THE FATE OF DIGESTATE C IN SOIL ADDED DURING BIOFERTILIZATION

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Biogas reactor (BR) is designed to produce methane during the anaerobic digestion (AD) of organic waste. The digestate is a by-product of the AD process that has been successfully used as biofertilizer and a valuable source of major plant nutrients (Nitrogen (N), Phosphorus (P), Potassium (K), and Carbon (C)), which are essential for plant growth, soil fertility and therefore sustainable crop production. The application of digestate can stimulate microbial activity and improve soil fertility through the supply of soil organic matter (SOM).

Digestate addition indirectly positively affects on the process of humification and SOM dynamics in general through the controlling of soil water regime, pH, available nutrients, and microbial activity. Moreover, several studies reported about partially humified organic carbon in the digestate related to the increase of soil organic carbon (SOC) after digestate addition. But the potential of digestate to increase soil carbon sink and storage depends on several factors primarily type of feedstock, operating conditions of AD, post-treatment technology, and type of the soil.

The aim of this study is to evaluate the digestate from major waste sources that has a larger contribution and for a longer time of C accumulation to soil.

The treatment with the digestate application leads to an overall increase in C soil content in contrast to mineral fertilizer application treatment (unpublished data). Strategies that improve the availability of nutrients in soils, in particular, C, N, P can help meet targets for nutrition security, soil conservation, and reinforce a multidisciplinary approach. Thus, the correct use of digestate in agricultural systems plays an important role by reducing the use of mineral fertilizers, which leads to positive results, namely reducing energy costs for their production and consumption of mineral resources, mitigating climate change, and maintaining soil quality.

SOC is a main compartment of the global C cycle, thus providing opportunities for climate change mitigation. In 2015, France released a global soil initiative called, ‘4 per 1000’ Initiative’, which aims to increase the carbon in soils by 0.4 % annually to stabilize the climate and to ensure food security. The initiative allows different actors to contribute what they feel is within their means to prevent soil degradation. SOC sequestration may be an effective solution to mitigate climate change, as some types of organic matter have a long retention time in soils [1].

SOC is an important indicator of soil health, particularly with regard to soil fertility for crops, because it has numerous benefits: improving soil structure through soil particle aggregation enabling better root access, increased water infiltration and retention, increased nutrient bioavailability due to SOM (soil organic matter) decomposition, and more exchange sites for mineral nutrients increasing the soil’s cation exchange capacity [2]. The digestate increases the content of organic C in the soil and reduces the rate of its transformation in comparison to non-digested input organic materials. According to study [3] the addition of digestate increases microbial diversity, and soil microbial biomass and activity. Such positive effect of digestate on the soil microbial community is very important because some plant growth promoting bacteria can occupy the rhizosphere of many plant species and have beneficial effects on plant growth through direct and/or indirect mechanisms, can facilitate the conversion of nutrients in soil to plant-available forms. Thus, the digestate used as fertilizer has a capability to increase yields of crops by C accumulation in the soil.

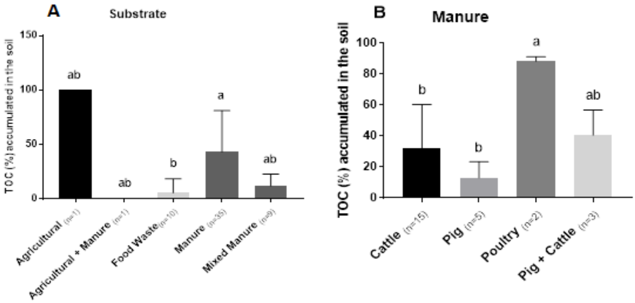
The fertilizer properties of digestate highly depend on the composition of feedstock. In recent years, the fertilizer properties of digestate in various feedstocks have been widely investigated [4]. Organic matter content, NH_4, the C/N ratio, and N content present in the different substrates or feedstocks that form the digestates, will show differences in efficiencies and productivity in plants and soils. Digestates mixed with pig-manure digestate and biowaste digestate tend to have higher concentrations of phosphorus and ammonium nitrogen, but lower concentrations of dry matter and potassium as well as lower concentrations of organic matter than digestates from cattle manure or energy crops or mixtures of the two.

The main question of this study: What is the effect of digestate originated from different types of feedstocks on the fate of organic carbon and its accumulation in soils?

Based on a literature survey of > 1000 papers, we observed that there is a relationship between the type of feedstock, type of soil and rate of TOC organic C increase after BD application. However, these results are based on a wide range of experimental setups and a rigorously evaluation of the effect of digestate on soil C concentration on soil a specific experiment is still missing. In order to fill in existing gaps, it is imperative the implementation of specific experiments, with specific questions, like the one proposed in this project.

Our preliminary meta-analysis showed that the addition of digestate increases soil C content, but the efficiency is apparently dependent on the type of substrate used in the AD and the type of soil that the digestate is being added. The addition of digestate increase the soil C content in the majority of the studied cases and some of the studies reported that the C increase was observed for a relatively longer period of time, i.e., after 7 years of digestate addition, the longest reported experiment. The digestate from AD feed with manure seems to have the best effect in terms of soil C accumulation. However, as it can be observed in Figure 1, the number of reported studies were pretty limited and there is a clear need for results based on studies with a specific experimental design, that are still lacking (fig. 1A).

It should be highlighted that digestate originated from cattle manure feedstock had the largest soil C increase. This can be explained given the large lignocellulose content in cow manure, that it is of relatively difficult to degrade, even at higher retention times in AD. If from one side the cow manure is of difficult AD degradation, it seems having high soil C accumulation rates and therefore is a promising substrate when the focus is soil C accumulation.



A) Efficiency of soil TOC incorporation from different substrate types added to BR;
B) Efficiency of soil TOC incorporation from different types of manure added to BR

Figure 1 – Soil TOC accumulation as a response from the primary substrate added to the Biogas reactor

Within the framework of this study, it is planned to conduct experimental field studies aimed at determining the potential of anaerobic digestate in soil C accumulation after long-term application (1 year). The crop rotation in the experiment will comprise oats (*Avena sativa cv. Freja*) and spring barley (*Hordeum vulgare cv. Baronessa*). The experimental design will be with randomizing the fertilizer treatments within each crop. We will use digestate from local feedstock (food waste, sewage sludge, cow manure, pig manure and agriculture waste) in different ratios and different types of pre-treatment technologies will be applied. Such chemical parameters as pH, dry matter, total organic carbon (TOC), organic N, TKN, P, K will be analyzed for digestate before fertilization, digestate for further experiments, soil before digestate addition, and after digestate addition.

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