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Copper dosing stimulates nitrification in full-scale biological drinking water filters

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Biological rapid sand filters are commonly used to remove ammonium through nitrification during drinking water production. Unfortunately, ammonium removal is sometimes incomplete, thereby causing deterioration of drinking water quality. This insufficient treatment performance can be caused by a limited availability of necessary trace metals for the microorganisms in the filters. The metal copper for example is required for the enzyme ammonia monooxygenase (Sayavedra-Soto and Arp, 2011), which catalyzes the first step in the oxidation of ammonium.
Because many water works in Denmark suffer from ammonium breakthrough (Naturstyrelsen, 2014), and copper concentrations in the raw water source are often very low, we have studied the effect of copper dosing on nitrification in full-scale biological sand filters. We hypothesized that poor filter performance can be caused by lack of available copper, and that it could be remediated through dosing of the metal.

Treatment at one of the investigated groundwater treatment plants consists of aeration with subsequent single-step rapid sand filtration. Before dosing of copper, effluent ammonium concentration from the filters was 0.23 mg NH_4/L, thereby exceeding the Danish guideline limit of 0.05 mg NH_4/L (Miljøministeriet, 2015). Copper was dosed in full-scale at concentrations <5 µg Cu/L to the influent of the biological filters, through applying a novel dosing method (patent pending). Ammonium removal was stimulated rapidly (Wagner et al., 2016), and within 3 weeks, effluent ammonium concentrations had decreased to approx. 0.02 mg NH_4/L. As copper dosing concentrations were kept very low, effluent copper concentrations did not exceed 1.5 µg Cu/L (Wagner et al., 2016) and were therefore well below the Danish water works effluent guideline of 100 µg Cu/L (Miljøministeriet, 2015) and the general health based guideline of 2000 µg Cu/L (WHO, 2011). The stimulation of nitrification persisted for several months after the dosing of copper had been stopped (Wagner et al., 2016).
Electrolysis dosing and additionally dosing through passive release from specially engineered solid trace metal structures (patent pending) was tested also at other full-scale groundwater treatment plants with different configurations of treatment units. In total, significant improvements of nitrification were observed at 10 out of 11 investigated plants.

Overall, trace metal dosing to biological filters increased the filters' ammonium removal performance and effectively remediated ammonium breakthrough. Our findings have important practical implications regarding the operation of biological filters, and the potential to greatly affect the water treatment industry.

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