EGU2020-18732
https://doi.org/10.5194/egusphere-egu2020-18732
EGU General Assembly 2020

Flux fields affect the spatial distribution of phosphorus in a tilled loamy soil

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Heterogenous flow pathways through the soil are a major component in the transport of water, dissolved and particle-bound nutrients like phosphorus (P) to water resources, and promote the eutrophication of water bodies. Non-uniform water flow patterns may also influence the spatial variability of the P-content in soils.

This study was designed to understand the spatial distribution of P in agriculturally used soils and the mechanism causing P accumulation and depletion at the centimeter scale. We conducted three replicate dye tracer experiments using Brilliant Blue on a loamy Stagnosol in North-Eastern-Germany. The plant-available phosphorus of stained and unstained areas was analyzed using double lactate extraction and diffusive gradients on thin films (DGT).

The DL-extractable P and the DGT-extractable P were strongly correlated ($p<0.001$, $R^2=0.63$) confirming that DL-P is a good measure for the mobile phase of soil phosphorus.

The plant available P contents of the topsoil were significantly higher than those of the subsoil in all three replicates. The topsoil's stained areas showed higher P contents than unstained areas, while the opposite was found for the subsoil. The P contents varied strongly over the soil profiles (0.4 to 11.2 mg P 100 g^{-1}) and different categories of flow patterns (matrix flow, flow fingers, preferential flow and no flow). The P contents of these flow patterns differed significantly from each other and followed the order: $P_{matrix\ flow} > P_{finger\ flow} > P_{no\ flow} > P_{preferential\ flow}$.

We conclude that P tends to accumulate along flow pathways in managed and tilled topsoils, while in subsoils at a general lower P level, P is depleted from the prominent preferential flow domains. It is likely, that P in the shallow groundwater origins from preferred flow zones from the subsoil.