

Abstract

Drinking water companies more and more implement Advanced Oxidation Processes (AOP) in their treatment schemes to increase the barrier against organic micropollutants (OMPs). It is necessary to decompose the excessive hydrogen peroxide after applying AOP to avoid negative effects in the following, often biological, treatment steps. A drinking water company in the western part of the Netherlands investigated decomposition of about 5.75 mg L^{-1} hydrogen peroxide in pre-treated Meuse river water with different catalysts on pilot scale.

In down flow operation, the necessary reactor Empty Bed Contact Time (EBCT) with the commonly used Granulated Activated Carbon (GAC) and waste ground water filter gravel (MCFgw) were the same with 149 s, corresponding with a conversion rate constant r of 0.021 s^{-1} . The EBCT of the fine coating of ground water filter gravel (MC) was significantly shorter with a little more than 10 s ($r = 0.30 \text{ s}^{-1}$).

In up flow operation, with a flow rate of 20 m h^{-1} , the EBCT of coating MC increased till about 100 s ($r = 0.031 \text{ s}^{-1}$), from which can be concluded, that the performance of this waste material is better compared with GAC, in both up and down flow operation.

The necessary EBCT at average filtration rate of full scale dual layer filter material (MCFsw) amounted to 209 s ($r = 0.015 \text{ s}^{-1}$). Regarding the average residence time in the full scale filters of 700 s, applying AOP in front of the filters could be an interesting alternative which makes a separate decomposition installation superfluous, on the condition that the primary functions of the filters are not affected.

1 Introduction

All over the world surface water is to some extent contaminated with organic micropollutants (OMPs). It is expected that the amount and concentrations of OMPs will increase, due to population growth, aging and global warming. A drinking water company in the western part of the Netherlands identified the threat of OMPs in their source the

DWESD

8, 1–20, 2015

Natural manganese deposits as catalyst for decomposing hydrogen peroxide

A. H. Knol et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



The two reactors R60 were fed with pre-treated Meuse river water, abstracted before the full-scale double layer sand filters. The reactors R20 and R40 were fed with the effluent of these full-scale double layer sand filters. The flow through the reactors could be varied between 1.0 and 3.0 m³ h⁻¹, which corresponds with flow rates between 4 and 100 m h⁻¹. The standard operation was down flow, but up flow operation also was applied with flow rates up till 40 m h⁻¹. Before the water flowed in the reactors, 10 % hydrogen peroxide was dosed into the water with a membrane pump with a maximum capacity of 3.0 L h⁻¹. The applied concentrations were about 5 and 10 mg L⁻¹ in the influent water.

2.2 Decomposing material

Three different catalysts were used: GAC and two types of manganese coated filter material.

The GAC type was extruded activated carbon with a diameter of 0.8 mm, especially suitable for catalytic processes. The manganese coated filter material were obtained from two different drinking water treatment facilities. The first material was manganese coated filter material from a groundwater treatment plant (MCFgw), replaced at the end of the filter life time. The second manganese coated filter material was obtained from a surface water treatment plant (MCFsw). The MCFsw was collected from the double layer sand filters.

During the first backwashing of MCFgw, a part of the coating was separated from the grains. This coating (MC) was also used as catalyst. With XRD analysis, besides calcium and iron compounds, the manganese containing compounds ramsdellite and birnessite were detected in MC (Hendrix, 2014). Specifications of the manganese containing materials are shown in Table 1.

Natural manganese deposits as catalyst for decomposing hydrogen peroxide

A. H. Knol et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



2.3 Analyses

The hydrogen peroxide concentration in water was analysed on site with a spectrophotometer. The measurement is based on the reaction of hydrogen peroxide with titanium(IV)oxysulphate solution, following DIN 38409 H15. Samples were collected and measured in a volumetric flask, after adding 5.0 ML of the titanium(IV)oxysulphate solution by a pipette. When higher concentrations were expected than 6 mgL^{-1} , the samples were diluted with milli-q water. The samples were measured at a wavelength of 420 nm and corrected for background absorbance, which were determined by analysing the samples without the addition of titanium(IV)oxysulphate solution. At a hydrogen peroxide concentration of 5.8 mgL^{-1} the standard deviation σ was 0.02 mgL^{-1} .

3 Results and discussion

3.1 Activated carbon

With GAC, 5 mgL^{-1} hydrogen peroxide was decomposed completely in just more than 120 s empty bed contact time (EBCT), see Fig. 1. In the same EBCT, 10 mgL^{-1} hydrogen peroxide was decomposed for about 90 %. This experiment confirmed that activated carbon is well-functioning catalyst for decomposing hydrogen peroxide, even at the low water temperature of 1.8°C .

3.2 Manganese coated filter material

The decomposition of 5 mgL^{-1} hydrogen peroxide with anthracite and gravel MCFsw is plotted in Fig. 2.

In about 250 till 350 s the hydrogen peroxide in both reactors was decomposed completely. The EBCT of the 0.25 m anthracite layer was about 200 s, which means that the anthracite had a major contribution to the decomposition. The total EBCT of 700 s of the 0.85 m bed layer was the same as the average EBCT in the full scale filters, which

Natural manganese deposits as catalyst for decomposing hydrogen peroxide

A. H. Knol et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



References

- Abrahamse, A. J., Ijpelaar, G. F., and Knol, A. H.: Project Uitbreiding Zuivering DZH, optionele technieken en locatie keuze, KWR, Dunea, 2007.
- 5 Bazri, M. M.: Assimilable Organic Carbon Formation during Ultraviolet-Hydrogen Peroxide Advanced Oxidation Treatment of Surface Water, University of British Columbia, Vancouver, 2010.
- Coulson, J. M. and Richardson, J. F.: Chemical Engineering, Part 1, Oxford, Butterworth-Heinemann Ltd, 1996.
- 10 Hendrix, R. W. A.: XRD Analysis of Sand Grains, Materials Science and Engineering, TU Delft, Delft, 2014.
- Houtman, C. J.: Emerging contaminants in surface waters and their relevance for the production of drinking water in Europe, *J. Integr. Environ. Sci.*, 7, 271–295, 2010.
- Kruithof, J. C., Kamp, P. C., and Martijn, B. J.: UV/H₂O₂ Treatment: a practical solution for organic contaminant control and primary disinfection, *Ozone-Sci. Eng.*, 29, 273–280, 2007.
- 15 Lekkerkerker-Teunissen, K., Knol, A. H., Altena, L. P., Houtman, C. J., Verberk, J. Q. J. C., and van Dijk, J. C.: Serial ozone/peroxide/low pressure UV treatment for synergistic and effective organic micropollutant conversion, *Sep. Purif. Technol.*, 100, 22–29, doi:10.1016/j.seppur.2012.08.030, 2012.
- Masel, R. I.: Chemical Kinetics and Catalysis, Wiley-Interscience, New York, 2001.
- 20 Petrucci, R. H., Harwood, W. S., Herring, G. E., and Madura, J.: General Chemistry: Principles & Modern Applications, 9, Harlow, Prentice Hall, 2007.
- Reeze, A. J. G., Matthijs, J. C. P., and Pancras, T.: Waterstof peroxide (H₂O₂) in infiltratieplassen, Eco(toxico)logische effecten en afbraaksnelheid, Arcadis Nederland BV, Apeldoorn, 24 pp., 2010.

Natural manganese deposits as catalyst for decomposing hydrogen peroxide

A. H. Knol et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Natural manganese deposits as catalyst for decomposing hydrogen peroxide

A. H. Knol et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Table 2. EBCT of catalysts to decompose a peroxide concentration of $C_0 = 5.75 \text{ mgL}^{-1}$ till $C = 0.25 \text{ mgL}^{-1}$.

Catalyst	$r \text{ (s}^{-1}\text{)}$	EBCT (s)
MCFsw	0.015	209
GAC	0.021	149
MCFgw	0.021	149
MC	0.30	10.4

Natural manganese deposits as catalyst for decomposing hydrogen peroxide

A. H. Knol et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

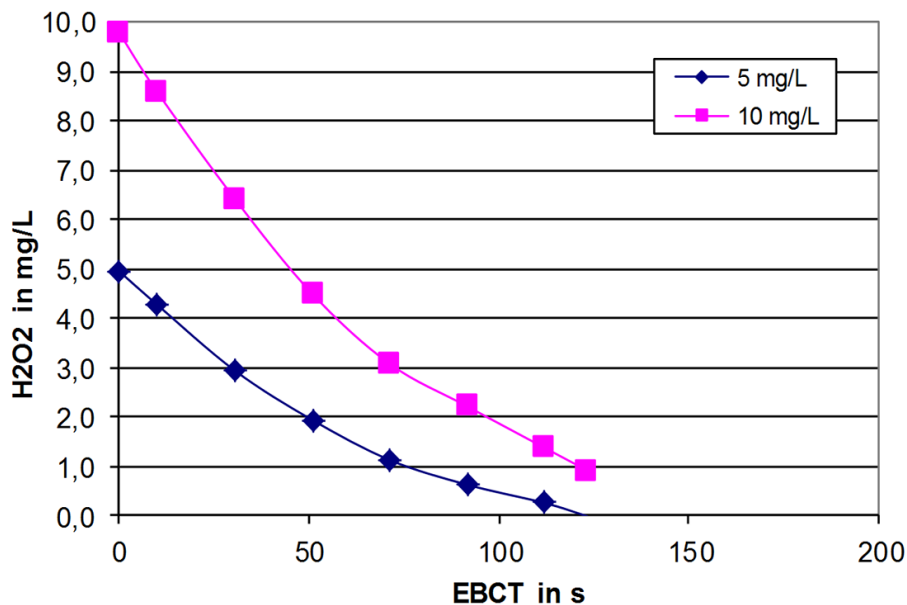


Figure 1. Decomposition of hydrogen peroxide with ROW 0.8 cat in R20 (bed height 1.4 m, flow rate 40 m h^{-1} , water temperature 1.8°C).

Natural manganese deposits as catalyst for decomposing hydrogen peroxide

A. H. Knol et al.

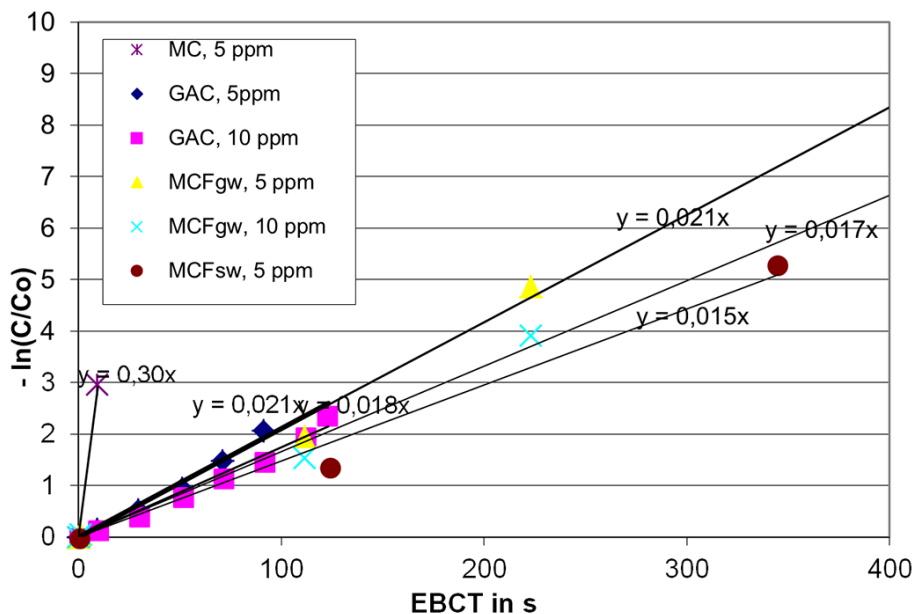


Figure 5. Conversion rate constants of the different tested catalysts.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



