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Transformations of Nitrogen from Secondary Treated Wastewater when Infiltrated in Managed Aquifer Recharge Schemes

Matthew Silver (1,2), Annette Wefer-Roehl (1), Christine Kübeck (2), Christoph Schüth (1,2)

(1) Applied Geosciences, Technische Universität Darmstadt, Darmstadt, Germany (silver@geo.tu-darmstadt.de), (2) Water Resources Management, IWW Water Centre, Mülheim an der Ruhr, Germany

The EU FP7 project MARSOL seeks to address water scarcity challenges in arid regions, where managed aquifer recharge (MAR) is an upcoming technology to recharge depleted aquifers using alternative water sources. Within this framework, we conduct column experiments to investigate transformations of nitrogen species when secondary treated wastewater (STWW) is infiltrated through two natural soils being considered for managed aquifer recharge. The soils vary considerably in organic matter content, with total organic matter determined by loss on ignition of 6.8 and 2.9 percent by mass for Soil 1 and Soil 2, respectively. Ammonium (NH_4^+) concentrations as high as 8.6 mg/L have been measured in pore water samples from Soil #1, indicating that ammonium could be a contaminant of concern in MAR applications using STWW, with consideration of the EU limit of 0.5 mg/L for NH_4^+.

The two forms of nitrogen with the highest concentrations in the secondary treated wastewater are nitrate (NO_3^-) and dissolved organic nitrogen (DON). In water samples taken from the soil columns, a mass balance of measured ions shows a deficit of nitrogen in ionic form in the upper to middle depths of the soil, suggesting the presence of unmeasured species. These are likely nitrous oxide or dinitrogen gas, which would signify that denitrification is occurring. Measurements of N_2O from water samples will verify its presence and spatial variation. The ammonium concentrations increase slowly in the upper parts of the soil but then increase more sharply at greater depth, after NO_3^- is depleted, suggesting that DON is the source of the produced NH_4^+.

The production of NH_4^+ is presumed to be facilitated microbiologically. It is hypothesized that at higher organic carbon to total nitrogen (C:N) ratios, more NH_4^+ will be formed. To test this, in the experiments with Soil #2, three different inflow waters are used, listed in order of decreasing C:N ratio: STWW, STWW with NO_3^- added to a concentration of 80 mg/L, and STWW diluted with tapwater and with NO_3^- added to 80 mg/L. Soil pore water samples show that at 30 cm depth, NH_4^+ concentrations are highest with the original STWW, and progressively lower with the NO_3^- enriched STWW and the tapwater-diluted STWW. This shows that the C:N ratio of the inflow water is positively correlated with NH_4^+ concentration in soil water and suggests lower inflow C:N ratios may diminish NH_4^+ production. In addition, outflow rates from the column with unaltered STWW are approximately 15% higher than outflow rates from the column with added NO_3^-, an effect that could be caused by gas (N_2 or N_2O) clogging of the soil.

As MAR is an upcoming technology already being practiced, these results will be used to develop guidance on how to mitigate the impact of pollutants to groundwater (NH_4^+) and the atmosphere (N_2O). Key factors diminishing the production of NH_4^+ appear to be lower organic matter content of the soil and elevated NO_3^- concentrations in the inflow water, although the latter could have adverse effects with respect to emission of N_2O.