Geophysical Research Abstracts,
Vol. 11, EGU2009-3198, 2009
EGU General Assembly 2009

Hyporheic nutrient transformation - A panacea for river restoration that solves the "Nitrate Time Bomb" ?

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The river – aquifer interface, also called the 'hyporheic zone' or 'interstitial' characterises the area of intensive mixing between groundwater and surface water within the streambed of a river. Its physical conditions, as hydraulic conductivity and residence time, control fluxes and exchange rates between groundwater and surface water. Because of its often steep and dynamic redox gradients, the hyporheic zone can represent an area of high chemical activity. Previous studies described how the transport and redox processes in the hyporheic zone can cause effective nutrient attenuation, e.g. by denitrification. Hence, river regulators and river basin management plans hope for the hyporheic zone to delimit the negative impact, polluted groundwater has for the stream ecological health. The desperation behind such expectations becomes apparent in light of increasing nitrate concentrations in many groundwater aquifers and their long residence times – the so-called "Nitrate Time Bomb".

In this study we investigate spatial and temporal patterns of physical streambed characteristics and redox chemical conditions and its controls on nitrogen transport and transformation in the streambed of several English rivers. For the streambed sediments of a 50 – 250 m stream reaches, pore water nitrate and ammonia concentrations were monitored together with common anions, redox conditions, dissolved oxygen levels and rates of groundwater upwelling and surface water mixing in a dense system of nested piezometer for a two year period.

The results of this study indicate that hyporheic nutrient transformation can well exceed the usually assumed streambed depths of a few cm and may occur in depths of up to 1 m. Our investigations furthermore detected, that within the research area the hyporheic passage has a spatially very variable impact on the exchange fluxes and nitrogen concentrations and transformation rates in the streambed. Nitrate attenuation due to denitrification was found in some areas as well as nitrification in others. The spatial patterns of nitrate attenuation or release areas were controlled by the hyporheic connectivity, described by the spatial and temporal coincidence of flow pattern and residence times within areas of variable redox conditions. The hyporheic nitrate contributions were furthermore found to have a seasonally variable impact on the in stream concentrations. The results of this study proof, that hyporheic impacts on in stream nutrient concentrations can be far more complex, even on a small scale, than it has been acknowledged so far.