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Spectroscopic surrogates of soil organic matter resilience in crusted semiarid Mediterranean ecosystems

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Arid and semiarid ecosystems represent nearly a third of the Earth's total land surface. In these ecosystems, there is a critical balance between C sequestration and biodegradation that could easily be altered due to human disturbance or global change. These ecosystems are widely characterized by the presence of biological soil crusts (BSCs) which play the most important role in the C-cycle in arid and semiarid areas. Consequently, soil organic matter (SOM) characteristics of crusted soil could readily reflect important information on the resilience of SOM in response to any global temperature increase or to inappropriate soil management practices. In this research, representative BSCs and underlying soils were studied in two different semiarid ecosystems in Southern Spain, i.e. Amoladeras (located in Cabo de Gata Natural Park), and El Cautivo (located in Tabernas desert). Chemical fractionation and characterization of the SOM in BSCs and underlying soils were carried out in order to assess not only the total amount of organic C sequestered but mainly the quality of humic-type organic fractions. After isolating the major organic fractions (particulate fraction, humic acid-like (HA), alkali-extracted fulvic acid (FA) and H3PO4-FAs), the macromolecular, HA fraction was purified and studied by derivative visible spectroscopy and resolution-enhanced infrared (IR) spectroscopy. Our results show differences in the structural characteristics of the HA-type substances, interpreted as progressive stages of diagenetic transformation of biomacromolecules. Amoladeras showed higher SOM content, and higher values of HA and HA/FA ratio than El Cautivo, with lower SOM content in BSCs and underlying soils. The latter site accumulates SOM consisting mainly of comparatively less recalcitrant organic fractions with small molecular sizes (H3PO4-FAs and FAs). Moreover HAs in samples from Amoladeras showed higher condensation and aromaticity (higher E4, lower E4/E6 ratio), pointing to increased maturation compared to HAs from El Cautivo. Measurable concentrations of perylenequinonic fungal pigments were also observed in the case of the soils under BSCs at Amoladeras, an indication for stable immobilization in the soil mineral matrix. In fact, the concentration of fungal pigments in the HA fraction of the soil under BSCs in Almoladeras are a proxy for the formation and stability of a clay-humus complex. The HAs in BSCs and their underlying soil at El Cautivo did not show these fungal pigments, which is interpreted as a lower complexity of the BSC and plant-soil trophic system, and concomitantly lower SOM quality. In general, the HA characteristics in crusted soils from Amoladeras (chromophore groups, broadband spectroscopic profiles pointing to chaotic structures…) suggest stronger resistance to biodegradability and higher potential for maintaining its properties against global warming compared to El Cautivo, in which HA features indicate comparatively lower resilience irrespective of global change. Our results showed that the spectroscopic characteristics in the visible and IR ranges of the BSCs-isolated HA-type substances might provide routine biogeochemical proxies informing on the SOM stability and quality from crusted semiarid ecosystems in the current scenario of global change.