Phosphorus Retention in Sediments of an Artificially Fertilized Boreal Lake

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In this study, sediment cores were collected in the oxygenated epilimnion and the anoxic hypolimnion of Lake 227 located in the Experimental Lake Areas (ELA) in northern Ontario, Canada. Lake 227 is a unique natural laboratory to study phosphorus (P) cycling, as it has been artificially fertilized with P without interruption since 1969. The onset of fertilization caused the lake to undergo a rapid transition from oligotrophic to eutrophic conditions. The cores contain a historical record of the associated changes in sediment P retention. Sediment chronology was established through ^{210}Pb dating; speciation of P, iron (Fe) and sulfur (S) was analysed using chemical extractions complemented by ^{31}P NMR spectroscopy and enzymatic hydrolysis assays. The results show that, following fertilization, the absolute and relative abundances of humic-metal-phosphate complexes and organically-bound P increased significantly in the sediments of both the epilimnion and hypolimnion. In particular, the formation of humic-metal-phosphate complexes appears to be one of the key mechanisms explaining the high retention of reactive P in the sediments and, consequently, the limited internal P loading of the lake. Enzymatic assays and ^{31}P NMR further reveal the accumulation of potentially labile organic P under eutrophic conditions. Sediment P dynamics in Lake 227 thus deviate markedly from the classic model of P recycling linked to early diagenetic redox transformations of Fe.