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L. Breda, Inês; Ramsay, Loren Mark; Søborg, Ditte Andreasen; Roslev, Peter

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

[Link to publication](#)

Citation for published version (APA):
L. Breda, I., Ramsay, L. M., Søborg, D. A., & Roslev, P. (2018). *Manganese oxidation and microbial diversity of non-inoculated and inoculated drinking water biofilters during start-up*. Poster session presented at NORDIWA Nordic Drinking Water Conference 2018, Oslo, Norway.

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MANGANESE OXIDATION AND MICROBIAL DIVERSITY OF NON-INOCULATED AND INOCULATED DRINKING WATER BIOFILTERS DURING START-UP

Inês L. Breda ^{a,b}, Loren Ramsay ^c, Ditte Søborg ^c, Peter Roslev ^b

^a Department of Chemistry and Bioscience, Aalborg University, Denmark
^b Group of Project and Development, Skanderborg Forsyningsvirksomhed A/S, Denmark
^c Research Group for Energy and Environment, VIA University College, Denmark

BACKGROUND AND OBJECTIVES

Manganese removal in drinking water biofilters is facilitated by biological and physico-chemical processes, but knowledge regarding the relative role of these mechanisms during start-up is very limited. The aim of this study was to identify the dominant process for manganese removal occurring during the start-up period of sand filters with and without inoculation by addition of matured sand collected from an operating groundwater-based waterworks. Inoculation with matured filter sand is frequently used to accelerate the start-up in virgin biofilters and to rapidly obtain compliant water quality.

DRINKING WATER TREATMENT

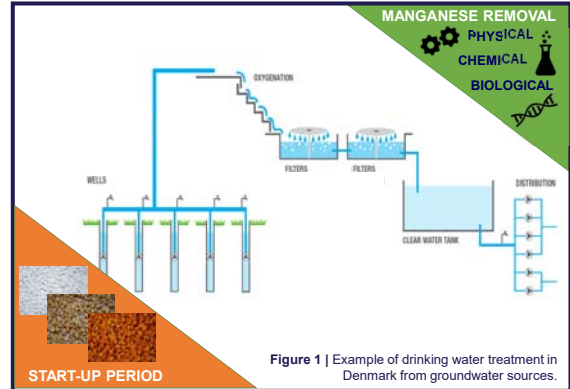


Figure 1 | Example of drinking water treatment in Denmark from groundwater sources.

MATERIALS

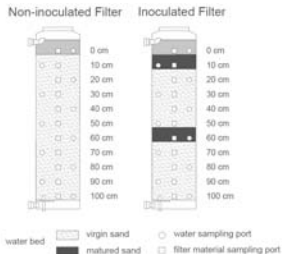


Figure 2 | Pilot setup

Table 1 | Source water quality.

Parameter	Unit	Average	Std. dev.
Manganese	mg/L	0.281	0.018
Iron	mg/L	0.019	0.01
Ammonium	mg/L	<0.02	-
Nitrite	mg/L	<0.001	-
Hydrogen carbonate	mg/L	276	0.5
pH	-	7.95	0.05
Oxygen	mg/L	10.8	0.05
Temperature	°C	10.7	0.2
NVOC	mg/L	1.0	0.1

Table 2 | Filter medium properties.

Parameter	Matured sand	Virgin sand
Grain size (mm, 10-90%)	1.03-1.86	1.10-1.76
Sphericity	0.90	0.87
Particle density (kg/L)	2.50	2.60
Porosity (%)	42.60	40.63

METHODS

- Manganese measurements in water samples (Figure 3 and Figure 5)
- Batch assay with and without NaNO_2 for determining manganese removal rates (Figure 4 A and B)
- Column assay with and without NaNO_2 for determining manganese removal rates (Figure 4D)
- DNA extraction and 16S rDNA amplicon sequencing and library preparation (Figure 6)
- Bioinformatics and statistical analysis (Figure 4 and Figure 6)

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- Breda, I.L., Ramsay, L., Roslev, P. (2017). Manganese oxidation and bacterial diversity on different filter media coatings during the start-up of drinking water biofilters. *Journal of Water Supply: Research and Technology - AQUA*, 66 (8), https://doi.org/10.2166/aqua.2017.084
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RESULTS

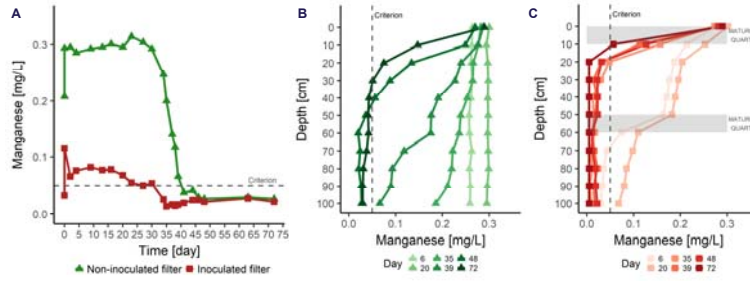


Figure 3 | A. Manganese concentration over time in pilot biofilters with and without inoculation. B. Manganese concentration profile of the non-inoculated filter over time. C. Manganese concentration profile of the inoculated filter over time.

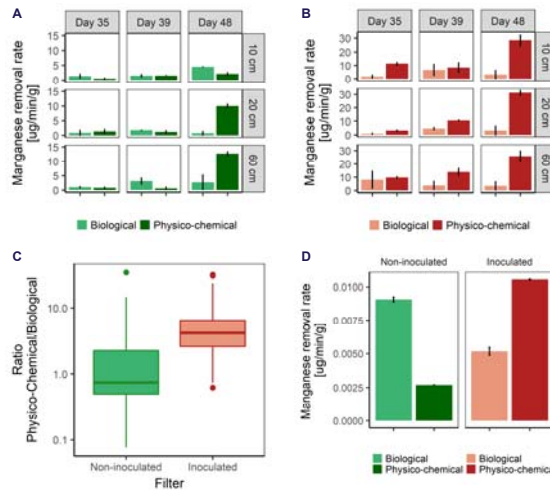


Figure 4 | Manganese removal rates in batch assay associated with biological and physico-chemical processes in filter medium samples collected from depth 10, 20 and 60 cm on Day 35, 39 and 48 from (A) the non-inoculated filter and (B) the inoculated filter. C. Boxplot of the ratio between physico-chemical and biological processes occurring at Day 35, 39 and 48 of both filters. D. Manganese removal rates in column assay associated with biological and physico-chemical processes in filter medium samples collected from 0-10 cm layer of both pilot filters at Day 72. Error lines indicate standard deviation between replicates in all plots.

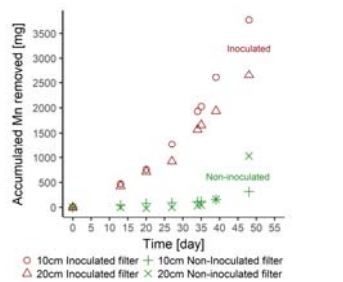


Figure 5 | Accumulated manganese removed of non-inoculated and inoculated filter at Depth 10 and 20 cm over time.

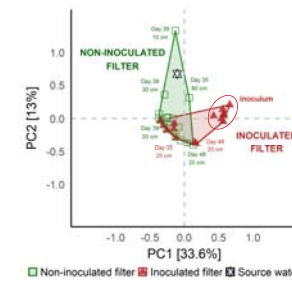


Figure 6 | Principal component analysis of bacterial communities determined from 16S rDNA amplicon sequencing of source water and medium samples collected from both filters over time.

CONCLUSIONS

The non-inoculated filter took 35 days to initiate significant manganese removal and 41 days to comply with manganese water quality criteria. The inoculated filter showed significant initial removal from Day 0 and compliance from Day 25.

From the onset of manganese removal to compliance, both physico-chemical and biological processes were contributing to the manganese removal in the non-inoculated filter.

The non-inoculated filter was dominated by biological processes, whereas physico-chemical processes were of more importance in the filter inoculated with matured sand.

Inoculation appeared to mainly enhance the physico-chemical manganese removal potential during start-up.

One week after compliance, biological mechanisms remained important for manganese removal at the top 10 cm of the non-inoculated filter, whereas physico-chemical processes were of more importance at deeper filter layers.

Bacterial diversity of the non-inoculated virgin filter changed over time and was initially distinct from the diversity of the source water. Bacterial diversity of the virgin sand in the inoculated filter remained different from the matured sand after 48 days.

The use of proactive inoculation by addition of matured filter sand contributes to a shorter start-up period of biofilters without affecting the microbial community developed in the adjacent layers of the filter.