Microbial necromass as a source for soil organic matter formation - implications for soil processes

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The vital role of soil microorganisms as catalysts for soil organic matter (SOM) formation has long been recognised. Plant residues are now considered to be transformed by soil microorganisms who use the plant litter as a carbon source for microbial biomass formation. How much carbon is retained as microbial biomass during transformation of plant material, critically depends on substrate availability, carbon use efficiency of the microorganisms, and maximum microbial growth. In addition, microorganisms presumably recycle biomass building blocks from plant or microbial material to avoid energy expenditure for biomass synthesis. After cell death, a part of the microbial necromass is cycling through the microbial food web; the other part is stabilised in soil (Miltner et al., 2012). Potential stabilisation mechanisms are similar to those for SOM in general, with organo-mineral interactions, in particular encapsulation and physical isolation, being important mechanisms. Independent of which pathway the plant-derived carbon goes, SOM constitutes a continuum of plant and microbial necromass at various stages of decay. The contribution of microbial necromass to the topsoil organic matter pool has recently been estimated to range from 30 to 60% (Liang et al., 2019). Such high contributions of microbial necromass have a number of important implications for understanding SOM transformation and sequestration processes. Most obviously, the chemical identity of the organic material changes. For example, while retaining a substantial part of the carbon, the elemental stoichiometry changes substantially. Some microbial necromass materials are rather long-lasting in soil. In general, cell envelope residues have a higher stability than bulk biomass carbon. Proteins have also been shown to be rather persistent in soil, presumably due to conformational changes and the spatial arrangement of microbial necromass material, e.g. fragments of cell envelopes presumably pile up in multiple layers and the material forms clusters of macromolecular size. Residual electron-shuttle biomolecules (e.g. oxidoreductases, Fe-S-cluster, quinoid complexes of respiratory chains) may persist and retain some activity and thus contribute to redox reactions in soil. In addition, the necromass is expected to cover soil particle surfaces and thus determine the surface properties of these particles. In particular, these materials contribute to the water storage potential. They affect water retention and nutrient diffusion as well as microbial motility. Adaption of microbes to water stress changes their cell surface properties and molecular composition and thus may determine overall soil wettability. Knowledge on the contribution of microbial necromass to SOM would thus be essential for modelling SOM formation and optimising soil management practices for
maintaining soil functions.

References: