Denitrification in the banks of fluctuating rivers: the effects of river stage amplitude, sediment hydraulic conductivity and dispersivity, and ambient groundwater flow

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Hyporheic exchange induced by periodic river fluctuations leads to important biogeochemical processes, particularly nitrogen cycling, in riparian zones (RZs) where chemically distinct surface water and groundwater mix. Based on field observations, we developed a two-dimensional coupled flow, reactive transport model to study the influence of river fluctuations on nitrogen cycling within the RZ during a single 24 h pulse. Sensitivity analyses were conducted to quantify the effects of river amplitude, sediment hydraulic conductivity and dispersivity, and ambient groundwater flow on nitrate removal efficiency. The simulations showed that nitrification occurred in the shallower zone adjacent to the bank where oxic river water and groundwater interacted while denitrification occurred deeper into the aquifer and in the riverbed sediments where oxygen was depleted. River fluctuations greatly increased the amount of nitrate being removed; however, the removal efficiency, the ratio of the mass of nitrate being removed due to denitrification and the total mass of nitrate entering aquifer, decreased as river amplitude increased. Similarly, increasing hydraulic conductivity increased overall nitrate removal due to a large denitrifying zone but with decreasing efficiency. In contrast, increasing sediment dispersivity increased the removal efficiency of nitrate. The presence and direction of ambient groundwater flow had a significant impact on nitrate removal efficiency when compared to neutral conditions. A losing river showed smaller removal efficiency (3.5%) while a gaining river showed larger removal efficiency (17.1%) compared to neutral conditions (5.4%). Our results demonstrated that daily river fluctuations created denitrification hot spots within the RZ that would not otherwise exist in a neutral or gaining conditions under natural baseflow.

Keywords: Riparian Zone, Denitrification, River fluctuation

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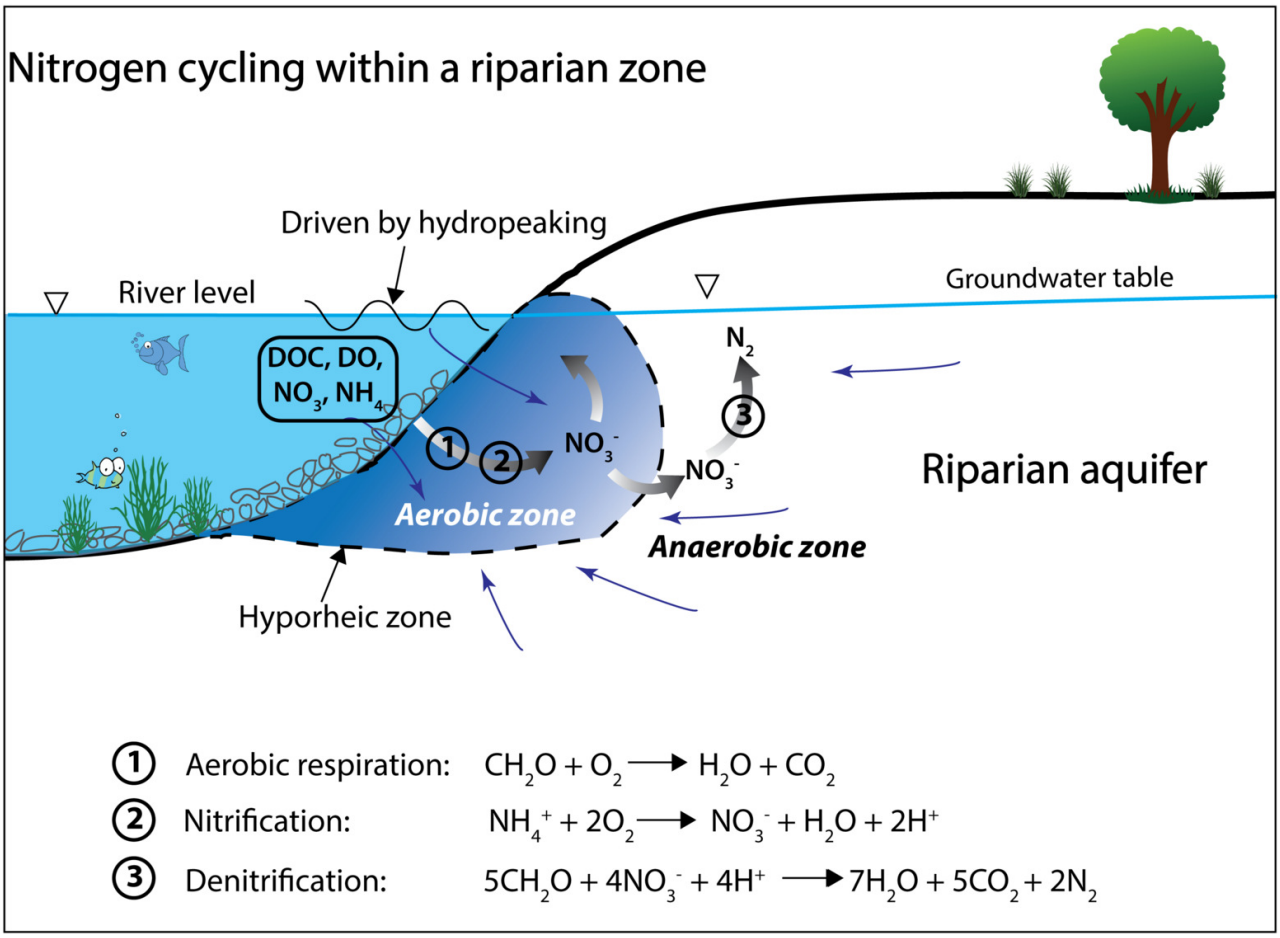

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