The Day of the Young Soil Scientist

Soil Science Society of Belgium

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Book of abstracts

Royal Academy, BRUSSELS

The opportunity for young scientists to present and discuss their work

Scientific program:

13.30 – 13.45: Registration and welcome coffee

13.45 – 14.15: Keynote speaker presentation

14.15 – 14.30: "Effects of different terrace protection measures on runoff, soil and nutrient losses in Buberuka highlands and Eastern plateau agro-ecological zones of Rwanda" by Jules Rutebuka (UGent)

14.30 – 14.40: PechaKucha "The impact of vegetation changes on soil moisture over the Dry Chaco" by Michiel Maertens (KUL)

14.40 – 14.55: "Monitoring of spatio-temporal variability of substrate moisture on green roofs with different substrates depths and link to biodiversity" by Cédric Bernard (ULiège)

14.55 – 15.05: PechaKucha "A review of Mongolian soil characteristics and its environmental issues" by Tamir Enkh-Amgalan (National University of Mongolia)

15.05 – 15.20: "Stable isotopic (^{2}H, ^{18}O) quantification of root water uptake distribution of tree and crop in agroforestry context" by Francoise Vanoverbeke (ULiège)

15.20 – 15.30: PechaKucha "Is there a change in the sources of bioavailable silicon over soil weathering degree?" by Félix de Tombeur (ULiège)

15.30 – 15.50: Posters presentation

15.50 – 16.20: Coffee break and poster presentations

16.20 – 16.40: “Sorption of ^{137}Cs on glauconite sands from the Neogene” by Yaana Bruneel (Belgian Nuclear Research Centre)

16.40 – 16.50: PechaKucha “Soil quality and microbial life: how sequencing can pierce the black box” by Caroline De Tender (Research Institute for Agriculture)

16.50 – 17.10: “Assessing the heavy metals pollution in soil and vegetable in Lanping lead-zinc mining areas” by Judith Deblon (ULiège)

17.10 – 17.20: PechaKucha “Study of the impact of century-old biochar on soil chemistry and nutrient cycling in soil-plant systems” by Victor Burgeon (ULiège)

17.20 – 17.40: “The effect of micro-topography on 3D electrical resistivity measurements for monitoring of soil moisture in potato fields on sandy soil” by Thibault Manhaeghe (ULiège)

17.40 – 17.50: PechaKucha “Soil processes controlling Si bioavailability by increased pH after biochar amendment” by Zimin Li (UCL)

17.50 – 18.00: Concluding remarks

Presentations

Effects of different terrace protection measures on runoff, soil and nutrient losses in Buberuka highlands and Eastern plateau agro-ecological zones of Rwanda

Jules RUTEBUKA(1,2), Nick Ryken(1), Aline Uwimanzi(1), Olive Nkundwakazi(1), Kagabo M. Desire(2), Pieter Vermeir(3), and Ann Verdoodt(1)
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Soil erosion continues to be a serious limiting factor to the agricultural production in Rwanda. Terracing has been widely adopted in Rwanda in the past years, but its effectiveness is little known. Besides the standard radical (bench) terraces (BT) promoted by the government and its partners, also progressive terraces with living hedges (PT) become adopted mainly by the farmers. The aim of this study was to evaluate the effects of these terracing practices on short-term run-off, soil loss and associated nutrient loss versus those recorded on non-protected (NP) fields. We used erosion plots (5 x 22.2 m) installed in two different agro-ecological zones, i.e. Buberuka highlands (Tangata) and Eastern plateau (Murehe) and monitored erosion during four consecutive rainy seasons from September 2015 to June 2017. The erosion plots were under maize in the first season and bean in the second season, and had slope gradients of 14 and 43 % for Murehe and Tangata sites, respectively. Runoff water was captured after each rainfall event and the collected water samples were dried to determine soil and associated nutrient losses.
The results showed that runoff, soil loss and nutrient loss were significantly higher at Tangata compared to Murehe and this was attributed to the difference in slope gradient, rainfall characteristics and soil properties. Tangata site revealed the higher rainfall amount associated with big number of erosive rainfall events, lower clay and higher sand contents than Murehe site. Both PT and BT were generally effective in reducing soil erosion from farmer's fields. The average runoff coefficients were very low at both sites ranging between <1% to 4%. Consequently, runoff effectiveness indexes for PT were -21 and 52 % while

they were 75 and 85 % for BT at Murehe and Tangata, respectively. Total average soil losses were 5, 3 and <0.1 t ha-1 yr-1 for NP, PT and BT respectively at Murehe whereas they were 47, 3, and <0.1 t ha-1 yr-1 for NP, PT and BT respectively at Tangata. Despite the ineffectiveness of PT at Murehe in reducing runoff, it reduced soil losses with 46% compared to NP plots, while the BT was effective at 93 %. On the other hand, the effectiveness indexes in soil loss reduction at Tangata were 93 and 98 % for PT and BT, respectively. Terraces proved also to be effective in limiting the loss of nutrients. BT reduced nutrient losses (OC, Ntot, Pavailable, Caexch, Mgexch) with more than 90% at both sites. The nutrient loss reduction for PT was less than 42% at Murehe whereas at Tangata, it was higher than 75%.

The poor performance of PT plots at Murehe in terms of reducing runoff and soil loss resulted from bad establishment of hedge rows on the risers and their inadequate maintenance by farmers. Yet, the effectiveness of PT to reduce soil loss and associated nutrient losses can approach that of bench terraces, once they are well managed and regularly maintained by farmers. This is confirmed by the observations at Tangata. The effectiveness of soil erosion control measures as well as their positive impacts on soil thus differ by terracing type and agro-ecological zone, and are moderated by the management or maintenance adopted by farmers.

The impact of vegetation changes on soil moisture over the Dry Chaco

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The Dry Chaco ecoregion is the world's largest continuous dry forest. The region is located west of the Paraguay River and east of the Andes in South America. Since the 1980s, the region has undergone an intensive process of forest degradation and fragmentation from selective logging, cattle, charcoal and soybean production. This unprecedented forest degradation causes a disruption in the hydrological cycle and dryland salinity.
This study aims at better understanding the impact of forest degradation on soil moisture and salinity changes over the Argentinian Chaco, using land surface modeling and remote sensing data. More specifically, default climatological vegetation parameters (LAI, NDVI, greenness) in state-of-the-art land surface models (LSM) grouped within the NASA Land Information System (LIS) will be updated using satellite-based dynamic vegetation data. The modeling output will be evaluated against in situ observations and microwave-based satellite retrievals (SMOS, SMAP, ASCAT) of soil moisture.
This presentation will show a first spatio-temporal analysis of state-of-the-art long-term LIS simulations using a range of land surface models, along with various retrieval products of soil moisture and vegetation optical depth from SMOS (operational Level 2 and SMOS-IC) and SMAP (operational Level 2) over the Dry Chaco. In addition, preliminary LIS results obtained by dynamically updating vegetation with MODIS-based indices will be presented.

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Monitoring of spatio-temporal variability of substrate moisture on green roofs with different substrates depths and link to biodiversity

Master's thesis in Environmental Sciences and Technologies
Author : Cédric Bernard
Promotors : Prof. Sarah Garré, Prof. Grégory Mahy and Prof. Aurore Degré

In a more and more urbanised world, green roofs provide a shelter for nature in a jungle of concrete. Those green roofs allow for an increase of biodiversity habitats, increase of air quality, thermal and acoustic isolation of the buildings, stormwater management, infiltration of rainfall, etc. Plants on green roofs do not have the same responses to water deficit or abundance, thus moisture content heterogeneity will create biodiversity heterogeneity. Knowing the spatial heterogeneity of water content onto the green roof will in consequence lead to a better understanding of biodiversity heterogeneity and a better management of the green roof. This Master's thesis is divided into three objectives with the aim to answer these queries.

The first objective is to test the suitability of different sensors to measure the moisture content of the green roof and its specific substrate. Two sensors' types have been selected: based on thermal conductivity (Plant-care OEM) and capacitive sensors (EC-5). These sensors will be tested on soil columns to see how they react to increasing soil moisture of the substrate. To do so, columns with the same substrate as TERRA green roof will be prepared, and with the use of scales the soil moisture content will be raised by step of 5 percent. The difference between the actual moisture content (known through the scales) and the measured moisture content (through sensors) will be evaluated in order to test the suitability of the two different sensors. The second objective of the Master's thesis is to put the selected sensors on the green roofs located on the TERRA building, and to explore possibilities for a realtime reporting. This will be done for moisture content but also for temperature and radiation. The third and final objective is to link vegetation patterns with soil moisture patterns. To achieve this objective, repetitive ERT (Electrical Resistivity Tomography) measurements will be executed and a collaboration with another Master's thesis on green roofs biodiversity is planned.

A review of Mongolian soil characteristics and its environmental issues

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Mongolia is a landlocked country in Northeast Asia, bordered by Russia and China and located in the transition zone between the great Siberian taiga and the Central Asian desert. Mongolia is far from the world oceans, surrounded by high mountains and highly elevated above the sea level averaging 1500 m. For that reason, the climate is characterized by strong continental weather with four distinctive seasons. The total population estimated to have recently passed 3 million, although the country witnessed a significant decline in population growth for the last two decades. However, with a land area of about 1.56 million km2 which is about 3 times the size of France and 15 times larger than South Korea. It remains the least densely populated country in the world.

Soil cover of the country still not fully studied and soil classification system up to now not completely developed. Mongolian soils divided into two big groups: Mountain soil and plain area soil and distinguished more than 36 type of soils from north to south following a longitudinal zonal schema. Steppe and forest ecosystem soils of Mongolia significantly drying last decades.

Mongolia is facing serious environmental issues due to mining and inadequate waste management. Overgrazing is also serious factors of land degradation (grazing land is 72.1 % of the total territory). The total number of livestock reached up to 66 million in 2017, which is increased 3 times compared to 1980s. In addition, the number of goats increasing due to the high price of cashmere and in 2017, total goats counts 27 million, which is nearly 40% of total livestock. Goat is most destructive cattle for pasture and soil and over 60% of total pastureland is overgrazed as of 2017 in Mongolia. Until recently, pasture capacity was not overloading dramatically like today.

There are also another environmental issues such as soil rehabilitation and remediation, land management, soil mapping, yellow dust storm, Ger area (rural houses) sanitation, mining, illegal disposal sites, water recourse shortage, glacier and permafrost melt, desertification, lack in agricultural activities (even though ~30% of total land is covered by very fertile and highly productive agricultural yields with its high moisture storage capacity - Chernozemic soil). Soil degradation and pollution are increasing along

with the rapid development of the country's society and economy. The rates of humus production and vegetative regeneration and growth are very low throughout the country and agricultural productivity is low in comparison to other countries of the same latitude. Rapid population increases (~50% of the total population) in Ulaanbaatar city lead to other environmental destruction besides air pollution; namely, soil contamination and degradation.

Soil contamination in Mongolia is a new research subject; however, it needs in systematic monitoring and assessment to reduce potential risks. Further development and improvement of soil quality assessment methodology are also challenging issue in Mongolia.

Stable isotopic (^{2}H, ^{18}O) quantification of root water uptake distribution of tree and crop in agroforestry context

Master in Environmental Sciences and Technology
Author: Françoise Vanoverbeke (Msc student in Gembloux Agro-Bio Tech)
Co-Promotors: Prof. Sarah Garré, Prof. Youri Rothfuss (Gembloux Agro-Bio Tech)

From carbon dating to hydrology, isotopic approaches have a wide range of applications, such as the study of climate change or nutrients cycling in soils. Water stable isotopic analysis is for example a promising tool to better understand water dynamics in soil since it can be used to quantify root water uptake at different depths.

The main objective of this MSc thesis is the determination and the comparison of vertical root water uptake profiles of trees and crops in an agroforestery context in order to obtain scientific evidence for competition or complementarity between tree and crop component. This will be done via the confrontation of stable isotopic compositions of soil water across depths, with stable isotopic compositions of (trees/crops) xylem sap water at the base of the plant collar (winter barley) and in twigs of the neighboring tree.

From March to June the experiment will take place in the agroforestery parcel of Gembloux Agro-Bio Tech, Belgium. In order to quantify soil water stable isotopic compositions, a nondestructive method will be used: the gas-permeable tubing and infrared laser absorption spectroscopy (Rothfuss et al. 2013). A different method will be used to quantify the stable isotopic compositions of xylem sap water through the use of a vacuum system. In this context, isotopic heterogeneity will be first tested to target any presence of fractionation. In parallel, temperature, soil moisture and water content will be measured because of its possible interaction with water stable isotopic composition measures and to validate water fluxes obtained from the isotopic measurements.

Is there a change in the sources of bioavailable silicon over soil weathering degree?

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Plants influence the silicon (Si) cycle at local and global scales. There is a widespread assumption that amorphous silica compounds formed in plants, also known as biogenic opal or "phytoliths", contribute to Si replenishment in the soil solution, when they are returned to the soil in litterfall. However, paleobotanists use phytoliths to reconstruct past vegetation, based on preservation of their species-specific shapes and their ability for long periods in the soil environment. Here, we test the hypothesis that phytoliths are the main source of bioavailable Si in soils in advanced stages of weathering (quartz enrichment in podzolic eluvial E horizon). We sampled soils from seven development stages over a long-term chronosequence in Southwest Australia, including Holocene (≤ 6.5 ka), Middle Pleistocene (120-500 ka) and early Pleistocene (~ 2000 ka) dunes. Pedogenesis in this chronosequence involves decarbonation, iron oxides individualization followed by their loss by eluviation. For each chronosequence stage, pedogenic horizons were sampled to a minimum depth of 1.5 m. We measured the so-called "bioavailable Si" in each horizon, using a 0.01 M $CaCl_2$ solution. XRD analyzes were performed on bulk soil samples in order to characterize mineralogy. Si extractable with $CaCl_2$ strongly increased towards the end of decarbonation, from the Holocene to Middle Pleistocene dunes (from 2 to 7.5 $mg.kg^{-1}$). It then strongly decreased towards the most weathered soil, developing on an Early Pleistocene dune (around 3 $mg.kg^{-1}$). The highest concentrations of bioavailable Si were encountered immediately after decarbonation, during the iron individualization process and the formation of secondary minerals such as kaolinite, detected only in those soils. The secondary Si-bearing minerals probably govern Si bioavailability in the intermediate soil weathering stage. However, the bioavailable Si concentration in the advanced soil weathering stage (quartz-enriched eluvial E horizon of at least 5 meters) remains higher than in the early soil weathering stages. In this system with soils comprised almost entirely of quartz, it is likely that phytoliths have become the only source releasing bioavailable Si into soil solution. Physical extractions of phytoliths (heavy liquid separation) and specific extractions in oxalate and Na_2CO_3 solution may support this assumption.

Sorption of ^{137}Cs on glauconite sands from the Neogene

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In Belgium, geological disposal is considered in poorly indurated clay (Boom Clay) 200 m below the surface, for long term storage of high-level and long-lived radioactive waste. In the NE of Belgium, the 100 m thick Boom Clay layer is situated between glauconite rich sands with glauconite contents up to 70 wt%. The objective of the PhD is to study the sorption behaviour of radionuclides on these glauconite sands. This to investigate whether these sands can act as an additional sorption sink to the Boom Clay and as a complementary sorption sink in the sandy embankment of the surface disposal facility for low and intermediate short lived radioactive wastes.

Glauconite is a complex mineral. It is described as an iron (Fe) - potassium (K) phyllosilicate ($(K,Na)(Fe^{3+}Fe^{2+},Al,Mg)_2(Si,Al)_4O_{10}(OH)_2$), comparable to an Fe-rich illite with K^+ the main interlayer cation. The structure contains both Fe^{2+} and Fe^{3+} due to formation in alternating oxidizing reducing conditions in marine shelf environment. Due to weathering the mineral can evolve, to a smectite-like structure with lower K content and a rim of oxides may develop. Leaching the interlayer cations opens the edges of the layers creating specific sorption sites for K, Cs or ammonium (NH_4).

Though low sorption potentials are generally expected in sands, the Neogene glauconite sands have shown a strong sorption potential for Cs comparable to the sorption potential in the Boom Clay. And even though there are major differences among these sands, the sorption potential stays the same for the whole range of Neogene glauconite sands. We have looked at samples from the Diest, Berchem and Voort formation and found unexpected trends. Glauconite content and sorption potential don't follow a linear trend in these sands. Additionally, the kinetics are not as expected, leading to a whole new set of questions.

Figure 1 Diest formation glauconite sands, as they occur in the region of Leuven (Lubbeek).

Soil quality and microbial life: how sequencing can pierce the black box

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Farmers manage their soils by irrigation, fertilizer usage, crop rotation, tillage or pest control. Each of these practices will contribute to the soil quality, including the microbial community inhabiting the soil. These soil microorganisms play an extensive role, as plants may rely on the organic nutrients that microorganisms mineralize for their growth and activity. The number of studies investigating these microorganisms is expanding, but assessing the soil microbiome remains difficult. First, because soils are populated by a multitude of microbial organisms: one gram of soil can contain up to 1 billion of microorganisms. Second, it is often difficult to relate changes in microbial communities to one specific practice.

At ILVO we have implemented several next-generation sequencing techniques to study microorganisms. Using these techniques on soil samples from field and pot trials, we were able to study the influence of tillage, crop rotation, manure, compost, chitin and biochar treatment on the microbial community of the soil. In addition, we were able to correlate changes in the soil's physicochemical composition with changes in the microbial community. To study taxonomical shifts in the microbial community, we make use of amplicon sequencing or metagenomics. By using the latter, we are able to look at the diversity (up to genus level) of all kind of organisms: bacteria, fungi, viruses, nematodes, etc. In addition we gain information on the functional potential of the organisms. To have an insight in the absolute abundance of bacteria and fungi in the soil, we combine these techniques with PLFA analysis. For example, we were able to correlate an improvement of plant growth and a reduction of zoonotic bacteria on lettuce leaves to an increase in fungal biomass, chitin-related genes and a specific fungal genus, *Mortierella*, in the rhizosphere of the lettuce plants.

Currently, we are expanding our technical capacities by applying metatranscriptomics on field soil samples. By studying the environmental RNA instead of the DNA, we will get information on the functional activity, e.g. N fixation and nutrient mineralization by microorganisms in Belgian soils.

Assessing the heavy metals pollution in soil and vegetable in Lanping lead-zinc mining areas

Deblon Judith (Msc student at Uliège - Gembloux Agro-Bio tech)
Promoters : Colinet Gilles (Professor at Uliège - Gembloux Agro-Bio tech) and Zu Yanqun (Professor at Agricultural University of Yunnan)

Heavy metals in soil have two different sources. Metals can naturally be present in soils after weathering of parent materials that contain a certain quantity of metals depending on their geochemical characteristics.
The second source of heavy metals is related to the anthropogenic activities, especially since the industrialisation, the mining exploitation and the conveyance. The toxicity and the mobility of metals depend on a series of parameters like the concentration, the specific chemical form and the properties of the metals as well as environmental factors and soil properties.
The soil is a matrix that allows the metalloids transfer into the ecosystems. By their mobility, heavy metals and metalloids can reach the groundwater, water sources and arable land that lead to an adverse effect on the environment by reducing biodiversity and land production. Moreover, heavy metals toxicity can induce health problem for both humans and animals by intake of heavy metal-contaminated vegetables.
The goal of this study is assessing the heavy metals in soil and vegetables in Lanping lead-zinc mine areas, in Yunnan province of China. During three months, an investigation on soil and vegetables in Lanping mining will take place. A series of soil samples will be taken in order to determine the concentration as well as the availability of lead and zinc present in the soil. The samples number, the sampling method as well as the sampling depth will be determined on the field. Digestion method could be used to determine the concentration of lead and zinc while the availability would be found by using an extractant (EDTA or DTPA) adapted to the soil pH.
Regarding the vegetables, a sequence of samples taking over the majority of plant species on the Lanping area will be picked up. Each part of the plant will be analysed separately. As soil sample, the vegetable samples will be digested with an acid and analysed by atomic absorption photometer.

Study of the impact of century-old biochar on soil chemistry and nutrient cycling in soil-plant systems.

NB - My pechakucha presentation will not aim at presenting the results of a study. Its purpose is rather to present to the SSSB the theme of my PhD and the CHAR project.

Victor Burgeon, Ezra Yehuwalashet, Julien Fouché, Sarah Garré, Bernard Tychon, Frédéric Nguyen, Jean-Thomas Cornélis.

Biochar is a form of recalcitrant black carbon obtained from the low-oxygen combustion of waste organic matter and inserted as an amendment in soils. This biochar is presented as a win-win-win solution improving carbon sequestration, clean energy production and improved soil physico-chemical characteristics (*Laird*, 2008). In soil sciences biochar has proven to be interesting through increased water retention, liming effects, increased nutrient bioavailability etc… depending on the combustion conditions such as feedstock type and combustion temperature. Although it is commonly accepted that biochar has a positive impact on soil parameters on the short term, little is known about how it evolves with time. In Belgium charcoal hearths, relics from the production of charcoal used as fuel for our siderurgy (150-200 years ago), are abundant throughout the landscape and because of similar production conditions are used as an analog to aged biochar.

Through my PhD thesis, as a part of the CHAR project, we focus on this old biochar to understand how it evolves with time to understand how amending biochar in soils today will modify soil parameters for the decades to come. More specifically we aim at understanding how the presence of century old biochar may influence soil physico-chemical properties and resulting elemental composition of soil solution. Moreover, we will study the influence of charcoal particles on nutrient retention in soils and their cycling in soil-plant systems. Through its interdisciplinary and multiscale approach, the CHAR project aim is to link how soil physico-chemical properties affected by charcoal presence control soil water dynamic and crop performance the field scale.

The effect of micro-topography on 3D electrical resistivity measurements for monitoring of soil moisture in potato fields on sandy soil.

Manhaeghe Thibault (Msc student at Uliège - Gembloux Agro-bio tech)
Promotors : Sarah Garré (Professor at Uliège - Gembloux Agro-bio tech), Gaël Dumont (Post-doc at Uliège - Gembloux Agro-bio tech).

Potato plants are characterized by a shallow root system and a high nitrogen demand. To sustain crop production during dry periods in the growing season, irrigation is increasingly used to maintain transpiration of plants at near potential level. Fertilization is also widely used to ensure the optimal yields. These two agricultural practices sometimes lead to pollution of fresh water and a decrease of water and nitrogen use efficiencies. A better understanding of water and nitrogen uptake by plants, combined with a precise knowledge of spatio-temporal variation during the season could lead to better agricultural practices leading to a sustainable and performant crop production. Geophysics, also called 'soil scans', is increasingly used to address this heterogeneity in space and time, but the link to soil moisture and ultimately different irrigation regimes, remains difficult to calibrate.

In this master thesis we will use electrical resistivity tomography (ERT) to measure spatio-temporal soil moisture patterns during the growing season of potato as a link between point scale soil moisture sensors and field scale soil scans using 'Electro-magnetic induction'. More specifically, we will address some of the challenges related to these ERT measurements related to the typical micro-topography of potato fields and the heterogeneity of soil properties.

A first phase of the project will be to simulate soil moisture dynamics in a potato field with HYDRUS 3D during the entire growing season with its specific micro-topography and the effects of soil properties. Using an experimental relationship between EC and SM, we will assess the sensitivity of ERT measurements, quantifying the possible errors caused by a change of topography during the season, smoothness constraint or a simple random error. The most suitable electrode placement and protocol will be chosen to correctly measure different soil moisture patterns.

In the second phase, we will verify the proposed data acquisition scheme in the field in Groot-Rees in the framework of the POTENTIAL project. The soil moisture pattern will be used with others measures on the field (Satellite and drone images, EMI, Soil texture,…) to delineate specific management zones.

Posters

How could activated biochar enhance the nutrient dynamics in degraded tropical soils in Burkina Faso?

Co-authors: Lucie Blondiau[1], Chloé Rauw[1]
Supervisors: Victor Burgeon[1], Hassan Bismarck Nacro[2] and Jean-Thomas Cornelis[1]
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Inspired from the high amount of black carbon found in Amazonian dark earth, biochar is produced by incomplete combustion of organic matter and mainly composed of recalcitrant carbon.
Amongst others properties, biochar increases the CEC of soil and also its ability to retain nutrients and water. In several cases, biochar enhances biomass yields. An activation process can improve those characteristics. Different ways of activation exist and can be used to enhance the effectiveness of biochar like combination between biochar and fertilizers and also composting biochar with other organic matter.
Today this technology could be applied in African Sub-Saharan countries like Burkina Faso. In addition to the high population growth rate, its degraded soils and the heavy rain weaken the agricultural productivity of this country during wet season.
The project BIOPROTECHSOL focus on enhancing soils fertilization and resilience in South East Burkina Faso through organic matter recycling. In that context two master theses are conducted in order to demonstrate the impact of organic and mineral activation on biochar.
Non-activated biochar from cultivated plots will be studied by microscopic analyzes in order to compare the coating on biochar after 6 months and 1.5 year of residence in soils.
At the particle scale, biochar has been activated by mixing dissolved organic and mineral fertilizers with biochar in order to absorb nitrate, phosphorous and potassium on its surface but also by a co-composting process. SEM/EDX analyzes will be conducted in order to find the location and the amount of added nutrients on biochar particles and nutrients sorption and desorption dynamics will be studied.
The macroscopic aspect of the biochar activation will be studied in a greenhouse soil column experiment composed of materials (compost, biochar and soil) from Burkina Faso. A NPK fertilizer input will be applied equally on the top of the columns and four different treatments (control, compost, biochar and composted biochar) will be compared. We will

analyze the leachate and the soil nutrients composition as well as the biomass quantity and quality.

Albeit numerous studies about biochar have been published lately, really few are concerning biochar organic and mineral activation, and even less under African Sub-Saharan soil and climate conditions. We are expecting those experiments to lead to new perspectives regarding biochar utilization.

Understanding soil microbiology in function of soil resistance and resilience

Lisa Joos[a,b], Caroline De Tender[a,b] , Lieven Clement[b], Jane Debode[a], Bart Vandecasteele[a]
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Agricultural practices affect the abiotic and biotic dynamics in the soil. Consequently, these practices will have an effect on the soil quality in terms of resistance and resilience, i.e., how the soil copes with external disturbances or stresses. Identifying soil microbiome indicators can be useful to assess the soil quality. While doing so, it is important that we can distinguish between the effect of inherent within-field variability and field history on one hand, and the effect of management practices, on the other.

Soils of five medium-term field trials subjected to different management techniques (tillage, fertilization and crop rotation) are examined. The microbial soil community is characterized by PLFA to determine microbial biomass and by amplicon sequencing to identify bacterial and fungal diversity. Correlations between the soil's physicochemical properties and the soil microbiome are studied, taking into account the within-field variability. Amplicon sequencing data analysis currently faces problems related to small sample size, high dimension and the presence of excessive zeros. Therefore, we are currently working on an improved statistical method to analyze this data.

Besides the inherent within-field variability, we additionally investigate the temporal variability of the soil microbiome and chemical parameters: (1) to understand how rapid these parameters react to agricultural practices or environmental changes and (2) to determine the representativeness of samples taken on a given time point. Therefore, on a monthly basis over a period of one year, samples from two of those five long-term field trials are taken and analyzed.

We will provide the necessary information on the effect of soil management practices and spatio-temporal variability on the soil microbiome, and how to use microbiological indicators to evaluate the soil resistance and resilience.

Calibration of different soil moisture sensors for a long-term field experiement

Co-authors: Sarah Garré, Lolita D'Ortona, Jimmy Duhamel, Yohann François, Henri Chopin, Stephane Becquevort, Anne Deligne, and Aurore Degré afield to the University of Liège, Gembloux Agro-Bio Tech, Gembloux, Belgium

The following work is part of ICOS-RI research infrastructure. A field localized in Lonzée, Belgium, is equipped to provide long-term data on both emission of greenhouse gases and associate environmental variables of an agricultural field.
Soil moisture is one of the state variables which are monitored with high temporal resolution and with several repetitions in the field to take into account soil heterogeneity. To use soil moisture FDR sensors at different depths on a stick, Sentek EnviroSCAN sensors have been used in a laboratory experiment. Several horizons have been defined in the three different profiles of the field and be employed to constitute soils column.
The aim of this project was to enhance the protocol of sensors calibration in laboratory conditions and create new calibration curves associated to each sensor. By the interpretation of these curves, it will be possible to know how it is necessary to calibrate these sensors and compare it to the results we got from a different FDR sensor: the ML3 ThetaProbe. Moreover, this experience has to supply a critical of the present protocols and bring to light the eventual defects of the method.
Finally, the difference between the universal calibration relationship and the experimental one gave quite similar results for a less 40% moisture contain. We can also have noticed that the higher the soil moisture content raise, the more is difficult to obtain a homogeneity soil in a column, which might have an impact on the sensor reading.

Mitigating arsenic contamination in rice plants with an aquatic fern, Marsilea minuta

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Dangers of arsenic contamination are well known in human civilization. The threat increases when arsenic is accumulated in food and livestocks through irrigated crops or animal food. Hence, it is important to mitigate the effects of arsenic as much as possible. This paper discusses a process for reducing the level of arsenic in different parts of rice plants with an aquatic fern, Marsilea minuta L. A pot experiment was done to study the possibility of using Marsilea minuta as a phytoremediator of arsenic. Rice and Marsilea minuta were allowed to grow together in soils. As a control, Marsilea minuta was also cultured alone in the presence and absence of arsenic (applied at 1 mg/L as irrigation water). We did not find any significant change in the growth of rice due to the association of Marsilea minuta, though it showed a reduction of approximately 58.64% arsenic accumulation in the roots of rice grown with the association of fern compared to that grown without fern. We measured a bioaccumulation factor (BF) of >5.34, indicating that Marsilea minuta could be a good phytoremediator of arsenic in rice fields.

Greater contribution of belowground than aboveground maize biomass to the stable soil organic carbon pool

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Crop residues return organic matter and nutrients to agricultural soil, but they could be potential resources for other uses, such as e.g. renewable energy production. Multiple field experiments have proven that belowground biomass contributes twice more than aboveground crop residues in buildup and preservation of soil organic carbon (SOC) in the long term. Alongside, a consensus has emerged that current biogeochemical models are particularly ill-parameterized for amount and degradability of belowground biomass. The mechanism explaining this *in situ* relative stability of belowground-derived SOC is, however, still poorly understood.

We used ^{13}C natural abundances to compare the relative stability of root- and shoot-derived SOC in two field trials with maize-based crop rotations (after C_3-C_4 crop transition). Our hypothesis was that root-derived C is more likely to accumulate in microaggregates due to the intimate contact of maize roots, promoting physical occlusion and stabilization during growing season. We also evaluated the effects of maize variety versus field (as affected by soil texture and field management history) on maize roots. We found that removal or incorporation of aboveground residues had but a minor impact on SOC accumulation. Belowground biomass was more efficient than aboveground residues in maintaining SOC, although root-derived C did not preferentially stored in microaggregates. Moreover, only the site significantly impacted belowground biomass, although both maize variety and field effects existed on aboveground biomass. The factor field also determined root system architectural 2D and 3D traits. Again no effects of variety were observed. Our results confirm the previous research about relative stability of belowground biomass and refute the hypothesis that occlusion in micro-aggregates would explain this stability. Maize root biomass and root system architecture to some extent depend on soil type and field history and is not necessarily in line with aboveground biomass.

Simulation of crop growth and water saving irrigation scenarios for lettuce: a case-study under monsoon climate in Kampong Chnnang, Cambodia

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Setting up water-saving irrigation strategies is a major challenge for farmers in order to adapt to climate change and to improve water use efficiency for their productions. Currently, vegetable production, like lettuce poses more challenges in managing effective water irrigation due to its sensitivity to water shortage. Crop growth models, such as AquaCrop, play an important role to explore and provide such irrigation strategies within various environmental conditions. The objectives of this study were (i) to parameterize AquaCrop model for lettuce (*Lactuca sativa* var. *crispa L*.) using data from farmers' fields in Cambodia and (ii) to assess the impact two distinct full (FI) and deficit (DI) irrigation scenarios under two contrasted soil types under Cambodian climate in silico, using Aquacrop. Field observations of biomass and canopy cover during growing season of 2017 were used to adjust the crop growth parameters of the model. The results confirmed the ability of AquaCrop to correctly simulate lettuce growth. The irrigation scenario analysis suggested that DI is a 'silver bullet' water saving strategy that can save water from 20 to 60% compared to FI scenarios in the conditions of this study.

Impact on soil-physical characteristics by cropping systems

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This research fits within the SOILCARE European H2020 project about profitable and sustainable crop production in Europe. The overall aim of the project is to identify and evaluate promising Soil Improving Cropping Systems (SICS) and land management techniques, which along with improving soil quality, will also increase profitability and farm sustainability. One of the key challenges is how best to monitor the 16 study sites across Europe and their soil physical properties, including soil water retention, hydraulic conductivity, bulk density, infiltration capacity, aggregate stability etc. This will be done in a consistent, cost-effective and reproducible way to allow for a comprehensive evaluation of soil quality. The partners in the study sites should be able to execute the methods after a short training and with good documentation. With such objectives in mind a set of monitoring methods are proposed. Soil samplings from all the selected CS will be collected and analyzed using, comparing and evaluating different methods and procedures developed and also, existing soil data from the long term experiments will be analyzed to assess the performance of the SICS. The impact of the different SICS on the physical parameters of the soil will be monitored across both short and long-term timescales at different study sites, and conclusions made to determine how each are affected. Furthermore, the crucial variables needed to monitor the soil quality and evaluation of different cropping systems under various conditions will be identified. All the results will be compiled in a database, with all information being made available to the study partners.

Do explosive volcanic eruptions act as local carbon sinks?

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Relatively short-lived explosive eruptions emit CO2 in the atmosphere and blanket the lanscape with tephra. As a result, soils may be buried with the organic matter they contain and are isolated from the surface.

Here we test the hypothesis that the total amount of soil organic C sequestrated below a tephra deposit surpasses the amount of C released into the atmosphere by the same eruption that laid down the tephra.

We determined the organic C content in soils below a ~930 km2 tephra deposit corresponding to the 2270 yr BP eruption of Atacazo volcano, Ecuador. We computed the C stocks by applying a linear regression model based on the correlation between local carbon stock and the altitude to our datapoints. The amount of volcanic C emitted by the 2270 yr BP eruption was inferred from the tephra deposit volume (~1.3 to 2.8 km3 [1]), assuming that each km3 of magma erupted releases ~10 Mt of CO2 [2].

Our results indicate that ~25 Tg of organic C are currently stored in tephra-buried soils. This stock of C is ~2.5 times higher than the amount of volcanic C emitted into the atmosphere by the 2270 yr BP eruption of Atacazo. We argue that tephra-rich explosive eruptions in subtropical and tropical regions where soils development is rapid may act as local sinks of C.

[1] Hidalgo et al. (2008) J Volcanol Geoth Res, 176, 16-26.
[2] Burton et al. (2013) Rev Mineral Geochem, 75, 323-354.

Crusting of volcanic tephra deposits: an experimental study

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Surface crusting of fresh tephra deposits is a common phenomenon occurring after a rain event. Tephra crusting may lead to a decrease in soil water infiltration and an increase in runoff and erosion. It also may hamper seed germination and depress plant growth, thereby posing problems to farmers. Although tephra crusting has long been observed, its formation mechanism and the controlling factors have not been investigated.

We present the results of a study in which tephra crusting was studied experimentally. Tephra samples from three eruptions, i.e. Eyjafjallajökull 2010 (EYJA), Mt. Merapi 2010 (MER) and San Cristobal 2000 (SC) were tested. The particle size distribution of these tephra samples differ: MER contains the largest contents of silt- and clay-sized particles, whereas EYJA is the coarsest sample. SC has lower amounts of silt-sized and clay-sized particles than MER. Besides, this sample also contains significant amounts of soluble sulphate and halide salts. A rainfall simulator was used to apply 5, 10, 15 and 20 mm of rain to reconstructed tephra deposits. All treatments were performed in triplicates. Polished sections of the treated samples were examined using optical and electron microscopy. Crust thickness and porosity were estimated using an image analysis software.

Exposure of MER and SC tephra to 5, 10, 15 and 20 mm of rain always led to surface crust formation. However, crusting of EYJA tephra was erratic. Crust thickness ranges from 0.1 to 0.8 mm and from 0.04 to 0.1 mm in MER and SC tephra, respectively, and correlates positively with the amount of rain applied. Porosity of the surface crust is typically lower (by a factor of up to 2.6) than that measured deeper in the tephra deposit. The crust that formed on top of MER tephra deposit showed a “washed out” and a “washed in” layer. These features are interpreted as the result of particle sorting. In contrast, crusting of SC tephra may be the consequence of compaction due to interaction of raindrops with the deposit surface. There is no evidence of chemically cemented particles in the SC tephra deposit. We suggest that the particle size distribution of a tephra deposit plays a key role in crust formation.

Quantification of the phytoliths pool in a tropical Andosol, A new method

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Silicon (Si) is the second most abundant element of the earth crust after oxygen. The Si cycle strongly depends on the bio-cycling of Si by plants. Plants roots absorb the dissolved silicon present in the soil solution, translocate it into their shoots through the transpiration stream and accumulate it in transpiration termini in which it precipitates into amorphous silica bodies called phytoliths (PhSi). By the deposit of plant materials on the ground, the PhSi are returned into the soil where they may constitute an important silica pool.

PhSi are 10^2 to 10^4 times more soluble than primary and secondary silicates and may therefore strongly contribute to the dissolved silicon pool; especially in desilicated and weathered soils where the primary silicate pool is exhausted.

To understand the soil-plant Si cycle it is thus primordial to quantify the importance of the biogenic silicon feedback loop by quantifying the PhSi pool in the soil. However, quantification methods are still not very well defined especially in soils in which pedogenic amorphous silica pools are abundant.

We propose here a new chemical quantification method of the PhSi pool in soils in which pedogenic amorphous silica pools are abundant. With this method, we also allow to quantify separately (i) the PhSi pool that is occluded in micro aggregates and thus not active in the biogenic silicon feedback loop and, inversely, (ii) the ‘’free” PhSi pool that can be considered as active in the biogenic silicon feedback loop.