Nitrate Reduction in Upper Mississippi River Sediments Using In Situ Microcosms

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Each summer up to 18,000 km^2 of water area in the Gulf of Mexico experiences hypoxia, threatening an important commercial and recreational fishery. Nutrients from the Mississippi River, and the Upper Mississippi River in particular, have been implicated as the source of the hypoxia. An average of 1 million metric tons of nitrate flow into the Gulf each year. We initiated preliminary studies of surface and pore water chemistry and sediment microbial processes during low flow to determine potential impacts of the sediment microbial communities on dissolved nitrogen in river water. Differences in pore water and surface water chemistry indicate there is an oxic stream channel over anoxic sediments. Nitrate concentrations are significantly higher in surface water (800 $\mu g\ N\ L^{-1}$) than pore water (150 $\mu g\ N\ L^{-1}$). Nitrate reduction was observed in sediments overlain by either low (2 mg $C\ L^{-1}$) or high (9 mg $C\ L^{-1}$) dissolved organic carbon surface water and was further stimulated by the addition of acetate. Nitrate loss was accompanied by nitrite and nitrous oxide increases in the presence of acetylene, indicating active denitrification. The zero-order rate for nitrate reduction was higher in unamended high-organic carbon, low-nitrate sediments (0.15 mg $N\ L^{-1}\ hr^{-1}$) than in low-organic carbon, high-nitrate sediments (0.05 mg $N\ L^{-1}\ hr^{-1}$). In acetate-amended sediments, nitrate disappeared at a rate of 0.30 mg $N\ L^{-1}\ hr^{-1}$ regardless of endogenous organic carbon content. Numbers of total aerobes, heterotrophic fermenters, and denitrifiers in main channel river water were similar to the respective numbers in the pore waters, with slightly more denitrifiers found in the high-nitrate pore water. Low numbers of iron-reducers and sulfate-reducers were found in water and on sediments in all locations. Methanogens were not present in concentrations greater than 2 per gram or per mL. Higher numbers of aerobes, heterotrophic fermenters, denitrifiers, and sulfate reducers were found on high-organic carbon sediments than on low-organic carbon sediments. Between high-dissolved organic carbon, low-nitrate sediments and low-dissolved organic carbon, high-nitrate sediments, differences in microbial numbers and nitrate reduction kinetics were found.