CHARCOAL INPUT INCREASES C SEQUESTRATION POTENTIAL OF SUBSOILS IN UMBRIC FERRALSOLS

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Climatic conditions of subtropical and tropical regions support fast carbon (C) mineralization, and thus an accelerated degradation of soil organic matter (SOM) if compared to temperate region. However, even in those regions, there are still soils that show notable C accumulation even in the deeper horizons. Examples for the latter are umbric horizons in typical tropical soils, such as Ferralsols. The occurrence of this soils with thick umbric epipedons (≥ 100 cm thickness) in areas of South Brazil still needs a better understanding, since the processes that are responsible for the thickness and darkness of the umbric horizons are of special interest with respect to the role of soils as carbon sink. Many of those soils are characterized by frequent fires caused by human activity during the last centuries and millennia. However, to which extend those fires and the subsequent input of charcoal affect the quality of the SOM or are responsible for the typical features of those soils is still not well understood.

In order to bring some light onto this issue, SOM from profiles of Umbric Ferralsols from Atibaia, Campinas (São Paulo State) and Chapecó (Santa Catarina State) developed under different environmental conditions were characterized by solid-state NMR spectroscopy. Their respective pyrogenic organic matter (PyOM) content was elucidated after their chemical oxidation with acid potassium dichromate and the quantification of chemical oxidation resistant aromatic carbon ($COREC_{arom}$). In order to reveal possible interaction with the mineral phase, iron and aluminium oxides were extracted with different extracting solutions (sodium pyrophosphate, ammonium oxalate and dithionite-citrate-bicarbonate solution) and related to SOM quality and quantity.

As it is typical for such soil, SOM concentrations in the A horizons of the studied soils are about times higher than those of other Ferralsols. Pyrogenic organic matter (PyOM) was identified down to the 2 meters depth. Interestingly, PyOM contributions were less in the top soils than in the deeper horizons, most tentatively because of efficient charcoal oxidation at the surface and the subsequent removal of the degradation products by further mineralization or by transport to deeper soil regions. According to solid-state NMR spectroscopy, the SOM of several deeper horizons was almost exclusively composed of PyOM. This observation demonstrates its preferential preservation in deep soils, possibly supported by its stabilization through the mineral phase. However, no correlation was revealed between clay content and aromatic C concentration. Only a week relationship between aromaticity and content of Al and Fe-oxides was found indicating that additionally to interaction between PyOM and mineral phase further mechanisms are involved in the preservation of PyOM in the deeper horizons.

A possible scenario which could explain the SOM distribution pattern in the examined soil may be that after initial oxidation of the charcoal in the topsoil, the residues were displaced either by leaching with the soil solution or by bioturbation along the profile. The low microbial activity and O_2 depletion in the deeper soil regions may have prevented or at least slowed down further O_2-requiring degradation of aromatic structures. Likely, this was contributing to the relatively high organic C concentrations in the subsoils of the studied umbric Ferralsols. Because the metabolization of carbohydrates, peptides and fatty acids is less effected by low oxygen availability, the PyOM was selectively preserved.

In summary our data clearly support that frequent charcoal addition can have a long-term impact on both the quality and quantity of organic matter in particular of deeper soil horizons. Here the oxidized PyOM is selectively preserved and seems to play a key role for increasing the amount of sequestered C in fire affected soils.