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Microbial processes dominate P fluxes in a low-phosphorus temperate forest soil: insights provided by ^{33}P and ^{18}O in phosphate

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The classical view of the P cycle in forests is that trees and mycorrhizal fungi associated with them take up most of their phosphorus as phosphate (P) from the soil solution. The soil solution is then replenished by the release of P from sorbed phases, by the dissolution of P containing minerals or by biological mineralization and/or enzymatic hydrolysis of organic P compounds. Direct insight into the processes phosphate goes through at the ecosystem level is, however, missing.

Assessing the relevance of inorganic and biological processes controlling P cycling requires the use of appropriate approaches and tracers. Within the German Priority Program "Ecosystem Nutrition: Forest Strategies for limited Phosphorus Resources" we studied P forms and dynamics in organic horizons (Of/Oh) of temperate beech forest soils in Germany with contrasting soil P availability (P-poor and P-rich). We followed the fate of P from the litter into the soil pools, using isotopes as tracers (stable oxygen isotopes in water and phosphate and ^{33}P) and relied on measurements in experimental forest sites and a three-months incubation experiment with litter addition.

Using an isotopic dilution approach we were able to estimate gross (7 mg P kg^{-1} d^{-1} over the first month) and net mineralization rates (about 5 mg P kg^{-1} d^{-1} over the first 10 days) in the P-poor soil. In this soil the immobilization of P in the microbial biomass ranged from 20 to 40% of gross mineralization during the incubation, meaning that a considerable part of mineralized P contributed to replenish the available P pool. In the P-rich soil, physicochemical processes dominated exchangeable P to the point that the contribution of biological/biochemical processes was non-detectable.

Oxygen isotopes in phosphate elucidated that organic P mineralization by enzymatic hydrolysis gains more importance with decreasing P availability, both under controlled and under field conditions.

In summary, microbial processes dominated P fluxes (70 to 80%) in the P-poor soil, while in the P-rich soil microbial processes could not be detected because of the higher baseline of physicochemical processes. Our results support the hypothesis that organic P has a faster turnover under conditions of low P availability and that net mineralization is the most relevant process providing available P for plants under these conditions.