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Assessing past and present P Retention in Sediments in Lake Ontario (Bay of Quinte) by Reaction-Transport Diagenetic Modeling

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Phosphorus (P) is an important macronutrient that can limit aquatic primary production and the risk of harmful algal blooms. Although there is considerable evidence that P release from sediments can represent a significant source of P and burial in sediments returns P to the geological sink; these processes have been poorly characterised. In this study, we applied a non-steady state reactive transport diagenetic model to gain insights into the dynamics of phosphorus binding forms in sediments and the phosphorus cycling of the Bay of Quinte, an embayment of Lake Ontario, Canada. The three basins of the bay (Belleville, Hay Bay and Napanee) that we investigated had differences in their phosphorus binding forms and phosphorus release, reflecting the distinct spatial temporal patterns of land use and urbanization levels in the watershed. Sediment cores from the three stations were collected during summer and under ice cover in 2013-14. Oxygen, pH and redox potential were monitored by microsensors; porewater and sediment solid matter were analyzed for P content, and a sequential extraction was used to analyze P binding forms.
In the reaction-transport model, total phosphorus was divided into adsorbed phosphorus, phosphorus bound with aluminium, organic phosphorus, redox sensitive and apatite phosphorus. Using the fluxes of organic and inorganic matter as dynamic boundary conditions, we simulated the depth profiles of solute and solid components. The model closely reproduced the fractionation data of phosphorus binding forms and soluble reactive phosphorus.
The past and present P fluxes were calculated and estimated; they related to geochemical conditions, and P binding forms in sediments. Our results show that P release from sediments is dominated by the redox-sentive P fraction accounting for higher percentage at Napanee station. The main P binding form that can be immobilized through diagenesis is apatite P contributing highest P retention at HayBay station. The mass balance of P was closed by our model.