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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.

MANGANESE REMOVAL PHYSICAL, CHEMICAL AND BIOLOGICAL

Start-up period  
Mn(II) diluted in water

Matured biofilter  
Mn(IV) coating filter medium

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)

PHYSICAL  
CHEMICAL  
BIOLOGICAL
RESULTS

Alternative filter materials
Column assay with 5 filter materials in triplicates

![Image of filter materials]

Figure 1 | 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 | 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)

![Experimental setup pilot scale]

Figure 4 | Experimental setup pilot scale.

Figure 5 | Manganese removal over time (top) and filters depth (bottom) by non-inoculated (green) and inoculated (red) pilot-scale biofilter.

Figure 6 | ATP abundance in the top 10cm of initially virgin quartz from the inoculated and non-inoculated filters during the filters maturation.

Figure 7 | Detection of MnOBs by lecoubelin blue in Leptotrix medium plate cultures using aliquots of fresh filter media samples from several depths of both inoculated and non-inoculated filter collected at the end of the start-up.

Figure 8 | Rate coefficient of manganese removal according to batch experiments using duplicates of fresh filter media with and without azide from depths 10 cm and 20 cm of both inoculated and non-inoculated filters.

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.