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Interactive effects of biochar ageing in soils related to feedstock, pyrolysis temperature, and historic charcoal production.

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Biochar is suggested for soil amelioration and carbon sequestration, based on its assumed role as the key factor for the long-term fertility of Terra preta soils. Several studies have shown that certain biochar properties can undergo changes through ageing processes, especially regarding charge characteristics. However, only a few studies determined the changes of different biochars under the same incubation conditions and in different soils. The objective of this study was to characterize the changes of pine chip (PC)- and corn digestate (CD)-derived biochars pyrolyzed at 400 or 600 °C during 100 days of laboratory incubation in a historical kiln soil and an adjacent control soil. Separation between soil and biochar was ensured by using mesh bags. Especially, changes in charge characteristics depended on initial biochar properties affected by feedstock and pyrolysis temperature and on soil properties affected by historic charcoal production. While the cation exchange capacity (CEC) markedly increased for both CD biochars during incubation, PC biochars showed no or only slight increases in CEC. Corresponding to the changes in CEC, ageing of biochars also increased the amount of acid functional groups with increases being in average about 2-fold higher in CD biochars than in PC biochars. Further and in contrast to other studies, the surface areas of biochars increased during ageing, likely due to ash leaching and degradation of tar residues.

Changes in CEC and surface acidity of CD biochars were more pronounced after incubation in the control soil, while surface area increase was higher in the kiln soil. Since the two acidic forest soils used in this this study did not greatly differ in physical or chemical properties, the main process for inducing these differences in the buried biochar most likely is related to the differences in dissolved organic carbon (DOC). Although the kiln soil contained about 50% more soil organic carbon due to the presence of charcoal particles, extractable DOC was lower and less aromatic than in the adjacent control soil, likely due to strong sorption of dissolved organic matter (DOM) onto charcoal particles. We suggest that higher sorption of DOM onto the surface of biochar in the control soil provided additional acid functional groups and thus increased the surface charge to a greater extent than in the DOC poorer kiln soil. Hence, biochars incubated in the kiln soil showed less changes in CEC and surface acidity. Higher availability of DOM in the control soil could also stimulate microbial activity to a larger extent, resulting in higher oxidation rates of biochars incubated in the control soil.