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Spectroscopic characteristics of soil organic matter as a tool to assess soil physical quality in Mediterranean ecosystems

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In Mediterranean areas, the loss of soil physical quality is of particular concern due to the vulnerability of these ecosystems in relation to unfavourable climatic conditions, which usually lead to soil degradation processes and severe decline of its functionality. As a result, increasing scientific attention is being paid on the exploration of soil properties which could be readily used as quality indicators, including organic matter which, in fact, represents a key factor in the maintenance of soil physical status.

In this line, the present research tackles the assessment of the quality of several soils from central Spain with the purpose of identifying the physical properties most closely correlated with the organic matter, considering not only the quantity but also the quality of the different C-forms. The studied attributes consist of a series of physical properties determined in field and laboratory conditions—total porosity, aggregate stability, available water capacity, air provision, water infiltration rate and soil hydric saturation—.The bulk organic matter was characterised by solid-state ^{13}C NMR spectroscopy and the major organic fractions (lipids, free particulate organic matter, fulvic acids, humic acids and humin) were quantified using standard procedures. The humic acids were also analysed by visible and infrared spectroscopies.

The use of multidimensional scaling to classify physical properties in conjunction with molecular descriptors of soil organic matter, suggested significant correlations between the two set of variables, which were confirmed with simple and canonical regression models. The results pointed to two well-defined groups of physical attributes in the studied soils: (i) those associated with organic matter of predominantly aromatic character (water infiltration descriptors), and (ii) soil physical variables related to organic matter with marked aliphatic character, high preservation of the lignin signature and comparatively low degree of humification (properties involved in the maintenance of physical support, water storage and air provision functions).

From the practical viewpoint, the results support the idea that the detailed structural study of the different soil C-forms is useful for accurately monitoring soil physical status. The quantification of total soil organic carbon ought to be complemented with qualitative analyses of the organic matter, at least at the spectroscopic level, which can be used for the early diagnosis of possible degradation processes. Moreover, in already degraded soils, the knowledge of the sources of variability for each physical property provides valuable information for the restoration of these ecosystems by adapting inputs of organic matter with specific features (aliphatic nature, oxidation degree, humification stage, etc.) to particular soil degradation problems (i.e. soil compaction, waterlogging, water erosion, etc.).