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Combining long term field experiments and nanoscale analysis to enhance process understanding of root litter stabilization by mineral interactions

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Mineral interaction may affect the stabilisation of root litter directly or indirectly after microbial decomposition and transformation. The importance of both processes may vary within the soil profile. In this study we studied C stabilisation of isotopically labelled root litter (13C and 15N), which was incubated during 3 year in the field at different soil depth. Samples from this field experiment were recovered and subjected to nanoscale analyses in order to elucidate mineral interactions occurring in different parts of the soil profile.

Our results showed enrichment of mineral associated organic matter in subsoil horizons. However, material derived from new plant litter may be stabilised at similar rates in top- and subsoil horizons. N-containing compounds are enriched in the mineral associated fraction of subsoil horizons, indicating enrichment of microbial derived material with depth. Nano scale analyses showed that indeed plant-derived material may be associated with metal oxides in topsoil horizons, whereas the mineral associated organic matter in subsoil horizons may consist of microbial cells. Interestingly, in contrast to short term laboratory analysis, decoupling of C and N through stabilisation with soil minerals was observed during this long term field experiment.

Our results indicate that the nature of OM stabilised by mineral interactions is depth specific. Therefore, we suggest, that plant derived lignocellulosic material may be preserved by mineral interactions in topsoil given its incomplete degradation, thereby leading to the formation of functional groups and favouring adsorption to soil minerals. This is consistent with the higher state of lignin-degradation observed in topsoil horizons as compared to subsoil. At depth, where microorganisms are most likely energy limited, degradation of fresh plant litter may be complete, thereby diminishing the formation of lignocellulosic compounds capable of sorption onto metal oxides. As a result stabilised OM may consist primarily of microbial cells. Thus our study is consistent with the microbial efficiency-matrix stabilisation (MEMS) hypothesis (Cotrufo et al., 2013), which says that microbial use efficiency determines stabilisation through interaction with the mineral phase. It also shows the importance of using long term field observations in addition to short term laboratory studies.

Reference

Cotrufo, M.F., Wallenstein, M.D., Boot, C., Denef, K., Paul, E., 2013. The microbial efficiency-matrix stabilisation (MEMS) framework integrates plant litter decomposition with soil organic matter stabilization: do labile plant inputs form stable organic matter? Global Change Biology, 19, 988-995.