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Hypolyminetic Oxygen Depletion And Dynamics of P Binding Forms: Insights From Modeling Sediment Early Diagenesis Coupled With Automatic Parameter Estimation

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Sediment diagenesis can significantly impact on lake water quality through depleting hypolimnion oxygen and acting as a sink or source of nutrients and contaminants. In this study, we apply MATsedLAB, a sediment diagenesis module developed in MATLAB [1, 2] to quantify benthic oxygen consumption and biogeochemical cycling of phosphate (P) in lacustrine sediments of Lake Baldegg, located in central Switzerland. MATsedLAB provides an access to the advanced computational and visualization capabilities of the interactive programming environment of MATLAB. It allows for a flexible definition of non steady-state boundary conditions at the sediment-water interface (SWI), the model parameters as well as transport and biogeochemical reactions. The model has been extended to facilitate the model-independent parameter estimation and uncertainty analysis using the software package, PEST.

Lake Baldegg represents an interesting case where sediment-water interactions control P loading in an eutrophic lake. It is of 5.2 km2 surface area and has been artificially aerated since 1982. Between 1960 and 1980, low oxygen concentrations and meromictic condition were established as a result of high productivity. Here, we use the cores for the measurements of anions and cations which were collected in April and June 2012 respectively from the deepest location (66 m), by Torres et al. (2013) to calibrate the developed model [3]. Depth profiles of thirty three species were simulated by including thirty mixed kinetic-equilibrium biogeochemical processes as well as imposing the fluxes of organic and inorganic matters along with solute concentrations at the SWI as dynamic boundary conditions.

The diffusive transport in the boundary layer (DBL) above the SWI was included as the supply of O_2 to the sediment surface can be diffusion-limited, and applying a constant O_2 concentration at the sediment surface may overestimate O_2 consumption. Benthic oxygen consumption was calculated as a function of the present and past deposited OM. The results revealed the transient nature of sediment oxygen uptake and existence of temporal lag associated with benthic oxygen consumption for the aerated versus non-aerated scenarios.

The model closely reproduced phosphate partitioning among OM and various redox-sensitive inorganic minerals. The results showed that P associated with OM is the dominant pool as inorganic binding P such as apatite, vivinite and adsorbed P contain a minor fraction of solid phase P. The calculated flux of dissolved P through the SWI under seasonal and decadal variations suggest that oxygen concentration at the SWI and the flux of settling OM along with its composition expressed as the ratio of degradable to inert OM are the major factors that control P release to the overlying water under dynamic forcing.

References

[1] Couture, R., et al. (2009). "Non steady-stae modeling of arsenic diagenesis in lake sediments." Environmental Science and Technology 44 (1): 197-203.

[2] Shafei, B., et al. (2010). "Arsenic sorption in aquatic sediments: equilibrium, kinetic and mixed modeling approaches." Geochimica et cosmochimica acta 74 (12): A938-A938.

[3] Torres, N. T., et al. (2013). "Sediment porewater extraction and analysis combining filter tube samplers and capillary electrophoresis." Environmental Science-Processes & Impacts 15(4): 715-720.