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Effectiveness of P retention in eutrophic peat lake sediments 10 years after Fe amendment

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Internal P loading due to release of legacy P accumulated in sediments affects the water quality of many European freshwater systems. Fe addition is a widely used mitigation method to reduce internal P loading, but its success depends on the treated system and is not always long-lasting. In the Dutch lake Terra Nova, a polymictic shallow peat lake, $FeCl_3$ treatment in 2010 was successful in reducing P levels for two years. Subsequently, however, seasonal peaks in surface water P concentrations started to appear and have been increasing in intensity over the past 8 years. To gain insights into controlling factors and the role of Fe in P retention, depth-resolved solid phase characterization by sequential Fe and P extractions was combined with bulk X-ray absorption spectroscopy (XAS) at the Fe K-edge and high-resolution micro-X-ray fluorescence spectrometry (μ-XRF) and μ-XAS for Fe speciation. At locations with distinctively high Fe contents, pyrite and Fe-rich phyllosilicates were identified by microscopic and spectroscopic analyses. The spectroscopic data, however, also pointed to a finely dispersed Fe species in the sediment matrix, which most likely corresponds to Fe complexed by OM in the surface sediment. The correlation of the distribution of P and Fe suggested that P is bound to these Fe-OM complexes. This interpretation was further supported by the sequential extraction results, which showed that the added Fe could be recovered in the top 6 cm of sediment with Fe-bound P representing the largest no-organic pool. Overall, the results of this study indicate that the application of $FeCl_3$ caused a change in sediment P dynamics towards a highly redox sensitive system in which P bound to Fe-OM is released to the surface water during seasonally low bottom water oxygen concentrations. Hence, $FeCl_3$ may not be the ideal additive for the effective remediation of internal P loading in water bodies with peaty sediment due to the complexation of Fe by OM.