Carbon-rich amendments stimulate microbially-mediated nitrate removal in pilot infiltration studies

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Managed aquifer recharge (MAR) systems improve water supply, and potentially water quality, by infiltrating surface water into shallow aquifers. Improving water quality with MAR requires a better understanding of subsurface, microbially-mediated nutrient cycling. We performed field tests to explore how soil microbial communities and nitrate removal rates respond to the presence of a carbon-rich material (woodchips). We infiltrated nitrate-rich water into instrumented plots, some with a horizontal woodchip layer, and others with un-amended native soil. Soil heterogeneities caused temporal and spatial variability in infiltration rates and residence times in saturated soil. Below woodchips, up to 20% of nitrate was removed, with more nitrate removed when residence times were longer. Much less nitrate (<5%) was removed in native soil. Dissolved organic carbon (DOC) remained >20ppm throughout the experiment, indicating that the system was not carbon-limited. DOC concentrations increased below woodchips, but remained constant in native soil. Woodchips may shift nutrient cycling dynamics by extending the thickness of saturated soil, providing additional carbon, and/or applying selective pressures on microbial communities. Analysis of beta diversity from 16s rRNA gene sequencing from samples at 10–40 cm depth demonstrated significant temporal changes in plots amended with woodchips ($p<0.03$). Two genera with large increases in relative abundance below woodchips were *Novosphingobium* and *Rhodovulum*. These groups contain diazotrophic species, suggesting the presence of N_2 as a result of denitrification. Nitrate removal was observed deeper, at 55–80 cm depth. To elucidate relationships between water chemistry and soil microbes in the full soil column (up to 1m depth), quantitative PCR was performed on a suite of denitrification and N-fixation genes including *nirS*, *nirK*, and *nifH*. This pilot-scale experiment is a novel way to examine factors that impact microbially-mediated water quality improvement during infiltration. We find that woodchips significantly impacted soil microbiology and water chemistry, possibly stimulating denitrification. This knowledge facilitates MAR system design to improve water supply and quality.