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Organic matter treatment determines structure development and aggregate formation in artificial soils

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Aggregation includes the formation of organo-mineral-associations, which become arranged in a heterogenic pattern and stabilized thereafter. Up to now, little is known about the role of different organic matter qualities in this process.

We developed a new approach to disentangle the role of organic carbon (OC) derived from particulate organic matter (POM-C) and from dissolved organic matter (DOM-C) for aggregate formation. This allows to study it separately in incubation experiments under controlled laboratory conditions in an artificial soil system. We designed an artificial soil with loamy texture, mimicking an arable Cambisol and performed an incubation for four weeks under constant water tension. Samples received either POM-C as milled hay litter or DOM-C as solution derived from hay. The influence of both treatments on structure development and aggregate formation, architecture and stability was investigated and compared with a control that did not receive OC.

After incubation we observed a significant formation of water-stable aggregates in all treatments with OC addition. POM-C addition led to an increase in mass contribution of the large macroaggregate fraction (3 cm-630 μm) from 6 % to 88 % and to a reduction in mass contribution of the small microaggregate fraction (< 63 μm) from 79 % to 11 % when compared to the original particle size distribution. DOM-C addition caused an increase in mass contribution of large macroaggregates to 59 % and a reduction in mass contribution of small microaggregates to 35 %. The OC distribution showed that 95 % of total OC was found in large macroaggregates for the samples receiving POM-C. In samples receiving DOM-C, the OC distribution showed a bimodal distribution between large macroaggregates (59 %) and small microaggregates (33 %). Organic matter mineralization was highest with DOM-C addition, where up to 60 % of total added OC was released as CO_2, whereas in soils with POM-C addition 20 % of the added OC was released. High-resolution μ-CT scanning of the samples revealed evenly distributed, small and narrow pores after POM-C addition, whereas DOM-C addition resulted in a pore architecture consisting of sparsely distributed, large and dendritic pores, indicating structural weaknesses.

We conclude that rapid aggregate formation in an artificial soil mixture is possible without mechanical stress and the action of changing water regime (wet-dry cycles). Organic matter addition as plant residues led to a rapid formation of mainly large, OC-rich macroaggregates. DOC addition also induced aggregate formation, but size of the formed aggregates is smaller.