Pyrolytic Characterization of Humic Acids in Relation to Carbon Sequestration Mechanisms in Representative Soils from the Basque Country (Northern Spain)

Amaia Ganuza¹, Gonzalo Almendros, María Cristina Zancada¹, Oliva Polvillo²*
Francisco J. González-Vila²

¹Centro de Ciencias Medioambientales, CSIC, 28006-Madrid, Serrano 115, Fax: 34-91-5640800, humus@ccma.csic.es, ²Instituto de Recursos Naturales y Agrobiología, CSIC, 41080-Seville P.O. Box 1052, figon@irnase.csic.es

Curie-Point analytical pyrolysis was used for the assessment of soil organic matter accumulation processes in representative ecosystems from the Basque Country (Northern Spain). The aim of the study is to identify the main mechanisms of carbon sequestration by carrying out a semiquantitative appraisal of biogeochemical processes ranging from selective preservation of plant macromolecular material to complex processes involving extensive depolymerization of plant-inherited constituents followed by synthesis of humic-type substances.

A total of 15 zones representing main soil uses and vegetation types were sampled. At each zone, 1 to 3 sites were sampled including ecosystems as native forests, coniferous plantations, shrubs, pastures and cultures.

The pyrolytic behaviour of the humic acids (HA), isolated from the sampled soils, was correlated with climatic and geological constraints and with routine soil parameters such as carbon content, nutrient availability and distribution of total C in different humic fractions. The pyrolytic compound assemblages released from the HA were found responsive to specific environmental factors related to C sequestration patterns:

The HA from soils under typical Mediterranean climate show a poor n-alkane pattern which contrasts with the abundance and diversity of alkanes from HA formed in Atlantic soils (C₂₀-C₃₀ with maximum near C₂₅). The alkanes from the HA in Mesomediterranean sites showed patterns with intermediate characteristics. It seems that climatic factors, temperature in particular, influence the accumulation of C, and also the structural features of the HA fraction.

The substitution of the original forest by pastures leads to a significant increase in organic C content of the topsoil in all the cases studied, whereas the contrary occurs when the original forest is substituted by an herbaceous culture. Although these changes are reflected in the assemblages of pyrolytic compounds, the humic acid fraction generally tends to retain some molecular information about the potential vegetation in the site, whereas the current land use is revealed by the occurrence of signature compounds (alkyl and lignin-derived).

iii) The establishment of a forest plantation does not have any significant quantitative effect on soil organic C budget in the cases studied. However, lignin-derived methoxyphenols were more responsive to vegetation types than to abiotic constraints. The substitution of the spontaneous broad-leaved vegetation by gymnosperm plantation is in most cases reflected by the abundance of guaiacyl-type phenols, with some local exception in sites recently reforested on calcareous substrate, where the spontaneous oak forest regrow.

iv) One diagnostic characteristic of HA from cleared ecosystems (both pastures and cultivated soils) is the dominance of propyl- and keto-substituted phenols, mainly of syringyl type. This could correspond to specific lignin types in herbaceous plants with a readily degradable structure based on cinnamic acids, and dominance of methoxyl units.

v) Application of multivariate data treatments showed the possibility to discriminate automatically the origin of the soil samples exclusively based on a reduced set of pyrolytic descriptors.