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BIOSTIMULATION STRATEGIES TO ENHANCE MANGANESE REMOVAL IN DRINKING WATER BIOFILTERS

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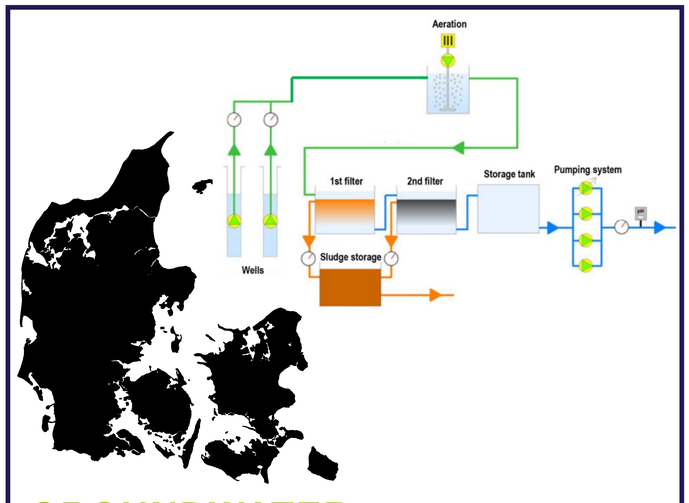
EFFECT OF START-UP STRATEGIES ON MANGANESE REMOVAL, AND ON THE BACTERIAL COMMUNITIES FORMED IN THE EARLY STAGES OF THE BIOFILTER.

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.

DRINKING WATER TREATMENT IN DENMARK



GROUNDWATER
– main water source for drinking water production

NO ADDITION OF CHEMICALS
– strong legislation controlling the addition of chemicals

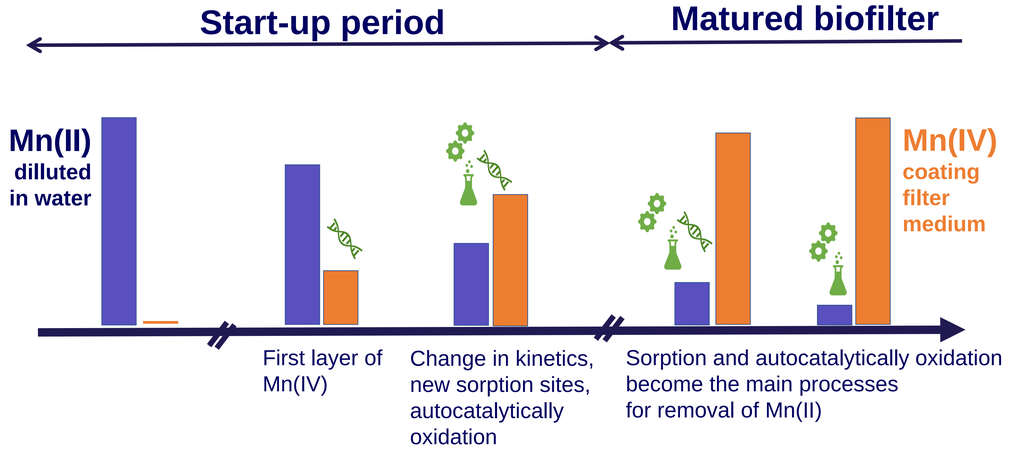
NO DESINFECTION
– no chlorine added to the drinking water

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



PHYSICAL

CHEMICAL

BIOLOGICAL

VIA University College

Innovation Fund Denmark
RESEARCH, TECHNOLOGY & GROWTH

EUROWATER
PURE WATER TREATMENT

International Symposium
Biological Treatment
January 24–25, 2018 | Austin, Texas

RESULTS

Alternative filter materials

Column assay with 5 filter materials in triplicates

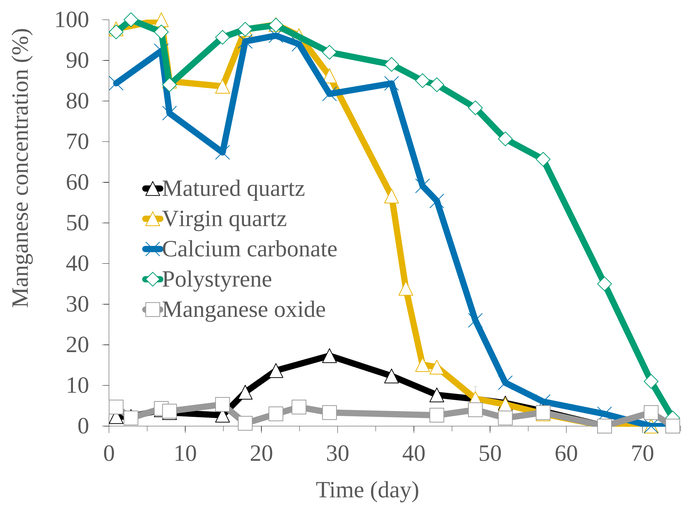


Figure 1 | Manganese concentration in the column outlets over time as a percentage of manganese concentration in the source water. Each datum point represents the average of three filter columns.

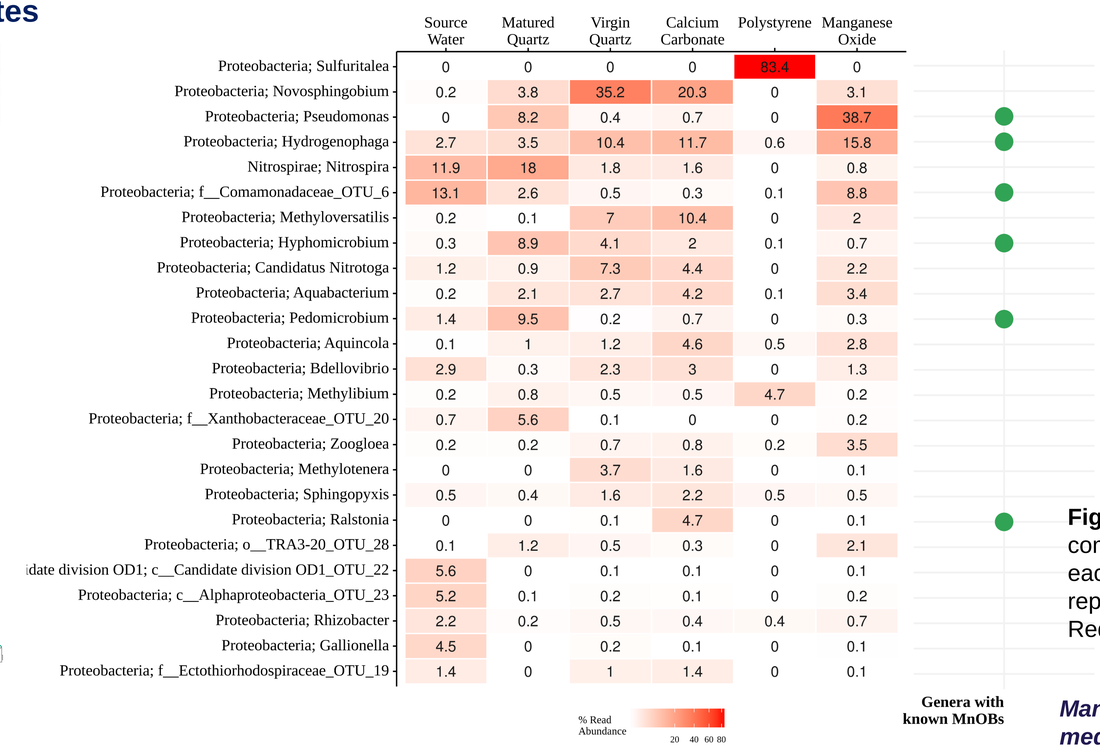


Figure 2 | Heatmap of the 25 most abundant genera present in filter media coatings at Day 75 (average of three filter columns). Shadings are based on read abundance (%) and dots mark indicate genera with known manganese oxidizing bacteria (MnOBs).

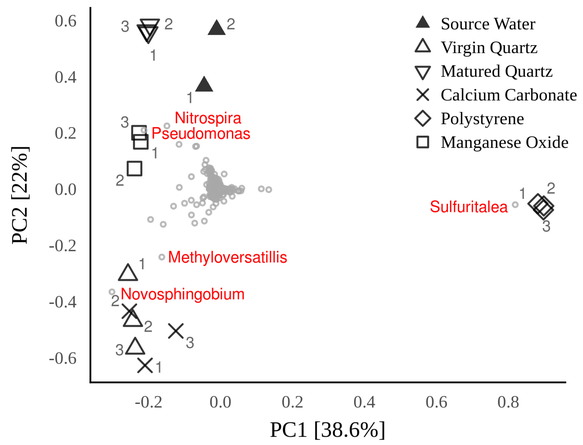
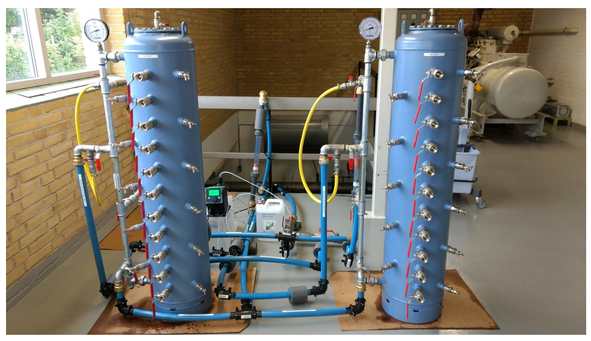


Figure 3 I Principal component analysis of bacterial communities present in the source water and on the coating of each filter medium type. Numbers 1 to 3 represent medium replicates. Grey dots illustrate the taxa detected in all samples. Red labels identify selected key taxa.

Manganese oxidation and bacterial diversity on different filter media coatings during the start-up of drinking water biofilters.
Breda I. L., Ramsay L., Roslev P.
Journal of Water Supply: Research and Technology –AQUA, 2017.
DOI:10.2166/aqua.2017.084

Inoculation of new filters with matured quartz

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



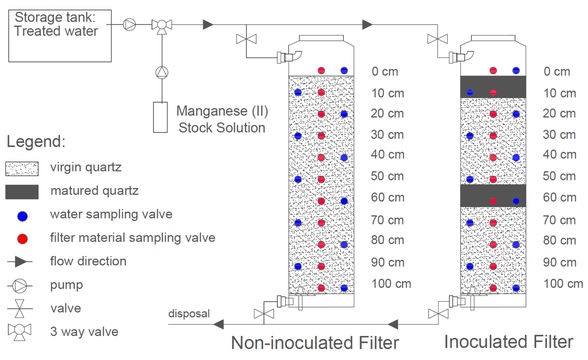


Figure 4 | Experimental setup pilot scale.

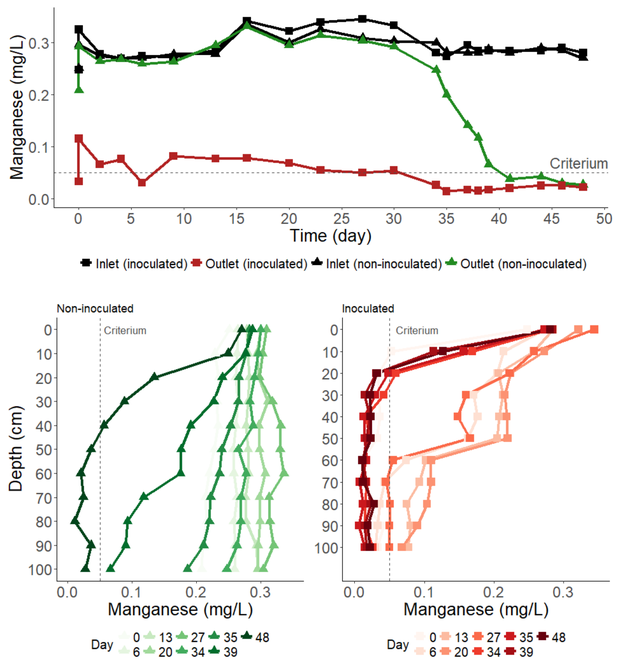


Figure 5 | Manganese removal over time (top) and filters depth (bottom) by non-inoculated (green) and inoculated (red) pilot-scale biofilters.

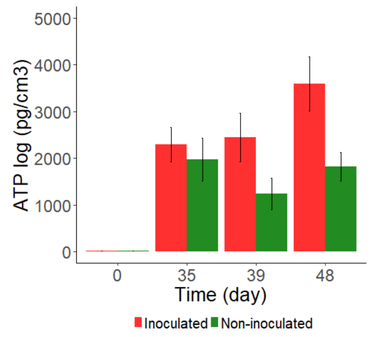


Figure 6 | ATP abundance in the top 10cm of initially virgin quartz from the inoculated and non-inoculated filters during the filters maturation.

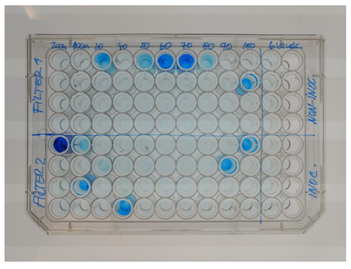


Figure 7 | Detection of MnOBs by lecouberlin blue in Leptotrix medium plate cultures using aliquots of fresh filter media samples from several depths of both inoculated and non-inoculated filter collected at the end of the start-up

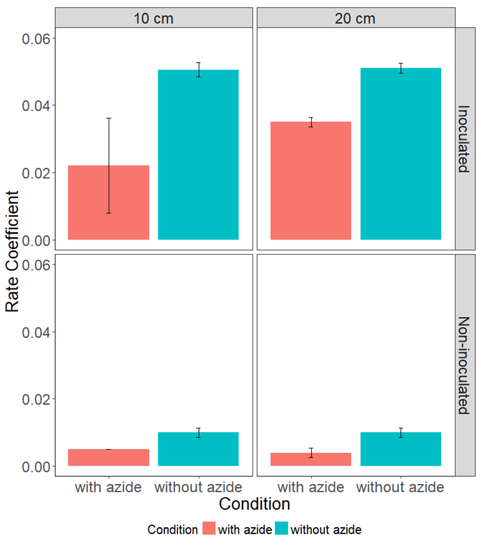


Figure 8 | Rate coefficient of manganese removal according to batch experiments using duplicates of fresh filter media with and without azide from depths 10 cm and 20 cm of both inoculated and non-inoculated filters.

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.**