Organic matter stabilization by thermal mediated mechanisms in continental Mediterranean soils

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The quantitative distribution patterns and molecular characteristics of the humic fractions from two soils affected or not by medium to high-intensity forest fires have been studied. The methodology used included non-destructive approaches such as visible and FT-IR derivative spectroscopies, 13C NMR and destructive Curie-point pyrolysis or wet chemical degradation with sodium perborate (NaBO3) followed by GC/MS analysis of the resulting fragments.

By being highly responsive to the effect of fire, a series of analytical variables were found appropriate surrogate descriptors for the pyromorphic humus accumulated in soils after a fire event (1). Other variables were found to depend to greater extent on the type of fire: medium intensity affecting mainly to the forest canopy and leading to the input of charred material to the soil, or high-intensity fires with litter burning and severe thermal impact on topsoil.

Higher yields of benzenecarboxylic acids were obtained from the humic acids isolated from fire-affected soils. It has been postulated that benzenecarboxylic acids are not chiefly formed from materials produced by humification processes and could betray the presence of black carbon in soil (2). The 13C NMR reflected increased amount of aromatic structures in pyromorphic humus concomitant to dehydration and condensation reactions leading to a decrease of the area of the alkyl and O-alkyl regions. Also, in the humic acids from fire-affected soils, the FT-IR peaks characteristic for lignins and carbohydrates disappear, what is in accordance with the lower yields for syringyl- and guaiacyl-type compounds by NaBO3 wet degradation.

Apparently more dependent of the type (intensity) of fire we found: changes in the elemental composition of humic acids with a decrease of C/N, H/C and O/C ratios; decreased amounts of extractable humic substances; decreased yields of indanes, steroids and mainly of methoxyphenols after pyrolysis in the fire affected-HAs, with the distribution pattern of the HA methoxyphenols being largely responsive to the effect of fire in the HAs structure.

Our results agrees with the studies that suggest that fire causes a decarboxylation and condensation of the organic matter (3). It seems that fire emulates some of the effects of humification processes based on microbial synthesis and reworking of macromolecules. Therefore, in some bioclimatic areas like semiarid Mediterranean regions not favourable to selective preservation of soil organic matter fractions but to intense mineralization, the importance of abiotic constraints such as fire, may represent a relevant factor in the formation of refractory forms of carbon through thermal mediated mechanisms of organic matter stabilization in the soil. The stability against microbial degradation is also demonstrated by in-vitro mineralization experiments.