Removal of micropollutants by ozonation: positive effects on microbiology and WWTP performance

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2. Sewer and wastewater

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The focus on micropollutants in treated wastewater has increased in recent years. Legislation have been implemented in e.g. Switzerland where larger centralized wastewater treatment plants (WWTPs) are required to remove micropollutants. Various technologies such as activated carbon (PAC), ozonation or moving bed biofilm reactors (MBBRs) can be applied as tertiary treatment. In this project, ozonation was applied directly in the process tank combined with tertiary treatment, so-called multipoint ozonation.

This technology was tested at a minor municipal WWTP (16 000 PE) located in Brædstrup, Southern Denmark. The WWTP has two separated but comparable biological treatment lines, and effects of multipoint ozonation could be directly compared to conventional treatment in the control line.

Dosing 3.98 mgO3/l in the process tank and 7.2 mgO3/l as tertiary treatment showed an average removal of 93% of the analysed micropollutants, and the concentration of all measured micropollutants were below PNEC (predicted no effect concentration). The ecotoxicity of the ozonated treated wastewater was equal or lower compared to conventionally treated wastewater. In addition to the successful removal of micropollutants, the direct ozonation in the process tank improved sludge volume index (SVI) and thereby the settleability of the sludge. DNA-based biological analysis of the activated sludge from both lines confirmed that the microbial communities in both process lines were similar until the start of the ozonation campaign. After the onset of ozonation, the community structure gradually became different in the two lines; however, no loss of any of the known process-critical genera was seen. The nitrifiers were affected by ozonation, but unexpectedly, they increased in relative abundance compared to the control line. Only few filamentous bacteria were present in the WWTP and none known to be associated with filamentous bulking. However, most filaments almost disappeared during the ozonation campaign. Light microscopy analysis confirmed the trends from SVI measurements as compactness and firmness of the sludge flocs improved during ozonation. Furthermore, ozonation caused an improved removal of antibiotic resistant bacteria determined by counting resistant colonies from replica plating methods.

The effluent quality was monitored weekly before ozonation and during ozonation campaigns. There was not observed any change (reduction or improvement) of biological performance in the ozonation line compared to the control line, as effluent concentrations of TN, P and COD were similar and stayed under the threshold limit values. This was supported by analyses of BioP capacity, oxygen uptake rate, and nitrification and denitrification rate, showing no clear and systematic differences between the lines before and after the onset of ozonation.

Multipoint ozonation proved efficient in micropollutant removal in a full-scale setup and the side effects of the direct ozonation in the process tanks were mostly beneficial including better settleability and more compact floc structure.