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ABSTRACTS

The impact of backwashing on nitrification in biological rapid sand filters under different ammonium loading conditions

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Abstract

Biological rapid sand filters can be a simple yet robust treatment process in removing both particles and dissolved contaminants in the production of drinking water. Biological removal of contaminants is performed by a complex community of microorganisms that colonize and grow on the filter media (Gülay et al., 2014; Tatari, 2014). One compound of concern in these filters is ammonium, which is removed biologically through the nitrification process. Nitrification is generally thought to be a two-step process involving ammonia-oxidizing bacteria (AOB), which oxidize ammonium to nitrite, and nitrite-oxidizing bacteria (NOB), which further oxidize nitrite to nitrate. There are many parameters that can affect nitrification performance (Lee et al., 2014), including operating parameters such as backwashing. Backwashing is a major operating parameter that is needed to ensure proper operation of these filters. Backwashing is used to remove biomass and particles that accumulate on the filter material over a filter run. It is often thought that backwashing can decrease the biological performance of a filter due to the excessive removal of biomass. The goal of this research is to determine the impact that backwashing has on both the nitrification process, and the nitrifying organisms established on the filter material under various ammonium loading and backwashing conditions.

Backwashing experiments were conducted on two pilot scale biological rapid sand filters at Islevbro waterworks, in west Copenhagen. The pilot columns were operated in parallel and filled with filter media from one of the full scale filters. The pilot columns were initially operated for several months to establish steady state conditions and to validate the performance of the pilot filters with the full scale filters. After this a series of short term (6-8 hours) ammonium load shift experiments were performed by increasing the ammonium concentration and/or flowrates of the pilot columns. The load shifts were designed not to alter the overall performance, or biological make-up of the pilot columns, and used to examine the ammonium removal rate before and after backwashing, and over the filtration run. These experiments showed that backwashing had little to no effect on either ammonium removal or ammonia-oxidizing bacteria, which showed only a 9% decrease after backwashing. Over a 23 day filter run, there was no change in ammonium removal, and ammonia-oxidizing bacteria only increased by approximately 14%. This strongly indicates that the ammonia-oxidizing bacteria are robust and well established and that the system is operating at steady state.

To access the effect of backwashing under long term increased ammonium loading conditions, the ammonium concentration to one of the pilot columns was increased from 0.1 to approximately 1 mg NH4-N/L for 50 days. The column was backwashed normally on days 23 and 45 and 'intensely' backwashed on day 50. Ammonium removal and biomass increased from day 0 to 23, but much of the increase in removal and biomass was lost after backwashing. The increased removal was transient and the newly developed biomass fragile and not yet well established. After another 22 days, the second backwash, on day 45, showed little effect on ammonium removal, and even the 'intense' backwash on day 50 did little to change the ammonium removal in the pilot column. The long term increased loading results showed that early on the newly formed biomass was not well established and easily removed by backwashing. Subsequent backwashes had little effect on ammonium removal though, indicating the biomass can quickly become established in these filters. These results show the robustness of well-functioning biological filters in removing ammonium from drinking water under different loading conditions.

Gülay, A., Tatari, K., Musovic, S., Mateiu, R. V, Albrechtsen, H.-J., Smets, B.F., 2014. Internal porosity of mineral coating supports microbial activity in rapid sand filters for groundwater treatment. Appl. Environ. Microbiol. 80, 7010–20.

Lee, C.O., Boe-Hansen, R., Musovic, S., Smets, B., Albrechtsen, H.-J., Binning, P., 2014. Effects of dynamic operating conditions on nitrification in biological rapid sand filters for drinking water treatment. Water Res. 64C, 226–236.

Tatari, K., 2014. Nitrification biokinetics in rapid sand filters for drinking water treatment.

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