

Energy cover crops for anaerobic digestion should increase soil organic carbon storage

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Energy cover crops for anaerobic digestion (AD) are inserted between two main crops. They replaced either bare soil or non-harvested cover crops. They thus do not compete with food production and allow the production of renewable energy (biogas) as well as of digestate, used as an organic fertilizer. Because of the changes in both quantity and quality of C returned to soil, the impact of energy cover crops on soil organic carbon (SOC) stocks is questioned. Our objective was thus to study the difference in SOC stocks induced by the introduction of energy cover crops for AD coupled with the application of the resulting amount of digestate. We used the AD model Sys-Metha combined with the soil C model AMG to simulate SOC stocks for 13 case studies with energy cover crop in France. The main results indicated that energy cover crops (with digestate returned to soil) led to higher SOC storage in comparison to non-harvested cover crops or bare soil (from 0.01 to 0.12 t C ha⁻¹ year⁻¹ during 30 years). The higher biomass production of energy cover crops (from 6.7 to 11.1 t DM ha⁻¹) in comparison to non-harvested cover crop (2 t DM ha⁻¹) or bare soil was the driver of SOC storage, leading to higher humified C input (belowground input and digestate) despite the high C losses in AD. The uncertainties in model calibration did not modify these results. However, in the case of equal biomass production between energy cover crops and non-harvested cover crops (not representative of actual field practices), SOC stocks would be lower with energy cover crops. Finally, a multicriteria assessment should be performed to consider other effects than SOC storage, especially the impacts of the intensification required to increase the biomass production of energy cover crop.

Keywords: cover crop; anaerobic digestion, SOC, modelling

Effect of long-term sewage sludge amendment on plastic distributions in soils

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Fertilizing soils with organic amendments such as wastewater treatment sludge is being prioritized by countries seeking to become bio-based societies. Moreover, recycling external organic matter rather than burning it contributes to carbon sequestration in soils. However, many organic amendments contain microplastics that thus contaminate the soils. While the number of studies demonstrating microplastic presence in agricultural soil under different management systems is increasing, there is still a considerable knowledge gap on the potential mobility of microplastics. Laboratory-based process studies indicate transport of microplastics. However, field investigations of microplastic distribution in the soil profile are still lacking which makes it challenging to understand their long-term fate and local impact. The environmental impact of organic amendments is thus not fully understood. The objective of this study was to investigate the abundance and spatial distribution of microplastics in soil profiles from a long-term field experiment, including field plots exposed to 25 years of bi-annual sewage sludge application in contrast to field plots without fertilization. To this end, soil cores of 90 cm depth were taken and segmented into 10 cm thick layers, except the plough layer (0-20 cm). Polyethylene (PE), polystyrene (PS) and polypropylene (PP) microplastics below 2 mm size were then analysed using pyrolysis gas chromatography mass spectrometry after density separation and subsequent organic solvent extraction with 1,2,4-TCB and p-xylene. Microplastic abundance and differences between treatments were polymer-specific with PE being more abundant when sewage sludge was applied to the soil. In contrast, PS and PP were less strongly related to sewage sludge applications and detected in occasional single instances in both treatments. The detection of PE, PS and PP in control plots indicates that the area may be exposed to other more diffuse input sources, albeit at low levels. Notably, all microplastics were at least partly detected below the plough layer (0-20 cm). PE was detected in significant levels down to approximately 40-50 cm in the soil profile, which is likely attributed to transport processes within the soil profile. On the one hand, this emphasizes the need to consider deeper soil layers for accurate mass estimates and monitoring purposes; on the other hand, our results indicate that depending on the soil properties, soils may act as a temporary sink for microplastics arriving in soils following addition of organic amendments.

Keywords: external organic matter; risk assessment; carbon sequestration

Bridging the gap between research and practice: the importance of biochar quality and pyrolysis yield for soil carbon sequestration

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Biochar is a carbon rich, relatively stable product produced from biomass, by anaerobic or oxygen-limited combustion known as pyrolysis. Storing biochar in soil has been suggested as a potentially effective long-term option to sequester CO₂. Under the rising international interest in the application of biochar to soils as a negative emission technology, there is an urgent need for a robust but simple tool to estimate its carbon sequestration potential. The H/C_{org} molar ratio has been widely recognized as a proxy to describe stability, in science and in practice. Empirical data deriving from different scientific field and incubation studies of biochar are being used to calculate the fraction of biochar carbon remaining in soil after 100 years (F_{perm}) as a function of the molar ratio H/C_{org}. In experiments, biochars of varying quality are applied. These sometimes do not represent well the properties of biochars typically used in practice. For the latter, often qualities adhering to the guidelines of the European Biochar Certificate (EBC) apply. We suggest how to bridge this gap between research and practice and show how biochar quality and pyrolysis yield influence the calculated F_{perm} for biochar based carbon sequestration. For our analysis, we only include those studies where the biochars are in accordance with the EBC criteria in terms of C_{org} content and H/C_{org} ratio. As a result, we propose a new parameter to describe pyrolysis efficiency in relation to stability of biochar and suggest an alternative model for estimating the carbon sequestration potential of biochar.

Keywords: biochar; carbon sequestration, model

Influence of biochar on nitrous oxide emission from vermicompost.

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Vermicomposting is the process of using worms to transform organic waste into a nutrient-rich fertilizer. The end product is called vermicast, which is used as fertiliser or as a soil activator. There are many advantages of vermicomposting, such as the improvement of soil aeration, enrichment of the soil with beneficial micro-organisms, increased water holding capacity, leading to improved root growth and structure, these positive effects are all well documented. However, there are some studies that suggest worms produce potent greenhouse gases (GHG), in particular nitrous oxide, although biochar (BC) addition to the soil-worm systems studied reduced the emissions. Biochar is pyrolysed biomass, specifically produced to be added to soil as a soil conditioner-carbon sequestration measure. It has been recognised that vermicomposting could play a significant role in the circular economy, particularly tackling food waste recycling in peri-urban areas, whilst creating green business opportunities. To confidently advocate these novel systems, knowledge of the pollution swapping risks must be assessed. Therefore a study was proposed to determine the influence of adding biochar to the vermicomposting process in order to reduce GHG emissions. The incubation experiment was a collaboration of a local industrial worm farmer (VERMIGRAND, Naturprodukte GmbH Absdorf) and the Institute of Soil Research, University of Natural Resources and Life Sciences (BOKU), Tulln and the Soil and Water Management and Crop Nutrition Laboratory of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Seibersdorf.

The aim of the research is to quantify the GHG emissions from the entire worm composting process and to assess the impact of the addition of BC to the vermicompost particularly its impact on nitrous oxide (N₂O) and carbon dioxide (CO₂) emissions, in addition to determining the influence of the timing of the BC addition, whether there was an effect if biochar was added before or after the initial hot composting process.

In this study two stages of composting and different types of vermicompost were be compared: In the first stage GHG's were be measured from regular feedstock hot composted normally (Comp) and feedstock pre-treated with 5% (v/v) BC added prior to hot composting (BC-Comp). Following hot composting an additional treatment where BC was added after the initial hot composting (Comp+BC) was included. Equal quantities of worms were added to the replicated treatments and the GHG's measured regularly throughout the compost maturation process.

The following measurements were conducted: compost temperature, pH, and salinity. In addition to N₂O and CO₂ concentrations measured using off-axis Integrated Cavity Output Spectroscopy (OA-ICOS) in continuous flow mode. Concurrently compost properties of total soluble nitrogen, soluble organic nitrogen, soluble inorganic nitrogen, total soluble carbon, soluble organic carbon and soluble inorganic carbon were be measured using a combination of standard colourmetric methods and elemental analysis.

Biochar as heavy metals immobilization agent

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Biochar can be produced from a wide range of organic wastes via pyrolysis, where due to its versatility it has been widely applied in many different research areas, i.e., for carbon sequestration in soils as physicochemical soil amendments and to improve soil productivity. Biochar like lime and fly ash increases soil pH and hence can act as an immobilizing agent for heavy metals. This study aimed to investigate biochar produced from different organic by-products effects on heavy metals immobilization into the soil. Three types of biowaste, such as corn stalks, digestates from sewage sludge biogas, and rapeseed residues of biodiesel production, were used for biochar preparation via pyrolysis and used as soil amendments. Vegetation experiment with two plants (mustard and buckwheat) were installed to determine biochar effect as an immobilization agent. It was evaluated heavy metals accumulation trends in roots and plant shoots, in the soil after harvest and in drainage water as well. Obtained results demonstrate that biochar is a prospective agent for heavy metals immobilization and could decrease its availability to plants. Organic amendments incorporation increased soil pH and reduced heavy metals availability to plants. Biochar additive increased bond to organic matter nickel and copper content. Biochar application on soil decreased bond to carbonates and bond to manganese and iron oxides content of copper. The hugest changes were observed with zinc. In the soil without, organic amendments around 80 percent of zinc were easily bioavailable to plants. While after organic amendments application residuals fraction increased and only around 20 percent of the total determined amount of zinc was found as a bioavailable fraction. The results will be presented during EJP Soil Science days breakout session are obtained by implementing the Interreg South Baltic Programme 2014-2020 project "Baltic Phytoremediation (BAPR)". This project show case solutions on phytoremediation and energy production from grown crops to clean polluted soil, and host a network to exchange cross-border knowledge through best practices/standards.

Keywords: biochar; heavy metals; phytoremediation; immobilization;

Repeated applications of external organic matters potentially enhance soil carbon storage and soil fertility with potential adverse effects

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Repeated application of organic amendments can enhance carbon sequestration in soils. These organic amendments are mainly issued from exogenous organic matters (EOM) (not directly produced from the soil where application occurs), coming from organic wastes or by-products related to other activities and often treated before application for different purposes (sanitation, stabilisation of organic matter,...). Their application in agriculture has been largely encouraged since it makes possible to recycle the nutrients they contain as substitute to mineral fertilizers and also potentially increase carbon storage in soils and improve associated soil properties. If agricultural and industrial wastes are largely recycled in agriculture, the recycling of urban wastes is strongly encouraged after biological treatments (composting or anaerobic digestion). These recycling participate to circular economy, however such practice needs to be proved to have no adverse impacts on soil, crop and water qualities. It is thus important to balance benefits and risks associated to their repeated application.

A network of long-term field experiments (SOERE-PRO) have been created among French research institutes, to quantify, explain and be able to predict the consequences of repeated fertilization with OW on soil and water qualities and on crop production and quality. The SOERE-PRO included different pedoclimatic conditions including temperate and tropical conditions, various OW including animal manures and slurries, sewage sludge composted or not, biowaste composts and digestates... with some experiments as old as 1998.

The presentation will explore how long-term experiments are useful tools to quantify the effects of repeated applications of EOM on soil C stocks, define indicators making possible to predict their efficiency, quantify the side effects they may have on soil ecosystem services but also potentially on soil contamination. By making possible the assessment of multiple impacts and their interactions, such experiments should be useful tools to help decision makers at providing new regulations or best management practices.

This abstract has been prepared for the “Carbon sequestration and amendments” session. But this session is not available on the web page.

Keywords: external organic matter, long-term field experiment, C storage, contaminant, nitrogen