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Production of biochars from crop residues for the remediation of trace elements contaminated soils

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Biochar is the solid material obtained from thermochemical conversion of biomass under oxygen-limited conditions (pyrolysis), which can be applied as soil ameliorant [1]. In general, biochar properties are very heterogeneous due to the diverse pyrolytic conditions and the wide variety of organic residues used as feedstock [2,3]. This study intends to discern the relationship between feedstock, pyrolysis conditions and biochar properties with the goal of producing biochar with a high potential for the stabilization of trace elements in contaminated soils.

For that purpose, biochars were produced using four different feedstock (rice husk, pruned olive trees, olive pit and "*alperujo*", a byproduct of olive oil production) and two contrasting pyrolysis systems: a batch reactor (temperature ranged from 350 to 600 ºC; reaction time from 0.5 to 4 h under N_2 atmosphere with a heating rate of 20 ºC min^{-1}) and a continuously feed reactor with a screw conveyor (Pyreka reactor; 500 ºC, residence time 12 min and N_2 flux).

Biochars were characterized by determining their pH, water holding capacity (WHC), elemental composition (C, H, N), ash content, internal structure by micro-computed tomography and chemical composition by field emission scanning electron microscopy with energy dispersive X-ray spectroscopy. To complete the characterization, Brunauer-Emmett-Teller specific surface area (SSA_{BET}; N_2 adsorptive) and solid-state ^{13}C-NMR spectroscopy were performed.

Biochars produced in the batch reactor showed that pH, WHC, TC, SSA_{BET}, ash content and aromaticity increased with temperature and reaction time. Rice husk biochars showed the highest WHC (> 100%), while olive pit biochars the lowest ones. Rice husk and olive pit biochars had the highest aromaticity (between 75 and 91% of aryl carbon). The H/C_{at} ratio decreased with increasing pyrolysis temperature, which suggests an increase in the condensation degree of the aromatic structures. SSA_{BET} surface area ranged from 20 to 100 m^2 g^{-1} and increased with temperature. Biochars produced in the batch reactor resulted in greater SSA values than Pyreka biochars. The pyrolysis conditions of 500 ºC and 2 h at the batch reactor resulted in similar biochars than those produced by the Pyreka reactor (500 ºC and 12 min). Taking into account the necessity of applying biochar to soil for remediation purposes, we selected those biochars of expected high stability (ratio H/C_{at} $\leq$ 0.7 & high aromaticity by ^{13}C NMR spectroscopy), great capacity for the sorption and stabilization of trace elements(SSA_{BET} $\geq$ 100 m^2g^{-1};pH $\geq$9) and good potential to act as soil amendment (high WHC). The pyrolysis conditions finally selected were 500 ºC and 2 hours for the steel-batch reactor and 500 ºC and 12 min for the continuous reactor. At these conditions, rice husk biochars showed the most appropriate characteristics to be used as soil amendment for trace-elements contaminated soils.

References:

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