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The role of fire in the formation of soil organic matter in tropical and subtropical climatic zones

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In tropical and subtropical areas, natural and prescribed vegetation fires lead to a considerable input of charcoal into soils. Whereas it is well accepted that an immediate effect of charcoal input represents the enhancement of the aromaticity of the soil organic matter (SOM) in particular of the topsoils, our knowledge about the long-term impact of this material on the humification processes is still scarce. Analyzing the SOM along various profiles of soils in Southern, Central and Northern Brazil indicated an ubiquitous presence of pyrogenic organic matter (PyOM) down to the C horizons. Interestingly, in several soils lower charcoal contributions were found in the topsoils than in the deeper horizons. Solid-state 13C and 15N NMR revealed that this PyOM is highly carboxylated. Most tentatively, charcoal was efficiently oxidized and biodegraded at the surface turning it into a more humus-like substance. However, some of the degradation products must have been transported into deeper soil regions where they were selectively preserved. Possibly, the oxygen depletion in subsoils or the interaction of oxidized PyOM with the mineral phase have increased its biochemical recalcitrance resulting in a preferential degradation of SOM derived from fire-unaffected sources. Our data clearly show that frequent charcoal addition can have a higher long-term impact on SOM of deeper soil horizons than commonly assumed. It may even represent an essential factor for defining the properties of such subsoil. Considering further that oxidized charcoal residues may also leach into the aquifer, a further evaluation of the impact of such residues on the groundwater is urgently needed.