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Synchrotron-based Infrared-microspectroscopy reveals the impact of land management on carbon storage in soil micro-aggregates

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Carbon stabilization in soil microaggregates results from chemical and biological processes that are highly sensitive to changes in land use. Indeed, such processes govern soil capability to store carbon, this being essential for soil health and productivity and to regulate emissions of soil organic carbon (SOC) as CO_2. The identification of carbon functionalities using traditional mid-infrared analysis can be linked to carbon metabolism in soil but differences associated to land use are generally limited. The spatial resolution of synchrotron-based Infrared-microspectroscopy allows mapping microaggregate-associated forms of SOC because it has 1000 times higher brightness than a conventional thermal globar source. These maps can contribute to better understand molecular organization of SOC, physical protection in the soil particles and co-localization of carbon sources with microbial processes.

Spatially-resolved analyses of carbon distribution in micro-aggregates (<200 μm diameter) have been conducted using FTIR microspectroscopy (Infrared Microspectroscopy beamline, Australian Synchrotron). Two soil types (Ferralsol and Vertisol, World Reference Base 2014) were collected from undisturbed areas and from a location(s) immediately adjacent which has a long history of agricultural use (>20 years). Soils were gently screened (250 μm) to obtain intact microaggregates which were humidified and frozen at -20°C, and sectioned (200 μm thickness) using a diamond knife and a cryo-ultramicrotome. The sections were placed between CaF2 windows and the spectra were acquired in transmission mode.

The maps obtained (5 μm step-size over ca. 150 $\times$ 150 μm) revealed carbon distribution in microaggregates from soils under contrasting land management, namely undisturbed and cropping land. Accumulation of aromatic and carboxylic functions on specific spots and marginal co-localization with clays was observed, which suggests processes other than organo-mineral associations being responsible for carbon stabilization. A substantial decrease in carboxylic compounds was observed for agricultural soils. Clays were mostly co-localized with alkenes and polysaccharides, particularly in agricultural soils, likely due to enhanced microbial activity in those spots.

Results will be linked to currently ongoing analysis of soil enzymes activities and characterization of dissolved organic carbon components. This novel methodological approach combines biological and chemical information on organic carbon dynamics in soil at a molecular level and will constitute a substantial advance towards understanding carbon storage in soil and the long term impact of land management.