Improving Biological Treatment of Drinking Water

F. B. Wagner

DTU Environment, Technical University of Denmark

INTRODUCTION

In Denmark, drinking water is not disinfected with chemicals such as chlorine, which makes the product water sustainable, environmentally friendly, and safe for the consumer. Thus, as no disinfection is used, unwanted microbial growth in the water distribution system needs to be controlled by keeping nutrient concentrations during distribution low. Ammonium (NH_4^+) is one nutrient of concern, and is typically removed in biologically active sand filters, during water treatment. The removal process is called nitrification, conducted by microorganisms which need nutrients to metabolize the NH_4^+. Hence, if nutrients are already too low during treatment, NH_4^+ removal can be incomplete, subsequently endangering water quality during distribution. The aim of this project was to investigate if addition of selected nutrients to biological sand filter columns could improve biological NH_4^+ removal from drinking water.

METHODS

Sand for the biologically active sand filter columns was collected from a real (full-scale) drinking water filter in Denmark with NH_4^+ removal problems, to test if one or more of the selected added nutrients were limiting nitrification at the water works. Studies were conducted in laboratory- and in pilot-scale; influent water to columns contained NH_4^+. In lab-scale, four columns were used. One column was operated as a control without addition of extra nutrients; the other columns were operated under different configurations of nutrients. Subsequent to the lab-scale study, nutrients which resulted in increased nitrification in lab-scale columns were added to a pilot-scale column, to test the stimulation at larger scale.

RESULTS

In lab-scale columns, the addition of the nutrient phosphorus in form of phosphate (PO_4^{3-}) showed a substantial effect on NH_4^+ removal. In a column with added PO_4^{3-}, removal of NH_4^+ during the experiment was on average 42 % higher than in the control column. PO_4^{3-} addition was therefore also tested in pilot-scale. The pilot column was first operated without addition, and showed incomplete NH_4^+ removal, like the full-scale filter from which sand was taken. As predicted in the lab-scale study, subsequent addition of PO_4^{3-} increased the NH_4^+ removal quickly. After 18 days of PO_4^{3-} addition, NH_4^+ removal in the pilot column was complete, corresponding to an increase in removal rate of 130 %, compared to the initial operation phase without nutrient addition. NH_4^+ removal continued to be complete, even 1 ½ months after stop of PO_4^{3-} addition, when monitoring of the pilot column was stopped. In lab- and pilot-scale studies, all added PO_4^{3-} was entirely retained in the filter columns.

CONCLUSIONS

Addition of the microbial nutrient PO_4^{3-} to biological sand filter columns with sand from a full-scale filter could clearly improve NH_4^+ removal. As results strongly suggested PO_4^{3-} limitation of nitrification at the respective water works, the municipality where the water works is located in, granted permission for addition of PO_4^{3-} to the full-scale filters at the water works (first granted permission ever in Denmark). Generally, the relevance for water utilities is high, as improved biological treatment can ultimately circumvent the use of chemicals for disinfection of the water, ensuring sustainable drinking water production.