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Phosphorus cycling in forest ecosystems: insights from oxygen isotopes in phosphate

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The current view on the phosphorus (P) cycle in forest ecosystems relies mostly on measurements and correlations of pools, and to a lower extent on measurement of fluxes. We have no direct insight into the processes phosphate goes through at the ecosystem level, and into the relative importance of organic and mineral pools in sustaining P nutrition of trees. The analysis of oxygen isotopes associated to P ($^{18}O_p$) is expected to bring this type of information. The German Priority Program SPP 1685 aims to test the overall hypothesis that the P-depletion of soils drives forest ecosystems from P acquiring systems (efficient mobilization of P from the mineral phase) to P recycling systems (highly efficient cycling of P). Our contribution to this project will consist in studying the relative importance of biological and geochemical processes in controlling the P cycle in temperate beech forest ecosystems in Germany along a gradient of decreasing soil P availability.

We will follow the fate of phosphate from litter fall to the uptake of P by plants via P release by decomposition of organic matter or after release from P-containing minerals, by using a multi-isotope approach (O in water and phosphate plus ^{33}P). To address our research question we will rely on measurements in experimental forest sites and on laboratory incubations of the organic layer or the mineral soil.

We present here the first results issued from the 2014 sampling on three study sites, where we characterized the P pools in surface soil horizons by a sequential extraction (modified after Tiessen and Moir, 2007) and we analysed the $^{18}O_p$ of the resin extractable- and microbial-P fractions.

Contrary to what was previously found (e.g. Tamburini et al. 2012) the isotopic composition of these fractions in most of the samples does not reflect the equilibrium value (as the result of the dominance of the pyrophosphatase activity on the other enzymatic processes, Blake et al. 2005). Depending on the P availability in the soil, deviations from the equilibrium are more or less pronounced. We hypothesized that the $^{18}O_p$ is the result of other processes such the mineralization of organic P by phosphatases.

These first results of $^{18}O_p$ on forest soils are suggesting that isotopic equilibrium driven by biological cycling (pyrophosphatase) is not always overprinting other processes. In addition, together with information on P speciation/concentration, $^{18}O_p$ seems to provide direct insights on P cycling at the ecosystem level.

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