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Upscaling microbial stoichiometric adaptability in SOM turnover using the SESAM model: specifics of phosphorous dynamics.

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In order to understand the coupling of land ecosystem carbon (C), nitrogen (N), and phosphorous (P) cycles, it is necessary to understand microbial element use efficiencies (C, N and P) of soil organic matter (SOM) decomposition. While important controls of those efficiencies by microbial community adaptations have been shown at the scale of a soil pore, an abstract simplified representation of community adaptations is needed at the ecosystem scale. The conceptual soil enzyme allocation model (SEAM) explicitly models community adaptation strategies of resource allocation to extracellular enzymes and enzyme limitations on SOM decomposition. It thus provides a scaling from representing several microbial functional groups to a single holistic microbial community. The model has been further abstracted using quasi-steady-state assumption for extracellular enzyme pools to the SESAM model. While initially, P optimality considerations have been treated analogue to N, we found with simulating a sequence of sites with a P availability gradient that model extensions were required for P. Here we discuss effects of explicitly considering two assumptions on SOM dynamics: (1) oxidative enzymes can acquire P from SOM without necessary stoichiometric decomposition of C and N, and (2) for the case where P is limiting, in addition to P cost, also the C and N cost of enzyme production are important for optimality. We found that neglecting these two assumptions did not significantly change system behavior and predictions in the case where P was not limiting soil microbes. However, it changed model predictions of ecosystem-scale SOM dynamics for the case where P started to become limiting.

This modeling study links knowledge of constraints at soil microbial scale to SOM dynamics at ecosystem scale. It highlights the important role of adaptability of soil microbial communities to resource supply and stoichiometry for the development of SOM stocks and nutrient availability.