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Process-oriented investigation of the nitrate-removal-capacity of the aquifers in the Hessian Ried

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The quarternary sediments of the Hessian Ried, a part of the Rhine valley, hold an important groundwater resource for the densely populated Rhine-Main region in germany. Studies related to the implementation of the EU Water Framework Directive (WFD) have shown high nitrate concentrations in the groundwater, especially in the upper parts of the aquifers. Recently, there are signs which indicate that the nitrate-removal-capacity may be exhausted and the denitrification is slowing down.

In aquifers, microbial autolitho- and heterotrophic denitrification is coupled to the consumption of the reactive phases pyrite (FeS_2) and organic carbon (TOC), respectively. These reducing phases occur often only in trace amounts which makes it difficult to determine their distribution, reactivity and content in the field. However, a process-based knowledge of the occurring reactions and the quantification of the nitrate-removal-capacity and -kinetic is required to predict future nitrate fate.

For this aim we combined different methods on a laboratory and field scale to identify the relevant nitrate degradation processes in the Hessian Ried. For determining the reactive phases (TOC and pyrite) in sediment samples, we modified and validated a combination of methods, ranging from sequential combustion for TOC and XRF for elemental and chromium reducible sulphur (CRS) for sulphide/disulphide determination. The analyses of core samples from different field sites in the Hessian Ried (forest and agricultural area) showed that especially the sediments under agricultural areas have much lower pyrite contents. Laboratory batch experiments with these sediment samples showed a much faster denitrification for sediments having higher sulphide content. $\delta^{34}S$ isotope analyses of solid-phase sulphide and water-phase sulphate proved to be a good tool for determining the progress of the autolithotrophic denitrification. With in-situ multi-parameter measurements (Eh, pH, nitrate, temperature and conductivity) in several monitoring wells in combination with water analyses, especially sulphur-isotopic-ratios, we were able to identify high risk areas with a low nitrate-removal-capacity which is mainly caused by the consumption of the pyrite during the denitrification process. Furthermore, we are focusing on process-based investigations of denitrification using $\delta^{15}N$-isotopes and N_2/Ar-measurements.

The identified high risk areas allow intensifying the implementation of programs planed under the WFD in agricultural areas with low nitrate removal capacity.