Biostimulation strategies to enhance manganese removal in drinking water biofilters
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**ABSTRACT**

Maturation of drinking water biofilters for removal of manganese can vary considerably. The aim of this study was to investigate biostimulation strategies to enhance manganese removal during start-up of biofilters for treatment of groundwater. Two major biostimulation strategies were investigated: biostimulation using different filter media (e.g. quartz, calcium carbonate, polystyrene, manganese oxide), and biostimulation using inoculation of virgin quartz filters with matured quartz. The onset and extent of manganese oxidation was determined spectrophotometrically, and the bacterial communities were characterized using qPCR, 16S rRNA pyrosequencing, and enrichments of manganese oxidizing bacterial consortia. The investigation suggested that when inoculating different filter media with an identical water source, the bacterial community formed during the start-up period is strongly influenced by the filter media type. Biostimulation of virgin media to enhance initial manganese removal should take place in the early stages of filter development whereas autocatalytic processes appear to become dominant with time. The complex interactions between biological and chemical oxidation processes should be considered when optimizing biofilters for efficient removal of manganese from drinking water.

**FOCUS**

EFFECT OF START-UP STRATEGIES ON MANGANESE REMOVAL, AND ON THE BACTERIAL COMMUNITIES FORMED IN THE EARLY STAGES OF THE BIOFILTER.

**DRINKING WATER TREATMENT IN DENMARK**

GROUNDWATER
– main water source for drinking water production
NO ADDITION OF CHEMICALS
– strong legislation controlling the addition of chemicals
NO DESINFECTION
– no chlorine added to the drinking water

**BIOFILTERS START-UP PERIOD**

A major disadvantage of biofilters is the long start-up period required for virgin filter medium to become fully functional.

Start-up of drinking water biofilters hinges on a set of interconnected physical, chemical and biological processes. When manganese is present, the duration of a start-up varies from weeks to more than a year.

**MANGANESE REMOVAL PHYSICAL, CHEMICAL AND BIOLOGICAL**

Start-up period
Matured biofilter

Mn(II)
diluted in water

First layer of Mn(IV)
Change in kinetics, new sorption sites, autocatalytically oxidation
Sorption and autocatalytically oxidation become the main processes for removal of Mn(II)

Mn(IV)
coating filter medium

PHYSICAL

CHEMICAL

BIOLOGICAL
RESULTS

Alternative filter materials
Column assay with 5 filter materials in triplicates

Matured quartz Virgin quartz Calcium carbonate Manganese oxide Polystyrene

![Figure 1](image1.png) | Manganese concentration in the column outlets over time as a percentage of manganese concentration in the source water. Each datum point represents the average of three filter columns.

![Figure 2](image2.png) | Heatmap of the 25 most abundant genera present in filter media coatings at Day 75 (average of three filter columns). Shadings are based on read abundance (%) and dots mark indicate genera with known manganese oxidizing bacteria (MnOBs).

Inoculation of new filters with matured quartz
Pilot scale filters with virgin quartz (non-inoculated filter) and with virgin and matured quartz (inoculated filter)

![Figure 4](image4.png) | Experimental setup pilot scale.

CONCLUSIONS

- The bacterial community formed during the start-up period is strongly influenced by the filter media type.
- Management of bacterial communities may be possible by selecting specific media to enhance growth and activity of specific bacteria.
- The interactions between biological and chemical oxidation processes should be considered when optimizing biofilters for efficient removal of manganese from drinking water.