The influence of ammonium, nitrate, and dissolved oxygen concentrations on uptake, nitrification, and denitrification rates associated with prairie stream substrata

Kemp, Melody J., Walter K. Dodds

Limnol. Oceanogr., 47(5), 2002, 1380-1393 | DOI: 10.4319/lo.2002.47.5.1380

ABSTRACT: Substrata samples were collected from Kings Creek on Konza Prairie Biological Station (Manhattan, Kansas) and incubated with varying levels of ammonium (NH_4^+), nitrate (NO_3^-), and dissolved oxygen (O_2) to examine the response of nitrogen (N) uptake and transformation rates. Substrata collected were fine benthic organic matter (FBOM), coarse benthic organic matter, filamentous green algae, bryophytes, suspended particulate organic matter, and epilithic diatoms. Nitrification and denitrification were estimated by use of the nitrapyrin and acetylene inhibition methods, respectively. Ammonium uptake demonstrated Michaelis-Menten kinetics, with the highest maximum rates (V_{max}) associated with filamentous green algae (5.90 mg N gdm^{-1} d^{-1}) and epilithic diatoms (4.96 mg N gdm^{-1} d^{-1}). Nitrate uptake did not saturate at the highest NO_3^- addition (25 µg N L^{-1}) above ambient when associated with FBOM. Overall, maximum uptake rates of NH_4^+ were 10-fold higher than for NO_3^-. Nitrification response to increasing NH_4^+ concentrations was highly variable, depending on the substrata type. Nitrification was lowest under low O_2 conditions, being undetectable when NO_3^- was added but not when NH_4^+ was added. Denitrification increased linearly with NO_3^- concentration when associated with epilithic diatoms and FBOM but became saturated at ~20 µg N L^{-1} above ambient concentrations when associated with filamentous green algae. Samples purged with N_2 gas had the highest rates of denitrification. We predicted stream ecosystem rates using equations derived from the experimental data and substrata mass estimates measured in the field. Substantial temporal variability was predicted in uptake (0-1,300 mg NH_4^+-N m^{-2} d^{-1}; 0-5.2 mg NO_3^--N m^{-2} d^{-1}), nitrification (0-35 mg NH_4^+-N m^{-2} d^{-1}), and denitrification (0-130 µg N2O-N m^{-2} d^{-1}) as due to natural variation in water column NH_4^+, NO_3^-, and O_2 concentrations.