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In-situ treatment of nitrate polluted groundwater by chemoautotrophic denitrification: flow-through tank experiments with methane as electron donor

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Under anoxic redox conditions dissolved nitrate in groundwater can be converted microbially into N_2. However, the lack of microbial available organic and inorganic electron donors such as Fe(II) or dissolved organic carbon may lead to insufficient denitrification in aquifers and nitrate concentrations above the drinking water limit of 50 mg/L are often observed. In view of the increasing drinking-water scarcity associated with climate change and the continuously high nitrate concentrations in near-surface aquifers, it is urgently necessary and prudent to develop practicable and cost-effective methods to reduce nitrate to N_2.

Faced with the persisting nitrate pollution in groundwater, we want to develop a new cost-effective in-situ remediation technology by hydrogen/methane coupled denitrification. We think that the microbial stimulation with water soluble gases may have several advantages to former artificial injection experiments using methanol and acetate as electron donors.

The first results are intended to fill the knowledge gap on the influence of methane (CH_4) as electron donor on denitrification. We hypothesize that theinjection of the water soluble electron donor CH_4 into groundwater may significantly enhance the rate of nitrate consumption by activation of denitrifying chemolithoautotrophic microorganisms that are already present in groundwater.

Here we show the results of a methane injection experiment into a 2D-flow tank with a length of 6 m. Isotopic and concentration measurements were performed along the flow direction and with a high depth-resolution of approximately up to 5 cm. Concentration profiles and the stable isotope composition of methane ($\delta^{13}C$) and nitrate ($\delta^{15}N$) linked with oxygen concentrations shed light on the methane coupled denitrification potential in the model aquifer. Our injection results demonstrate that methane can be sufficiently injected by the horizontal well into the model aquifer. Methane concentrations of up to 1,06 mmol/L were detected at different depths and up to a flow distance of 3 m from the injection well. Moreover, we found some isotopic evidence that nitrate is reduced to N_2 or N_2O with nitrite as intermediate. Nitrate concentrations decreased from around 0,89 mmol/L to 0,58 mmol/L at the outflow of the tank and decreased within the 2D-flow tank exactly there, where we observed an isotopic shift in methane to heavier (less negative)

values.