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Relating dynamic conditions to the performance of biological rapid sand filters used to remove ammonium, iron, and manganese from drinking water

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Abstract:

Biological rapid sand filters are used throughout the world to remove both particulates and dissolved compounds from drinking water and is a proven and effective treatment technique for providing safe and secure drinking water. However, experience has shown that some filters have problems consistently meeting regulatory guidelines for compounds like ammonium and reduced forms of iron and manganese. These compounds can cause biological instability in the distribution system and can lead to many problems including the growth of pathogens and aesthetic problems (taste, odor, and color).When problems occur in these filters, current solutions are often based on rules of thumb and guess work rather than on firm scientific principle. The goal of this research is to characterize the underlying processes that control the biological performance of biological rapid sand filters in order to link filter management to performance.

This research uses both pilot and full scale studies conducted at Islevbro water works, a drinking water plant in west Copenhagen, to determine how operating conditions and substrate loading affect the performance of the biological rapid sand filters. The pilot columns consist of two columns that are run in parallel and fed with influent water from the water works. The sand in the pilot columns was taken from one of the full scale filters and matches the depth profile of the full scale filter. The pilot columns were initially operated for approximately 2 and a half months at similar operating conditions as the full scale filter to validate the performance of the pilot columns. After this, the pilot columns were fed with varying loading rates of iron, ammonium, and manganese. To fully examine the changes in filter performance several parameters were analyzed. Water and media samples were collected throughout the depth of the column and over the operational cycle of the columns. Substrate analysis included ammonium, nitrite, nitrate, iron, and manganese. Qpcr analysis were also performed to quantify ammonium oxidizing bacteria (AOBs), ammonium oxidizing archea (AOAs), nitrite oxidizing bacteria (NOBs), and total bacteria with both depth and time. Similar analyses were performed in the full scale filters. The data is used to validate a mathematical model that can both predict process performance and is used to gain an understanding of how dynamic conditions can influence filter performance. The results presented will show how these varying conditions affect both the biological distribution and performance of these filters and will increase the understanding of biological rapid sand filters used to treat drinking water. This research helps to extend the knowledge on the roles of both Ammonium oxidizing bacteria (AOBs) and Ammonium oxidizing archea (AOAs) in the biological removal of ammonium in rapid sand filters and how varying substrate loadings and operating conditions can affect the biological performance of these filters.