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Phosphorus recycling in sediments– the classic model and the anomalies

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Sediments recycle phosphorus (P) and regulate the productivity of many aquatic ecosystems. Estimating sediment P effluxes is important in understanding the water column P dynamics and resilience of the ecosystem in the long term. Sediment P fluxes have long been explained by the classic models of P cycling coupled to those of other elements carbon (C), iron (Fe), and sulfur (S). In Fe-rich freshwater or coastal marine environments, sediment P fluxes are considered controlled by the reduction of Fe-bound P, whereas in low-Fe and/or high S offshore marine sediments, P fluxes are mostly driven by the decomposition of organic matter. In this talk, however, I will show why generalizing P flux mechanisms may be difficult, by using examples of anomalies from a diverse range of environments. I will show how P fluxes from C-poor and Fe-rich sediments of oligotrophic lakes are more predictable by the rates of organic matter decomposition rather than Fe reduction. I will also show other scenarios of sediments in a shallow estuary, where P release is strongly coupled to anaerobic Fe reduction but surprisingly not sensitive to oxygen. The increase of sulfate can weaken the control of Fe on P fluxes, but the extent of decoupling depends on the availability of reactive organic matter. In addition to the carbon-driven heterotrophic Fe-S-P coupling, chemoautotrophy can drive the P fluxes at a low-carbon settings, such as deep-sea methane seeps. Using these examples, I will highlight the challenges and potentials in modeling sediment feedbacks to the water column dynamics.