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Effects of Fe addition on sediment P dynamics in a eutrophic lake

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The decline of surface water quality due to excess phosphorus (P) input is a global problem of increasing urgency. Finding sustainable measures to restore the surface water quality of eutrophic lakes with respect to P, other than by decreasing P inputs, remains a challenge. The addition of iron (Fe) salts has been shown to be effective in removing dissolved phosphate from the water column of eutrophic lakes. However, the resulting changes in biogeochemical processes in sediments as well as the long-term effects of Fe additions on P dynamics in both sediments and the water column are not well understood.

In this study, we assess the impact of past Fe additions on the sediment P biogeochemistry of Lake Terra Nova, a well-mixed shallow peat lake in the Netherlands. The Fe-treatment in 2010 efficiently reduced P release from the sediments to the surface waters for 6 years. Since then, the internal sediment P source in the lake has been increasing again with a growing trend over the years.

In 2020, we sampled sediments at three locations in Terra Nova, of which one received two times more Fe during treatment than the other two. Sediment cores from all sites were sectioned under oxygen-free conditions. Both the porewaters and sediments were analysed for their chemical composition, with sequential extractions providing insight into the sediment forms of P and Fe. Additional sediment cores were incubated under oxic and anoxic conditions and the respective fluxes of P and Fe across the sediment water interface were measured.

The results suggest that Fe and P dynamics in the lake sediments are strongly coupled. We also find that the P dynamics are sensitive to the amount of Fe supplied, even though enhanced burial of P in the sediment was not detected. The results of the sequential extraction procedure for P, which distinguishes P associated with humic acids and Fe oxides, as well as reduced flux of Fe(II) across the sediment water interface in the anoxic incubations, suggest a major role of organic matter in the interaction of Fe and P in these sediments.

Further research will include investigations of the role of organic matter and sulphur in determining the success of Fe-treatment in sequestering P in lake sediments. Based on these data in combination with reactive transport modelling we aim to constrain conditions for successful lake restoration through Fe addition.