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In-situ treatment of nitrate polluted groundwater by chemoautotrophic denitrification: flow-through tank experiments

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INTRODUCTION

Nitrate contamination in shallow groundwater systems is a global problem. Even decades after nitrogen inputs have been reduced, nitrate concentrations often exceed the EU drinking water limit of 50 mg/L (Wild et al. 2018). An accelerated removal of dissolved nitrate from aquifers can only occur through the redox processes denitrication and anammox (anaerobic oxidation of ammonium). However, the presence of dissolved oxygen in groundwater may often limit the microbial degradation of nitrate (Wild et al. 2018) and it was speculated that a lack of microbial available electron donors represents the bottleneck of the self-purification processes. Therefore, this project aims to develop a technical solution for the in-situ reduction of dissolved nitrate in groundwater through the injection of gases such as CH_4 as electron donor.

EXPERIMENTAL SETUP

The flow-through tank (Fig. 1) has dimensions of 6.0 x 2.5 x 1.8 metres and is filled with sandy gravel. For water sampling a total of 52 filters were installed with a high depth-resolution of around 5 cm. After steady state conditions were reached, nitrate was continuously injected into the flow-through tank. The measurements of physico-chemical parameters showed dissolved O_2 concentrations between 9.00 and 0.05 mg/L.

Fig. 1: Illustration of the flow-through tank in the Obernach test centre of the TU Munich.

RESULTS

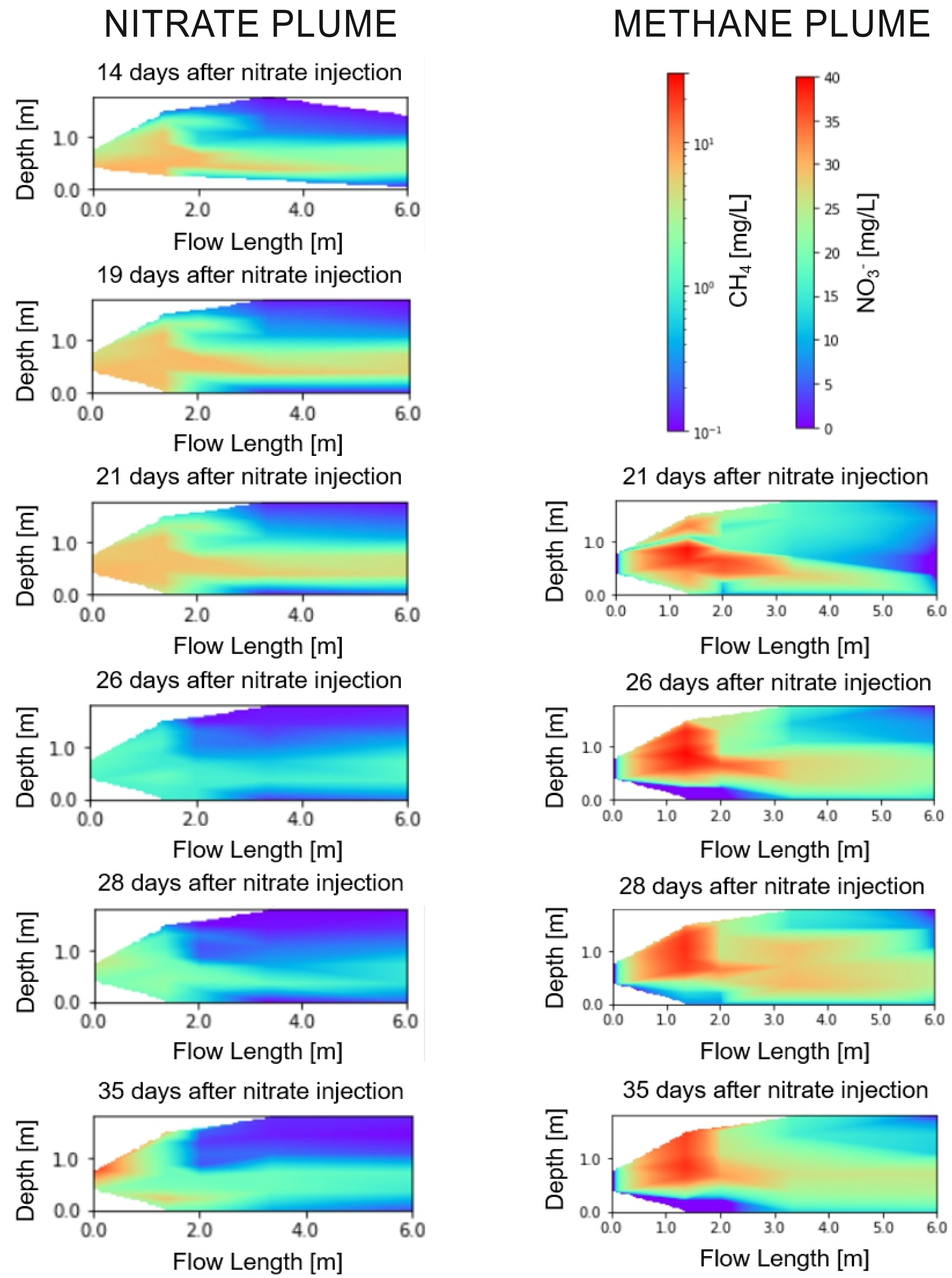

Fig. 2: Horizontal and vertical distributions of nitrate (left) and methane (right) at different sampling times.

REFERENCES

Wild, L.M., B. Mayer, and F. Einsiedl, Decadal delays in groundwater recovery from nitrate contamination caused by low O_2 reduction rates. Water Resources Research, 2018. 54(12): p. 9996-10,012.

STABLE ISOTOPES

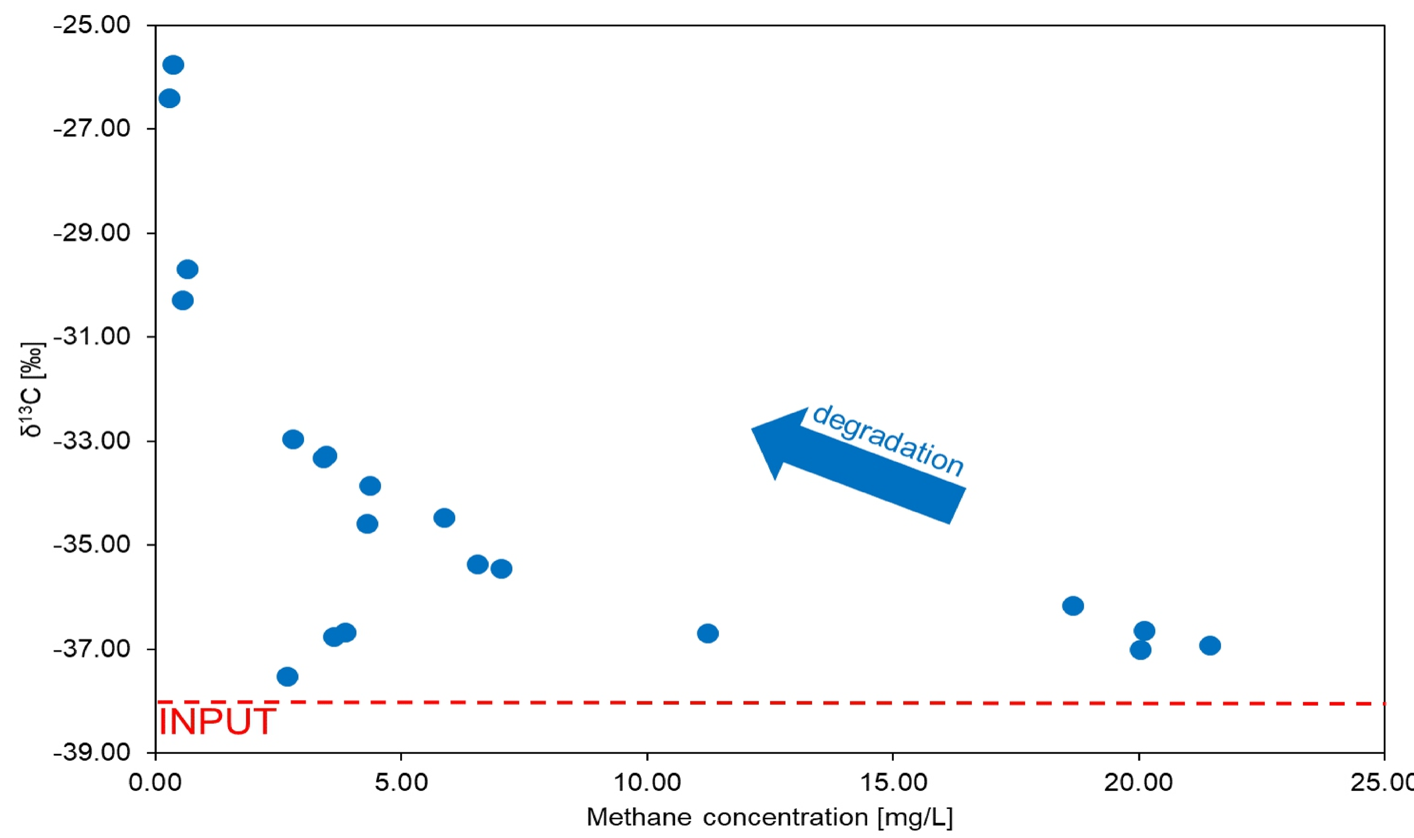

Fig. 3: Methane concentration versus $\delta^{13}C$ of methane.

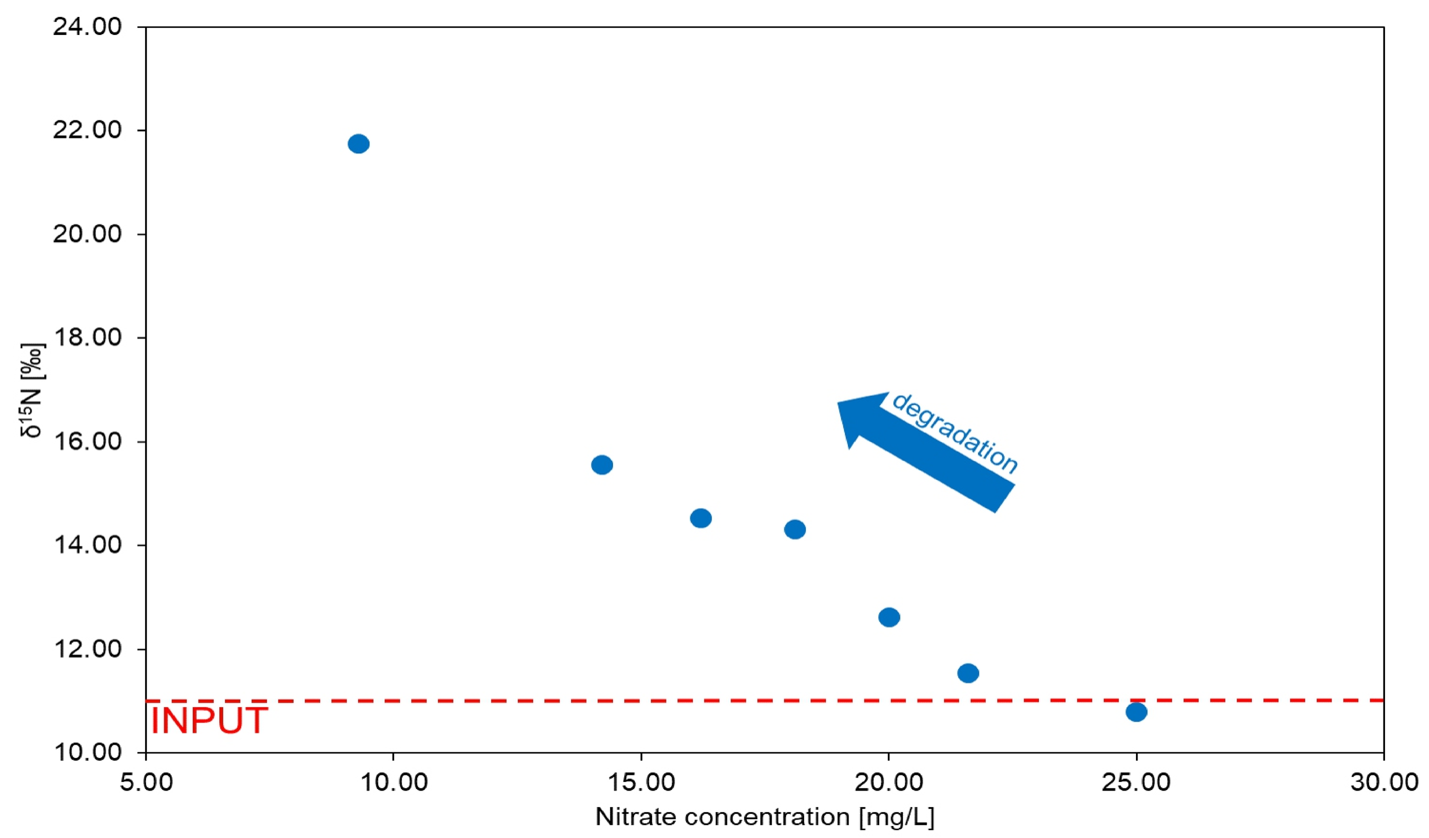

Fig. 4: Nitrate concentration versus $\delta^{15}N$ of nitrate.

SUMMARY

- Nitrate and methane could successfully be injected into the artificial aquifer (Fig 2).
- The spatial distribution of both proxies within the flow-through tank was satisfactory (Fig. 2).
- Evidence of nitrate degradation with methane as electron donor could be demonstrated by stable isotopes (Fig. 3 and 4).
- Additional investigations such as the microbial community distribution and the identification of known key-players for methane oxidation along the flow path could support our interpretation.
- The new methode will also be tested in a field experiment.