Soil enzyme allocation strategies affect long term soil organic matter cycling and nutrient recycling.

Introduction

The global element cycle of carbon and nitrogen are strongly linked and cannot be understood without their interactions (XXCStorebyN). The links between nutrient cycles are especially strong in dynamic of soil organic matter (SOM) because all of the SOM has to be depolymerized and successively mineralized by a microbial community with a rather strict homeostatic regulation. Faced with stoichiometric imbalances between OM substrates and synthesized biomass, decomposers have to lower their carbon use efficiency (CUE) or nutrient use efficiency (NUE) (XXSterner, Mooshammer). The regulation of CUE has shown to have large consequences on prediction of carbon sequestration in SOM (XX Allison follows, Manzoni). Regulation of NUE has consequences for nutrient recycling and loss of nutrients from the ecosystem (XXMooshammer) and soil plant feedbacks (XXRastetter 97). In addition, however, decomposers could also regulate allocation into production of extracellular enzymes to preferentially depolymerize food sources of different stoichiometry in order to match their requirements (XXSterner, Mooshammer). This hypothesis was recently formalized by XXMoorehead with the conceptual EEZY model. While this model showed the principle feasibility of this strategy in short term, it did implement feedbacks to substrate pools and therefore could no look at consequences for longer term SOM cycling. The associated change in CUE and NUE, however, can have severe consequences on the long term SOM cycling and our understanding of soil carbon sequestration and plant- soil- atmosphere elemental feedbacks.

The aim of this study, therefore, is to further develop the conceptual model of enzyme allocation including feedbacks of turnover to the substrate pools and explore the different consequences of alternative enzyme allocation schemes on long term SOM dynamics and nutrient recycling.

To this end we developed a conceptual model of SOM cycling that explicitly represented several extracellular enzyme pools involved in the depolymerization of specific substrates which differed in their elemental ratios. Several variants were developed that differed by the strategy of enzyme allocation: either fixed or flexible, and either based on stoichiometry only or on pool sizes too. Simulations scenarios were devised to study effects on mineralization fluxes and buildup of SOM. Specifically, we first studied under which ranges of substrate stoichiometry decomposers with flexible allocation could use the substrate more efficiently and decrease mineralization fluxes (including overflow respiration as carbon mineralization). Second, we tested with which strategies sustainable microbial communities could develop under constant litter input, by simulating a steady state. Third, we were interested in different responses of subsoil SOM mineralization and nutrient recycling after amendment of fresh litter (priming). And fourth, we studied consequences for development of SOM pools in a scenario of CO2 fertilization.

We show that different decomposers enzyme allocation strategies have large consequences on long term SOM dynamics and nutrient recycling and suggest further ways to study these strategies by both experimental, modelling and combined studies.