Effect of the carbonization process of sewage sludge on the properties of the chars and their potential benefits as soil amendments

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Containing high amounts of nitrogen (N), phosphorus (P) and organic matter (OM), sewage sludge (SS) constitutes an excellent feedstock to produce soil amendments. Applied to contaminated sites, SS can improve soil health by increasing soil OM and by providing nutrients both to plants and soil microbiota. However, adding untreated SS directly to the soil can create hygienic problems. Its low biochemical stability can lead to N and P leaching, meaning that instead of being recycled for the production of plant biomass, these nutrients turn into potential contaminants of groundwater. The thermochemical carbonization of SS at elevated temperatures in the absence or low presence of oxygen has been considered to achieve the needed stabilization and hygienization of this material. In addition, compared to other treatments like composting, during carbonization all organic pollutants usually found in this residue are destroyed. In the presence of water, this low-oxygen carbonization is called hydrothermal carbonization (HTC), whereas in the absence of water it is known as pyrolysis. The solid by-product that results from pyrolysis can be called pyrochar, whereas the product of HTC is usually called hydrochar.
Both types of carbonizations include reactions such as dehydratation, decarboxylation, aromatization and recondensation. However, our studies showed that the different process conditions lead to significant differences of both the chemistry and physical characteristics of the solid products, therefore varying their potential benefits once applied to soils. Detailed characterization of the pyrolysis products showed that SS-hydrochars preserved a higher amount of N than SS-pyrochars, whereas pyrolysis led to a higher relative enrichment of P than HTC. During carbonization, part of the N is incorporated into heterocyclic aromatic structures. Pot experiments confirmed that these forms are biochemically more recalcitrant than the original peptide-like N in SS, confirming that SS-hydrochars can act as a slow-release source of N for soils. In contrast, SS-pyrochars, due to its lower N content and higher condensation degree compared to hydrochars, seemed to be more suited to increase soil OM in the long-term at the same time that P is provided. Subsequent pot experiments monitoring the biochemical degradability of SS-chars and their impact on soil N and P cycles confirmed this hypothesis.

Keywords: carbonization, sewage sludge, soil amendments

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them. Grant agreement No. 101059546.