Geophysical Research Abstracts
Vol. 13, EGU2011-3725, 2011
EGU General Assembly 2011

The role of microorganisms in the incorporation of carbon into mineral-organic associations

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The pivotal role of mineral-organic associations in the retention of carbon (C) has been evidenced by numerous studies, but little is known on how C gets associated to minerals. The role of microorganisms and, further on, of bacteria and fungi in the incorporation of C within mineral-organic associations is still a matter of debate. To close that gap, we tracked a 13C tracer within biomarkers of bacterial and fungal activity by combining in situ labelling experiments and liquid chromatography coupled with an isotope ratio mass spectrometer measurements (LC-IRMS). 13C-glycine (98% 13C excess) and 13C-beech litter (3.1% 13C excess) incubations were conducted at 20°C in the laboratory over 12 weeks on a Cambisol collected from the 0-2.5 cm depth horizon of an acidic forest, what is equivalent to ca. eight months in situ. Soils samples were sampled after seven days and twelve weeks of glycine incubation and after twelve weeks when incubated with leaf litter. Four mineral-organic associations were isolated by density without sonication: plant debris with few trapped minerals (density <1.65 g.cm-3), plant aggregates (1.65-1.85 g.cm-3), microbial aggregates (1.85-2.4 g.cm-3) and single mineral grains with little organic matter (>2.4 g.cm-3). They were then successively hydrolyzed, filtrated and purified using a cationic exchange resin to isolate the soluble fraction containing amino sugars, which are considered as specific microbial biomarkers.

The quantification of amino sugars and its 13C content revealed the contribution of bacteria and fungi to mineral-associated organic matter of each density fraction. Indeed, galactosamine and muramic acid are indicative of bacterial activity, whereas glucosamine is indicative of fungal activity. The incorporation of the 13C tracer within amino sugars indicated which, from bacteria and fungi, is the most efficient incorporating the carbon derived from leaf litter and glycine. The incorporation of the C derived from glycine was fast ($\leq$ seven days) and clearly governed by fungi. Even though some differences can be noted, the incorporation of C derived from leaf litter was much more balanced in between bacteria and fungi for each type of mineral-organic association. Overall, our results suggest that the activity of the decomposers is governed by the chemistry of the substrate.