Effect of macrozoobenthos on two-dimensional small-scale heterogeneity of pore water phosphorus concentrations in lake sediments: A laboratory study

Lewandowski, Jörg, Michael Hupfer

Limnol. Oceanogr., 50(4), 2005, 1106-1118 | DOI: 10.4319/lo.2005.50.4.1106

ABSTRACT: We used mesocosms equipped with two-dimensional (2D) pore water samplers (24 rows X 24 columns, 9-mm spatial resolution) to resolve and quantify some of the complex spatial patterns in diagenetic reactions produced by irrigated biogenic structures. The mesocosms were filled with an organic-, iron-, and phosphorus-rich sediment, and chironomids and oligochaetes were added in high densities to three of six mesocosms; the other three mesocosms served as controls. In the mesocosms without macrozoobenthos, a classic redox zonation developed. In the mesocosms with macrozoobenthos, profiles of redox-sensitive dissolved species were less steep in the vicinity of the sediment-water interface, and more irregular throughout the sediment, than in the mesocosms without macrozoobenthos. Furthermore, pore water P concentrations were decreased overall and showed much more small-scale 2D heterogeneity in the mesocosms with macrozoobenthos than in the controls. A comparison of the calculated heterogeneity indices of pore water P concentrations (the ratio of horizontal to vertical flux components) of this laboratory study with in situ-determined indices of previous studies indicates that the presence of macrozoobenthos is the major factor causing heterogeneity. A conceptual model of the effects of macrozoobenthos on biogeochemistry along with pore water and sediment analysis showed a close coupling of P cycling with iron and sulfur cycling. This led to the conclusion that pore water P concentrations and heterogeneity were mainly redox-controlled by association of P with iron oxyhydroxides precipitating along oxidized burrow walls, and not a consequence of mineralization processes occurring in organic-rich "hot spots" of increased P turnover. Decreased P release rates accompanied addition of macrozoobenthos and indicated that redox control of P release by iron oxyhydroxide precipitation and dissolution was of major importance.