Detection of Geochemical Markers to Monitor the Recovery of Soils After Wildfire Events

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Forest fires are considered the main disturbance in the Mediterranean basin (Naveh, 1990) and exerts both immediate and lasting ecological and environmental impacts. This is in part caused by a depth transformation of soil physical, chemical and biological characteristics associated to qualitative and quantitative changes in the most functional fraction of soil such is organic matter (González-Vila and Almendros, 2003; González-Pérez *et al.*, 2004; Knicker *et al.*, 2005). Changes exerted to soil organic matter (SOM) is reflected in the structure of the whole system and negatively affects soil health and quality (Arias *et al.*, 2005) favouring the occurrence of erosive processes and the lost of a non-renewable natural resource such is soil.

However, the effects of fire on soil colloidal properties and on the microbial community are reversible. After the passage of fire soil properties may naturally revert to a situation close to that before fire; erodibility is reduced and soil functionality is again achieved. This is especially evident in the so-called cold fires including controlled burnings and fires in open forest at semiarid environments with pyrophytic vegetation (Mutch, 1970; Pyne, 1996). The starting hypothesis is that if reversible effects do occur, then we may be able to find out biogeochemical surrogated indicators informing on the recovery of soil quality. An early detection of the impact of fire in soil and the possibilities for soil recovery is relevant for decision making and planning of environmental restoration actions.

The objective of this collaborative work between IRNAS-CSIC, the University of Alcalá, Junta de Andalucía and EGMASA, was the identification of proxies for the recovery potential of soils affected by forest fires. This was approached by a transdisciplinary study of fire affected soils at different time scale (cronosequences) chosen in a variety of scenarios from Andalusia (Southern Spain). Included were different soil types affected by fires during the past 10 years under different vegetation, located close to control soils with no recent history of forest fires.

Changes in soil fractions and forms of OM (free lipid fractions, fulvic acids and humic acids and other highly resilient forms of C that may be incorporated like charred biomass) were studied by different analytical techniques providing complementary windows of information (GC/MS, Py-GC/MS, Solid State ^{13}C ^{15}N NMR and TG-DSC-IRMS).

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Significant chemical modifications were observed after fire in soil samples, such as aromatic enrichment and an important increase in the Organic Carbon (OC) content. Good agreement was observed between recalcitrant C as determined by TG analysis and the aromatic content measured by ^{13}C NMR, also new forms of N (heterocyclic) were detected in soils affected by forest fires by ^{15}N NMR. Among the main results is the detection of markers to monitor the recovery of soils short time after fire events by the analysis of thermoevaporation products, mainly furan derivatives, released from whole soil samples using sub-pyrolysis temperatures. Shifts in fatty acid patterns and other families of pyrolysis products from soil were observed by conventional Py-GC/MS. Extracted soil lipids were also a valid proxy and differences were found in the distribution pattern of certain aliphatic series and terpenes. These differential characteristics could be used as markers to monitor the recovery of soils after wildfire events.

References

Arias, M.E.; González-Pérez, J.A.; González-Vila F.J.; Ball, A.S. 2005. **Soil health-a new challenge for microbiologists and chemists**. Int. Microbiol. 8: 13-21.

González-Pérez, J.A.; González-Vila, F.J.; Almendros, G.; Knicker, H. 2004. **The effect of fire on soil organic matter – a review**. Env. Int. 30: 855–870.

González-Vila, F.J.; Almendros, G. 2003. **Thermal transformation of soil organic matter by natural fires and laboratory-controlled heatings**. In: Natural and Laboratory Simulated Thermal Geochemical Processes. Dordrecht: Kluwer Academic Publishing.

Knicker, H.; González-Vila, F.J.; Polvillo, O.; González-Pérez, J.A.; Almendros, G. 2005. **Fire-induced transformation of C- and N- forms in different organic soil fractions from a Dystric Cambisol under a Mediterranean pine forest (*Pinus pinaster*)**. Soil Biol. Biochem. 37: 701-718.

Mutch, R.W. 1970. **Wildlandfires and ecosystems a hypothesis**. Ecology 51: 1046-1051.

Naveh, Z. 1990. **Fire in the Mediterranean – A landscape ecological perspective.** In: Goldammer, J.G.; Jenkins, M.J. eds. Fire in Ecosystems Dynamics: Mediterranean and Northern perspective. SPB Academic Publishing. The Hague.

Pyne, S.J. 1996. **Wild Hearth. A Prolegomenon to the Cultural Fire History of Northern Eurasia.** In: Goldammer, J.G.; Furyaev, V.V., eds. Fire in the Ecosystems of Boreal Eurasia. Kluwer Academic Publishers. Dordrecht, The Netherlands.Sample.