Characterization of the key pathways of dissimilatory nitrate reduction and their response to complex organic substrates in hyporheic sediments

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ABSTRACT: Laboratory incubations with river-bed sediment collected from riffles and pools were used to quantify potential pathways of dissimilatory nitrate reduction in the hyporheic zone of a groundwater-fed river. Sediments collected from between 5-cm and 86-cm depth in the bed of the River Leith, Cumbria, United Kingdom, were incubated with a suite of ^{15}N-labeled substrates ($^{15}NO^{-}_{3}$, $^{15}NH^{apns;}_{4}$, and $^{14}NO^{-}_{3}$) to quantify nitrate reduction via denitrification, dissimilatory nitrate reduction to ammonium (DNRA), and anaerobic ammonium oxidation (anammox). Denitrification was the dominant pathway of dissimilatory nitrate reduction in the hyporheic sediments, although recovery of ^{15}N from the ammonium pool indicated that DNRA was also active. The potential for anammox was confirmed by the production of $^{29}N_2$ during the $^{15}NH^{apns;}_{4}$ and $^{14}NO^{-}_{3}$ incubation, but it was much smaller than denitrification. Potential rates of denitrification were highest in shallow sediments and decayed exponentially with depth thereafter. There were clear differences in denitrification activity between riffle and pool sediments. After the production of ^{15}N-N_2 had stabilized, we added a spike of bacteriological peptone to determine the effect of complex organic substrates on denitrification potential. The potential rate of denitrification increased uniformly at all sediment depths but the total amount of denitrification fueled by the organic substrates decreased markedly with depth, from 90% in the shallow sediments to 30% in the deepest sediments. In addition, a considerable fraction of the $^{15}NO^{-}_{3}$ could not be accounted for, which suggested that up to 87% of it had been assimilated in the deepest sediments.

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