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Formation of composite building units of soil microaggregates in the presence of extracellular polymeric substances

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Soil functions depend on the structure and properties of soil microaggregates that are composed of smaller structural units referred to as composite building units (CBUs) (Totsche et al., 2018). Virtually any constituent of the solid mobile fraction of soil solutions, e.g. organo-mineral associations, can be considered as CBUs as they potentially combine into microaggregates. Yet, despite their ubiquitous occurrence still little is known about the processes that control their formation. In this study, we investigated the formation of CBUs from suspension containing minerals typical for temperate soils (i.e. quartz, goethite and illite) in the presence of extracellular polymeric substances (EPS) as surrogate for microbially derived organic materials. Depending on the chemical milieu, we observed the formation of CBUs with different structural properties after shaking for 24 h in presence or absence of EPS. EPS-free approaches showed a homogenous distribution of the minerals and the formation of mineral-mineral associations. In contrast, EPS-containing approaches developed a heterogeneous distribution of minerals after a drying procedure as shown by EDX maps. This is explained by the formation of organo-mineral associations. Compared to the unassociated minerals, a reverse in surface charge is observed due to the screening of surfaces with EPS that prohibited further attachment. Thus, we conclude that electrostatic interactions control the association of minerals and EPS as well as their spatial conformation. Approximately 50% EPS-C and 90% EPS-P were found to be associated to mineral surfaces as shown by TOC and ICP-OES measurements. This points to the importance of phosphorous-containing functional groups of the EPS for the formation of CBUs. Laser light diffraction measurements revealed a decrease in the silt fraction and an increase in the fine sand fraction that supports the role of EPS as a “binding” agent. These results highlight the impact of microbially produced organic matter for surface properties of minerals and their consequences for the initial CBU formation.

References

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