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Microdialysis of Soil P: A means to mimic root uptake?

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Standard procedures to assess P availability in soils are based on batch experiments with various extractants. However, in most soils P nutrition is less limited by bulk stocks but by slow diffusion of phosphate through the soil solution. More comparable to the root's approach is to strip phosphate locally from the solid phase by lowering the soil-solution concentration, which can be achieved by establishing an infinite diffusional sink, such as DGT. An alternative diffusive sampling technique is microdialysis (MD), well established in pharmacokinetics. Briefly, this method uses miniaturized flow-through probes where the perfusate gets in diffusive contact to the external solution by a semipermeable membrane. Important aspects of P supply to roots resemble MD sampling. This is not only the mostly diffusive transport, but also an elongated capillary tube-like geometry of absorption. The diameter of typical commercial MD probes is around 500μm. One additional inherent feature of microdialysis is the possibility to release low-molecular substances from the perfusate by diffusion into the matrix, such as carboxylates. However, microdialysis has yet not been used for P in soils. We tested microdialysis in topsoils of an acid beech forest, of an unfertilized grassland and of a fertilized crop site. Three perfusates have been used: 1 mM KNO_3, electrolyte + 0.1 mM citric acid, and electrolyte + 1 mM citric acid. We observed rates of uptake into the probes in a range between $1.5*10^{-15}$ and $6.7*10^{-14}$ mol $s^{-1}cm^{-1}$ in case of no citrate addition. Surprisingly, these uptake rates were mostly independent of the bulk stocks. Citrate addition increased P yields only in the higher concentration but not in the forest soil. The order of magnitude of MD uptake rates from the soil samples matched root-length related uptake rates from other studies. The micro-radial citrate release in MD reflects the processes controlling phosphate mobilization in the rhizosphere better than measurements based on "flooding" of soil samples with citric acid in batch experiments. Important challenges in MD with phosphate are small volumes of dialysate with extremely low concentrations and a high variability of results due to soil heterogeneity and between-probe variability. We conclude that MD is a promising tool to complement existing P-analytical procedures, especially when spatial aspects or the release of mobilizing substances are in focus.