Agricultural use of co-hydrochars from biowaste and sewage sludge

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Biowaste management's environmental impact can be reduced by converting biowaste into valuable products such as energy, catalysts, or soil amendments. Hydrothermal carbonization (HTC) is a thermochemical technology, which allows the treatment of high moisture waste without the energy-intensive step of feedstock drying. This process yields a solid carbonaceous material (hydrochar) under mild temperatures (180 ºC - 250 ºC), self-generated pressure and short reaction times. This study aimed to characterize the hydrochars produced via HTC and co-HTC of garden and park waste (GPW) with food waste (FW) or sewage sludge (SS) in three mixing ratios (1:3, 1:1 and 3:1 wt:wt), as well as those subjected to various post-treatments to enhance their properties for application as a soil amendment for tomato (*Solanum lycopersicum* L.) growth.

HTC and co-HTC were performed in a 2-L PARR 4530 reactor at 180 ºC for 1 h. The resulting solid product, designated as fresh hydrochar (FHC), underwent both a washing procedure (yielding washed hydrochar, WHC) and an aging post-treatment (yielding aged hydrochar, AHC) to minimize potential phytotoxic compound content and enhance hydrochar stabilization.

The use of these hydrochars was compared with a biochar produced via pyrolysis at 650 °C for 1 h in a rotary tube furnace. All chars were characterized by elemental and proximal analysis, mineral content, surface chemical groups and textural properties. Furthermore, pH, electrical conductivity and cation exchange capacity were measured.

Three doses of each char (1%, 3% and 5%, d. wt. basis) were added to agricultural soil, used as a control. For each treatment, Petri dishes containing 45 g of the respective soil-char mixture were prepared, watered and kept at 28 ºC for 1 week to stabilize. Then, 5 tomato seeds were sown in each replicate (5 replicates per treatment), and the conditions were maintained for 4 days. The seedlings were then transferred to a growth chamber for 3 days. 7 days after sowing, the germination index (GI), fresh biomass and seedling length were measured.

Characterization showed that biochar exhibited lower volatile matter and higher fixed carbon content compared to all hydrochars, regardless of the feedstock, reflecting the greater stability of the biochar. The higher temperature of pyrolysis compared to HTC also caused the reduction of chemical surface groups, which in turn decreased the cation exchange capacity of the resulting biochars. All chars were suitable for soil application according to European Directive (Council Directive 86/278/EEC 1986). Co-HTC of wastes decreased the high mineral content associated with some of them, such as SS or FW, reducing the concentration of potentially toxic elements (PTE) or the electrical conductivity. Hydrochars exhibited an acidic pH (4.6 – 5.5) while biochar showed a basic one (pH > 9.4) in all cases. In the germination experiment, lower doses of all hydrochars did not cause significant differences with respect to the unamended control. However, increasing the dose of fresh hydrochar from FW or SS inhibited seed germination, while WHC improved the results. Regarding tomato seedling growth, FHC, AHC and biochar from FW and SS negatively affected plant growth as the dose increased. This effect could be related to the higher EC of biochar and the presence of phytotoxic compounds found in the leachates of the hydrochars. However, GPW did not decrease germination or seedling growth, therefore, co-HTC improved tomato seedling response as an increase of the GPW ratio in the initial mixture decreased PTE concentration and phytotoxicity.

References

Council Directive 86/278/EEC (1986) of 12 June on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture. https://eur-lex.europa.eu/eli/dir/1986/278/oj/eng

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