Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.5752

Quantitative remediation study to avoid orthophosphate dynamics between sediment and water column at a shallow eutrophic lake

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The formation of algal and cyanobacterial blooms caused by eutrophication of water bodies is a growing global concern. Phosphorus is an essential element for biomass synthesis in all living organisms and is considered to be one of the crucial factors fostering eutrophication. Aim of this study is I) to assess quantitatively the re-dissolution from sediment in a shallow eutrophic lake with regular cyanobacterial blooms and II) to provide improvements for remediation strategies of eutrophic lakes.

Our study was conducted at Lake Seeburg, a shallow (< 4 m deep) unstratified lake in central Germany. Orthophosphate concentrations of the lake and its only inflow and outflow were analyzed monthly over a three-year period. In addition, orthophosphate concentrations of sediment pore waters were investigated monthly for one year. Orthophosphate was analyzed photometrically according to EN-ISO-6878.

Orthophosphate is the most bioavailable form of phosphorus. Over the observation period, its concentrations in the inflow constantly ranged from 0.12 to 0.33 mg/L. In the lake, orthophosphate was near detection limit in spring and summer. However, during late summer cyanobacterial blooms, concentrations peaked up to 0.68 mg/L. Simultaneously, orthophosphate concentrations in sediments pore water strikingly increased up to > 30 mg/L, thus implying a major input of orthophosphate from the sediment during summer months. Due to the shallow depth of the lake, sedimentary released orthophosphate is distributed throughout the water column and supports the production of additional cyanobacteria. This leads to a self-enhancing effect with high biomass production. Organic phosphorus deposited in the sediment after biomass decay can be released as orthophosphate in future years and is additionally available for new cyanobacterial blooms.

Our data show a strong sedimentary orthophosphate release during late stages of cyanobacterial blooms. Based on these findings, remediation strategies can be optimized by applying measures at the most efficient time. Since orthophosphate is sedimentary bound in winter, measures such as dredging the sediment will be more likely to succeed then. In contrast, phosphate binders should only be applied at a late stage of a cyanobacterial bloom, as the highest concentrations of sedimentary released orthophosphate in the water column are expected then.