

The need of analytical techniques for in-situ study of soil organic matter

Opinion

The term soil organic matter (SOM) refers to the sum of all natural and thermally altered biologically derived organic material found in the soil or on the soil surface irrespective of its source, whether it is living or dead, or stage decomposition, but excluding the aboveground portion of living plant. In predominantly inorganic soils, which include most agricultural soils, inorganic and organic soil constituents often are so closely associated that it is necessary to separate the two before either can be examined in greater detail. This separation is usually achieved by extracting the SOM. More than 200 years ago, the use of dilute NaOH solution¹ but it criticized from time to time because it could alter SOM through hydrolysis and auto-oxidation.² Dilute solutions of neutral salts ($\text{Na}_4\text{P}_2\text{O}_7$) are widely used for the extraction of SOM.³ The solutions of 0.1 M NaOH extract more high-molecular weight SOM than does 0.1M $\text{Na}_4\text{P}_2\text{O}_7$.⁴ A sequential extraction procedure developed for the removal of SOM from soil by using hexane-chloroform-0.1M $\text{Na}_4\text{P}_2\text{O}_7$ -0.5 M NaOH- distilled water.⁵ So far a vast amount literature exists on the extraction of SOM by large number of different reagents under widely differing experimental conditions. SOM is usually portioned into three fractions:

- i. humic acid (HA);
- ii. Fulvic acid (FA); and
- iii. humin.

Over the years, many objections have been raised against the use of dilute alkaline solution as SOM extractants. The use of alkaline solutions could alter SOM through hydrolysis and oxidation.² But because of their great efficiency, dilute alkaline solution are still widely used for the extraction of SOM. These are tedious, laborious, time consuming and inefficient procedures that are not suitable for the analysis of large number of soil samples. Also, aside from the separation of organic from inorganic soil components, extractions do not provide any chemical information on the organic materials that have been removed.⁶ The question invariably associated with soil organic matter (SOM) studies is whether to work with intact soil or to fractionate and if so, how. The early emphasis on humic and fulvic acids (HA, FA) and the often acrimonious debate on their relevance, was driven in part by the need to isolate those SOM forms which are both high in carbon and reasonably soluble and thus, most amenable to the chemical and spectroscopic techniques then available.⁷ Instead, recently developed modern analytical techniques like Solid-state ¹³C Nuclear Magnetic Resonance Spectroscopy (¹³C NMR), Pyrolysis-Field Ionization Mass Spectrometry (Py-FIMS) and Fourier Transform Infrared Spectroscopy (FTIR) can be used for the in-situ study of SOM in soils. These techniques identify the major chemical components of SOM without extraction and fractionations and yield valuable information on the main chemical structures in the whole soils.

NMR offers great potential as a technique for identifying and quantifying the different forms of organic C in soil.^{8,9} However, new

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family of NMR instrument (Fourier transformation, Cross-polarization and Magic angle spinning) has emerged as most reliable analytical technique. There is great scope for methodological developments to overcome the current limitation of paramagnetic properties, which interfere with the NMR signals or to further define those limitation for specific situation by use of hydrogen fluoride pretreatment (2%) of soil has proved to be the most effective method,¹⁰ as there is no contamination or major structural change of the sample and the SOM is concentrated with the removal of the inorganic matrix. Harvest residue management effects are noticeable in the spectra of ¹³C NMR through the A/O-A ratio⁹ and nutrient availability in soils. As far as the analysis of solid-state samples is concerned, Py-FIMS is the only analytical procedure¹¹ that allow soil chemist and other interested scientists to perform comprehensive SOM analysis at the molecular level on air dried soils without any pretreatment. Py-FIMS is more sensitive than ¹³C NMR and gives reliable identification (e.g. purity) due to chromatography.⁶ FTIR spectroscopic technique found to be suitable for the investigation of SOM chemical composition¹² and the possible molecular change induced by organic amendment.¹³ More precise information on how pesticides interact with SOM will provide a rational basis for their effective use and for minimizing undesirable side effects.⁶ Modern spectroscopic methods are complementary and where possible effort should be made to utilize combinations of these methods to confirm and enhance data pertaining to the chemical structure of soil organic materials. A better knowledge of the structural chemistry of SOM will help SOM chemists and other soil scientists to better understand the complex chemical and biochemical reactions that occur in soils and will enable them to develop practices that will improve soil management and soil productivity.

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Conflict of interest

The author declares no conflict of interest.

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