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Modeling of priming effects in soil: a necessary minimum

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Priming effects are strong short-term changes in the turnover of native soil organic matter (SOM) induced by comparatively moderate treatments of the soil. Such treatments might be, e.g. inputs of organic or mineral fertilizer to the soil, exudation of organic substances by roots, decomposition of plant residues etc. In the course of priming large amounts of C, N and other nutrients can be released or immobilized in soil in a very short timescale, generally several days to weeks.

Our proposed definition of the priming effect implies that the decomposition intensity of SOM is not constant and depends not only on the environmental factors (i.e. temperature and soil moisture), but also on the changing activity of microbial biomass. This contrasts with the concepts for SOM decomposition used in many models of C and N dynamics in soil (reviewed in Smith et al., 1997). Some experimental studies showed that the degradation rates of organic carbon (C) depends on composition of microbial community, size, and its physiology – the parameters which directly affect the enzyme activity in the soil. Therefore, more recently nonlinear models accounting for the coupling between microbial biomass and its substrate have also been proposed (Blagodatsky and Richter 1998; Neill and Gignoux, 2006; Manzoni, Porporato, 2007).

The aim of the study was to compare approaches of different complexity for modelling of priming effects and to test this approaches on the previous results of priming effects induced by addition of easily available substances such as glucose or plant residues to the soil.

The approaches tested for the modelling of priming effects were classified according main factors affecting intensity of SOM decomposition: 1) intensity of plant residues decomposition, 2) amount of easily available substances in the soil, 3) amount of microbial biomass, 4) activity of microbial biomass, and 5) amount of mineral N in soil.

The parameters of SOM decomposition models were adjusted based on total and ^{14}C labelled CO_2 efflux from soil after addition of ^{14}C labelled easily available substances. The labelling allowed separate estimation of the decomposition rates of the SOM and of the added substances. Comparison of CO_2 efflux derived from SOM with and without addition allows calculation of priming effects and estimation of the parameters.

It was shown, that the best correlation between the experimental and modelled data can be observed by using approaches based on second-order kinetics considering the amount and activity of soil microbial biomass, which depends on the availability of C and N sources. However, the choice of the best approach for priming effect modelling depends on the possibility to verify model parameters. More detailed model approaches with higher numbers of pools and parameters (i.e. including microbial biomass and its activity) fit experimental observations better, but the uncertainty in parameter estimation increased in these models also.

References

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