Geophysical Research Abstracts
Vol. 19, EGU2017-17543, 2017
EGU General Assembly 2017

Small scale denitrification variability in riparian zones: Results from a high-resolution dataset

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Riparian zones are important compartments at the interface between groundwater and surface water where biogeochemical processes like denitrification are often enhanced. Nitrate loads of either groundwater entering a stream through the riparian zone or streamwater infiltrating into the riparian zone can be substantially reduced. These processes are spatially and temporally highly variable, making it difficult to capture solute variabilities, estimate realistic turnover rates and thus to quantify integral mass removal. A crucial step towards a more detailed characterization is to monitor solutes on a scale which adequately resemble the highly heterogeneous distribution and on a scale where processes occur. We measured biogeochemical parameters in a spatial high resolution within a riparian corridor of a German lowland river system over the course of one year. Samples were taken from three newly developed high-resolution multi-level wells with a maximum vertical resolution of 5 cm and analyzed for major ions, DOC and N-O isotopes. Sediment derived during installation of the wells was analyzed for specific denitrifying enzymes. Results showed a distinct depth zonation of hydrochemistry within the shallow alluvial aquifer, with a 1 m thick zone just below the water table with lower nitrate concentrations and EC values similar to the nearby river. Conservative parameters were consistent inbetween the three wells, but nitrate was highly variable. In addition, spots with low nitrate concentrations showed isotopic and microbial evidence for higher denitrification activities. The depth zonation was observed throughout the year, with stronger temporal variations of nitrate concentrations just below the water table compared to deeper layers. Nitrate isotopes showed a clear seasonal trend of denitrification activities (high in summer, low in winter). Our dataset gives new insight into river-groundwater exchange processes and shows the highly heterogeneous distribution of denitrification in riparian zones, both in time and space. With these new insights, we are able to improve our understanding of spatial scaling of denitrification processes. This leads to a better prediction and improved management strategies for buffer mechanisms in riparian zones.