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Stabilization of microbial necromass by co-precipitation with Fe and Al oxyhydroxides at different O_2 supply levels

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Microbial necromass has been identified as an important source of soil organic matter (SOM) formation. In order to contribute to long-term carbon storage, these materials have to be stabilised in soil. In the past, organo-mineral interactions have been reported to stabilise organic compounds in soil. We therefore studied the effect of microbial necromass-oxyhydroxide co-precipitation on the mineralisation and stabilisation of intact cells and cell envelope fragments under two different levels of O_2 supply (fully oxic and increasingly O_2-depleted). Mineralisation kinetics initially were lower for intact cells than for cell envelope fragments, later mineralisation rates were similar for both cell fractions. Similarly, the effect of O_2 supply was limited unless the redox potential was really strongly reduced. In contrast, co-precipitation with Fe and Al oxyhydroxides strongly stabilised both cell fractions. This effect, however, was strongly affected by limited O_2 supply in case of Fe oxyhydroxide co-precipitates due to reductive dissolution of the stabilising mineral. Taking the sizes of microbial necromass particles (cells, 1 μm; cell envelope fragments, 200-500 nm) and freshly precipitated oxyhydroxides (few nm) into account, we conclude that the microbial residues are encrusted and impregnated by the minerals. This reduces accessibility of the microbial material for degrader organisms and enzymes, thus protecting it against enzymatic degradation. This protection, however, can be neutralised by dissolution of the mineral particles, e.g. reductive dissolution of Fe oxyhydroxide and thus be a transient effect. We therefore conclude that minerals substantially contribute to the stabilisation of microbial biomass residues. The extent and longevity of this stabilising effect, however, strongly depends on environmental conditions.