Inorganic nitrogen transformations in the bed of the Shingobee River, Minnesota, USA: Integrating hydrologic and biological processes using sediment perfusion cores

Sheibley, Richard W., John H. Duff, Alan P. Jackman, Frank J. Triska

Limnol. Oceanogr., 48(3), 2003, 1129-1140 | DOI: 10.4319/lo.2003.48.3.1129

ABSTRACT: Inorganic N transformations were examined in streambed sediments from the Shingobee River using sediment perfusion cores. The experimental design simulated groundwater-stream water mixing within sediment cores, which provided a well-defined one-dimensional representation of in situ hydrologic conditions. Two distinct hydrologic and chemical settings were preserved in the sediment cores: the lowermost sediments, perfused with groundwater, remained anaerobic during the incubations, whereas the uppermost sediments, perfused with oxic water pumped from the overlying water column, simulated stream water penetration into the bed. The maintenance of oxic and anoxic zones formed a biologically active aerobic-anaerobic interface. Ammonium (NH^+_4) dissolved in groundwater was transported conservatively through the lower core zone but was removed as it mixed with aerated recycle water. Concurrently, a small quantity of nitrate (NO^-_3) equaling ~25% of the NH^+_4 loss was produced in the upper sedi-ments. The NH^+_4 and NO^-_3 profiles in the uppermost sediments resulted from coupled nitrification-denitrification, because assimilation and sorption were negligible. We hypothesize that anaerobic microsites within the aerated upper sediments supported denitrification. Rates of nitrification and denitrification in the perfusion cores ranged 42-209 and 53-160 mg N m^{-2} day^{-1}, respectively. The use of modified perfusion cores permitted the identification and quantification of N transformations and verified process control by surface water exchange into the shallow hyporheic zone of the Shingobee River.