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Long-term effects of wildfires on the biochemical quality of soil organic matter: A study on Mediterranean shrublands

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ABSTRACT

Wildfires affect soil organic matter (SOM), mainly resulting in losses of the most labile fractions (in particular carbohydrates), an increased abundance of recalcitrant fractions and, specifically, an increase in SOM aromaticity. Most of these effects have been studied in laboratory experiments: under field conditions, post-fire recovery of the vegetation must be taken into account, for it results in new and fresh inputs of organic matter to the soil. Thus the short-term effects of wildfires on SOM biochemical characteristics could be of little relevance in the medium or long term. We tested this hypothesis in the Valencia region (E Spain), in very healthy shrublands, never cropped, and which have been diversely affected by wildfires in recent decades (either 0, 1 or 2 wildfires). The study aimed at a quantitative description of SOM recalcitrance. Soil samples (uppermost 5 cm) were submitted to a four-step chemical fractionation, consisting of an extraction with dilute K_2SO_4 solution, and two consecutive hydrolyses, first with H_2SO_4 2.5 M and next with 72% H_2SO_4, further diluted down to 1 M. The unhydrolysed residue was taken as the recalcitrant fraction, and submitted to a further chemical attack with H_2O_2, to obtain the refractory fraction. Wildfires dropped both total OC and N in soil, and increased the fraction of total C and (somewhat less clearly), the total N found in both recalcitrant and refractory fractions. Carbohydrates accounted for about 20% of total OC, irrespective of the number of fires. Carbohydrates are selectively lost as a consequence of thermal shock during wildfires; thus their recovery in burned soils is an indicator of the post-fire restoration of the C cycle. The effects of wildfires are shown in the relationship between several parameters (cellulose to total carbohydrates ratio, aromatic extractable C, etc.) and total OC in the horizon, which suffer shifts as a consequence of the first wildfire, and disappear after the second. Overall, our dataset show that in burned plots the biochemistry of SOM has apparently recovered many features of the unburned plots, but a long-term effect of wildfires is still detectable in the relative abundance of recalcitrant or refractory forms. We did not detect increased aromaticity either in the overall SOM (by ^{13}C NMR analysis) or in the extractable or hydrolysable fractions (either by absorption at 280 nm or by analysis of phenolic compounds), a fact that suggests that the increased SOM recalcitrance results from an increased abundance of condensed forms, not necessarily linked to an increase in aromatic C.

1. Introduction

Wildfires drive the behaviour of many biomes. In areas with a Mediterranean climate, they are determinants of landscape structure (Trabaud, 1998). Wildfires are natural events, but the increased recurrence of wildfires in recent decades has an obvious anthropogenic component. In Catalonia, for instance, the number of large-scale fires has increased from 1942 to 2002 (González and Pukkala, 2007). The persistence of these events inevitably affects soils, as components of the terrestrial ecosystems; and since one of the primary effects of fires is the loss of a substantial part of the carbon in vegetation, and the temporary interruption of the carbon cycle, the recurrence of wildfires undoubtedly has a big impact on the soil carbon balance.

In addition to a general decrease in the amount of soil organic matter (SOM), a change in its biochemical properties as a direct result of the thermal shock suffered by the uppermost soil profile has also been noted. The most predictable change is an increase in the amount of black carbon forms (Schmidt and Noack, 2000), even though a consistent accumulation of black carbon in fire-affected soils may be low, sometimes undetectable (Dai et al., 2005; Rovira et al., 2009; Rumpel et al., 2006). Besides the rising increase of black carbon forms, the thermal shock suffered by a soil when a wildfire occurs above it results in profound changes in SOM biochemistry (González-Pérez et al., 2004). Some changes affect specific compounds: thus the fatty acids signature shifts towards a dominance of short-chained fatty

Abbreviations: SOM, soil organic matter; OC, organic carbon; C, carbon; N, nitrogen; LP I, labile pool I (first hydrolysate); LP II, labile pool II (second hydrolysate).

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