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The effects of wastewater discharge on the microbiological nitrogen cycle of the lake sediments

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Anthropogenic wastewater inputs alter the natural dynamics of nitrogen (N) cycle by providing high concentrations of nitrate and organic matter to the sediment microbes. It can also change the microbial community composition and N removal potential but this is currently not that well studied. To study these aspects, we conducted ecosystem-scale experiment in Lake Keurusselkä, Finland. In the experiment, the wastewater discharge to the recipient lake was optimized with sediment filtration, which increased the surface and retention time of the nitrified wastewater with the sediment.

In addition to N transformation rates, which showed that optimization enhanced denitrification, we studied the microbial responses at the sediment. Genetic potential of nitrogen transformation processes, such as denitrification, dissimilatory nitrate reduction to ammonium (DNRA) and nitrification were studied by targeting the functional genes (i.e. *nirS*, *nirK*, *nosZ*$_{I}$, *nosZ*$_{II}$, *nrfA*, *amoA*$_{archaea}$ and *amoA*$_{bacteria}$) with quantitative PCR and digital droplet PCR. In addition, changes in the microbial community composition along the wastewater gradient were examined by using next generation sequencing of the 16S rRNA genes.

In line with our hypothesis, the relative abundance of denitrifying genes followed the observed denitrification rates, being highest near the nitrate-rich wastewater discharge. Furthermore the microbial community composition in the discharge point differed clearly from the control and downstream sites, having also the highest numbers of rare OTUs. Abundance of nitrifying bacteria was higher than nitrifying archaea near the waste water discharge, whereas the opposite was seen at the control site. The results indicate that wastewater is not only increasing the denitrification rates, but can also alter the structure and genetic potential microbial communities.