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Dynamic response of microbial activity to irregular disturbance: effects of dormancy in biogeochemical simulations of multispecies systems.

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Motivation
Soil habitats as many other environmental systems are characterized by frequent changes of living conditions of the microbial community. Microorganisms are known to respond to such changes by switching their physiological state between activity and dormancy. This allows them to endure periods of unfavorable environmental conditions. As a consequence, the competitiveness of microbial species is not only controlled by their growth performance under plentiful conditions but also by their ability and readiness to respond to periods of unfavorable environmental conditions. To our knowledge, the effects of dormancy and reactivation of individual microbial species on the composition of microbial communities and their biodegradation activity have hardly been addressed conceptually, especially not in the context of biogeochemical simulations of environmental systems. The aim of this study is to simulate the response of microbial model systems – containing two competing species with different growth and de-/reactivation efficiencies – on intermittent changes of environmental conditions.

Approach
Microbial respiration and population dynamics are modeled using the numerical simulation software BRNS (Biogeochemical Reaction Network Simulator). Active and dormant biomasses are included as state variables, growth of microorganisms is described by established approached and is combined with kinetic expressions derived to account for the deactivation and reactivation of the microorganisms. The kinetic expressions are functionally linked to the energy yields of the corresponding respiration pathways, as well as to the maintenance requirements of the organisms. We also take into consideration variation in the yield factor, depending on the energy budget and consider loss of biomass during reactivation. The model was used to simulate the dynamics of the microbial models systems for different/irregular frequencies of feeding events.

Results
Model simulation show that – as anticipated – the competitive advantages of species differ with the frequency of the feeding events – higher frequencies favoring species with high growth performance whereas low frequencies favor species exhibiting an efficient switching between physiological states. Nevertheless, long term coexistence of species was observed for nearly all simulated scenarios, which supports hypotheses form ecological theory that highest diversities are to be found at intermediate disturbance levels. Oscillations of microbial concentrations do not necessarily follow the frequency of the feeding event but may show either a chaotic behavior or a non-trivial dependency on the frequency of the feeding events. Simulation results also indicate that any irregularity of stress (here irregularity of feeding frequency) gives advantage to microorganisms having the more effective ability to switch between active and dormant states.