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Soil organic degradation: bridging the gap between Rock-Eval pyrolysis and chemical characterization (CPMAS 13C NMR)

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Being a source of mineral nutrients, organic matter contributes to soil chemical fertility and acts on soil physical fertility through its role in soil structure. Soil organic matter (SOM) is a key component of soils. Despite the paramount importance of SOM, information on its chemistry and behaviour in soils is incomplete. Numerous methods are used to characterize and monitor OM dynamics in soils using different approaches (Kogel-Knabner, 2000). Two of the main approaches are evaluated and compared in this study. Rock-Eval pyrolysis (RE pyrolysis) provides a description of a SOM's general evolution using its thermal resistance. The second tool (13C CPMAS NMR) aims to give precise and accurate chemical information on OM characterization.

The RE pyrolysis technique was designed for petroleum exploration (Lafargue et al., 1998) and because of its simplicity, it has been applied to a variety of other materials such as soils or Recent sediments (Disnar et al., 2000; Sebag, 2006). Recently, RE pyrolysis became a conventional tool to study OM dynamics in soils. In RE pyrolysis, a peak deconvolution is applied to the pyrolysis signal in order to get four main components related to major classes of organic constituents. These components differ in origin and resistance to pyrolysis: labile biological constituents (F1), resistant biological constituents (F2), immature non-biotic constituents (F3) and a mature refractory fraction (F4) (Sebag, 2006; Coppard, 2006). Main advantages of the technique are its repeatability, and rapidity to provide an overview of OM properties and stocks. However, do the four major classes used in the literature reflect a pertinent chemical counterpart?

To answer this question, we used 13C Nuclear Magnetic Resonance Spectroscopy in the solid state (13C CPMAS NMR) to collect direct information on structural and conformational characteristics of OM. NMR resonances were assigned to chemical structures according to five dominant forms: alkyl C, O-alkyl C, aromatic C and phenolic C and carbonyl–carboxyl C. Moreover, in order to avoid the influence of pedogenesis, we decided to use "less complex OM", i.e. compost samples. The choice to use compost samples has been dictated by the fact that i) composting processes are well described and referenced in the literature, and ii) these samples have already been studied previously (Albrecht, 2009).

Significantly high correlations are observed between classes, or indices, from RE pyrolysis and main classes of organic matter detected by NMR e.g. F1 and labile / easily degradable components (alkyl C et O-alkyl C); F3/F4 and humified OM (aromatic C and phenolic C); R index (contributions of bio-macromolecules) and phenolic and aromatic C; I index (related to immature OM) and labile / easily degradable components (alkyl C et O-alkyl C).

This work confirms the interest of RE pyrolysis in soil science (notably by using the R/I index ratio). Compost was an ideal model with a clear chronological evolution of organic matter. The next step consists of using more complex samples such as bulk soil samples.

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