW irrigation, and the bacteria of Proteobacteria, Actinobacteria and Firmicutes and some ISs were closely associated with the detected ARGs. Most ARGs were found to co-occur with metals and biocides resistance genes through the mechanism of efflux pump. These findings highlight the significance of improving crop management in mitigating the dissemination of ARGs in soils irrigated with RW.
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P-642

Impact of Sea Level Rise on Ion Selectivity in Non-Saline Coastal Soils

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Rising sea levels, due to climate change, are exacerbating flooding and saltwater intrusion along coastal areas throughout the world where more and more people are living. The impact this has on soil processes and reactions, especially on soils not previously impacted by saline water, is poorly understood. For example, how will cycling of elements be affected, which has major implications on food production, human health, and national security. Flooding due to sea level rise and land subsidence is a particular problem along the East Coast of the U.S. where a large percentage of the U.S. population lives. Sea levels are predicted to rise by 1 m by 2100. Consequently, historically non-saline soils in these areas are increasingly being affected by salinity, resulting in orphan forests and crop damage. It is unclear how potential changes in the physical and chemical properties of the soils, due to salinity, will be impacted. In order to predict what may happen, ion exchange selectivity studies on coastal, non-saline and salt-impacted soils were conducted at multiple ionic strengths to mimic the typical soil solution, river water, and sea water. Ion exchange selectivity coefficients, equilibrium constants, and other thermodynamic exchange parameters were determined. Kinetics of ion exchange investigations were also carried out under the different salinity regimes.

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P-643

Abiotic and biotic mineralization of varying characteristic biochars depend on biochars' labile C quality and temperature under laboratory conditions

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We investigated abiotic and microbial mineralization of a range of low-pyrolysis temperature (400 °C) biochars at 15, 30 and 45 °C incubation temperatures. Biochars were developed from eucalyptus leaves (ELB), wheat straw (WSB), poultry manure (PMB), cotton sticks (CSB), vegetable waste (VWB), lawn grass (LGB) and citrus leaves (CLB). In addition to elemental composition, biochars were characterized for pH, electrical conductivity (EC), labile organic C (L-OC) and LOC characteristics including specific ultraviolet absorbance (SUVA), aromaticity, hydrophilic and hydrophobic C fractions and total phenolic contents. Carbon mineralization was measured for seven days using abiotic (sterile incubation with mineral nutrients) and microbial (microbial inoculum with mineral nutrients) experimental conditions. We found that abiotic degradation of biochars were generally less than microbial degradation, however, these patterns significantly varied between feedstocks and incubation temperatures. Both abiotic and microbial C mineralization was also strongly controlled by incubation temperatures. Percent C mineralized (PCM) of L-OC was higher under microbial incubation at 30 °C and higher for PMB, CSB and CLB. Water extractable OC (WEOC) also showed significant variations with respect to biochars and incubation temperature whereas WEOC correlated significantly positively with CO2 efflux under abiotic and microbial incubation conditions. Characteristics of L-OC seem to have strong influence on both abiotic and microbial biochar degradation; positive relationships with pH, volatile matter, L-OC and total phenolics and negative relationships with EC and SUVA. These observations warrant the consideration of abiotic (chemical & photo-oxidation, solubilization) and microbial decomposition of biochars before its application to soils.
N.A

P-644

Nutrients distribution in a silver birch (Betula pendula Roth) biomass growing on poor soils.

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This study aimed to evaluate bioaccumulation rates of chosen elements in a silver birch biomass growing on nutrient-poor soils (Arenosols) developed from aeolian sands in Central Poland. The study covered three stands in the age of 12, 20 and 34 years. Ten average trees were sampled at each stand, including fine roots, coarse roots, stem wood, bark, coarse branches, fine branches and leaves. Moreover soil samples were taken from depths of 0-10; 10-20; 20-40 and 40-80 cm at each location. Contents of total organic carbon, N and S were determined by dry combustion (Vario MacroCube, Elementar), whereas total P, K, Ca, Mg, Fe, Mn, Cu and Zn was analyzed using the ICP-OES (Avio 200, Perkin Elmer) technique after acid digestion. Soil analysis included also pH and particle-size distribution. The studied soils were strongly acidic and poor in the studied elements. Distribution of the elements in birch biomass strongly varied. Most of them showed the highest concentrations in leaves followed by bark (N, S, Cu), roots (P, K, Mg) or branches (Ca). Fe occurred at highest amounts in fine roots, whereas Mn and Zn in bark. Large variability showed also bioaccumulation factors. It was usually the highest in leaves or bark and the lowest in stem wood. N showed the highest bioaccumulation intensity among the studied elements followed by S, Zn, Cu, Mn and P. Differences between the studied birch stands in elements content and bioaccumulation intensity were low in most cases when compare the same kind of biomass.

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P-645

Elucidating Novel Pathways for Potassium fixation in Soil Clay and Metal Oxide Minerals

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Recycling of elements and nutrients critical to our ecosystems occurs in soil. However, soil elemental cycling is controlled by chemical processes such as adsorption to soil minerals and newly formed surface precipitates. Potassium (K) is one of the essential plant nutrients which can be sequestered by phyllosilicate clays. Our goal is to understand why fast novel pathways of K fixation are occurring in soil clay mineral systems. Our specific objective is to determine how K can be incorporated into newly formed surface precipitates. Batch adsorption experiments were carried out at pH 7.5 and 8.5 and were reacted for one week and one month. Potassium was reacted with ɣ-Al2O3 and SiO2 minerals in the presence or absence of cations (Co, Fe, Mg, Zn, and Ni). Overall, our results showed increased amount of K sorption for samples reacted for longer time, suggesting that K sorption is time dependent. Furthermore, the samples that contain both ɣ-Al2O3 and SiO2 minerals showed greater K adsorption than the single mineral. The presence of Zn, Ni, and Mg was found to enhance the formation of surface precipitates that are similar in structure to layered single and double metal hydroxides. These hydroxides will incorporate dissolved Si to form silicated mixed metal hydroxides, effectively providing additional sorption sites for K to bind. Collectively, these results imply that considering only the traditional view of K fixation, which relies solely on K incorporation into the soil clay minerals already present, could perhaps underestimate the potential of soils to sequester K.

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P-646

Circular fertilizers to improve the sustainability of intensively managed grasslands

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Intensively managed grasslands represent a large part of the global agricultural land and are emitting more nitrous oxide (N_2O) than arable lands. Grasslands store on average more soil organic carbon (SOC) and have the potential to store even more. We aim at optimizing the fertilization of these grasslands in order to reduce emissions and increase SOC stocks. We set up a field experiment including six different fertilizer treatments (digestate, vacuum-degasified digestate, recovered diammonium sulphate, an alternation over time of these two, calcium ammonium nitrate (CAN) and unfertilized control), applied on six different plant communities. We completed six fertilization-harvest cycles of six weeks each and measured N_2O emissions on average twice a week per cycle. Selected treatments were sampled using soil cores down to one meter depth, and measured for SOC stocks and nutrient contents. Hyperspectral imaging in the Vis-NIR range was performed on undisturbed core-samples in order to resolve SOC and nitrogen spatial distribution along the soil profile. N_2O emissions were the highest for plots fertilized with CAN and similarly lower for all the other fertilizer treatments (excluding unfertilized control). Emissions were overall the highest for clover monocultures and the lowest for grasses and the species mixture. We expect the SOC stocks to be higher for the digestate and vacuum-degasified digestate compared with CAN, and the soil nitrate content to be higher for the digestate compared with the vacuum-degasified digestate. We prove that multi-species grasslands fertilized with circular fertilizers are equally sustainable for farmers as well as for the environment.
No references

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Investigating the fate of C in the mineral associated SOC pool

Mr Sam Walrond, Dr Jeanette Whitaker, Professor Nick Ostle, Professor Caroline Peacock

Reversing the trend of decreasing soil carbon stocks is important to help mitigate current environmental challenges. Improving knowledge on the mechanisms that control the stabilisation and persistence of soil organic carbon will provide a foundation from which to tackle this issue. This includes the mechanisms controlling the stability of organo-mineral associations, considered to be the most stable and persistent pool of soil carbon. Uncertainties remain on the persistence of OC associated to soil minerals - in particular iron oxide minerals, due to their redox reactive nature.
A laboratory experiment has been set up to investigate the fate of OC associated to ferrihydrite when under reducing conditions. Batches of organo-minerals of known composition is synthesised by co-precipitating ferrihydrite and OC of increasing carboxyl richness. Once exposed to reducing conditions, the fate of the mineral associated OC is measured as the total C remaining associated to the mineral and the desorbability of this C over time. We hypothesised that carboxyl rich OC is less vulnerable compared to carboxyl poor OC by being able to inhibit reductive dissolution of ferrihydrite to a greater extent.
Findings from this experiment will improve understanding of the vulnerability of organo-mineral associations to destabilization under varying soil redox conditions in relation to the intensity that the OC functional groups associate to the mineral. This is of increased applicability due to changing precipitation regimes caused by climate change is altering soil redox conditions and subsequently the vulnerability of organo-minerals to destabilisation.

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P-648

Sulphur supply from microbial mineralization in Norway spruce stands after former high atmospheric sulphur deposition

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During the 1950-1990's forests in Central Europe were strongly affected by atmospheric sulphur (S) deposition. Subsequent studies focussed on the polluting effect of S, while forest sites were regularly limed to reduce soil acidification impacts. However, a recent survey revealed that foliar S contents are decreasing, most notable in Norway spruce (Picea abies) stands, indicating that S is shifting from a pollutant towards a potential deficiency. Consequently, the S nutritional status in forest ecosystems is increasingly relying on internal S cycling (from mineralization).
Here we studied the impact of high S stocks, as legacy pool of former S deposition, on nutrient cycling in the organic and mineral soil under Norway spruce. Therefore, forest stands along a gradient of former atmospheric S deposition were considered: from very high (Altenberg, Germany; former "Black triangle") to low S deposition (Schluchsee, Germany) and a forest stand remote from atmospheric S inputs (Davos, Switzerland). Samples were taken from the organic and topsoil layer for an incubation-percolation experiment, to quantify microbial biomass C/N/S contents and to determine the nutrient stocks and stoichiometry in the soils.
Foliar S contents indicated that sulphur is slightly deficient at the Davos site, while it is still easily available at the Altenberg site. We expect that the site with limited S availability (Davos) will show a relative high S mineralization in the organic layer, indicating a more efficient S cycling as compared to S enriched forest systems. Consequently, microbial biomass likely contains relative less sulphur with lower soil S contents.

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Does the rhizosphere biogeochemistry of Sorghum landraces bear a yet unexplored potential to overcome concurrent nutrient and water limitation?

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Climate change scenarios predict for many regions of sub-Saharan Africa an increased drought abundance and severity. In low fertile soils, crops will suffer concomitant nutrient and water scarcity. Drought-adapted crops such as Sorghum bicolor are, in consequence, one of the potential strategies facing the biogeochemical challenges of climate change for food supply. To identify most-promising belowground traits of Sorghum genotypes (landrace, open pollinated variety, hybrid) shaping drought-resilient element cycling in the rhizosphere we performed a quadrupole isotope labeling experiment (15N, 33P, 2H and 13C) in so-called double-ring pots allowing to disentangle the contribution of mycorrhiza to nutrient and water uptake from unfertile Acrisols. We assessed uptake of inorganic N, P and water and plants' C investment into belowground mechanisms (fueling microbial community members including mycorrhiza, releasing organic acids, enzymes or mucilage, etc.) triggering element cycling in the rhizosphere.
Whereas under well-watered conditions, biomass decreased from hybrid via the variety towards the landrace, drought leveled out these differences. Only the landrace maintained biomass production levels. We identified roots to play a major role in plant P and N uptake under well-watered conditions, but mycorrhiza took over P and for some genotypes even partially N uptake under drought conditions, mining for mineral nutrients in the root-exclusion compartment. This and further identified belowground traits fueled by plant C allocation to the rhizosphere point out the relevance of understanding rhizosphere processes under multiple resource limitation and identifying crucial traits required by "future crop genotypes" ensuring food safety in (sub-)tropical regions.
none

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The contribution of deadwood to soil carbon dynamics in contrasting temperate forest ecosystems

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Deadwood forms a significant carbon pool in forest systems and is a potential source of dissolved organic carbon (DOC) input to soil, yet little is known about how deadwood effects forest soil carbon cycling. Deadwood DOC inputs to soil may be retained through sorption or may prime microbial decomposition of existing organic matter to produce additional DOC. To determine impacts of deadwood on soil C cycling, we analysed surface soil from beneath deadwood or leaf litter only, along chronosequences of stands of lowland oak and upland Sitka spruce. The concentration and quality of water-extracted soil DOC (water-extractable organic carbon; WEOC), in situ decomposition 'tea bag index' (TBI) parameters and enzymatic potential assays (β-D-cellubiosidase, β-glucosidase, β-xylosidase, leucine aminopeptidase, phosphatase, phenol oxidase) were determined. Presence of deadwood significantly ($p<0.05$) increased WEOC concentration (~1.5 - ~1.75 times) in the mineral oak soil but had no effect on WEOC in spruce soils, potentially because spruce deadwood DOC inputs were masked by a high background of WEOC (1168 mg kg-1 soil) and/or were not retained through mineral sorption in the highly organic (~90% SOM) soil. TBI and enzyme evidence suggested that deadwood-derived DOC did not impact existing forest carbon pools via microbial priming, possibly due to the more humified/aromatic quality of DOC produced (humification index of 0.75 and 0.65 for deadwood and leaf litter WEOC, respectively). Forest carbon budgets, particularly those for mineral soils, may underestimate the quantity of DOC if derived from soil monitoring that does not include a deadwood component.

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P-651

Lost in transition? Under-investigated mechanisms linking organic and inorganic carbon pools in calcareous soils

Dr Maria Luz Cayuela

Inorganic C stocks prevail in soils of arid and semiarid regions and constitute one of the most important C reservoirs in terrestrial ecosystems (Zamanian et al., 2021). Still, the interactions between soil organic and inorganic C in these soils and the factors that influence the transition of C between these two pools have been scarcely investigated (Lal, 2000). Several mechanisms can lead to the transformation of organic C into inorganic C stocks and vice versa. For example, the mineralization of both fresh organic inputs or soil organic matter produces CO2, which is normally released to the atmosphere. However, in alkaline soils, dissolved CO2 can lead to the formation of secondary carbonates, which constitutes a direct link between organic and inorganic soil C pools and a pathway of inorganic C sequestration (Sun et al., 2021). On the other hand, the rhizodeposition of organic C by plants might temporarily trigger the dissolution of soil carbonates, which fate (emitted as CO2 to the atmosphere, recrystallization, incorporation into microbial biomass, migration to deeper soil horizons) will depend on many factors, such as the soil pH, availability of Ca, soil moisture, etc. Through laboratory incubation studies with 13C labeled substrates (glucose, acetic acid, proline) we evaluate the contribution of mineralized substrates to the soil inorganic C pool and how different factors (e.g. pH or the presence of pyrogenic C) influence C fate in a calcaric fluvisol subjected to several drying-rewetting cycles.

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P-652

The impact of land-use type on soil organic carbon decomposers in a tropical agricultural landscape

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Soil organic carbon decomposers (SOCD) play a central role in the global carbon (C) cycle affecting C sequestration potential and nutrient turn-over in soils. A study was conducted to assess the effect of land-use type on activity of SOCD in a tropical agricultural-landscape. Soil samples were collected at 0-15 cm depth from lands under three land-uses; T1- vegetable-based farming system (n=20), T2- tea cultivation (n=17) and T3-forest cover (n=18), in a mini-watershed in Nuwara-Eliya (WU3 agro-ecological region), Sri Lanka. Soils were analyzed for respiration, substrate induced respiration (with glucose and cellulose), percent decomposition of cellulose filter papers (D-cel), microbial biomass C (C-mic), permanganate-oxidizable C (POXC) and soil pH. Metabolic quotient (qCO_2) was calculated and data were statistically analyzed. All the measured parameters were significantly affected ($p<0.05$) by land-use type. Soil pH ranged from 3.77 to 7.10. T1 had the highest qCO_2 (0.45 µg CO_2-C/g C-mic/h), respiration (60 µg CO_2/g soil/h), glucose and cellulose induced respiration rates (41 and 52 µg CO_2/g soil/h respectively), and D-cel (78.3 %), and the lowest C-mic (164 µg C/g soil) and POXC (472 mg/kg); and these were significantly different ($p<0.05$) from T3. Soil respiration, qCO_2, and C-mic were not significantly different ($p>0.05$) between T1 and T2. Cellulose decomposition potential indicated by D-cel showed significant positive correlations ($p<0.05$) with cellulose-induced respiration ($r^2=0.561$) and glucose-induced respiration ($r^2=0.592$). In conclusion, from the three land-uses, soils under vegetable-based farming comprised of the most active SOCD community. Hence, C sequestration could be challenging under this land-use type.
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P-653

Temporal and spatial variation of soil respiration under sclerophyllous and thorn vegetation of Central Chile

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Sclerophyllous ecosystems of Central Chile have been historically degraded by human activity, including forest fires and non-sustainable agriculture followed by abandonment. Such processes have caused a decrease in biodiversity and plant productivity and less capacity of soils to store water and carbon. In a decadal time period, ecosystem degradation usually causes a change in vegetation from scherophyllous vegetation to thorny shrublands. This plant cover change affects soil CO2 fluxes (Rs), however, how Rs vary in space and time across the same plant community is not known. In contiguous sclerophyllous (QTC) and thorny vegetation (ESP) ecosystems, both of them having annual grass coverage between trees or shrubs; we established two 400 m2 plots. At each plot, Rs (closed chamber IRGA), soil temperature (Ts), soil water content (⍰), and soil organic carbon (SOC), determined at 0-6 cm depth, were seasonally measured in 100 systematically distributed sampling points. Differences between plant cover type and seasons were tested using a Kruskal-Wallis followed by a Nemenyi test (Moran Index showed that observations were spatially independent). Models of Rs versus Ts, ⍰, and SOC were fitted. Spline methods were used to spatially interpolate Rs. No significant differences between plant cover types were found. Within each cover type, significant differences ($p<0.05$) in Rs were found between grass and shrub-tree vegetation. A large spatial variability of Rs and no spatial autocorrelation was observed. Rs was greater for the most altered ecosystem when ⍰ was not limited. Rs was mostly explained by ⍰, while SOC did not influence it.
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P-654

Accumulation of Hg in the forest floor of Pinus pinaster plantations along a coastal-inland transect in SW Europe

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Forested areas play a key role as a sink of atmospheric mercury (Hg) in terrestrial ecosystems, being coniferous species the most efficient in the scavenging of atmospheric Hg while soils account for most of the accumulation of Hg (Ma et al., 2019).
This study evaluates the total Hg content (HgT) and the Hg pool (HgP) in the organic subhorizons (Oi, Oe, Oa) collected from 17 Pinus pinaster stands along a coastal-inland transect in NW Spain. According to the stand distance to the coast and the total annual rainfall, two regions were defined: coastal region (CR; <50 km; >1200 mm); inland region (IR; >50 km; <1200 mm).
For each organic subhorizon, HgT was significantly higher ($p<0.05$) in CR than in IR stands, with averages for the entire organic horizon of 80 and 67 µg/kg, respectively. Total Hg varied significantly ($p=0.000$) among O subhorizons in both CR and IR stands, and followed the sequence Oi<Oe<Oa, with average ranges of 72-87 and 62-71 µg/kg in the CR and IR stands, respectively. Total Hg in the Oi subhorizons showed a strong correlation with annual rainfall (rho=0.447; $p<0.05$).
The pool of Hg (HgP) for the entire O horizon was higher in the CR plots (130 µg/m²) than in the IR ones (119 µg/m²). In both CR and IR stands, HgP varied significantly depending on the organic subhorizon ($p=0.000$) and increased with more decomposed organic matter (Oi<Oe<Oa), showing ranges of 108-150 and 104-136 µg/m² in the CR and IR stands, respectively.

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P-655

Amending coarse-textured agricultural soils with pulp and paper mill sludges

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Pulp and paper mill sludge amendments have been found to reduce the leaching of suspended solids and total phosphorus in percolating waters from Finnish clay soils (Rasa et al., 2020). To investigate their effects on e.g. yield, nitrogen (N) availability, carbon (C) input and soil structure on coarse mineral soils, a two-year field experiment was conducted in 2020-2021 on a fine sandy loam (Eutric Stagnic Cambisol) in east-central Finland. The field experiment was supported with laboratory incubation experiments, being completed in 2022. Prior to sowing of grass ley under barley in June 2020, two different fibre sludges were applied to the soil surface with four replicates (21-28 fresh-t/ha, containing approx. 15 kg available-N/ha and 3100 kg C/ha) and harrowed to a depth of about 7 cm. Both sludge treatments were conducted with two levels of mineral N fertilization (40 and 80 kg N/ha). In addition, control treatments containing no sludge were established with four increasing mineral N fertilizer application levels. Due to sludge-induced N immobilization, the grain yield of barley was on average 22% lower among the sludge treatments than in the corresponding mineral N treatment at the lower N application level. However, in the first forage cut in 2021, the sludge treatments produced on average 14% higher dry matter yields than the corresponding mineral fertilized plots, which can be explained by slow mineralization of N. According to the preliminary results, a pre-sowing interval is recommended after sludge applications especially when combined with a relatively low mineral N fertilization rate.

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P-656

Soil viruses: Sneaky enablers by day and night

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Plant root exudates allow soil microorganisms to do what they do best: consume resources and excrete wastes. Root exudates are not a constant in a rhizosphere microbe's life however, with both quantity and composition changing in response to the plant's circadian rhythms and other stressors (Cho, Schroth, & Zeyer, 2012). In wet soils, rhizosphere microbes are further buffeted by drastic changes in soil environmental conditions such as oxygen content and pH (Zhao, Ma, Xu, Stirling, & Xu, 2021). These daily extremes mean that rhizosphere microbial communities need to be highly responsive to their immediate environment. Microbial communities do not act in isolation though: they are assisted by the soil virus community.

Viruses frequently carry mobile genetic elements that enable their hosts to achieve additional functions (such as Auxiliary Metabolic Genes; AMGs) (Bi et al., 2020). We explored the response of rice soil and rhizosphere metagenomes and viromes to diurnal changes in their environments via both greenhouse and field experiments through a lens of biogeochemical cycling pathways. Rice plants actively pump oxygen and carbon into their roots during daylight hours, making them an excellent model system to investigate biogeochemical cycling under varying redox and pH conditions.

Initial results from these experiments show complex responses from both the microbiome and virome, with viral AMGs enabling extended functional capacity of the rhizosphere microbiome. Further analyses will explore the specific role of soil viruses in iron and sulfur cycling, which may prove useful for managing severely acidified soils into the future.

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P-657

Loss of inorganic carbon stocks in croplands induced by nitrogen fertilizers risk soil health

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The application of nitrogen (N) fertilizer in agriculture has altered global nitrogen biogeochemical cycle. The negative effects of N fertilizer on quality of atmosphere, water and soil have been intensively studied. The inorganic carbon in soil (SIC) has important role in processes, such as, acidity buffering, aggregates formation and stabilization, organic matter stabilization, nutrient cycling and availability. However, the effect of soil acidification by nitrification of N fertilizer on SIC stock of cropland remains largely unexplored. China has consumed near one third of N fertilizer in the world. Therefore, we have compared the SIC stocks in Chinese croplands between 1980s (N=996) and 2010s (N=933). The SIC contents in 1980s were obtained from second national soil survey and published studies. The SIC contents in 2010s were based on resampling of soil profiles from the same locations during 2019 and 2020, as well as data from published studies. We found that Chinese croplands have lost 27-38% of SIC stocks from the 0-40 cm depth and that the soil pH has decreased by 0.53 units over the past 30 years. These SIC losses increased with the ratio of precipitation (P) to potential evapotranspiration (PET) and most notably with N fertilization. The SIC density (SICD) decreased greatly in humid and semiarid regions, and these losses were enhanced by high N fertilization rates; however, the SICD increased in very arid regions. The SIC loss will risk soil health of cropland by soil acidification, loss of base ions, increasing the pollution risk of heavy metals.

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P-658

Long-Term Perennial Management and Cropping Effects on Soil Microbial Biomass for Claypan Landscapes

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Soils managed with various long–term perennial vegetive management systems that increase soil microbial biomass and improve carbon sequestration may help mitigate environmental change consequences. The objective of this study was to evaluate the effects of grass buffer (GB), biomass crop (BC), grass waterway (GWW), and agroforestry buffer (AB) on soil microbial biomass and soil organic carbon (SOC) as compared to continuous corn (Zea mays L.)-soybean [Glycine max (L.) Merr.] rotation (row crop [RC]) on claypan soils. The study site was located at Greenley Memorial Research Center in Missouri, USA. Soil samples were collected from the 0- to 10-cm depth at summit, backslope, and footslope landscape positions. Within AB treatment, soils were sampled from the 50-cm and 150-cm tree distances. Total microbial biomass and biomass of gram-positive bacteria, gram-negative bacteria, actinomycetes, rhizobia, fungi, arbuscular mycorrhizae, saprophytes, and protozoa were determined by phospholipid fatty acid (PLFA) analysis. Results showed that soil microbial biomass and SOC across all soil microbial communities were significantly higher ($P < 0.01$) under perennial vegetation treatments compared with RC. The footslope position showed the highest total microbial biomass and SOC compared with the summit and backslope. The distance of 50 cm from the tree base showed 16% higher total microbial biomass and 15% greater SOC than the distance of 150 cm. Overall, these findings highlight those perennial systems, landscape positions, and tree distances have the potential to increase soil microbial biomass and SOC in degraded RC management.

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P-659

Long-term prescribed fires effects on biological properties of a Calcaric Cambisol (Asín de Broto, Central Pyrenees)

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Livestock density reduction, together with climate change, is facilitating the substitution of grasslands by shrublands (Komac et al., 2013), which leads to a higher fire risk (Vélez, 2012) and a loss of soil biodiversity (Caballero et al., 2009). Fire Service performs prescribed fires in different shrublands with two objectives: reducing the fuel load and recovering pasturelands. However, these prescribed fires could damage the soil properties, especially the biological ones (Santín & Doerr, 2016).

To find out, a study has been conducted to determine the short (B0), medium (5 years, B5) and long-term (9 years, B9) evolution of prescribed fires effects on topsoil properties, especially biological ones, in a location of Central Pyrenees. Soil was sampled up to 3 cm, based on Girona et al. (2019). Microbial carbon (Cmic), soil respiration (SR) and enzymatic β-glucosidase activity (β-G) were analyzed. Some physical (water repellency, aggregate stability) and chemical (pH, electrical conductivity, organic carbon) properties were also measured.

Results obtained showed non-significant interaction between time after the fire and depth for all the studied properties. There was a short-term increase of Cmic, which disappeared after 5 years and returned to unburnt (UB) values. β-G activity showed no short-term effects, but suffered a significant decrease 5 years after the fire, that remained also for B9. No significant effects were found for SR. Both chemical and physical properties did not show significant long-term effects, except pH, which significantly increased after the fire and whose values remained higher than the UB ones even after 9 years.

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P-660

Belowground networking: Biogeography of EcM fungi and species variation at different woodland ages

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Ectomycorrhizae (EcM) are evolved mutualistic associations between soil fungi and plant roots. It has been shown that there can be species-specific differences in the ability to colonise roots. Colonised roots have increased longevity, and greater resistance to pathogens, toxic elements in the soil and extreme conditions of temperature, acidity and moisture [1].
EcM inocula are an essential resource in forest management. Nevertheless, measures being implemented worldwide to promote forest cover recovery to reduce atmospheric CO2 levels can cause ecological shifts. Shifts to ecological communities take place as species become more or less abundant, are wiped out or colonise new habitats. However, these changes may not be captured by metrics focusing on species richness alone.
The lack of direct evidence of large-scale EcM temporal change in fungal community structure or function over time - commonly used in animal and plant research - is a basic, structural knowledge gap [2]. Understanding temporal changes in community composition, whether via species losses and gains, or alterations to relative abundance and dominance is therefore essential to fathom the performance of terrestrial ecosystems.
This study will characterise EcM fungi in woodland sites of varying ages. This study uses a space-for-time approach, benefiting from a collection of sites part of a wider study on the biodiversity responses to woodland planting.

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P-661

Co-Limitation of Tree Growth by N and P is Dependent on Mycorrhizal Type

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Associations between plant roots and fungi, or mycorrhizae, aid the growth of roughly 90% of terrestrial plants. Dominance by one of two mycorrhizal types, ecto- and arbuscular mycorrhizae (EM and AM respectively), can have far-reaching effects on soil organic matter content and soil nutrient availability. The influence on nutrient availability is especially important as understanding of biological nutrient requirements is changing, with examples of multiple element limitation, or co-limitation, of productivity described in ecosystems worldwide. Mechanisms of co-limitation include sequential co-limitation, where availability of two elements is linked, leading to effectively alternating limitations. Given the influence of different mycorrhizal types on soil nutrient availability, dominance of one mycorrhizal type could influence the rate at which sequential co-limitation arises in an ecosystem. We investigated this possibility in an ongoing long-term, factorial N×P experiment in a New Hampshire hardwood forest. We quantified tree growth responses to nutrient additions over two periods of 4 years to test the hypothesis that the responses would differ based on the trees' mycorrhizal type. We found that EM trees significantly responded to nutrient increases in the first growing period while AM trees responded in the second growing period. Our results demonstrate the importance of mycorrhizal interactions in regulating ecosystem function. These mycorrhizal connections may help stabilize the ecosystem nutrient economy in the face of increasing anthropogenic nitrogen deposition. To better understand how hardwood forest ecosystems ameliorate threats from such anthropogenic change, this ongoing study aims address the dynamics of nutrient limitation and availability in northern hardwood forests.

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P-662

Comparison of nematode communities in managed and natural temperate forests.

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We analysed the effect of the interaction between stands of natural forest and stands influenced by human activity on nematode communities, necessary for realistically assessing the specific potentials of forest soils, plant protection, forest management, and land use management. Our study identified important relationships amongst types of forest management, age classes, and soil nematode communities. The trees affected the composition of the nematode communities more than the community indices by affecting the nematode genera and a range of trophic groups. The species-rich deciduous forests supported by extensive root systems had a higher diversity of nematode taxa and a higher abundance of herbivores than the species-poor coniferous forests. Nematode abundance and biomass were lower in the old managed and the unmanaged forests, perhaps associated with the more extensive root systems or the sequestration of soil C. These findings suggest strong bottom-up effects of belowground tree inputs and indicate that some components of the nematode community may be differentially affected by the resource quantity and quality.

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P-663

Mycorrhizal activity as a quality indicator in forest livestock crop integration system with Cagaita - Eugenia dysenterica

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The System of Crop, Livestock and Forest Integration is defined as a sustainable production strategy, which integrates agricultural, livestock and forestry activities, carried out in the same area, whether in a concrop, succession or rotation. Thus, it covers diversified production systems for the production of food, fibers, energy, timber and non-timber products, as well as products of plant or animal origin, in order to optimize the biological cycles of plants and animals, as well as the insums and their respective residues. The determination of a quality assessment methodology is fundamental as a management and decision-making tool. In this sense, the objective of this study was to evaluate the density of spores and the rate of mycorrhizal mycorrhizal colonization as an indicator of environmental quality in a system of crop, livestock and forest integration using Cagaita. The treatments evaluated were 1) Cagaita + Arachis pintoi./Callopogonium mucunoides; 2) Cagaita + Crotalaria Juncea L;3) Cagaita + Dolichos lablab L;4) Cagaita + Urochloa decumbens without nitrogen and; 5) Cagaita + Urochloa decumbens with Nitrogenio. Treatment 3 showed higher spore density than the other. There was no difference in mycorrhizal colonization rate in the treatments evaluated.

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P-664

Changes in the activity of enzymes involved in the C cycle and functional diversity of soil microorganisms – the effect of soil depth and soil-forming processes

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Most studies on soil microorganisms and enzymes are focused on the upper horizons of the soil profile even though they transform the soil organic matter at every depth of the soil profile. Since large amounts of organic carbon (even up to 60%) are stored at depth greater than 30 cm, subsoils have been identified as a potential carbon sink and are important in carbon sequestration (Hou et al., 2012). The enzymes involved in carbon transformation are of great importance because the hydrolysis products of these enzymes are sources of energy for soil microorganisms. Therefore the aim of the study was to determine the activity of C-cycling enzymes, microbial biomass content and microbial functional diversity depending on the soil depth and different pedogenic processes. Four soil profiles (Luvisols, Gleysol, Stagnosol) were excavated in fields with alfalfa (Medicago sativa L.). Generally, the studied microbial properties throughout the profiles were mostly affected by the carbon content, while influence of the soil-forming processes was less pronounced and not clear. The highest enzymatic properties and carbon substrate utilization were found in the top layers while in deeper layers differences were associated with the amount of the available substrates. Almost all activity of egzocellulase, endocellulase, endoxylanase and amylases was located in the surface horizons because of large organic compounds that they break down. The enzymes that target the easily decomposable compounds (egzoxylanase, α-glucosidase, ⍰-glucosidase, invertase) were also significantly active in the deeper horizons.

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P-665

Effect of cadmium bioavailability in agricultural soils on microbial greenhouse gas emissions under future climatic conditions

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Agricultural soils cover up to 12% of terrestrial Earth surface and contribute about 5% to total anthropogenic greenhouse gases. Current and legacy industry-born atmospheric deposition and more recent intensive use of phosphate fertilizers and pesticides in farming procedures have manifested in elevated toxic heavy metal cadmium concentrations in agricultural soils. Besides the increase in total soil cadmium, transient Earth's climate may lead to changes in cadmium bioavailability in soils. Both, elevated soil cadmium and a climate-driven change in cadmium bioavailability may alter soil microbial activity and the cycling of elements with potential implications for the emission of the climate-potent gases CO2, CH4 and N2O.

To investigate that link, we conducted climate-controlled mesocosm experiments with agricultural soils bearing three cadmium concentrations (0.15, 0.6, 3.1 mg kg-1 dry soil), representing geogenic background, low and high contamination, for 16 weeks. Imposed climates simulated today's and future conditions, the latter with +4°C atmospheric temperature and doubled CO2.

Future climatic conditions increased porewater cadmium concentrations 1.4-times for low and medium soil cadmium compared to today's climate, while no significant difference was observed under high soil cadmium. Porewater cadmium differences are explained by decreased porewater pH due to decreased microbial activity under future climatic conditions, which was also reflected in 1.45- and 1.10-fold lowered global warming potentials for low and medium soil cadmium conditions. Our results show that the coupled effect of cadmium contamination and climatic change conditions can play an important role in agricultural greenhouse gas emissions.

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P-666

Soil microbiome and mycobiome as an important driver of plant health and soil quality

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Healthy ecosystems are essential to boost resilience and sustainable agricultural and horticultural production. However, there is a need to research soil microbiome and mycobiome compositions, structure and functions, as well as their interactions with plants to develop new solutions and production strategies, especially in changing climatic conditions, including new pathogens occurrence. Poland is one of the biggest producers of organic fruits in Europe and the world. Therefore, the overall goal of the research is to support the effective increase of fruits quality in organic farming including control of key fungal pathogens, protection and maintenance of soil biodiversity, by developing new biotechnological solutions for diagnostics, control and monitoring of the quality of soils and plants. The following specific objectives included: to develop rapid and specific methods for detection of key fungal and fungal-like pathogens; to develop new bioproducts to control these pathogens; to develop new bioproducts for preservation and maintenance of soil biodiversity; to characterize the microbial activity and diversity of soils after application of various bioproducts; to select the relevant indicator(s) for monitoring of soils microbial diversity as ecosystem health marker(s); to propose the microbial diversity indicator(s) as the most significant in the determination of ecological soil status. This research indicated that microbial inoculants and biopreparations influenced the microbiome and mycobiome status, while soil micro- and mycobiota communities impacted plant health and soil quality maintenance.
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P-667

Understanding the impacts of antibiotics from human excreta derived fertilizers on the soil-microbial-plant nexus

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Meeting the increasing food requirements of our population sustainably remains one of the greatest challenges of our time. It is clear that recycling human wastes has a strong potential to accomplish multiple societal goals at once. For example, it can provide effective fertilizers for enhancing crop production, soil amendments for improving carbon sequestration and water-holding capacity, and a means for improving public sanitation and health. As such, human excreta derived fertilizers (HEDFs) are applied to agricultural fields in many areas globally. However, the potential health risks of such practices are debated, especially as little is known regarding how human antibiotics contained in these fertilizers will impact the soil-microbial-plant nexus. In this greenhouse trial, we compared the impact of antibiotics contained in four different HEDFs on the soil bacterial and fungal community structure, ecosystem functioning, the development of antibiotic resistance genes, and the uptake of antibiotics into edible plant parts. Specifically, we assessed two urine-based HEDFs (raw stored urine and nitrified stored urine) and two that include carbon-rich feces (compost produced using sewage sludge and municipal green wastes and vermicompost produced from human excreta as the main feedstock). These HEDFs were then applied to two soils with contrasting geochemical properties that we hypothesized would impact sorption-desorption dynamics. Additionally, two different crop types were grown to compare uptake of antibiotics into aboveground edible plant parts (spinach) and belowground edible plant parts (carrots). Our results are considered in the context of soil quality, sustainable agriculture, and potential negative toxicological impacts to human health.
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P-668

Isolation of cellulolytic strains of Aspergillus and Trichoderma for potential improvement of food waste composting

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The continuous production of organic waste is a global problem that has highlighted composting as a sustainable solution while generating a product potentially useful to agriculture. Within the variety of existing methods, the inoculation of cellulolytic fungi ubiquitous in soil is an interesting way of exploring biodiversity in order to increase the composting efficiency. In the present study, compost samples were collected with the purpose of identifying potential cellulolytic fungi.

The collected samples were mixed in NaCl 0.85% and incubated in Martin medium. Fungi colonies were then incubated in PDA medium and identified using the microscope. We obtained 19 isolates: 9 Aspergillus sp., 9 Trichoderma sp. and 1 unidentified by morphology.
All isolates were then grown in a selective medium with carboxymethylcellulose (CMC) as described by Carder (1986) to test for their cellulolytic potential. After 6 days, 18 isolates presented enzyme activity. The Aspergillus strains had enzymatic indexes varying from 0.0 to 2.4, whereas the Trichoderma strains had indexes varying from 0.7 to 9.7. To test for the temporal dynamic of enzyme production, a second test was carried out with selected strains incubated for 3 days in CMC. The enzyme indexes varied from 0.0 to 0.4.

As suggested by recent studies, we also believe that the Aspergillus and Trichoderma fungi can greatly improve industry processes and agricultural techniques. With a better understanding of the capacity and functioning of the enzymes produced by our strains, it is possible to consider their use to enhance the efficiency of food waste composting.

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P-669

Long-term tillage in combination with fertilization practices affects soil organic carbon content, N2O emissions, and microbial community composition

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Reduced tillage intensity is known to increase soil organic carbon (SOC) in the topsoil. Its effect is positively related with microbial community, however conflicting results were reported regarding impact on N2O emissions. In the present study, two different tillage systems were studied in a long-term field experiment at the University of Ljubljana: no till (NT) and conventional tillage with mouldboard ploughing (CT); in combination with three different fertilization strategies: mineral fertilization, compost and unfertilized control. After 21 years, the data showed a clear increase of SOC in NT compared to CT at 0-10 cm depth (the average difference was between 0.6 – 1.3 % SOC, depending on the fertilization). In addition, a clear stratification of organic carbon was observed in NT with decreasing values at greater depths (0-1, 0-10, 10-20, 30-60 cm) which was mirrored by microbial biomass and abundance of 16S and fungal ITS genes.
In 2021, N2O emissions and relevant soil physicochemical parameters were continuously followed during maize growing season (May to October). The main question is relationship between N2O emissions and the N-cycle functional guilds, possibly influenced by the different SOC and available N contents. Preliminary N2O emission results are showing differences between the two tillage systems and between the different fertilization strategies, with rain events being the main trigger of N2O emissions. Further results regarding the abundance of N-cycle functional genes such as nirS, nirK, nosZI, nosZII, nrfA, bacterial and archaeal amoA are still under investigation and will be presented at the conference.
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P-670

Rapid nitrification induced by repeated nitrogen fertilizers depends on the diversity gradient of soil microbial community

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Microbial diversity is important for many terrestrial ecosystems and sustaining ecosystem functioning and resilience. Agricultural nitrogen (N) input is reported to change the soil microbial community and N-cycling functions. In particular, intensive agriculture systems that repeatedly apply N to the soil can be one of considerable environmental stresses for the soil microorganisms. Previous reports showed that short time repeated N application induces rapid nitrification and increases the number of ammonia-oxidizing archaea (AOA) or bacteria (AOB). However, it was not clear how diversity of soil microbes were related to the promotion of nitrification by repeated N application. Therefore, our study aims to elucidate how microbial diversity is contributing to the environmental adaptation at the repeated N application phase. To produce diversity gradient, the serially diluted soil suspension [4 level; D1(10−1), D2(10−2), D3(10−3), D4(10−4)] was inoculated to the sterilized soil. Then, the samples were incubated at 25°C with ammonium N (200kg N/ha) for 5 weeks. Repeated N application was performed at the beginning of week 6 then further incubation was performed for 5 weeks. NH4+-N, NO3−-N, and the quantitative abundance of AOA and AOB were measured. The result indicated the diversity gradient was the important factor controlling the nitrification at repeated N application phase. Most rapid nitrification was observed with D1. Moreover, repeated N application also induces rapid nitrification even in the low diversity level D3. It was demonstrated that a diversified microbial community could facilitate rapid nitrification more efficiently at the repeated fertilization phase.
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P-671

Temporal effects of tillage on microbial characteristics and soil organic matter in semi-arid South Africa

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Tillage has temporal effects on microbial attributes and soil organic matter. Three tillage systems (NT, no-tillage; MT, mulch tillage; MP, mouldboard ploughing) were used to assess the impact on soil organic carbon (SOC), total nitrogen (TN), easily extractable-glomalin (GEE), dehydrogenase (DHA), β-glucosidase (β-glu), urease (URE), acid-(AcP) and alkaline-(AlP) phosphatase over time in a sandy-loam Plinthustalf cropped annually with winter wheat and occasionally oat in central South Africa. Soil samples were collected during oat (October 2010, November 2010), fallow (February 2011, April 2011, May 2011) and wheat (August 2011, September 2011, October 2011) at 0–5 and 5–10 cm depth. When averaged over sampling dates, SOC, TN and enzyme activities were 6–85% higher under NT than in MT and MP in the upper 5 cm soil. Trends changed at the 5–10 cm depth, with 20–32% higher enzyme activities recorded under MT. Soil quality indicators exhibited different trends over time, with GSWC, TN, DHA, AcP and AlP generally increasing during the fallow period and decreasing during oat and wheat phases, while β-glu was higher during both crop phases than at fallowing. URE was 33.6–174.3% higher during the oat phase than at the fallow and wheat phases. The opposite was observed with SOC, C/N ratio and GEE. Enzyme activities were sensitive indicators, but SOC and TN can be used to assess temporal changes in soil quality in resource-limited countries. However, temporal effects on SOC and TN were probably built in the long-term, hence further research focusing on multiple seasons is required.

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P-672

Changes in soil quality of an urban wetland as a result of anthropogenic intervention

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Changes in soil properties as a result of anthropogenic disturbance are used to assess the loss of soil quality in an ecosystem. The objective of this research was to evaluate the effect of nearby anthropic disturbance on the chemical, physical and biological properties of the soil associated to an urban wetland. Study site was the soil of the Angachilla urban wetland located in the city of Valdivia, Chile. Four sites were selected according to the degree of anthropogenic disturbance (P1-P4). Undisturbed samples (metal cylinders: 230 cm3) and disturbed samples by horizon were collected in the soil profile. Additionally, disturbed soil samples (0-20 cm depth) were collected to evaluate chemical and biological properties (composition of bacterial genes). Our results, shown that the sites evaluated present a significant variation in soil condition parameters which is associated with soil type and management. Thus, it is evident that the anthropic intervention generated a significant change in the OM content of the soil associated with the urban wetland, showing > 20% more OM in all horizons of P4 - low anthropic intervention than in P1 - anthropic-agricultural intervention older than 20 years-. In this context, it has been shown that disturbed have lower OM content than undisturbed wetlands on shallow horizon. Moreover, P4 shown a higher bacterial diversity and richness than other sites. Therefore, the anthropogenic disturbance on wetland ecosystem soils results in the loss of the soil organic horizon. Also, its chemical, physical and biological soil quality and subsequently its capacity to provide ecosystem services.

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P-673

Changes in soil microbial functional diversity across European field crop farms are mostly driven by environmental variables

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Nutrient cycling in agroecosystems is essential to maintain plant growth and development, being biochemical cycles mostly driven by microorganisms[1]. We evaluated 188 field crops under conventional and organic farming systems across nine European pedoclimatic regions to assess their microbial functional diversity in relation to farm management, soil characteristics and climate variables. Microbial functional diversity was evaluated by quantitative PCR using amoA, narG, and nirK genes involved in the nitrogen cycle, and cbbL red-like and GH7 genes to assess the carbon cycle. We found that functional gene abundance strongly differed across pedoclimatic regions, showing the northern regions the highest abundances and the Mediterranean regions the lowest. Conventional farming significantly increased the abundance of the amoA gene, whereas organic management significantly increased nirK gene abundances. The content of narG, cbbL, and GH7 genes were not significantly altered by the management practice. Principal Component Analysis showed that most of the northern regions clustered together in relation to the functional genes, while Continental, Lusitanean, Mediterranean North, and Mediterranean South regions were more different and dispersed. Multivariate analysis showed that amoA and narG were strongly associated to soil nitrate and moisture, while negatively associated to mean annual temperature. The genes nirK, cbbL, and GH7 were strongly associated to annual precipitation, followed by soil organic carbon and nitrogen while negatively associated to soil pH. Overall, the pedoclimatic region had a stronger influence on soil microbial functional diversity than the farming system. This work was funded by the H2020 program through the SoildiverAgro-project grant agreement 817819.

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P-674

MYCORRHIZAL FUNGI ARBUSCULAR IN FORAGE GRASSES CULTIVATED IN CERRADO SOIL

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The use of different weed cultivars for forage cover is growing increasingly popular because the climate changes from region to region and the response of these plants to the climate varies. Mycorrhizal fungi can bring numerous benefits to the plants with which they are associated. Therefore, investigating their influence on forage grown in soils of the Brazilian Cerrado is fundamental for understanding and for developing more efficient management practices of this crop in the Cerrado region. In view of the above, the objective of this work was to verify the mycorrhizal activity in different forages cultivated in Cerrado soils. The experiment was conducted at the Agrostological Field of the Ricardo Fontoura Experimental Station of the Cerrado which is part of the Evangelical College of Goianésia, Brazil. The density of spores and the mycorrhizal colonization rate of 14 forage grasses were evaluated. There was no difference in spore density in the rhizosphere of the studied plants; Urochloa decumbens forage had a higher rate of mycorrhizal colonization, and Megathyrsus maximus cv. Mombasa presented the lowest values. The genera of Mycorrhizal fungi identified were commonly found in the rhizosphere in all grasses investigated, except for the genera Gigaspora, Scutelospora and Sclerocysts, which indicates that the association with these genera of fungi is less recurrent than with the other genera.

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P-675

How soil microbes and plant are influenced by induced organic matter/nutrients and induced microbiota

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Soil microbes play an important role in sustaining ecosystem services. Unfortunately, due to intensive agricultural practices worldwide and climate change, soils suffer from erosion, nutrient depletion, pathogen threats, declining biodiversity, and consequently from declining agricultural productivity. Composts are commonly used as soil amendments to sustain and improve the functionality of agricultural soils and mitigate the environmental change consequences. Compost has abiotic (organic matter [OM], nutrients) and biotic characteristics (microorganisms). A number of studies show that compost-associated microorganisms can change the composition or activity of soil microorganisms and improve soil health. These effects disappear after sterilization or pasteurization of the composts. However, studies also report that compost-associated microorganisms are outcompeted by native soil microorganisms, and changes in the characteristics of the soil microbial community are mainly due to the input of OM rather than due to the microbial characteristics of compost. Debates are still ongoing in terms of the relative effects of abiotic and biotic components of composts on the soil microbial community and crop growth. Therefore, our study aims to disentangle the impacts of abiotic and biotic properties of compost on soil microorganisms and wheat growth in a microcosm experiment. We report that compost-associated microorganisms (rather than OM/nutrients) are essential to modify soil microbial community but may not benefit crop growth. Our study highlights the importance of understanding the role of abiotic and biotic properties of composts as common soil amendments on improving the functioning of agricultural soil.

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P-676

Investigating the relationship between fungal-to-bacterial ratios and soil organic carbon.

Miss Sandra McEwan

High fungal-to-bacterial biomass ratios (F:B) are considered an indicator of greater soil organic carbon (SOC) pools, as fungal-dominated communities produce a broader array of enzymes than bacteria, have slower turnover rates and greater carbon use efficiencies. However, the merit of F:B ratios is contested because they do not reflect the current understanding of microbial communities as complex ecosystems. Our research has employed phospholipid fatty acid analysis to evaluate how changes in F:B ratios correlate with soil organic carbon in seven sites across Northern Queensland. The results revealed no observable relationship between F:B ratios and SOC; however, total microbial biomass was positively correlated with SOC. Emerging research suggests that continued cell proliferation/growth/death in microbial communities leads to the accumulation of necromass and metabolites in the soil, which then contribute to SOC. This hypothesis supports our findings, as a larger biomass would result in a greater accumulation of SOC. Interestingly, biomarkers for arbuscular fungi were also found to have a significant relationship with carbon content across all sites. This corroborates the importance of mycorrhizal associations as channels of carbon (in the form of hyphae and glomalin proteins) into the soil, which can accumulate and persist as SOC. This data implies that 1) overall microbial biomass has a greater influence than the proportion of fungi to bacteria, and 2) the importance of F:B ratios is related to the abundance of mycorrhizal fungi in the soil rather than their size relative to bacterial biomass.

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P-677

Analogue soil porosities from contrasting land use and soil management can be explained by soil carbon fluxes.

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Soil organic carbon has been correlated with important soil biological and physical functions. A range of mechanisms have been proposed to explain these links, however, there is no consensus on how many of these critical soil properties emerge because of nutritional management and land use. We have used two of the long-term experiments at Rothamsted Research, Broadbalk, Highfield ley arable experiment, and back to nature treatment that has returned to a woodland state. We present porosity estimations from X-ray Computed tomography (XCT) Soil from the different treatments was scanned using XCT at two resolutions: 1.5µm and 40µm and the images were segmented to identify pore and solid volume. These resolutions capture pore space that is responsible for drainage (40 µm) and retention (1.5µm) of water. The treatments selected in Broadbalk were inorganic fertilised (NPK), farmyard manure (FYM), inorganic fertilised with no added phosphorous (NK), and no added nutrient treatment (Nil). We compared the porosities and carbon flux of these treatments with earlier analyses on the Highfield experiment on bare fallow (BF), arable inorganic fertilised (A), and permanent grass (G) treatments. Porosity was analogous between the two experiments. At the aggregate scale FYM, back to nature, and Highfield grass had the highest measured porosity with 40%,35%, and 33%. The inorganic arable in both sites and Nil presented similar porosities 25%, 24% and 23%. finally, BF and NK showed the lowest porosities with 15% and 12%. Porosity followed the carbon flux modelled with RothC, demonstrating its critical in structural development in soils.

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P-677

Effects of a megafire on the arbuscular mycorrhizal fungal community and parameters in the Cerrado ecosystem

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This study aimed to evaluate the effects of a mega-fire on the arbuscular mycorrhizal fungi (AMF) community and parameters in soils under Cerrado vegetation.
Chapada dos Veadeiros National Park, Goiás, Brazil. This site suffered the biggest fire in its history on October 10, 2017, with an affected area of 66,000 ha.
Materials and methods: In this study, we analyzed AMF spore density, roots' mycorrhizal colonization rate, easily extractable glomaline, as well as the AMF genera present. These parameters were evaluated in burned and unburned areas of five common phytophysiognomies of the region.
Fire presence immediately influenced the mycorrhizal community parameters in Cerrado soils, which tended to increase afterwards. The presence of AMF genera did not differ between burned and unburned areas, with Acaulospora, Claroideglomus, Diversispora, Glomus, Funneliformis, Sclerocystis, and Gigaspora being present. The recovery of AMF community conditions in the Cerrado after fire events could also be observed in the parameters evaluated, as the values of density, roots' mycorrhizal colonization rate, and easily extractable glomaline were similar in the burned and unburned areas.
AMF diversity and especially their community parameters show great recovery after fire events, since they are crucial in processes like nutrient cycling and soil aggregation.

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P-678

Changes in community structures and activities of soil ammonia-oxidizing bacteria and archaea by land-use changes in multiple sites in Zambia

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In sub-Saharan Africa, soil nitrogen (N) has been lost with soil degradation due to excess cultivation. Ammonia-oxidation by soil microbes provides N to crops but can be a cause of N loss when it occurs excessively. Thus, microbial changes under soil degradation can accelerate further N loss. However, it is unclear how the soil ammonia-oxidizing bacteria (AOB) and archaea (AOA) form their communities and work under soil degradation. Therefore, the investigation of changes in their communities and ammonia-oxidizing abilities in the degraded soil is needed. The shaken-slurry method was used to investigate the nitrification potentials (NP) in two land-uses (natural, farm) at three sites (A–C) in Zambia. The soil DNA was extracted and sequenced by targeting 16s rRNA and ammonia monooxygenase subunit A (amoA) both for AOB and AOA, followed by the analysis of their community structures. The NP was 4.3 to 9.1 times higher in site A compared to the other sites on average. Besides, in each site, farm soils showed relatively higher NP possibly related to N loss in farms. The direction of changes in the community structures of ammonia-oxidizers by land-use change was different among sites, although Nitrosospira multiformis which might be related to NP increased its relative abundance similarly across site B and C, where original NP was relatively low. Overall, the sensitivity to land-use changes of the ammonia-oxidizers' community was site-dependent, but they seemed to change to form fast nitrifying community structures especially when they had been originally in the soils with lower NP.

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P-679

Bacterial microbiome of regenerating lodgepole pine – an ally supporting host growth and survival in an aggregate mining ecosystem?

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Soil and plant microbiome plays a central role in plant response to abiotic stimuli, improving plant fitness under challenging conditions[1]. Despite little soil development and organic matter accumulation, lodgepole pine (Pinus contorta var. latifolia) trees consistently show vigorous growth on bare gravel substrate of aggregate mining pits in parts of Canadian sub-boreal forests[2]. This study aimed to investigate the bacterial microbiome of lodgepole pine growing at a gravel pit in central British Columbia and suggest their potential role in tree growth following mining activity. We characterized the structure of bacterial communities in rhizosphere and endosphere niches of pine trees regenerating at the gravel pit and compared them with a nearby undisturbed forested site using metabarcoding approach[3]. Proteobacteria, Actinobacteria and Acidobacteria were the most abundant phyla at both sites. Soil and plant nutrient analyses revealed that despite drastically lower soil-N at the gravel pit than the forest site, the tissue N-levels of pine at both sites were identical. Taxa involved in N-fixation including Rhizobiaceae, Acetobacteraceae and Beijerinckiaceae dominated pine niches at the gravel pit[4]. Bacterial beta-diversity differed significantly between gravel pit and forest site. Alpha-diversity was significantly lower in aboveground-niches compared to belowground-niches at both sites, indicating that the rhizosphere-root interface acts as a bottleneck to bacterial diversity and that adaptation to needle-stem niches is taxa specific. Our results suggest that, following mining activity, regenerating pine trees recruit distinct bacterial communities that appear beneficial in supporting pine growth, with a potential role in N-nutrition in an otherwise severely N-limited disturbed environment.
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P-680

Linking microbial traits with carbon cycling in degraded and restored peatlands

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Peatlands are the most carbon dense ecosystem on earth. They only cover approximately 3% of the land area on Earth and yet store ~21% of the global total soil carbon stock, meaning peatlands have an important role in climate change mitigation. However, around 10% of peatlands globally have been drained or mined, which emit 5% of anthropogenic GHG emissions annually.

Recent restoration of peatlands has led to the return of soil carbon sequestration, and associated climate benefits. Despite this the microbial community and associated microbial functioning does often not approach that of pristine peatlands even 20 years post restoration. How the altered microbial functioning impacts long term carbon storage and resilience in restored peatlands is unknown. A mechanistic understanding is required to both predict and manage carbon cycling processes in peatlands in a changing climate.

Here we demonstrate the effects of peatland degradation and subsequent restoration on microbial physiological processes and their consequences on peatland carbon transformations. Seven peatland sites across the UK, each containing near-natural, degraded and restored areas were sampled and microbial carbon cycling traits such as carbon use efficiency and stress tolerance are being quantified using a combination of shotgun metagenomics and stable isotope tracing. First results indicate that lower moisture and higher oxygen levels in degraded peatland areas are linked to higher CO2 flux as compared to near-natural and restored areas. The project aims to quantitatively link microbial traits and carbon cycling processes which will enable a better mechanistic understanding of the carbon dynamics in peatlands.

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P-681

Farming system induced differences in soil fungal community are strongly linked to pedoclimatic European region

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Fungi are superior decomposers of plant residues and indispensable mycorrhizal symbionts enhancing water and nutrient uptake by plant. Moreover they contribute to pathogen control, stress tolerance and growth promotion of plants, driving diverse functions in agroecosystems. A comprehensive sampling across nine European pedoclimatic regions, 188 wheat fields of conventional and organic farming systems were conducted to get an overview of the current state of soil fungal biodiversity. Fungi were detected by using ITS marker and Illumina MiSeq sequencing.

Pedoclimatic region had the strongest impact on both fungal alpha- and betadiversity. Fungal richness was highest in the Nemoral region and lowest in Mediterranean regions. Shannon diversity index was highest in the Pannonian region. There was higher richness under organic farming system in the Nemoral region and in the Lusitanean region.

The abundance of symbiotic arbuscular fungi was not affected by the region nor the farming system. However, the total proportion of all symbiotic fungi was highest in the Nemoral region compared to all regions. Interestingly, differential abundance analysis revealed increased abundance of dark-septate endophytes (DSE) in the Lusitanean region. DSE are suggested to have many positive impacts, e.g., on soil C sequestration and plant growth.

Since the regional differences affecting fungal community were evident, next the impact of climatic factors, soil properties as well as the applied management practices on fungal communities of the European wheat fields will be studied in more detail.

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P-684

Cyanobacterial diversity from gypsum soils at White Sands National Park, New Mexico, USA.

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Gypsum soils with their unique chemical and physical properties are known to harbor charismatic endemic communities of macroscopic organisms. In contrast, our knowledge of the soil microbial diversity is limited. Due to their important role in soil stability and fertility we have been investigating the soil cyanobacterial flora from diverse locations at White Sands National Park, USA, which protects the largest gypsum dune field in the world. We used culture dependent dilution plating to isolate cyanobacteria and study their life cycle. Unialgal cyanobacterial strains were characterized using the polyphasic approach including morphological observations, the molecular characterization of the 16S rRNA gene region, and the secondary structure of the 16S-23S ITS region. Taxa identified to date are phylogenetically diverse and include species from at least 6 orders in Cyanobacteria. Represented genera included Nodosilinea, Oculatella, Trichocoleus, Leptolyngbya in Synechococcales, Cyanosarcina in Chroococcales, Phormidium, Symploca, and Symplocastrum in Oscillatoriales, Chroococcidiopsis in the Chroococcidiopsidales, Pleurocapsa and Myxosarcina in Pleurocapsales, as well as Scytonema, Nostoc, Hassallia, and Desikacharya in Nostocales. Our floristic study contributes first comprehensive insights into a unique soil biota and will expand the biodiversity inventory of such a unique environment. Further, our culture-based phylotaxa will inform future next generation sequencing surveys with the goal of identifying potential indicator species to soil erosion resistance and drought tolerance, an important objective to White Sands National Park's resource management.
N/A

P-685

Effect of the depth of straw addition combined with slurry fertilization on the microbial community composition and respiration

Sara Pintarič

In organic farming systems, where plant nutrition depends on either organic matter inputs or nitrogen fixation by legumes, it is crucial to understand the effects of different crop residue management. To evaluate these effects under different tillage options we conducted a pot experiment simulating (1) minimum tillage (MT) by mixing in rye straw to a depth of 10 cm and (2) no-tillage (NT) by applying the straw to the soil surface. We also included the control treatment without straw amendment (CONT). An additional factor in the experiment was fertilization (slurry 170 kg/ha). After fertilization the CO_2 efflux (µmol/m2/s) was measured regularly over a four-month period. Regular soil sampling was performed to monitor the abundance of the total bacterial community and nitrogen cycle microbial guilds as well as the dynamics of labile nitrogen and carbon fractions (NH_4-N, NO_3-N, DOC) in the soils at different depths (0-1 cm, 1-10 cm, 10-20 cm). We observed the highest CO_2 peak in the fertilized treatments MT, NT and CONT, respectively. Further, among the tillage simulation treatments we detected significantly higher CO_2 efflux in MT soil, following NT and CONT. Highest DNA content and the abundance of the 16S rRNA bacterial gene was found in the 0-1 cm soil layer in comparison to deeper layers in all fertilized treatments. Among the N-cycling microbial community, fertilization stimulated the abundance of nitrifiers (amoA) and denitrifiers (nirS, nirK, nosZI and nosZII). While, the effects of the depth of straw addition on the studied microbial community were less pronounced.

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P-686

The responses of N-cycling enzyme activities and functional diversity of soil microorganisms to soil depth, soil-forming processes and cultivated plants

Prof. Anna Piotrowska-Długosz, Prof. Jacek Długosz, Dr Agata Gryta, Prof. Magdalena Frąc

The rates of N cycling and soil enzyme activities involved in the transformation of soil N-related nutrients are rarely measured in soils below a 30 cm depth, even though substantial amounts of nitrogen are stored in deep soils (Darby et al. 2020). The aim of this study was to determine how the soil microbial functional diversity and enzymatic activity changed as a function of depth across the soil profiles that differed in their soil-forming processes (Luvisol, Gleysol, Phaeozem). Two soil profiles were excavated in the fields with lucerne and two under winter wheat cultivation. We assessed the activity of urease, nitroreductase, proteases, N-acetyl-β-D-glucosaminidase, the microbial utilization of the N-substrates, the microbial biomass nitrogen content and related physicochemical properties. In general, the highest enzymatic properties and nitrogen substrate utilization were found in the Ap horizons and decreased with depth, but no consistent trends were found with regard to the sharpness of the gradient. The enzyme activity in the subsurface layers was also affected by factors that are associated with the pedogenic processes (e.g., the lessivage process, clay content). Only the nitroreductase activity was higher in the horizons with potential reducing conditions compared to the oxidative horizons. The lessivage process significantly reduced the microbial biomass and enzymatic activity. In general, the nitrogen substrate utilization decreased with depth and was greater in lucerne than the winter wheat profiles, and also in the Gleysol and Phaeosem profiles than in the Luvisols.

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P-687

Shift in diazotrophic community structure in fire-affected soils under sclerophyll forests in the Mediterranean zone of central Chile

Dr Claudia Rojas, Dr Humberto Aponte

Fires are important drivers of vegetation evolution and adaptation in Mediterranean biomes. However, in Chile they have not been considered an evolutionary force to select for fire-prone vegetation (Rundel et al., 2018, 2016). The negative effect of fires on soil properties is well recognized globally, and the greater sensitivity of soil biological properties to disturbances (compared to abiotic factors) is also established. These effects have been observed on microbial composition, diversity, and proportion of different members, and on taxonomic groups with specific functional capabilities. This study aimed to evaluate non-mutualistic diazotrophic community structure in rhizosphere samples of herbaceous species and bulk soils from two fire-affected sclerophyll forests (one 33 and the other, 17 months after fire occurrences) in the Mediterranean zone of central Chile. Molecular analyses based on qPCR and Illumina MiSeq of the nifH genes reflected a legacy of fire occurrence which was more notorious in the most recent fire-affected site. This was evidenced by a reduction of gene copy numbers and the decrease in alpha diversity indexes in burned soils. Moreover, and alterations of relative abundance of diazotrophic taxa, including members of the order Clostridiales, Rhizobiales, Bacillales, and Fibrobacterales was observed after fire occurrence. In an ecosystem frequently affected by fires and whose vegetation is not well adapted to such events, our results allow for a better understanding of the local state of diazotrophic diversity and composition after different time periods following fire, conditions that likely influence the ecological processes taking place during recovery of fire-affected ecosystems.

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P-688

Enzymatic and microbial stoichiometry shifts upon nutrient addition do not adequately capture growth-limiting nutrients of soil microorganisms

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Liebig law states that the resource lowest in availability limits the growth of an organism. Since direct growth responses to nutrient additions are hard to measure for soil microorganisms, indirect stoichiometric approaches with carbon-, nitrogen- and phosphorus-acquiring enzymes or microbial C, N and P contents have been used as indicators to infer growth limiting nutrients. So far, these methods have not been verified against actual growth responses to nutrient additions.
Therefore we added C, N and P in a full factorial design to a subtropical grassland soil, evaluated enzymatic and microbial C:N, C:P and N:P stoichiometry as well as microbial community composition, and compared it to actual direct growth responses of soil bacteria and fungi.
While microbial growth responses showed a clear limitation by C, enzymatic C:N, C:P and N:P ratios suggested P limitation. Moreover, a month of C addition–which should shift enzyme activity towards more N- and P-acquisition–shifted the growth-limiting nutrient for fungi, yet not enzymatic C:N and C:P ratios.
P- and NP-addition to the grassland soil significantly decreased the microbial N:P ratio, which suggests increased N- relative to P-limitation. Microbial growth responses however did not indicate a shift away from C limitation.
Microbial community shifts could not reliably explain the observed shifts in microbial and enzymatic stoichiometry.
Our data suggest that the relative resource availability determines the degree of microbial resource partitioning towards growth, production of extracellular enzymes or intracellular storage, implying that enzymatic and microbial stoichiometry do not adequately capture growth-limiting nutrients for soil microorganisms.

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P-689

Belowground C allocation of tropical rainforests in response to drought:an ecosystem $^{13}CO_2$ labeling approach

Dr lingling shi, Pratiksha Acharya, Dr. Xujuan Bai, Niklas Schmuecker, Dr. Nemiah Ladd, Prof. Christiane Werner, Prof. Laura.K Meredith, Prof. Michaela Dippold

To explore the extreme drought impacts on the tropical rainforests, within the framework of manipulation experiment on “Water, Atmosphere, and Life Dynamics" (WALD) at the Biosphere 2 in Arizona, we conducted a whole ecosystem stable isotope labeling with atmospheric $^{13}CO_2$ to gain in-depth insights into tree belowground C allocations and the C partitioning at the soil–microbe-root interface under ambient conditions and drought stress. In particular, we hypothesized that key drought-adaptation strategies would include i) increased C allocation into subsoil layers with higher moisture than dried-out topsoils and ii) increased relative C investment into rhizodeposits and mycorrhizal fungi. In contrast to our hypotheses assimilated ^{13}C tracer accumulated in topsoil roots, but this C allocation did not contribute to a higher root biomass, suggesting that tropical plant might modify their root composition (e.g., forming osmolytes) to resist drought stress. The rhizodeposition (allocation of assimilated C into rhizospheres soil) increased in the subsoil, suggesting that trees aim to keep rhizomicrobial activity high in subsoils, where moisture was still available throughout the drought. However, we found pronounced plot- and thus plant-specific differences in belowground C allocation, especially between understory plots versus those with tall trees, suggesting species-specific drought response strategies. Results on ^{13}C incorporation into rhizosphere phospholipid fatty acids will provide further insights into microbial C utilization in root proximity and complete our picture of belowground drought adaptation strategies. In summary, quantification of tree C belowground allocation patterns at the plant-microbe-soil interface enables us to disentangle distinct belowground drought response strategies of tropical rainforests.
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P-690

Arbuscular Mycorrhizal Fungi associated with maize plants (Zea mays L): a biotechnological and sustainable strategy to overcome a dry period

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Drought is one of the environmental stresses, with the occurrence of climate change, more serious that negatively affects plant growth and productivity. However, Arbuscular Mycorrhizal Fungi (AMF) that are associated with plant roots increasing the root system area, water absorption and nutrients, relieve the negative effects caused by water restriction. Corn has high water consumption to meet its physiological needs and when it is in a situation of water deficit there is a reduction in carbon fixation in the photosynthetic appendage and productivity. The aim of this study was to verify the biotechnological potential of arbuscular mycorrhizal fungi associated with maize (Zea mays L.) plants after dry season. Corn seeds were inoculated with Rhizophagus clarus, Claroideoglomus etunicatum, and Rhizophagus intraradices (Rootella BR®), separately, at sowing and grown in greenhouse. Subsequently, they were submitted to water deficit in phase V3, keeping the vessels at 20% of the field capacity for 10 days, and then reirrigated for 2 days and physiological analyses performed. The experiment was a double factorial, being 2 water treatments (irrigated irrigation and water deficit) x 4 inoculation treatments (Control, Rhizophagus intraradices, Rhizophagus clarus, Claroideoglomus etunicatum) x 5 replicates per treatment, totaling 40 vessels. After the dry season, maize plants associated with AMF recovered favorably with improvement in photosynthetic rate, stomatic conductance, electron transport rate and photosynthetic pigments. Therefore, the use of these microorganisms helps the recovery of corn plants after a drought, and this symbiotic association is an alternative to overcome abiotic stress resulting from climate change.
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P-691

Differential Temperature Sensitivity of Intracellular and Extracellular Soil Enzyme Activities

Dr Adetunji Alex Adekanmbi, Mr Laurence Dale, Professor Liz J. Shaw, Dr Tom Sizmur

Predictions concerning the feedback of soil heterotrophic respiration to a warming climate often do not differentiate between the extracellular and intracellular processes involved in soil organic matter decomposition. We measured the temperature sensitivity of both extracellular (β-glucosidase and chitinase) and intracellular (glucose-induced CO2 flux) enzyme activities in a UK grassland soil. Soils were assayed at a range of temperatures (5°C, 15°C, 26°C, 37°C, and 45°C) and Q10 (the increase in enzyme activity that occurs after a 10°C increase in soil temperature) was calculated to assess temperature sensitivity. Between 5°C and 15°C intracellular and extracellular enzyme activities had equal temperature sensitivity, but between 15°C and 26°C intracellular enzyme activity was more temperature sensitive than extracellular enzyme activity and between 26°C and 37°C extracellular enzyme activity was more temperature sensitive than intracellular enzyme activity. These results imply that extracellular depolymerisation of higher molecular weight organic compounds is more sensitive to temperature changes at higher temperatures (i.e. more likely to be influenced by changes to daily maximum temperature) but the intracellular respiration of the generated monomers is more sensitive to temperature changes at moderate temperatures (i.e. more likely to be influenced by changes to daily mean temperature). We therefore conclude that the extracellular and intracellular steps of soil organic matter decomposition are not equally sensitive to changes in soil temperature. These processes should be accounted for in global climate change models.
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P-692

Microbial diversity and assemblages across plant life stages under drought scenarios: implications for dryland restoration

Ms Jana Stewart, Prof Richard Kingsford, Dr Miriam Muñoz-Rojas

Drylands support 40% of the earth's population. But, with naturally low and infrequent rainfall, these systems are particularly vulnerable to the impact of climate change over longer and more severe droughts. This is of concern for Australia where drylands support the majority of grazing, and sustain unique and diverse flora and fauna, which have already suffered great biodiversity loss. This project aims to identify key microbes influencing seedling establishment of native plants in grazed drylands under drought scenarios. Furthermore, we aim to discern how plant community assemblage may buffer the impacts of drought and improve restoration efforts. We will focus on combinations of three functionally different key species- Acacia aneura, Atriplex nummularia, and Astrebla leppacea, to understand compositional or functional changes that may occur in soil biota under drought stress. In this on-going experiment, soil microbes are being examined at germination and again after a drought simulation to assess key microbial communities for seedling establishment and resilience to drought.

In this presentation, I will show which microbial functional groups are most vulnerable to drought, and also those most resilient and resistant. The results of this study can offer powerful baseline information to understand ecosystem responses to changes in climate and assist in establishing priorities in land management strategies.

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P-693

Cover Crop and Tillage Effects on Temporal and Spatial Variations of Phospholipid Fatty Acid Profile of a Corn Cropping System

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Abstract
Soil microbial structure is identified as one of the most important soil health parameters. The objective of this study was to evaluate the CC and tillage effects on the spatial and temporal variations of soil microbial community composition of a corn (Zea mays L.) - soybean (Glycine max L.) rotation during a corn year. The treatments were, 1) no till cover crop (NC), 2) conventional till no cover crop (CN), 3) no till no cover crop (NN), and Grass strip. Soils samples were collected in April 2020, September 2020, and April 2021. In April 2020 sampling, the G treatment had significantly higher total microbial (3525.21 ng g-1) and actinomycetes biomass (499.21 ng g-1) compared to CN (2175.91 ng g-1, 269.11 ng g-1). During the September 2020 NC had significantly lower total microbial biomass at 0-5 cm depth (5439.73 ng g-1) compared to G. At 0-5 depth, CN and G plots had significantly higher total bacterial and actinomycetes biomasses compared to NC. During the April 2021 sampling, G and NC showed similar total microbial biomasses, which were 2 times and 1.8 times greater than NN (2181.93 ng g-1) at 0-5 cm depth. The total bacterial biomasses in G and NC were 2.3 times and 1.7 times greater compared to NN (874.64 ng g-1). Results of this study show that the CC treatment managed to improve the microbial structure of the soil over the time. It can be speculated that long-term management of CC potentially improve the soil microbial community structure.

No references In ABSTRACTS

P-694

How biocrusts determine soil carbon and nitrogen cycling in a changing climate

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In arid and semi-arid ecosystems, water limitation strongly restricts plant growth. Instead, a substantial part of primary production takes place in the uppermost millimeters of the soil, within a layer of complex microbial communities and soil particles, forming biocrusts. These communities, composed e.g. of bryophytes, cyanobacteria, algae, and fungi, can account for up to 70% of the living cover in drylands[1], and are known to hold a key role in biogeochemical processes such as nutrient cycling and C sequestration in scarce and fragile soil ecosystems[2,3]. However, there is little knowledge on how climate change might affect biogeochemical fluxes between atmosphere, biocrusts and subsurface soils and, thus, the key functioning of dryland soils.

We aimed to quantify inputs of C and N from biological fixation in biocrusts into the soil and to determine whether these processes are altered by drought stress and elevated temperatures. This was realized in a climate simulation experiment, where biocrusts were established in soils from an arid and semi-arid site in Chile under two climatic conditions; current climate, and a +5°C warming scenario. During five-month incubation, ^{13}C and ^{15}N pulse labelling was applied and CO_2 uptake and respiration was assessed to determine microbial activity. The fate of the fixed ^{13}C and ^{15}N into specific soil pools, as well as into microbial biomass, was determined via organic matter fractionation and PLFA analyses. This study hereby aims to gain insight into biocrust-soil-microorganism interactions at the process-scale, and to provide answers to how these interrelations are impacted by climate change.

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P-695

Impact of herbicides on soil microorganisms based on three decades of studies

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Traditional crop production practices involve the use of numerous chemicals (herbicides, pesticides, insecticides and fertilizers) in agricultural fields, which affect the abundance, biodiversity and activity of soil microorganisms. In recent years, an increasing body of research has drawn attention to the ecotoxicological effects of pesticides on soil ecosystems, and therefore the study of the impact of herbicides on soil ecosystems is essential for sustainable agricultural practice. The Department of Soil Science at the University of Debrecen has a long history of soil microbiological studies of currently authorised and used herbicides. In this thesis, the effects of 16 herbicides used in significant quantities over the last three decades on the abundance and activity of soil microorganisms in small plot experiments are evaluated. Among the herbicides used, the older formulations had the most negative effects on the soil microbial community, while the newer formulations had the most positive effects. From a soil ecology point of view, neither the negative nor the positive effect is beneficial, since the positive effect is often due to the proliferation of micro-organisms on easily taken up nutrients after the death of species sensitive to the product and a large reduction in biodiversity.

Soil microbial diversity and activity were most reduced by a herbicide containing the active ingredient glyphosate. From the results of the study, it can be concluded that the secondary effect of herbicides is influenced by the effect of the season, as the negative effects of the chemicals are more pronounced under unfavourable (drier) conditions.

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P-696

Residual chlorinated organic pollutants in paddy soil may induce methane release as revealed by coupling between methanogenesis and reductive dechlorination

Dr Yan He, Dr Jing Yuan, Dr Jie Cheng, Dr Xueling Yang, Dr Jianming Xu

Residues of chlorinated organic pollutants (COPs) in environment is still a major public concern. Reductive dechlorination is the most efficient way for depletion of COPs in paddy soil, where the methanogenesis is usually mass-produced. Both processes are essentially microbial-mediated electron accepting processes and received much attention in last decades, due to their great importance for soil remediation polluted by COPs, and the effect of global warming, respectively. In this study, we applied meta-analyses, incubation experiment and quantum modelling to investigate the associations between reductive dechlorination and methanogenesis. Results indicated the accelerated methanogenesis were commonly synergistically coupled with the accelerated removal of COPs. Some methanogens were showed as the core taxa co-occurring with dechlorinators in the microbial networks of COP-polluted environments. Also, methanogenic species could promote some COP dechlorination by regulating cell metabolic functions, e.g., the coenzyme F430 could reduce the activation barrier of reductive dechlorination. Further regulation based on a mixed culture through microbial electrolysis cell verified the possibility to synchronously regulate these two processes via the application of suitable electrostimulation. Collectively, our work provides a novel insight into the multiple environmental function of methanogens that likely contribute to COP dechlorination, and the associations between dechlorination and methanogenesis may occurred and can be modified in COP residual paddy soil. Caution is thus necessary to be paid on the potential risk of increased methane release from paddy soil polluted with COPs.

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P-697

Soil biochemistry and main microbial groups are resilient to an increasing fire recurrence in Pinus pinaster forests of central Spain

Ms M. Belén Hinojosa, Mr Enrique Albert-Belda, Mr Vito Armando Laudicina, Mr José M. Moreno

Mediterranean ecosystems are considered to be resilient to fire[1]. However, changes in the fire regime may compromise the stability of ecosystems. It is expected that, in the future, as a consequence of changes in land-use and climate fire frequency might increase[2]. Here, we determined the effect of the fire history (fire frequency, time since the last fire and fire return interval) on soil C and N dynamics and the main microbial groups in Pinus pinaster forest in central Spain. 28 stands were chosen differing in the number of fires (0,1,2 and 3), in the time elapsed since the last fire and the time between the last two consecutive fires. Soil C and N fractions as well as their mineralisation rates were analysed. Additionally, the microbial community of these soils was characterised. We found that, in general, most of the studied biogeochemical and microbial variables differed between unburned and burned stands. Increased wildfire frequency only modified total C and nitrification rate. The time interval between the two most recent consecutive fires was generally not a significant variable. The time elapsed since the last fire was the most important fire history variable and governed the main soil dynamics. Recovery of pre-fire values of the studied variables took about 30-40 years after fire. The fact that palaeoecological records hint at fire return intervals of more than a century for native Pinus pinaster forests[3], support the strong resilience of these soils to increased fire frequency.

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P-698

Insight into Malaysia's tropical peatland metagenomics: the influence of land-use change

Frazer Midot, Ms Mui Lan Yap, Dr Kian Mau Goh, Dr Kok Jun Liew, Dr Sharon Yu Ling Lau, Dr Lulie Melling

Tropical peatland is a globally significant terrestrial carbon reservoir, where peat accumulates from organic matter of mostly plant materials in acidic waterlogged conditions. Malaysia has approximately 1.7% of the global tropical peatland area, with 70% of Malaysian peatland located in Sarawak. The study of peat microbial and functional diversity, as well as the impact of land-use on the natural microbiome, is mostly unknown in tropical peatland. Thus, microbial monitoring was carried out between the Batang Saribas River and the Batang Lupar River in Sarawak tropical peatland. The study site had transitioned from a historically logged over secondary peat swamp forest to an oil palm plantation in 2018. Peat samples collected throughout the land-use change period were examined using metataxonomic approaches. This study also aims to reveal the essential genes involved in various geochemical cycles through functional annotations of metagenome shotgun data. The dominant phyla were Acidobacteria, Actinobacteria, and Proteobacteria. Together with other phyla, they harbour important carbon metabolism for energy generation and conversion, especially in the glycoside hydrolases families. This information will be the baseline for understanding the effect of land-use change on microbial communities and the underlying biological processes. They will contribute to the development of scientific-based solutions for tropical peatland sustainable management.

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P-699

Effect of chitin extract from shrimp shells on soil microbial community functions

Ms Alys Swaffield, Dr Adrian Crew, Dr Sam Bonnett

Chitin (poly-(1→4)-β-N-acetyl-D-glucosamine) is a novel bio-stimulant derived as a by-product from sustainable fish production (Pichyangkura & Chadchawan, 2015). This study observed the effect of chitin derived from shrimp shells on agricultural soil microorganism metabolism and on greenhouse gas emissions. Additions of ≤10% shrimp shell concentrations at <63µm, 63-125µm, 125-250µm, 250-500µm, 500-1000µm, and 1000-2000µm particle size fractions were added to temperate agricultural soil in mesocosms under laboratory conditions. Phenol oxidase and the hydrolase enzymes glucosidase, chitinase, and phosphatase were assayed to determine substrate utilisation in relation to soil organic matter, pH and greenhouse gas production (CO2 and CH4). Larger applications of chitin resulted in acidification and enzymatic response from glucosidase, phosphatase, whilst smaller applications and smaller particle sizes resulted in neutral soil pH and higher phenol oxidase activity. Chitin additions at 1-5% concentrations and <63-125µm particle sizes had the most complete microbial utilisation and balance between CO_2 emission and CH_4 sequestration, as a result of the priming effect of the chitin and successive microbial enzyme responses to the pH shift and reactivity of sites from solubilised particles. The importance of surface area and aerated lattice structure within the chitin particles was also shown. The use of fractionation rather than chemical processing of the chitin substrate increased solubility, reactivity, uptake and retention. The project demonstrated that use of chitin by-products can achieve positive effects within soils when applied appropriately. The benefits may include creating a multiplicity of soil micro-habitats, improving nutrient retention, enhancing soil quality and promoting microbial interactions in the rhizosphere.

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P-700

Moss biocrust promotes the recovery of fungal communities in soils affected by a wildfire and post-fire salvage logging

MsC Minerva García-Carmona, PhD Clémentine Lepinay, PhD Fuensanta García-Orenes, PhD Petr Baldrian, PhD Jorge Mataix-Solera

After wildfires in Mediterranean forests, mosses are typical fast soil colonizers in early successional stages of plant colonisation. The dense moss biocrust that precedes the establishment of vascular vegetation promotes soil erosion mitigation, enhances soil fertility and boosts microbial development. However, it is still poorly understood how the biodiversity of microbial communities is impacted by the emergency of such biocrusts after a fire, especially in soils disturbed by post-fire management. Therefore, the aim of this work was to evaluate the medium-term effects of a moss biocrust, developed after a wildfire and affected by a very aggressive salvage logging treatment as post-fire management, on the soil fungal community composition. After six years, post-fire management legacies still remain, such as the degradation of physicochemical and biological soil properties, parameters partially recovered thanks to the biocrust emergence. Higher fungal richness was observed in control soils (with burned wood maintenance) compared to soils with salvage logging, with moss-colonized patches harbouring the majority of species. The presence of a moss biocrust determined the composition of fungal communities. Organic carbon and nitrogen content were the main drivers of fungal assemblages in control soils. Basidiomycota were favoured by the biocrust presence, while Ascomycota were more abundant in managed soils in which saprotrophs were the dominant fungal ecological group, compared to the ectomycorrhizal fungi mainly present under moss biocrusts. This study demonstrates that the development of moss biocrust buffers the negative effects of salvage logging, resulting in increased resilience for fungal community.

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P-701

Assessment of soil biological quality across different monitoring programs

Mrs Anna-Sofia Hug, Dr Janine Moll-Mielewczik, Dr Andreas Gubler, Thomas Gross, Dr Reto Giulio Meuli

Soil organisms play a central role in maintaining soil ecosystem functions. In order to assess whether those functions are preserved in the long term, information on the status of soils and its evolution is essential. Since 2012, the Swiss Soil Monitoring Network (NABO) has been annually assessing micro- and molecular-biological parameters on 30 selected sites (NABObio) [1,2]. Spatially and temporally high-resolution soil biological data are scarce. In order to expand our database and to make optimal use of synergies with other programs, we analyzed data from four different monitoring programs (NABO and three cantonal programs), which are using the same analytical methods [3]. We assessed the microbiological parameters biomass and basal respiration using reference values with five qualitative categories [4]. This qualitative assessment is crucial for communication with environmental policy makers. In addition, we introduce a status indicator Q that is calculated by dividing measured values by a site-specific reference value. Q is a continuous numerical quantity, which simplifies graphic representation and statistical evaluations. Q also allows comparing microbial values from soilsamples originating from different depths. Our work has shown that it is possible to evaluate data from different monitoring programs even if they show methodological sampling differences. This knowledge is of great importance for the valorisation of soil data and can be used on a European or global level. In 2021, the NABObio sites were sampled for the 10th time. This unique time series is essential to develop soil quality assessment tools further.

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P-702

Characterization of marine bacterial carbonic anhydrase from Corynebacterium lipophiloflavum and their Carbon dioxide sequestration abilities based on a soil microcosm

Mrs Panchami Jaya

The novel technology of biological carbon sequestration using microbial enzymes have numerous advantages over conventional sequestration strategies. In the present study, extracellular carbonic anhydrase CA and urease producing bacteria were isolated from water samples in the Arabian Sea, India. A potential isolate, Corynebacterium lipophiloflavum isolate AS-205 was identified based on 16S rDNA sequence analysis. The culture conditions suitable for CA production were 32 °C incubation temperature with 10% NaCl and 25mM Zn supplementation. Experimental optimization of culture conditions enhanced the enzyme activity to 224 U mL-1. Based on the soil microcosm studies, it was found that CA could sequester CO2 to the tune of 85% ± 0.49% in sterilized soil with enzyme microcosm. The results show that, the application of enzyme could be an effective method in removing atmospheric CO2.
Keywords: CO2 sequestration; Carbonic anhydrase; enzyme optimization; kinetics; microcosm.
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P-703

Isolation of Indigenous Soil Microbes and Evaluation of Storage Effects to Develop a Viable Soil-Microbial Inoculum

Mr. Buddhika Rasanjaya Kulasekara, Ms. Aloka Maralanda, Mr. Asiri Weerasinghe, Mr. Lahiru Kumarasiri

Rhizosphere microorganisms (RMs) are important in crop production but, they have been badly affected by agrochemicals. Hence, restoration of beneficial RMs is required for soil rehabilitation. This study was designed to isolate indigenous soil microbes (ISM) and tested their survival in a nutrient-enriched broth culture medium (BCM). BCM was prepared by using ingredients i.e., sugarcane molasses, rice bran and water. A virgin soil sample was collected from Udawalawe, Dry zone of Sri Lanka and it was introduced to BCM and incubated at ambient conditions for six months. After that, BCM was filtered and stored in amber colour containers. The standard dilution plating method with specific culture mediums was followed to identify RMs present in BCM and recorded their colony-forming units (CFU). Accordingly, BCM was tested for storage conditions i.e., ambient condition, refrigerator (4°C), sunny and darker. In vitro results indicated that ISM viz. Anaerobic nitrogen-fixing bacteria, Herbaspirillum spp., Root nodule bacteria-Rhizobia, Azospirillum spp. and Phosphate solubilizing bacteria can be survived in the developed BCM for more than six months with the average CFU/ml counts of 7.00×1058, 8.75×1058, 7.50×1058, 15.00×1058 and 57.00×1058 respectively. The direct sunlight exposure reduced the population of ISM in BCM. In darker conditions, microbes were survived successfully. Under the refrigerator condition, ISM was sustained well. The ambient condition was better for the prolonged survival of ISM in a cost-effective way. For future advancements, in vitro morphological and species-level characterisation studies and field-level studies on effectiveness as an SMI are needed.

Keywords: Indigenous soil microbes, inoculum, rhizosphere

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P-704

Soil microbial characteristics and influencing factors in four typical regions of China

Soil Microbial Characteristics and Influencing Factors in Four Typical Regions of China Taibo Liang[1], Soil microbial characteristics and influencing factors in four typical regions of China Huaxin Dai[1], Soil microbial characteristics and influencing factors in four typical regions of China Zhen Zhai[1], Soil microbial characteristics and influencing factors in four typical regions of China Yanling Zhang[1]
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Soil microorganism is an important part of soil, which plays an important role in the formation and function maintenance of soil fertility. The soil microbial communities in four different ecological regions were analyzed by 16S V4 high-throughput sequencing, and the differences of soil microbial community characteristics and influencing factors in different regions were analyzed. The results showed that there were significant differences in the number of OTUs of soil microorganisms in four different ecological regions, and the overall trend was Heilongjiang> Guizhou > Yunnan> Henan. The difference of species abundance at the microbial genus level showed that soil type has a significant impact on the abundance of microbial community. Among the soil functional microorganisms in the four regions, Proteobacteria and actinobacteria have the highest relative abundance of microorganisms, and ascomycetes are the most abundant fungi in soil samples. Soil texture plays an important role in microbial diversity, the content of soil clay sand was positively correlated with the diversity of soil bacteria and fungi. Environmental conditions are closely related to the diversity of soil bacteria and fungi. Soil microbial diversity was significantly positively correlated with temperature, precipitation, altitude and latitude.

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P-704A

Managing functional resilience of soil microbiomes for sustainable production and ecosystem health

Dr Gupta Vadakattu

Microbiomes in terrestrial ecosystems are multifunctional through their vast genetic, metabolic and physiological diversity. Both human induced and environmental stimulus and stress events can alter the composition, diversity and activity of microorganisms. The degree of functional redundancy in the species present and the nature of soil physico-chemical environment is suggested to determine the degree of resilience in biological functions. In agricultural soils, the depletion of carbon rich microsites can affect the distribution, diversity and metabolic status of microbial communities and the overall biological resilience. We investigated the impact of multi-year of crop rotation, disturbance and nutrient management practices on microbial activity, diversity and resilience in field experiments on Alfisol and Vertosol soils in different agroecological regions of Australia. Molecular, biochemical and isotopic techniques were used to quantify changes in the genetic and catabolic diversity, and responses in abundances and activities of specific functional groups of microbes related to C turnover, N cycling and plant health. Results indicate that increasing the diversity of crops in the farming system, and/or increasing the proportion of time that crops are growing (e.g. reducing fallow periods), will bring about improvements microbiome (bacteria, fungi, archaea and protist) diversity and their beneficial functions such as nutrient supply, plant growth and disease suppression. Conversely, systems with low crop diversity and/or with long fallow periods and less C-inputs are likely to deplete microbiome diversity and soils beneficial biological functions. This presentation aims to discuss latest understanding about functional diversity of soil microbiomes and their resilience in Australian agroecological setting.
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P-705

CO_2 emissions in rhizosphere soils of a Colombian dry forest

PhD Gerardo Ojeda, Francy Ceballos, PhD Camila Pizano

Contextualization: The rhizosphere could be considered as a bridge between atmosphere and soil, able to regulate ecological functions in terrestrial ecosystems. Despite of its importance, exist a clear global trend to reduce forest areas, with several consequences for global environment.
Knowledge gap: Studies about tree rhizosphere influence on carbon stocks in Colombian dry forest soils are scarce.
Purpose: The main objectives were: (a) Determine the maximum respiration rate in rhizosphere and non-rhizosphere soils at 30° and 40°C and (b) Evaluate soil organic carbon storage by different indexes.
Methodology: CO_2 emissions from rhizosphere and non-rhizosphere soils were evaluated during soil drying process. In addition, several indexes (carbon mineralization coefficient, percentage of carbon mineralization, mean retention time of carbon, temperature sensitivity) were calculated, in order to evaluate carbon persistence in soils.
Results and conclusions: In general, temperature gradient was not able to influence soil properties. The maximum soil respiration rates at the rhizosphere of different tree species (Anacardium excelsum, Cordia alliodora, Gliricidia sepium, Guazuma ulmifolia) were dependent of soil organic carbon contents, not to soil-water contents or bulk density. Carbon mineralization could occur preferentially in rhizosphere soils. Colombian dry forest soils could be resistant to important changes in temperature, in terms of water retention and CO_2 emissions.
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P-706

Relative contribution of high and low elevation soil microbes and nematodes to ecosystem functioning

Mrs Sarah Semeraro, Mr Alan Kergunteuil, Mrs Sara Sánchez-Moreno, Mr Jérémy Puissant, Mr Tim Goodall, Mr Robert Griffiths, Mr Sergio Rasmann

Along with the climatic crisis, terrestrial ecosystems are undergoing significant modifications, both above and belowground. The steep elevation gradients of the European Alps might be particularly concerned because of their close connection to temperature gradients. Ecosystem productivity is largely dependent on soil nutrient cycling, which, in turn, is driven by decomposition rates governed by locally-adapted belowground soil communities. However, how climate change will impact soil biota and the associated ecosystem functioning remains largely an open question.
To address this challenge, we first characterized differences in soil microbial and nematode communities and functional characteristics from soils collected from the foothills or in sub-alpine elevations of the Alps. We used a full-factorial reciprocal transplant common garden experiment at two elevations. We wished to characterize whether the elevation-related differences in communities caused altered ecosystem responses with climate change and further specifically examine which biotic components were causal through reciprocal translocation experiments of microbial and nematode communities across the elevation gradient. Specifically, we separately transplanted soil microbial and nematode to communities from low and high elevation in their home or opposite elevation in pots added with a common plant community. We found evidence for ecotypic and functional differentiation of the microbial and nematode communities growing in. We also observed a decrease in microbial diversity and activity at high elevation, and additionally, through nematodes' functional characterization, we found increased fungal-dominated energy channels at high elevation. Climate change can reshuffle soil communities depending on organism-specific variation in range expansion, ultimately affecting soil fertility and vegetation productivity.

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P-707

Impacts of legume inclusion on soil greenhouse gas emissions in semi-arid pasture ecosystems.

Dr. Lindsey Slaughter, Raavi Arora, Charles West, Sanjit Deb, Veronica Acosta-Martinez

Researchers are challenged with developing agroecosystems that conserve limited resources while improving production in the face of land degradation and climate change. This is critical in semi-arid systems already vulnerable to soil erosion, nutrient depletion, and extreme water scarcity. One economically feasible option is converting high-input row crop systems to grazed perennial grasslands, which conserve water and nutrient resources while minimizing disturbance, increasing biodiversity, maximizing continuous living roots, and providing soil cover. Enteric methane (CH4) production from grazing cattle is a potential sustainability tradeoff in these systems, but it is likely possible to mitigate climate impacts through integrated soil-plant-animal management. The objective of this three-year study was to quantify how legumes (alfalfa, Medicago sativa L.) influence soil greenhouse gas (GHG) flux in established long-term pastures by comparing N-fertilized warm-season perennial grass (WW-B.Dahl Old World bluestem, Bothriochloa bladhii (Retz) S.T. Blake) monocultures to unfertilized grass-legume mixtures. Soil GHGs (CO_2, CH_4, N_2O) were collected using static chambers in the field on a bi-weekly basis during the forage growing season from late spring to early fall, and on a monthly basis during the fall to spring. Soil samples (0-5 cm) were analyzed for microbial community size and structure using ester-linked fatty acid methyl ester (EL-FAME) analysis. The results of our study demonstrated differences between soil microbial communities and soil GHG emissions in the two perennial management systems. This research will help to select more efficient and resilient semi-arid agricultural management strategies.
none

P-708

Agricultural practice altering soil microbial diversity and nitrogen functional genes comparing to adjacent native forest soils

Ph. D. Tiehang Wu, Mr. Michael Sabula, Ms. Holli Milner, Mr. Gary Strickland, Mr. Gan Liu

Soil microbial diversity and community are determined by anthropogenic activities and environmental conditions, which greatly affect the functioning of ecosystem. We investigated soil bacterial diversity, communities, and nitrogen (N) functional genes with different disturbance intensity levels from crop, transition, to forest soils at three locations in the coastal region of Georgia, USA. Illumina high-throughput DNA sequencing based on bacterial 16S rRNA genes were performed for bacterial diversity and community analyses. Nitrifying (AOB amoA) and denitrifying (nirK) functional genes were further detected using quantitative PCR (qPCR) and Denaturing Gradient Gel Electrophoresis (DGGE). Soil bacterial community structure determined by Illumina sequences were significantly different between crop and forest soils ($p < 0.01$), as well as between crop and transition soils ($p = 0.01$). However, there is no difference between transition and forest soils. Compared to less disturbed forest, agricultural practice significantly decreased soil bacterial richness and Shannon diversity. Soil pH and nitrate contents together contributed highest for the observed different bacterial communities (Correlations = 0.381). Two OTUs (OTU5, OTU8) belonging to Acidobacteriales species decreased in crop soils, however, agricultural practices significantly increased an OTU (OTU4) of Nitrobacteraceae. The relative abundance of AOB amoA gene was significantly higher in crop soils than in forest and transition soils. Distinct grouping of soil denitrifying bacterial nirK communities was observed and agricultural practices significantly decreased the diversity of nirK gene compared to forest soils. Anthropogenic effects through agricultural practices negatively affecting the soil bacterial diversity, community structure, and N functional genes.

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P-708A

Climate history dictates microbial metabolic response to drought stress: from semi-arid soils to tropical forest precipitation gradients

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The frequency and intensity of environmental fluctuations play an important role in shaping microbial community composition, trait-distribution, and adaptive capacity. We hypothesize here that a communities' climate history dictates it's metabolic response to future perturbation under a changing climate. Such a response is significant as changes in microbial metabolism can, in turn, feedback onto metabolite exudation, the chemical structure of necromass, and the formation and stability of soil organic matter. Here we use laboratory and field experiments to examine the metabolic pathways invoked under osmotic and matric stress within semi-arid and tropical soils.For example, using non-destructive, synchrotron-based Fourier-transform infrared spectromicroscopy we profiled the stress response of phylogenetically similar bacteria isolated from soils with contrasting climate histories subjected to both matric and osmotic stress. We note a strong carbohydrate-based, metabolic response of tropical microbes that is entirely absent in semi-arid organisms. At the field scale, we use metagenomic sequencing and metabolite analysis to demonstrate how four different sites established across a 1 m precipitation gradient from the Caribbean coast to the interior of Panama respond to a 50 % reduction in throughfall. The precipitation gradient permits the development of distinct communities at each site that show clearly divergent response to imposed hydrological perturbation. Our contribution here will discuss how communities adapted to different precipitation regimes respond metabolically to drought conditions, and how these change feedback onto the structure and stability of soil organic matter.

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P-709

Activity and burrowing behaviour of wireworms

(Agriotes spp.) in the presence or absence of roots

Mr Samuel Booth, Dr Benedikt Kurtz, Dr Martine de Heer, Professor Sacha Mooney, Dr Craig Sturrock

Click beetle larvae (Elateridae), commonly known as wireworms are burrowing insects found commonly in many habitats. Some species can be a significant agricultural pest, reducing crop yields and produce quality such as Agriotes spp. which are common in Europe and North America. X-ray Computed Tomography (CT) has previously been demonstrated as a viable method for investigating wireworm interaction in soils with living plants (Booth et al. 2020). In this study, we used X-ray CT to visualise and quantify wireworms, their burrow networks and the root architecture of maize, barley and bare soil over a 96-hour time period in order to monitor the typically cryptic behaviour of these organisms. Components within these CT scans were subsequently segmented and volume, size and complexity data collected. Wireworm burrow volume was significantly greater in bare soil compared to maize and barley planted columns, suggesting a behavioural difference in the wireworms elicited by the presence of root structures. Burrow volume was significantly greater at 96 hours compared to 24 hours. Burrow networks with maize were significantly shallower and less complex in structure compared to their barley and bare soil counterparts. Burrow network depth did not vary significantly over time. The presence and species of crop roots caused differences in wireworm behaviour, leading to variation in both the volume and structure of the burrow networks. Further work is needed to determine the specific type of behaviour of wireworms (e.g. random searching behaviour) and the mechanisms that influence it (e.g. CO_2 and Volatile organic compound gradients).

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P-710

Determinants of enzyme activity profiles

with soil depth

Determinants of enzyme activity profiles with soil depth Fatima EL MEKDAD, Determinants of enzyme activity profiles with soil depth Naoise NUNAN, Determinants of enzyme activity profiles with soil depth Xavier RAYNAUD, Determinants of enzyme activity profiles with soil depth Samuel ABIVEN

Classification of soil enzyme depth profiles based on a novel Gaussian process regression

Soil extracellular enzymes are largely responsible for the decomposition of soil organic matter. These enzymes reflect microbial nutrient and energy acquisition and limitations. Whilst enzyme activities (EA) in surface soil layers have been widely studied, activities in deeper soil layers have received far less attention. Here, we present the results of a meta-analysis of hydrolase activities and oxidases involved in the C, N and P cycles as a function of soil depth. The aim of the analysis was to understand how microbial communities relationship with their nutritional environment changed with depth. We assembled a database from 155 soil profiles published in 24 studies from diverse locations, soil types, land uses and climates. In order to compare activity profiles, we used Gaussian process regression, followed by hierarchical clustering. Our results highlight that, when expressed per soil mass, the majority of hydrolases activities decrease with increasing soil depth. However, this is not the case for a majority of oxidases activities, which show activity peaks below the surface layer, suggesting that microbial communities may change resource acquisition strategies with depth. Whilst EA, no matter the type of enzyme, decrease with soil depth when expressed per soil mass, they tended to increase with soil depth when expressed per microbial biomass. These results indicate an increase in microbial allocation to resource acquisition in response to decreased resource (C, N and P) availability and/or an increased enzyme stabilization on mineral and organic surfaces.
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P-711

Fungivorous tarsonemid mites (order Acari): an underappreciated aboveground-belowground link

Dr Monica Farfan, Mr John Coffey, Dr Rebecca Schmidt-Jeffris

Fungivorous soil mites are common across many ecosystems and are important for regulation of soil microorganisms and their functions. Recently, a soil inhabiting fungivorous mite, Tarsonemus bilobatus Suski (Acari: Tarsonemidae), was observed on leaves in Cucurbita maxima and Cucurbita pepo agroecosystems in association with a common plant pathogen, Podosphaera xanthii, and a common predatory mite, Proprioseiopsis mexicanus Garman (Acari: Phytoseiidae) in the southeast U.S. We asked, what are the roles of T. bilobatus and P. xanthii as food resources for P. mexicanus, a foliar predator? In a laboratory experiment, P. mexicanus that were provided a diet of P. xanthii material did not survive past the protonymph stage and we concluded this was not a sufficient food resource. In a second experiment, T. bilobatus were cultured on C. pepo leaves inoculated with P. xanthii and then utilized as an experimental diet for P. mexicanus. The T. bilobatus diet resulted in a developmental time of 3.2 days for female P. mexicanus and 2.7 days for males. This length of time is comparable to some of the highest quality pollen resources tested previously (Farfan et al. 2021b, 2021a). Pre-oviposition time was 2.1 days and rate of oviposition was 1.8 eggs per female per day. Pre-oviposition time was longer and oviposition rate decreased for females on the T. bilobatus diet compared to Citrullus lanatus pollen, a high-quality resource. T. bilobatus and other fungivores that consume microbes in soils as well as on plants have important roles in energy transfer between above- and belowground systems.
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P-712

Mycorrhizal type of woody plants influences understory species richness in British broadleaved woodlands

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Mature temperate woodlands are commonly dominated by ectomycorrhizal trees, whereas understory plants predominantly form arbuscular mycorrhizal associations. Due to differences in plant-fungal compatibility between canopy and ground layer vegetation the "mycorrhizal mediation hypothesis" predicts that herbaceous plant establishment may be limited by a lack of suitable mycorrhizal fungal inoculum.
We examined plant species data for 103 woodlands across Great Britain recorded in 1971 and again in 2000 to test whether herbaceous plant species richness was related to the proportion of arbuscular mycorrhizal woody plants. We compared the effect of mycorrhizal type with other important drivers of woodland plant species richness. To assign mycorrhizal type at the species level we reviewed published databases and re-examined original sources. We found a positive effect of the relative abundance of arbuscular mycorrhizal woody plants on herbaceous plant species richness, which increased between surveys. By contrast, the positive effect of soil pH on richness declined between surveys and negative effects on richness were associated with soil organic matter (year 1) and shading (year 2). This work supports the mycorrhizal mediation hypothesis in British woodlands and suggests that increased abundance of arbuscular mycorrhizal woody plants is associated with greater understory plant species richness.

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P-713

Effects of parent material on soil bacterial community assembly, diversity and degradation functions in rubber plantations of Hainan Island

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The parent material of soils is, besides climate, the most important of the five main factors in soil formation. Microorganisms correlated to parent material tightly along with soil genesis. Yet the effect of parent material on soil microbial assembly and function was less known. This study combines soil physiochemical analysis with microbial high-throughput sequencing to understand the variance of soil microbial community assembly, diversity and carbon cycling functions at different parent material sites, including basalt, granite, metamorphic rock and marine sediment soil in rubber plantations of Hainan Island. Null model analysis of ecological process showed that bacterial assembly was dominated by homogeneous selection with significantly lower phylogenetic turnover rate as expected, which varied from 56% to 75% among different parent material soils. While the climate of high precipitation and temperature homogenize the environment for biomes on the tropical island, especially along the basalt soil profile. In addition, parent material influences the degradation function of bacteria, which significantly distinguished basalt soil from marine sediment soil. To synthesize those findings, we performed structural equation modeling, indicating the cascading effect of parent material on bacterial assembly, diversity and composition through moisture, soil organic carbon and dissolved organic carbon indirectly. Community assembly was the most important factor responsible for significantly lower degradation of carbohydrate and aromatic compounds at basalt soils than at marine sediment soils. Together, our results advance the understanding of the importance of parent material on soil microbial community assembly and function at the island scale.
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P-715

Sequestration of quaternary ammonium compounds by soil smectites – implications for antibiotic resistance development

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Quaternary ammonium compounds (QACs) are surface-active, biocidal, High Production Volume Chemicals with broad application in agriculture. Predicted environmental concentrations (PEC) for QACs that are applied to soils with manure are in the order of 3.5 mg kg-1 (Mulder et al., 2018). The positively charged QACs are in all likelihood sorbed to clay minerals but data on QAC concentrations in soils are still missing. On the other hand, the occurrence of QAC resistance genes in soils has been well documented (Byrne-Bailey et al., 2011; Jechalke et al., 2014).
We propose that QACs might be sequestered into interlayer regions of 2:1 layer silicates in clay-rich soils, reducing their acute toxicity, while increasing their persistence.
In order to test our hypothesis, we determined the minimal inhibitory concentrations (MIC) of QACs of various microorganisms in the presence and absence of clay minerals. In the presence of smectite the MICs for all tested organisms and both QAC-compounds were reduced, while kaolinite showed no effect. Sorption isotherms confirmed that in the microbial trials, the free QAC concentrations were reduced by smectite thus buffering their acute toxicity.
The release of QACs from sequestered form potentially maintains concentration levels in soil solution that are sufficient to select for antibiotic resistance in the environment.

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P-716

What are the key drivers of earthworm community distribution at landcape scale and ecosystem service associated

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Soil biodiversity is strongly impacted by anthropic parameters such as land use and agricultural practices, and also by environmental factors such as pedological and climate contexts. Therefore, environmental context (natural and anthropic) are strong drivers of soil biota spatial distribution. For some taxa such as earthworms, this spatial distribution has been assessed at several scales from field, regional, national, European to global scales, but the key drivers of this distribution depending on the studied scale are still unknown and models still need to be developed. In SoilServ project, one of the aim is to collect biological data in order to answer the following questions: (i) which are the environmental drivers (soil characteristics, land use management, agricultural practices) that affect earthworm distribution ? Are the drivers of soil biota spatial distribution the same when changing scale (i.e. how does soil biota structure change depending on studied scales)? In march 2018, 90 points were sampled on a french catchment (5 km²), on both crop fields and pastures; in may 2018, another campaign limited to crop field was done. Results presented in this study will assess the earthworm community distribution and the relationship between soil organisms and infiltration rate.
no

P-717

Exploring the role of soil-plant microbiome in sustaining the growth of conifer species on disturbed, nutrient-poor soils

Dr. Akshit Puri, Dr. Kiran Preet Padda, Dr. Timothy Philpott, Dr. Chris Chanway

Forest ecosystems are commonly affected by anthropogenic disturbances such as gravel mining, leading to poor edaphic conditions for plant growth[1]. However, Douglas-fir (Pseudotsuga menziesii) and lodgepole pine (Pinus contorta var. latifolia) trees have been thriving on unreclaimed gravel mining sites lacking topsoil, organic forest floor and essential plant nutrients in British Columbia, Canada[2]. To evaluate the role of soil and plant microbiome in sustaining tree growth, we examined the bacterial and fungal communities inhabiting bulk soil, rhizosphere and endosphere niches of Douglas-fir and lodgepole pine trees at a gravel mining site. We found that the structure of bacterial and fungal communities differed significantly among various niches, suggesting a plant-driven selection of microbes[3]. Overall, Douglas-fir and lodgepole pine harboured distinct fungal communities with Rhizopogan dominantly colonizing Douglas-fir rhizosphere (30%) and roots (12%) and Suillus dominantly colonizing pine rhizosphere (60%) and roots (30%). Along with enhancing nutrient uptake from the soil, these ectomycorrhizal fungi have been reported to harbour nitrogen-fixing bacteria in their tuberculate structures[4]. No significant differences were observed in the bacterial community composition and diversity of both Pinaceae species. The most abundant phylotypes in both tree species belonged to Bradyrhizobium, Beijerinckia and Rhizobium, genera commonly associated with nitrogen-fixation. The patterns observed for soil-plant microbiome of Douglas-fir and lodgepole pine suggest that both tree species largely associate with plant-beneficial bacterial and fungal communities that could help explain their growth on severely nutrient-limited gravel substrate. Such understanding of native soil-tree microbiome is important to help comprehend natural revegetation strategies following disturbance events.

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P-718

Hotspots of the underground – Spatial distribution of enzyme activities along preferential flow paths in a subsoil

Miss Theresa Reinersmann, Professor Bernd Marschner, PhD Stefanie Heinze

The nutrient and substrate supplies for soil microorganisms decrease with increasing depth. Consequently, subsoils are characterized by low soil organic matter and nutrient contents, which additionally are distributed very heterogeneously. Often, these supplies in subsoils are linked to preferential flow pathways or root channels causing hotspots of microbial activities along these input pathways, whereas the lack of substrate and nutrient input in the surrounding matrix soil limits microbial activity and leads to a life in dormancy.
To investigate, if and how soil microbial enzyme activities in subsoils are controlled by the input of nutrients and substrates along flow pathways, we irrigated a Dystric Cambisol (Lower Saxony, Germany) with a Brilliant Blue tracer solution in a field campaign in October 2021. Undisturbed soil slices were sampled from three depth increments (0 to 30 cm, 50 to 80 cm and 110 to 160 cm), each soil slice containing dyed and non-dyed areas (corresponding to flow pathways and matrix soil). Image-based soil zymography is currently performed to identify hotspots of microbial enzyme activities and link them with dyed preferential flow pathways. Furthermore, distinct effects of substrate and nutrient solutions (based on: glucose, ammonium nitrate, dipotassium phosphate, artificial root exudate and sterile DOC solution) on activity states of soil enzymes in dependence of depth and location in the flow path or in the soil matrix are examined. We expect a higher abundance of enzymatic hotspots and a lower substrate limitation in preferential flow paths compared to matrix soil.
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P-719

Biostimulants: moving towards a mechanistic understanding of their impact on soil health

Miss Dannielle Roche

Biostimulants are gaining interest for their promise to improve crop productivity by positively impacting crop yield and quality, nutrient use efficiency, and tolerance to abiotic stresses. These benefits are independent of their own nutrient content and without causing adverse environmental side effects, as can be the case with conventional fertilizer and pesticide use on agricultural land. Biostimulants include both non-microbial products such as humic substances, seaweed extracts, and protein hydrolysates, and microbial products including fungi and bacteria.

Biostimulants are thought to provide these benefits through processes such as mimicking hormones which is closely related to inducing crop stress responses, and upregulating specific plant genes for greater uptake of nutrients from the soil. However, there is a lack of deep mechanistic understanding of how biostimulants provide said benefits, including their impact on the native soil microbiology as a crucial mechanism.

The first phase of this research focuses on the impact of non-microbial biostimulants on soil microbiology as a pathway to improving soil nutrient bioavailability to plants, contributing to the overall health and development of crop biomass. Pot trials using seaweed extract treatments evaluate microbial responses via rapid automated bacterial impedance (RABIT) and carbon biomass techniques. This is part of a wider PhD research topic investigating how non-microbial biostimulants may impact crop nutritional quality (referring to nutrients, minerals, and antioxidants) under different soil conditions such as drought, compaction, and water-logging.

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P-720

Mycorrhizal symbiosis induces divergent patterns of uptake, transport and partitioning of cadmium and zinc in Populus trichocarpa

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Plants have several mechanisms to tolerate Cd and Zn toxicity, these being affected by symbiotic associations, such as with arbuscular mycorrhiza (AM). Here we hypothesised that AM alters Cd and Zn uptake and partitioning in Populus trichocarpa, modulating the expression of metal transporters and chelator genes in the plant.
P. trichocarpa was grown under Cd and Zn contamination with and without AM inoculation (Rhizophagus irregularis). Metal accumulation and partitioning were assessed. Expression of genes involved in trace element transport and chelation were determined in roots and leaves. The function of metallothionein PtMT2b was verified by heterologous expression in yeast under Cd contamination.
P. trichocarpa was highly tolerant to both metals. AM increased Zn accumulation (mg plant-1), but kept its partitioning pattern. AM did not affect Cd accumulation, but restricted its translocation to shoots. High Zn and Cd down-regulated PtHMA4 in roots and up-regulated PtZIP1 in leaves, suggesting that these are involved in transporting both metals in poplar. PtMT2b was highly up-regulated in mycorrhizal roots (except under high Zn) and could be linked to high Cd immobilisation. PtMT2b enhanced Cd tolerance in yeast.
R. irregularis increased Cd retention in poplar roots, but did not alter Zn partitioning – maintaining its high Zn concentration in leaves. The gene expression patterns observed offer a glimpse into the mechanisms behind trace element uptake and translocation dynamics in poplar, as affected by AM symbiosis (De Oliveira et al., 2020). This system, along with the genes presented here, are candidates for future biotechnological applications, including phytoremediation.

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P-721

Microbial interaction drives community assembly in porous environment through spatial niche partitioning

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Biofilm is a central microbial living strategy in subsurface porous environments. Due to the inherent microscale spatial heterogeneity of microbial communities and activities, the role of microbial interactions and the underlying mechanisms that shape biofilm community structure are poorly understood. Here, we employ a microfluidic chip to show that microbial interactions between free-living and biofilm-forming bacteria drive deterministic community assembly through spatial niche partitioning in porous environments. Our findings demonstrate that a positive interaction taking place during initial colonization improves the fitness of both biofilm and planktonic populations and thereby promotes their respective dominance in segregated niches. The initial niche preemption exerts a priority effect to determine the subsequent community structure. Through exometabolomics and pairwise interaction analyses, we show that free-living Arthrobacter enhances biofilm fitness by scavenging the biofilm inhibitor, D-amino acids. Collectively, our results reveal how microbial interactions impose selective forces on microbial community assembly and provide a roadmap towards understanding the intricate microbial interactions at biologically relevant scales.

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P-722

Soils biological activity in uneven-aged logged forests in South Taiga (European part of Russia)

Mrs Marina Dorokhova

Currently, there is a lack of information about soils’ biological activity in uneven-aged logged forests in the Taiga region in Russia – an important soil property that has a considerable impact on soil recovery rate. This research was done at the Moscow state university scientific field station Satino located in the Central European part of Russia in South Taiga in Albic Retisols subzone. In this area, the soils are functioning under permanent intensive logging (> 200 years).
In this research, we have examined biological activity of the soils in nominally indigenous forests and uneven-aged logged forests both using the following parameters: cellulase activities, urea decomposition rate, earthworms population rate, microphototrophs’ (soil cyanobacteria and algae) species composition. Albic Retisols biological activity in nominally indigenous forests in Satino is characterized by the high earthworms population rate and cellulase activities rate and the average microphototrophs’ species diversity and urea decomposition rates. 5 years after the forest logging, due to the dramatic change of soil habitat, the microbiota composition went through a sharp transformation (on the example of microphototrophs); biological activity of the soils had significantly decreased according to all parameters. 30-40 years after the forest logging, a plant community with a spruce in I storey is formed and the forest Albic Retisols microbiota starts to recover. By this period, some of soil biological activity parameters tend to reach their rate in nominally indigenous forests’ soils.
Thus, this research has detected a high recovery rate of the logged forests’ soils in the examined region.

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P-723

Soil bioanalysis: a simple and effective tool to access and interpret soil health

PhD Ieda-Carvalho Mendes, PhD Guilherme Chaer Montandon, PhD Fabio Reis-Junior Bueno, M.Sc Ozanival Dantas Dario, M.Sc. Juaci Malaquias Vitoria, Ph.D Maria Oliveira Lopes Ines

Soil health (SH)/ Soil quality (SQ) is associated not only to the ability of a soil to function in order to provide biological productivity, but also to provide important environmental services. As in other parts of the world, in Brazil the metrics for SH assessments in agroecosystems also have been discussed. In the past 20 years, Embrapa´s research group on Bioindicators of Soil Quality, has been dedicated to the selection of robust SH bioindicators, to be used in commercial routine soil analyses. The main objective was to provide a simple, effective and practical tool, which would allow SH monitoring at farm scale, so that farmers not only will know exactly what, why, how, and when to evaluate but, most importantly, they will know how to interpret what is being evaluated. As a result of these studies, two soil enzymes, arylsulfatase (ARYL) and β-glucosidase (GLU) (associated to the S and C cycles, respectively) were selected and interpretative algorithms were developed. The inclusion of these two soil enzymes in routine soil analysis has been termed soil bioanalysis technology (SoilBio). Since 2020, GLU and ARYL have been used in large scale on-farm SH assessments in the Brazilian Cerrados region, representing an opportunity to engage producers in soil testing beyond the standard chemical test approaches. ARYL and GLU are sensitive indicators of decline or improvement of SQ. They are precise, coherent and their determinations involve simple and inexpensive analytical procedures. GLU and ARYL also are highly correlated with crop yields and soil organic matter.

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P-724

Land Management Effects on Soil Enzyme Activity and Greenhouse Gas Emissions in the Missouri River Floodplain

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Optimizing land-use management can reduce greenhouse gas (GHG) emissions from agricultural operations. Agronomic practices influence soil microbial and enzyme activity as well as GHG emissions from soils by affecting soil organic C and N. This study investigated the activity of β-glucosidase and β-glucosaminidase during the growing season from three distinct land management practices: (i) intercropping pecan tree-grass agroforestry system (AF), (ii) row crop system (corn-soybean; AG), and (iii) riparian forest system (RF) located in the Missouri River Floodplain, New Franklin, Missouri, USA. Soil N_2O, CO_2, and CH_4 emissions from these selected land-use management systems were evaluated using static chambers. The greatest GHG emission occurred after a flooding event with an average of 207 g N_2O-N/(ha d) and 148 g CH_4-C/(ha d) from AF treatment, and 57,000 g CO_2-C/(ha d) from RF. Results from enzyme analysis revealed higher levels of β-glucosidase and β-glucosaminidase activity in AF and RF relative to AG management. The highest β-glucosidase activity of 168 µg pNP/(g soil h) was observed in the AF system while the lowest activity of 78 µg pNP /(g soil h) was attributed to the AG. β-glucosaminidase showed the highest activity of 40 µg pNP/(g soil h) in both AF and RF treatments compared to that of 23 µg pNP/(g soil h) in AG. This study provided evidence that although higher quality and quantity of C and N substrates are available in RF and AF (based on enzyme activity), flooding events could trigger higher GHG emissions from those systems.

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P-724A

Does long-term no-till decrease soil nitrous oxide emissions during corn years in a corn-soybean rotation?

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Switching from chisel-disk (CD) operations to no-till (NT) often improves soil properties in a long-run but effects on nitrous oxide (N2O) emissions in poorly-drained Alfisols are less known. The objective of this study was to determine the influence of contrasting tillage practices (CD vs. NT) on soil N2O emissions; soil nitrogen (N) dynamics; corn (Zea mays L.) grain yields, N removals and balances; soil volumetric water content (VWC) and temperature following 48 and 50 years of tillage implementation in a long-term corn-soybean (Glycine Max L.) rotation experiment in Southern Illinois, USA. A four-times replicated randomized complete block design was conducted with a split-plot arrangement. The main plots were tillage treatments: (i) CD (grower's current practice) and (ii) NT. Subplots were (i) a no-fertilizer control (CTR) and (ii) fertilizing corn with 196, 24, and 140 kg ha-1 of N, P, and K (NPK) (Weidhuner et al., 2021). Corn grain yield was greater in CD (9.3 Mg ha-1) than NT (7.2 Mg ha-1) in 2018 but not in 2020. Majority of soil N2O-N emissions were recorded before Mid- to late-July mainly reflecting on high soil NO3-N availability as soil volumetric water content (VWC) was mainly high (30% in 2018 and 25% in 2020). The CD treatment had a higher two-yr cumulative N2O-N emission (11.9 kg N2O-N ha-1) than NT (9.1 kg N2O-N ha-1) indicating NT has a potential for reducing N2O-N in poorly-drained Alfisols. We concluded that after 48 and 50 years, NT can maintain corn grain yield and mitigate N2O-N emission.

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P-725

Assessing the implications of chloride from land application of manure

Graduate Student Matthew Belanger, Dr. Erin Cortus, Dr. Gary Feyereisen, Dr. Melissa Wilson

Rising chloride contamination in ground and surface waters is a growing concern in Minnesota. Previous studies estimate 87% of the chloride load to originate from road salts, fertilizers, and wastewater treatments plants with 6% originating from manure fertilizers. However, these estimates may be outdated as the livestock industry and manure application practices have evolved since these estimates were calculated in 2004. It also remains unclear the effect varying manure and soil types have on chloride leaching following manure application. The aim of this study is to understand the movement of manure-based chloride through a series of intact core leaching studies. In-tact soils cores with a depth and diameter of 30.4 cm will be taken from fields containing fine, medium, and coarse-textured soils around Minnesota in Fall 2021. For the first round of experiments, each core will be surface applied with either liquid manure, or potassium chloride; cores with no nutrient application will serve as the control. Core leachate will be analyzed to measure total chloride concentration following a series of wetting events, each amounting to 50.8 mm of simulated rainfall. Future attempts in creating chloride-based mass balances for the state of Minnesota and other parts of the world will benefit from this study.

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P-726

Nutrient-containing nanocomposite minimises nitrogen loss from soil while maintaining yield

Ms Jessica Chadwick, Dr Peng Zhang, Professor Iseult Lynch, Professor Sami Ullah, Dr Ryan Mushinski

Agriculture-derived pollution is a global problem – unbalancing the nitrogen (N) cycle, resulting in a myriad of effects including ozone depletion, eutrophication, and soil acidification. Minimising the polluting effects of agriculture is essential, yet high yield must be maintained. Identifying alternatives to conventional fertilisers and understanding their impacts on N cycling, and the microbial communities facilitating those processes, is of imminent concern. Nanofertilisers are nanoscale materials that are able to utilise their unique size-based properties to adsorb biomolecules to their large surface area, changing their reactivity and stability as they enter new environments. Previous work (Ramirez-Rodriguez et al. 2020) showed that urea-doped amorphous calcium phosphate (U-ACP), a nanocomposite, maintained wheat yield and quality when applied in lower concentrations than urea. Our study compared the effect of U-ACP to that of urea on lettuce growth, N-cycle community size, N leachate concentration and reactive N-oxide (NOY) emissions. Lettuce biomass did not statistically differ between urea and U-ACP additions (both higher than control), but U-ACP significantly reduced the production of NOY emissions compared to urea-treated soils, producing the same concentration as control soils. Similarly, aqueous reactive N concentrations were significantly higher for the urea treated soils, with U-ACP minimising ammonium, nitrite, and nitrate in leachate. Denitrifying bacteria were more prevalent in U-ACP treated soils, indicating that the nanofertiliser may be able to aid in more complete denitrification and reduce intermediary pollutant production. Combined, this work illustrates the potential of nanomaterials to reduce agriculture-derived pollution, while maintaining yield.
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P-728

Combining the effect of phosphorus sources and the application method in the quantification of phosphorus runoff losses

MSc Florencia De Lucca Agrelo, PhD Carlos Perdomo

Phosphorus (P) is one of the most important nutrients due to its impact on both the productivity and quality of crops. Nevertheless, Uruguayan agricultural soils have low available P levels, therefore, fertilization is necessary to satisfy the requirements of crops. However, the rate at which P fertilizers are applied exceeds the requirements and absorption capacity of the crops, causing an increase in runoff P to water bodies, and its consequent loss of quality. In this sense, the use of controlled-release P sources arises as an alternative, which limits the contact of the P applied with the soil, synchronizing the release of P with its demand by the plant, improving the use efficiency. The objective of this work was to quantify and evaluate the effect of the P sources and the form of application on runoff P losses in a wheat crop. To assess that, two P sources, DAP and controlled-release P fertilizer were applied at four doses (0, 16, 40, 80 kg P_2O_5 ha-^{1}), using two application methods (applied on the soil surface and incorporated into the soil). On these treatments, surface runoff was generated using a Cornell infiltrometer (Ogden et al., 1997). The collected water samples were analyzed for soluble P (SP) and total P. The results suggested that the incorporation of P fertilizer reduced SP losses by almost 50% compared with soil surface application; and the use of controlled-released P reduced between 30-40% the runoff P losses. Further studies are needed to adopt these practices in crop rotations.

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P-729

Soil management practices to mitigate phosphorus losses in runoff water in agricultural-dairy systems in Uruguay.

Ingeniero Agrónomo Nicola Di Muro

Currently, the agricultural-dairy systems of Uruguay have intensified to greater productivity. The increasing area of cultivated pastures and annual grasses fertilized with high rates of phosphorus (P) on the soil-surface, together with the increase in concentrates in the animal diet, and the high stocking-rates, have resulted in positive P balances in these systems, and its potential loss in runoff water. The objective of this work was to evaluate the implementation of management practices to reduce the runoff P losses, especially under soluble form (DRP). To assess that, 2 sites were selected where the following treatments were applied: two doses of FeCl3 (0 and 50 L ha^{-1} diluted in water in a 20: 1 ratio) pulverized on the soil surface and the inversion of the soil profile utilizing a plow. On these treatments, surface runoff was generated using a Covert & Jordan (2009) rain simulator. The collected water samples were analyzed for DRP. Before and after the simulation, soil samples were taken to determine PBray1 at 0-2.5 cm. The results suggested that the soil profile inversion reduces DRP losses from 0.162 to 0.059 mg L^{-1}; while the PBray1 values at 0-2.5 cm decreased from 81 to 12 mg kg^{-1}. On the other hand, the application of FeCl3 to the soil surface did not have significant effects on the decrease of DRP or PBray1.

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P-730

Tree species influence on soil moisture dynamics.

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Forest soils play a key role in the supply of clean water and resilience to floods and droughts. Soil moisture, which is an essential variable affecting hydrological processes, biomass production, and the health of ecological system might be affected by different tree species and be relevant for the response of a given soil type. Different tree species influence hydrological processes by influencing infiltration rates, runoff and evapotranspiration. We hypothesize that tree species that differ in rooting system and water consumption, may lead to different soil moisture dynamics. To test this hypothesis, we compared soil moisture patterns at different soil depths in Pinus radiata, Eucalyptus globulus and Fagus sylvatica forests in a temperate humid climate with similar soil characteristics. Volumetric soil water contents at 5, 40 and 80 cm depth and soil water potential at 40 cm were measured in 30 min intervals with TEROS 10 and TEROS 21 sensors from spring to autumn 2021. In beech forest, the highest volumetric content was observed at 5 cm depth and decreased with soil depth. However, in pine and eucalyptus forests the water volumetric content at 5 and 80 cm depth was similar and lower at 40 cm depth. Soil water potential reached its minimum at mid-September in all forests but while soil water potential reached -25 kPa in pine forest, -90 kPa was reached in beech and -250 kPa in eucalyptus. The preliminary results suggest that different tree species might lead to different soil moisture patterns at the same soil type.

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P-730A

Seasonal soil moisture dynamics under sloping and terraced vineyards

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The seasonality of soil moisture dynamics was investigated in two soil profiles under sloping and terraced vineyards in Hungary. The total soil water content (SWC) of the profiles to a depth of 120 cm showed that the SWC of the section on the terrace exceeded that of the section on the slope by more than 20% on average over a year. This difference resulted in a surplus of 80-100 mm of water on the terrace during the summer months. In the summer period, the difference was greatest at the end of August, due to the different drying patterns, while in the winter-spring period the difference was due to the different intensity of soil moisture recharge. The terrace reached its maximum water capacity in the frost-free period at the end of December and maintained it with minor fluctuations until the beginning of April, unaffected by the frosty period in February-March. The slope section gradually filled up, its water capacity increased from mid-December during the typically frost-prone January-February period, and then "peaked" in early April, approaching the terrace's water capacity of 30 mm. The difference in recharge patterns shows that while the terrace is not sensitive to the typically frosty February-March period due to early recharge, the slope recharges well into the potentially frozen period, and its water supply is more influenced by changes in the number of days below zero temperature than the terrace.

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P-731

Effects of grassland sward composition (grass monoculture, grass/clover and multispecies) on Dissolved Reactive Phosphorus (DRP) and Suspended Sediment (SS) losses in a winter storm runoff event: a field-scale grazing experiment in Ireland.

Mr Fergal Horan, Dr Helen Sheridan, Dr David Wall, Dr Karl Richards, Prof Alex Evans, Dr Conor Bracken, Prof Tommy Boland, Dr Paul Murphy

Nutrient (N, P) and soil/sediment losses from agricultural soils to water are a major threat to water quality. Grass/clover and multispecies (grass/legume/herb mixtures) swards differ from grass monoculture swards in their nutrient cycling and management characteristics and may also affect soil water dynamics. It was hypothesised that grass/clover and multispecies swards would have lower nutrient and sediment loss in runoff compared to grass monoculture. To investigate this, twelve 2 ha hydrologically isolated units (HIUs) were established in Summer 2019 with four replicates of three pasture types: 1) Lolium perenne monoculture (PRG) receiving 205 kg N ha-1 yr-1 2) Lolium perenne and Triflium repens (PRGWC) receiving 90 kg N ha-1 yr-1, and 3) a grass, legume, forage herb mixture (6 species) (MSS) receiving 90 kg N ha-1 yr-1. The site, the Long-term Grazing Platform at UCD Lyons Farm in Eastern Ireland, is on a poorly drained Gleysol with a temperate maritime climate. Prior to sowing, the HIUs were established using a combination of French drains (perforated pipe at 80 cm depth with crushed stone to surface), impermeable membranes and berms on the down-slope sides of each HIU, with water from each HIU draining to a flume for monitoring of water flow and water sampling. Each sward type was grazed by their own herd in a high output dairy calf-to-beef system at a stocking rate of 2.5 livestock units ha-1.
This poster reports on initial results of water flow and nutrient and sediment losses in runoff from the winter of 2021/22.

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P-732

Rising Seas Bring Dead Contaminants Back to Life!

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Rising global sea level is a critical outcome of climate change. High levels of toxic metals are found along many coasts, particularly along the Mid-Atlantic coasts of the US, where Sea-level rise (SLR) rates are higher than elsewhere in the world. Coastal sediments are subject to episodes of resuspension due to a combination of SLR-induced flooding, waves, and currents that can disturb sediments and mobilize pollutants into overlying water. However, the mechanisms of mobilization and impacts on water quality are yet to be fully understood. In this study, sediments collected from a contaminated industrial site in Wilmington, DE, USA, projected to be inundated by 1 m of SLR-induced flooding by 2100, were exposed to a range of shear stresses typically encountered in coastal environments using a laboratory-based erosion chamber and the concentrations and speciation of contaminants in the overlying water and resuspended sediment were quantified. We found potential for a significant release of As and NO3 from sediments at shear stress levels typically measured in estuaries. Over the post-flooding period, a significant increase in As(III) concentration was observed. Thus, resuspension releases solutes both during erosion events and over a longer timescale. Solid-phase speciation based on XAS of As from the reacted and non-reacted samples showed a mix of As(V) and As(III) were present. Overall, our results demonstrate that sediment resuspension is an important mechanism controlling dissolved metals concentrations in the water column and can influence the fate of pollutants in coastal waters.

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P-733

Greenhouse gas emissions from Kazakhstan's croplands: sources and mitigation potential

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Land resources are already under increasing pressure from anthropogenic impacts exacerbated by climate change. At the same time, keeping global warming well below 2°C can only be achieved by reducing greenhouse gas emissions (GHG) in all sectors, including land use, food sector [1].
The global community's efforts to mitigate climate change are mainly focused on reducing carbon dioxide (CO2) emissions.
Direct and indirect agricultural emissions associated with land use are accounted for in the agriculture, forestry and other land uses (AFOLU) sectors. Collectively, emissions from the AFOLU sector include greenhouse gases produced by agriculture (non- CO2), net CO2 emissions from soils used in agriculture, and net CO2 emissions from deforestation and other land uses (AFOLU). Emissions from the AFOLU sector are increasing as a result of expanding farmland, increasing livestock, and increasing soil and fertilizer use. Livestock and especially ruminants are the largest source of direct emissions and the main cause of LULC. Synthetic fertilizers also contribute greatly to direct emissions from agriculture [2].
In our research we study and assessment of GHG (CO2, CH4, N2O) and albedo in the arable light brown soils of Kazakhstan in the Almaty region when using fertilizers and applying various types of basic tillage for different crops (corn, soybeans, winter wheat).
This study began in April 2021 and will be conducted until the end of December 2023. The research work is carried out with the support of the grant of the State Financial Service of the Ministry of Education and Science of Kazakhstan IRN_AP09057853-KC-21.

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P-734

Effect of biochar and nanoclay amended compost on soil organic matter (SOM) from tropical grassland soils.

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Stabilized organic amendments can contribute to C sequestration (Bolan et al., 2012). In this research, the NMR spectroscopy was used to analyze the different contribution of compost with no additives (NA) and amended with biochar (B), iron oxide (Fe), halloysite (Ha) and their combination on soil organic matter (SOM) composition in a short term incubation (60 days) with leptisol and umbrisol from Planalto region, southern Brazil. Carbon losses for control soil without compost addition were up to ~8% of the original total organic carbon (OC) content. Most of those losses were detected in the O-alkyl and N-alkyl regions. The non-amended compost showed similar losses of O-alkyl C than the control soil. A tradeoff between N-alkyl C and alkyl-C was found, compared to the predicted values. This could be assigned to a higher contribution of protein-rich material rather in detriment of aliphatic chains. The same trend has been observed for all the other treatments. The addition of biochars to compost as expected provided a higher quantity of aryl C, described as a less degradable pool of OC. For Fe-amended and Ha compost, C losses were observed for all the spectral regions following the initial>predicted>measured order, except for the N-alkyl/Methoxyl region, in which the measured intensity was higher than the initial value. Both Fe and HA amendment protected compost from degradation during our incubation experiment. The addition of additives included biochar and nano-minerals can contribute to reduce the degradation of applied compost potentially contributing to C sequestration. Acknowledgements to Fondecyt Nº11201107.

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P-735

Influence of conservation agriculture and shallow water table on glyphosate transport through the soil profile

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Conservation agriculture (CA) was included by the IPCC (2019) among adaptation options to address climate risks, both mitigating GHGs emissions and reducing impacts on the environment. Concerns remain about the sustainable use of glyphosate (GLP) for cover crop termination, especially in agroecosystems where a shallow groundwater level can enhance the risk of contamination of water resources. A transport study through tracer (KBr) and GLP application was performed in May 2019 in 8 buried lysimeters (1 x 1 x 1.5 m3) in a factorial combination of two cropping systems (CA and CV, i.e. conventional) and two water table depths (120 and 60 cm). The aim was to evaluate the susceptibility to groundwater contamination as affected by soil structure and hydraulic changes under different crop management. After KBr and GLP distribution, an automated system was used to monitor the soil moisture and matric potential and sample the soil-pore water with suction cups for 48 days at different depths (15, 30 and 60 cm). Soil-water-solute dynamics were combined with laboratory-estimated Freundlich adsorption coefficients to inverse modeling with HYDRUS 1D and predict the solute transport (e.g., dispersivity) and GLP degradation parameters along the soil profile (first-order rate constant for solid phase). Preliminary results showed that contrasting cropping systems, by modifying the soil and vegetation management, affected differently GLP degradation dynamics along the soil profile. Moreover, a shallow water table, by modifying the flow field, might drive a fast GLP vertical movement likely bypassing the soil surface layers and in turn compromising the groundwater quality.

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P-736

Accumulation of hexavalent uranium by highly organic soils at the Needle's Eye Natural Analogue site, South West Scotland.

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Nuclear power has the potential to provide electricity with lower emissions of greenhouse gases than electricity generated by combustion of fossil fuels. However, a downside of nuclear power generation is the production of waste products which will be radioactive for long timescales into the future. Safe storage of generated waste is a significant consideration for the future use of nuclear power. Studies have been undertaken at the Needle's Eye Natural Analogue site in Southwest Scotland to evaluate if the highly organic soils (loss on ignition > 80%) at the site are an effective barrier for uranium (U), a major component of nuclear waste. Analysis of soils by x-ray absorption spectroscopy (XAS) demonstrated that, despite the dominant waterlogged and anaerobic conditions in the soil at the site, conducive to the reduction of U to U(IV), the majority of U in the upper 30 cm of the soil profile was present as U(VI) complexed with oxygen functional groups of soil organic matter (SOM). Results of SOM characterization (UV/Vis spectroscopy, FTIR and ^{1}H NMR) demonstrated that SOM in the region of the soil profile with greatest U accumulation was relatively enriched with carboxylate functional groups and fulvic acid organic matter compared to deeper in the soil profile where aromatic structures and humic acids became more prominent. The results indicate that highly organic soils can be an effective barrier to the mobility of U in the surface environment, with implications for the future selection of sites for long-term storage of nuclear waste.

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P-737

Quantifying Microplastic Pollution in Soil and Sediment Samples using Py-GC/MS

Ms Rebecca Peel, Dr Stephen Roberts, Dr David Naafs, Dr Huw Griffiths, Dr Claire Waluda, Dr Kevin Hughes, Dr Charlotte Lloyd, Dr Ian Bull

Plastic pollution is a considerable and growing environmental problem (Fischer & Scholz-Böttcher, 2017). With detrimental impacts to humans, wildlife and national economies, the ubiquity, longevity and minute size of micro- and nanoplastic particles are especially concerning (Barnes, Galgani, Thompson, & Barlaz, 2009; Fischer & Scholz-Böttcher, 2017). Plastics have even been detected in the most remote locations on Earth, (Courtene-Jones, Quinn, Gary, Mogg, & Narayanaswamy, 2017), however, the exact anthropogenic source of this contamination and the transport mechanisms are still unclear (He et al., 2018). To develop effective mitigation strategies, quantification of the spatial and temporal variability of environmental microplastics across the globe is required. As the majority of plastic waste originates on land, investigation into the terrestrial aspect of these source-to-sink pathways is particularly relevant (Hurley and Nizzetto, 2018).

In this project, pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) techniques have been developed and implemented to identify and quantify microplastic distributions in terrestrial soils and sediments. Indicator moieties for eight common plastics have been selected, with a view to identify these polymers in environmental samples. Their peak areas, along with internal standards, have been used to create calibration models for each polymer type. Extraction protocols have also been established and tested against the model to determine their recovery. These will then be applied to probe microplastic concentrations in soil and sediment samples from Signy Island, Antarctica and around the Netravathi River system in southwest India. The resulting dataset will help further our remediation efforts, with potential policy implications.

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P-738

Impact of fluvial flooding on potentially toxic element mobility in floodplain soils

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With increasing flood frequency and duration predicted due to climate change, floodplains may change from being a sink for contaminants to becoming a source of legacy pollution. The mobility of potentially toxic elements (PTEs) in floodplain soils can increase or decrease due to the net effect of five key processes; 1) a change in the speciation of redox sensitive PTEs, 2) an increase of soil pH, 3) complexation with dissolved organic matter, 4) reductive dissolution of iron (Fe) and manganese (Mn) hydroxides, and 5) precipitation of metal sulphides. A field-based approach was taken, extracting soil pore waters by centrifugation of soils sampled on multiple occasions from multiple locations across a floodplain site in southeast England before, during and after a flooding event. Flooding did not influence the environmental fate of all PTEs in the same way. Flooding generally decreased pore water PTE concentrations and significantly lower pore water concentrations of Cd, Cu, and Cr were found post-flood compared to pre-flood. The dominant process responsible for this observation was precipitation with sulphides resulting in PTE removal from the pore water post-flood. The changes in pH were found to be associated with the decreased pore water concentration of Cu, which suggests the pH rise may have aided adsorption mechanisms or precipitation with phosphates. Further work is required to identify which soil properties should be measured to improve our capability to predict the impact of future floods on the environmental fate of individual PTEs in geochemically contrasting floodplain soils.

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P-739

The effects of structure lime on soil aggregate stability, microbiome and leachate quality

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Structure lime is a mixture of active lime ($CaO/Ca(OH)_2$) and ground limestone ($CaCO_3$) used in agriculture to reduce clay soil erosion and loss of phosphorus into surface waters (Ulén and Etana, 2014; Blomquist et al., 2018). In addition to increasing soil pH, dissolution of structure lime increases ionic strength (EC) in soil water thus enhancing flocculation of clay particles. The added calcium further promotes the formation of micro aggregates through cation bridging. We tested the short- and long-term effects of structure lime on soil erosion, aggregate stability, and dissolved phosphorus and carbon mobilization in rain simulations. Also, microbial community structure in the soils was studied. Two sets of material were used: i) incubated soils with a range of clay contents and ii) soils from fields that were previously (2013-2018) treated with structural lime and their untreated controls. In the rain simulations, structure lime reduced turbidity of percolation water especially in soils originally low in EC, and increased dissolved organic carbon concentration in percolation water. Structure lime did not have consistent significant effect on the soil microbiome. Also, aggregate stability in the fields previously treated was rather unaffected if structure lime treatment was done more than a year before the sampling. However, in structure-limed field soils, organic carbon content appeared to be higher below 40 cm depth.

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P-740

Impact of aging and sea level rise on chromium speciation and release in iron- and manganese-rich soils

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Chromium (Cr) is a redox-active element posing a threat to the environment and human health. The aging process may decrease Cr mobility and toxicity in soils; however, the long-term aging effect on Cr cycling remains unclear, especially in contaminated coastal soils which are susceptible to Cr release due to saltwater intrusion and redox change. This study investigates the speciation and solubility of Cr in soils as affected by aging and sea level rise (SLR). Two soils with different iron (Fe) and manganese (Mn) oxides levels were aged up to 180 days with Cr(III) and Cr(VI), and Cr oxidation state and speciation were examined with X-ray absorption near edge spectroscopy. Additionally, aged soils were subjected to several desorbing solutions, including artificial seawater, to observe Cr release as impacted by aging and salinity. Preliminary short-term Cr(III) aging showed that Cr was likely to be retained as Cr(III)-bound ferrihydrite in aged low Mn soils, while Cr(VI) was the main species in aged high Mn soils. The aging effect was pronounced in aged low Mn soils in which Cr release in NaCl solution greatly decreased over 30 days. Conversely, Cr desorption from aged high Mn soils slightly decreased and remained above the WHO and USEPA standards for drinking water. Although Cr release decreased during short-term aging, the investigation on Cr speciation and solubility in aged soils will be continued to understand the importance of aging processes and Fe and Mn minerals on long-term Cr cycling in Cr-contaminated soils under the impact of SLR.

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P-741

Water and CO_2 Gas Flow through High Density Roots in an Artificial Macro-pore for the Shaft Tillage Cultivation Method

Ms. Koharu Tasaki, Dr. Ieyasu Tokumoto, Dr. Shujiro Komiya, Dr. Kosuke Noborio

The shaft tillage cultivation method is a no-tillage method for transplanting seedlings in an artificial macro-pore that facilitates placement of the crop roots much deeper than weeds (Lopez et al., 2013). The artificial macro-pore plays an essential role in water and carbon dynamics. This study aims to examine water and CO_2 gas flow through the artificial macro-pore for the shaft tillage method. The soil type is Andisol. Water and gas flow experiments were conducted to observe the process of root growth and water and CO_2 gas flow around an artificial macro-pore (8 mm diam., 20 cm long） under drip irrigation. Two-dimensional matric potential distribution was monitored using the tensiometer method. Column experiments showed high-density roots in the artificial macro-pore. The dry matter content of roots and leaves was higher after using the shaft tillage method compared to the method without an artificial macro-pore. We observed preferential water flow through the high-density roots, indicating a shift to deeper water sources for plant growth. CO_2 gas concentration in the macro-pore was less than 0.1% under field water capacity conditions. The macro-pore would contribute to the gas exchange between the soil and the atmosphere.

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W. Yukumoto, M. Jitsuno, M. Kato, E. Sakaguchi,
J. Tatsuno and T. Ishii: Guidance of a transplanting
skid steer vehicle with variable center of gravity,
Int. J. Envior. Rural Develop., 75 – 80（2013）

P-742

Near-surface Soil Moisture Observation on the Hillslope using Cosmic-ray Neutrons: A Case Study of Landslide Warning System

Dr. Ieyasu Tokumoto, Mr. Yuta Hrashima, Ms. Koharu Tasaki, Dr. Hideki Miyamoto

Most landslides are triggered by episodic events such as heavy rainfall events, earthquakes, or combinations of both. Near-surface soil moisture observation plays a vital role in landslide detection. We installed Cosmic-ray soil moisture observing system (COSMOS)(Zreda et al., 2012), a method of measuring cosmic-ray neutrons (ϕ) near the soil surface at the mountainside, including the ranch, to establish an innovative landslide warning system. Near-surface soil moisture content (θ) was monitored with time domain transmission (TDT) on the hill slope side. The soil type is volcanic ash soil near the soil surface, but spatial variability of soil hydraulic properties was high due to different organic matter content from the mountainside to the ranch. The response of ϕ to soil water index (SWI) and/or θ was confirmed during the rainy season. However, the determination of θ based on ϕ-value was difficult due to the heterogeneity and uncertainty of water balance within the sensing slope area. We believe that the COSMOS would be a unique method to monitor θ of the whole slope area if a compatible soil moisture model considering the growth of plant communities and 3-dimensional topographic data are proposed.

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P-743

Environmental Impacts Of Phosphorus Management Strategies In Subtropical Grazingland Ecosystems

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Biosolids, the byproduct of municipal wastewater treatment, provides a range of environmental benefits (Chinault & O'Connor, 2008; Singh & Agrawal, 2008), including improvement of soil health conditions and water quality protection. This 2-yr field study evaluated the effects of different P management strategies (biosolids vs. inorganic fertilizer, applied at either N- or P-based rates) on water quality of a perennial subtropical grass pasture. The predominant soil in the experimental area is Smyrna sand (Sandy, siliceous, hyperthermic Aeric Alaquods). Each experimental unit was 6x9 m with 1.8-m alleys between plots. Treatments were a factorial arrangement of two fertilizer sources (biosolids and inorganic fertilizer) applied at annual rates of 45, 90 and 135 kg P_2O_5/ha. Control treatments (no N or P added) were also evaluated. Nitrogen and P leaching was monitored using passive-capillary drainage lysimeters installed at a depth of 30 cm. Leachate samples were sampled every two weeks or after significant rainfall events (> 10 mm) and analyzed for soluble phosphorus, ammonium (NH_4-N), and nitrate (NO_3-N) concentrations. Biosolids or inorganic fertilizer showed no effect on leachate NH_4-N or NO_3-N concentrations. However, inorganic fertilizer increased P leaching by 18% compared to control treatments. No differences in leachate P between biosolids and control treatments were observed. Regardless of the P source, negligible amounts of P leached mainly due to the relative high soil P sorption capacity. Results suggested that regardless of the rate, biosolids resulted in significant lower risks of P losses via leaching than inorganic fertilizer.

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P-744

Effects of earthworm macropores on soil hydraulic conductivity, sorptivity and macroscopic capillary length in a temperate Alpine soil

Prof. Stefano Barontini, Dr. Marco Peli, Dr. Dario Pezzotti, Prof. Roberto Ranzi

From 9 March 2016 to 12 November 2018 we conducted an intensive experimental field campaign, the WormEx I Experiment, to quantitatively assess the role of earthworm macropores and of their seasonality at characterizing the soil hydrological properties.

Six 1—m² undisturbed plots were selected in two shallow soils in Valle Camonica (Central Italian Alps) at an altitude of 274 m a.s.l. (Köppen–Geiger climate type: Cfb) and 935 m a.s.l. (between Cfb and Dfb). Several infiltration tests were performed, with a tension–infiltrometer in different seasons and in different conditions of earthworm activity. The presence of earthworm macropores was assessed using number and magnitude of earthworm castings as a proxy. Inspired by Darwin's seminal work, the earthworm digging activity in two plots was stimulated by amending the soil with a thin layer of calcium trioxocarbonate.

Earthworms mainly belonging to the species Lumbricus Rubellus and Lumbricus Terrestris were found in the investigated plots. Earthworm digging activity showed a marked seasonality with Winter hibernation and medium or great activity during the other seasons. A peak of Summer and Autumn macropores was detected in the site at 935 m a.s.l.. Castings number resulted well positively correlated to antecedent air temperature and precipitation – correlation increasing with the time window in the range of 1 day to 8 weeks – and to soil water content in the range of 1 to 4 days.

Both hydraulic conductivity, sorptivity and macroscopic capillary length increased in presence of soil biopores, not only at saturation but also in near–saturation conditions.

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P-745

Enhanced removal of organic contaminants in water-saturated soils using designer biochars with tailored electrochemical properties

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Biochar amended soils are a potential remedy to contaminant runoff (Ahmad et al., 2014; Mohanty et al., 2018). The low cost, porosity and heterogeneous surface of the material allows the removal of a wide range of contaminants, which explains its increasing use as a biofilter (Reddy et al., 2014; Ulrich et al., 2017). Besides the sorption of the pollutant, the electrochemical properties of biochar (its conductivity and redox capacity) influence its ability to degrade many organic contaminants, either directly on the surface of biochar or indirectly through its interaction with microorganisms. However, the variability in the feedstock material and pyrolysis methods used for its production makes it difficult to predict and obtain a biochar with the desired physicochemical properties.

In this work, we show how tailored electrochemical properties in modified biochars enhance the degradation of specific contaminants. Pentachlorophenol and acetaminophen (paracetamol) are used as model contaminants in a water-saturated soil amended with biochar, each requiring different electrochemical properties for an efficient degradation.

The modification strategies are based on altering pyrolysis temperatures and treating biochar with potassium permanganate, which can be recycled and reused for an environmentally friendly and sustainable modification strategy. Additionally, we characterize the adsorption capacity, aging resistance and reusability of the designer biochars to demonstrate how this modification can further improve its role as a biofilter and soil amendment.

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P-746

Treating farm dairy effluent with poly-ferric-sulphate dramatically reduces phosphorus and E. coli leaching through sub-surface drains

Miss Xueying Che

Land application of farm dairy effluent (FDE) recycles nutrients back onto farmland, reducing the need for chemical fertilisers. However, effluent irrigation may lead to surface water and groundwater contamination, by contaminants such as phosphorus (P) and E. coli.

A new FDE treatment technology using poly-ferric-sulphate (PFS) has been developed to recycle wastewater in FDE for washing the farmyard. A physical drainage model study was conducted to investigate the effect of treating FDE (TE) with PFS and TE stored for three weeks before application (TE-S) on phosphorus and E. coli leaching through model sub-surface drains.

The cumulative DRP lost to drainage water over the trial period from the TE and TE-S treatments were 93.1% and 92.2% lower than that from the FDE treatments and were not significantly different from the Control. Additionally, compared to the FDE treatment, there were 98.27% and 99.99% reductions in E. coli coliforms in the drainage water from the TE and TE-S treatments which were not different from the control. Plant biomass and P uptake were not affected by the effluent treatments.

Land application of PFS-treated effluent, fresh or stored, on drained pasture soils can produce significant environmental benefits by reducing the concentration and amount of P and E. coli in the drainage water, without adversely impacting plant growth.

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P-747

Can irrigation modulate soil microbiological response to high levels of tropospheric ozone?

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High tropospheric ozone concentrations show adverse effects in agrosystems. Ozone can reduce the C transfer to plant roots with changes in root composition and exudates. Thereby, affecting soil microorganisms and nutrient cycling. Water deficit seems to modulate the ozone effect on plants and presumably on soil microbiota. We investigated whether the soil water availability can alter the soil chemical and microbial response to elevated tropospheric ozone of a sensitive winter wheat cultivar. A field experiment with open top chambers (OTC) was stablished in Central Spain in 2019. Four ozone levels (filtered air, non filtered air, +20 ppb O3, +40 ppb O3) and two irrigation levels were combined. Wheat was sampled (0-20 cm) at grain filling phase. Results for 0-5 cm soil layer, where most of the roots grew, showed higher ozone sensitivity in the rhizospheric soil fraction compared to the bulk, as expected. Soil chemicals variables were more sensitive to water availability than to ozone level, and rarely an interaction between both factors was found. Soil microbiological and molecular variables were more sensitive to ozone than soil chemical variables, and in some cases, the irrigation level modulated their response. Microbial biomass C and N showed decreases in ozone-enriched treatments regardless of irrigation level. However, abundances of total bacteria (16S) and total fungi (ITS) increased in ozone-enriched treatments, especially with high water availability. Our results indicate that soil microbial response to elevated tropospheric ozone in a Mediterranean wheat agrosystem is complex, and can be modulated by irrigation.

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P-748

The effect of environmental factors on CO2 efflux under different tillage in Cambisol

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The effect of environmental factors on soil CO_2 efflux is of great interest worldwide as it has great importance in agronomy and climate change situation.
The changes of soil CO_2 efflux were investigated by a closed chamber method from 0-5 cm depth of Cambisol under conventional tillage (CT), reduced tillage (RT) and no-tillage (NT) management in a long-term field trial. Volumetric water content and soil temperature were registered at the same time as carbon dioxide emission. Measurements were done 4-6 times per crop growing season annually during 2017-2020. The efflux values ranging from 0.14 to 2.68 µmol CO_2 $m^{-2}s^{-1}$ in CT, from 0.21 to 2.69 µmol CO_2 $m^{-2}s^{-1}$ in RT and from 0.24 to 2.68 µmol CO_2 $m^{-2}s^{-1}$ in NT were recorded. Soil CO_2 efflux averaged, tended to decrease in the following order: RT>NT>CT. In all experimental plots, the same trends of CO_2 efflux during the growing season were observed. Soil temperature amounted from 14.2 to 36.9 °C in CT, from 14.6 to 36.5 °C in RT, from 14.8 to 36.7 °C in NT and volumetric water content from 3.4 to 27.6% in CT, from 2.9 to 27.6% in RT, from 1.8 to 30.5% in NT were recorded.

Topsoil carbon dioxide efflux was directly related to soil temperature and volumetric water content. Soil temperature ($y=0.07x-0.36$, $R^2=0.65$) and volumetric water content ($y=-0.10x+2.79$, $R^2=0.61$) were dominant factors enhancing CO_2 under different arable lands.

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P-749

Sorption of antibiotics on particulate organic matter at macro- and micro scale

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Particulate organic matter (POM) is an organo-mineral complex, which is an important fraction of the soil organic matter. POM plays a vital role in the sorption of antibiotics in the soil environment. However, the spatial heterogeneity of POM for the sorption of ciprofloxacin (CFC) at a microstructure scale is unclear. Here, POM isolated from wetland soil was used to study the sorption of antibiotic CFC at a microstructure scale using NanoSIMS and 13C isotopic tracer. With POM separated from soils (oil waste field and farmlands) were used to study the sorption mechanisms via batch sorption experiments. The results showed that the maximum CFC sorption capacity of POMs ranged from 65.20 mg g-1 to 77.51 mg g-1, indicating that POM played a vital role in CFC sorption in soil environment. Both the sorption kinetics results and NanoSIMS results showed that the CFC sorption included surface distribution and intra-particle diffusion, and CFC sorption on the surface was greater than that of subsurface (from the 15 nm to 150 nm depth). The surface accumulation effect and marginal accumulation tendency at microstructural scale could be observed in CFC sorption by POM. Combining with the results of the effect of pH and salinity and spatial distribution of 13C-/12C- isotopic ratio of the POM adsorbed for 13C labeled CFC indicated that CFC could be adsorbed dominated by organic components.

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P-750

Application of leaching potential indices in a clay-loam soil to assess the risk of groundwater pollution by triazole fungicides

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In this work we have examined the behavior (adsorption, degradation and leaching) of three widely used triazole fungicides (flutriafol, myclobutanil and triadimenol) on a clay-loam soil to assess the risk of groundwater pollution by means of leaching potential indices (LPIs). For this purpose, sorption, degradation and leaching experiments were conducted at laboratory scale with a typical semiarid Mediterranean soil (calcareous Regosol). Sorption studies were carried out following the batch equilibrium method. Degradation tests were performed in aerobic and dark conditions for 60 days. Finally, the leaching potential was assessed using disturbed soil columns. Soil and water samples were analysed by HPLC-MS^2 (Aliste el at., 2021). Low adsorption in the soil (log KOC ≤ 2.5) was observed for the three fungicides. The calculated half-lives ranged from 79 to 136 days for triadimenol and flutriafol, respectively, showing moderate to high persistence in soil (Gavrilescu, 2005). All fungicides were detected in leachates with percentages ranging from 12 % (triadimenol) to 26 % (myclobutanil) of the initial mass added. Concentrations found in total leachates (13, 17 and 23 µg/L for triadimenol, flutriafol, and myclobutanil, respectively) were in all cases higher than the maximum admissible concentration (0.1 µg/L) established by the European Commission for groundwater (EC, 2006). In accordance with the screening indices used (GUS, RLPI, LIX and ELI) all fungicides behave as mobile or very mobile compounds. Our findings suggest that the studied fungicides are candidates to pollute groundwater resources, mainly in areas with intensive yearly rainfall regimes.
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P-751

Precise Estimation of Dodecylbenzenesulfonate (DBS) Concentration from DBS-DOM Complex Solution Using UV- Spectrometry

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Precise estimation of sodium dodecylbenzenesulfonate (DBS), an anionic surfactant widely used as a detergent, is essential for understanding its adsorption in soils, transport, toxicity, fate, and its application in the remediation of contaminated soil and groundwater. The benzene ring of dissolved organic matter (DOM) acts like DBS in DBS–DOM complex solutions under UV-spectrometry. This phenomenon increases the absorbance at the UV spectrum during the UV-spectrometric detection of DBS concentration and eventually becomes responsible for the excess quantity of DBS that misleads the measurement. This study was conducted to propose a precise spectrometric measurement of DBS concentration of the solutions containing DOM at pH 6.0 and pH 12.5. To elucidate the influence of DOM during the measurement of DBS in the aqueous solution, 222.5 nm UV and 400 nm UV-vis spectra were measured. The DOM was extracted from a highly humic non-allophanic volcanic ash (Andosol) soil using 1 mmol NaCl/L as the extractors. The absorbance at 222.5 nm and 400 nm wavelengths increased proportionally to the DOM concentration, whereas only the absorbance at 222.5 nm increased for DOM-free DBS solution for both pH conditions. Differently, absorbances at 222.5 nm and 400 nm spectra showed opposite trends (increase and decrease respectively) for the pH 12.5 compared to pH 6.0. The linear regression between the absorbances at 222.5 nm and 400 nm spectra for DBS-free DOM solution was used to eliminate the influence of DOM for the DBS–DOM solution successfully. The proposed method is simple, rapid, and efficient and requires no reagents [1].

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P-752

Surface Charge governs the adsorption behaviour of glyphosate in the Australian Oxisol Soil System

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Glyphosate adsorption pattern is important for determining its environmental fate. Australian Oxisol soil systems were found to adsorb maximum glyphosate in the presence of biochar, however, the mechanism was not known. This article provides information concerning the role of surface charge in the case of Oxisol soil systems. Potentiometric titrations were done as a part of PhD research at the University of Sydney, Australia. To calculate the surface charge in the case of Oxisol soil system, the instrument 836 Titrando (Metrohm) was used.The relative charge was obtained by plotting the pH as a function of the volume of the titrant. Maximum adsorption of glyphosate in the Oxisol soil system in the presence of char was found due to an increase in net positive surface charge. This finding is of great importance to understanding the mechanism of herbicide soil interactions.

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P-752A

Selected Conservation Buffer System Effects on Adsorption of Fluorescent Labeled E. coli

Mr. Nasruddeen Al-Awwal, Dr. Stephen Anderson, Dr. Majed El-Dweik

The magnitude of bacterial transport by runoff into surface water and infiltration into groundwater is influenced by adsorption processes in soil. This research work evaluated Fluorescent labeled E. coli adsorption to soil from agroforestry buffer (AB), row crop (RC) and grass buffer management. The native bacteria in the treatments were determined using the Matrix-Assisted Laser Desorption/Ionization (MALDI) Biotyper with the screening tests revealing similar native bacteria for the treatments. Adsorption experiments were conducted with soil from the treatments with the fluorescent labeled E. coli. Model efficiency for the linear adsorption isotherm improved when only data within a limited concentration range 105 -108 cfu/ml of E. coliO157:H7-GFP were used. It was observed that the Freundlich isotherms described observed sorption data well for all treatments (model efficiency, E = 0.97 for the agroforestry buffer (AB), E = 0.75 for the row crop soil (RC) and E = 0.94 for Grass buffer (GB) with a greater log kf (1.16) value in the agroforestry buffer compared to both row crop and grass buffer. Evidence of greater adsorption occurred in the agroforestry buffer system.

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P-753

Refining Digital Soil Mapping Protocols to Improve Soil Ecotope Mapping in the KwaZulu-Natal Bioresource Classification System

Dr Jonathan Atkinson, Dr Willem Willem P de Clercq, Dr Andrei Rozanov

The preservation, development and sustainable use of agricultural land are considered critical for economic growth and poverty reduction in South Africa. A significant operational decision support resource already developed to provide a reconnaissance appraisal of the natural resources for both environmental impact assessments and the agricultural potential of KwaZulu-Natal (KZN) is the classification of the province into a collection of Bioresource Units (BRUs). Each BRU can further be defined by a range of conceptual soil ecotopes that represent the potential of the soil for production. The BRU Report Writer has not seen a major revision for over two decades. Still, the natural resource information it contains provides land managers, policymakers and farmers with invaluable access to regional and farm level qualitative estimations of agricultural productivity. Classification of soil type and soil ecotopes was performed with random forest (RF) implemented in ArcGIS Pro Forest-based Classification and Regression GeoAnalytic Tools suite of applications. A favorable result must be that all soil types and soil ecotopes reported overall accuracy that far exceeded expectations compared to similar regional DSM applications. Overall prediction accuracy varied from 76% to 91% when modelling all seven soil types and 92% to 98% for the 27-modelled soil ecotopes. This research has demonstrated that using the ArcPro RF model to predict soil type and soil ecotope properties using a set of environmental covariates, including detailed soil calibration locations, can be a gateway approach for updating the natural resource DSS information delivered by the BRU Report Writer.
none

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National scale trends in top soil carbon content from the UK Countryside Survey

Dr Laura Bentley, Dr Amy Thomas, Angus Garbutt, Professor David Robinson, Professor Bridget Emmett, Dr Inma Lebron, Dr Claire Wood, Dr Simon Smart

Understanding variation in soil organic carbon (SOC) at a national scale is a priority for managing soil health and function, as well as for the targeted mitigation of greenhouse gas emissions from soils. The Countryside Survey is the longest running national survey of British soils, spanning four decades (1978-2021). This unique data set has been assembled following rigorous scientific methods to allow for the detection of trends in soil condition across all broad habitat types, and provides a valuable baseline to assess the impact of land use management initiatives. Measurements of SOC (0-15cm) have been collected over four survey campaigns using a stratified random sample of 1 km squares. We report an analysis of SOC using mixed effects modelling to determine the trajectory of SOC within broad habitats and vegetation classes. We also explore the responses of SOC to land use change, which is a strong driver of SOC change. A consistent and significant decline in the topsoil SOC of soils under crops and weeds has been detected, falling from 51.5 t/ha in 1978 to 46.2 t/ha in 2007. At the same time, the SOC content of fertile grasslands has increased from 62.8 t/ha to 69.9 t/ha. We will show if these trends continue using an updated dataset following the 2021 field campaign. These results show the value of the Countryside Survey for identifying priority issues for SOC at a national scale and how these SOC changes are impacting on both soil health and GHG emissions.

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P-755

AN IMPACT OF BIO-BASED AND MINERAL FERTILIZERS ON SOIL P DYNAMICS

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Modelling phosphorus (P) behaviour and dynamics in agricultural soils requires an understanding of P turnover rates. We applied a novel isotope pool dilution (IPD) technique with 33P as a tracer to model P dynamics in soils fertilized with conventional and recycled fertilisers. Soils from an experimental P site were used to provide baseline soils with low, moderate and high P content. Untreated soils and soils amended with mineral fertilisers (SSP) and recycled dairy processing sludge (DPS) were analysed to measure P availability and P fluxes supplying available and labile P pools. Soil P pool sizes were assessed using the agronomic test (Morgan P) as well as the isotope technique (E-value), reflecting the size of available and labile P pools, respectively. P fluxes were measured using the IPD method.

Preliminary results enabled the design of a conceptual diagram for P cycle and quantification of P fluxes in the baseline soils and in soils following application of mineral and recycled fertilisers. Both fertilizers increased P availability in P deficient soil to a level optimal for crop production. A net flux in amended soils enables prediction of soil response to the application of fertilizer. In low and moderate P soils amended with DPS the flux supplying labile P pool was predominant. These results are consistent with slower P build-up in these soils and suggest that deficiency in labile P pool can impact P build-up dynamics. The net flux in soils amended with SSP indicates faster P build-up compared with soils amended with DPS.

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P-756

SOIL RE-USE PLANNING TO DELIVER SPECIES-RICH HABITATS AND REDUCE MAINTENANCE REQUIREMENTS IN MAJOR INFRASTRUCTURE SCHEMES

Dr Bruce Lascelles, Mr Ben Hewlett

Major infrastructure development projects can result in large volumes of topsoil, subsoil and bedrock being generated, stripped and stockpiled, requiring a re-use plan. Recognition of the value and importance of soils in the final design and successful delivery of schemes, including landscape planting schemes, land to be returned to agriculture and creation of new species rich habitats has highlighted the need to understand the characteristics and function of the soils present, as well as how these can best be used to deliver specific elements of the final scheme design. National Highways; the UK Government company which plans, designs, builds, operates and maintains England's strategic road network, has developed a specific initiative to drive the creation of species-rich grassland habitats on newly created road landscapes and safety critical areas. This will utilise low nutrient soil materials to drive biodiversity gain and reduce management inputs, while also reducing the time operatives are on the highways, providing a Health and Safety benefit. Ben Hewlett from National Highways, with Bruce Lascelles from Arcadis, will discuss the challenges which need to be overcome to ensure successful implementation of this initiative. This includes the timely availability of quality and appropriate soil data and soil science expertise, changing perceptions and acceptance of a sparser sward and some bare ground, while ensuring this does not result in surplus soil resources with no re-use options. There is significant interest from a range of organisations in formalising this approach and developing best practice guidance and their viewpoints will be incorporated.

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P-757

Irrigation-induced soil salinity as a limiter of soil quality in a semi-arid Mediterranean growing area

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Nowadays, safe food production is necessary to supply the entire world population. However, some anthropic actions generate problems that can lead to the losses of soil quality. To avoid these facts, it is necessary to previously characterize the soil and evaluate it according to its properties and characteristics. This evaluation is usually carried out in the short term and can produce a decrease of crop yield. In this sense, this research carries out a rigorous analysis of the evolution of the suitability of soils subjected to irrigation in a semi-arid Mediterranean area that has suffered soil degradation problems due to poor resource management. The research has been carried out in the province of Alicante (Spain) where soils have been monitored from 1974 to the present. 103 soil samples have been analysed in 28 pits during 45 years (1974, 1995-97, 2001 and 2019). All samples: were analysed (texture, electrical conductivity, pH, cations, anions, content of organic matter and carbonates, as well as other soil properties such as stoniness and type of management.) Moreover, subsequently evaluated by the USBR method. As the main result, it can be established that there has been a deterioration of soil quality derived mainly by salinization and sodification. If we compare the data since 1974, soils of the highest aptitude and quality have worsened, increasing the soils with a medium-poor quality compared to those suitable for the development of crops. This class occupied in 1974 more than 60% of the area and nowadays they have disappeared
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P-758

Does soil type affect deadwood production and carbon stores?

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Deadwood is an important, but often overlooked, part of forest carbon cycles. The carbon held in deadwood is now required for reporting under the Kyoto protocol. However, not much is known about how soil type influences deadwood production, and subsequent carbon stores. Soil type can influence the risk of trees being subjected to water stress from drought and/or flooding, alters nutrient conditions, and thus can cause ill health and mortality. Additionally, planting trees on the wrong soils can affect their growth rate, health, and lifespan. The National Forest Inventory (NFI) collects data on woodland condition and tree health, with measurements of deadwood in each woodland also being collected. Potentially, healthier trees will have longer lifespans and produce less deadwood over time, while those in unfavourable conditions suffer ill health and tree death, leading to the creation of pulses of deadwood. The underlying soil type can influence not only tree health but also the mobility of carbon held within it. To identify the link between soil type and deadwood production, we used data from the UK NFI and a harmonised GB soil map, classified according to the World Reference Base. Key tree species for UK forestry were selected to assess how volumes of deadwood, and the carbon stocks held within, changed with soil type. Tree ages were split into 0-20, 21-40, 41-60,61-100, 100+ years, based on year of planting. We also aim to identify whether occurrences of pest and disease as a cause of tree death were increased on unfavourable soils.

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P-759

Soil-landscape assessment as a tool for rural development in semi-arid regions of Israel

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The semi-arid areas of the Mediterranean region are extremely valuable for modern and sustainable agriculture and for activities for recreation and leisure. These areas are characterized by their high spatial diversity of natural resources and by the richness of cultural heritage sites.
In order to improve land-use planning and management practices, a soil-landscape method for the assessment of semi-arid regions was developed. The method was applied at the North-Western zone of the Negev desert, Israel. It is based on a two-fold view of the territory. First, the regional mapping of main properties of soils and landscapes that limit agricultural development. Materials of previous soil surveys were analyzed and soil profiles reflecting the current state of landscapes were studied from morphological, analytical, and geographical points of view. Secondly, cultural heritage sites, which constitute landscape-historical complexes were inventoried. They were assessed as indicators of the historical development of successive cultures from the Bronze Age until today, and as territorial units which enclose unique landscape features. Special attention was paid to soil and geological outcrops, badlands, forest massifs, and branched river networks.
The method proposed provides a tool that seeks to harmonize the relationship between agricultural activity and the transformation of the territory into an attractive space for present and future generations, balancing the needs of the agricultural industry and society, and simultaneously underlining cultural heritage sites, valuable for conservation and restoration.

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P-760

Effect of land use on physical and chemical properties of soil in the catchment of Renuka wetland, a Ramsar site

Deevana Elias, Dr Keely Mills, Dr Tara Chand

Soil is a complex matter that constitutes minerals, soil organic matter, water and air that together supports life. These components influence the soil texture, structure, and porosity and the potential of soil to function. The physical-chemical properties influence soil health and quality. The study aims at analysing the physical-chemical properties of soil with changing land use. It evaluates the effects of different land use on the soil physical and chemical properties and relates the health of catchment soil and its impact on wetland. Soil samples were collected from four land use (forests, scrub, settlement and agriculture) at two depths (0-15 cm and 15-30cm) from 2019-2021.
Seven parameters were analyzed viz., pH, Electrical Conductivity (EC), Nitrogen (N), Phosphorous (P), Potassium (K), Bulk Density (BD), Organic Carbon (OC). The results showcased that land use significantly affected the
value of soil properties. Minimum pH was seen in forest (6.5) and the maximum pH (7.87) in settlement. Minimum EC was found in scrub and maximum in settlement. BD in the catchment ranged from 1.05-1.6g/cm3 with minimum values in forest and maximum in settlement. OC values varied from 2.99-3.75%. The minimum value for OC was found in settlement and maximum in forest. N values ranged from 249.62kg/ha -342.45kg/ha. The minimum N content was observed in settlement and maximum in forest. Similar results were observed for Phosphorus and Potassium. A healthy catchment leads to healthy wetlands and thus appropriate land use practice and policies are important to maintain productivity of both land and wetlands.

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P-761

Estimation of soil moisture through multiple linear regressions in Llano Brenes, Costa Rica

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Introduction. Soil moisture is an important variable in the supply of water for agriculture. However, its measurement in the field tends to have limitations, so its prediction is necessary for various agricultural planning and research activities. Objective. To develop three multiple linear regression models in order to predict daily soil moisture at the crop scale, based on meteorological information. Materials and methods. The study was developed in Llano Brenes, Costa Rica; Time domain reflectometry (TDR) sensors were installed and they recorded information every 20 minutes of soil moisture from November 2018 to December 2019. The soil was taxonomically classified as Lithic Ustorthents, in a farm with coffee cultivation in production. Undisturbed soil samples were taken for TDR calibration and a temporal stability analysis was performed. The first model (RLM1) was a multiple linear regression with meteorological variables, in the second model (RLM2) in addition to the meteorological variables, the precipitation was separated into sub-periods which were introduced as dummy variables, while the third model (PCA) consisted of a main component analysis and a linear regression model. Results. The RLM2 (R2 = 0.838) and PCA (R2 = 0.823) models presented a better performance compared to the RLM1 (R2 = 0.540) model. However, the RLM2 model was considered more useful due to its simplicity and because it presented the best goodness-of-fit indicators. Conclusion. Linear regression models with meteorological variables allowed estimating soil moisture, this because soil moisture receives an important contribution from seasonal patterns of precipitation and tends to follow these variations.

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P-762

Time-dependent changes in ecological parameters due to mechanical stress on agricultural soils

MSc Richard Schroeder

Objective:
This study deals with the changes in the ecological parameters: Saturated Hydraulic Conductivity (Ks), Air Capacity (AC) and Air Conductivity (Ka) under conventionally managed areas during the last 40 years, in relation to soil mechanical parameters (precompression stress Pc, cohesion c and angle of internal friction φ).
Methods:
A database of undisturbed soil samples from publications of “The Horn working group” at the Soil Science Institute in Kiel, Germany was compiled. This database of over 460 profiles enables to focus on the specific description of soil mechanical parameters. Only subsoils under conventional tillage were selected for the study. In this presentation changes in ecological parameters are presented as a function of time (1979 - 2019).
Key results:
Conventional soil management in Europe tends to a continuous negative development of relevant soil ecological parameters (Ks, Kl, AC) in arable soils. Highly frequented and increasing mechanical stress application by agricultural machinery results in a continuous worsening of the ecological quality of these areas. Overcompaction, deformed and disturbed hydraulic conditions, decreasing soil stability and quality can be related to the longterm soil management for various texture, structure and organic carbon.
Conclusions:
By elaborating such a database, specific management concepts and framework guidelines can be developed. In particular, maintaining the stability of sensitive subsoils of highly productive sites requires a comprehensive understanding of soil mechanical relationships and the development of pedotransfer functions. These findings can help to improve future-oriented management methods and ensure the productivity of arable sites in the long term.

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Dynamic Soil Properties and Soil Health Reference Conditions for Soil Survey

Dr. Skye Wills, Tiffany Carter, Sharon Perrone, Kristen Veum

Traditional soil survey maps provide information on properties that do not change with time (i.e.: inherent soil characteristics). However, users are interested in more dynamic soil properties (DSPs) that may change as influenced by land use and management. The Soil and Plant Science Division (SPSD)of USDA-NRCS has amended our technical guidance to include the collection and measurement of DSPs as part of standard soil survey procedures. Meanwhile, soil health is an increasing important issue for soil scientists, conservation practitioners, and land managers. As soil health indicators become more relevant to agency and societal goals, soil survey is coordinating a project called Dynamic Soil Properties for Soil Health (#DSP4SH) as part of a broader Science of Soil Health Initiative. Standard methods were used by sixteen cooperators to measure soil carbon, aggregate stability, permanganate oxidizable carbon (POXC), soil enzymes and other common soil health metrics. Each cooperator designated a local business-as-usual, soil health management system, and perennial reference conditions. The use of ecological sites, state and transition models and soil security will be used as concepts to compare and interpret results. The Soil Health Assessment Evaluation Protocol (SHAPE) will be applied to interpret results relative to similar soils.

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The synergy of biochar and bacteria inoculant with compost or phosphorus fertilizer on soybean yield and chemical fertility of tropical acidic soil

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Most crops in tropical savanna ecosystems are 30 to 60% below their achievable yield, primarily due to inherently poor soil fertility. This study used an integrated soil management approach involving Bradyrhizobium japonica inoculant and rice husk biochar in a composite treatment with compost or phosphorus fertilizer for soil fertility improvement and soybean yield. In the Guinea savannah zones of Ghana, we conducted a two-factor pot experiment in a greenhouse. The soil amendment involved unamended control, 20 t ha-1 rice husk biochar (B) and a co-application of 10 t ha-1 biochar with either compost (B+CM), rock phosphate (B+RP) and triple superphosphate (B+TSP) at 5 t ha-1, 60 kg ha-1 and 60 kg ha-1 respectively. Non-inoculated and Bradyrhizobium japonica inoculated soybean seeds were sown and grown to maturity. The lone application of biochar and its integration with compost and P fertilizer showed a significant improvement in SOC, pH, CEC, and available P of the soil. The forward adjustment of these parameters led to an increase in pod length, nodules count, and plant height relative to the control soil. Up to 47%, 87%, 69%, and 72% increase in grain yield were indicated in B, B+CM, B+RP, and B+TSP amended soil. Compared to non-inoculated control soils, Bradyrhizobium japonica promoted nodule development in soil treated with B (+40%), B+CM (+70%), B+RP (+61%) and B+TSP (+67%). Biochar and its combination with P fertilizer were beneficial to soil and soybean beans. However, the combined biochar-compost amendment was superior and promoted the activity of Bradyrhizobium japonica enhanced nodulation.

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P-766

Biochar effects on agricultural soil functions: Experimental insights into the durability of biochar using simulated leaching and ageing procedures

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Emission of nitrous oxide from agricultural soils is an environmental issue that must be addressed. Four differentially treated oilseed rape biochars (i) unleached unaged (UU) biochar, unleached aged (UA), leached aged (LA) and leached unaged (LU) biochars were prepared using established leaching and ageing procedures to simulate biochar leaching and ageing processes similar to those experienced within the soil environment over time. Each type of biochar was assumed to reflect a different time point on the trajectory of biochar behaviour in soils over time. The ability of each type of pre-treated biochar to retain nutrients (ammonium cations and phosphate anions) was compared and assessed experimentally using a controlled batch adsorption experiment with diammonium phosphate. Arable soils with and without diammonium phosphate fertiliser applications were amended with each type of pre-treated biochar to assess the impacts of leaching and ageing on the durability of biochar functions within soil – specifically nitrous oxide emission reduction, liming value and nutrient cycling within agricultural soil systems. Overall the purpose of this work was to experimentally assess the durability of and mechanisms responsible for biochar nutrient retention, liming and nitrous oxide emission reduction in order to identify the practical boundaries with respect to biochar application and its beneficial effects on agricultural soil functions.

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P-767

4D structural changes and pore network model of standard biomass feedstock during pyrolysis

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Several biomass feedstocks, namely miscanthus straw pellets (MSP), wheat straw pellets (WSP), oilseed rape straw pellets (OSR), and rice husk (RH) were heated in the temperature range from 50 to 800 ºC and simultaneously imaged using synchrotron x-ray microtomography. The results showed a wide range of variation in the pore structural characteristics of the biochar depending on feedstock and pyrolysis temperature, with observed porosity in the range of 7.41 – 60.56%. Biochar produced from OSR had the highest values for porosity (60.56%), total pore volume (0.076 mm3), total surface area (14.27 mm2), pore volume and equivalent diameter of largest pore (0.056 mm3 & 457.9 µm), macropore (>75 µm) volume (0.075 mm3) and median throat length (283.43 µm). The pore size distribution had multimodal peaks and varied based on feedstock type and temperature. Majority of the pores for all biochar produced were within 3 – 100 µm pore sizes which are essential for many soil processes. Biochar from MSP and RH had larger volume of micropores (5 – 30 µm) and mesopores (30 – 75 µm), respectively compared to biochar from other feedstock. The pore structural development also depended on pyrolysis temperature. The effect of pyrolysis temperature on pore network model and connectivity largely depended on the feedstock type. Extensive analysis of the pore structural characteristics of biochar will help to accurately predict biochar impacts on a wide range of environmental processes (e.g., soil amendment and waste-water treatment).

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P-768

Nitrogen availability in two amended biochars.

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Nitrogen availability in two fertilised biochars.

Biochar, carbonaceous product obtained by the thermochemical processes of biomass, has recently gained attention for its potential, when used as a soil amendment. Moreover, biochar can retain certain nutrients, reducing nutrient loss via leaching or gaseous emission. Biochar has high cation and anion exchange capacity, and, therefore, a great potential as a slow fertiliser when applied fertilised-biochar to soils. The objective of this study was to evaluate the ability of nitrogen charged biochar to release nitrogen to the soil solution. Two different biochar obtained from pine branch (BPR) and gardening pruning of various species (BJ) were enriched with two different fertilizers: Ecocomplet (EC), an organic NPK fertiliser, and Compost-tea (TC), a water-soluble extract obtained from compost. The release of N to the soil solution was studied by applying the equivalent to a 15 mm rain to the fertilized biochar in nine cycles. Leachates were collected and nitrogen was determined. Soluble N content decreases as the number of leachates progresses, always higher in biochars fertilised with Ecocomplet due to its higher nitrogen initial content. The first BPR-EC, BJ-EC, BPR-TC and BJ-TC leachate had (mgN/L) 19.56±1.18 and 20.50±0.33, 0.57±0.24 and 1.15±0.50, which represented 12.7, 11.8, 1.5 and 3.9% of the initially applied N, respectively. At the end of the experiment, the last leachate of BPR-EC and BJ-EC represented 2.3 and 1.4%, respectively. Our results suggest that charging biochar with nutrients is a promising technique to improve the properties of biochar as a soil amendment in agriculture.

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P-769

Waste to value: The use of black soldier fly frass for sustainable soil health and food production.

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The black soldier fly (BSF) has emerged as a promising insect in advancing the circular economy through the re-valorisation of organic waste. BSF frass is excrement of black soldier fly that can be utilised as a potential source of soil amendment. The aim of this study was to determine the effect of BSF frass on soil health, microbial abundance and plant growth. The experiment consisted of seven different rates of frass: 0, 2, 4, 6, 8, 10 and 12 g/kg soil. The chilli (Capsicum annuum L.) plants were grown in a temperature-controlled glasshouse for 14 weeks. BSF frass treatment significantly increased the shoot and root weight, flowers, and shoot N content. Soil NH4+, NO3-, and pH increased with the increasing rate of the frass. Frass rate above 6 g/kg soil plateaued microbial biomass C and microbial biomass N but plant biomass decreased. Increasing the BSF frass rate caused a decrease in alpha diversity. BSF frass amendments increased the relative abundance of the rhizosheath bacterial phyla of Firmicutes and Bacteroidetes but decreased Acidobacteria and Proteobacteria. The predicted abundance of the C cycling gene SrpA (catalase) significantly increased with the increasing frass rate but it decreased for ChiC (chitinase) and SusB (glucoamylase). The increasing rate of BSF frass also leads to an increased abundance of denitrification genes (nirK and nosZ). N fixation was reduced, but nitrification increased with a rising rate of frass. This study highlighted how the BSF frass could alter soil biological processes that influence plant growth.

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P-770

Effective encapsulation of biochar-based fertilizer: Utilizing the grafting potential of chitosan for sustained nitrogen release

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Essential plant nutrients are released very rapidly from conventional chemical fertilizers and so the nutrient use efficiency (NUE) of plants is low. The unused portion of the fast-soluble nutrients can also contaminate soil, and water reservoirs, necessitating methodologies to generate slow-releasing fertilizer. The potential of biochar to recycle plant nutrients and act as a carrier for slow-releasing fertilizer is getting considerable attention. However, nutrient release from biochar-based fertilizers (BBFs) produced from nutrient-rich feedstock or by chemical fertilizer loading is often faster than the desired rate. Thus, an effective encapsulation of BBF is essential to improve the sustained nutrient release mechanism. In this study, we used chitosan as a biopolymer to efficiently coat nitrogen-rich chicken-manure biochar (CMB). The design of this durable coating was based on chitosan's potential to form grafts with amides of CMB by microwave irradiation (960 W, 70 s). The coating was performed with a rotational speed of 50 rpm for 1 h and chitosan (4 mg/g biochar) promoted the beneficial granulation of BBF. Fourier transform infrared spectroscopy showed that easily soluble primary amides on CMB transformed to less soluble forms by creating grafts with chitosan. In addition, cumulative nutrient release in water from pristine and chitosan-coated biochars (with or without microwave irradiation) was investigated. Results revealed that chitosan coating, especially with microwave irradiation, significantly ($p < 0.05$) retarded the nitrogen release from BBF. Therefore, chitosan-coated BBF with sustained nitrogen release is anticipated to increase the NUE of plants as well as mitigate adverse environmental impacts.

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P-771

Effect of biochar on immobilization of chromium, nickel and lead in soils amended with slag

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The use of steel plant slag (SPS) as a liming material is a common practice in agriculture in several countries, South Africa included. However, application of SPS is usually accompanied by the addition of heavy metals to the soil. Previous studies have demonstrated the potential of biochar as an effective ameliorant to remediate contaminated soils. This study investigated the use of biochar as a potential ameliorant to immobilize Cr, Ni and Pb in slag amended soils. A greenhouse pot experiment consisting of two soils of different texture (sand and clay), two biochar derived from poultry litter and acacia AB feedstocks and four biochar application rates (0, 5, 10 and 20 t ha-1) in a 2 x 2 x 4 factorial arrangement, replicated four times in a completely randomized design was conducted with spinach as a test crop. Increasing the application rate of both biochar types decreased the amount of extractable Cr, Ni and Pb in both soils, with the amount extractable being lower in clay than in sand soil. Acacia biochar (AB) immobilized an average of 27% Cr, 18% Ni, and 55% Pb in sandy soil and 37% Cr, 28% Ni and 46% Pb in clay soil. Poultry litter biochar (PLB) immobilized an average of 37% Cr, 35% Ni and 52% Pb in sandy soil and 49% Cr, 49% Ni and 63% Pb in clay soil. PLB was more effective especially at the 20 t ha-1 application rate. Therefore, biochar may be used to immobilize heavy metals in contaminated soils.

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P-772

Linking above- and below-ground processes in biochar-mineral fertilizer amended nutrient and organic C depleted alkaline calcareous soil cultivated with raddish

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Biochar is recalcitrant carbon (C) rich material developed from pyrolysing the biomass waste under no or limited supply of oxygen. Biochar generally imparts multiple benefits to soil-plant systems; however, these benefits vary across soils and climatic conditions, and depends on feedstock type and pyrolysis conditions. In the light of this discussion, a pot experiment was used to investigate the effects of corncob-derived biochar on raddish (Raphanus raphanistrum) biomass production and soil biochemical properties in the presence of chemical fertilizer in nutrient poor alkaline aridisol. Biochar was applied at 0, 1.5 and 3% w/w basis whereas recommended chemical fertilizer (RCF) was applied at 0, 50 and 100% RCF rates following completely randomized design (CRD) using three replicates per treatment. Experiment was conducted for 12 weeks and changes in plant parameters and soil biochemical properties were recorded. Biochar and mineral fertilizer enhanced raddish biomass and significantly improved soil biochemical and nutrient properties including soil mineral N, phosphorus and potassium contents. Biochar enhanced microbial biomass C whereas mineralizable C was the lowest at higher biochar application rates resulting in lower microbial metabolic quotient (qCO2) that suggested higher microbial C use efficiency. The results also demonstrated that biochar increased nutrient use efficiency of chemical fertilizer. Above-ground plant productivity was significantly positively correlated with below-ground biochar-led increase in soil nutrient content. We concluded that biochar has potential of increasing above- and below-ground plant biomass, soil nutrients' availability, soil organic C contents, soil biochemical quality in organic matter deficient alkaline soils in arid and semi-arid regions.
N.A

P-773

Comparative effects of sewage sludge and sewage sludge-derived biochar on wheat straw mineralization in contrasting textured alkaline soils

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Deleterious effects of sewage sludge (SSL) on soil quality can be overcome by converting SSL into SSL-biochar (SSL-B). Sewage sludge was pyrolyzed into biochar at 600 °C for 30 minutes. Sandy and clayey textured soils were amended with wheat straw, SLL and SLL-B and incubated for 30 days following a completely randomized experimental design. Sewage sludge and SSL-B had contrasting effects on wheat straw decomposition, but cumulative CO2 efflux was higher in clayey than sandy soil. Sewage sludge biochar caused positive priming of native soil C in clayey whereas suppressed wheat straw decomposition in sandy soil. Microbial biomass C was significantly higher in SSL-B and wheat straw treatments in both soils. Cold water-, hot water- and salt-extractable organic C fractions indicated significant changes in soil organic matter quality. Changes in specific ultraviolet absorbance (SUVA), aromaticity and, hydrophobic and hydrophilic properties of dissolved organic C suggested contrasting effects of SSL and SLL-B on soil organic C quality. Total organic C contents were significantly higher in both soils when wheat straw was amended with SSL-B and SSL. Significantly less values of microbial metabolic quotient (qCO2) in wheat straw amended SSL-B than wheat straw amended with SSL could suggest higher microbial C utilization efficiency in both soils. Our study provided evidence that SSL can be better utilized as SSL-B to improve microbial activity, soil organic C and soil biochemical quality in nutrient and organic matter depleted soils in semi-arid regions.
N.A

P-774

Effect of adding fertilized biochar on soil phosphorous bioavailability and plant growth in greenhouse conditions.

Effect of adding fertilized biochar on soil phosphorous bioavailability and plant growth in greenhouse conditions. Jenny Solis, Effect of adding fertilized biochar on soil phosphorous bioavailability and plant growth in greenhouse conditions. Santiago Espinoza, Effect of adding fertilized biochar on soil phosphorous bioavailability and plant growth in greenhouse conditions. Nuria Roca, Effect of adding fertilized biochar on soil phosphorous bioavailability and plant growth in greenhouse conditions. Anna Rigol, Effect of adding fertilized biochar on soil phosphorous bioavailability and plant growth in greenhouse conditions. María Isabel Trillas, Effect of adding fertilized biochar on soil phosphorous bioavailability and plant growth in greenhouse conditions. Teresa Sauras

Effect of fertilized biochar on soil phosphorous bioavailability and plant growth.

Biochar's positive effects on the soil ecosystem have been proposed to derive either directly from biochar itself, or indirectly from its ability to sorb and retain nutrients. This study aimed to investigate the biochar effect on soil fertility and uptake of phosphorous by Solanum lycopersicum plants in 3-liter pots grown in a greenhouse for 10 weeks. The experiment included six treatments, two soils S1 (sandy) and S2 (clay) with two doses of fertilized biochar (D1=125ml/pot and D2=250ml/pot), one fertilizer (Ecocomplet EC), an organic NPK fertilizer, and Trichoderma (T-34) (1x104 UFC). Tree replicates per treatment were used. Biochar was produced from gardening pruning of various species in a kontiki oven. Biochar showed a very high pH values (10.06), relative moderate conductivity (3.33 dS/m) and high-Water Holding Capacity (222 %), low specific surface area (3.06 m2/g) and low P content (28±3mg/kg). The fertilized biochar increased both water and CaCl2 extractable P content (5.02±0.06 g/kg and 1,38±0.07 g/kg respectively). At the end of the cultivation period, plant growth range (minimum and maximum) between treatments (cm) was 113.0±20.3 in S2+BD2+T-34 and 140.0±11.53 in S1+BD1). The treatments with the highest tomatoes production were S1+T-34 (16±2 g/pot?), S2+BD1 (16±3 g/pot?). In the present study no significant difference in total growth or number of fruits between soil treatments were observed.

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P-775

Rice Husk Biochar and inorganic P fertilizer effect on nutrient uptake of Maize

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Biochar, an ecologically friendly soil conditioner, is produced from the thermal decomposition of organic materials called pyrolysis. It has the ability to increase soil fertility by carbon sequestration and mitigate greenhouse gas emissions. This study aimed to examine the impact of combined application of rice husk biochar (RHB) and lime with P fertilizer application rates could increase the availability of phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) of soil, and nutrient concentration and uptake of maize yield. A glasshouse pot experiment was conducted of eleven treatments with two rates of rice husk biochar (RHB) (10 and 15 t ha-1), two rates of lime (100% and 75%) with three rates of P fertilizer (100%, 75%, and 50%). The result revealed that the combined application of RHB, lime, and phosphorus fertilizer significantly increased soil pH, nutrient availability compared to the control, at the same time increasing nutrient uptake by maize. Compared to the unamended treatment, the highest soil pH increased by 36.75%, and the maximum available P increased by 158.75%. The maximal K uptake, 1934.39 mg plant-1 revealed from T6 (75% lime + 10 t ha-1 RHB + 100% TSP) and the maximum P uptake from maize, 250.98 mg plant-1 showed from T10 (75% lime + 15 t ha-1 RHB + 75% TSP).

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P-776

Effect of biochar on the hydraulic functions of a sand and sandy loam soil

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There is an increasing need to look for sustainable farming practices aimed to water and soil conservation. Biochar amendment has the potential for improving water conservation and soil biochemical, physical, i.e. mechanical and hydraulic characteristics. There are an extended number of variables influencing its impact that require further measurements. This study aimed to determine the effect of wood-based biochar on two different textured soils and to evaluate their influence on some hydrological properties: water retention, shrinkage behavior and the effect of wetting and drying periods on the hydraulic conductivity. Test samples were prepared by adding 2.5 and 5% (by dry mass) of pyrolyzed mango-wood biochar to a sand and a sandy loam. Soil water retention and soil shrinkage curves were measured. Additionally, extra core samples were exposed to four intense cycles of wetting and drying, by drying the samples at 30 °C for three consecutive days. Biochar amendments increased water retention in the coarse textured sand compared to the unamended soil. Pore size distribution was significantly altered in the sandy substrate, reducing the fraction of wide coarse pores and increasing meso porosity. Repeated wetting and drying cycles enhanced the structural stability of the pore system increasing the saturated hydraulic con ductivity. Soil rigidity, especially in the sandy mixtures, was enhanced by the addition of biochar, forming an internal pore structure able to resist better hydraulic deformation due to drying. These results confirm the suitability of biochar to overcome extreme hydrological conditions.

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P-777

Effect of sewage sludge stabilized with clay minerals and biochar on soil properties and Lolium perenne L. growth

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Dewatered sewage sludge treated with bentonite, vermiculite and biochar as well as limed and air-dried sewage sludge were evaluated as soil amendments for Lolium perenne L. (ryegrass) growth. All materials were added to two soils (one acid and one alkaline) at rates 0 (control) and 2% (treatments). Inorganic fertilization treatment was also included. Then, ryegrass plants were grown in treated soils in pots and three harvests of the aboveground biomass were conducted. Soil organic C and total N significantly increased at all treatments in comparison to control; the highest organic C content was obtained with the biochar-treated sludge. All treatments significantly improved the fertility of both soils compared to control; however, the lowest soil available N concentrations were observed with the biochar-treated sludge. For both soils, electrical conductivity increased above 2 dSm-1 (limit of salinity hazard for sensitive crops), only at the air-dried sludge treatments. Cumulative plant yield of all treatments increased compared to control and it was 194-313% and 172-217% higher, for the acid and alkaline soil, respectively. The same stands for cumulative nutrients' uptake. Apart from Cu and Zn, which are essential micronutrients for plants, the rest of the heavy metals, that regulate the agronomic use of sewage sludge according to law, were not-detectable in ryegrass's biomass. In conclusion, soil application of sewage sludge treated with the specific clay minerals and biochar can improve soil properties and plant yield. Moreover, possible adverse effects, i.e. salinity risk, could be alleviated.
Keywords: Biochar, clay minerals, sewage sludge, soil fertility, ryegrass
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P-778

Evaluation of Biochar Application to Crop yield and Soil Carbon Sequestration in Taiwan

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Biochar is an alkaline and carbon-rich material with improved soil structure and high carbon sequestration potential. It can retain carbon in soil at least 100 years to increase soil organic carbon (SOC) and also improve crop growth by increasing pH, maintaining water and nutrients in soil. This study aims to assess the effect of biochar application on yield of Brassica chinensis and the soil carbon sequestration in Taiwan. According to the pot study of 38 kinds of biochar by 6 agricultural research and extension stations, applying 2% biochar in acid soil could increase 5-23% of Brassica chinensis yield. The field experiments reveal the similar results. However, applying biochar in alkaline soil, yield will be decreased. The total area of strong acid soil (pH<5.5) in Taiwan is about 300,000 ha. The soil carbon sequestration is expected to increase about 4.2 million Mg if 2% biochar applied in all of the strong acid soil. The soil carbon sequestration can increase about 0.1 ‰ per year if 2% biochar applied on 2000 ha farmland per year. In addition to crop yields and soil carbon sink benefits, the application of biochar could also reduce soil greenhouse gas emissions in some condition.

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P-779

Evaluation of sewage sludge treated with clay minerals and biochar as soil amendment for Trifolium repens L.

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Dewatered sewage sludge stabilized with bentonite, vermiculite and biochar were evaluated as soil amendments for Trifolium repens L. in comparison to limed and air-dried sewage sludge. The materials were added to two soils (acid and alkaline) at rates 0 (control) and 2% (treatments) and inorganic fertilization was also included as additional treatment. Trifolium plants were grown in treated-soils, in pots and aboveground biomass was harvested once. Soil electrical conductivity increased at all treatments of both soils compared to control, without exceeding the limit value (for salinity hazard for sensitive crops) of 2 dSm-1, except for the air-dried sludge treatments. Soil organic C, total N and available N-P-K significantly increased at all treatments of both soils compared to control. The highest organic C content was obtained for the biochar-stabilized sludge treatments. From the soil micronutrients, Zn concentrations of all sludge treatments were several times higher than control, especially in the case of air-dried sludge (up to 10 times). Trifolium aboveground biomass yield and macronutrients' uptake significantly increased at all treatments of the alkaline soil compared to control, whereas at the acid soil significant increases were observed only for treatments with the sludge stabilized with clay minerals and biochar and the air-dried sludge. Therefore, soil application of sewage sludge stabilized with bentonite, vermiculite and biochar can increase soil organic matter (especially in the latter case), improve soil fertility and enhance plant yield. However, caution is needed in respect to possible soil salinity risk.
Keywords: Biochar, clay minerals, sewage sludge, soil fertility, trifolium

Samara, E., Matsi, T., Zdragas, A. (2019). Use of clay minerals for sewage sludge stabilization and a preliminary assessment of the treated sludge's fertilization capacity. Environmental Science and Pollution Research, 26:35387-35398. doi.org/10.1007/s11356-019-05132-y

P-77A

Measuring soil carbon in highly variable grazing systems using flux towers

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Soil carbon sequestration in grazing lands has been touted as having significant potential for achieving MLA's goal of carbon neutrality by 2030. A major constraints for demonstrating this potential is the high cost of validating incremental changes in stocks under different management in landscapes with high soil and vegetation variability. This study tested eddy covariance "flux" towers, capable of monitoring highly sensitive changes in carbon sequestration and emissions at a landscape scale near Goondiwindi, southern Queensland. Preliminary results confirm the potential for flux towers to provide accurate and cost-effective estimates in changes in the carbon and water cycles that traditional soil sampling could not pick up. Following the first rainfall in mid-January 2020, daily Net Ecosystem Exchange showed the soil was initially a short-term net source of carbon, with a net total of 230 kg C ha-1 was lost during this two-week period before the paddock became a net sink. Maximum growth rates of 150 kg C day-1 were obtained around 20 February 2020, before soil moisture once again became limiting and growth rates were reduced. Over the ~6 month measurement period the pastures were a net sink of CO2, with cumulative carbon sequestration in the soil and biomass >4 t ha-1. While the relatively high upfront costs of flux towers limit their widespread deployment for verification of sequestration mechanisms, additional inputs to allow upscaling from remote sensing and biogeochemical process modelling could potentially see flux towers becoming an essential tool in validating soil carbon sequestration methodologies and offsets.
NA

P-780

The Soil Health Concept Through Time

Dr Eric Brevik

Soil health has been popular over the last two to three decades, but the earliest references to soil health actually date to over 100 years ago. Fields including soil science, agronomy, forestry, and the medical profession contributed to the development of the soil health concept. The first definitive mention of soil health was in 1910, but soil health was not a frequent topic in the literature prior to the 1990s and discussion of soil health increased considerably in the 2000s. The original 1910 soil health referred to a concept that was based largely in soil fertility, but by the 1930s aspects of soil biology had been added and links between soil health and human health had been recognized. Pioneers of the organic agriculture movement such as Howard, Balfour, and Rodale were interested in soil health issues in the 1940s. Economic aspects of soil health were discussed by the 1970s and the need for benchmark data to track soil health changes over time was discussed in the 1980s. The 1990s saw considerable effort to develop a definition of soil health and debate over whether or not soil health and soil quality were synonymous. Indicators of soil health were investigated in the 2000s, and the Soil Health Division of the USDA Natural Resources Conservation Service was formed in 2014. Between 1910 and 2020 soil health has evolved into a concept that is widely utilized by scientists and farmers and has an integral place in the quest for sustainable soil and land management.

Brevik, E.C. 2019. A Brief History of the Soil Health Concept. The Profile. https://profile.soils.org/posts/field-and-historical-notes/a-brief-history-of-the-soil-health-concept.

P-781

On the origin and naming of soil science

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A scientific approach to the study of soil was started in the mid-1800s. Two lines of approach were followed: one that focused on the chemistry of the soil, and one that had strict geologic base that named themselves as agrology, agrogeology, and agropedology. It took about 50 years before ‘soil science’ became the overarching term for soil studies, and then to be recognized as a scientific discipline. The term ‘soil science’ gained usage from the early 1900s onwards, and initially it was equivalent to soil biological studies. It became common and more broadly used after the journal Soil Science was started in 1916 by Jacob Lipman, and when the International Society of Soil Science was established in Rome in 1924. For many years, the Bureau of Soils preferred ‘physical geography’ instead of soil science or pedology. In 1929, the American Soil Survey Association (predecessor of SSSA) passed a resolution to equate ‘soil science’ to ‘pedology’. But that did not happen, and this talk traces the history of the naming of our discipline.
Hartemink, AE 2021. Soil Science Americana - Chronicles and Progressions 1860 - 1960. Springer, Dordrecht

P-783

The Soil Scientist's Role in 21st Century Society

Dr. Thomas Sauer

Recent events have thrust the value and reliability of scientific knowledge into high profile social media and political discussions. To many scientists this development is perceived as a rapid onset of antiintellectualism while in fact hostility towards science has a long history. In this presentation I will provide an analysis on the sociology of science as it relates to current issues and the role soil scientists could or should have to play in solving societal problems. Hostility toward science results when research findings conflict with values held by individuals or institutions from which they derive a strong sense of satisfaction. Another potential source of hostility results when rapid technological development leads to economic injustice. In both examples, scientists and their discoveries can be portrayed as arbitrary and fickle with negative consequences for those whose views are in opposition. Scientists, meanwhile, often have a large emotional investment in their way of life and struggle to understand how the non-scientist community fails to recognize the value of their profession and its discoveries. While scientists view their own skepticism as a virtue, they do not view societal doubts of science positively. It is important to accept that no research is conducted in a social vacuum, and research findings should not automatically be assumed to be beneficial to society. Soil scientists can benefit from an understanding and awareness of public skepticism toward science and adjust their interactions to achieve a more effective result.

Merton, R. K. (1938). Science and the social order. Philosophy of Science, (5), 321-37.

P-784

Cursed Soil? Genesis 3.17
Fossil evidence for the clay-life hypothesis by Glasgow scientist A.G. Cairns-Smith?

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Cairns-Smith (1982) proposed ‘primary organisms’ about which Robert Shapiro (1986) wrote: “… Mineral beings … would live at first in stable, protected environments, below the ground or near the bottom of the sea. Only later would they spread to more variable locations, close to the surface, they would be rooted in their location, like plants rather than animals in this respect.”
Could it be possible that one of such locations was represented by the Garden of Eden (earthly paradise) or the Norse Midgard where respectively the Tree of Knowledge and Yggdrasill had their place as symbol for the 'Other World', both entwined – almost embodied – by that (old earth) snake-like creature; the eorðdraca in Beowulf.
Can you imagine similar entities as described in microbiology (e.g. social bacteria/amoebae), but expressed in a vaster design? Cairns-Smith (1986): “On what scale though? The apparatus that I am trying to imagine would have been built on a somewhat larger scale than the machinery that is so important in our cells now. This is partly because clay crystals on the whole are a couple of orders of magnitude bigger than protein molecules with, I think, a much lower information capacity.”
Would you like to join me in this case as a scientist and detective to disentangle some curious phenomena in relatively recent geological deposits, containing objects, loamy in origin, with enigmatic morphologies? Due to later diagenetical Fe-enrichment, they constituted an eagerly prospected ore, for the medieval production of wrought iron (Moerman, 1957).

Cairns-Smith, A.G. (1982) Genetic Takeover and the Mineral Origins of Life. Cambridge: Cambridge University Press.
Cairns-Smith, A.G. (1985) Seven Clues to the Origin of Life: A Scientific Detective Story. Cambridge: Cambridge University Press.
Cairns-Smith, A.G. (1986) Clay Minerals and the Origin of Life. Cambridge: Cambridge University Press.
Moerman, J.D. (1957) Oude Smeedijzerindustrie Deel I, IJzerkuilen en klapperstenen. Bijdragen en Mededelingen Gelre 56:3-32.
Shapiro, R. (1986) Origins: A Skeptic's Guide to the Creation of Life on Earth. London: Penguin Books.

P-785

PromoSolsEduc: a tool for identification and valuation of educational resources on soil knowledge and preservation

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The french branch of the International Union of Soil Science, the 'Association Française pour l'Étude du Sol' (AFES) is a national society which aims to share knowledge about soils in order to contribute to the protection of this crucial resource. Among the various activities undertaken by AFES, the PromoSolsEduc project gathers and shares teaching material to improve soil education.

The PromoSolsEduc project brings together a community of more than 80 scientists and teachers involved in the development of good practices in soil science education, through a network where they can discuss their experience, exchange on difficulties encountered and share solutions. This initiative is based on a multidisciplinary working group comprising members of AFES Board, soil researchers and engineers from various structures, teachers and soil education specialists.

The first step was to compile, but also to evaluate existing resources (books, videos, web sites…) and to develop a search engine on the AFES's website, allowing easier access to this material. In a second phase, a survey was conducted among education institutions, showing the great diversity of teachers engaged in the transfer of knowledge in soils sciences. Furthermore, this investigation revealed the specific needs of teachers, such as scientific support in order to access more efficiently complete and reliable teaching materials. This works led to a dynamic mapping of the key resource people in soil education. A new step has recently been reached with an interactive workshop where teachers pointed out difficulties, helping the AFES Board to plan future improvements of its website.

Arrouays, D., Richer-de-Forges, A. C., Baize, D., Rossignol, J. P., Chevallier, T. & Héliès, F. (2019). Numéro spécial « Communiquer et sensibiliser le grand public aux sols ». Etude et Gestion des Sols, 26, 288 p.

P-786

A trip through the soil to raise public awareness

Dr Delphine Aran, Dr Florence Maunoury-Danger

Created specifically for the International Year of Soil, a pedagogical project focused on soil has been developed by the University of Lorraine, and since regularly renewed. The aim of this project is to elaborate an educational activity about soils, through observations and experiments designed for a young audience and for a general public.

Therefore, the authors and students from bachelor and master levels have jointly developed this activity and make it evolve every year. Students had thus the opportunity i) to practice and improve their knowledge about soil sciences, and ii) to debate about teaching methods and sharing their knowledge with different people (public, schoolchildren). This kind of active learning is regarded as one of the effective educational methods (Field et al., 2011).

This educational activity has been built as a trip to explore different aspects of soils. Students drive pupils from primary school toward different stands where they can observe soil biodiversity, experiment on soil composition, learn about soil properties and functions (soil retention, biodegradation…). The session end with a discussion on some of the essential services provided by soils and their protection.

For the general public session, people are free to switch from one stand to another, while students and authors answers to their questions and initiate debates. Since a few years, a special activity is proposed in relation with the World Soil Day theme. This project is a good opportunity to promote the role of soil to a large audience, from children to students and general public.

Field, D. J., Koppi, A. J., Jarrett, L. E., Abbott, L. K., Cattle, S. R., Grant, C. D., McBratney, A. B., Menzies, N. W., & Weatherley, A. J. (2011). Soil science teaching principles. Geoderma, 167, 9-14.

P-787

Soil threats in education. The evaluation of students' sustainability awareness.

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[1]*Nicolaus Copernicus University In Torun, Torun, Poland*

Teaching basics of soil science as a part of geography creates an opportunity for transfer a knowledge about environmental problems and ways of solving them. However, proper education in this field is needed for present and future generations. People are not aware of the threats to soils. School textbooks, similarly to the media, provide far too little information, or in an insufficiently attractive way.
This study aims at analyzing the soil sustainability concepts in teaching geography, indicating the difficulties in teaching soil science content within geography and making the people aware of soils threats along with other environmental threats.
The data come from survey for teachers and high-school students. Respondents from Czech Republic, Hungary, Poland, Romania, Turkey, and UK indicated strengths and weaknesses of selected geographical concepts. The level of difficulty (Difficulty Index) of each part is different for students. Soils and biosphere is one of the most difficult and the least attractive part for students. The research clearly shows that students are not enough aware of problems related to the soil cover. There are significant differences between the level of students' knowledge about threats related to Soil and biosphere and others. However, soil threats: soil depletion, soil erosion or desertification are equally or even more dangerous for human being. Soil scientists, teachers and authors of the core curricula as well as media should be involved in increasing public awareness of soils, their role in the environment and the threats posed by unsustainable development in the field of soil management.

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P-788

Nationwide study of soil life by citizen science in Hungary

Dr Péter László[1], Zsófia Adrienn Kovács[1], Tünde Takáts[1], Dr Mátyás Árvai[1]
[1]*Institute For Soil Sciences, Centre For Agricultural Research, Budapest, Hungary*

Citizen science is a form of research that has been around for decades, in which researchers ask the public for help with a research project. In our country, astronomical, botanical or even bird-watching programmes have been running successfully for many years, but no citizen science programme has yet been launched in soil research. Several years ago, the Canadian Department of Agriculture started the "soil your undies" program to raise public awareness of soil health. Since then, many US states and many European countries have adopted the initiative, where farmers can test their soils with a simple test. The "Life in the Undies" campaign was launched by Institute for Soil Sciences, in Hungary. In the campaign public were given a cotton underwear to bury in a hole about 20 cm deep, providing "food" cellulose for soil-dwelling organisms. After more than two months of digging out the underwear, decomposition signs can be observed, which is an indicator of soil life activity and, indirectly, of soil health. The excavated undies were photographed by volunteer researchers and then the digital image of them was returned to us via a Google Forms questionnaire along with information about the land use and soil management. By analysing digital photographs of the remaining underwear, the work of soil-dwelling organisms can be estimated. With the help of social media calls and targeted group advertisements, about 1193 people applied for the programme nationwide, with a total of 1966 sites, giving the research a nationwide coverage.

László Pásztor, Gábor Szatmári, Annamária Laborczi, János Mészáros, Tünde Takáts, Zsófia Kovács, Mátyás Árvai, Péter László, Sándor Koós, András Benő
Application of information originating from spatially non-exhaustive ancillary observations in digital soil mapping
GEOPHYSICAL RESEARCH ABSTRACTS 23 Paper: 5116 (2021)

P-789

A global network of soil museums to promote soil education and knowledge

Mr Stephan Mantel, Ms Emily Toner, Ms Mariana Amato, Ms Yulya Timofeeva, Ms Mai Shalaby, Ms Ryma Affani, Mr Marcos Bacis Ceddia, Mr Fabrício de Araújo Pedron, Erika Flávia Machado Pinheiro

A significant amount of museums, exhibits and educational centers are dedicated to soils or education about soils in their exhibit or program. Richer-de-Forges et al (2020) made a review of soil museums and exhibitions around the world. Authors from that paper initiated a network of soil museums, as was also proposed at the WCSS in Rio (Mantel, 2018). The purpose of the network is to promote soil knowledge, educate about soil diversity and functions, and explain soil's interface with human activity. This network strengthens connections between entities for whom soil education is a primary goal and cultivates the possibility for cooperation. It aims to increase opportunities for collaboration and connections between soil collections, museums and education centres worldwide. This will be achieved through workshops and symposia, the exchange of tools and methods and new ideas around topics of shared professional interest such as collection management, exhibit design and education program development. The network will further organize joint awareness campaigns, exhibitions and education programs and develop and implement joint research programs and projects. The Global Soil Museum Network operates with a website and will be guided by a management board. Membership will be established through a cooperation agreement between individual members and the network. Online events have been organized on World Soil Day (2020 and 2021). While the formal status of the network is further established, activities continue and provide a basis for the support for and expansion of soil education and advocacy in museums and centers.
Richer-de-Forges, A. C., et al. (2021). Chapter Five - A review of the world's soil museums and exhibitions. Advances in Agronomy. D. L. Sparks, Academic Press. 166: 277-304.

Mantel, 2019. A global network for a virtual world soils exhibition: a new approach to education and advocacy on soils. In: 21WCSS: Proceedings of the 21st World Congress of Soil Science; 2018. August 12-17; Rio de Janeiro, Brazil: SBCS. Vol. I, p 223.

P-78A

Options for soil carbon sequestration in northern Australian grazing lands

Dr David Rowlings[1], Dr Elaine Mitchell[1], Dr Peter Grace[1]
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Increasing soil carbon through improved grazing management practices is intimately linked to increasing soil health, drought resilience and the sustainability and profitability of northern Australia's pastoral industry. Soil organic carbon (SOC) sequestration in grazing lands has also been identified as having significant potential for achieving the livestock industry's goal of carbon neutrality by 2030. A major constraint for demonstrating this potential is the uncertainty around the best management options for increasing SOC stocks. Two options that have gained interest within the industry are deep rooted perennial legumes, and regenerative grazing. This project used a paired-sites approach to look at the soil sequestration potential of these management options across the clay-rich soils in the 600-1000 mm rainfall zone of Queensland and New South Wales. Over 40 sites were sampled (n= 24) down to 1 m, each with a "conventionally managed" control and a treatment paddock consisting of a known >5-year history of either the legume Desmanthus or time-controlled grazing. Samples were analysed for SOC, nitrogen and core soil parameters to ensure background soil texture and minerology of the pairs were comparable. Preliminary results demonstrate the extremely high spatial variability of soil carbon in grazing landscapes and the difficulties in certifying SOC changes even following long-term management changes. The results will help drive uptake of sustainable grazing management across the 49 M ha of clay-rich soils in Eastern tropics of Australia and underpin the industries aim to become carbon neutral.
NA
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P-790

The complex world of soils condensed into practical tools for farmers

Msc Julia Miloczki, DI Günther Aust, DI Dr. Michael Englisch, DI Rainer Reiter, Dr. Andreas Bohner, Dipl.-Ing. Dr. Sigrid Schwarz, DI David Keßler, Dr. Andreas Baumgarten

Soil managers must meet numerous demands between the priorities of food production, sustainability, science and practice (FAO, 2017; Opdam, 2018). With the aim of increasing the scarce understanding of soil as a resource among those who decide on its condition through their actions, hands-on tools – soil field guides and soil discs - were developed for agricultural practice in Austria.

The new soil field guides for arable land and grassland enable a simple determination of soil types and their properties, contain basics of soil science and provide concrete management recommendations adapted to the capacities of the site.

The soil discs aim to assess and avoid selected soil risks (e.g. compaction, erosion). Based on the local soil and management parameters, an analogue colour system estimates the risks and offers management options for melioration. Since digitalisation is a key focus in the new common agricultural policy (CAP), these products are also offered as an informative and educational mobile app.

In order to ensure the practical relevance and applicability of the tools, three co-creation workshops were held in the project, in which the tools were tested and optimised based on the participants' feedback. The tools can be used by farmers in the field and integrated by teachers, advisors and other multipliers into existing and new in-service trainings, workshops and school education. Thus, a teaching module for the "farmers of the future" - the students of agricultural schools - was created to consolidate the understanding of soils' facets in the next generation.

FAO (2017). Voluntary Guidelines for Sustainable Soil Management Food and Agriculture Organization of the United Nations Rome, Italy.

Opdam, P. (2018). Exploring the role of science in sustainable landscape management. An introduction to the special issue. Sustainability 2018, 10, 331.

P-791

Paulo Freire´s pedagogy applied to Soil Education

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Soil education has its roots in the fields of soil science and education. In general, it has developed within the soil scientist's community, where teaching and research on the field has been challenged by principles and proceedings of human and social sciences. We have experienced to do it based on the pedagogics proposed by Paulo Freire, a well-known Brazilian educator. Its basic assumption is that before reading words, anyone reads the world by experiences and informal learning from the reality each one lives in. So, the departure point to any effective learning needs to start from each one´s reality, using meaningful references. Since soil is usually familiar to people, educate about soils can be developed based on such experiential situations creating a significant connection between the basic knowledge on soils and the experience each one brings. If not directly, as it happens with people connected with soils, it works indirectly with strictly urban people by approaching food, water, pharmaceuticals and its provenance. A set of strategies developed for soil education under Freire´s principles and its application and results will be presented.
none

P-792

An education break out in Soil classification subjects, a gamification tool to improve motivation and knowledge

Phd Héctor Moreno-Ramón, PhD Sara Ibañez-Asensio

Motivation and knowledge are two key aspects in the student's learning process, and must be promoted by the lecturers because it improves their skills. Active methodologies with information and communication technologies can favour the subject-student connection. Gamification is one of the methodologies that are being used more recently in the educational field, being widely applied at basic levels of education. In higher education, it seems that playing is not very appropriate and therefore, although there are developed experiences, they are less common. In soil science for example, soil taxonomy is quite dense to study due to the rigidity of the diagnostic criteria, epipedions and endopedions, which must be previously known to later classify the soils. That is why an educational break out has been proposed in front of a dense, tedious and monotonous theoretical class. The gamification has been applied in a Master's Degree in Health and Vegetable Production within the subject of Intensification in soil technology. Students have made an educational break out defined in the Lessons tool (Sakai platform) on the educational digital platform of the Polytechnic University of Valencia. Flip teaching, Crosswords, educational videos and encrypted questions have been prepared for students to recognize and work in a relaxed way on soil diagnostic criteria for their subsequent classification. As main results, it should be noted that the break out motivated more than 80% of the students, classifying it as suitable for higher education level. It also facilitated their learning in a more enjoyable way.

Clarke, S. J., Peel, D. J., Arnab, S., Morini, L., Keegan, H., & Wood, O. (2017). EscapED: A Framework for Creating Educational Escape Rooms and Interactive Games to For Higher/Further Education. International Journal of Serious Games, 4(3). https://doi.org/10.17083/ijsg.v4i3.180
Long, T., Cummins, J. & Waugh, M. (2017) Use of the flipped classroom instructional model in higher education: instructors' perspectives. J Comput High Educ 29, 179–200. https://doi.org/10.1007/s12528-016-9119-8
O'Brien K, Pitera J. (2019) Gamifying Instruction and Engaging Students With Breakout EDU. Journal of Educational Technology Systems 48(2):192-212. doi:10.1177/0047239519877165
Subhash, S., Cudney, E.A. (2018) Gamified learning in higher education: A systematic review of the literature, Computers in Human Behavior, Volume 87, Pages 192-206, https://doi.org/10.1016/j.chb.2018.05.028.
Vlachopoulos, D., Makri, A. (2017) The effect of games and simulations on higher education: a systematic literature review. Int J Educ Technol High Educ 14, 22. https://doi.org/10.1186/s41239-017-0062-1

P-793

University campuses as living laboratories for teaching about sustainable soil management

Dr Miranda Prendergast-Miller[1], Dr Helen Glanville[2], Dr Andrew Suggitt[1], Prof Zoe Robinson[2]
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Living laboratories are increasingly used on university campuses to support pedagogic learning and engagement across university communities to support and drive sustainable management practices (Gomez and Derr, 2021). This research project seeks to explore the links between soil quality across different habitats on university campuses. We want to understand the perceived value students place on soils and sustainability and how soil quality can be used in campus management plans. Undergraduate university students at levels 2 and 3 were selected from Geography and Environmental Science departments at Northumbria and Keele Universities. Students enrolled on modules ‘Ecosystems Processes in the Anthropocene’ and ‘The Science of Soil’ at Northumbria and Keele respectively were asked to take part in an online survey at the end of teaching on their modules. Both cohorts had an assignment where soils from different habitats on their respective campuses were sampled for soil physical, chemical and biological properties. As part of their assessments, students conducted lab analyses and had to produce a final report assessing soil quality in different habitats. However, while Keele is a campus-based university with access to its own extensive green space, Northumbria is a city-based campus within Newcastle, where the range of habitats is relatively limited compared to Keele. Here we present results from the survey and explore student reflections on their attitudes towards soil and teaching content on soil, and whether they valued their university campuses as ‘living laboratories’ where soil quality and campus habitat management unknowingly intersect in university sustainability agendas.

Gomez, T., and Derr, V. (2021). Landscapes as Living Laboratories for Sustainable Campus Planning and Stewardship: A Scoping Review of Approaches and Practices." Landscape and Urban Planning 216: 104259.

P-794

Geosciences in Secondary Education Structure in Catalonia (Spain) from the teachers' point of view

PhD Núria Roca, PhD Pura Alfonso, PhD Telm Bover-Arnal, PhD Antoni M Calafat, PhD Teresa Calvet-Pallas, PhD Xavier Delclòs, PhD Maite Garcia-Valles, PhD Marta Guinau, PhD Elisabet Playà-Pous, PhD Martín Ríos

The teaching of geoscience is crucial in the training of future professionals. Experts of geosciences have a very important role to play as the exploration and exploitation of natural resources, environmental impacts, geological hazards and climate change. Furthermore, the knowledge of our planet made easier that people be more friendly with the environment. However, a low level of geoscience knowledge affects the majority of citizens, who may complete their secondary studies without having learned the basic geological concepts. The main objective of this research is to analyze the current work, perception, and the knowledge of Geoscience among the secondary teachers. A survey for Secondary school teachers was used to collect the information. A total of 408 teachers participated in the experience, including 385 of public schools (94.4%) and 259 from compulsory secondary education (63.5%). Secondary teachers highlight by a good perception of their geology level (3.5 out of 5), including teachers trained in the field of biosciences (3.3 out of 5) with a great confidence (3.6 out of 5). In southern Europe and most Latin American countries, biology and geology are the two science disciplines that must share teaching time. The 85% of teachers consider that it is necessary to develop the learning of both sciences. However, there are significant differences in the number de lessons taught in the last year of obligatory studies between geologist teachers (4 lessons) and biologist teachers (2.9). It is necessary to take actions to increase the learning of geology in secondary school.
Roca, N., & Garcia-Valles, M. (2020). Trainee Teacher Experience in Geoscience Education: Can We Do Better?. Geoheritage, 12(4), 1-15.
Guinau, M., Playà, M.; Aulinas, M., Rosell, L., Rivero, Ll. (2017). Improving transversal competences by using wikis in collaborative work. Journal of Technology and Science Education, vol. 7(2): 172-183.
Playà, E., Guinau, M., Aulinas, M., Rosell, L., Rivero, Ll. (2016). Millora de competències transversals mitjançant el treball col·laboratiu amb wikis. CIDUI 2016. ISSN: 2385-6203.

P-795

Strategies for adapting soil science to information and communication technologies (ITC)

PhD Núria Roca, PhD Susana Mangas

Soil science cannot be effectively taught following generic teaching principles because the unique nature of the subject matter requires special teaching techniques and learning experiences. There are several problems that make the transference of knowledge on soil more difficult. One of them is the difficulty in identifying soil properties. New learning strategies could contribute to create powerful and effective learning environments. One of these is a QR code (abbreviated from Quick Response code). A major benefit of the use of active methodologies is that they help students to develope their own capacity in the research field, to undertake responsibility for their own learning process and to solve problems with their own resources.

The objective of this paper is to present a strategy for active learning based on simples visual and tactile observations taken in the lab, with the aim to arouse interest in students about soil value. The methodology proposed includes an undisturbed soil sampling and information panels in the form of QR codes. These QR codes give clues and additional information to solve the proposed problem. This methodology provide a multifaceted learning through traditionals soil observations combined with information and communications technology (ICT). Simulated field conditions combined with undisturbed soil sampling realized in a real context could be particularly beneficial for learning instead of more traditional passive methodologies (lectures o demonstrations). After this exercise, students should be able to identify characteristics and processes involved in soil formation.

Roca, N., & Ríos, M. (2019). Soil classification maps: A valuable tool for learning, interpreting and transferring soil knowledge. Catena, 180, 103-109.

P-796

Engaging Growers in Soil Health by 'Soiling their Undies'

Dr. Linda Schott

Agricultural crop and livestock producers depend on affordable access to clean water, healthy and productive soils, and quality grazing land to remain profitable. However, the ‘soil health movement’ has been slow to reach areas outside of the Midwest in the US. Consequently, agricultural producers have been left wondering how their management practices impact soil health and productivity. Thus, the overall goal of this project was to assess ways to engage growers in the soil health programming in order to increase adoption rates. In collaboration between ten conservation districts, growers, USDA NRCS, USDA ARS and university extension personnel, a total of 31 production fields and 64 replicated plots had cotton underwear 'planted' in them in the summer of 2019 across Southern Idaho. Fields and plots represented a wide range of crops, management practices, and soil textures. The basis of the “Soil Your Undies” initiative was for growers and their advisors to evaluate their soil health by burying and assessing decomposition of 100% cotton underwear in paired fields. This project not only helped to elucidate a soil health measurement metric that was both indicative of soil functioning and sensitive to management changes but also empowered growers to monitor their progress toward healthier soil in a cost effective manner.
None

P-797

Augmented Reality (RA) to the creation of hybrid maps applied in soil sciences: A study case in Ixmiquilpan Hidalgo, Mexico

Fernando Ayala, Augmented reality (RA) to the creation of hybrid maps applied in soil sciences: A study case in Ixmiquilpan Hidalgo, Mexicomented reality (AR) to create hybrid maps in soil sciences José, M. Cortés-Caballero, Augmented reality (RA) to the creation of hybrid maps applied in soil sciences: A study case in Ixmiquilpan Hidalgo, MexicoApplication of augmented reality (AR) to create hybrid maps in soil sciences Ángel, A. Pérez-Martínez, Augmented reality (RA) to the creation of hybrid maps applied in soil sciences: A study case in Ixmiquilpan Hidalgo, Mexico Francisco López-Galindo, Augmented reality (RA) to the creation of hybrid maps applied in soil sciences: A study case in Ixmiquilpan Hidalgo, Mexico Diego, A. Fabila-Bustos, Augmented reality (RA) to the creation of hybrid maps applied in soil sciences: A study case in Ixmiquilpan Hidalgo, Mexico Macaria Hernández-Chávez

Aumgented reality applications become to be increasingly relevant due to their ability to present virtual information using technological devices creating interactive and innovative learning environments. In the case of soil science, it has the potential to create learning tools for students who seek to develop thei raptitudes and analytical skills, accesing interactive and immersive contento on landforms, topography, digital elevation models, as well as the possibility of display specialized information from particular training sites. Despite the fact that cartography is one of the oldest sciences, the development of hybrid maps using digital tools is a recent reality. In the present study, the database of edaphological profiles of the Ixmilquilpan, Hidalgo, Mexico area with a coverage of more than 70 thousand hectares was used to develop an augmented reality application for Android mobile devices, which includes information on more than 20 sites of interest. Layers of topographic information, altitude, satellite images, as well as 3D models of the soil profiles were included along with their physical-chemical information. The present proposal aims to establish an interactive learning strategy designed for users interested in the interpretation of edaphic profiles through a prototype system based on the augmented reality approach in soil sciences.
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P-798

Promotion of Farmers' Soil Education using Soil Profiles Investigations and Soil Health Tools for Sustainable Soil Management

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Soil scientists of Taiwan have expanded soil educations not only for university students, but also for primary and senior high school students and farmers since 2015. The objectives of three efforts to teach farmers are how soil profile characteristics influenced plant root growth and techniques to improve the effective soil management practices. The first and third cases were on the platform of "Farmer Academy" set up in National research institute and District agricultural extension stations. First author selected representative soil series of different districts to explain the "soil morphology characteristics" related to roots growth, soil structure, organic matter content, root respiration, drainage, water retention and fluctuation of groundwater level, shown by a standard soil profile (1.5m x 1.5m x 1.2m depth). The third author focused on "integrated soil health assessment and management", including methods to determine soil chemical, physical and biological indicators; identifications of the soil health levels and practices to manage the soils' health. A soil profile (30cm x 30cm x 30cm depth) was used to check root growth, soil structure, drainage, hard pan, and earth worm numbers. The second author focused on how to identify the soil constraints and improve soil health management in organic farming, using a soil profile (60 cm x 60 cm x 60 cm depth), which was cooperated with "Tse-Xin Organic Agriculture Foundation". The farmer students were very impressive by the soil profile investigations and soil management knowledge. A group was set up in "Line.app" after courses, and some consultative interactions will be provided.

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P-799

The soil in the school context of basic education in Brazil.

Dr. Deborah de Oliveira

In Brazilian basic education, the soil is studied in the subjects as Science, Geography and Biology. The document called Common National Curriculum Base does not treat the soil with the scope it deserves, so that the student can get to know the soil, understand its importance and help to preserve it from degradation.
We take as a starting point the soil functions established by the FAO, which illustrates well the complexity of the importance of the soil, which is often unknown by students and often even by teachers. In Brazil, only the functions are more publicized: Provision of food, fibre and fuel, Provision of construction materials and Foundation for human infrastructure. The following ground functions are simply ignored or barely mentioned by our Common National Curriculum Base: Carbon sequestration, Water purification and soil contaminant reduction, Climate regulation, Nutrient cycling, Habitat for organisms, Flood regulation, Source of pharmaceuticals and genetic resources and Cultural heritage.
In this sense, we analyzed what the Common National Curriculum Base proposes for the study of soil and what should be taught so that the student has a complete understanding of soil functions.
Furthermore, we believe that all K-12 teachers can teach about the soil to their students, not just Science, Geography and Biology teachers.
We believe that while the entire school community is not involved in the issue of soil, we will not succeed in educating our children and young people to respect the soil as a mainstay of life on Earth.
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P-800

Loess soil seen from a new perspective – awareness for the Soil of the Year 2021

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Soils and their ecosystem functions shall be made aware to as many people as possible in order to promote a responsible use and hence protection of this essential resource. For this purpose, in Germany the soil of the year has been selected and presented by the Advisory board Soil of the Year since 2005. In 2021, the choice fell to the loess soil – one of the most productive soils of the world.
With several activities, the Federal Institute for Geosciences and Natural Resources (BGR) promotes specific features and thus the importance of loess soil for humans and the environment. On the World Soil Day 2020, BGR hosted an event to present loess soil as the soil of the year 2021 to the public. Probably the most striking public outreach is achieved with a travelling exhibition showing comprehensive information on loess soil with different theme posters including genuine soil profiles. One highlight of the exhibition is a soil tunnel. Visitors can walk through the tunnel to experience loess soil from a new perspective with optic, acoustic and haptic features. In order to reach a wider audience, the loess soil exhibition is now also available as a virtual 360°-tour. Via mouse click or motion sensor of a mobile device the visitor navigates through the exhibition and experiences the three-dimensionality of objects, for example carbonate concretions within the soil profiles. This technique provides new insights into the soil. Various activities around the Soil of the Year offer great opportunities for soil education.
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P-801

Proposal to apply the concept of Knowledge, Learner focus, Practice, and Scholarship to realize an international guideline for soil education

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It is pointed out that the concept of four dimensions of Knowledge, Practice, Learner Focus, and Scholarship in education are important to guide the future soil science education (cited from Field et al. 2020). In the conference of the Japanese society of soil science and plant nutrition, the contents of four dimensions have been discussed to establish systematic soil education from pre- and elementary school level through high school level in harmony with the course of study in Japan (curriculum standard set by government).
As a result, the soil scientists recognized the importance of the concept of “perception – sensitization – be aware of – know of – know” based on four dimensions for establishing stepwise learning program in formal and/or informal way pre-empted by sensing soil under each cultural and/or environmental condition. If we could develop such learning program, attendees could know the uniqueness, roles, and functions of soil, resulting in understanding soil is indispensable for their life and society.

Finally, their attitude of active engagement with soil created by such understanding might lead to sustainable development in their surrounding region. If this trend would be widespread over the country, it would promote realization of SDGs in national and/or international society. Hence, soil education based on the said scheme would result in growing human resource to engage actively with sustainable development. We therefore proposed the improved concept of “Four dimensions → Understanding soil is indispensable for one’s life and society”. This would be an international guideline for soil education.

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P-802

What universal contents do we need for the international soil education guideline in preschool, primary school, and secondary school

Ms ケイコ モリ, Mr Hideaki Hirai, Ms Ikuko Akahane, Mr Mitsuru Toma, Ms Maki Asano, Mr Youki Asano, Mr Shokichi Wakabayashi

Despite the importance of soil in understanding the nature of the earth, soil education in school may not be currently enough in many countries. If we had standard and universal contents of soil education which can be arranged in each country considering various circumstances, it would be a torch for making education curriculum in countries where soil education is not yet comprehensive. Having curriculum which hardly include content of soil, we have searched universal contents of soil education in pre-school, primary, and secondary school, which then develop to high school and higher education.
At the pre-school stage, the influence of surrounding environment (e.g. urban or countryside) on learners is large. Ideally, learners naturally recognize or feel soil. However, at any circumstances, touching soil to recognize it as a part of nature, which is regarded as perception – sensitization step (Field et al., 2020), should be encouraged. In primary school, scientific knowledge would back up this step. Firstly, the nature of soil should be introduced. Secondly, most important soil functions should be included. We suggest including five functions; supply nutrients, provide place for decomposition and habitats for various organisms, play an important role in water circulation and gas exchange. In secondary school, soil should be dealt with in relation to ecosystems.
Field, D. J., Brevik, E., Hirai, H. (2020). Guiding the Future of Soil (Science) Education: informed by global experiences. In T. Kosaki, R. Lal, L. Bertha & R. Sanchez. (Eds.), Soil Sciences Education: Global Concepts and Teaching (pp.191-198). Catena Soil Science.

P-802A

Learning by doing is more memorable: soil judging as an educative tool

Dr Carol Margaret Smith, Dr Sam Carrick, mr Josh Nelson, Dr Josie Mazzetto, ms Veronica Penny, ms Judith Butel

Soil scientists are increasingly working in a multidisciplinary world where they interact with professionals from different disciplines and diverse end user groups. The ability to communicate, and to be an effective team player are just as important skills as the ability to apply practical field skills and describe soil profiles. The kinesthetic approach embodied in soil judging allows the student to also connect with pedological theory; and it is a pedagogically-aligned style of learning.
At Lincoln University we first adopted this innovative, experiential learning in 2016 to address these issues. Soil judging in New Zealand is in its infancy compared to other countries, but the undergraduate student soil science society and academic staff have been enthusiastic in practicing soil description skills and land use interpretation; participating in soil judging contests in New Zealand and Australia. Students report that they have become more confident in soil description and that it has stimulated their interest in learning about soil science. We designed a micro credential to recognize the academic work of the students. Several soil judging graduates have secured employment as pedologists with Crown Research Institutes. It can be an effective recruitment pipeline into the discipline: offering students with a practical and kinesthetic aptitude who perform well at soil judging an insight into the academic side of the soil science discipline. We posit that soil judging competitions are an effective framework for students to acquire a valuable range of practical, field-based skills for a professional career in soil science or allied enterprises.

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P-803

Ammonium Adsorption in Alpine Tundra Soil: Implications for Nutrient Loss and Acidification

Dr. Andrew Evans, Dr. Joshua McGrath

Nitrogen biogeochemistry in alpine tundra soils is complex due to simultaneous processes involving organic and inorganic N transformations. Reactive NH_4^+ is of interest, due to its ability to displace base cations and contribute to soil acidification. To examine NH_4^+ adsorptions impact on cation leaching in an alpine tundra soil, a series of batch equilibration and column leaching studies were conducted using NH_4^+ concentrations in the 0 – 40 mg L^{-1} range, adjusted to pH 4.5. Ammonium additions to the O/A1, A2, and Bw horizons, collected from a Humic Dystrocryepts, resulted in significantly higher Ca^{2+}, Mg^{2+}, and K^+ concentrations in solution, with base cation concentration increasing linearly with ammonium concentration. Ammonium adsorption was modelled using the Langmuir equation, with the NH_4^+ adsorption energies ranging from 19.1 – 23.9 KJ/mole, suggesting physical adsorption within each soil horizon. Column experiments, using both composite O/A1, A2, and Bw soil columns and intact soil cores, were eluted with a 20 mg L^{-1} NH_4^+ pH 4.5 solution. Elevated base cation concentrations were observed within the eluent wetting front for both composite and intact soil columns, with Ca^{2+}, Mg^{2+} and K^+ concentrations exceeding 20, 3, and 10 mg L^{-1}, respectively. Nonsymmetrical NH_4^+ breakthrough curves coupled with tailing cation elution curves suggest competitive adsorption between NH_4^+ and base cations for similar electrostatic adsorption sites. It is postulated that NH_4^+- base cation exchange is occurring at metal-water bridging sites within the soil organic matter coatings, and may contribute to a “cascade effect” resulting in accelerated nutrient loss.

Evans, A., & Jacobs, M. B. (2020;). Oxalate-fluoride anion exchange in alpine tundra soil: Impact on aluminium transport. European Journal of Soil Science, 72(3), 1219-1230. https://doi.org/10.1111/ejss.13020

P-803A

Biological Activity of Palsa Mire Soils In The North Western Siberia

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Peatlands comprise 19% of the permafrost area in the subarctic zone, they store 277 Pg of organic carbon(Tarnocai, 2009). Peatlands in that area are represented by palsa mire. The palsa mire consisted of frozen peat mounds (palsa), thermokarst depression and the wet bog without permafrost. The aim of this work is to study a biological activity soils of palsa mire ecosystem. The studies were carried out in 2018-2021 in the northern taiga zone, Western Siberia (65°18'52"N, 72°52'32"E).
We observed parameters of typical soils, represented by palsa(Cryic Histosol) and bog (Fibric Histosol). The active layer thickness in the soils of the palsa was 0.66±0.07 m, in the soils of the bog is absent. An average soil temperature of palsa was 8.31±0.45°C, soil moisture - 30.98±2.49%. Temperature and moisture in soil of bog increase 1.6-2.3 times in comparison with the palsa. The methane emission in bog was 30 times higher (15.3±16.17 mgCH4/m2/h) than in palsa. At the same time, the biological activity was not significantly different (182.50±13.21 mgCO2/m2/hour) due to the complex mechanism of redistribution of greenhouse gases over surface the permafrost.
The methanotrophic barrier plays a significant role, increasing the flux of CO2 dioxide from the surface of wetted areas of the bog. Thus, for palsa mire, climate change and degradation or aggradation of permafrost will not cause a significant change in biological activity.

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P-804

Micromorphological characteristics of Andean cryogenic deposits produced by landslides in Erizos valley, San Juan, Argentina

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Erizos valley in the Andes of San Juan (31.707149 ° S, 70.275189 ° W), Argentina, is covered by geoforms produced by catastrophic processes with different dynamics and genesis. The study area is surrounded by the Santa Cruz Mountain Range, which exceeds 4700 m asl., with a periglacial environment (>3700 m asl) and mountain permafrost in an unstable condition. A tongue-like landslide, which has already appeared in images since 1985, clearly comes from a root of the process located in the level with permafrost, verified through perennial snow patches and nearby rock glaciers. The distal part of the landslide shows a typical randomly distributed molard field. Along the landslide however, it is possible to detect aligned cones. The lithology in the studied profiles (at 3100 m appr.) are from the Late Cretaceous, which are conglomerates and red-purple sandstones. Angular gravels immersed in fine sand and silt predominate in the deposit. The residual cones result from the landslide erosion, apparently associated to the ice-dynamics, ice amount and freezing thickness. The 60 cm sedimentological cover of the profile is chaotic and disaggregated. Today the molards are thawed, dry and shrunken. The thin sections of the samples portray indicators of their past Andean tundra environment with freezing and ice through a meta-fragmoidic fabric, c/f= close porfiric, without organic indicators, broken lithics, sedimentary vesicles connected with irregular, curved planes of variable diameter, silt cappings, fine sediment rings around angular lithics indicating illuviation, conglomeric sectors of fine sediments and brown to blackish globules of iron hydroxides.
None

P-805

Sedimentology and dynamics of cryogenic soils in a rock glacier of the Central Andes (San Juan, Argentina)

Lic. Martín Mendoza López, Dr. Carla Tapia Baldis, Dr.rer.nat Dario Trombotto Liaudat, Dr. Darío Trombotto Liaudat

Cryosols in the Central Andes are the result of typical periglacial processes, which involve active frost weathering, sediment transport mechanisms and freeze-thaw processes that may produce either cryoturbation or sorting phenomena (e.g., reverse gradation; patterned ground). In the study area (31°53'S - 70°11'W), permafrost-related cryoforms are located between 3400 and >4500 m a.s.l. We analyzed the sedimentological setting and thermal properties at two sites of the active layer in "El Candidato" rock glacier. The profiles were identified as turbic cryosols with no presence of vegetation or any organic horizon. Pebbles are major grain size (>50%), predominantely between 16 and 64 mm, and their main composition are lithic fragments of rhyolite. Above 15 cm depth, soil matrix is near 25% of the total mass and the silt content is around 3.1%. From 15 to 65 cm depth, pebbles and cobbles are concentrated, whereas matrix content is only 15%. Down to 90 cm depth, matrix content increases up to 28%, with a minor presence of silt (1.9%).

This arrangement points to a cryogenic law that would have carried pebbles and cobbles upwards within the active layer. Concentration of silts in the top of the profile could be related with an overlapped process of frost-related extrusion in the first 65 cm of soil. As a result, the top layer shows up to 39% reduction in thermal conductivity along with an increment in matrix porosity. This distribution proves the effect of cryoturbation processes on heat fluxes within the active layer of permafrost-related cryoforms.

None

P-805A

Pyrogenic carbon age and stocks in permafrost mineral soils of Northern Canada

Mr Marcus Schiedung, Dr Philippa Ascough, Mr Severin-Luca Bellè, Prof Samuel Abiven

Pyrogenic carbon (PyC) is a residue of incomplete combustion during wildfires, which are a major disturbance of boreal ecosystems. The quantity and age of PyC in boreal forest mineral soils are largely unknown beside being a major contributor to the total soil organic carbon (SOC). Here we sampled eleven forest soil sites (with nine replicates) across the Canadian Boreal and Taiga Plain. We sampled soils under continuous permafrost (northern sites) and under sporadic and discontinuous permafrost (southern sites) at different landscape positions (e.g. elevated, slope and depression) and used hydrogen pyrolysis (HyPy) to separate the PyC-HyPy from the non-fire-derived SOC for quantification and radiocarbon measurements. The SOC stocks were higher in soils from the northern sites with on average 57 ± 29 Mg/ha (16-188 Mg/ha) compared to the southern sites with 26 ± 20 Mg/ha (10-153 Mg/ha) in the upper 0-15 cm. The PyC represented of the total SOC around 7% in soils of the northern and 5% in soils from the southern sites. Along the larger quantities of SOC and PyC-HyPy, the age of the PyC-HyPy was much higher in the northern soils (2 083-10 407 radiocarbon years BP) compared to the southern soils (495-3 275 radiocarbon years BP), which indicates the importance of permafrost and associated cryoturbation for the whole carbon cycle of boreal forests soils.

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P-806

Forest soil acidification risk assessment in the Czech Republic using the digital soil mapping tools

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Forest soils in the Czech Republic were significantly impacted by acid deposition in the second half of the 20th century. High amounts of sulphur and nitrogen compounds have been deposited in the soils and led to a decrease of soil pH and base saturation, and loss of base cations (particularly Ca and Mg), especially in the mountainous regions. Though sulphur deposition decreased significantly in 1990s, the high amounts of sulphur accumulated in the forest soils combined with low contents of base cations still present a risk for forest ecosystems. This study tries to map the risk of forest soil acidification using a large forest soil property database compiled from several forest soil surveys. It is focused on several aspects: 1) selection of the most suitable criteria for soil acidification risk assessment based on data from various soil depths (pH, base saturation, exchangeable base cations); 2) selection of the most important environmental covariates, from terrain parameters (altitude, slope, slope aspect, slope curvature, contributing area, topographic wetness index, etc.), soil classes, forest tree species composition, climate data etc.; 3) selection of the most accurate spatial prediction approach, either a single model from a rank of machine learning methods (random forests, support vector machine, multivariate adaptive regression splines, Cubist) and geostatistical methods (ordinary or universal kriging), or a combination of methods (ensemble learning). The various output maps are compared based on validation results and interpretability of the map.

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P-807

Digital Soil Mapping Using Different Sample Sizes with Multiple Machine Learning Algorithms

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We evaluated the impact of sample size on the prediction performance of different machine learning algorithms for preparing digital soil maps for a geographic extent of 8,303 square km in eastern India. A total of 1,024 surface soil samples were collected, out of which 800 were used for model training, while the remaining 224 were reserved for validating the resultant maps. The original training set of 800 samples was reduced by random selection into six different sample sizes viz. 800, 400, 200, 100, 50, and 25 to create digital soil maps separately for 14 different soil properties including soil physicochemical properties (soil organic carbon, pH, electrical conductivity), macro-nutrients (available nitrogen, phosphorus, potassium, calcium, magnesium, sulphur), and micro-nutrients (iron, manganese, copper, zinc, and boron). The covariate stack included terrain attributes derived from a 30 m resolution-SRTM DEM (e.g., hydrologic routing and multiple analysis scales of slope gradient, relative elevation, and aspect) and spectral attributes based on time-series aggregated Sentinel-2 imagery (e.g., individual bands as well as soil and vegetation indices). Feature selection was performed using Lasso to select the most relevant covariates for modelling. Machine learning (ML) algorithms tested included cubist, random forest, quantile regression forest, and artificial neural networks. Each modelling treatment was used to produce maps at a 10 m resolution for each of the soil properties using each of the sample sizes. Prediction performance of the ML algorithms was measured by Lin’s concordance correlation coefficient (CCC) and root mean squared error (RMSE) using the independent validation set.
NA

P-808

Ensemble soil map assessment highlights challenges for predicting topsoil organic carbon concentration at national scale

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Soil organic carbon (SOC) concentration is the fundamental indicator of soil health, underpinning food production and climate change mitigation. SOC storage is sensitive to various environmental stressors, with one third of all soils degraded and losing carbon (FAO & ITPS, 2015). Digital soil mapping can reveal hotspots of SOC storage and where losses to the atmosphere are most likely. Yet, attempts to map SOC often disagree. We compare national scale SOC concentration map products with each other, and with nationwide survey data built on a stratified random sampling design. To resolve why differences occur, we also stratify our analysis by latitude, land cover and major soil type to compare predictions within smaller land units representing controls on SOC contents at national scales (Weismeier et al., 2019). This revealed agreement of data in mineral soils, with progressively poorer agreement with increasing SOC concentrations. Divergences in map predictions from each other and survey data widen in the high SOC content land types we stratified. Given the disparities are highest in carbon rich soils, efforts are required to reduce these uncertainties to increase confidence in mapping SOC storage and predicting where change may be important at national to global scales. Going forward, our map ensemble could be used to map SOC risk where concentrations are high and should be conserved, and where uncertainty is high and further monitoring should be targeted. Reducing inter-map uncertainty will rely on mapping SOC from richer observational databases that fully represent the landscape that predictions are generated for.
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P-809

Random Forest Spatial Interpolation for 3D Digital Soil Mapping

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Random Forest (RF) is one of the most popular machine learning (ML) techniques used for spatial modelling. Recently, Random Forest Spatial Interpolation (RFSI) was developed, which potentially improves the performance of RF for spatial predictions by including the observations and distances to the nearest locations of the prediction locations as covariates. The idea that near things are more similar than distant things (first law of geography) is the very basis of kriging and many deterministic interpolation methods. In this study, we adjusted RFSI for digital soil mapping (DSM) in three-dimensional space by restricting the nearest observations to those that have the same or similar sampling depth as the prediction depth. We hypothesize that RFSI can potentially yield more accurate predictions because in addition to environmental covariates it makes use of both local and soil-profile specific information. We tested the performance of RFSI compared to regular RF for two different case studies: 1) mapping soil organic carbon (SOC) in the Edgeroi district NSW, Australia, using 359 profiles and 36 covariates; 2) mapping soil pH using 4230 profiles and 200 covariates in the Netherlands. Cross-validation and design-based inference were used to evaluate model performance in case studies 1 and 2, respectively. First results reveal that the ability of RFSI to outperform RF largely depends on landscape heterogeneity, the spatial distribution of the soil profile locations and the availability of covariates. Although additional tuning is necessary, using RFSI in DSM can potentially improve the performance of ML for local estimation over 3D space.
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P-810

Soil Carbon accumulation and Soil salinization, undetectable variables to define homogeneous units in hydric soils of coastal wetlands

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Coastal wetlands play an important role in the global carbon cycle and with greater relevance in arid or semi-arid areas such as Mediterranean wetlands. In addition, these ecosystems can present salinity problems due to their proximity to the coast and a salinized water table. Historically, wetland soils have been classified and mapped according to the traditional methodology of homogeneous soil units, but the presence of non-detectable variables have caused problems in the cartographic delimitation. A variable salinity water table or organic carbon accumulation in soil profiles can modify the predefined homogeneous units. This situation is predominant in the Albufera of Valencia, a wetland with 15,000 ha which is located to the east of the Iberian Peninsula (Spain). To determine how soil salinity and carbon accumulation can modify hydric soils classification and mapping, it has been developed a semiautomatic tool in GIS that allows autonomously delimiting the different wetland soil units. Soil samples have been analysed during several campaigns, and defined the different diagnostic criteria to classify the soils according to the Soil Taxonomy. One layer for each criteria was generated and superimposed to define the different types of soils (classified at the subgroup level). With this tool, it was possible to define with greater precision hydric soils, detecting variations in classification due to salinity and organic carbon. For example, it was possible to delimit the Aridisol from Entisol area due to salinity interpolation or define the organic carbon buried layer and the Thapto-Histic characteristic at subgroup level.

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P-811

Using hand-feel soil texture as a proxy for Digital Soil Mapping predictions of soil particle-size distribution

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Most of the digital soil mapping (DSM) products rely on machine learning (ML) prediction models and/or the use or pedotransfer functions (PTF) in which calibration data come from soil analyses performed in labs. We explored the potential of an ordinal qualitative variable, i.e. the hand-feel soil texture (HFST) estimating the mineral particle distribution (PSD): % of clay (0-2µm), silt (2-50µm) and sand (50-2000µm) in 15 classes. The PSD can also be measured by lab measurements (LAST) to determine the exact proportion of these particle-sizes. However, due to cost constraints, HFST are much more numerous and spatially dense than LAST.
Soil texture (ST) is a very important soil parameter to map because it controls many soil properties and functions. Therefore, an essential question arises: is it possible to use HFST as a proxy of LAST for the calibration and / or validation of DSM predictions of ST?
We compared HFST with LAST on a representative set where both information were available in a French region. The accuracy of HFST was assessed, and each HFST class was characterized by a probability distribution function (PDF) of its LAST values. We tested our results on a PTF predicting the water retention capacity of the soil, on using HFST as a calibration variable, and as a tool for evaluating DSM performances. As in numerous countries, the HFST observations are very numerous, these promising results pave the way to an important improvement of DSM products in all the countries of the world.
digital soil mapping, improvement of digital soil mapping predictions, Potential of using hand-feel soil texture, Soil texture prediction.

P-812

The mapping of trace elements on fine grids from dense data on covariates from remote sensors and high-resolution environmental predictors

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The distribution of trace elements in the surface soils is complex and reflects the geochemistry of the original geological substrate modified by a variety of environmental and human-induced factors. Since the covariate datasets representing these factors are usually in a much finer resolution than the geochemical surveys, the auxiliary variables were employed for the predictive mapping of As, Cd, Ni, and Pb using a quantile random forest model. Taking into account the multi-conditional nature of topsoil geochemistry, various remote sensed or high-resolution covariates were selected for predictive mapping within the study in the Czech Republic supported by the Technology Agency of the Czech Republic – project No. SS03010364. Geological variation was conceptualised using the airborne geophysical (gravimetric, radiometric, and magnetometric) data together with local effects represented by the intensity of mineral exploration from an inventory of mining dumps. Soil conditions for the binding capacities were represented by DEM derivatives and predictions for organic carbon and clay contents from dense legacy data. Finally, the precipitation and deposition rates from continuous ground measurements, and night-time lights data covered the natural and human-induced distributional effects. Moreover, the model was tested for an increase of prediction capability when using a mosaic of bare soils from Sentinel-2 satellite data or the Euclidean buffer distance maps to better capture the spatial dependencies. The relative importance of covariates and cross-validated metrics varied across the range of elements which hinted at the controls of their distributions or the effects of underrepresented processes within the suite of auxiliary variables.

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P-813

Comparison of direct and indirect mapping of soil water retention at global scale

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Maps of soil water retention (SWR) are mostly developed using either direct mapping, in which measured SWR data are combined with environmental covariates to derive a regression model that predicts SWR from covariates, or an indirect approach in which pedotransfer functions (PTFs) are applied to maps of the basic soil properties required by the PTFs themselves. The present SoilGrids product includes recently developed global maps obtained by direct mapping of SWR, at 10, 33 and 1500 kPa, with associated uncertainty at 250 m resolution. We compared the SoilGrids maps with three indirect mapping products for the six GlobalSoilMap standard depths. Besides map inter-comparison, the accuracy of the four products was evaluated using independent SWR data from WoSIS (World Soil Information Service). The map comparison showed very diverse distributions and geographical patterns amongst the products. SoilGrids had the lowest root mean square error between all products, with 6.4, 7.1, and 6.5 cm^3/cm^3 for respectively 10, 33 and 1,500 kPa. SoilGrids also had a model efficiency coefficient substantially closer to 1 than the other products, with values of 0.43, 0.38, and 0.47 at 10, 33 and 1,500 kPa, respectively. For 10 kPa, the performance was similar to that found for the indirect products, which may be explained by the smaller calibration data set available at this pressure.

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P-815

Digital soil mapping for spatiotemporal modeling of active and total soil organic carbon pools

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Spatiotemporal modeling of dynamic soil properties, like soil organic carbon (SOC), is valuable for sustainable soil management in agriculture. Digital soil mapping (DSM) is being widely used for predicting the total SOC pool; however, modeling of the active fraction of the SOC pool has remained unexplored. Active SOC pool, commonly measured as potassium permanganate oxidizable carbon (POXc), is highly sensitive to shifts in land management practices. Hence, monitoring of POXc is significantly important for developing effective soil management strategies in regenerative agriculture. This study conducted a DSM analysis in Truro, Nova Scotia, Canada for spatiotemporal modeling (2015/16 – 2019/20) of total organic carbon (TOC) and POXc. We utilized two machine-learning models, namely Random Forest and Stochastic Gradient Boosting Model, and a suite of environmental covariates developed from Landsat satellite imagery, LiDAR-derived digital elevation model, and crop inventory data. Both models performed equally well with a concordance of 66%–68% for TOC and 53%–0.54% for POXc. We predicted absolute change in POXc in 98% of the study area (loss in 65%, gain in 33%); however, only 27% of the area (loss in 22% and gain in 5%) experienced an absolute change in TOC. The study demonstrated the effectiveness of DSM for spatiotemporal modeling of multiple SOC pools to support sustainable agricultural soil management.
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P-816

RECURSIVE FEATURE ELIMINATION TO IMPROVE DIGITAL MAPPING OF Fe2O3 AND TiO2 CONTENTS, IN "MORRO DOS SEIS LAGOS", BRAZILIAN AMAZON

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The goal was to evaluate the performance of the Recursive Feat Elimination (RFE) algorithm, as a strategy to reduce the set of input covariates, to predict Fe2O3 and TiO2 contents in Morro dos Seis Lagos (Amazon, Brazil), by using Radial Support Vector Machine (vsmRadial) and Random Forest (RF) models. The sample set gathers 341 points (soil, sediments and rock materials) from the surface layer, available in the Geological Survey of Brazil (CPRM) official database. The morphometric covariates were generated from the Digital Elevation Model (DEM-HC) and for the set of remote sensing covariates the Sentinel-2A sensor and Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER) were adopted to create spectral indices that highlights mineralogical characteristics. The results obtained showed the best performance for Fe2O3 (R2=0.43), TiO2 (R2=0.18) in the RF model, while for vsmRadial it was obtained for Fe2O3 (R2=0.34), TiO2 (R2=0.14). In conclusion, the best optimization was observed by using RFE -RF, highlighting for both models' the importance of the covariates: elevation, Saga Wetness Index, as great predictors to explain the variability of Fe2O3 and TiO2 contents at the area.

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P-817

Direct measurements versus electromagnetically measurements of soil Magnetic Susceptibility

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As a physical property of soil, magnetic susceptibility (MS) has a variety of applications in soil sciences including soil erosion and degradation, pollution, drainage, archaeology and paleo-environmental studies. Direct measurements of soil MS can be done using collected soil core samples or over soil exposures in an open pit. In this case, the variations of soil MS by depth can be precisely measured by handheld or laboratory based MS meters. Other way to measure soil MS is through electromagnetic induction (EMI) methods which use a transmitter coil to generate alternating primary magnetic fields. These fields penetrate to the soil and induce currents in it. In this case, the in-phase component of secondary magnetic field, produced by induced currents and sensed by a receiver coil, is proportional to MS of a volume of soil impacted by primary magnetic field, called apparent MS. The variations of soil MS by depth can then be calculated by inverting apparent MS measured in different configurations of transmitter and receiver respect to soil surface. While the former method is invasive and time consuming, the latter method is fast and non-invasive. Although the MS values calculated by inversion of apparent MS data are not as precise as direct measurements of soil MS but our measurements show that the trend of MS variations in both methods are highly correlated. So, as EMI methods are fast, they can be utilized to measure and map soil MS of a large area, for different applications, in a cost efficient way.

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P-818

Digital soil mapping for soil fertility assessment in the Thung Kula Ronghai region, Thailand

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Digital soil mapping (DSM) has developed from the traditional soil mapping approach, which has a higher potential to create updatable, accurate, and high-resolution soil maps. Although DSM has often been applied to map soil carbon content and chemical properties, soil fertility has not been expressed through DSM probably due to the complexity to integrate various soil chemical properties. In this study, principal component analysis (PCA) was applied to extract the most suitable soil indicator for soil fertility. A digital map of soil fertility was created using a multiple linear regression (MLR) model. Then, the accuracy of the soil fertility map was checked by the uncertainty analysis and compared with actual rice yield in the Thung Kula Ronghai (TKR) region of Thailand. The calculated soil fertility was significantly explained by soil pH, electrical conductivity, organic matter, and contents of macronutrients (P, K, Ca, and Mg). The spectral indices (brightness, coloration, normalized difference water, and moisture stress) and topographic indices (slope and topographic wetness) were the important predictor variables to predict soil fertility. Besides, the digital map indicated that more than half of the TKR region was occupied by “very low” to “low” soil fertility, which was consistent with the actual rice yield data. The soil fertility information obtained from this study is valuable for soil nutrient improvement and sustainable land management in the future.

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P-818A

Developing China Soil Information Grids

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High-quality soil information is required for solving global and regional issues such as food security, water regulation, land degradation and climate change. Accurate prediction of soil variation over large and complex areas with limited samples remains challenging, which is especially significant for China due to its vast land area which contains the most diverse soil landscapes in the world. With predictive soil mapping paradigm, we developed an adaptive depth function fitting method, and integrated it with ensemble machine learning and pedotransfer models in a high-performance parallel computing environment to generate 90-m resolution 3D national gridded maps of a set of basic soil properties (pH, SOC, nitrogen, phosphorus, potassium, CEC, $CaCO_3$, bulk density, stoniness, sand, silt, clay, soil colour and thickness) and soil hydrological properties. Their predictive uncertainty was quantified over space. The element stocks were also estimated for land use types. This was based on 6000 representative soil profiles collected in a recent national survey and a suite of covariates characterizing soil-forming environments. The predictive accuracy ranged from very good to moderate (MEC 0.71~0.36) and mostly declined with depth. Compared with previous soil maps, we achieved significantly more detailed and accurate predictions which could well represent soil variations across China and are an important contribution to the GlobalSoilMap.net project. Our ambition in the following years is to build the National Soil Information Grids of China at higher resolution and accuracy and richer contents (soil functions). This study highlights the requirement of new paradigms and methodologies for broad-scale soil mapping.

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P-819

Evaluation of soil scanning instruments for precise fertilizer decision making

Mr Tadesse Gashaw Asrat

Soil spectroscopic could be useful to improve fertilizer decision making in low income countries where soil testing options are often limited and not accessible to many farmers. Hence, this study compared commercially available soil spectral sensing instrumentations viz., Neospectra, Fieldspec-4 with contact probe and mug light and Bruker Tensor-II, in their precision, uncertainty and ease of applicability to predict key soil properties for fertilizer decision making. The comparison was made by scanning 350 archived soil samples at Rothamsted Research which were collected from 0-20cm soil depth in Ethiopia, Kenya and Tanzania. Six soil spectral pre-processing techniques and two sub-sampling methods for selecting train and test sets were evaluated for their effect on the prediction of soil properties using a PLSR model. Most of the soil properties (Exch-Al, Exch-Fe, pH, SOC, total N, Exch-Ca, Exch-K, Exch-Mg) were well predicted with a CCC value between 0.88-0.96 and RPIQ between 1.4-5.9 by all the soil scanning instrumentations considered. However, exchangeable iron, SOC and TN prediction using Neospectra were inferior. Ammonium-oxalate extract of P was predicted better than Olsen-p by all instrumentations, which signify that the conventional soil analysis method should be considered when predicting available soil P. Use of the predictions for the development of fertilizer recommendations gave promising results when compared to the use of the wet chemistry soil characters. In conclusion, the least cost and easily applicable Neospectra can be used to determine major soil properties with a reasonable precision for fertilizer decision making in East African agricultural soils.

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P-820

Estimation of Nitrous Oxide Surface Emissions by Gas Diffusion Analysis of the Measured Soil Gas Concentrations

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Nitrous oxide (N2O) fluxes are estimated through direct measurements from the soil surface. The need for expensive high precision devices is a major constraint to expanding the low concentrated gas-level measurements. As detectable N2O concentration in soil atmosphere is higher than surface detection, this experiment shows the simulation process of N2O flux from the diffused gas in the soil-entombed silicone diffusion cell (SiDC), measured by a low-cost nondispersive infrared (NDIR) device. In the experiment, 4 kg soil mixed with 4 g of ammonium sulfate (NH4)2SO4 was kept in the enclosed chamber. The soil moisture content was controlled, completely saturated, and drained for 2 days. The diffused soil gas was measured every 30 minutes by the NDIR device with SiDC placed at 4 cm depth. To detect the actual emission (MF), headspace gas was measured by Fourier-transform infrared (FTIR) spectrometer, closing and ventilating the chamber for 30 minutes and 1 hour, respectively. The diffusion coefficient of the silicone tube (DcS) was determined from the temporal variation of diffused gas concentration in SiDC placed in a known gas concentration. Solving the diffusion equation, the temporal gas concentrations in the soil (Tgcs) were estimated from the DcS and recorded gas levels in the SiDC. The estimated N2O flux (CF) was simulated by solving the diffusion equation with four soil gas diffusivity models for Tgcs. Enabling low-cost devices for estimating soil N2O fluxes, along with Campbell. 1985 diffusivity model, a higher cross-correlation (0.9765) was observed on cumulative temporal fluxes of CF and MF.

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P-822

Evaluating sensor data fusion for soil health assessment of irrigated cropping systems in South Africa

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Soil health assessment is essential for sustainable soil management and enhancement of soil ecosystem services. The principal aim of this study was to evaluate a sensor data fusion approach in soil health assessment of two irrigated fields in South Africa using mid-infrared (MIR) spectra in conjunction with apparent electrical conductivity (ECa) sensor data. Soil samples were collected from 0 – 0.3 m soil depth at two irrigated fields with identical cropping systems using ECa-directed sampling approach. Measurements of soil health indicators and MIR spectral data were obtained in the laboratory, while ECa data was obtained in the field. The overall soil health status was assessed using the Soil Management Assessment Framework (SMAF) algorithms. Regression models were developed with step wise multiple linear regression (SMLR), principal component regression (PCR) and partial least squares regression (PLSR) and model performance was evaluated using coefficient of determination (R2), root mean square error (RMSE) and residual prediction deviation (RPD). Generally, models for measured soil health indicators based on sensor fusion of MIR and ECa data were more robust as compared to the models developed from individual sensors. Furthermore, sensor fusion also improved models of SMAF scores and overall soil health index (SHI). PLSR emerged the best method in handling data fusion for soil health indicators and SMAF scores. For the overall SHI, the performance of the sensor fusion techniques were fairly similar. The study concludes sensor fusion can enhance the efficient and robust measurement of soil health indicators and overall soil health in irrigated agriculture.

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P-823

Developing and validation of a practical setup to study soil pressure

Ma Svenja Hagedoorn, MSc Karin Pepers, Dr. Gera van Os

A practical setup for measuring soil pressure caused by heavy machinery in the agricultural sector does not yet exist. Such a system would provide the opportunity to test measures that reduce soil pressure and compaction in order to improve soil quality and contribute to sustainable soil management.

The Soil Innovation Lab consists of a permanent basin, 6 by 20 meters and 1,2 meters deep, built in an indoor location to exclude weather influences. In this basin we will combine pressure sensors, acceleration sensors, moisture sensors and density sensors, originally designed for other applications, to measure soil compaction. This experimental setup offers the possibility to vary in soil type, moisture content and soil pressure.

After installation of the sensors the system will be calibrated and validated using agricultural vehicles. Further research will be focused on pressure waves through the soil.

Project partners are Aeres University of Applied Sciences, Saxion University of Applied Sciences, Wageningen University and Research, Abemec and several farmers.

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P-825

Monitoring of Electrical Signal of Pepper under Different Nutrient and Water Treatments

<u>Prof. Jin Hee Park</u>, Ms Jee Hyokyung, Ms Han Na Kim

Imbalance of soil nutrients and water supply causes nutrient deficiency and imbalance in plant growth. Plant physiological responses under changing environmental conditions can be non-destructively monitored using electrodes as plant-induced electrical signal (PIES). Objective of the study was to monitor PIES in response to different level of water and nutrient supply. Pepper was grown in sandy loam soil treated with insufficient and excessive amount of water and urea and compared with control treatment with suitable amount of water and urea. During the treatment of soil, PIES of the pepper was monitored and growth of pepper was evaluated at the harvest. ICP-OES was used for ion analysis of plant stem extracts. Chlorophyll fluorescence and chlorophyll and proline contents were analyzed for stress evaluation of the plants. PIES was highest for the pepper grown in soil with excess urea. Insufficient water supply significantly reduced PIES indicating abnormality of water and nutrient transport in plant. The ion content of plant stem was high in excessive fertilizer treatment, and PIES was highly correlated with K, P, and S. Both chlorophyll and proline contents were high in excessive nutrient treatment although the difference was not significant.
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P-826

Use of soil EC sensor for the prediction of soil nutrient status

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Smart farm in field soil requires sensors to monitor soil nutrient status for precision supply of nutrients. However, sensors to monitor nutrient levels in soil are not available. Therefore, the objective of the study was to evaluate possibility of using soil EC sensor for the prediction of plant available nutrient levels in soil. The sensor EC value was affected by soil water condition. Therefore, EC value should be calibrated against soil water content. Various soils with different properties were collected and saturated with water and soil bulk EC was monitored while naturally drying. Soil bulk EC value was linearly decreased with decrease in water content and value for EC calibration was acquired for different soils. The bulk EC was highly correlated with water extractable EC and nutrient contents in soil pore water indicating that bulk EC can be used to monitor nutrient status in soil. However, salts such as Na and Cl also may affect EC value and EC value should be used with care in salt affected soils. The bulk EC can be used to monitor change in plant available nutrients in soil, but it does not represent nutrient itself. Therefore, the EC value should be calibrated when it was first applied in soil.

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P-827

Performance of a portable low-cost NIR-MEMS spectrometer to predict soil features

Prof. Simone Priori, Prof. Raffaele Casa, Dr. Nada Mzid, Dr. Simone Pascucci, Dr. Stefano Pignatti

In the last few years, NIR spectrometers based on micro-electromechanical systems (MEMS) have become to be available in the market, and they are starting to be used also in soil science (Sharififar et al., 2019; Tang et al., 2019). Such technology allows to miniaturize and to reduce the cost of the spectrometers, allowing a wider use for agricultural consultants, technicians, and scientific researchers. The aim of this work was to evaluate if such less costly technology can determine soil properties with similar accuracy as the standard Vis-NIR spectrometers.
Soil samples, with very different soil characteristics, air dried, and 2 mm sieved have been scanned by a Vis-NIR traditional spectrometer (ASD Fieldspec 3 Hi-Res) and then by portable NIR-MEMS spectrometer (NeoSpectra Scanner), with spectral wavelength ranges of 350–2,500 and 1,300–2,500 nm, respectively. The soil samples were previously analyzed by conventional laboratory methods, to determine texture, total organic carbon (TOC) and total carbonates (TCa). Both Partial least squares regression (PLSR) and support vector machine (SVM) calibration methods were assessed for the prediction of soil features using spectral data of the two instruments. Cross-validation analysis was performed for evaluation of the models and devices accuracies.

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P-828

Distribution of soil surface properties within the northern Antarctic Peninsula region using reflectance spectroscopy

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Soils of the South Shetland Islands are formed under maritime climatic conditions in ice-free areas where permafrost distribution and continuity is variable. Furthermore, soils are influenced by the presence of bird and seal colonies as well as by human induced impacts mainly carried out around research stations and due to tourism activities. Proximal and remote sensing data techniques using visible near-infrared spectroscopy (VNIR; 400–2500 nm) and imaging spectroscopy with optical satellite data are useful for predicting a range of soil properties, including topsoil mineralogical composition, soil organic carbon content, available nutrients and textural information.
Our objectives include: 1) to compile a site specific spectral library for different soil properties found in ice-free areas; 2) determine relationships between acquired lab-based spectra together with physical and chemical soil analyses; 3) obtain a reference model for specific soil properties that are relevant to the region and 4) use hyperspectral data to determine their spatial distribution.
Soil samples were obtained from 35 different locations. Chemical and physical soil analysis included pH, electrical conductivity, organic matter content, total carbon and nitrogen contents, available phosphorous content and mineralogical composition. Spectral measurements were recorded in laboratory and in field conditions using a VNIR spectroradiometer ASD FieldSpec3. This has resulted in a site-specific spectral library with 125 samples. Partial least-squares regression was used taking into account different soil properties and reflectance measurements. This information was then used to determine the spatial resolution using current and upcoming high spectral resolution satellite sensors such as PRISMA and EnMAP.

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P-829

Validating a new in-situ soil bulk density sensor

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Soil bulk density is gaining in importance as soil parameters. For soil compaction, water infiltration, retention and rootability properties related to food production and climate change adaptation, but also as input to soil carbon content calculations and pedotransfer functions. The standard measurement of soil bulk density with rings is labour intensive and therefore expensive; existing sensor approaches require extraction of the soil core and are not widely used. As a possible solution to this challenge to measure bulk density in situ, a sensor is developed that measures the soil bulk density of a full soil profile. This RhoC or MS-Rho sensor, measures soil bulk density every 5 cm up to 1 m depth, without the need to extract the soil core. The sensor measures the backscatter of gamma radiation emitted from a (low-activity) source, which can be used without legislation. The signal is absorbed by matter (soil or water) and the remaining radiation is measured by a scintillation crystal, or detector, 5 cm away from the source. We performed a first validation study over a limited soil bulk density range in different soil types in the Netherlands with promising results (good accuracy, low precision). The sensor has recently been extended with a soil moisture sensor, allowing to measure dry soil bulk densities. This sensor is used in an extended study to a wider feature space range and larger dataset in 2021 and 2022. The results of these validations will be presented in the presentation.
Presentation at Dutch CBAV meeting 2021

P-829A

Development of an open soil spectral estimation service with a handheld near infrared spectrophotometer

Dr. Jonathan Sanderman, Colleen Smith, Ms. Sadia Mitu, Dr. Yufeng Ge, Mr. Richard Ferguson, Dr. Keith Shepherd

Diffuse reflectance infrared spectroscopy has become an indispensable laboratory tool for rapid estimation of numerous soil properties to support various soil mapping, soil monitoring and soil testing applications. Recent advances in hardware technology have enabled the development of handheld sensors with similar performance specifications as laboratory-grade near infrared (NIR) spectrophotometers. In this study, we develop a spectral library consisting of 2000 diverse soil samples using the Si-Ware NeoSpectra-Scanner. Validation results suggest that useful to good predictions of multiple soil properties can be obtained using memory based learning, a local modelling approach. Results from independent test sets consisting of air dried and field moist agricultural soil samples will be presented. Advantages, limitations and future development needs of this handheld scanner will be discussed in relation to agronomic support and soil carbon monitoring applications. The spectra and calibration models for these soil properties are hosted at the Open Soil Spectral Library, a free service of the Soil Spectroscopy for the Global Good Network [1], enabling broad use of these data for multiple soil monitoring applications.
1. soilspectroscopy.org

P-830

Effect of local samples on X-ray fluorescence-based spectral prediction model accuracy based on total amounts of some measured elements

Dr Csaba Centeri, Viktória Vona, Dr. Márton Vona, Dr. Sam Sarjant, Dr. Renátó Kalocsai, Dr. Attila József Kovács

The performance of prediction models built on a global calibration database vs. local calibration database is often evaluated. In the present paper, an evaluation is made for • total N, K, Ca, Mg, Al and Fe measured with Epsilon 3, EDXRF sensors and total N determined via Dumas method. The local dataset of 640 samples was split into 90% train and 10% test samples. To illustrate the benefits of using local calibration samples, three separate prediction models were built per element. For each model, 0-50-100% of the local training samples were added to the global dataset. The remaining 10% local samples were used for validation.
The results show that many models already exhibit an excellent level of performance (R2≥0.95) even without local samples, except Mg (R2=0.91) and K (R2=0.94). R2 values remain the same when N, Ca and Al are measured. In the case of total Fe R2 decreases with adding 50% of the training data to the model and reaches the same level of performance with the original global data. RMSE values show a nice decreasing trend in the case of total N, Ca, K and Al. The results show that the global dataset (17,000) of AgroCares already has enough information to predict the total N, Ca and Al successfully, regardless of the number of Hungarian samples present. However, RMSE values can be improved with the inclusion of Hungarian data.

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P-832

Soil electric resistivity and conductivity of a tropical soil under integrated crop-livestock-forest system

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The development of near-surface equipment and methods has helped improve the advances in soil studies and allow for increased capacity to acquire real-time on-the-go and large-scale data. However, the use of apparent electrical conductivity (ECa) and resistivity (ρ) of soils methods to characterize the properties of agricultural soils is a new challenge and active investigation field. Crop-livestock-forest integrated systems (CLFIS) provide a strategy of sustainable agricultural production which integrates annual crops, trees, and livestock activities in the same area and the same season. This study aimed to characterize the spatial variability of soil ECa and ρ of agricultural soils cultivated with different crop-livestock-forest integrated systems. The research was conducted in a study area of 30 ha of 8years-CLFIS (São Carlos, Brazil) in a medium-textured Red-yellow Latosol, i.e., Haplortox. The CLFIS system includes different combinations of Piatã grass (Urochloa brizantha) pasture, corn (Zea mays), and Eucalyptus urograndis. Soil resistivity (ρ) measurements were obtained with the commercial sensor ARP-system® in 3 depths: 0-0.5m, 0-1m, and 0-2m; and CEa with a prototype sensor in 2 depths: 0-0.3m, 0-0.9m. Data were interpolated and mapped. As a result, there was a relationship between soil ECa and ρ, allowing the delimitation of regions to indicate land use differences. Moreover, these differences considered the spatial variability of soil properties such as texture, porosity, structure, water content, and chemical composition. So, soil ECa and ρ were additional tools for the studies of tropical agricultural soils by deep near-surface imaging and reducing and driving the effort of direct measurements.

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P-833

Soil thermal properties of Kastanozems from agricultural regions in North Bulgaria

Dr. Katerina Doneva, Dr. Milena Kercheva, Dr. Viktor Kolchakov

In the current study was obtained data from direct measurements (in field and laboratory conditions) of thermal properties of Kastanozems in plane, agricultural regions and under different soil tillage. The soil samples were collected from non-cultivated and cultivated area in the region of village Kovachitsa (Lom) and in Trastenik (Ruse), North Bulgaria. Thermal conductivity, thermal diffusivity and volumetric heat capacity were measured with SH1 sensor of KD2Pro device (Decagon Devices) during the process of drainage of the soil samples at different matric potential in laboratory conditions. Thermal conductivity was also measured with TR1 sensor of KD2Pro device at transitory soil moisture in field conditions. The received experimental results for thermal properties were presented as a function of soil water content.
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P-834

Mid-infrared spectroscopy calibration models for soil property prediction within the Western Highveld, South Africa

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Precision agriculture (PA) relies on knowing the spatial distribution of soil properties, which requires repeated, quick, accurate, and cost-effective soil analysis. Conventional methods of soil analysis are slow and costly, reducing the application of PA in South Africa. Soil spectroscopy can fulfil the need for quick cost-effective soil analysis, but depend on robust calibration curves, of which none exist openly for South Africa. Conditioned Latin Hypercube sampling (cLHS) was used to select 1 000 samples from a 5 180 sample dataset based on the pH, Effective CEC and P values of the dataset. The samples were then prepared and scanned with Mid Infrared (4 000 cm^(-1) to 400 cm^(-1)) to create a spectral library. The soil property database and spectral library was combined and the R programming language was used to create calibration models using Cubist, Partial Least Square regression (PLSR) and Random Forest (RF). These models were validated using statistical performance measures including root mean square error (RMSE), squared correlation coefficient (r^2), standard deviation, bias and ratio of performance to deviation (RPD). Results show that models created for pH with Cubist and pre processed spectral data had the best performance (R^2=0.86,RMSE=0.3,RPD=2.66) along with effective CEC with Cubist (R^2=0.86,RMSE=0.3,RPD=2.66) and RF (R^2=0.85,RMSE=0.72) and then P with some success using PLSR (R^2=0.51,RMSE=14.55) and P with RF (R^2=0.57,RMSE=13.48,RPD=1.51). Findings are consistent with other studies conducted worldwide but with little to no data to compare from South Africa more research and data is needed to create models for all soil properties.

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P-835

Combining remote and proximal soil sensing for defining soil management zones for precision agriculture

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Measurements of apparent electrical conductivity (aEC) are frequently done using EM38-MK2 sensors in precision agriculture. During the fieldwork, the operator follows transects and generates a considerable volume of data points. There is a frequent question about the optimal density and spacing of the transects, which involves a trade-off between the intensity and costs of the fieldwork and the accuracy of the resulting Soil Management Zone (SMZ) maps. The objective of this study was to compare Ordinary Kriging (OK) and Kriging with External Drift (KED) to create SMZ using aEC maps derived with sparse sampling density. KED was used to improve the aEC map by combining it with remote sensing products (Landsat-8, Aster, Sentinel-2, and Alos Palsar). The data collection was done in a 72-ha grain farm in São Paulo, Brazil, where 200 aEC points were measured by an EM38-MK2 in four transects with a maximum distance of 150 m. The SMZs were validated using 72 laboratory samples (0-10 cm depth; 1 sample per hectare), and their means were compared using analysis of variance. The aEC maps generated using OK and KDE presented a root mean squared error (RMSE) of 1.61 mS/m and 1.15 mS/m, respectively, which means that the use of KED presented a Relative Improvement Index of 30%. Three SMZs were created using the k-means algorithm and the KED map. KED proved to be significantly better to OK for producing more accurate aEC maps from a sparse set of in situ data and proved more suitable for deriving SMZs

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P-836

Strategy of efficient estimation of soil organic matter at the local scale based on the national spectral database

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The aim of this paper was to compare the prediction performance of three strategies: general global Partial least squares regression (PLSR) using CSSL with and without spiking samples, memory-based learning (MBL) using CSSL with and without spiking samples and general PLSR using only spiking samples to predict soil organic matter in the target area. A series of spiking subsets randomly selected from the total spiking samples which were selected by conditioned Latin hypercube sampling (cLHS) from the target sites. We calculated only the mean squared Euclidean distance (msd) between the estimates density function (pds) of the PCs of vis-NIR spectroscopy from the validation dataset and subset and statistically inferred the optimal sampling set size to be 30.

Our study showed that when the number of spiking were lower than 30, the accuracy derived from global PLSR using CSSL spiked with and without extra-weighted samples was greater than the predicted accuracy derived from the general PLSR using the corresponding number of spiking samples only when the number of spiking samples is no less than the optimal sampling set size. Global PLSR using CSSL spiked with the statistically optimal local samples can achieve higher predicted performance (with a mean RMSE of 5.75). MBL spiked with five extra-weighted optimal spiking samples achieved the best accuracy with an RMSE of 3.98, an R2 of 0.70, a bias of 0.04 and an LCCC of 0.81. The msd is a simple and effective method to determine an adequate spiking set size using only vis–NIR data.

vis-NIR spectroscopy, soil organic mater estimating, memory-based learning

P-837

ManureDB: A case for standardizing organic soil amendment information

Mrs. Nancy Bohl Bormann, Dr. Melissa Wilson, Dr. Erin Cortus, Dr. Kevin Janni, Dr. Kevin Silverstein, Mr. Tom Prather, Mr. Larry Gunderson

Compared to commercial fertilizers, there is a lack of standardized information on organic soil amendments, particularly livestock manure. Manure provides a significant portion of crop nutrients in agricultural production systems. Collecting and aggregating yearly manure analysis results from United States laboratories to update outdated manure book values was the driving factor behind the creation of a manure database. Most manure book values used today were derived from samples prior to 2003. A team of researchers, nutrient management specialists, laboratory managers, and computer scientists created a dynamic manure test database where manure nutrient data can be collected and manipulated multiple ways, including temporally, by species, manure storage type, and eventually spatially. The database will meet the FAIR principles (Findable, Accessible, Interoperable, and Reusable). Four laboratories have shared data and these current values can be compared to previously published manure book values to demonstrate ManureDB capabilities. Expected benefits of ManureDB include more accurate soil nutrient management planning, manure storage design, prioritization of conservation programs, and agricultural modeling as values change over time due to changing genetics, feed sources, and manure handling.

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P-839

Recent developments of the Portuguese soil information system

Dr. Tiago Ramos, Dr Ana Horta, Mr. João Fernandes, Dr. Maria Gonçalves

The INFOSOLO legacy database (Ramos et al., 2017), developed in 2015, was the first soil information system in Portugal. The database included soil profile data previously scattered in soil surveys, research projects, and academic studies carried out by public Portuguese and other European institutions between 1966 and 2014. The original dataset (9934 horizons/layers from 3461 soil profiles) was now extended to soil data produced since 2015. New soil properties (the electrical conductivity of the soil saturation extract) were added to the database. Digital maps of soil texture, dry bulk density, and soil hydraulic properties were also produced for southern Portugal at two spatial resolutions (250m and 1000m) from geostatistical simulations. Lastly, a WebGIS with Web Map (WMS) and Web Feature (WFS) Services was created to facilitate the access to soil data and produced digital soil maps (https://projects.iniav.pt/infosolo/). Thus, INFOSOLO continues providing the basis for improving soil information in the country and for raising national awareness of the importance of soil resources to the country's development.
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P-840

Open Source Spatial Data Infrastructure framework for Soil Mapping and Land Management in Romania

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The main purpose of this framework is to provide an integrated platform for large scale soil mapping and land resources management designed specifically not only for soil surveyors, but also for agricultural stakeholders.

The main components of SDI are: the spatial database which integrates SMU and soil profile properties from both legacy and field data and other spatial layers representing different soil forming factors (lithology, terrain features and properties, climate, land use/cover, vegetation, hydrology); tools and models developed for database management using Open Source software (processing models and add-ons, queries, functions); web mapping application for updating and viewing the geodatabase.

Through this platform, the soil surveyors can easily access structured soil data and metadata and ready-to-use spatial layers to help them produce more accurate soil and land suitability maps.

The resulting data and maps automatically updates the geodatabase ensuring the availability for future use.

Also, through web mapping applications, the agricultural stakeholders can access valuable information regarding land characteristics in terms of soil properties and quality, which enables them to take better decisions and properly manage their farm.

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P-842

Multi-user hierarchical Soil-Landscape Information System

Dr. Aleksandra Nikiforova, Dr. Klim Kim, Dr. Nina Belyonova, Dr. Maria Fleis, Dr. Julia Kim

The multi-scale hierarchical Soil-Landscape Information System (SLIS) is designed to develop, visualize and use the Soil-Landscape Classification System (SLCS), as well as integrate information on soils and landscapes. Currently, the SLIS allows integrating information on the names and diagnostic criteria of natural soils and landscapes, the essential properties of natural landscapes and their basic elements (namely, parent rock material, natural water, air, living and dead organisms) that determine the basic properties of associated soils, the possibilities of using soils and recommended measures to enhance these possibilities. In addition, there is already an idea on how to integrate information on anthropogenic-natural soils and soil evolution in the SLIS.

The theoretical basis of the SLCS is the systems approach and contemporary theories of classification. From the point of view of the systems approach, natural soils are considered not only as natural bodies (material systems), but also primarily as derived elements of material systems of a higher hierarchical level - natural landscapes, therefore, the consecutive division of natural landscapes in the process of classification is accompanied by the simultaneous consecutive division of natural soils.

The SLCS is being created in the process of multiscale soil-landscape GIS mapping in accordance with the developed rules for the selection and ranking of the differentiating criteria. Multiscale soil-landscape maps are understood as a system of interconnected soil-landscape maps of all scale ranges (from global to local).

The SLIS is seen as an important step towards the global integration of soil and landscape information.

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P-843

Monitoring the Amount of Fertilizer Used for Facility Cultivationg Field

So-hye Choi, Monitoring The Amount Of Fertilizer Used For Facility Cultivationg Field Yeo-Uk Yun, Monitoring The Amount Of Fertilizer Used For Facility Cultivationg Field Jang-Yong Choi, Monitoring The Amount Of Fertilizer Used For Facility Cultivation Dong-Chan Kim, Monitoring The Amount Of Fertilizer Used For Facility Cultivation Jin-Il Lee, Monitoring The Amount Of Fertilizer Used For Facility Cultivation Jung-Il Ju, Monitoring The Amount Of Fertilizer Used For Facility Cultivation Su-Dong Kim, Monitoring The Amount Of Fertilizer Used For Facility Cultivation Sam Kang

Chinese matrimony vine is a deciduous shrub that belongs to medicinal herbs and is classified as a good medicine. It is known to need a lot of fertilizers due to its good absorption properties of fertilizers, so farmers grow that every year while applying application of fertilizers. This study was conducted to compare the actual fertilizer usage of farmers and the recommended amount of fertilizer use through soil test by understanding the soil chemical characteristics of the cultivation site of the Chinese matrimony vine and the amount of nutrients added to the cultivation farmers.After selecting 47 farms, soil chemistry was analyzed, and the recommended amount of fertilizer use was calculated. As a result of soil chemistry survey, 42.6% of pH was higher than the appropriate level, and 36.2% of OM was insufficient. Effective phosphoric acid, ex. cation K, Ca, and Mg were respectively 100, 87.2, 83.0, and 80.9% in excess of the appropriate range. As a result of the fertilizer usage survey, the total fertilizer usage of the farms was nitrogen 42.6, phosphoric acid 23.0, and potassium 37.0kg/10a and the fertilizer usage was investigated as nitrogen 26.9, phosphoric acid 17.7 and potassium 21.4kg/10a. The compost usage was was about 6 times more than the recommended amount. The average organic fertilizer usage amount was 549kg/10a. The recommended amount of fertilizer use is 1.6 times more nitrogen, 7.8 times more phosphoric acid, and 2.1 times more potassium compared to the amount of farm use.
Chemical properties, representative soil, Soil testing, Chungnam, Chinese matrimony vine

P-844

Measuring Soil Colour to Estimate Soil Organic Carbon Using a Large-Scale Citizen Science-Based Approach

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Rapid, low-cost methods for large-scale mapping and assessment of soil organic carbon (SOC) are essential for climate change mitigation. Our work explores the potential for citizen scientists to gather SOC estimates by measuring soil colour as an alternative to slow and expensive conventional laboratory analyses of SOC. The methods of data and sample collection took place during a 2-year period using topsoil colour and SOC data gathered by citizen scientists and scientists from urban parks in the UK and France. We evaluated the accuracy and consistency of colour identification by comparing “observed” Munsell soil colour estimates to each other and to “measured” colour derived from reflectance spectroscopy, and calibrated colour observations to ensure data robustness. We examined the statistical relationship between carbon content collected by Loss On Ignition (LOI) in the laboratory and (i) observed and (ii) measured soil colour using three colour components: Hue, Lightness, and Chroma. Results demonstrate that although the spectrophotometer offers higher precision in colour determination, there was a correlation between visual and spectroscopic measured colour for both scientists (R2 = 0.42; R2 = 0.26) and citizen scientists (R2 = 0.39; R2 = 0.19) for Lightness and Chroma, respectively. Foremost, although a slightly stronger relationship was found between measured SOC from LOI with predicted SOC derived from spectroscopic colour values (R2 = 0.69), citizen scientists yielded comparable results (R2 = 0.58). These findings highlight the potential of using Citizen Science to collect soil colour data for SOC prediction at meaningful scales for climate change mitigation.

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P-847

Difference between soil water retention curves determined in the field and in the laboratory

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Understanding the behaviour of soils in the unsaturated state is important for many agricultural and geotechnical applications. The soil water retention curve (SWRC), which describes the relationship between soil water content and matric potential, provides important information about soil hydraulic properties (Malaya & Sreedeep, 2012; Novák & Hlaváčiková, 2019). Traditionally, soil water retention properties have been determined in the laboratory. With the development of new equipment that allows continuous measurement of soil water content and matric potential, it is possible to produce SWRCs in the field (Bordoni et al., 2017). The aim of our research was to determine SWRCs in the field, see how they change over time, and compare them to SWRCs determined in the laboratory on undisturbed soil samples using the evaporation method. Measurements were made on two plots with different tillage intensities, conventional tillage and no-till. In addition to temporal variability, spatial variability of SWRCs was also evaluated. Our results show significant differences between the SWRCs constructed in the laboratory and in the field. For a given value of matric potential, SWRCs in the laboratory often achieve higher water contents, which can be attributed to the difference in soil wetting in the laboratory and in the field. SWRCs constructed in the field exhibit temporal and spatial variations. Therefore, we can conclude that using a single laboratory-derived SWRC to describe the relationship between water content and matric potential is not sufficient for comprehensive soil characterization.

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P-848

Assessment of the land potential for biosolids use in coastal Mediterranean karst region

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The aim of this study was to evaluate the long-term potential of agricultural land in the coastal Adriatic karst region (Šibenik region, Croatia) for biosolids application by integrating spatial data from different sources: digital maps and remote sensing, parcel identification system, GIS field observations and measurements focusing on specific land and soil attributes. Management options for land application of biosolids require a comprehensive characterization of both SS and SS-amended soils. The assessment of agricultural land in the study area for SS disposal was based on EU and national legislation. In addition to the restriction on the choice of crops, one of important points in sludge-related regulation is the establishment of limits for heavy metal concentrations, pathogens, and organic compounds, as well as sludge and soil analysis and their frequency. The evaluation revealed that the agricultural land in the study area covers 25735.8 ha, which is only 10 % of the total area, but only a quarter of the existing land (6064.46 ha) is suitable for biosolids application. In addition, the data indicate that, with regards to soil metals levels according to Croatian legislation, the biosolids could be safely applied to the soil. The short-term potential of the land to sustainably provide this ecosystem service, namely soil amendment with biosolids, should be used to determine the inherent long-term potential by means of land degradation resistance and resilience. However, caution is advised, and the long-term effects studied before biosolids are continuously used for land applications.
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P-849

Characterization of Spatial Variability of Soil Properties in Southern Idaho Production Fields

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Idaho ranks in the top 10 in the US for dairy, potato, barley, hay, sugar beet, corn silage, and dry bean production. The highest producing areas in the state for these commodities are in Southern Idaho. Agricultural producers in this region, just like many other regions, are tasked with managing irrigation water and soil fertility on large fields with spatial heterogeneity in a way that results in homogeneous crop production. Management practices implemented to the 'average' of the field limit the ability to attain maximum efficiencies of inputs, such as fertilizer and water. To better advise agricultural producers on precision agricultural practices, first spatial variability of typical production fields must be assessed and quantified. To this end, two 130-acre fields in Southern Idaho were evaluated from fall 2019 through fall 2021. Fields were sampled at different spatial resolutions for soil physical, chemical, and biological properties at multiple depths. Crop production properties, such as yield and nutrient uptake, were also assessed. Initial results showed the presence of spatial variation in the soil properties like cation exchange capacity, pH, organic matter, nitrate, ammonium, and phosphorus. However, the degree of the variation was different for each property. The presence of spatial variation in soil properties across the field and between the management zones will serve as the basis for site-specific management to attain higher nutrient use efficiency, water use efficiency, and optimum crop productivity.
None

P-850

Considerations when Setting Up Long-Term Soil Research Sites

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TThe Idaho Center for Agriculture, Food and the Environment (Idaho CAFE) is an important initiative that will enable the University of Idaho and its partners to address critical problems of worldwide significance. Agribusiness is vital to Idaho's diverse economy and is a major state-wide employer. Livestock, dairy, crop production and food processing are growing sectors that intersect in challenging ways — in Idaho and beyond. Idaho CAFE will be a national leader in addressing constraints on water usage and environmental quality, while supporting the agricultural sectors of dairy, livestock and cropland, as well as the food processing industries. Idaho CAFE is composed of three parts: a research dairy and demonstration farm, a discovery complex for general public education and agro tourism, and a food processing pilot plant. The mission of the 640-acre Sustainable Water and Soil Health Demonstration Farm (CAFE Demonstration Farm) is to improve the resiliency
of diverse cropping systems across the West. Farm-scale testing, evaluation and demonstration of regenerative management practices, and methods to reduce producer input costs and improve farm profitability will all be part of
the demonstration farm. The ability to promote sustainable resource use and minimize ecological impacts will ensure production of uniform high-quality raw materials that agricultural processors need. U of I purchased the farm in March 2019 and immediately began work to ensure that the CAFE Demonstration Farm will be a productive, valuable resource for 30+ years. However, factors outside of soil properties should be considered when starting an interdisciplinary, large research farm.
None

P-851

Development of a meta-model to identify continental-scale drivers of soil carbon change across Australian agricultural production systems

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Complex spatial-temporal process-based models can be challenging to utilise in assessments of key drivers of model outputs- information often required for policy makers and land managers seeking to utilise such complex models. Here, a machine learning algorithm was applied to develop a meta-model (and emulator, or surrogate of a more complex process-based model) of simple empirical relationships for prediction of changes in 0-30 cm soil organic carbon stocks utilising the key inputs and outputs of Australia's Full Carbon Accounting Model (FullCAM). Because this work aims to inform Australia emissions estimates for international reporting as per the UNFCCC reporting requirements, two distinct meta-models were developed: "Cropland remaining Cropland" and "Grassland remaining Grassland". In the development of the meta-models, an innovative set of model drivers were included. Key results indicated that the past carbon inputs and climatic variables are the top model drivers. Further, fully independent validation results revealed that both models reported a Lin's Concordance Correlation Coefficient value > 0.70 and root mean square error value 0.5 Mg C/ha/yr. The meta-model provides many advantages over process-based models due to the simplicity and the ability to mimic and explain much of the variation of soil carbon change in space and time using commonly available model drivers. Future work aims to spatialise the meta-model to derive more accurate soil carbon change in space and time.
NA

P-852

Water regime and soil water balance of Retisols with different exposures in the Carpathian Mountain, Poland

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Soil moisture content is the basis for establishing conservation and management strategies for mountain areas highly vulnerable to climate change, as well as providing basic information for establishing local/global models for the sustainable governance of water resources in regions with long periods of drought and intense rainfall. The objective of this study was to analyze the water balance and soil water regime between the years 2015-2019 in Retisols with different exposures in the north of The Carpathian Foothills.
The studies were carried out on the northern and southern exposures in cultivating areas (280 m.a.s.l.) in a region with a mean annual temperature of 8 ℃ and mean annual precipitation of 700 mm. The soil moisture was recorded by 5MT sensors at 5 depths (10, 20, 40, 60, 80cm). For soil water balance the daily average data from the meteorological station (245 m.a.s.l) and the water balance equation proposed by FAO were used.

Two zones differing in the type of water regime were distinguished in Retisols: an upper zone comprising humic and eluvial horizons, and a lower zone consisting of illuvial and parent material horizons. The border between these zones is generally around 50 cm depth.
The upper zone shows lower moisture content, smaller retention of water available for plants, and relatively wide fluctuations in moisture content, compared to the lower zone, that presented stable moisture content during the 5 years, with values around the water field capacity. These soil moisture regime dynamics are independent of slope exposure.

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P-853

CSCS2.0: A comprehensive soil classification system for quantitatively identifying soils across the world

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Soil classification enables understanding of the variation and sustainable use of soil across the landscape and ultimately across the world. Due to the different criteria used in soil classification, cross-referencing between systems is difficult. Although efforts have been made to build classification systems representing the world's soils (e.g., World Reference Base for Soil Resources – WRB, Soil Taxonomy – ST), adopting these more global systems is often difficult given the intensive soil information previously collected and characterized using existing national systems. Recent research organized via the IUSS Working Group on Advances in Universal Soil Classification has attempted to build a dynamic Comprehensive Soil Classification System (CSCS) sequentially merging existing soil taxa (approximately at Great Group level) from global, regional, and national systems. Here, we present an updated system (CSCS2.0) comprising centroids of soil morphological (e.g., color), physical (e.g., particle size), and chemical (e.g., pH, exchangeable cations) properties measured in the 0–1.5 m depth. The optimized soil taxa originate from ST, WRB, Australian Soil Classification (ASC), New Zealand Soil Classification (NZ), French Soil Classification (Fr), Russian Soil Classification (Ru), Brazilian Soil Classification (Br), and Korean Soil Classification (Kr). CSCS2.0 characterizes soil taxa in the principal component space of the soil properties defining the centroids and allows identifying unknown soils quantitatively using names of existing soil taxa from various classification systems which are combined, or via a new systematic nomenclature created for the CSCS2.0. We hope to sequentially add taxa from other soil classification systems to build up a truly global representation.

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P-856

Coupling soil hydraulic properties and transfer function for the estimation of pesticides travel times

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The assessment of groundwater vulnerability for the risk management of pesticide pollution of groundwater resources is approached either by static map-overlay procedures or by analytical advective-dispersive transport models. The former suffers of a strong empiricism and the latter of computational troubles.
The scope of this work is to present a fast and reliable model (named Pest-TFM-ext), which simulates the spatio-temporal distribution of pesticides from the soil surface, along the vadose zone, till the groundwater. The model assumes a steady-state flow and is based on transfer function, defining the probability density functions of the travel times at a given depth. Here, the transfer function is derived from the soil hydraulic conductivity curve, thus giving a physical meaning to the statistically based transfer function approach; furthermore, both mass decay and retardation factor of any specific pesticide are considered.
The model was validated on the experimental results of non-reactive solute transport experiments along four undisturbed layered soil columns resulting on average r=0.95 and RMSE=0.18. Thus, the model was applied to estimate [Cl-] mean travel times to the groundwater table depth on forty-six field soil profiles. The results were compared to those coming from the HYDRUS model, giving a correlation coefficient of 0.83, a mean absolute error of 40 days and a percent bias of -15.8 %. Finally, a variance-based global sensitivity analysis was performed, which resulted in a relatively higher sensitivity of the model to the "n" and "τ" coefficients of the van Genuchten-Mualem hydraulic conductivity model.

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P-857

Simulated nitrous oxide (N2O) emissions under different precipitation regimes

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The frequency, intensity and duration of precipitation events is predicted to increase with climate change and clearly, their impacts already unfold (Dore, 2005). Possibly, nitrous oxide (N_2O) emissions from soils will be affected by these changes as they are known to be sensitive to dry-wet cycles (Congreves et al., 2018; Griffis et al., 2017). To account for this potential feedback to the climate system, biogeochemical models are powerful tools to estimate future impacts of changing precipitation patterns. However, the parametrization and validation of models to future conditions is not possible. Consequently, current models need to be tested for plausibility operating under default parametrization.
For nitrogen-saturated soils, as common in industrialized countries, we follow the hypothesis that an increase in the heterogeneity of precipitation will lead to prolonged wet and dry soil conditions which in turn elevate cumulative annual N_2O emissions as compared to originally more homogeneously distributed precipitation.
We manipulated existing precipitation data to have a homogeneous or heterogeneous distribution at the same total precipitation amount. To exclude possible biases, the remaining parameters were unified, i.e., homogeneous soil horizons and no crop rotation. In addition, each simulation period was initialised with the same parameters to exclude possible changes in fluxes resulting from soil carbon and nitrogen cycling.
Evaluating the effect of precipitation patterns on N_2O emissions will provide important feedback on the spatial and particularly the temporal significance of extreme events and N_2O emission and their potential importance for soil-atmosphere feedbacks in Earth System Models (ESMs).

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P-857A

Derivation and harmonization of soil data for SWAT+ modelling in European catchments

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Knowledge on how processes in water and nutrient cycling will respond to climate and land use change is crucial for designing climate-smart water and agricultural management. Analysing the impact of these changes on water and nutrient retention at the catchment scale requires detailed spatial information about the soil properties.

In the OPTAIN (H2020) project we use the Soil and Water Assessment Tool (SWAT+) to quantify the effects of natural/small water retention measures (NSWRMs) on crop production and the environment at catchment scale. The model requires a variety of soil-related input, such as soil layering, rooting depth, crack volume, moist bulk density, available water capacity, saturated hydraulic conductivity, organic carbon content, clay, silt and sand content, rock fragment content, moist soil albedo of the top layer, USLE soil erodibility factor and soil nutrient content.

The project is concerned with 14 European case studies where the availability of soil data is diverse in terms of resolution, type of available soil properties and measurement methods. Therefore it was important to convert the available data into soil variables used by the SWAT+ model and, if needed, derive the missing data. We present the workflow for the derivation and harmonization of soil data used for European applications of the SWAT+ model. Special emphasis is put on the calculation of soil physical and hydraulic properties, mapping soil phosphorus content and harmonizing particle size distribution data.

The OPTAIN project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 862756.

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P-858

A new approach for estimation of parameters and uncertainties for common models of soil hydraulic properties

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Soil hydraulic parameters are used in conductivity and retention models and required for the simulation of water movement in the unsaturated soil. Water movement affects directly solute transport as well as plant nutrition. These parameters are commonly obtained through data fitting procedures. General solvers can be used for this purpose, however there are software focused in this task. The uncertainty of a parameter is generally estimated through the formula

$\sigma^2 * Hi = C$

where σ^2 is the variance, Hi is the inverse of the Hessian matrix and C is the covariance matrix [1]. Although the above equation provides good results to the uncertainty when the deviations are low, the exactness tends to lower as the deviation increases [2], leading to an error on the uncertainty estimation. In this work, we propose a new fitting procedure, allowing independent calibration of the parameters of the retention and conductivity functions, including the estimation of parameter uncertainty. The results show a more flexible parameter estimation and more robust parameter uncertainty deviations, allowing a more practical use of the uncertainties.

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P-859

Effect of percolation in frost soil on hydrological simulation in a cold climate watershed in Northeastern Japan

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Uncertainty of frozen-soil hydrology is a challenge in material cycle prediction under changing environment in cold climate regions (Wang et al. 2020). Objectives of this study were to build a basin-scale hydrological model that can simulate frozen-soil percolation, and to analyze the effect of water movement in frozen soil on the basin hydrology.
Two modules were added to Soil and Water Assessment Tool (SWAT): a soil temperature equation that considers heat conduction of soil-snow layers, and phase change of ice and liquid water (Qi et al. 2016), and a frozen-soil percolation model that considers interception by soil ice (Iwata et al. 2011). Original and modified SWAT were setup in Tokoro River watershed, Northeastern Japan, from 2012–2019, and the performance in river flow and soil temperature estimation were evaluated. Furthermore, soil percolation and soil water content estimated by both models were compared.
Original SWAT underestimated soil temperature in winter, but the modified SWAT reproduced the observed trend of soil temperature well. Modified SWAT showed a better performance in river flow simulation. When soil frost weakly developed, the modified SWAT simulated higher soil water percolation on March than the original SWAT by 2.4–22.3 mm/month. At that time, the original SWAT simulated higher soil water content than the modified SWAT by 1.9–30.1 mm. It indicates that original SWAT, which ignores frozen-soil percolation, overestimates soil water contents in early spring when the soil frost is shallow. Therefore, the water movement in frozen soil is a key process of hydrology in cold climate regions.

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P-860

Water and salt budgets in Mediterranean perennial crops grown in the Roxo Irrigation District, southern Portugal

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Secondary salinization risks have long been reported in the Roxo Irrigation District (RID), in southern Portugal, due to use of saline prone irrigation water and the existence of poor structured soils. This study evaluates the soil water and salt budgets in RID field sites with olive, almond, pomegranate, and citrus orchards using the HYDRUS-1D model during the 2019 and 2020 growing seasons. Model calibration was performed through inverse modelling of soil water contents measured in each site during 2019. Data on the electrical conductivity of the soil saturation extract paste measured monthly in those sites was also used in the calibration process. The modelling approach included the computation of evapotranspiration potential fluxes by the FAO Penman-Monteith with the application of the dual crop coefficient, the simulation of the electrical conductivity of the soil solution as a nonreactive tracer, and the Feddes (1978) and Maas and Hoffman (1977) approaches for quantifying root zone stressors. The data collected in 2020 was then used for model validation, with results assumed as baseline for scenario analysis. Soil salinization risks and respective leaching requirements were then quantified based on irrigation needs for a typical wet, normal, and dry average year, assuming a probability of exceedance for crop irrigation needs of 20, 50, and 80%, respectively.

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P-861

Determination of soil water retention curves using thermal conductivity curves and simple parameters

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Soil water retention curves (SWRC), which represent the relationship between soil pressure head (h) and water content (θ), are essential for studying water flow and solute transport in soils. There is no single laboratory device available for measuring a SWRC from dry to saturation. It is common to describe a SWRC with the van Genuchten (VG) model, which includes saturated water content (θs), residual water content (θr), and three parameters: α, m, and n (1/(1-m)). In this study, we present two approaches for estimating the VG model parameters. In approach 1, α and n are determined from soil texture and bulk density (ρb). In approach 2, the information of soil texture, ρb, and a θ measurement at -30 kPa are used to estimate α and n. For both approaches, θr is estimated from the thermal conductivity curve λ(θ), and θs is obtained from ρb. The two approaches were evaluated with laboratory and field measurements on 41 soils of various textures, ρb values, and θ ranges. Results showed that for repacked, undisturbed, and field soils, approach 1 had average root mean square errors (RMSEs) of 0.05, 0.08 and 0.06 m3/m-3, respectively, and the corresponding values of approach 2 were 0.04, 0.03 and 0.06 m3/m-3, respectively. Both approaches have the potential to provide accurate SWRCs.

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P-863

Modelling phosphorus dynamics in European agricultural soils and assessing phosphorus policy goals

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Phosphorous (P) is an essential macronutrient for all plant growth. P fertilizers are made from non-renewable geological P deposits or organic sources. Unfortunately, plants take up only part of the P from fertilizers applied to agricultural systems. Much of the P mobilized by humans is transformed into insoluble compounds and ends up in aquatic systems. To come up with effective solutions for this environmental problem, we need to be able to depict the P cycle in agricultural soils. However, we currently lack a spatially explicit P model, which hinders the prediction of the P flows, interactions with other biogeochemical elements, and the possibility to predict the effect of management scenarios.

Here, field observations of long-term agricultural trials are used to calibrate and validate the P cycle into a daily-time step biogeochemical model used to simulate carbon, nitrogen, and P fluxes between the atmosphere, vegetation, and soil. This model enables the exploration of the full P cycle in agricultural soils including P input (mineral, organic), P export (via plant harvest, erosion, leaching), and the transfer among soil P pools. A large-scale European wide integration will assess the current state of the P cycle, as well as advance prediction capabilities of planned policy scenarios such as the estimation of decreasing P fertilization aimed in the Farm to Fork Strategy goals of the European Commission (reduce fertilizer use by at least 20%). This model will help connect soil science and land management policy and be of assistance in developing management strategies for policymakers.
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P-864

Differences in the mineralogy and geochemical composition of oxidized and waterlogged acid sulphate soils in northern Sweden.

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Acid sulphate soils (ASS) are a common feature along Swedish coastlines and they have the potential to cause significant negative environmental and economic impacts. One of the major sulphide minerals found in ASS is pyrite. Its oxidation generates sulphuric acid which leads to the dissolution of rocks, acidification of aquifers and mobilization of heavy metals. We present the mineralogy and the chemical elements distribution (Raman spectroscopy, SEM-EDS and ICP-SFMS) of one oxidized and one waterlogged soil profile from four sites in northern Sweden (Luleå) (Gunnarsson, 2018). According to the degree of oxidation, it was possible to recognize different zones (oxidation, transition, and reduction). Our results suggest that changes in the groundwater table generates variations in the zone's thicknesses. The oxidized profiles show a thicker oxidation zone compared to the transition zone as the groundwater table is permanently lowered. The waterlogged profiles show opposite results due to varying groundwater levels. Fe and S concentrations in all profiles ranged between 2.5 to 5 wt% (±4.1 wt%) and 0.1 to 2.3 wt% (±1 wt%). The transition and reduction zones of the oxidized profiles present the highest concentrations of Fe and S. The distribution of these elements over the profiles is consistent to the electron images, which show framboidal (and cubic) pyrite in both the transition and reduction zone. The pH presents its highest values in the waterlogged profiles, which increase with depth and permit us to identify intact framboidal pyrite. Varieties in sulphide minerals could explain the differences in oxidation rates zones.

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P-865

Pseudoacid sulfate soil materials

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An important issue to consider during mapping and classification of acid sulfate soils (ASS) is how to handle soil materials where the pH due to sulfide oxidation drops considerably during soil incubation, or during field conditions, to values close to, but not triggering, the diagnostic criteria for classification as an ASS. Using current international classification systems, such soils are considered non-ASS even though their possible environmental impact, e.g. release of acidity and metals (especially Al), may potentially be very high (e.g. Mattbäck et al., 2017; Mattbäck et al., 2022). Mapping of ASS in Finland and Sweden have shown that areas with this type of soils can be quite large.

In the Finnish and Swedish ASS classification, the term pseudo acid sulfate soil, first described by Pons (1965), has been re-introduced to describe a soil not fulfilling the ASS criteria, but which may have a considerable environmental impact due to sulfide oxidation. It has been shown that pseudo ASS materials may contain higher acidities than coarse grained AS soil materials, which due to poor buffering capacities expresses sub-four pH-values upon sulfide oxidation even though the sulfide concentration is also low. Pseudo ASS materials include “pseudo sulfuric material”, which is characterised by a pH of 4.0–4.5 in the oxidised horizon for mineral soil materials and between 3.0–3.5 for organic soil materials, and “pseudo hypersulfidic material”, which during incubation display a pH-drop of ≥0.5 units to values between 4.0–4.5 and 3.0–3.5, for mineral and organic soil materials, respectively.

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P-866

Acid Sulphate soils: how to safely oxidize and reuse excavated soils

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Sulphide soils are common along the coasts of the Baltic Sea. These soils are extremely sensitive to changes in their redox state and are a threat to the environment. Construction of infrastructure and buildings excavate these soils, which are usually classified as hazardous waste and normally deposited with extra cover material. We present the chemical and mineralogical composition of the three main zones (oxidized, transition, reduced) of an acid sulphate soil profile from Skellefteå (northern Sweden). Major and trace element compositions of whole rocks and soluble phases (Dold, 2003; Rizq, 2020) (ICP-SFMS), and SEM were used to focus on the occurrence of framboidal pyrite. Electron images showed the occurrence of framboidal pyrite in all three zones of the ASS profile. With increasing framboidal pyrite concentrations from 0.5% in the oxidized zone towards 35% in the reduced zone. Contrarily the organic matter concentration decreased from 29 to 0.5% from the oxidized towards the reduced zone. The relationship between the organic matter and framboidal pyrite suggests that organic matter is important for this kind of pyrite formation. Element screening showed a strong depletion of S and sulphide-associated trace elements such as Cd, Cu, Ni and Zn, due to the oxidation of Fe-sulphides during exposure in the oxidized zone. The results suggest that the oxidation of iron sulphide minerals in these soils is a fast process, and that controlled oxidation of the soils will allow the reuse of the material for construction purposes (Rizq, 2020).

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P-867

Recent developments at the Risöfladan Experimental Field

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Agriculture on a boreal acid sulfate soil is usually both possible and very successful once the pH of the plough layer has been raised to a suitable level. However, the soil horizon below the plough layer and down to drainage depth is not affected by liming activities at the surface, and the drainage water from this soil layer is still very acidic and rich in leached metals.

A 12-hectare experimental field at Risöfladan (Vaasa, Finland) is an integral part of a series of projects. By utilizing the subsurface drainage system, treatment chemicals mixed with irrigation water are injected into the environmentally critical subsoil. The experimental field is divided into twelve 1-hectare subfields, each with its own drainage system. Every subfield is surrounded by a plastic sheet that extends from about 0.4 m below the surface down to about 1.9 m. This sheet prohibits hydraulic contact between the subfields and between the subfields and the open ditches.

In the present project, Sustainable productive farming with the PRECIKEM method (ProPRECIKEM), a novel system of injection pipes is installed in two subfields. These pipes lie about 50 cm above the drainpipes and enables injection of the treatment suspension into the structured upper subsoil.

In order to make the method useful for farmers, novel equipment has been developed for the preparation of the suspension by automating the dosing of ultrafine-grained limestone and mixing with river water.

The drainage water from the field has been followed since 2012 (see e.g. Dalhem et al. 2019).

Dalhem, K., Engblom, S., Stén, P. & Österholm, P. (2019). Subsurface hydrochemical precision treatment of a coastal acid sulfate soil. Applied Geochemistry, 100, 352-362.

P-868

Machine learning techniques for acid sulfate soil mapping in southeastern Finland

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Acid sulfate soils are one of the most environmentally harmful soils existing in nature. This is because they produce sulfuric acid and release metals, which may cause several ecological damages. In Finland, the occurrence of this type of soil in the coastal areas constitutes one of the major environmental problems of the country. To address this problem, it is essential to precisely locate acid sulfate soils. Thus, the creation of occurrence maps for these soils is required. However, the traditional methods used for acid sulfate mapping are very laborious and time-consuming. Nowadays, different machine learning methods can be used following the digital soil mapping approach. Machine learning techniques can streamline the mapping process as well as improve its accuracy. The main goal of this study is the evaluation of different supervised machine learning techniques for acid sulfate soil mapping. The methods analyzed are Random Forest, Gradient Boosting and Support Vector Machine. Our results show that both Gradient Boosting and Random Forest are suitable methods for the classification of acid sulfate soils, the resulting probability maps have high precision. However, the Support Vector Machine is not able to correctly distinguish acid sulfate soils. In addition, it overestimates non-acid sulfate soil occurrences, leading to a probability map with less accuracy.
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https://doi.org/10.1016/j.geoderma.2021.115446

P-869

Optimization of sampling and laboratory approaches using chip-tray methods for improved assessment, classification and communication of acid sulfate soils

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Chip-trays are plastic containers (50.5 cm long, 5.5 cm wide, 3.5 cm deep) that contain multiple compartments/cells that can be closed with a snap lock lid (i.e. partly air-tight). For 2 decades we have used chip-trays in a wide range of acid sulfate soil (ASS) investigations globally. Chip-trays as a tool for collecting and characterising ASS has proved essential for environmental risk assessment, monitoring campaigns, community volunteers in citizen science projects and mineral exploration to collect, describe and test samples to identify ASS materials. This paper focuses on adaptations to ASS protocols that rely on the use of chip-trays in the development of improved field sampling, archival storage and moist incubation methods to better characterise and classify a wide range of ASS with sulfuric, hypersulfidic, hyposulfidic, and monosulfidic materials. Field protocol involves soil sub-samples to be placed in two separate chip-trays. The first chip-tray is used to display the morphology of representative intact aggregates for visual description. Salt efflorescences and/or mineral precipitates are also placed in separate cells for mineralogical analyses. The second chip-tray is used for laboratory incubation testing, via maintaining optimum ASS oxidation conditions to inform risk assessment. Compartments are filled to approximately ⅓ full with soil and kept moistened (not saturated) with deionised water. The pH is re-measured incrementally over 8-weeks (and/or longer periods) of incubation, and soil is visually checked for formation of minerals (e.g. jarosite), to assess whether acidification (e.g. pH<4) has occurred. The chip tray method results were assessed against conventional acid-base accounting methods.

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P-870

Formation of acid sulphate soils along coastal hydro-toposequences in the southern Baltic Sea region

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Soils of the coastal flat plains in the southern Baltic region demonstrate a recurring pattern of spatial distribution (Hulisz 2013). There is a similar, small-scale variation in soil morphology and properties, depending on the local geomorphological and hydrological conditions. It can be referred to as a topohydrosequence, which occurs within beaches (near the waterline), beach ridges or micro-cliffs fixed by vegetation, and small, wet depressions filled with organic sediments (farthest from the waterline). Four soil sequences located in Germany (Greifswald Bay) and Poland (Puck Lagoon) were selected for the study. Soils within the sequences were affected by sea flooding during storms and shallow ground waters rich in sulfates (up to 1.5 g·dm-3). It was revealed that the lack of regular sea tides and the occurrence of organic soils contributed to the increase of degree of soil sulfidization along the sequences with the distance from the waterline together with the salinity level. This phenomenon was usually observed in the limited (100 m) zone from the water line. The highest pH drops to values below 3.5 after sample oxidation and lowest C:S ratio values (< 10) were recorded farthest from the waterline. The spatial pattern of salinization and sulfidization was opposite to that found in the sequence of tidal salt marsh soils from the North Sea coast (Hulisz et al. 2013). We believe that our findings help to understand the soil variability at small (topical) scale on selected coastal sections of the Baltic Sea, where potential acid sulfate soils dominate.

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P-871

Dredging and deposition of metal sulfide rich river sediments results in rapid conversion to acid sulfate soil materials

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Baltic coastal sediments can contain considerable amounts of metal sulfides that if dredged and exposed to air, can rapidly release high concentrations of acid and toxic metals into recipient water bodies. Two river estuaries in western Finland were dredged from 2013¬ to 2018 and the deposited dredge spoils were limed to buffer the pH and mitigate acid and metal release. Geochemistry and 16S rRNA gene amplicon based microbial communities were investigated over time to explore whether the limestone prevented a conversion of the dredge spoils into acid producing and metal releasing soil. The dredge spoils pH decreased with time indicating metal sulfide oxidation and resulted in elevated sulfate concentrations along with a concomitant release of metals. Calculations indicated only approximately 5% of the added limestone had been dissolved. The microbial communities decreased in diversity as taxa most similar to extremely acidophilic sulfur, and in some cases iron oxidizing Acidithiobacillus species became the dominant characterized genus in the dredge spoils as the oxidation front advanced. Other taxa characterized as involved in oxidation of iron and sulfur were identified including Gallionella, Metallibacterium, Sulfuricurvum, and Sulfurimonas. These data suggest a rapid conversion of the dredge spoils to severely acidic soil similar to actual acid sulfate soil and the liming efforts were insufficient to halt this process. Hence, future dredging and deposition of sulfidic dredge spoils should not only take into account the amount of limestone used for buffering but also its grain size and mixing into the soil.

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P-872

Transformation of jarosite during remediation of a sandy sulfuric soil

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When acid sulfate soils dry, oxidation of pyrite causes acidification and formation of iron oxyhydroxy sulfate phases such as jarosite. Remediation by re-establishment of anoxic conditions promotes jarosite transformation to Fe oxyhydroxides and/or Fe sulfides, and the transformation product type strongly affects the potential re-acidification risk. We investigated a sandy, jarosite-containing soil (initial pH = 3.0, Eh ~600 mV) in a 15-week laboratory incubation experiment under submerged conditions, either with or without wheat straw addition. Additionally, a model soil composed of synthesized jarosite mixed with quartz sand was used. Eh and pH values were monitored weekly. Solution concentrations of Fe, S, and K were analysed at the end of the experiment. Mössbauer spectroscopy and X-ray diffraction were used to characterize the mineral composition of the soils. Only when straw was added to natural or artificial sulfuric soil, the pH increased to 6.5, and Eh decreased to about 0 mV. The release of Fe, K, and S into the soil solution indicated redox- and pH-induced dissolution of jarosite. Mineralogical analyses confirmed jarosite loss in both soils and formation of Fe oxyhydroxides such as goethite and lepidocrocite. Non-sulfidized, probably organically associated Fe(II)/Fe(III) occurred in both soils, but no (re-)formation of Fe sulfides. Unlike Fe sulfides, the formed Fe oxyhydroxides are not prone to support re-acidification in the case of future aeration. Thus, inducing moderately reducing conditions by moderate supply of organic matter could be a promising way for remediation of soils and sediments acidified by oxidation of sulfuric materials.

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P-873

Iron and sulfate reduction dynamics in coastal soils undergoing seawater inundation from sea level rise

Ms Emily Leyden, Dr Juraj Farkas, Dr John Hutson, Associate Professor Luke Mosley

Sea level rise induced seawater inundation will begin to change the biogeochemical cycling of iron, sulfur and carbon in coastal wetland soils. By progressively inundating intact soil cores collected from a saltmarsh/mangrove transect in South Australia with seawater, we were able to observe how coupled iron and sulfate reduction occurs over longer time scales (19 months) and in soils with different organic carbon (TOC) contents, at specific depth intervals (10 cm intervals, 0 - 60 cm total length). Soils with high organic carbon rapidly induced iron and sulfur reduction as anoxic conditions established, evidenced by free Fe+2 and H2S in the dissolved fraction. The free Fe+2 and H2S chemically bound to create iron sulfide (FeS) compounds, evidenced by increased AVS and CRS. As inundation progressed, iron reduction began to slow, due to limited iron hydroxides available to be microbially reduced. Microbially meditated sulfate reduction continued as abundant sulfate was available in the incoming seawater. In the absence of Fe+2, H2S was able to build up in the porewater, but only in those soils inundated for more than 13 months, and with greater than 5% TOC. This study gives new insights into the biogeochemical cycling of iron and sulfur in soils with differing total organic carbon contents at longer timescales and illustrates that sulfidization will affect coastal wetland soils as sea levels rise progressively over the next century.
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P-874

Comparing small scale (1:250 000) and large scale (1:20 000) acid sulfate soil mapping results in Simojoki catchment area, Finland

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The Geological Survey of Finland completed the mapping of acid sulfate soil (ASS) occurrence in 2020 (GTK, 2021), covering coastal areas (~50 000 km²) in Finland below the highest shoreline of the ancient Littorina Sea. The mapping started in 2009 and was performed in a scale of 1:250 000. Since 2011, ASS mapping has been one of the key actions mentioned in the national ASS strategy prepared by Ministry of Agriculture and Forestry and Ministry of the Environment (MMM, 2011). Systematic mapping with common methods locates the occurrence of ASS. Thus, sampling and further studies can be targeted to areas most vulnerable to negative impacts of ASS.

Simojoki catchment area is located in the southern part of the Lapland region. Simojoki river drains into Bothnian Bay and has been an important salmon habitat for centuries. Salmon is one of the fish species that suffers the most from the leaching of acidity and metals from ASS.

Small scale mapping (1:250 000; 61 observations; ~1,5 observations/ km²) in the Simojoki catchment area was carried out during 2012-2014, focusing mainly on fine-grained sorted sediments. Detailed mapping (1:20 000) in three study areas (in total 89 km²) was performed in 2016 with 62 additional observations, including also coarse-grained sediments and tills.

In the detailed maps, the extent of areas classified as a medium and high probability for ASS occurrence increased compared to the small scale maps. In the near future, the results will also be compared to digital soil maps, created using modelling techniques.

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P-875

Finnish Acid Sulfate Soil Land Systems

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The concept of land systems was introduced by Christian & Stewart (1953) and define areas of similar geology, soils, land cover and land use. Land systems are often used to study and describe the relationship between people and their environment (Reenberg, 2006). The term “land system” have previously been mentioned in papers dealing with AS sulfate soils (Pons et al., 1982; Pons & van Breemen, 1982; Madsen & Jensen, 1988), and we intend to elaborate this further by identifying and describing AS soil land systems in Finland, based on the type of AS soil material, land cover and land use (e.g. agriculture, sand mining, peat excavation), landforms (e.g. estuaries, peat bogs, river valleys etc.), hydrology and sulfur geochemistry.

The goal is characterize the main types of AS soil materials and AS soil land systems in Finland by utilizing data from the national mapping of Finnish AS soils (25 000+ observation) together with LiDAR derived covariates, geological data and land cover data to produce conceptual models of the AS soil land systems. By fulfilling this goal, we wish to improve sustainable land use planning on areas with actual or potential AS soils by information in a new way to the Finnish authorities. This study will be an important step towards developing AS soil risk maps, which complement the national AS soil probability map that show the possibility of AS soil occurrences but not the environmental risk.

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P-876

Predictive mapping of Acid Sulfate Soil along the Bothnian coast

Dr Gustav Sohlenius, Dr Marina Becher, Quaternary geologist Christian Öhrling

Acid sulfate soil (AS-soil) can cause significant economic, environmental, and health-related issues due to its ability to lower pH and mobilize elements to surface waters. With machine learning, we have produced a map of AS-soil occurrence along the Bothnian coast in Sweden, where these soils are commonly occurring. These AS soils are usually associated with organic-rich clay and silt sediments that were deposited, and reduced during anoxic conditions, in brackish-water environments. Due to the postglacial isostatic rebound these potential AS soils have been uplifted.
The map predicts the distribution of three classes: 1) No acid sulfate soils, 2) Active on top of potential acid sulfate soil, and 3) Potential acid sulfate soil. The model was produced by using data from 1 135 sites that were classified by using pH data. This data was used together with other geographical data such as maps of Quaternary deposits, and most importantly a high-resolution digital elevation model based on LiDAR from which several derivatives was extracted. The modelled map shows that active AS-soils are common in flat areas with fine-grained sediments close to the sea level where the groundwater level has been lowered by ditches. Potential AS-soils are common in peat covered wetlands and is found in larger geographical area compared to active acid soils.
The map can be used during planning of infrastructure projects, ditch cleaning and to take actions to mitigate the negative influence from AS-soils or for recognising sites suitable for restauration of wetlands to prevent further negative influence.

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P-877

Biogeochemical cycling in palustrine wetlands in Puerto Rico

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Wetlands provide essential ecosystem services which are largely anthropogenically disrupted. It is essential to enact progressive measures for wetland recuperation, restoration, and protection. Ecological indices to establish the degree of human intervention, document improvement, and define costs of recovery endpoints are needed. 151 palustrine wetlands in Puerto Rico, distributed among forested and emergent categories were ranked according to the degree of anthropogenic disturbance. Twelve wetlands corresponding to most impaired sites and reference wetlands (i.e., best attainable conditions) were chosen for sampling. Soils were sampled and analyzed for (i) detritus decomposition rates, (ii) reduction of iron and manganese oxide, (iii) soil enzyme activities, (iv) nitrification rates, (v) composition of communities of ammonia oxidizers and denitrifiers, (vi) soil respiration, (vii) microbial biomass C and N, and (viii) labile C. 30-d detritus decomposition mass loss ranged from 79.6 a 85.8% and 28.9 y 37.6% for green and red tea, respectively. The incubation time exceeded the validity of the assay to calculate stability (S) and rate (K) constants. Soil enzyme activities decreased with soil depth with maximum values in the organic soil horizons. Sheets indicative of iron and manganese reduction in soils (IRIS and MRIS, respectively) had depletion rates of 5 to 13%/day for IRIS and 38 to 50% for MRIS. Results indicate that the parameters selected can serve to discriminate among wetlands having contrasting nutrient inputs and productivity.
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P-878

Quantification of the leakage of cadmium and nickel from acid sulfate soils in western Finland

Dr Janne Toivonen, Dr Anton Boman

The coastal plain of western Finland is to a large part underlain with sulfide-bearing sediments. Due to drainage for agriculture and forestry, acidity and metals are flushed to nearby streams. The water quality in many water courses in the area exceeds the environmental quality standards (EQSs) set in the EU:s Water Framework Directive (2000/60/EC) regarding Cd and Ni. European water policies commits states to achieve good ecological and chemical status of all water bodies. The aim of this study is to examine the yearly load of Cd and Ni carried to the Baltic Sea from a region in western Finland. Rivers are relatively easy-monitored, while the load from the numerous streams draining areas between the river catchments remains more or less unknown.

The load of Cd and Ni is calculated as a flow weighted average for each river. The rivers (drainage area > 100 km2, n=17) drain a total area of 17 164 km2. A selection of small streams n=31) was chosen to represent the catchments between the rivers (2 441 km2). The total yearly load carried to the Baltic Sea is 0,69 t Cd and 79 t Ni. Of this load, the small streams contribute with 26 and 21 %, respectively, even though they drain only 12 % of the area. This confirms the importance of understanding the diffuse load carried by small unmonitored streams from the nearest field.

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P-879

Reconstructing the spatial distribution of historic bog iron ore deposits in the Bourtangermoor, a former raised bog in the Netherlands

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The location of bog iron ore deposits is determined by groundwater seepage. Bog iron ores in raised bogs will thus provide information on the interaction between a developing bog and its underlying groundwater system. Yet recent research focusses mainly on its chemical and mineralogical composition. In our research we used present-day groundwater data from wells in the subsurface of the Bourtangermoor, a former extensive raised bog in the Netherlands. We used the waterhead heights of the aquifers to locate seepage areas and compared these visually in ArcGIS with bog iron ores mapped on historic maps and bog iron ore data found in historic peat research performed in the Bourtangermoor when it was still partly intact. Our seepage calculations showed two distinct seepage patterns: shallow (above) and deep (below) the only continuous clay layer in the subsurface (30–40 m below surface). Classic-type bog iron ores (limonite and goethite) were mapped on historic maps along natural streams and showed a visual overlap with shallow seepage and surface water runoff. Bog iron ores described in historic peat research had a different mineralogy and showed a visual overlap with deep seepage. These deposits occurred low within the peat column and consisted of siderite (Fe-carbonate) and vivianite (Fe-phosphate), minerals containing reduced iron and thus deposited under anaerobic conditions. We conclude that recent seepage can be used as a proxy for historic bog iron ores. However, multiple seepage patterns can exist, relating different bog iron ore types to seepage from different aquifers.

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P-880

Soil nutrients cycling and carbon sequestration under medium and long-terms organic management in Central Italy

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Currently, there is a scientific interest on the impact of the application of the so-called carbon (C) farming practices (Sharma et al. 2021) to mitigate climate change by increasing carbon sequestration and, at the same time, improving soil quality in terms of nutrients cycling. In this pair plot study, we compared organic and conventional agriculture areas at different locations in Central Italy. At the different locations, the selected organic farming fields were converted since a period varying from 7 to almost 20 years. Mineral soil samples were collected at different depths down to 30 cm, in three plots per area and characterized for their physical and chemical properties and for their soil organic C (SOC) and nitrogen concentration by dry combustion. In general, the fields under organic management showed significantly better soil nutritional conditions; with increased level of total nitrogen, while a consistent increase in total organic carbon was only detectable on the long term (e.g., 15 years). Results of the study suggest that, over the period of 7 year, organic management method used in the organic agriculture (e.g., reduced till, organic fertilizer) in a Mediterranean environment strongly affects nutrients cycling and soil quality indicators, while a clear impact on the SOC content and relative stocks can be observe only on the long-term.
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P-881

Future precipitation increases will reduce nitrogen use efficiency and alter optimal fertilisation timings in agriculture

Dr Daniel Mckay Fletcher

Nitrogen fertilisation is vital for productive agriculture and efficient land use. However, approximately 50% of the applied nitrogen is lost globally to the wider environment causing inefficiencies, pollution, and greenhouse gas emission. Rainfall, through its effect on soil moisture, plays a major role in determining nitrogen losses in agriculture, thus changing rainfall patterns can accelerate nitrogen inefficiencies. We used a mechanistic modelling platform to determine how precipitation-optimal nitrogen fertilisation timings and resulting plant nitrogen uptake have changed historically (1950-2020) and how they are predicted to change under the RCP8.5 climate scenario (2021-2069) in the South East of England. Results showed that neither historic optimal fertilisation timings nor their resulting plant uptake changed significantly in the rolling mean over decadal intervals. In the 2030s, where wetter conditions are expected, optimal fertilisation timings are predicted to be later in the season and the resulting plant uptake is noticeably lower. After 2040 the optimal uptakes are projected to increase and the optimal timings decrease closer to the historical values, corresponding to the projected mean daily rainfall rates decreasing to the historical values in these years. However, projected inter-annual variation in optimal uptake is expected to increase, which is possibly related to the projected increase in the number of extreme rainfall events in these years. Ultimately, projected changes in precipitation patterns will affect nitrogen uptake and optimal fertilisation timings. Bespoke fertilisation strategies which use the short-term weather forecast in each growing season are recommended to optimise crop nitrogen uptake in uncertain climates.
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P-882

Effects of organic fertilizers pre-treatment on soil organic carbon stocks along the agricultural soil profile

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Organic fertilization has been widely used to increase soil organic carbon (SOC) stocks, to boost soil fertility and, therefore, to maintain sustainable agriculture. The long-term effects of different organic fertilizers on SOC stocks and soil fertility, particularly in subsoil, need accurate investiga-tion. Here, we investigated the influence of different pre-treated organic fertilizers (i.e. pig slurry unseparated, solid and liquid fractions and biodigestate) on topsoil and subsoil OC stocks over several years. In September 2019, we sampled soil to a depth of one metre in two randomized experimental fields running for several years in Catalonia, Spain (Tona site started in 2015 and Mas Badia site in 2014). We quantified SOC and total nitrogen (TN) stocks as well as soil nutrient (NO3-, NH4+, PO43-) contents. For both sites, the highest C concentrations were found at 0-10 and 10-20 cm for all treatments. At the Tona site, the soils receiving the solid frac-tion of pig slurry had the highest OC stocks in the top layer (0-10 cm), while the addition of the liquid fraction of pig slurry had the highest effect in deeper layers (20-80 cm). At Mas Badia site, untreated pig slurry treatment resulted in lower OC stocks than mineral fertilizer and biogas digestate at 0-40 cm depth and higher OC stocks than other treatments at 40-80 cm. The separa-tion of liquid and solid fractions of pig slurry before its use as fertilizer helped to increase profile soil OC stocks compared to untreated slurry or mineral fertilization after five years of application.

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P-883

Recovery of fertility in agricultural soils under greenhouse intensive farming: vermicompost as beneficial source of C, nutrients and microbial activity

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The Plain of Sele river in Campania Region (South Italy) is a flagship area for horticulture crops. In particular numerous farms cultivate baby leaf vegetables under greenhouse, destined for ready-to-eat food (rocket, spinach, lettuce, etc.). This area is also characterized by numerous buffalo and cattle farms representing a great source of organic amendments to counteract the fertility loss of soils under intensive agriculture. Local anaerobic digestion plants for animal sewage sludge produce solid digestate (not suitable to direct spread in soils producing vegetables for ready-to-eat food) that is further treated to produce vermicompost, pathogen-free, non-phytotoxic compost, rich in organic matter and nutrients, also able of containing telluric pathogens and stimulating plant growth. Experimental fields have been prepared in organic and conventional farms to verify how vermicompost affected soil chemical, biochemical and microbiological properties and crop yields and quality. First results have been encouraging as the organic C, phosphorous availability, microbial biomass C, enzymatic activities, microbial diversity, and crop yields were improved in plots received the vermicompost based organic amendment. Vermicompost demonstrated also to counteract the negative effects of solarization, an agricultural practice carried out to control weeds and soil-born pathogens. In addition, vermicompost resulted pathogen free and thus suitable for crops earmarked to ready-to-eat food.
This approach could favour a virtuous network among horticultural crop farms and livestock farms through a circular economy system to validate by analysis of the environmental and socio-economic impact.

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P-884

Greenhouse gas fluxes from sorghum fields in the U.S. Great Plains using eddy covariance: Controlling factors and carbon intensity implications

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Sorghum (Sorghum bicolor) is a major crop in the United States. Approximately 30 to 35% of sorghum produced in the U.S. is used for ethanol production (Yan et al., 2011). Unlike corn (Zea mays), sorghum is cultivated primarily as a dryland crop with less inputs. Accurate estimates of greenhouse gas (GHG) emissions (CO2, N2O, and CH4) at the ecosystem-scale are important in assessing the sustainability of sorghum as an ethanol feedstock. In addition, knowledge about the soil, plant, and environmental variables controlling the diurnal and temporal dynamics of CO2, N2O, and CH4 emissions have been limited. In this study, we used the eddy covariance method to continuously measure CO2, N2O, and CH4 fluxes from a 90-acre sorghum field in the U.S. Southern Great Plains region. The field was managed with minimum tillage and nitrogen fertilizer was not applied during the growing season. Our results indicate that diurnal and growing season CO2 exchange and respiration from the field were strongly affected by soil, plant, and environmental conditions. During the growing season, the field was a net carbon sink with an uptake of approximately 4,200 kg ha-1. The N2O and CH4 emissions in carbon-equivalents was approximately 300 kg ha-1. In addition, we found significant correlation between diurnal N2O emissions and soil heat flux during high emission periods in the growing season. Incorporating results from our study with modelling can improve our understanding of the GHG budget of sorghum cropping systems and its impact on overall carbon intensity of sorghum ethanol production.
Yan, S., Wu, X., Bean, S. R., Pedersen, J. F., Tesso, T., Chen, Y. R., & Wang, D. (2011). Evaluation of waxy grain sorghum for ethanol production. Cereal Chemistry, 88(6), 589-595.

P-885

Biochar Effect on Greenhouse Gas Fluxes from Subtropical Perennial Pastures

Dr Maria Silveira, Dr Yanyan Lu, Dr Joao Vendramini, Mr. Leandro Vieira, Dr. Marta Kohmann

Land application of biochar as a soil amendment is often associated with numerous agronomic and environmental benefits, including greenhouse gas (GHG) mitigation and increased soil C storage. However, most previous biochar studies consisted of short-term experiments, mainly conducted under controlled, laboratory conditions. The limited number of field-scale studies underlines the need for additional field validation. This study evaluated the impacts of co-application of biochar with organic and inorganic fertilizer sources on GHG emissions from subtropical perennial pastures. Treatments consisted of fertilizer sources (inorganic fertilizer and aerobically-digested biosolids) applied at a rate of 160 kg plant available N ha-1 yr-1 with or without biochar (applied at 20 Mg ha-1). Greenhouse gas (CO2, CH4, and N2O) fluxes were monitored using the vented-static chamber technique. Results demonstrated strong seasonal variability associated with GHG emissions from perennial pastures fertilized with organic and inorganic amendments. Fertilizer source had no effect on soil CO2 and CH4 emissions, but annual cumulative N2O emissions increased with biosolids (8 kg N2O ha-1 yr-1) compared with inorganic fertilizer (5 kg N2O ha-1 yr-1). This response was possibly due to the higher total N application load associated with biosolids treatment (240 kg ha-1 yr-1 for biosolids vs. 160 kg ha-1 yr-1 for inorganic fertilizer). Data suggested that environmental conditions played a more important role on GHG fluxes than nutrient additions. Our finding suggests that adding biochar to agricultural soil amended with biosolids and inorganic fertilizer modestly suppressed CO2 emissions (< 9%) but had no effects on N2O and CH4 emission.

NA

P-886

Impact of crops residue in contrasting soils on active pools of organic carbon and nutrients release under varying land use

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Addition of crops residue of wide and narrow C:N ratios are the main input in soils for maintaining soil organic carbon (SOC) and alter the nutrient cycling through mineralization or immobilization turnover. In India, Varanasi and Mirzapur districts of eastern part of Uttar Pradesh fall in the agro-climatic zones of eastern plain and Vindhyan, representing irrigated lowland alluvial soil (Inceptisols) and rainfed upland red soil (Alfisols), respectively. Four cereals residue of wide C:N ratios (rice, barely, maize and wheat) from the Inceptisols of Varanasi and three pulses residue of narrow C:N ratios (gram, lentil and pigeonpea) from the Alfisols of Mirzapur were used in 90 days of incubation study under control condition to estimate the active pools of soil organic carbon and pattern of nutrients release (N, P, K and S). The experiment was laid out in a factorial CRD with three replications. The highest values of water soluble carbon, water soluble carbohydrate and CO_2 evolution were associated with addition of pulses residue as compared to cereals residue over control in both the soils. The results further showed that using pulses residue boosted substantially higher soil microbial biomass carbon over control. Addition of cereals residue had slow release of nutrients (N,P, K and S) up to 45 days and then rapid released at 60 and 90 days. On the other hand, addition of pulses residue had significantly rapid rate of nutrients release (N, P, K and S) up to 45 days and declined at 60 and 90 days.

Singh, S., Sharma, P. K & Singh, S (2021) Nitrogen and sulphur release from added millets and oilseeds residues in Indo-Gangetic Black and Alluvial soils of Varanasi. Journal of the Indian Society of Soil Science, 69 (2) 216-219.

P-887

Modeling Long-Term Land Use and Soil Managment Changes with the DayCent Model in the Planalto Médio (RS - Southern Brazil)

Dr Carlos Tornquist, Dr. Ana Caroline Messias Magalhães, Dr. Ricardo Bergamo Schenato

Biogeochemical models are useful tools to assess the effects of land use and soil management changes on soil properties under climate change scenarios. We conducted a spatially-explicit application of DayCent model (Del Grosso et al., 2001; NREL, 2021) to estimate soil C (SOC), nitrogen and greenhouse gas (GHG) in the Planalto Médio of Rio Grande do Sul state (RS), a subtropical region (6670 km2) in Southern Brazil. Soybeans is the dominant cash crop, under major soil management changes (adoption of no-tillage system) for several decades. A geospatial database was compiled with soil/land use status (2015 baseline). Additionally, daily meteorological data from stations within the study area were used to create unique combinations of soils, land use (2015) and climatic regions, which resulted in 34 simulation units. Current (business-as-usual) and alternative land-use scenarios (including forestry/crop integration and conversion to perennial pasture) were simulated in DayCent, using RCP 4.5 and 8.5 future climate scenarios to 2099 – as presented in IPCC AR5 (IPCC, 2014). Our long-term predictive simulations with the DayCent model showed that climate change as predicted in this region would result in larger SOC and N stocks, whereas GHG emissions would also be higher. Soybean growth would be favored by predicted climate change, whereas alternative cropping systems such as perennial pastures would increase SOC stocks in all climate scenarios. These results highlight the importance of cropping systems with high C inputs to the soil to maintain current C stocks, especially under predicted climate scenarios that would favor SOC decomposition.
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NREL - NAtural Resources Eology Lab. Daycent Model. https://www.nrel.colostate.edu/projects/century/index.php. Acessed in Dec. 2021.

P-888

Impact of crops residue in contrasting soils on active pools of organic carbon and nutrients release under varying land use

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Addition of crops residue of wide and narrow C:N ratios are the main input in soils for maintaining soil organic carbon (SOC) and alter the nutrient cycling through mineralization or immobilization turnover. In India, Varanasi and Mirzapur districts of eastern part of Uttar Pradesh fall in the agro-climatic zones of eastern plain and Vindhyan, representing irrigated lowland alluvial soil (Inceptisols) and rainfed upland red soil (Alfisols), respectively. Four cereals residue of wide C:N ratios (rice, barely, maize and wheat) from the Inceptisols of Varanasi and three pulses residue of narrow C:N ratios (gram, lentil and pigeonpea) from the Alfisols of Mirzapur were used in 90 days of incubation study under control condition to estimate the active pools of soil organic carbon and pattern of nutrients release (N, P, K and S). The experiment was laid out in a factorial CRD with three replications. The highest values of water soluble carbon, water soluble carbohydrate and CO2 evolution were associated with addition of pulses residue as compared to cereals residue over control in both the soils. The results further showed that using pulses residue boosted substantially higher soil microbial biomass carbon over control. Addition of cereals residue had slow release of nutrients (N,P, K and S) up to 45 days and then rapid released at 60 and 90 days. On the other hand, addition of pulses residue had significantly rapid rate of nutrients release (N, P, K and S) up to 45 days and declined at 60 and 90 days.

Singh, S., Sharma, P. K & Singh, S (2021) Nitrogen and sulphur release from added millets and oilseeds residues in Indo-Gangetic Black and Alluvial soils of Varanasi. Journal of the Indian Society of Soil Science, 69 (2) 216-219.

P-889

Effects of carbon supplementary on soil carbon dynamics and microbial community

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Soil organic carbon (SOC) plays an important role in agricultural carbon cycle and soil micro ecology, which is affected by different material organic matters (OMs) inputs. The present study evaluated the impact of OMs (Corn straw, CS；tobacco stalk, TS; peanut shell biochar, PB) on carbon dynamics and microbial diversity in cinnamon soil. The results showed that OMs application increased SOC level significantly. During a 70-day incubation, soil total organic carbon (TOC) content changed slightly, particulate organic carbon (POC) increased greatly, while the dissolved organic carbon (DOC) and soil mineralizable organic carbon (SMC) decreased greatly. PB treatment exhibited the highest increase of POC/TOC from 31.19% to 58.53%, followed by CS with lower level in TS and CK treatments. CS treatment showed higher AOC content and AOC/TOC values during the whole incubation period compared to other treatments. OMs application also increased soil bacterial diversity and the relative abundance of Proteobacteria with the highest in TS treatment which also showed significantly higher cbbM and cbbL genes expression compared to other treatments. These results suggested that PB treatment facilitated carbon stock in soil. Both of CS and TS treatments showed carbon activation effect, which acted on carbon activity, Proteobacteria and cbbM/cbbL genes, respectively.
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P-889A

Evaluating efficacy of novel green fertilisers derived from carbon capture technology into organic waste materials

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Over reliance and indiscriminate use of mineral fertilisers (MF) have contributed towards declining soil health. Furthermore, MF production contributes close to 1% of UK's greenhouse gas emissions. Organo-mineral fertilisers (OMFs) are currently being investigated as a more environmentally sustainable alternative to MF as they reduce its amount by combining with organic materials. This promotes circular economy by returning recycled nutrients to the soil. Here we evaluated the efficacy of a novel OMF that entailed capturing point source carbon dioxide into organic waste materials. A field trial was carried out involving 80 plots, each 12 m^2 distributed in a randomised block design using three OMF formulations (5, 10 and 15%N) and compared them to a MF and control in two soil types and two crops (winter barley and winter wheat). Four doses comprising 50%, optimum (100%), 150% and 200% of each formulation was applied. For the optimum dose yields for winter barley and winter wheat were 6 and 7.2 t/ha respectively. We found that all fertilisers produced significantly more yield than the control ($p < 0.05$) but that there were no significant differences between the fertilisers. There were no significant differences between the stimulated root growth for any treatments ($p = 0.60$) and the same for organic matter, microbial biomass, pH, available and total nutrients (N, P, K) and metals. This leads to the conclusion that OMF can perform at least as well as MF. Further work in progress to assess fertiliser efficacy and carbon sequestration over coming seasons.

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P-890

Soil Organic Carbon and Nitrogen Dynamics in the North-eastern Basin Ecosystem of Bangladesh

Dr Md. Jashim Uddin, Mr Arafat Rahman

A study was conducted to investigate soil organic carbon (SOC) and total nitrogen (TN) dynamics at different landscape levels in the North-eastern haor basin ecosystem of Bangladesh. This was achieved by revisiting 9 soil profiles in 2021 from the Surma-Kushiyara alluvium which were previously sampled in 1973 by the Soil Resource Development Institute (SRDI), and collecting 48 new samples. It is important to note that there are 06 profiles belongs to Inceptisols, 01 profile belongs to Entisols and 02 profiles belong to Histosols. A comparison of the SOC and TN in the 2021 samples with their historic levels (1973) revealed that overall SOC and TN declined across the study sites. Moreover, SOC contents decreased in 06 profiles and remained unchanged in 03 profiles. The decrease of SOC in the Histosols is at an alarming rate. It is expected that there is a tremendous loss of SOC from the Histosols due to climate change. Since the SOC levels are unchanged in 03 profiles, it may be said that there are some records of siltation there. Similar levels of dynamics take place in case of total nitrogen. The overall level of SOC contents is below the reference soil quality level. The land use patterns changed from grasslands or local rice to high yielding rice cultivars with imbalanced uses of chemical fertilizers. It is the high time to formulate safeguarding policies to restore soil carbon pools in basin ecosystem to tackle climate change and food security issues.

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P-891

Micronutrient recycling by grass in soils of low/high OM applied with excreta of sheep given organic or inorganic mineral supplements

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Grass is a major feed for ruminants. The micronutrient content of grass is one of the key indicators of its nutritional quality. Insufficient provision of a micronutrient not only affects the quantity and quality of animal products but can also lead to metabolic disease in animals. Typically, farmers feed mineral supplements to prevent potential diseases driven by micronutrient deficiency in grazing livestock. From a nutrient cycling point of view, it is not known to what extent this practice affects micronutrient cycling in a grass-soil-animal system. To address this knowledge gap, we firstly offered mineral supplements containing Cu, Zn, Mn and Se in either inorganic or organic form to sheep at either a standard industry or a lower level of inclusion for 2 weeks and quantified the excretion of micronutrients in sheep through urine and faeces. Subsequently, the urine, faeces or a mixture collected from the sheep offered the different mineral supplements were applied to soils of different organic matter (OM) levels but of the same soil type. Perennial ryegrass (Lolium perenne) was grown in the system and harvested for three times. The concentrations and total accumulation of the micronutrients in grass were analysed to evaluate the grass nutrient quality and recycling efficiency. Our evidence indicates that in a grass-soil-animal system, the interaction between soil OM and animal excreta and the synergism between macro- and micro-nutrients, have much larger effects on the recycling of micronutrients by grass relative to the chemical forms of mineral supplement given to the ruminant animals.

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P-891A

Effects of soil acidity correction with nitrogen on the carbon and nitrogen accumulation in soil.

Ms Maria Andrade, Mr Ciro Rosolem

The addition of nitrogen (N) to the soil under conservation systems alters the flux of carbon (C) in the labile and stable fractions of the soil. However, a little is known about the effect of applying N when associated with an acidity corrective application, especially within aggregate classes. The objective of this work was to evaluate the effect of the addition of cations and N on the change and distribution of C and N in aggregates. The study was realized from 2020 to 2021, in continuation of a long-term experiment, in an integrated system of cultivation with soybean grown in the summer, followed by intercropped mayze-forage. The treatments consisted of a combination of: control, lime and lime + gypsum application, in addition to four N rates (0, 80, 160, 240 kg ha-1) applied to the maize crop. The results suggest that the distribution of C and N-total results from the size of the aggregates and not from the doses of N, or the presence and absence of limestone and agricultural gypsum. Within the aggregate classes, there was a higher content of C in macroaggregates (> 2.00 mm) of C, 45% and N, 46.31%, compared to micro-aggregates (0.25-0.05 mm), indicating that the physical protection provided by larger aggregates is essential to the stabilization of total-C and N-in production systems. Thus, the increase in the level of soil aggregates promotes greater accumulation of total C and N-, improving its physical and chemical quality.

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P-892

Preliminary results about soil carbon stabilization associated to soil management in Mediterranean environments

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Estimation of soil organic carbon (SOC) is necessary in Soil Science and climate change. The method to measure soil organic matter by loss on ignition (LOI) of organic matter is considered an easy and fast method, but it has some limitations associated to the temperature reached and the presence of carbonates. On the contrary, the Walkley-Black method (WB) is widely used and it is considered a relatively accurate method but recalcitrant carbon substances can resist the oxidative attack. Our study aims to evaluate the statistical relationships between these two methods in order to estimate the recalcitrant organic matter that remains in the soil. For this purpose, 59 samples were collected at a depth of (0-20cm) in soils under different soil management practices in Southern Spain.

The results of LOI and WB were compared by simple linear regression equations. LOI gave us higher estimations of SOC, while the WB method had lower estimates for all samples. There was a good relationship between these two methods in urban soils ($R2=0.82$, $p < 0.001$), this relationship was moderate in low- or undisturbed soils (pastoral soils, tree crop soils) ($R2=0.41$, $p < 0.05$), however there was no relationship in recently disturbed soils (recently restored soils, intensive crops) ($R2=0.09$, $p > 0.05$).

The differences between soil organic matter content determined by using LOI and WB, revealed that no tillage or undisturbed soils promoted stabilization and storage of organic carbon, while in tilled soils, in the top soil, soil organic carbon stabilization may be more difficult.

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P-893

Dynamic of carbon stock in soils of the Kazakh Hummock central part.

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One of the most pressing environmental issues of global importance is the issue of carbon balance in the atmosphere. The increase in carbon dioxide entering the ground-level atmosphere is not only related to industrial emissions but is also largely due to poor environmental management, which disrupts the natural biological cycle of ecosystems. Uncontrolled economic activities lead to the exclusion of soils from the biological cycle; poor farming systems reduce soil fertility, which is primarily determined by humus, including soil carbon stocks.
As a result of the study, a system for monitoring carbon stocks was established. From 2004,2008 to 2021. The research sites have different carbon balance dynamics, depending on agronomic applications and the underlying state of the land cover, which in turn is defined as a factor of prior anthropogenic impacts, and morphogenetic soil features. Nevertheless, based on the studies, the main trends in the carbon balance of the observed sites can be determined, but additional measures to increase carbon stocks in soils are also needed. All hay growers need an additional fertilizer mineral to compensate for the loss of nutrients used by plants during vegetation. Arable soils, in addition to the measures mentioned above, require additional organic fertilizers. The arid climate is best served by irrigation. The development of specific agronomic measures for carbon balance should take into account all soil formation factors and the morphogenetic characteristics of soils.

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P-894

15-year climate warming effect on organic carbon fraction and molecular character in Mollisols

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Understanding the changes of Mollisols soil organic carbon (SOC) and SOC fractions associated with global climate change is of fundamental importance to soil health and food security. We examine the changes in SOC content and internal molecular structure of labile, slow, and recalcitrant SOC with different initial soil organic matter (SOM) at in situ and transplanted soils to simulate 15-year climate warming in a soil transplant experiment. 15-year climate warming only decreased total OC (TOC) content by 25.6%-44% in higher initial SOM bulk soils through decreasing O-alkyl C. Warming noticeably increased dissolved OC (DOC) content by 20.1%-47.7% in transplanted soils, but decreased SOC content of light fraction OM (LFOM) by 19.1%-20.6% through declining polysaccharide materials. Furthermore, 15-year climate warming significantly decreased SOC contents of “coarse particulate OM inside macroaggregates and outside microaggregates” [M(c)POM] fraction by 25.8%-40% through reducing alcohol and phenol substances in slow C, and decreased “silt+clay OM inside microaggregates-within-macroaggregates” (mM-MOM) fraction in recalcitrant C by 11.9%-13.8%. Whereas, the SOC contents of “mineral OM” (MOM) fraction via decreasing organiosilicone materials and “non-aggregated silt+clay OM” (nA-MOM) fraction via increasing phenol C and decreasing carboxyl C were significantly enhanced by 24.6%-190%. Additionally, recalcitrant C of mM-MOM fraction within macroaggregates and slow C of Fm-POM fraction within free microaggregates are more sensitive to temperature changes. This study implys that lower initial SOM Mollisols may not result in net SOC loss to the atmosphere as climate warming, at least over the timeframe of our research.
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P-895

Organically managed soil systems are more resilient to climate change than conventional systems: isotopic evidence

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In recent years, soil management practices typical of organic cropping systems have been gradually adopted in conventional systems to increase soil fertility and soil health(1). It is expected that these practices also enhance agriculture sustainability and climate change resiliency (2); however, direct evidence is still lacking. This study aimed to understand the potential climate change resiliency of organic and conventional systems by investigating crop yield, nitrogen (N) and carbon (C) contents, and the isotopic composition (13C) of the fresh produce for a variety of crops and geographic regions. Over ten years of observation, yields in organic systems were more stable than in conventional systems. Organic produce with high N content (i.e., celery) showed a higher 13C content than conventional produce, indicating increased water use efficiency. Moreover, the variation in 13C content caused by geographic regions was smaller in organic than in conventional systems. This study indicates that organic systems have greater potential to adapt to climate change than conventional systems and including typical organic management practices in conventional systems has the potential to address climate resilience.

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P-895A

Temperature dependency of organic matter decomposition is regulated by substrate quality and soil tillage practices

Dr Kazumichi Fujii, Dr Chie Hayakawa, Dr Jinsen Zheng, Dr Tiningsih Sukar, Dr Yoshiyuki Inagaki, Dr Takashi Kosaki

Converting forest to agricultural land or intensive tillage risks to increase soil organic matter (SOM) decomposition and leads to a rapid loss of SOM in tropical regions. Microbial decomposition increases with increasing temperature, whereas the effects of temperature on decomposition rates can vary depending on substrate traits, soil types, and tillage practices. To investigate substrate traits (crop/forest litter), soil type, and tillage practices (conventional/no-tillage) on decomposition rates and their temperature dependency, we compiled the decomposition rates of cellulose filter paper, litter (maize, rice, wheat, lichen, and moss), and SOM and calculated decomposition rate constant in the first-order kinetics and activation energy (Ea) using the Arrhenius equation. We found that decomposition rate constants increased with air temperature, but the rate constants (standardized at 15°C) increased with increasing cellulose contents and with decreasing lignin to nitrogen ratios in the substrates. The temperature dependency and Ea of decomposition decreased with increasing turnover time, with higher Ea of substrates with higher cellulose contents. SOM decomposition under the conventional and no-tillage practices displayed a similar temperature dependency, but the no-tillage practice decreased the SOM decomposition rate by 21–94%, compared to conventional tillage. The wide variation in SOM decomposition rates suggests that the inputs of litter with low substrate cellulose content and the no-tillage practice could slow decomposition even in tropical cropland soils.

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P-896

National-Scale Soil Organic Carbon Prediction and Classification in Forest Soil Horizon Using Spectroscopic Data

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Soil Organic Carbon (SOC) in a forest varies not only laterally, but also vertically. But the SOC content of forest soil horizons has not been investigated over large scales. Visible–Near Infrared (vis–NIR) spectroscopy enables rapid and cost-effective examination of forest SOC distribution. This study aims to evaluate the potential of vis–NIR spectroscopy for classifying and predicting the SOC of organic and mineral horizons in forests of the Czech Republic. We investigated 1080 forest sites across the country, each with five soil horizons, representing the Litter, Fragmented, and Humus organic horizons, as well as the A1 and A2 mineral horizons. We, then, used Support Vector Machines (SVMs) to classify the soil horizons based on their spectra and also to model the SOC concentration of (i) the profile (organic and mineral horizons together), (ii) only the organic horizons, (iii) only the mineral horizons, and (iv) each individual horizon separately. Results show that the SVM with radial basis kernel could accurately classify the soil horizons. The SOC model developed for the soil profile performed. The model of the combined organic horizons was considerably more accurate than that of the combined mineral horizons. Estimates of SOC in the individual soil horizons had R2 values greater than 0.63 but those of the F and A1 models were better with R2 > 0.70. The study indicates that vis–NIR spectroscopy can effectively characterize the SOC concentration of the highly variable forest soil horizons in the Czech Republic.
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P-897

Effects of biochar on mineralization of native and added organic substrate

Mr. Subin Kalu, Aino Seppänen, Outi-Maaria Sietiö, Kevin Mganga, Kristiina Karhu

The soil application of biochar has potential for effectively sequestering atmospheric CO_2. However, this potential may be enhanced or reduced depending on how biochar interacts with soil organic carbon (SOC)[1] and fresh organic substrate e.g. root exudates[2]. We aimed to explore the effect of biochar on the mineralization of SOC and fresh labile carbon and investigate the probable mechanisms.

A 180-day long incubation experiment was conducted with six treatments: 1) Soil only, 2) Soil+B15, 3) Soil+B30, 4) Soil+^{13}C glucose (G), 5) Soil+B15+G and 6) Soil+B30+G. The B15 and B30 treatments represent biochar additions equivalent to 15 and 30 tons/ha in the field, respectively. The amount of ^{13}C glucose added (15 mg of 20 at% ^{13}C glucose per gram soil C) as a one-time application was high enough to cause positive priming effects. The CO_2 and $^{13}CO_2$ production, and microbial biomass carbon (MBC) and ^{13}MBC were periodically measured.

Glucose addition resulted in immediate positive priming effect. After 12 days, biochar treatments showed negative priming. Biochar seemed to reduce the mineralization of ^{13}C glucose by improving the microbial carbon use efficiency i.e. more of the ^{13}C was used to build new microbial biomass rather than respired. The analysis of density fractions and aggregate stability will further shed light on the mechanism involved behind reduced mineralization of SOC and added glucose with biochar. We will also investigate whether part of the ^{13}C cycled through microbial biomass stays in the soil in the longer-term (at the end of the 6-month incubation).

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P-898

Summer drought inhibited soil respiration in an Asian monsoon forest in Taiwan

Dr. Poneng Chiang

Soil respiration (Rs) is the second largest carbon flux in terrestrial ecosystems and plays an important role in regulating soil carbon pools and fluxes. Seasonal and annual variation of Rs responded to extreme events in the monsoon forests remain largely uncertain. We conducted continuous multichannel automated chamber system to observe Rs variation during 3 years contained drought events in Asian monsoon forests in Taiwan. The objectives of this study were to assess Rs magnitudes at seasonal and annual timescales, and exam the influences of soil temperature and moisture on autotrophic and heterotrophic respiration under drought event. The annual mean soil respiration and heterotrophic respiration during 2019 and 2021 were 5.12 ± 2.05 μmol CO_2 m^{-2} s^{-1} and 4.67 ± 1.21 μmol CO_2 m^{-2} s^{-1} for Rs, and 3.23 ± 1.18 μmol CO_2 m^{-2} s^{-1} and 3.39 ± 0.88 μmol CO_2 m^{-2} s^{-1} for Rh, respectively. The mean annual Rs and Rr values presented significant 19.2% and 47.0% higher in 2019 than those in 2020, respectively ($p<0.05$). The positive effects of summer drought on autotrophic respiration and the negligible response of summer drought on heterotrophic respiration should be incorporated into models to improve the prediction of global C cycle. The findings from summer drought provide new insights into the effect of altered precipitation on soil respiration in Asian monsoon forests in Taiwan and may have significant implications for soil and global C budget in future climate change.

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P-899

Technoerosion and Deposols (Colluvisols), their meaning for sustainability of Urban Areas

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In rural areas soil erosion and its impact due to loss of fertile land is a wide spread phenomenon and many times investigated. Soil displacement occurs in a vast dimension also in cities by diverse measures such as excavating for construction of cellars, foundations or for surface shaping. These technical processes of soil movement will be designated as Technoerosion. Until now it did not find awareness in soil science. The presentation will give a first insight in this process and impact by it.
The displaced soil material will be deposited at any other location and will become soils. According to the process of deposition the soils are called Deposols or Colluvisols. The gained new soils Deposols (Colluvisols) are introduced in the German soil classification system to designate technical deposited soils.
Soil capacities of urban areas are lost in part by in part sealing (pavements) and total sealing (streets) cover above soils. Total loss of soil capacities is due to technoerosion. The kind of capacity lost by technoerosion and its dimension, and its meaning for the sustainability of urban areas will be presented. It will be compared with in part sealing and sealing. Particular the importance of technoerosion for climate and hydrological management in cities will be discussed.
There will be new soil from natural soil like deposits, designed as Deposols or Colluvisols. From deposition they have particular properties. The soil capacities of these soils will be described in short.

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P-900

Water infiltration capacity of urban soils for storm water management

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Space of storm water uptake by soils of urban areas is limited due to sealing. Besides this, the infiltration and capacity for storage of storm water is restricted by soil compaction, draining soil pore destruction and differences of water permeability and water storage capacity of different soil substrates found in urban areas. For the measurements of water infiltration and water uptake by infiltration a special investigation design was developed. Examples of storm water infiltration measurements of soils with different properties and performance of storm water infiltration sites will be given
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P-901

Assessing urban soil contamination with portable XRF: model development for Cd predictions when measurements are below LOQ.

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Soil quality assesment has become a major challenge nowadays for urban and periurban areas. There is a rising concern about suitability of urban areas for development of activities such as biomass production, water regulation or leisure activities. Soil contamination represents a major threat in this context.
Portable XRF is dedicated to rapid measurement of content of inorganic elements in soils. However, the performance of portable devices is usually limited by relatively high quantification limits and strong influence of water content. Among elements that are usually measured in soil contamination assesment, Cd presents LOQ by pXRF particularly higher than needed.
Our research intended to evaluate performances of pXRF (Titan) to correlate to chemically extracted elements, specifically aqua regia content which is imposed from regulation on soil contamination. After defining a protocol of data acquisition in lab mode, we implemented a database of more than 350 samples with pseudo-total contents ranging from LOQ to tens for Cd and Hg, tens to hundreds for As, Cr, Cu, and Ni, tens to some thousands for Pb or Zn. Samples were collected from diverse types of environment including agricultural fields, kitchen gardens and brownfields.
Regarding prediction of Cd content from pXRF, as no direct measurement could be quantified by the apparatus, a predictive model was built by CART-regression with the other inorganic elements and the origin of the samples. Results show good predictions with errors lower than 10% for most of the samples, which opens excellent perspectives of use of pXRF in contamination assesment.
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P-902

Does a mixture of compost and minerals become soil after five years? The answer from organic matter.

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We wish to study the evolution of certain soils under controlled conditions after treatment with living organisms (inoculating earthworm species, planting plant species) in order to understand the development of their hydrostructural properties. In this respect, the evolution of aggregation is essential. The analysis of the nature and stability of the organic matter by thermal analysis (Rock-Eval® method) will allow us to discuss the transfer and stabilization phenomena in which the worms participate in the presence of such plant species. The hypothesis to be verified is that the content and properties of the organic matter collected in the macro-aggregates that will appear on the surface of the column constitute an emergent property of the ecosystem determined by the input of fresh OM and the action of the soil's ecological engineers. Several Rock-Eval® parameters will be used to document the ecological functions of these composite soils. Compositional parameters (Hydrogen Index, Oxygen Index) will be used to trace the origin and degree of transformation of organic carbon forms (Schomburg et al., 2018). Thermal parameters (R-index and I-index) will be used to document organic carbon dynamics and the degree of ecosystem service restoration (transition from artificial composite soil to functional technosol). These data will allow us to determine the forms of carbon storage in these soils and their capacity to respond to agronomic (nutrient supply for crops) or environmental (carbon sequestration) issues.

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P-903

Remediation of iron-ore mine tailings by growing perennial ryegrass (Lolium perenne L.)

Prof. Zed Rengel, Dr. Zakaria Solaiman, Mrs Sajeevee Sarathchandra

Revegetation of degraded mine sites is difficult due to their inferior physicochemical and microbial properties. This investigation aimed to improve tailings properties for better plant growth and rhizosphere activities. A pot experiment was conducted to assess the influence of agricultural topsoil amendment on remediation of iron-ore mine tailings collected from site A and site B (Western Australia) to promote the growth of perennial ryegrass (Lolium perenne L. cv Ausvic). Each pot was filled with pre-defined ratios of topsoil to mine tailings (0, 10, 20, 30, 50 and 100 % w/w). Harvested ryegrass after 60 days were analysed for growth, root morphological characteristics and heavy metal uptake. The addition of topsoil significantly decreased pH, but EC, CEC and TOC increased with an increased proportion of topsoil. Total concentrations of As, Co, Cr, Cu, Ni, Pb, Zn, Fe and Mn decreased with an increased proportion of topsoil in growth medium. The highest dry root biomass was observed in the treatments with 30% and 50% topsoil addition to tailings, whereas shoot dry biomass only increased with 50% topsoil. Total root length increased significantly with 50% topsoil addition to site A tailings. A significant increase in microbial biomass carbon was reported with 50% addition of topsoil than control. Microbial quotient (MBC/TOC) decreased significantly with the addition of topsoil to both types of tailings. Heavy metal contents in ryegrass shoots decreased with the increasing rate of topsoil where ryegrass was an effective phytoextractor of Cu, Zn and Mn.

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P-904

Creating soil profiles to support calcareous grassland re-creation

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Calcareous grasslands are some of Europe's most species-rich plant communities and important biodiversity sites. However, these habitats are threatened, and many in the UK were lost to changing land use during the 20th century. A growing number of projects are working to restore or re-create chalk grassland ecosystems. This includes a case study within the UK High Speed 2 (HS2) rail development, where a large area of calcareous grassland is being recreated to deliver the UK Government's Environmental Minimum Requirement of "No Net Loss" (NNL) in biodiversity. Part of this work includes the testing and evaluation of artificial soil profiles with soil amendments to re-create calcareous grasslands on previously degraded land. The findings for this project will inform the creation of 90 hectares of calcareous grassland in the Colne Valley, England.

The properties of underlying soils are critical for the development and health of this internationally important ecosystem. Physical, chemical and biological factors such as soil structure, drainage, and nutrient availability are essential for supporting diverse plant assemblages found in calcareous grasslands. In this project, we are testing the effects of different calcareous ameliorants and artificial soil profiles to support calcareous grassland, assessing the potential for reusing HS2 construction by-products (chalk, limestone and concrete) in creating these profiles. We will present findings, scaling up from mesocosm columns to 1 m3 lysimeters, to assess how artificial soil profiles affect key factors for habitat re-creation, including soil microbial dynamics, species establishment and diversity, and nutrient cycling.

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P-905

Biological and chemical properties of young Technosols assessed with Vis-NIR spectroscopy

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The aim of the work was to assess the microbial community response to chemical features in three young Technosols compared to two volcanic natural forest soils developed on the same parent material. In the area of Naples (Southern Italy), Isolatic Ekranic Technosols were built in 2006, in mesocosms filled with building wastes and volcanic soils, covered by spontaneous vegetation. On Mt Gauro, two natural Eutri-Humic Cambisol and Humi-Tephric Regosol were chosen, covered by a chestnut grove and holm oak respectively. In all soils profiles, chemical and biological analyses were performed together with Vis-NIR spectroscopy (DRS) measurements coupled with component regression (PCR) analysis. The PC1/PC2 projection scatter plot, according to the soils Vis-NIR spectra, showed three populations, different on the loading values. The PC1 axis explained 73% of the total variance and was positively correlated with depth and Rb, V, Th, and negatively correlated with TOC, Fe, Sr and Ti, whereas the PC2 (24% of the variability) was positively correlated mainly with soil biological properties. Anyhow, the pH raise, $CaCO_3$ accumulation and lower CEC were due to the limited weathering of building wastes. The content of Fe, Mn, Pb, Th and Zr in the Technosols were similar compared to the volcanic soils, reflecting the same geo-lithological origin. However, in the Technosols the lowest SOM content limited microbial respiration and Cmic, and raised qCO_2 with consequent microbial community stress.

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P-906

Key factors of soil formation in Japanese polders affected by sedimentary environment

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Polders on reclaimed lands by artificial drainage along seacoasts or lake shores have been created nationwide in Japan mainly for agricultural land uses. However, previous studies for developmental processes of polder soils have not been studied nationwide but only in a polder for agricultural uses (Motomura, Lapid and Yokoi. 1970). In this study, to clarify the soil developmental processes in Japanese polders, soil properties from 11 soil profiles were evaluated from the viewpoint of reclaimed ages and land uses. Soils from four polders in Akita (Hachirougata polder), Okayama (Kasaoka bay and Kojima bay polders) and Nagasaki (Isahaya bay polder) were evaluated. Principal component analysis (PCA) was conducted using soil properties to find a controlling factor classifying polder soils. Organic matter accumulation and acidification characterized a principal component to differentiate soils according to polders. Furthermore, the first principal component can be also characterized by differences in parent materials affected by sedimentation processes. The second principal component was explained by ground water drainage followed by desalinization. The first component well discriminated soils of polders according to locations, indicating that soil development in Japanese polders can be controlled by parent materials as bottom sediments reflecting each environmental condition. Vertical changes of scores of the second component with depth well explained vertical development of soil materials mainly through drainage affected by soil particle composition. Differences in sedimentary process affected by both aquatic and watershed environment promote soil formation at each polder in Japan.

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P-907

Above and below-ground soil invertebrates as indicators of restoration success in a rehabilitated mine tailings chronosequence

Miss Sara Pelaez

Over the past decades, traditional assessments of rehabilitation success in mine lands primarily focused on above-ground indicators, such as vegetation composition, or physico-chemical analysis of the substrate. Much less attention has been paid to the response and functional roles of soil fauna (Cross et al., 2019, Courtney et al., 2010). However, the extended literature suggests that soil fauna, specially meso- and macrofauna, are major drivers in soil formation and development, and soil functions in post-mining sites (Frouz, 2008, Frouz, 2014). Our aim is to understand the colonization and community development of soil invertebrates, especially soil ecosystem engineers in rehabilitated mine sites. We compared invertebrate communities from three different rehabilitation stages (5, 15 and 30 years old). Invertebrate samples were taken using D-vac and pitfall techniques during the 2019 and 2020 summer season. We found that Shannon diversity index calculated for all soil fauna groups was at its highest at the beginning of the rehabilitation, then decreased and increased again at late stage successional sites. Nonetheless, the abundance of soil fauna ecosystem engineers Formicidae and Lumbricidae, was significantly higher in later stage of succession (30 years old). Our results suggest that monitoring and assessment of rehabilitation success by targeting soil fauna ecosystem engineers is a more promising tool than looking at diversity indexes alone in metalliferous mine tailings. Further research is required on the links between above- and belowground food webs to understand how soil fauna communities and their interactions contribute to soil functions in restored industrial sites.

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P-908

Use of biochars and rhamnolipids as enhancers of TPHs bioremediation processes

Dr. Carlos Rad, Mrs. Sandra Curiel, Dr. Blanca Velasco, Dr. Carlos Rumbo, Dr. Juan Antonio Tamayo, Dr. Aqib Hassan Ali Khan, Dr. Rocío Barros

Petroleum hydrocarbons are an important source of pollution due to their intensive use by industrial, transport and urban sectors. Pollution associated with petroleum products is of great concern due to its damages for human and ecosystem health, causing the degradation of soils, surface, and groundwater. Low-cost biotechnology approaches are promising techniques for the remediation of polluted soils. In this work, an aged, polluted soil with petroleum hydrocarbons and heavy metals was treated with a microbial consortium (bioaugmentation) and different stimulation strategies that could act as enhancers of the microbial activity: (I) two biochars produced at 450 and 650 °C (BH1 and BH2, respectively), applied at a rate of 5% (v/v); and (ii) 1% (w/w) of commercial rhamnolipids (RML). Two hundred soil microcosms were incubated at 21°C and at 50% of field capacity for 30 and 90 days, after which extractable petroleum hydrocarbons (EPHs) were quantified by gas chromatography (GC-MS). The highest degradation of total EPHs was achieved in the first 30 days of incubation, remaining without significative changes until the end of the incubation period. EPHs of high molecular weight (C21-C35) were the predominant fractions in the mixture, which poses an important challenge for their degradation by microbial pathways. Samples with the bioaugmentation treatment increased five times the degradation of EPHs in comparison with treatments without microbial inoculation, from 5-15% until 25-30%, with the best results achieved with the use of BH2 at 30 days, and RML at 90 days, but without statistical significance with the rest of bioaugmentation treatments.

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P-909

Vitrification: the first step in the creation of vitroceramics from polluted urban soils

PhD Núria Roca, PhD Maite Garcia-Valles, PhD Pura Alfonso

The vitrification technology is one of the most promising alternative methods for the immobilization of heavy metals contained into polluted soils. However, it may be the first step towards sustainable remediation. Soils contaminated with heavy metals may have application in industry to produce glassceramics. The studied polluted urban soil of Barcelona shows a basic pH with secondary $CaCO_3$ accumulation in all depths. The organic carbon content is low and decreases with depth. Sandy-loam and loamy texture classes are observed in the topsoil and subsoil, respectively. The main pollutants in this soil are Cu, Pb and Zn with about 930, 1330 and 5379 mg/kg, respectively. Glass was formulated using 80 wt% of soil and 20 wt% of Na_2CO_3. The mixture was molten at 1450°C. Crystallisation temperatures, obtained by Differential Thermal Analysis, were 790°C, 842°C and 879°C. Nepheline, diopside and rhönite crystallized from glass treated at exothermal peaks. The endothermic peak at 1259°C corresponds to the melting temperature. Glass transition temperature, determined by dilatometry was 632°C. Viscosity-temperature curve was used to calculate the relevant temperatures for the process. The conformation range is between 995°C and 1298°C, and the workability interval ranges from 1293°C to 1302°C. The contents of the elements leached from the glass are well below the limits established by the European legislation. Thus, the vitrification is an effective remediation technique for contaminated soils

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P-910

Effects of amendments on the extractability and phytoavailability of As, Cd, Pb, and Zn in contaminated urban kitchen garden soils

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Moderately metal(loid)- contaminated urban kitchen garden soils can benefit from gentle remediation options including the use of soil amendments, which are able to improve soil function and agronomic quality while decreasing environmental and human health risk. This study analyses the effects of common doses of a various commercialized soil amendments on the extractability, environmental availability, and phytoavailability of metal(loid)s in contaminated urban kitchen garden soils, and on a vegetal model grown upon the amended soils. Fourteen different amendments and amendment mixes were tested on three kitchen garden soils with diverse sources of anthropogenic or geogenous contamination and varying physico-chemical characteristics. Extractable metal(loid)s were evaluated with 0.05 M EDTA buffered at a pH of 7, and a 1 M ammonium nitrate extraction, in order to select the most pertinent amendments for each soil. The effects of these amendments were then tested in a conjunction with a vegetal model, lettuce, grown in controlled greenhouse conditions. Changes in physico-chemical soil characteristics, extractability and environmental availability of metal(loid)s in the soil, and phytoavailability in the lettuce were then tested. Results show that it is possible to reduce both extractable and phytoavailable metal(oid)s with amendment addition. However, variable effects are seen according to the contaminated soil tested, and differences arise in the presence of a plant model.

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P-911

From tailings to soil: the geochemical evolution of bauxite residue during accelerated in situ remediation

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Bauxite residue is the highly alkaline (~pH 12) and saline sodic tailings material produced during the Bayer process for alumina production. Approximately 120 million tonnes of bauxite residue are deposited annually into storage facilities across the globe (IAI, 2017). Currently only 2% of bauxite residue produced is recycled (IAI, 2017), however there is growing interest in reusing residue by transforming this by-product into a productive soil material through in situ remediation. This technique aims to transform the residue into a soil-like medium suitable for plant growth through the addition of targeted amendments, to reduce pH and salinity and improve other unfavourable conditions. As in situ remediation is an emerging technique, little is known about the long-term geochemical behaviour of remediated residue systems

Here we present a detailed geochemical model built using MIN3P (Mayer, Frind, & Blowes, 2002), incorporating two years of geochemical, hydrological and mineralogical data from a large (L=15 m, W=10 m, D=2 m) field scale lysimeter undergoing in situ remediation. A one-dimensional reactive transport model was built to simulate the field lysimeter, and was subsequently refined by comparing field observations and modelled values. The model was then used to predict long term (5-50 years) residue behaviour (including residue pH, mineralogy and leachate quality) and the progression of soil formation within the residue. Our work indicates that developing accurate geochemical models is essential for predicting and assessing long-term residue behaviour post remediation.

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P-912

Optimising bauxite residue for reuse in closure and revegetation of tailings storage areas in mining

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Successful establishment of vegetation on fresh bauxite residue is constrained by high alkalinity and salinity, high concentrations of Al, Na, and trace elements, and low plant available nutrients (Gräfe, Power, & Klauber, 2011; Santini & Fey, 2013). Currently, either cap and store (fresh topsoil importation from offsite) or in situ remediation (application of organic and inorganic amendments) are used to provide a suitable plant growth medium for closure and revegetation of residue storage areas (Santini & Fey, 2018).

In order to reduce costs and contamination risk, we developed a new approach to onsite management of bauxite residue that couples locally available amendments with residue leaching to develop improved capping materials. Three types of residue (mud, mud plus 10% sand, sand) were blended with three waste amendments (sewage water, fly ash, eucalypt mulch) either alone or in combination to create 15 capping materials. Capping materials were leached in the glasshouse for 18 weeks (three x six week cycles of wetting and drying) to assess changes in pH, EC, mineralogy and nutrients. pH decreased in all treatments from 10.5 to <10. EC also decreased in all treatments by at least 3.9 mS/cm, with greatest changes observed in bauxite residue sand amended with sewage water (reduced from 7.0 to 0.3 mS/cm). Amendments increased C and P contents of capping material. With leaching, C and P as well as most elements decreased, which was reflected in cap mineralogy. Germination experiments are ongoing to fully assess which capping material and treatment favours improved plant establishment.

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P-913

Effect of varied tree species on carbon, nitrogen, phosphorus stock and stoichiometry in soils at afforested post-mining and post-fire sites

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In this work, we present the effects of Scots pine (Pinus sylvestris), common birch (Betula pendula), and black alder (Alnus glutinosa) on total carbon (C), nitrogen (N), and phosphorus (P) stocks and stoichiometry in the uppermost soil horizons (litter, 0–5 cm) at afforested post-mining sand pit and post-fire forest sites in Central European conditions. These results were compared to those for undisturbed forest sites of the same tree species. The C stock and N stock of the post-fire soils was similar to that of the undisturbed soils, while it was lower for the reclaimed mine site. Compared to other tree species, pine was characterized by a higher C stock in the litter horizons of post-mining and undisturbed soils. In the 0–5-cm soil horizons, the highest C stock values were detected under alder at the post-mining site and under birch and alder at the undisturbed site. The C:P and N:P ratios in mineral soil horizons were higher at the post-fire site than at the post-mining and undisturbed sites, which can indicate a P deficiency for the given content of C and N. The 0–5-cm mineral horizons under pine and birch at the post-mining sites were characterized by lower C:N, C:P, and N:P ratios than those observed in soils at the undisturbed sites. Furthermore, black alder as N-fixers can increase C:P and N:P ratios on poor sandy soils after disturbance, especially at post-fire soils.
This study was financed by the National Science Centre, Poland (Grant No. 2018/31/D/ST10/02137).
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P-913A

How to mitigate Arsenic and Selenium mobilization from mining soils?

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Mining activities can affect to surround soils quality by increasing the presence of metalloids, and therefore, affecting to run-off water due to pollutants mobilization. In this work, we propose a combination of soil amendments for the remediation of an As and Se polluted soil located in a mining area. To this end, 9 plots (2x3 metres) were treated with organic and inorganic amendments, alone and in combination, and monitored during 6 months. Sludge compost, biochar, and zero-valent iron in form of microparticles (ZVI) or nanoparticles (nZVI) were used in this experiment. Furthermore, an untreated plot was also monitored as a control. Then, after an incubation time of 10 days, Lolium perenne L. seeds were applied to the soils to achieve an integrated restoration. The remediation approach was monitored by analysing As and Se concentration in pore water and plants samples taken along the experiment.

Preliminary results revealed that the application of organic amendments immobilized the Se presented in the soil and favour plant growth, although As was extremely mobilized. However, the combined application of these amendments with ZVI and nZVI mitigated the As mobilization, especially when using the nanomaterial. Finally, although the application of ZVI at micro- and nanoscale results in the total immobilization of As and partially of Se, plants were not able to growth properly due to the absence of organic matter and nutrients. In conclusion, the application of organic amendments in combination with ZVI is a promising technology for mining polluted soils remediation.

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P-914

In situ application of nano zero-valent iron and biochar coupled to phytoremediation for remediation of arsenic and metals polluted soil

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Brownfields are derelict and underused sites, in most cases affected by the presence of pollutants in groundwater and soils. In this context, biochar and zero-valent iron nanoparticles (nZVI) are promising amendments for soil remediation. The application of the mixture of these amendments is a rising technique, although explored in a lesser extent, especially at pilot scale experiments and/or in combination with phytoremediation. In this work, we tested the in situ application of biochar and nZVI in a brownfield soil affected by arsenic and metals, and consequently Brassica juncea was used for improving soil phytostabilization. To this end, a pilot scale experiment was performed using 4 plots (1 m2) with different soil treatments: untreated soil, nZVI, biochar and their combination. Consequently, Brassica juncea seeds were sown in each plot. Along the experimental time (2 months), soil samples were taken and As and metals mobility were monitored. The plant biomass was harvested at the end of the experiment, and different physiological stress parameters and metal(loid)s concentrations were measured. Results revealed that all amendments decreased the available concentrations of As, Cd, Cu, Pb and Zn, notably in treatments including nZVI. Higher oxidative stress was detected in plants growing in nZVI-treated soils, although its application in combination with biochar mitigated the negative impacts. Moreover, the highest biomass was obtained in the biochar treated soils, alone and in combination. In conclusion, the mixture of nZVI and biochar is an up-and-coming technology for polluted soil remediation which favours pollutants immobilization and plant growth

- Baragaño, D., Gallego, J. L. R., & Forján, R. (2021). Short-term experiment for the in situ stabilization of a polluted soil using mining and biomass waste. Journal of Environmental Management, 296, 113179. http://doi:10.1016/j.jenvman.2021.113179
- Baragaño, D., Forján, R., Fernández, B., Ayala, J., Afif, E., & Gallego, J. L. R. (2020). Application of biochar, compost and ZVI nanoparticles for the remediation of As, Cu, Pb and Zn polluted soil. Environmental Science and Pollution Research, 27(27), 33681-33691. http://:10.1007/s11356-020-09586-3

P-915

Soil quality of public recreational areas in the City of Brussels

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Children living in urbanized areas often play in public playgrounds. Hereby they come into contact with the soil as a result of their hand-mouth activity. Other exposure routes are the inhalation of dust from the soil, and dermal contact. Monitoring of soil quality is therefore of great importance. In the present study, the geochemistry of 86 playgrounds soils in Leuven and Mechelen, two medium-sized cities in Flanders (Belgium), was investigated. Compared to the background, slightly increased concentrations of Pb and Zn were found, most likely related to emissions from traffic. However, Pb and Zn concentrations were below remediation standards, except for one location. Extractions with ammonium-EDTA and acetic acid were used to give a first estimation of the mobile pool of metal(loid)s in the soils. Overall, Pb and Zn showed the highest potential mobility, but the near neutral pH of the soils limits the actual mobility. The organic carbon content had a significant influence on the pseudo-total contents of Cu, Pb and Zn in the playground soils. The influence of the grain size on the pseudo-total content of As, Cu, Pb and Zn was also significant, with the finest grain size fraction (<45µm) containing a significantly higher pseudo-total content of As, Cu, Pb and Zn, compared to the coarser fraction (45µm≤x<250µm).

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P-916

Geochemistry of playground soils in two medium-sized cities in Flanders (Belgium)

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Children living in urbanized areas often play in public playgrounds. Hereby they come into contact with the soil as a result of their hand-mouth activity. Other exposure routes are the inhalation of dust from the soil, and dermal contact. Monitoring of soil quality is therefore of great importance. In the present study, the geochemistry of 86 playgrounds soils in Leuven and Mechelen, two medium-sized cities in Flanders (Belgium), was investigated. Compared to the background, slightly increased concentrations of Pb and Zn were found, most likely related to emissions from traffic. However, Pb and Zn concentrations were below remediation standards, except for one location. Extractions with ammonium-EDTA and acetic acid were used to give a first estimation of the mobile pool of metal(loid)s in the soils. Overall, Pb and Zn showed the highest potential mobility, but the near neutral pH of the soils limits the actual mobility. The organic carbon content had a significant influence on the pseudo-total contents of Cu, Pb and Zn in the playground soils. The influence of the grain size on the pseudo-total content of As, Cu, Pb and Zn was also significant, with the finest grain size fraction (<45µm) containing a significantly higher pseudo-total content of As, Cu, Pb and Zn, compared to the coarser fraction (45µm≤x<250µm).
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P-917

Iron application to paddy soil increases rice productivity by enhancing nitrogen-fixing activity of iron-reducing bacteria

Assistant Senior Researcher Hirotomo Ohba, Iron application to paddy soil increases rice productivity by enhancing nitrogen-fixing activity of iron-reducing bacteria Yoko Masuda, Iron application to paddy soil increases rice productivity by enhancing nitrogen-fixing activity of iron-reducing bacteria Ryo Takano, Iron application to paddy soil increases rice productivity by enhancing nitrogen-fixing activity of iron-reducing bacteria Sakura Sato, Iron application to paddy soil increases rice productivity by enhancing nitrogen-fixing activity of iron-reducing bacteria Hideomi Itoh, Iron application to paddy soil increases rice productivity by enhancing nitrogen-fixing activity of iron-reducing bacteria Yutaka Shiratori, Iron application to paddy soil increases rice productivity by enhancing nitrogen-fixing activity of iron-reducing bacteria Keishi Senoo

Rice is a key cereal crop that feeds half of the world’s population. Nitrogen fertilizers have been applied to fields to increase rice yield and stabilize food supply. However, long-term or excessive application of nitrogen fertilizers promotes the release of nitrogen loads from fields to the environment.
Apart from nitrogen fertilizers, biological nitrogen fixation is one of the primary routes for supplying nitrogen to paddy soils, which supports sustainable rice production. Anaeromyxobacter and Geobacter, iron-reducing bacteria belonging to Deltaproteobacteria, are newly discovered nitrogen-fixing bacteria predominant in paddy soils by our metatranscriptomic analysis and bacterial cultivation study. We hypothesized that adding ferric iron as an electron acceptor for respiration of iron-reducing bacteria could enhance their nitrogen-fixing activity in paddy soils.
In laboratory soil microcosm study, soil nitrogen-fixing activity significantly increased after adding ferric iron oxides to soil. Nitrogen fixation gene transcripts analysis suggested Anaeromyxobacter and Geobacter were involved in the enhanced soil nitrogen-fixing activity.
In the field study, application of iron powder to soil enhanced soil nitrogen-fixing activity, rice nitrogen uptake, and rice growth such as stem number and crop yield. Even under no-nitrogen fertilization, increased rice yield was obtained with iron application, which was more than that obtained under conventional fertilization. The effect of iron powder application continued for at least three years.
The results of this study may lead to the development of novel paddy soil management strategies to increase soil nitrogen fertility and ensure rice yields with a reduced nitrogen fertilizer input and a lower environmental nitrogen burden.
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P-918

Foliar PK fertilizers improve rice yield

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Rice is the main food crop of an estimated 40% of the world's population, with cultivating area of ~73.7 million ha in Asia alone. Soil application of fertilizers is more common and effective for nutrients that are required in higher amounts, though, under certain situations, foliar fertilization can be more economic and effective. Foliar feed offers faster nutrient utilization and allows more rapid deficiencies correction compared with soil application. Foliar fertilization can be used during the crops growth cycle when soil application is inefficient (e.g., soil-applied nutrients immobilization, high cost, of application methods are restricted). Different foliar PK (phosphorus and potassium, no nitrogen) fertilizers were tested on rice compared with the farmer practice, in China (0-45-45) and Malaysia (0-46-30+2MgO+0.2B). in China, the effect of foliar application by drone vs. regular foliar spray was tested as well. The fertilizers' effects on plants' growth and yield were measured. In Malaysia, the best treatment was two applications of the fertilizer (2kg/ha), once during tillering and once during panicle initiation. In China, the best results were achieved when applying the fertilizer at 1.5 kg/ha, with no significant influence of the application method. These results suggest that foliar applied fertilizer can be a good alternative to soil-applied fertilizers when it comes to paddy rice nutrition.
ICL group LTD.

P-919

Foliar feed in rice as a way to improve paddy nutrition and reduce losses

Dr Adi Perelman

Rice is the main food crop of ~40% of the world's population, with cultivating area of 73.7 million ha in Asia alone. Rice grows well in flooded soils, which makes it unique among other major food crops. When applying nitrogen (N) under flooded conditions, it is susceptible to different kinds of losses, which can reach up to 60%. Chemical fertilizers' global usage has increased up to as high as 150 kg N/ha, while 10% out of the total N fertilizers in use are applied to rice. Rice response to N fertilizers is lower compared with other crops because the N cycle under flooding is more complex. Most rice soils are N deficient; thus, N fertilizers applications are necessary to meet the crop requirements. A portion of the applied N is lost in different processes, e.g., leaching, denitrification, and ammonia volatilization. These losses can harm the environment by polluting groundwater, the atmosphere, and aquatic systems. Soil-applied fertilizers are more common and effective for nutrients that are required in higher amounts, though, under certain circumstances, foliar fertilization can be more economic and effective. Foliar feed offers faster nutrient utilization and allows more rapid deficiencies correction compared with soil application. Foliar fertilization can be used during the crops growth cycle when soil application is inefficient (e.g., soil-applied nutrients immobilization, high cost, of application methods are restricted). Thus, foliar application of N fertilizers can assist in reducing excess usage of N fertilizers and reduce N losses and pollution when fertilizing in flooded soils.

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P-920

Effect of Organic Sources of nitrogen on Yield and quality of Rice (Oryza sativa L) in Inceptisol of India

Dr Pramod Sharma

A pot experiment was conducted during kharif 2019 and 2020 in the Department of Soil Science and Agricultural Chemistry, Institute of Agriculture Sciences, B.H.U., Varanasi on fine texture loam soil, to study the effect of organic and inorganic sources of nutrients on yield attributes and yield of Kala Namak variety of rice. The experiment consists ten combination of treatments i.e.T1-Control, T2-RDF (100%) (120:60:60 Kg ha-1), T3-50% RDN + 50% N through FYM (14 t ha-1), T4-50% RDN + 50% N through Vermicompost (5 t ha-1), T5-50% RDN + 50% N through Poultry Manure (5.26 t ha-1), T6-50% RDN + 50% N through Sewage & Sludge (7.5 t ha-1), T7-100% N through FYM (28 t ha-1), T8-100% N through Vermicompost (10 t ha-1) T9-100% N through Poultry Manure (10.53 t ha-1) and T10-100% N through Sewage & Sludge (15 t ha-1).Organic and inorganic sources of nitrogen significantly influenced yield attributing characters and yield of rice. Application of 100% RDF significantly recorded increasing the yield attributing character and yield of rice in comparison to other treatment as followed by 50% RDN + 50% through vermicompost. 100% RDF (120:60:60 NPK kg ha-1) was increased the plant height (130.44 cm 90 DAS), chlorophyll content (36.64 90 DAS), panicle length (23.67 cm), No. of filled grain (132 panicle-1), No. of tillers (10 plant-1), test weight (23.65 g), Straw yield (46.67 g pot-1) and grain yield (35.32 g pot-1) in over absolute control. The lower yield attributes and yield of rice observed in the control treatments

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P-921

Estimation of Turnover Time of Microbial Biomass Potassium in Paddy Field Soil

Dr. Yoshiki Tokonami, Taketo Funao, Toshiya Oga, Mizuhiko Nishida, Tomoki Takahashi, Susumu Asakawa

Substantial amounts of potassium (K) are present in microbial biomass in upland and paddy field soils, indicating that the microbial biomass K plays an important role in the reservoir of K in soil. However, information about K flux through the microbial biomass K as the source of K is lacking. In the present study, turnover time of microbial biomass K was estimated in paddy field soils for the first time. The turnover time of microbial biomass K was estimated from the declines of the biomass K with time, which was increased by adding substrates of carbon, nitrogen, and phosphorus, during the incubation for 60 days. The amounts of microbial biomass K were periodically determined by the chloroform fumigation-extraction procedure. In three paddy field soils, the microbial biomass K increased to twice (51.4–72.3 mg K/kg soil) of that in the unamended control 5 days after the addition of the substrates, and gradually decreased nearly to the values in the control (25.2–44.0 mg K/kg soil) until 60 days of the incubation. The turnover time of the microbial biomass K ranged from 80.4 to 98.5 days, which roughly corresponded to the cultivation period of rice (about 100). These results indicated that microbial biomass K plays important roles in the supply of K source as well as the reservoir of K in paddy field soil.

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P-922

Characterization of soil organic matter in paddy soils in Thailand by physicochemical fractionation, functional group analysis, and 14C dating

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Paddy soils are important for rice production, but their carbon contents are low in Thailand, especially in the Northeast region due to sandy texture. The objective of this study was, therefore, to characterize SOM in paddy soils in Thailand by physicochemical fractionation.
Thirty-eight samples were collected from the surface layer of paddy fields in Thailand; 4 from each of the Bangkok plain (BK), the Central plain (CE), the North (NT), and the Northeast (NE), and, additionally 22 from the NE. SOM was fractionated into Light, Heavy, Oxidizable, and Non-Oxidizable fractions (LF, HF, OxF, NOxF) by combining the physicochemical methods. Total carbon contents of their fractions were determined and, functional group analysis and ^{14}C dating were also performed.
The mean amount of carbon for all regions of Thailand (16 samples) was 15.1 g C/kg, with the proportion of 44% OxF, 29% NOxF and 13% HF. That for the NE (26) was 6.4 g C/kg, with the proportion of 46% OxF, 22% NOxF and 20% HF. These results indicated that the OxF and NOxF were the major fractions, and the HF was also important in the NE. Functional groups analysis revealed that the peaks of amide groups of the HF were in the BK and CE, but not in the NE. ^{14}C dating indicated that carbon in the HF had much shorter residence time than those in OxF and NOxF. These results indicated that elucidation for HF was the key to improve the soil fertility of the NE.

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P-923

Changes in available phosphate of paddy soils under flooded conditions and their relationship with temperature

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Resources of phosphate rock are limited and, given that the price for phosphate rock is generally increasing (World Bank 2015), efficient use of phosphate fertilizer is required. Information about changes in available soil phosphate under flooded conditions during the early growth stage, in which the soil phosphate supply is crucial for rice plants (Oryza sativa L.), will be invaluable in improving phosphate management in paddy soils (Yoshino and Honya 1970; Shiga et al. 1976; Shiga and Yamaguchi 1976). This study was performed to clarify the changes in available soil phosphate under flooded conditions and their relationship with soil temperature. An incubation experiment was conducted under submerged conditions at three temperatures (10°C, 17.5°C and 25°C) using paddy soils collected over a widespread area in Japan. In most soils, the available phosphate tended to increase as the cumulative temperature increased. In some soils, the available phosphate scarcely increased with the cumulative temperature. In 22 soils out of 26 soils, significant positive correlations were observed between available soil phosphate and cumulative temperature to 650°C, which corresponded to the tillering stage in the cool climate region of Japan. Relationships between the y-intercepts and slopes of those regression lines of the available phosphate against cumulative temperature to 650°C and selected soil chemical properties measured in air-dried soil were investigated. The results suggest the possibility that the available phosphate of paddy soil against cumulative temperature during tillering stage under submerged conditions could be estimated from the results of air-dried soil analyses.

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P-924

Effects of organic matter application on the nitrogen budget in a paddy-rice and upland-soybean rotation field in cool-temperate region, Japan

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Recently, decreasing in soybean yield along with soil nitrogen fertility have been reported in paddy–upland rotation systems with soybean cultivation in northern Japan. As a countermeasure, application of organic matter is required. A seven-year lysimeter experiment was conducted to evaluate the nitrogen budgets in paddy–upland rotation fields of two-year for upland soybean cultivated with different types of organic matter application and three-year for paddy rice cultivated without organic matter. During the upland period, soybean was cultivated in three lysimeter plots (gray lowland soil): the control plot without organic matter application, the hairy vetch (HV, a leguminous green manure) plot and the compost plot (cow-based livestock manure compost). During the paddy period, all plots were cultivated with high-yielding rice variety without organic matter application. Nitrogen flows for input and output were measured and the difference between them was used as the field nitrogen budget. In the control plot of upland-soybean, the output (mainly harvesting and leaching) exceeded the input (mainly nitrogen fixation), resulting in nitrogen loss (-13.2 to -6.3 g N m-2 y-1). The nitrogen loss was mitigated in the HV plot (-7.9 to +0.1 g N m-2 y-1), and nitrogen accumulation occurred in the compost plot (+0.1 to +11.6 g N m-2 y-1). The nitrogen budget in the high-yielding rice-growing paddy was -7 g N m-2 y-1 regardless of the organic matter application during the upland soybean. Nitrogen loss occurred throughout the paddy–upland rotation, and the nitrogen loss was mitigated by the organic matter application during upland.

No reference

P-925

Dynamics of Gallionella-related iron-oxidizing bacterial community in paddy field soil

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The redox cycle of iron (Fe) is a central process in the biogeochemistry of paddy field. Recently, a microaerophilic Fe oxidizer belonging to the family Gallionellaceae has been isolated from a paddy field. In the present study, the dynamics of Gallionella-related Fe-oxidizing bacterial community (FeOB community) were analyzed in field and incubation experiments to reveal their relations to the Fe-oxidizing process in paddy soil.

A considerable number (10^5–10^8 copies/g dry soil) of 16S rDNA of Gallionella-related FeOB community was detected from conventional paddy fields in Japan. The numbers were higher when the contents of Fe(II) were lower. When their dynamics were investigated in an alternate-wetting and drying (AWD) water-saving paddy field in the Philippines, the copy numbers in the AWD field at the later growing period of rice were higher than those in a continuously flooded field, probably because of the frequent drainage. In all the investigated fields, the copy numbers were negatively correlated with the Fe(II) contents, indicating that their abundance increased in the process of Fe(II) oxidation in the soils.

To reveal their distribution in the surface thin layer of flooded paddy soil, the site where the active redox cycle of Fe occurs, the community in an incubated paddy soil was analyzed. The copy number was highest at the 0–2 mm depth, at which an opposing gradient of dissolved O_2 concentrations and Fe(II) contents was observed.

These findings indicated that Gallionella-related FeOB community plays an important role in the Fe-oxidizing process in paddy field soil.

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P-926

The implications of the intensification of a temperate rice-livestock rotation, in terms of nitrogen.

Mr Jesus Castillo

The Uruguayan rice-livestock system is one of the most productive worldwide, adding meagre amounts of N as fertiliser and reaching a very tight nitrogen (N) balance (N-BAL), low N surplus (N-SUR) and a high system N use efficiency (NUE), being a good example of a circular economy system. Nevertheless, in the search for additional economic incomes, the system is now exploring more intensive rotations which could lead to altering the current status, regarding the environment in the current climate change scenario. Here, we assess three rice rotations: continuous rice (Ri-Ri), rice-soybean (Ri-Soy) and the business-as-usual rice-pasture-livestock rotation (Ri-Liv), in terms of N-BAL (N inputs minus N in food products), N-SUR (N inputs minus all N outputs) and NUE in percentage (N in food considering all the N inputs). We use productive, management and modelled records of the last nine years from a rice long-term experiment. While no differences in the N balance among rotations (8.5, 0.5 and -5.3 kg ha-1 yr-1, for the Ri-Ri, Ri-Liv and Ri-Soy respectively) were found, the N surplus of Ri-Ri was higher (47.4 kg N ha-1 yr-1) than the Ri-Soy and Ri-Liv rotations (14.7 and 11.6 kg N ha-1 yr-1 respectively). The N use efficiency was higher in the Ri-Soy rotation (98%) compared with Ri-Soy and Ri-Liv (64.4 and 67.5% respectively). The results show that the Ri-Soy rotation could be an alternative to the current Ri-Liv rotation, combining tight N balances and high NUE, minimizing negative environmental issues based on the N surplus value.
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P-927

Influence of tillage practice during the flooding period on major pathways of methane (CH4) emission in rice paddy field

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Natural farming, in which adds tillage practice during the growing season of rice in fertilizer-free and pesticide-free paddy fields, can achieve high yields. It is attracting attention as agriculture that reduces the environmental load. But, according to the Ministry of the Environment, about 42% of Japan's total CH_4 emissions come from rice cultivation. Consequently, it is important to evaluate the environmental load of this farming. Generally, CH_4 produced in paddy fields is released to atmosphere through three pathways: diffusion, bubbles, and via rice. Therefore, this study aimed to quantify CH_4 dynamics each three pathways and clarify the effect of tillage on the CH_4 dynamics. This study was compared with four treatment plots (conventional farming (CF), and natural farming with zero-tillage(T0), two-tillage(T2), and five-tillage(T5)). Since the porosity of the upper soil layer fluctuated in T2 and T5, the range of soil disturbance by tillage was considered to be there. And, focusing on the upper soil layer environment of T5, the dissolved oxygen concentration and redox potential tended to be relatively lower than other plots, and the CH_4 concentration in the upper soil layer tended to be higher than lower soil layer. It indicates that interaction among oxygen supply and tillage enhanced organic matter decomposition. And it creates an anaerobic environment, which is a favorable condition for CH_4 production. However, the contribution of the diffusion at T5 to total emissions was small, and bubbles were dominant next to via rice. Bubbles were seemed to be generated during the decomposition of organic matter.

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P-928

The effect of multiple inter-tillage weeding on greenhouse gas emissions in paddy field without application of chemical fertilizers and pesticides

graduate student Kasane Shimada, graduate student Hiyori Namie, graduate student Shuangshuang Zhao, Professor Yo Toma, Professor Munehide Ishiguro, Proffesor Ryusuke Hatano

Kasubuchi et al. (2019) reported that multiple inter-tillage weeding (ITW) without application of chemical fertilizers and pesticides had made possible to get yield comparable to conventional farming in Japan. However, in Japan, rice paddy accounts for 45% of total CH_4 emission. The purpose of this study is to clarify the effect of ITW on greenhouse gas (GHG) emissions.
This study was conducted in a paddy field at the Field Science Center of Northern Biosphere, Hokkaido University. Four treatments were established at three replicates: (1) conventional (CF), (2) zero ITW (T0), (3) two-times ITW (T2), and (4) five-times ITW (T5). Except for CF, chemical fertilizers and pesticides were not applied. Fluxes of CO_2, CH_4 and N_2O, surface soil properties and DO, and rice growth were measured frequently. Carbon and GHG budgets were calculated.
Average brown rice yield was 168, 300, 355 and 473 g/m² for T0, T2, T5 and CF, respectively. CH_4 emission was significantly higher in CF due to largest application of rice straw in the previous year. As the number of ITW increased, soil NO_3^- and SO_4^{2-} concentrations increased, but DO decreased more rapidly, and CH_4 emission tended to increase. These results suggest that increasing ITW influenced the fluctuation of soil redox condition. Furthermore, ITW improved carbon budgets, and this mitigated GHG budgets by reducing CH_4 emission. ITW showed a potential to reduce the risk of GHG emissions, but so far lower yield than conventional. Further study is required to clarify the factors controlling rice yield under multiple ITW.
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P-929

Climate Change Adaptation In Rice Production Through Fertilizer Management

Ms Navya M

Rice is an important food crop and half of the world population depends on rice for meeting their food needs. The rising temperatures and carbon dioxide and uncertainties in rainfall associated with climate change may have serious direct and indirect consequences on crop production and hence the food security. A field experiment on Climate change adaptation in rice production through fertilizer management was conducted during April 2016 to September 2016 at the Regional Agricultural Research Station of the Kerala Agricultural University at Pattambi, Palakkad district, Kerala with rice variety Jyothi. The result showed that the fertilizer treatment and weather had a significant impact on grain yield and yield attributes of rice. The highest grain yield (5816.33 kg/ha) was recorded in crop transplanted in the open field with fertilizers given as per soil test results along with foliar application (19:19:19 NPK @ 2.5 kg per ha at 15 days interval) and silica (8 kg per ha). Crops transplanted inside the climate-controlled greenhouse with fertilizers given as per POP recommendation recorded the lowest grain yield (4520.67 kg/ha). Even though the temperature inside the climate-controlled greenhouse was very high the yield gap between open field and climate-controlled greenhouse was reduced even with additional fertilizers. This study concluded that changes in fertilizer use, soil test-based fertilizer recommendation, application of micronutrients and additional inputs like silica will help to minimise the yield reduction under adverse weather conditions.

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P-930

Affiliation of soil science with forensics solved a criminal case in Bangladesh

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This paper presents a case study that demonstrates field knowledge of Pedology was applied in a synergistic way to support criminal investigation of Bangladesh Police by the successful location of the grave of a missing renowned businessman, Mr. Jamal Uddin, in Fatikchhari, Chattogram, where the victim's body had previously lain undiscovered for two years. In the dark period of Fatikchhari, thousands of people were kidnapped and some of the bodies were disposed of in remote hill areas. The area is moderately hilly, well drained, brown piedmont soil with an acid reaction (pH =5.25). The soil is reddish-brown sandy loam, rich in iron. The average annual rainfall in the area is 3000 mm. Landslides are common and triggered by heavy rainfall in the area, which can be explained based on the basic concepts of unsaturated soil mechanics. Further investigation of a police officer whose academic background was Soil Science, found landmass falling on the slope of the hill. Excavation of the slope showed the ultimate recovery of the human remains, which were located at a considerable depth. The visually unrecognized skeleton was refused acceptance by his family. Then the DNA analysis of the skeleton was done in Singapore and proved to be Jamal Uddin's body. The police report was submitted after four years only due to the lack of forensic laboratories in Bangladesh. A reopened closed case ultimately ended in a successful conclusion through a mix of investigative skill, technical expertise and the use of the science of soil.

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P-931

Mineralogy, elemental composition and indigenous knowledge of some geophagic and healing/cosmetic soil materials from KwaZulu-Natal, South Africa

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Ethnopedological studies focus on agricultural soils resulting in undervaluation of non-agricultural soil materials during land classification. In this study, ethnographic and ethnopedologic methods were used to elicit local knowledge and gain in-depth understanding of non-agricultural soils and their use for geophagy, healing and cosmetic purposes in two villages in KwaZulu-Natal, South Africa. An iterative process, involving a progression of questioning from a broad descriptive approach to a more detailed analysis, was adopted. In each village a questionnaire was administered to fifty randomly selected individuals from which ten knowledgeable volunteers (including eight geophagists from two villages) provided details on the selection criteria, the desired properties and why the soils performed the claimed role. Users based their selection on macromorphological features (e.g. colour, texture and location within the soil) and indigenous knowledge. Geophagic materials were mainly sourced from C horizons with weathering rock. They were mostly fine-grained with mica, kaolinite and quartz, and elements such as copper (Cu), zinc (Zn), cobalt (Co) and lead (Pb). Natural pigments, such as iron oxides in highly weathered soils, were recognised as sunscreen materials. Although the mechanisms were not understood by users, laboratory analyses showed that the mineralogical and chemical properties of the soil materials made major contributions. The sunscreen and healing capabilities of these soils were related to high contents of titanium dioxide (TiO_2) and hematite (Fe_2O_3) and the presence of kaolinite. Further appraisal of these soil materials is necessary for their conservation and inclusion in land classification.

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P-932

A Care-Inspired Soil Ethics

Professor Sabine Grunwald

Although land and environmental ethics have been formalized, an explicit soil ethics is lacking. The discourse of how to know, use, and manage soils has focused predominantly on science aspects such as the characterization, classification, digital mapping and modeling of soils. However, cultural and psycho-spiritual aspects that discover personal relations to soils have not received the same level of attention in the soil science community. The novel Pluralistic Integral Soil Ethics (PISE) that is a care-inspired soil ethics will be presented. PISE synthesizes multiple ethical pillars into a coherent soil ethics. The first pillar of PISE is focused on soil and environmental valuation and people's moral standards toward soil. This virtue ethics strand explores how to minimize soil degradation by managing soils from the perspective of "good" virtuous land managers. The second pillar is focused on soil and environmental literacy (i.e., observable data, facts, knowledge, maps, and models of soils) and assessment of the consequences of soil use and management (consequentialist ethics). The third pillar is focused on soil and environmental competency and awareness. This pillar represents ethics of care that stresses the empathic subjective and intersubjective intimate relations with soil/nature. Soil care is associated with people's closeness to personalize soils and making them one's own through sensing, feeling, and experiences of soil and nature. PISE is an integrative ethics that reframes 'soil care' as a noun into an active process: to care of soil. PISE inspires multi-perspectival discourse to address wicked and complex global soil-environmental problems.
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P-933

The archaeological implications of the soils developed on shell midden (sambaqui) from southeast coast of Brazil

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Shell middens (sambaquis) are artificial formations made up of shells, with traces of human food, remains of terrestrial fauna, fish bones, lithic and ceramic artifacts and sometimes human burials, found along the entire Brazilian coast and Amazon floodplains. This work carried out a pedoarchaeological study to understand the archaeological implications of the soils developed on shell middens from southern coast of the Espírito Santo state. Standard chemical and physical analysis, X-ray fluorescence, X-ray diffraction mineralogy, micromorphology, electron microprobe and C^{14} dating were performed. The morphology and properties of the studied soils portray a typical panorama of other Brazilian sambaqui archaeo-anthrosols, and support interpretations of human occupation in the place. Só far, the absence of burials and the large amount of burning activities could be indicative of a possible sambaqui for worship, working as a space for devotion, meeting and signal fires. The period of occupation that led to the construction of the Rio Preto 1 sambaqui is approximately 1,300 years, being so far the oldest sambaqui on the south coast of the Espírito Santo state (Brazil), with more than 6,000 years. The absence of organic pedogenetic horizons in depth, formed by the degradation of shells with a strong participation of vegetation, as occurs on the surface, suggests that the sambaqui did not have periods of great abandonment. The presence of many bonfires remains in the subsurface reinforces this interpretation, with an eminently worship and meeting uses, since so far no burials have been identified in the area.

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P-934

Ethnopedological praxis and properties of earthenware pottery-making soils of southern Botswana

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Abstract
Pottery making is a common in southern Botswana, and has been one of the mainstay of their economy for centuries. As a result, local potters classify pottery-making soils based on native knowledge. This study explores information on the criteria used by indigenous potters in classifying pottery-making soils. It also presents results on scientific characterization of the soils. Routine laboratory procedures were used to measure properties of two representative pedons. Three properties, namely colour, texture and plasticity are the bases for classifying pottery-making soils in Botswana. Two soils were identified: seloko se se hibidu (red clay) and seloko se se sweu (white clay) as the soils used for pottery. With the exception of texture, data on scientific analysis are consistent with indigenous soil classification system. The soils had sandy clay loam texture with clay contents ranging from 25.3 to 31.8 %, while sand dominates with over 50 % composition. The soils have mixed clay mineralogy consisting of sepiolite, smectite, kaolinite, illite, mica, montomorillinolite and vermiculite. The coefficient of linear extensibility (COLErod) of the soils are high to very high (0.10 – 0.18), implying the dorminance of 2:1 clay minerals. As the depth increased, the soil colour became more reddish (LT1; 10YR 5/3 > 10R 7/3 and LT2: 10YR 8/2 > 10R 8/2 > 10R 7/4 > 10R 7/4). Data on the pedological properties of the pottery-making soils would find enormous application in sustainable management of the soil resources in places with similar environmental conditions.

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P-935

Zacamilola intlalli: Sustainable management of soil organic carbon in Nahua agroforestry systems of the Zongolica mountain range, Mexico.

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In their daily activities, the communities of the Zongolica mountain range support complex human-environment processes such as slope management, multiple resource management, habitat protection and construction of organic horizons for soil improvement. This direct interaction with ecological, geomorphological and edaphological processes is the result of a collective memory-knowledge-experience that has been generated in relation to cosmos, nature and themselves.

From their own episteme, they have generated categories of space that allow them to name, signify and classify places through placenames and landscape units at different scales in the territory based on climate, altitude, main geoform, soil, roof vegetation and the historical dynamics of the community.

These local classifications help to identify advantages and environmental limitations of soils, improve them and design strategies for their use and management.

The sustainable use of land in mountain ecosystems is then, a co-production between society, culture and nature of important contributions towards people, which allows the maintenance of fundamental ecosystem functions for life, such as the supply of water at the macroregional level, the food security and climate regulation.

This research approached, through the ethnoedaphological methodology, to the local classifications of rocks, soils and landscapes of Zacamilola community and its intimate relationship with agroforestry system management. In turn, through quantitative methodology, it was estimated the contribution of six agroforestry systems and their management practices to the soil organic carbon content.

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