COMBINED MEMBRANE FILTRATION AND BIODEGRADATION – A NOVEL HYBRID CONCEPT OF BAM REMOVAL IN DRINKING WATER PRODUCTION

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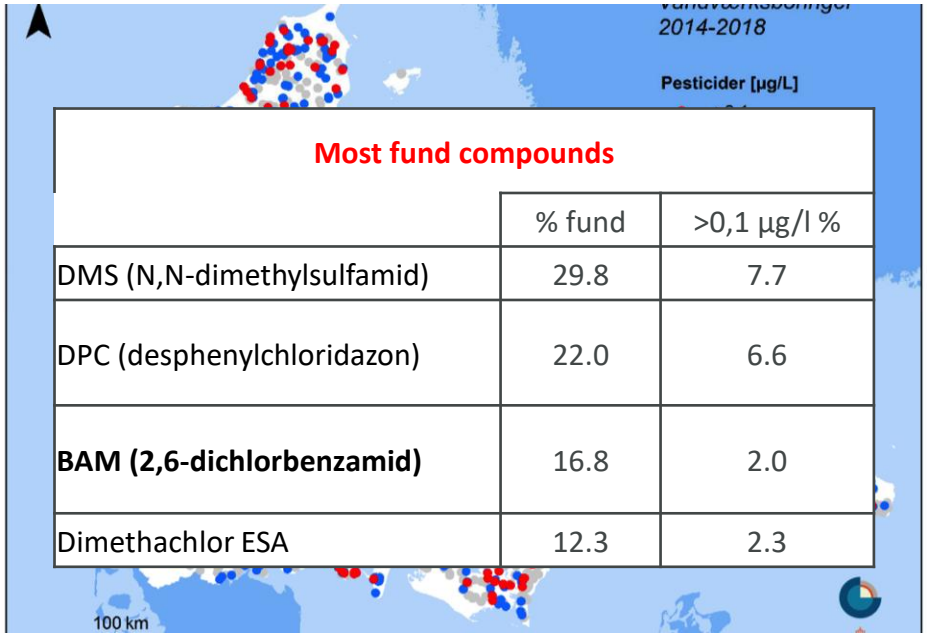
GROUNDWATER IS CONTAMINATED – SOLUTION?

- **Groundwater well closing**
  - *pesticides and degradation products*
- Pesticides are biological degradable by microorganisms
- These degrading microorganisms can be isolated and grown in lab – **Could these be a solution for bioremediation?**

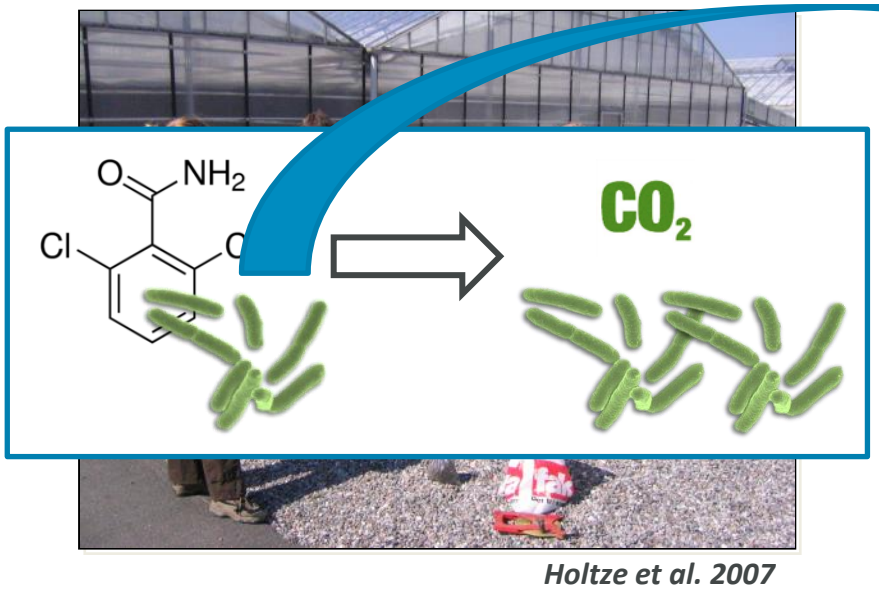


Most fund compounds

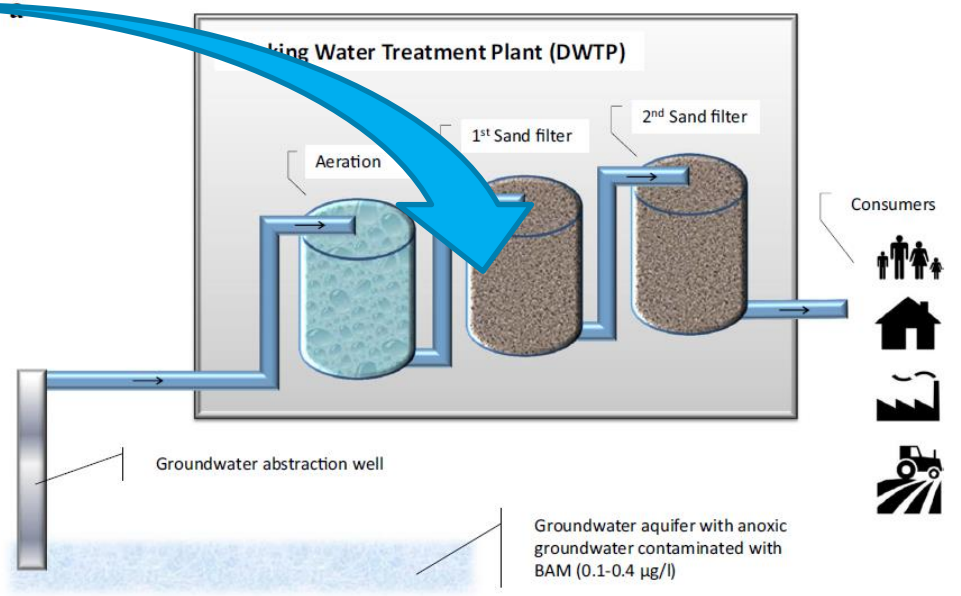
	% fund	>0,1 µg/l %
DMS (N,N-dimethylsulfamid)	29.8	7.7
DPC (desphenylchloridazon)	22.0	6.6
BAM (2,6-dichlorbenzamid)	16.8	2.0
Dimethachlor ESA	12.3	2.3

POTENTIAL SOLUTION FOR BAM REMOVAL

Specifik degrader Bacteria -
Aminobacter sp. strain MSH1

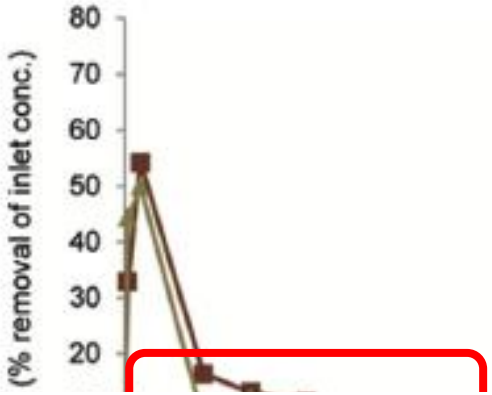


Holtze et al. 2007

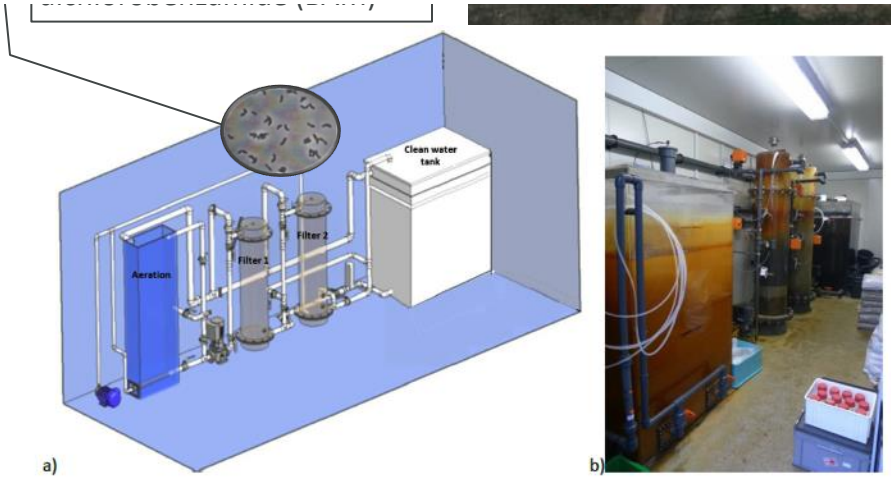


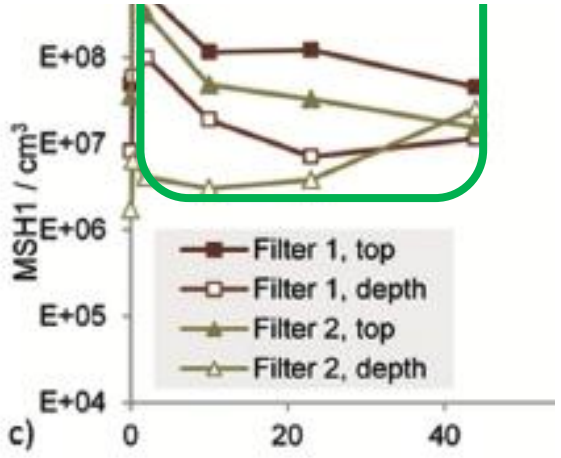
Ellegaard-Jensen et al. 2017

LESSON FROM THE PAST



Most bacteria (and degradation) were lost within a few weeks but some persist

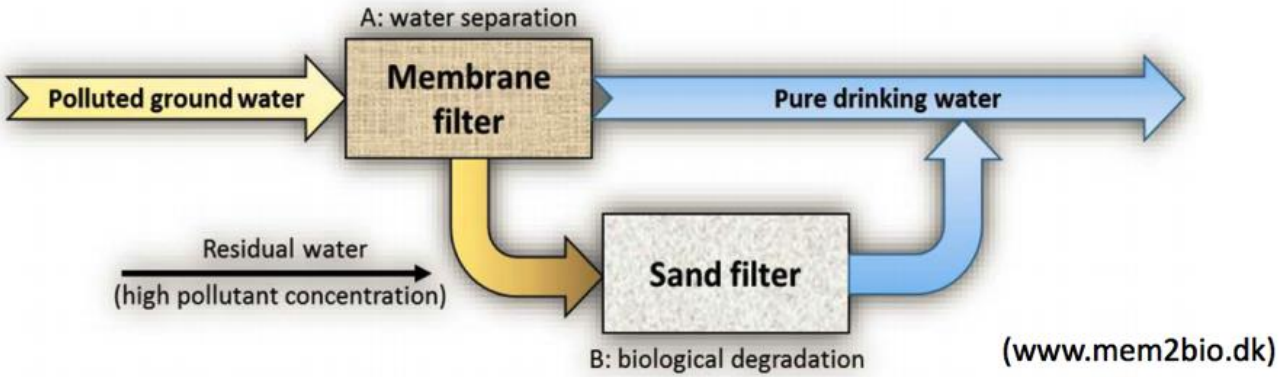




Albers et al. 2015

MEM2BIO PROJECT

SILHORKO REN VANDBEHANDLING
DIN FORSYNING
TREFOR



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APPLIED BIOMIMETIC

GEUS

Combine RO membrane filtration with bioaugmented sand filter to increase concentration of **wanted** compounds, including nutrients

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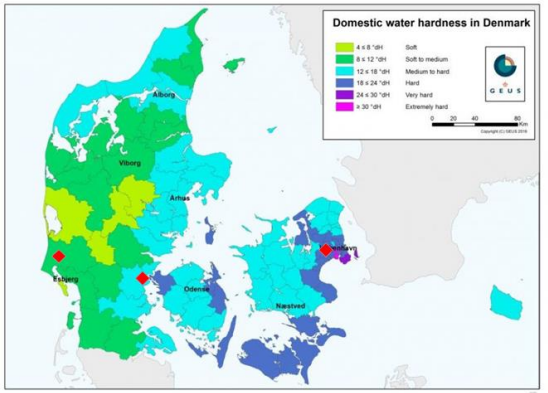
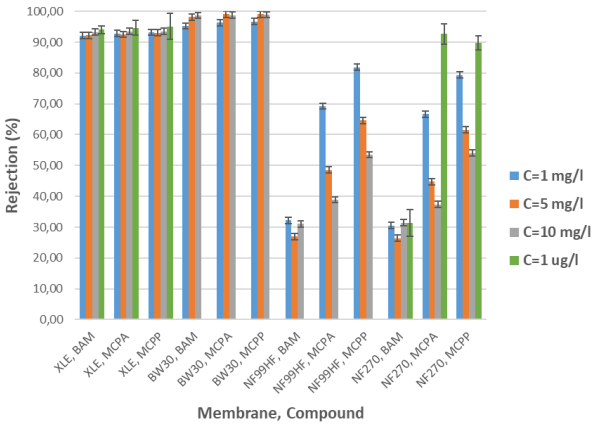
MEM2BIO



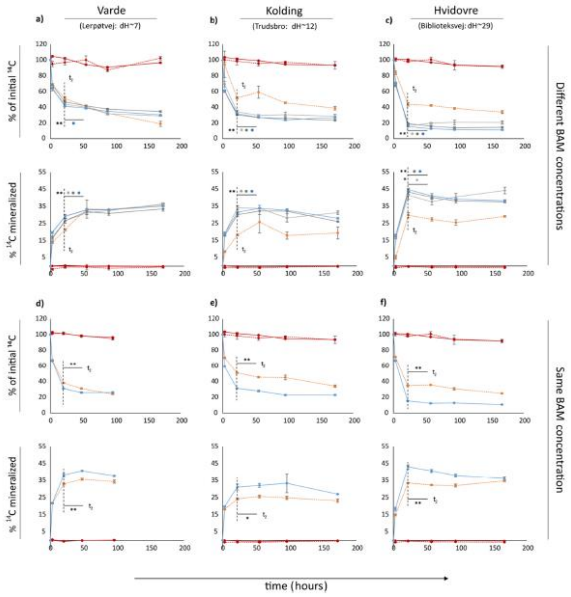
LAB SCALE RESEARCH

Membrane selection

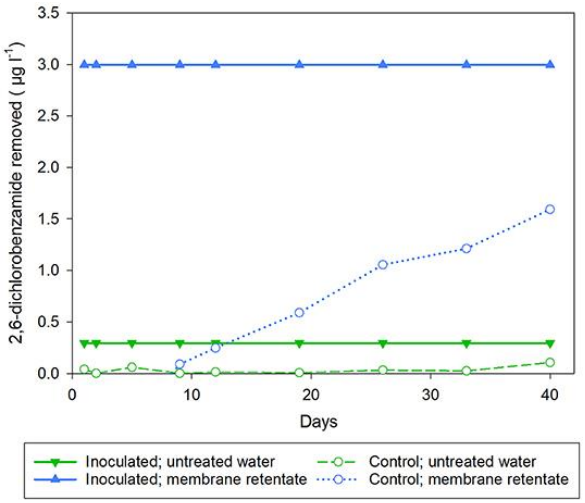


Fini et al. (2019)

Batch studies



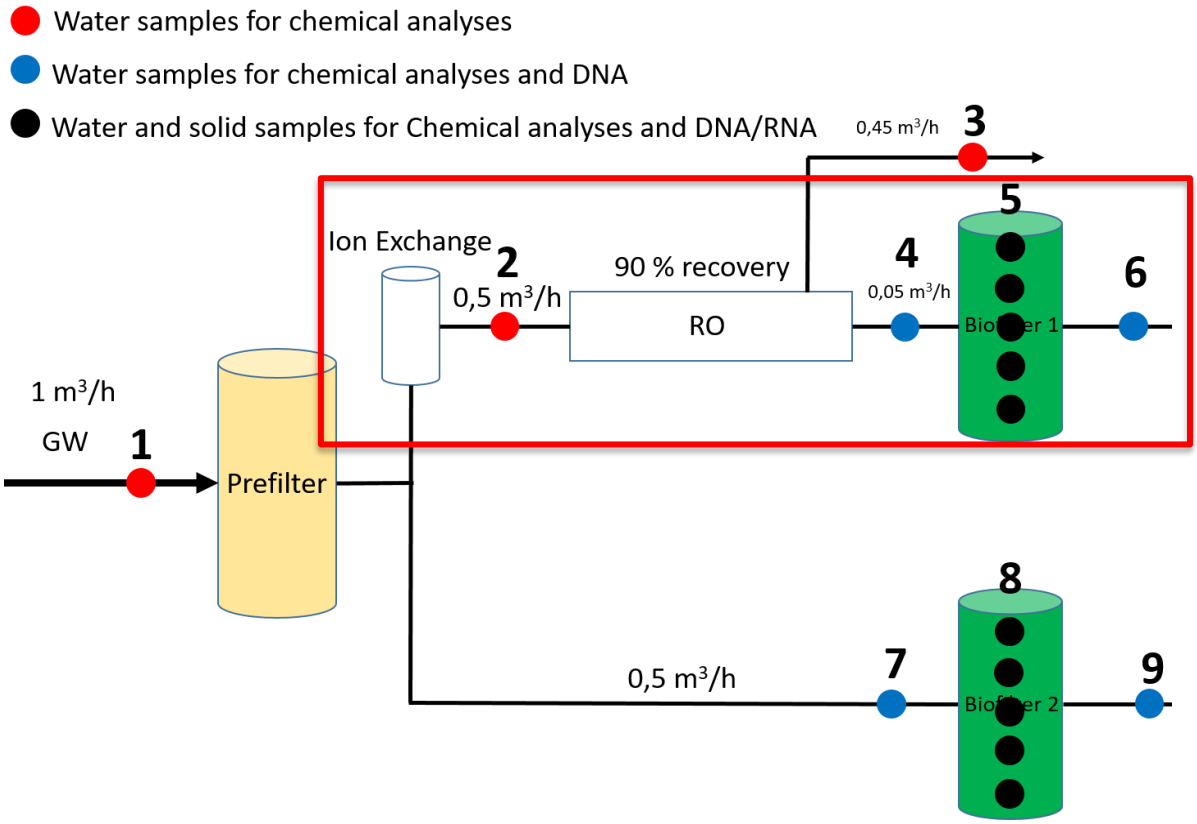
Column studies



Ellegaard-Jensen et al. (2020)

Proof-of-concept demonstrated in Hylling et al. (2019) **A novel hybrid concept for implementation in drinking water treatment targets micropollutant removal by combining membrane filtration with biodegradation**. *Sci. Tot. Environ*. 694.

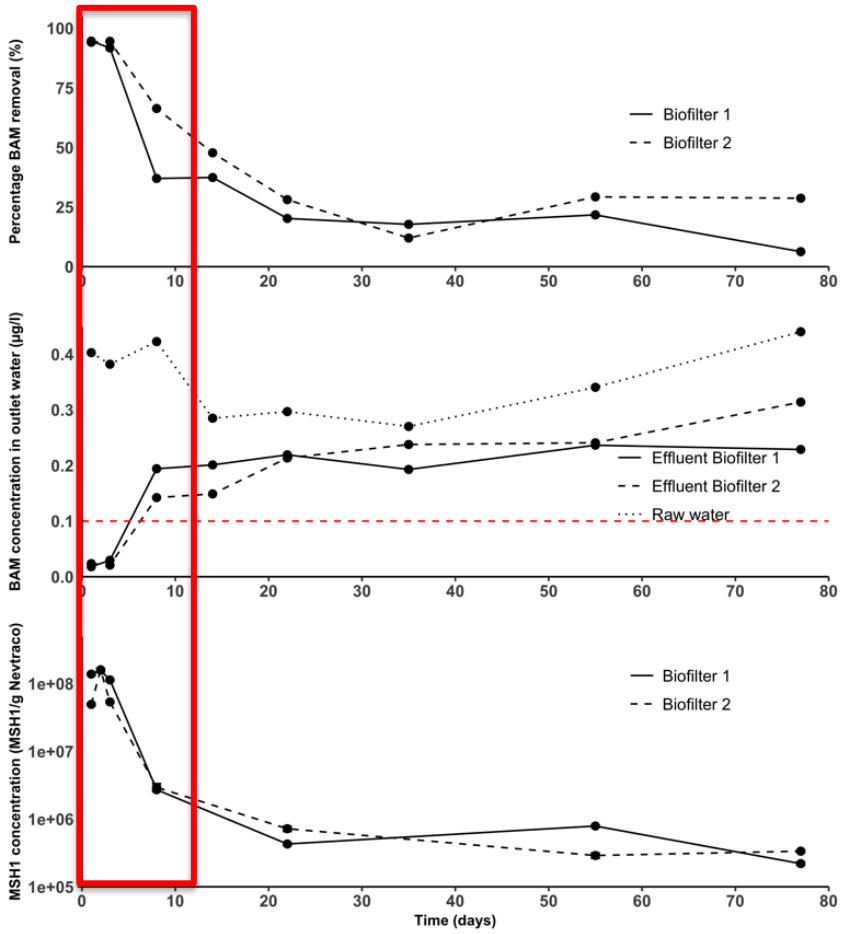
PILOT TESTING



1. PILOT – EQUAL RESIDENCE TIME

- 10^8 cells (MSH1) per gram of filter material
- Equal flow on both filters
  - 80 L/h
- Residence time of 28 minutes

- **Efficiency lost with 8 days**
- **Loss of bacteria**



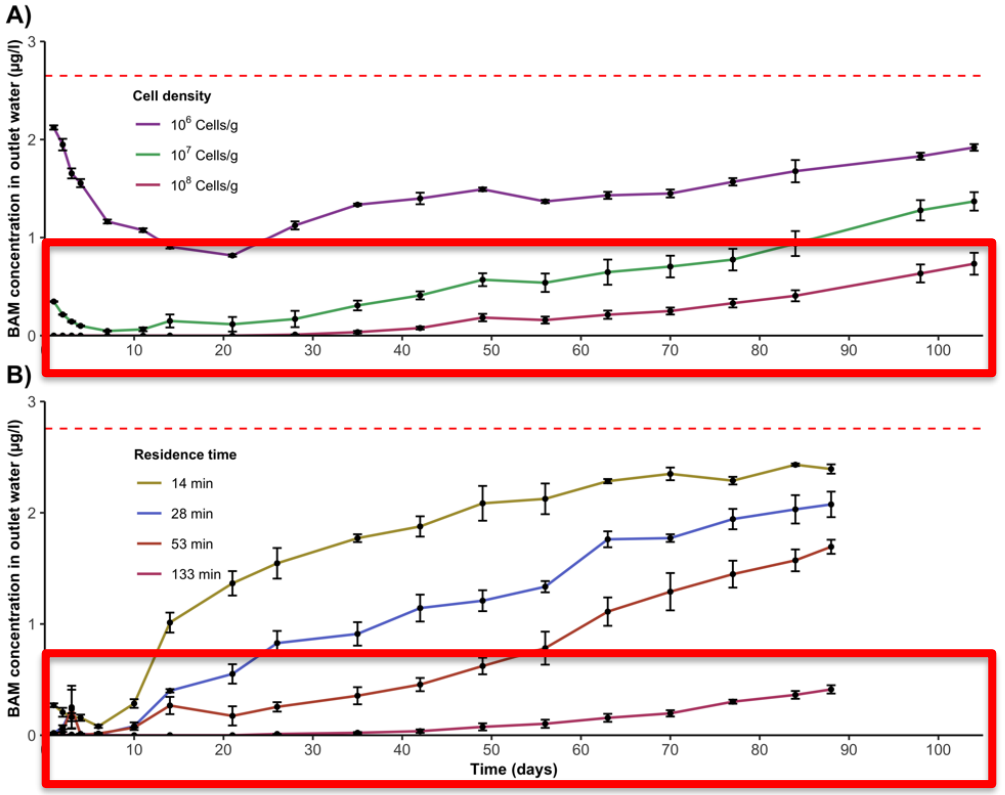
BACK TO THE LAB – WHICH PARAMETERS MATTERS?

Cell density:

10^6 ***Cells/g filter material***

10^7 ***Cells/g filter material***

10^8 ***Cells/g filter material***



Residence time:

14 min (Top Yellow)

28 min (Blue)

53 min (Brown)

133 min (Bottom Pink)

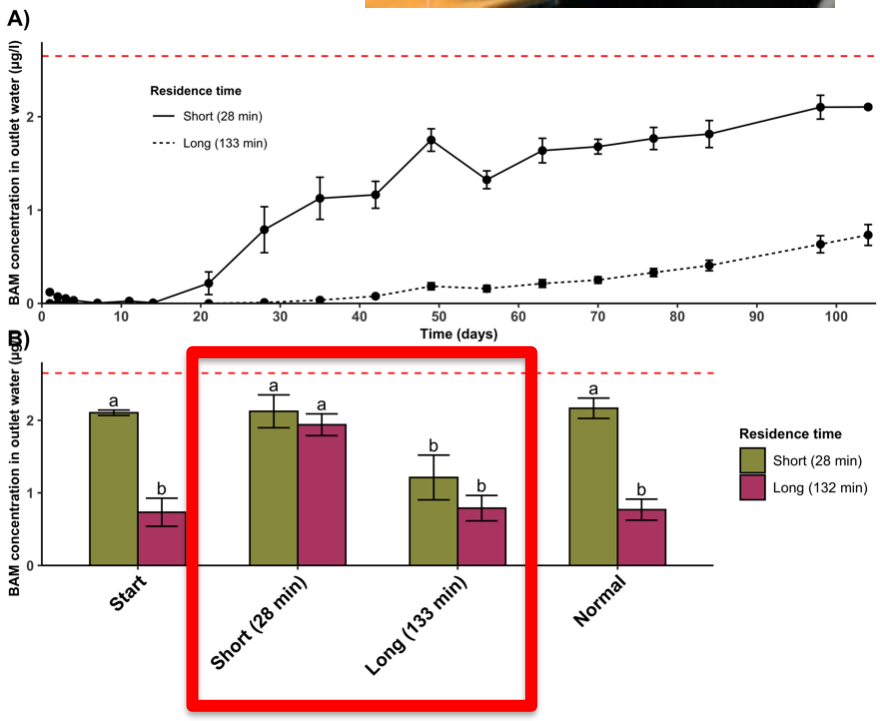
LAB – CHANGE IN RESIDENCE TIMES

Change the residence time after 104 days:

First all short residence time (28 min)

Then all long residence time (133 min)

- Clearly effect of residence time.

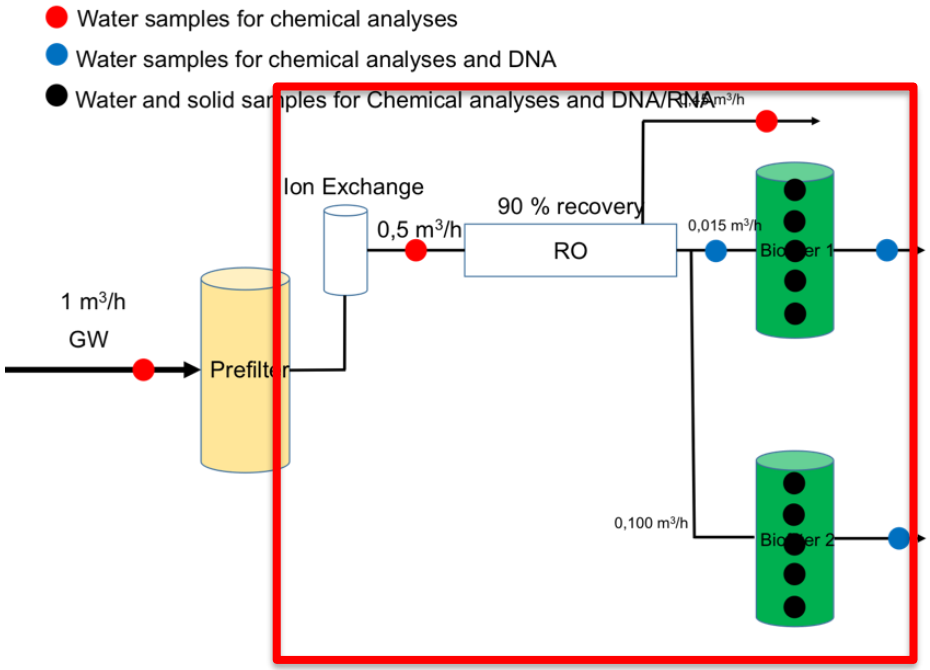


2. PILOT – TESTING RESIDENCE TIME

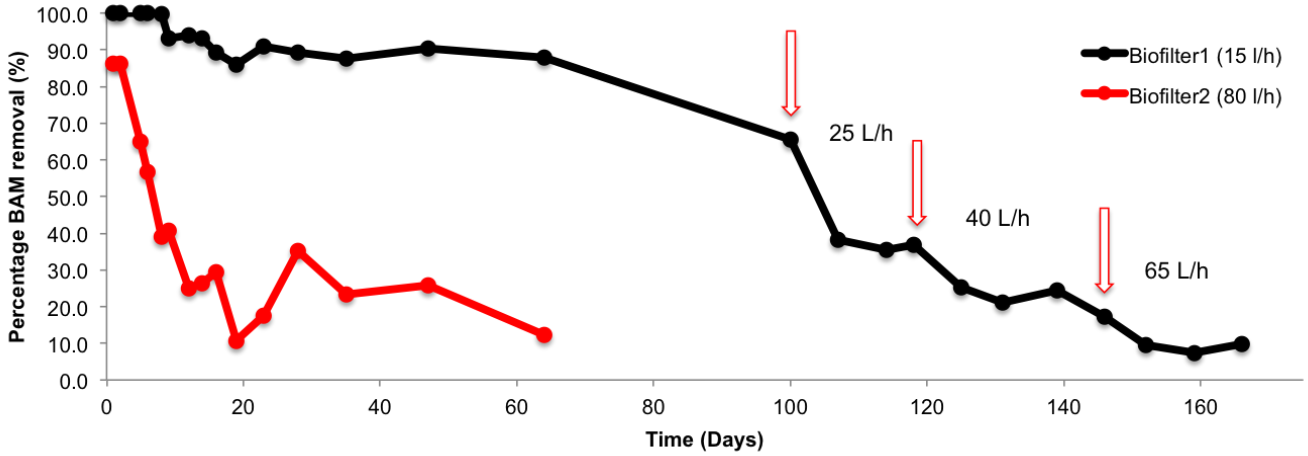
Change the design to test only residence time on the pilot waterwork.

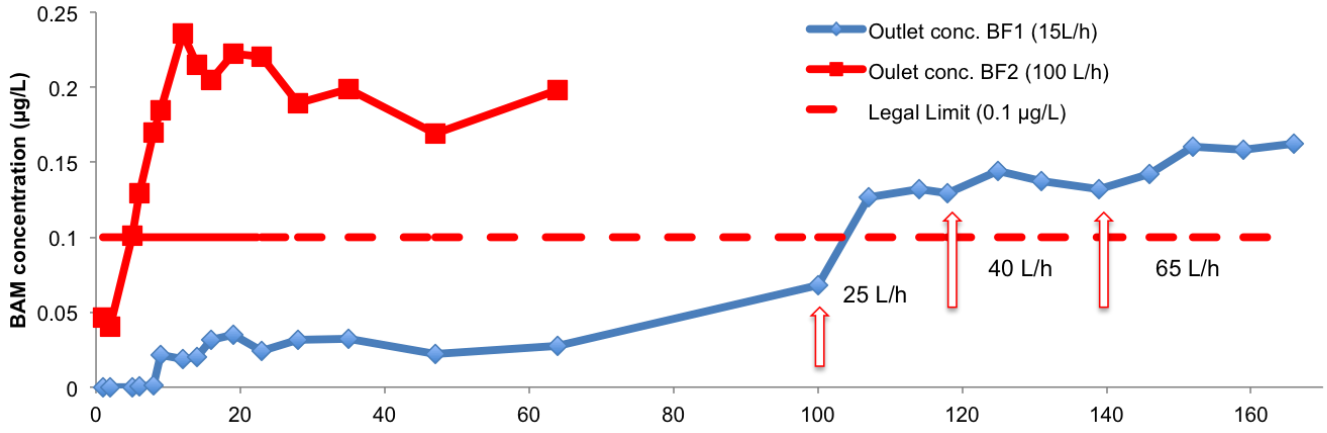
Membrane retentate on both filters.

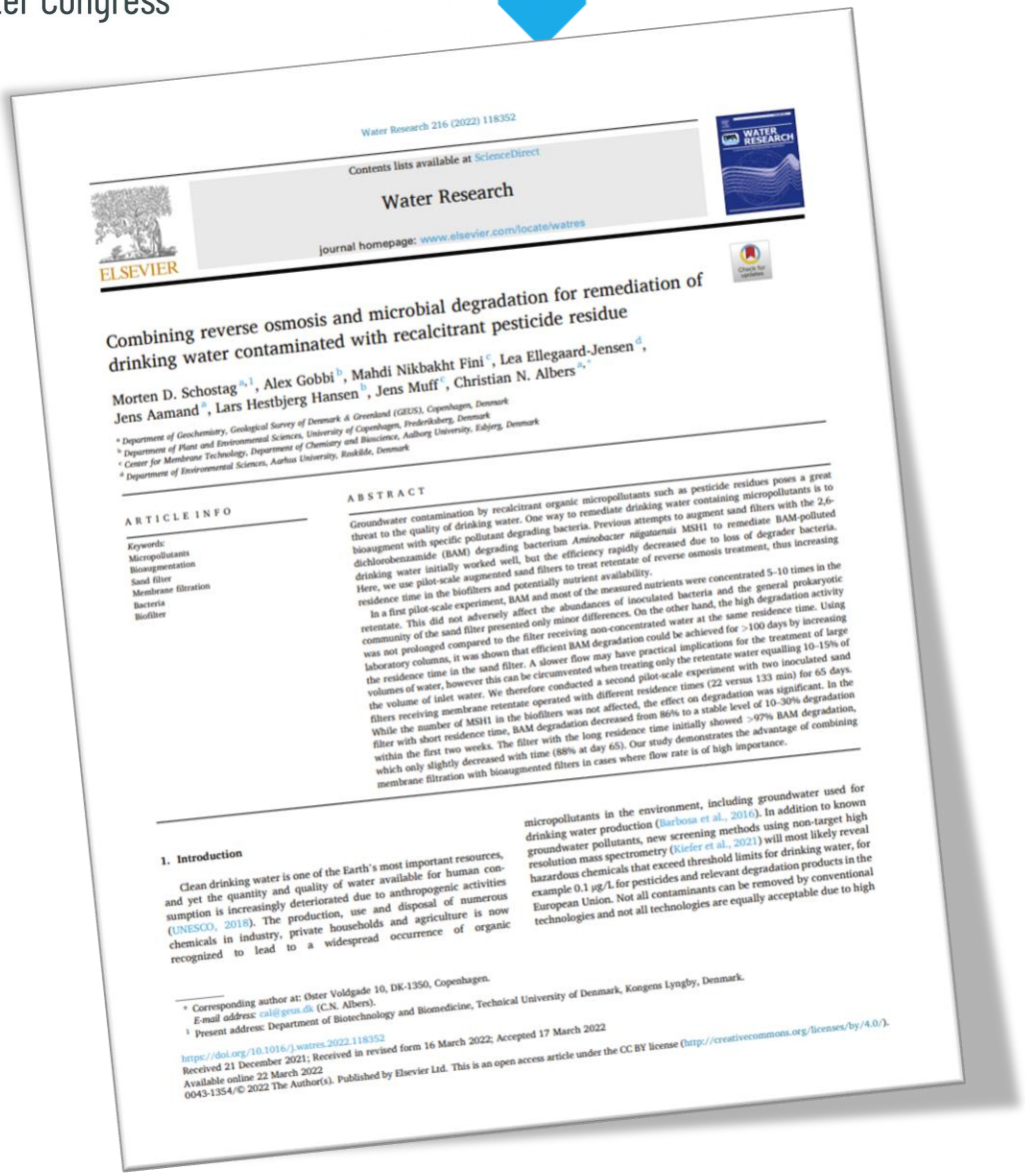
~133 vs. 22 min



2. PILOT – TEST OF RESIDENCE TIME







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Combining reverse osmosis and microbial degradation for remediation of drinking water contaminated with recalcitrant pesticide residue

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ABSTRACT

Groundwater contamination by recalcitrant organic micropollutants such as pesticide residues poses a great threat to the quality of drinking water. One way to remediate drinking water containing micropollutants is to bioaugment with specific pollutant degrading bacteria. Previous attempts to augment sand filters with the 2,6-dichlorobenzamide (BAM) degrading bacterium *Aminobacter niigataensis* MSH1 to remediate BAM-polluted drinking water initially worked well, but the efficiency rapidly decreased due to loss of degrader bacteria. Here, we use pilot-scale augmented sand filters to treat retentate of reverse osmosis treatment, thus increasing residence time in the biofilters and potentially nutrient availability.

In a first pilot-scale experiment, BAM and most of the measured nutrients were concentrated 5–10 times in the retentate. This did not adversely affect the abundances of inoculated bacteria and the general prokaryotic community of the sand filter presented only minor differences. On the other hand, the high degradation activity was not prolonged compared to the filter receiving non-concentrated water at the same residence time. Using laboratory columns, it was shown that efficient BAM degradation could be achieved for >100 days by increasing the residence time in the sand filter. A slower flow may have practical implications for the treatment of large volumes of water, however this can be circumvented when treating only the retentate water equalling 10–15% of the volume of inlet water. We therefore conducted a second pilot-scale experiment with two inoculated sand filters receiving membrane retentate operated with different residence times (22 versus 133 min) for 65 days. While the number of MSH1 in the biofilters was not affected, the effect on degradation was significant. In the filter with short residence time, BAM degradation decreased from 86% to a stable level of 10–30% degradation within the first two weeks. The filter with the long residence time initially showed >97% BAM degradation which only slightly decreased with time (88% at day 65). Our study demonstrates the advantage of combining membrane filtration with bioaugmented filters in cases where flow rate is of high importance.

1. Introduction

Clean drinking water is one of the Earth's most important resources, and yet the quantity and quality of water available for human consumption is increasingly deteriorated due to anthropogenic activities (UNESCO, 2018). The production, use and disposal of numerous chemicals in industry, private households and agriculture is now recognized to lead to a widespread occurrence of organic micropollutants in the environment, including groundwater used for drinking water production (Barbosa et al., 2016). In addition to known groundwater pollutants, new screening methods using non-target high resolution mass spectrometry (Kiefer et al., 2021) will most likely reveal hazardous chemicals that exceed threshold limits for drinking water, for example 0.1 μg/L for pesticides and relevant degradation products in the European Union. Not all contaminants can be removed by conventional technologies and not all technologies are equally acceptable due to high

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CONCLUSION

- The XLE RO membrane concentrate pesticides, DOC, trace metals etc.
- The membrane filtration alone did not improve the length of BAM degradation (Bacterial survival)
- Residence time have a large impact on the biodegradation
- Longer residence time prolonged the duration of which the process performed – in the lab and in the field
- Using a membrane filtration step gives longer residence time (10x), with the same amount of treated water.

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All partners in MEM2BIO
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NY BIOTEKNOLOGI SKAL FJERNE PESTICIDER FRA DRIKKEVAND

Forfatterne

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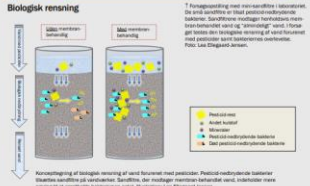
Et nyt forskningsprojekt skal kombinere særlige membraner og pesticidædende bakterier, så man derved kan rense drikkevand, der er forurenet med pesticider. Denne teknologi kan for eksempel blive et vigtigt værktøj i områder, hvor det er meget svært at finde nye, pesticidfrie drikkevandsressourcer.

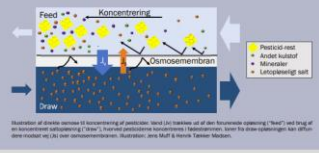
På globalt plan er adgang til rent vand en af de helt store udfordringer nu og i fremtiden. Men der er store forskelle i de udfordringer, vi står med forskellige steder i verden. Hvor man i mindre udviklede lande kæmper med problemer som sundhedsskadelige bakterier i vandet eller ren og skær mangel på vand, har vi i Danmark været vant til at kunne pumpe næsten drikkeklart vand direkte op af undergrunden. Dette koncept er dog udfordret af, at man i flere og flere grundvandsmagasiner finder spor af sprøjtegifte (pesticider) og deres omdannelsesprodukter.

I Danmark overvåges tilstanden af grund- og drikkevand af GEUS (De Nationale Geologiske Undersøgelser for Danmark og Grønland), og her finder man typisk pesticider i omkring 40 % af grundvandsindtagene samt omkring 25 % af prøverne fra vandværkerne. Overvågningen begyndte i starten af 90'erne, og siden har man observeret en stigende forurening af grundvandet. Denne stigning skyldes dog ikke, at vandet er blevet mere forurenet, men snarere, at man har målt for et øget antal af forskellige pesticider. I de seneste år har antallet af fund af pesticider stabiliseret sig, men nyligt fund af stoffet desphenyl-chloridazon illustrerer, at der stadig kan gemme sig pesticider, som vi ikke har opdaget endnu.

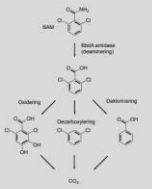
I Danmark har vi principielt en

Biologisk rensning





Bionedbrydning af BAM



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