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Sedimentary P and Fe dynamics in a eutrophic peat lake after Fe-amendment

MELANIE MÜNCH[1], RIANN VAN KAAM[1], KAREL AS[2], STEFAN PEIFFER[3], GERARD TER HEERDT[4], CAROLINE P. SLOMP[1] AND THILO BEHRENDS[1]

[1]Utrecht University
[2]University of Bayreuth
[3]Department of Hydrology - University of Bayreuth
[4]Waternet

Presenting Author: m.a.munch@uu.nl

Increased phosphorus input into surface waters over the last decades has led to eutrophication of surface waters worldwide. Besides such external inputs, release of phosphorus from lake sediments also impacts the water quality of lakes. Addition of iron(III) salts has been proposed as a sustainable measure to prevent phosphorus mobilization from lake sediments. Treatments at the field scale show variable effects between lakes, however, emphasizing the need to better understand biogeochemical processes involving iron and phosphorus in sediments.

Terra Nova, a shallow, well-mixed peat lake in the Netherlands, was treated with iron chloride in 2010. For 6 years, phosphorus concentrations in the surface water were effectively reduced, but since 2016 concentrations have steadily been rising to higher levels than before the treatment. We collected sediment cores at three sites in Terra Nova after the spring algae bloom in 2020. The porewater and sediment were analyzed for their chemical composition. Sequential extractions of phosphorus and iron were performed to gain insight into the interaction of these two elements in the sediment. Additionally, undisturbed cores were incubated under oxic and anoxic conditions to measure the fluxes of phosphorus and iron across the sediment water interface.

The results confirm a coupling between iron and the phosphorus dynamics in the sediment and show that the amount of iron added to the system is crucial for the phosphorus speciation. However, in Terra Nova enhanced availability of iron does not lead to an increased burial of phosphorus. The incubation experiments show that during periods of oxygen depletion more phosphorus escapes to the water column than iron, preventing the exhaustive scavenging of phosphorus with iron oxides once oxygen rich water layers are reached. Further, the phosphorus sequential extraction points towards the importance of humic substances for phosphorus binding in the sediment and suggests that associations of phosphorus, iron and organic matter play a significant role in the observed dynamics.

Further investigations into the nature and behavior of phosphorus-iron-organic matter associations combined with reactive transport modelling will aim at determining the key factors and conditions for successful lake restoration by iron-amendment.