Fe solid phase chemistry and its effect on P retention in the sediment of a eutrophic peat lake 10 years after Fe amendment

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Globally, surface water quality and ecosystem functioning are challenged by anthropogenic P inputs. While sterner legislation has led to lower external P loading, internal loading fed by legacy P accumulated in the sediment has become the controlling factor of surface water P concentrations in many European freshwater systems. Fe amendment is a treatment method to control internal P loading, but is not always successful on the long term. In Lake Terra Nova, a polymictic shallow peat lake in the Netherlands, treatment with FeCl₃ only led to a temporary decrease in sedimentary P release. Two years after treatment seasonal peaks in surface water P concentrations started to appear and have been increasing in intensity for the past 8 years. Depth-resolved solid phase analysis 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. At spots with distinctively high Fe contents, pyrite and silicate-bound Fe are identified by microscopic and spectroscopic analyses. The spectroscopic data, however, also point 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 suggests that P is bound to these Fe-OM complexes. This interpretation is supported by the sequential extraction results which showed that the Fe treatment induced a shift in the dominant P pool from Ca-bound P to Fe- and OM-bound P. Overall, the results indicate that FeCl₃ application 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. The results of this study therefore indicate that FeCl₃ may not be the ideal additive for the remediation of internal P loading in peaty water bodies due to the high affinity of Fe to OM.