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Optimizing nitrification in biological rapid sand filters: Diagnosing and supplementing micronutrients needed for proper filter performance

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Submitted for oral presentation

Nitrification is an important biological process commonly used in biological drinking water filters to remove ammonium from drinking water. Recent research has shown that a lack of micronutrients could be limiting the performance of these filters. Because nitrification is a biological process, carbon, nitrogen, phosphorus and other micronutrients, such as copper, are required to ensure growth and activity. In nitrification, copper is a micronutrient that is needed in the amoA enzyme used by ammonia-oxidizers to oxidize ammonium to nitrite. Increasing nitrification performance is needed in many filters that are unable to meet ammonium guideline values for drinking water, and can also be used to optimize filter performance by increasing water treatment capacity. Although copper supplementation can increase nitrification in some filters with nitrification problems, it does not always work. Therefore, in order to avoid the time, expense, and regulatory hurdles of supplementing a filter with copper, there is a need to accurately diagnose copper limitations in these filters.

To determine if copper addition could increase nitrification in filters with nitrification problems, a bench scale batch essay was developed and tested. Initial batch experiments showed that proper mixing was needed to avoid concentration gradients, and that caution should be taken when mixing to avoid damaging the filter coating. Initial experiments were used to determine the proper mixing regime, which was then applied to all further batch tests.

A collaboration between DTU Environment, industrial partners, and different water works was established to test the batch essays at two different water works. Both water works had trouble meeting the Danish guideline value for ammonium (0.05 mg NH_4/L). At the start of the batch essays, ammonium removal was determined at 3 different ammonium concentrations, both with and without copper addition (for a total of 6 different batch essays). This was done at both water works to determine the initial removal rates. After initial dosing, the ammonium to each batch set up was increased to 10 mg NH_4/L to allow for a period of incubation. After a week, the batches were re-spiked to the 3 different ammonium concentrations examined initially.

Copper supplementation did not show any observable difference in ammonium removal at the start of the batch essays. After the cultivation period, one of the water works showed increased ammonium removal with copper addition at all examined ammonium concentrations. This was also observed in the corresponding full scale waterworks. The addition of copper yielded no observed difference in ammonium removal at the second water works, which was also observed in the corresponding full scale filter. These findings are important as they show that the batch essays can be used as a diagnostic tool to determine if copper supplementation can increase nitrification performance.

The developed batch essays have important practical implications in optimizing nitrification performance. They can not only be used to diagnose and improve nitrification in existing filters, but can also be used to determine if the nitrification capacity of a filter can be increased, which could optimize filter operation. The batch essays have the potential to be an important diagnostic tool that could decrease regulatory hurdles, and save time and money.

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