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Temporal variation of hyporheic denitrification in a lowland agricultural drainage system

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Diffuse nitrogen pollution in surface water is important especially in regions with intense agricultural land use. These nitrogen loads depend on nitrogen export from various sources and are influenced by natural attenuation processes like denitrification. The objective of this study was to identify the temporal variation of nitrogen turnover and loads and the role of hydrological factors controlling these variations. The investigations were conducted in the “Schaugraben” catchment, a small Pleistocene lowland catchment in northern Germany. The catchment is characterised by a dendritic channel system that runs partially dry during summer, therefore having relatively high variations in discharge (4 to 400 l/s) and flow velocity (0.04 to 0.4 m/s). We investigated in-stream N-turnover in situ using the isotope pairing method applied in a newly developed benthic-flow-chamber. With this method we were able to measure the impact of stream flow velocity on benthic denitrification. Additionally we analysed stream water and seepage water as well as shallow groundwater for water chemistry and natural isotopic abundances of nitrate to identify temporal variation of nitrogen turnover and loads on a larger scale.

We found a negative impact of increasing stream flow velocities on denitrification. In the experiments we varied flow velocities from 0.04 to 0.2 resulting in denitrification rates between 100 to 40 mg/m2/d. Regarding diurnal patterns, day-night measurements showed clearly increased rates of denitrification in the sediment boundary-layer for nighttime compared to daytime. The response of benthic denitrification to light and flow velocity is mediated by oxygen dynamics at the sediment boundary. Temperature dependence showed a typical value (Q10 = 2). Due to high flow velocities and low

temperature denitrification is severely decreased during winter time. Even if potential denitrification rates were high in summer, nearly no nitrate degradation occurs due to low nitrate concentrations in this season. These low concentrations are caused by groundwater level variations resulting in disconnection of tributaries from which 60 percent of the nitrogen input originate in other seasons. For the whole stream we could identify hyporheic denitrification as an important process only in spring. Because of the observed disconnection of nitrate polluted groundwater during summer part of the self-purification potential of the stream remains unused. Temporal variation of benthic denitrification shows a complex pattern of temperature, light, nitrogen concentration and stream velocity.