Natural inactivation of phosphorus by aluminum in preindustrial lake sediments

Kopácek, Jirí, Marie Marešová, Josef Hejzlar, Stephen A. Norton

Limnol. Oceanogr., 52(3), 2007, 1147-1155 | DOI: 10.4319/lo.2007.52.3.1147

ABSTRACT: Noncalcareous phosphorus (P)-rich lake sediments typically release P associated with iron hydroxide [$Fe(OH)_3$] during the development of hypolimnetic anoxia. High concentrations of aluminum hydroxide [$Al(OH)_3$] in such sediments (e.g., in aluminum [Al]-treated lakes) can prevent the P release. Here we show that sediment ability to bind P can naturally develop during lake history because of changes in the $Al(OH)_3$ concentration and the $Al(OH)_3$ to $Fe(OH)_3$ ratio in sediment. We reconstructed the development of sediment Psorption characteristics through the Late Glacial and Holocene periods on the basis of sequential fractionation analysis of P, Al, iron, calcium, and magnesium in a ~14,000-yr-long sediment record, fresh settling seston, and bedrock from Plesˇne´ Lake, Czech Republic. The most significant change occurred at the Late Glacial-Holocene transition (~10,000 yr before present), when the watershed became forested and soil erosion decreased. The Late Glacial sediment was rich in mineral detritus, derived from the watershed till and bedrock, had most of its P associated with $Fe(OH)_3$ (37%) and calcite and/or apatite (42%), and was probably able to release P during anoxia. In contrast, the Holocene sediment was highly organic, the P release during anoxia was likely negligible, and >90% of P was associated with $Al(OH)_3$. This $Al(OH)_3$ originated from photochemical liberation of Al from dissolved organically-bound Al (Alo) exported to the lake from soils. Because the photochemical mechanism was a more efficient source for $Al(OH)_3$ than for $Fe(OH)_3$, the sediment became a P trap by the beginning of the Holocene. The ability of the sediment to immobilize P increased further during the anthropogenic acidification era because of elevated terrestrial export of ionic Al. Similar sediment fractionation results in cores from six lakes in Maine suggest that this P-immobilizing mechanism is a general process that can occur in lakes with high Alo inputs.

Article Links

Download Full-text PDF

Return to Table of Contents