

Seasonal Variability and Chemical Stability of Colloidal Phosphorus Leaching in Nordic Agricultural Catchments.

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Colloidal phosphorus (P) significantly contributes to P transport from agricultural soils to aquatic ecosystems, worsening eutrophication. Despite its importance, the chemical stability of colloidal P under fluctuating environmental conditions remains under-explored. In Nordic agricultural landscapes, a considerable portion of P leaching occurs during snowmelt and soil thaw in spring. However, the potential effects on the leaching of colloidal P species have not been thoroughly investigated.

We employed synchrotron P *K*-edge X-ray absorption near-edge structure (XANES) spectroscopy to determine the chemical forms of colloidal P (>0.45 µm) from four tile-drained agricultural sites in Sweden (Figure 1). Samples were collected between January and April 2019. We also monitored hydro-physicochemical parameters to identify the key drivers of P mobilisation.

Our results reveal that colloidal P accounted for ~80% of the total P in leachates, with the abundance of distinct chemical species showing significant temporal variation. From January to early March, leaching was low to moderate, with occasional peaks in colloidal P, predominantly in the forms of organic P (P-org) and P adsorbed to surfaces of aluminium-bearing particles (P-Al). In mid to late March, a sharp increase in colloidal P leaching occurred, particularly in P-org and P-Al. These episodic events suggest that P mobilisation is not continuous, and a single measurement may not accurately reflect the concentrations or chemical forms of leached colloidal P.

Despite seasonal hydrological fluctuations, organic P and aluminium-bound P consistently dominated colloidal P leaching, accounting for approximately 75%. Strong correlations between dominant P forms, total organic carbon (TOC), and suspended solids indicate that organic matter and mineral interactions are critical drivers of P transport.

Overall, our findings show that robust biogeochemical controls govern colloidal P dynamics in Nordic agricultural systems. These findings highlight the importance of timing in managing P leaching, particularly during periods of high mobilisation, such as snowmelt and soil thaw, to effectively mitigate phosphorus losses and reduce eutrophication risks in aquatic ecosystems.

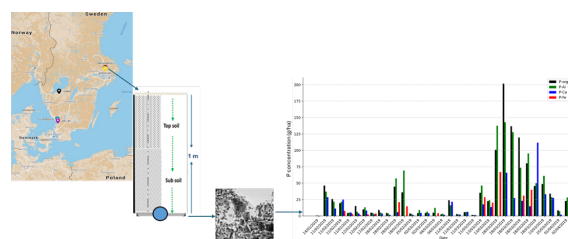


Fig.1 Temporal variation in the speciation of colloidal P leaching from tile-drained agricultural catchments in Sweden