Drivers of iron and phosphorus partitioning in eutrophic waters and their sediments: insight from monitoring and experimental redox front manipulation

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Linkages between iron and phosphorus behaviour are critical to understanding algal blooms in shallow eutrophic lakes, where benthic fluxes can be a dominant micro and macronutrient source in the euphotic zone. At one such site, Missisquoi Bay of Lake Champlain, we have demonstrated that nutrient fluxes and associated algal dynamics, are driven by fluctuations in the position of the redox front relative to the sediment-water interface (SWI). Through analysis of time series water column and sediment chemistry, coupled with experimental manipulation of SWI redox conditions in mesocosm experiments, we explore the relationship between environmental drivers, SWI redox front position, and the chemical partitioning of Fe and P in sediment and overlying water. We couple high frequency sensor measurements from environmental monitoring arrays (e.g. DO, T, Chl-A) with direct (Fe EXAFS, P XANES, voltammetry, P NMR) and indirect (SEDEX and Enzyme Hydrolysis extractions, ultrafiltration) measurements of metal and P partitioning to explore these relationships. Water column stability, promoted by warm calm weather or persistent cold with ice cover, drives the release of P and Fe from sediment profiles into the water column, with concurrent build-up of dissolved and colloidal species across a bottom water gradient. Conversely, periods of mixing suppress the redox front relative to the SWI, which promotes accumulation of reactive P and Fe phases in sediment profiles. Storm and snowmelt provide input of dissolved/nanocolloidal P and Fe, and riverine sediment enriched in ‘inorganic’ P. Phosphorus species pools respond most to SWI redox conditions, pH and organic matter input from blooms. Experiments indicate that the duration and frequency of redox front oscillations impacts the partitioning, concentration and reactivity of Fe and P in sediments and bottom waters. Consequently, our analysis demonstrates that partitioning and release or sequestration of Fe and P in these systems is highly dynamic and sensitive to an array of chemical, physical, and biological drivers.