Root system-mediated P heterogeneity in forest soils: From aggregate surfaces to single trees

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Individual trees differ in their rates and forms of nutrient input into the soil as well as in their nutrient uptake from the soil through their root system, and/or mycorrhizae. Thus, trees likely contribute to soil heterogeneity patterns in forests. This study analyzes the interaction between P distribution and speciation in soils of two sites with contrasting P availability and the root system of single European beeches at scales, ranging from aggregate surfaces to the scale of single tree influence patches.

The spatial heterogeneity of soil P and related soil parameters has been investigated with a combination of NanoSIMS, µ-XRF, µ-XANES, enzyme assays, wet chemical analyses, biomarker approaches and geostatistics.

We found clear gradients of increasing contents of easily available inorganic P (P_i-$NaHCO_3$) and citric-acid extractable P with increasing distance from the stem and root system of single beeches. Moreover, the activity of alkaline phosphatase decreased in the inner zone of tree influence, whereas the activity of acid phosphatase was highest in strongly rooted patches below the tree crown. Soil organic matter (SOM) from root input (analysed as suberin-derived monomer concentration) was the dominant factor for the formation of pedon scale heterogeneity patterns of P_{tot} and P_{org} stocks throughout the whole profile at the P rich site. In contrast, the spatial distribution of suberin-specific monomers was not spatially correlated with P_{tot} or P_{org} in the soil of the P poor site. Here, dithionite-extractable Fe (Fe_{dith}) and Al (Al_{dith}) depth gradients as well as microbial C, N and P were the most important parameters governing the pedon-scale spatial patterns of P_{tot} and P_{org} stocks. Soil aggregates sampled from both pedons differed considerably in their P distribution patterns: P was finely dispersed in Al and Fe mineral assemblages of the P-rich soil, but concentrated in the quartz grain coatings of thesample taken from the P-poor soil. NanoSIMS, µ-XRF, and µ-XANES data show that P in both aggregates is primarily co-localized with and bound to Fe and Al. Contrarily, SOM in both aggregates seems to play a minor role for P distribution and storage. These results indicate that abiotic factors rather than biotic ones were the most important paramters governing soil P distribution at single aggregate surfaces.