

Benefits and risks of adding iron-containing water treatment residuals to lakes for reducing the internal phosphorus loading

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Release of phosphorus (P) from sediments to the overlying water, the so called internal P loading, is often hampering the recovery of eutrophic lakes after external P loading has abated. In the H2020-MSCA-ITN project P-TRAP, addition of iron-containing water treatment residuals (Fe-WTRs) to fresh water systems has been investigated as a measure to reduce internal P loading. Addition of Fe-WTRs can reduce internal P loading via 1) adsorption of dissolved P, 2) coprecipitation with Fe when Fe-WTRs become reduced in the sediment and the produced Fe(II) is re-oxidized in the oxidizing layers of the sediment or in the overlying water, or 3) by increasing the formation of authigenic P minerals. In this project, characteristics of 18 Fe-WTRs were investigated and their redox reactivities were determined by measuring the rates of reductive dissolution by ascorbic acid. Based on the source water and treatment process, the composition, mineralogy and physical properties of Fe-WTRs can vary considerably. The diversity in properties should be taken into consideration when selecting Fe-WTRs for lake restoration. The effect of Fe-WTR addition on P release from sediments was studied in laboratory experiments with sediment cores and in ditches as surrogates for shallow lakes in a peaty environment. In all cases, Fe-WTR amendment increased the P retention in the sediments over the duration of the experiments. At high dose, this effect can be predominately ascribed to enhanced P adsorption. Fe-WTR addition also intensified the Fe redox cycle in the sediments or between the sediments and the overlying water implying potential P removal via coprecipitation of dissolved P with Fe(III) hydroxides upon the oxidation of Fe(II). No indications for enhanced formation of authigenic P minerals, such as vivianite ($\text{Fe}_3(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$), were obtained. Despite the current beneficial effects, sulfidation of Fe-WTRs as well as binding of Fe to organic matter can jeopardize the success of Fe-addition on the long term. Complete sulfidation of Fe-WTR might even increase internal P loading when the applied Fe-WTRs already contained P prior to application.