Geophysical Research Abstracts
Vol. 21, EGU2019-15504-2, 2019
EGU General Assembly 2019

Modeling can add to experimental designs on soil aggregate dynamics in the rhizosphere

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Based on an artificial root experiment that studied the effects of different concentrations of root exudates on microbial community composition and soil aggregation in different soil depths (Baumert et al., 2018), we developed a mechanistic model of soil aggregate formation. The aggregate size distribution was modeled from spatial pattern of gluing agents produced by microorganisms (bacteria and fungi) growing on the root exudates. Soil binding strength which defined further changes in aggregate size distribution depended on contents of gluing agents, fungi and soil moisture. In the laboratory experiment, the bulk soil moisture was kept constant. However, the model predicted a heterogeneous soil moisture profile with distance from the root. Higher moisture content in the rhizosphere (within 6 mm around the root) relative to the rest of the soil (bulk soil) was required in the model to explain the differences in aggregate size distribution from the beginning to the end of the experiment.
Soil aggregation was promoted by root exudates via increase in gluing agents (products of microbial metabolism) and fungal biomass. Whereas aggregate slaking was induced by elevated soil moisture content around the artificial root (which only exudes and does not uptake water). The balance between these two opposite processes resulted in higher macroaggregation in the subsoil rhizosphere compared to bulk subsoil, where TOC was lower and thus gluing agents had a more pronounced effect than slaking. For the topsoil rhizosphere, slaking prevailed macroaggregation, so that in the end of the experiment bulk topsoil had a higher content of stable macroaggregates than the rhizosphere.
The model suggests that the spatial pattern of microbial activity as well as the spatial pattern of water content around the root may be major factors of aggregate stability and should be measured. In the vicinity of a real root which can consume water and thus keep the rhizosphere dryer enhancing soil aggregation on the roots both in top and subsoils.