

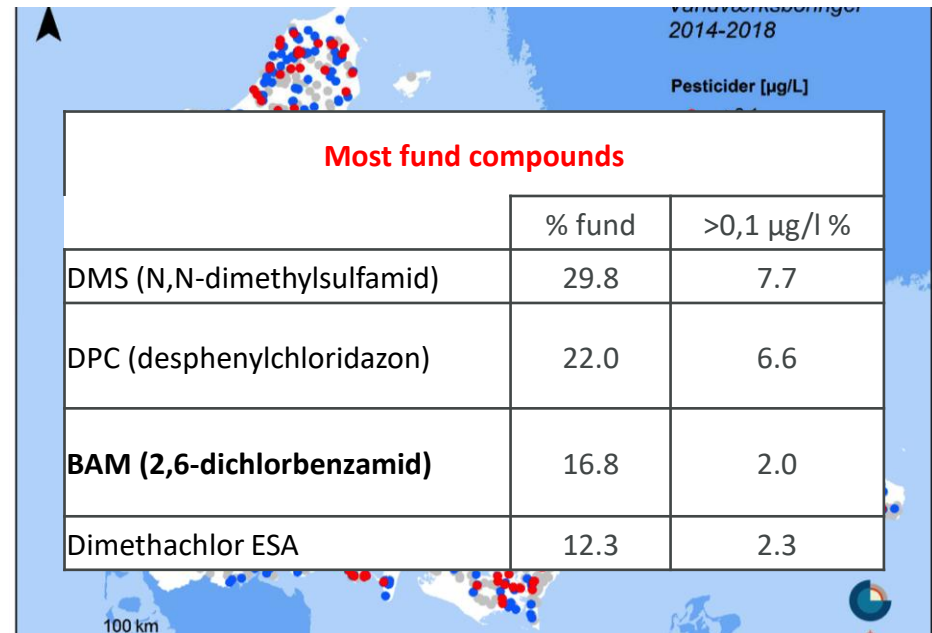
## COMBINED MEMBRANE FILTRATION AND BIODEGRADATION – A NOVEL HYBRID CONCEPT OF BAM REMOVAL IN DRINKING WATER PRODUCTION

24 MAY – 4 JUNE 2021

***Morten D. Schostag, GEUS; Alex Gobbi, UCPH; Mahdi Nikbakht Fini, AAU; Lea Ellegard-Jensen, AU; Torben Buhl, Silhorko; Arne C. Koch, Silhorko; Søren Christensen, Silhorko, Søren Duch-Hennings, Silhorko; Ole Hylling, AU; Ole Silkjær, TREFOR; Peter Hyldgaard, DIN Forsyning, Iben Kirchberg, DIN Forsyning; Jens Muff, AAU; Lars H. Hansen, UCPH; Christian N. Albers, GEUS.***

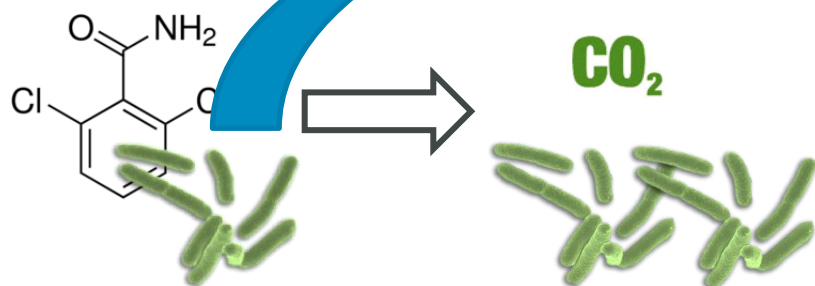
## GROUNDWATER IS CONTAMINATED – SOLUTION?

- **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?**

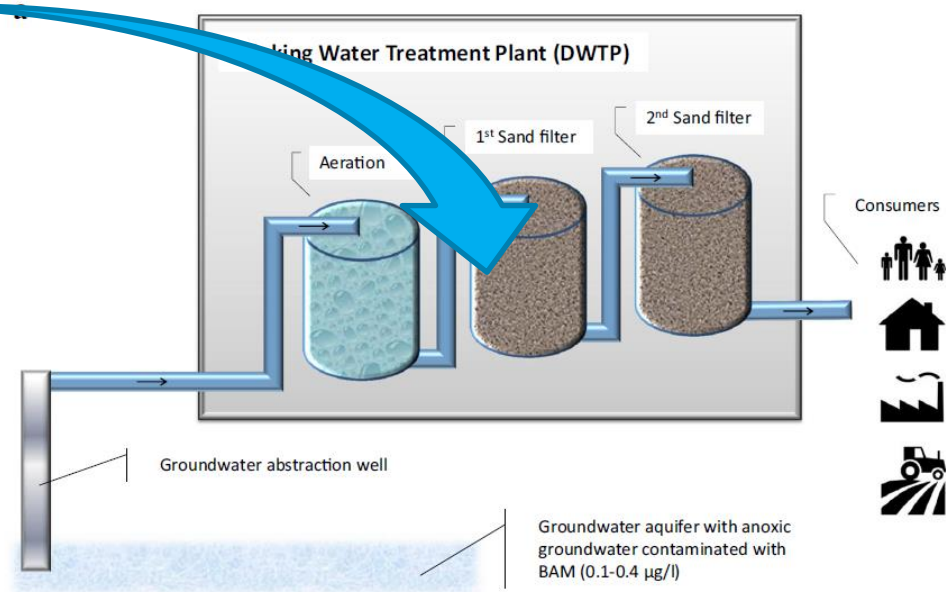


## POTENTIAL SOLUTION FOR BAM REMOVAL

Specific degrader Bacteria -  
*Aminobacter sp. strain MSH1*

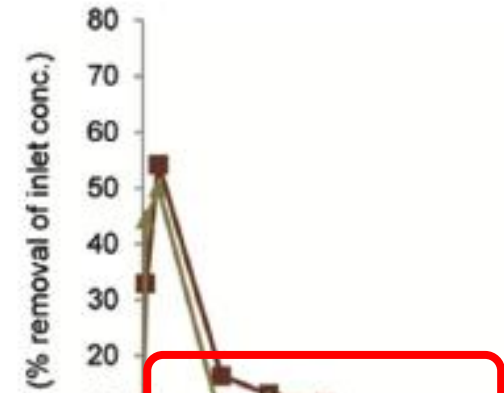


Holtze et al. 2007

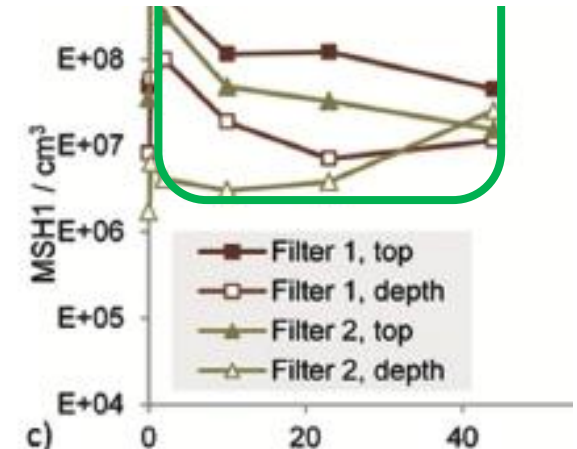
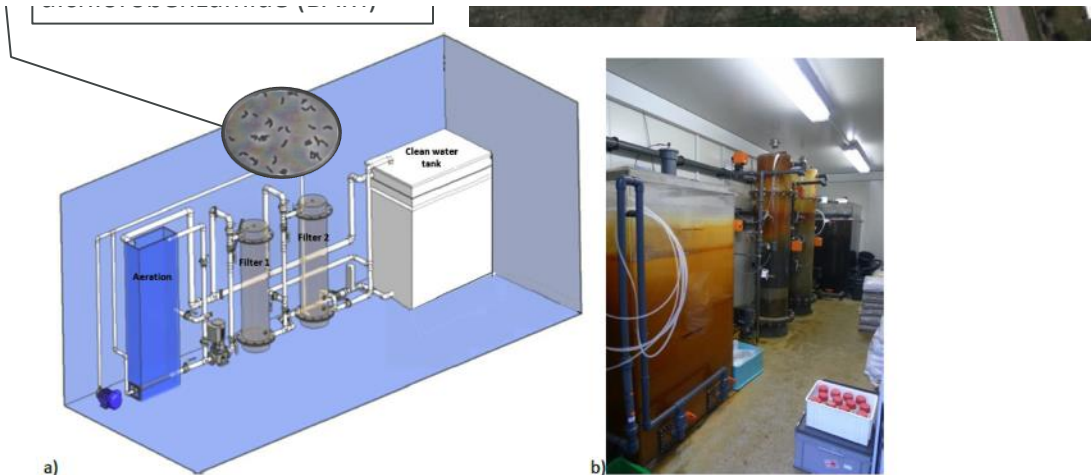


Ellegaard-Jensen et al. 2017

## LESSON FROM THE PAST



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



Albers et al. 2015

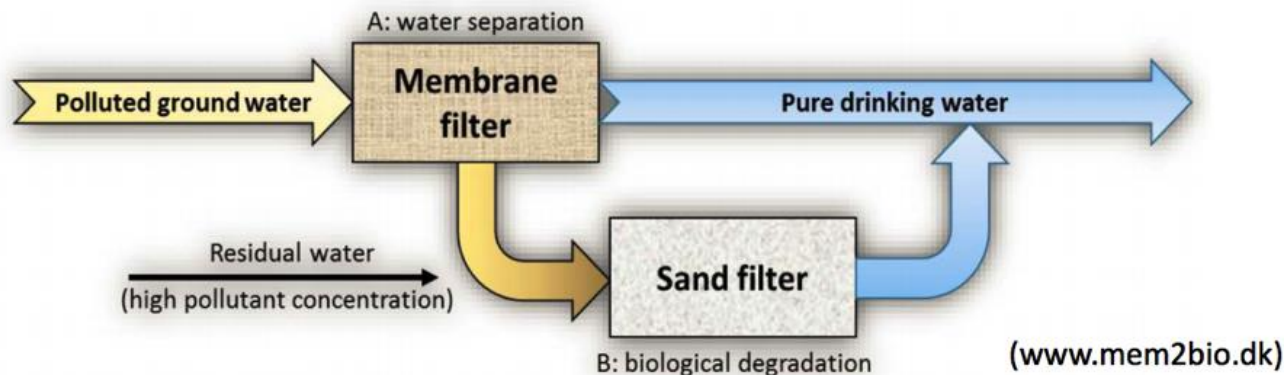
## MEM2BIO PROJECT

**SILHORKO**  
REN VANDBEHANDLING



**DIN**  
FORSYNING

**TRE FOR**



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

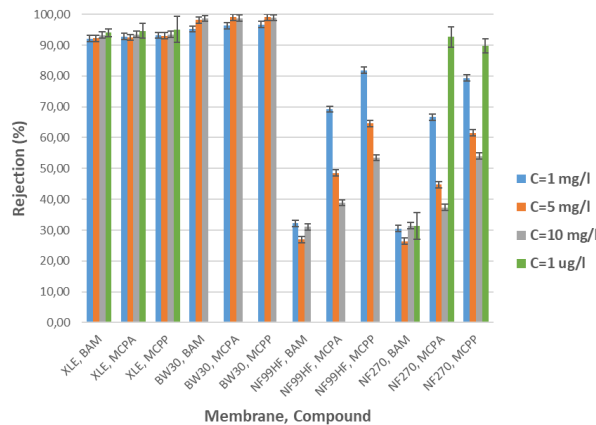
**APPLIED BIOMIMETIC**





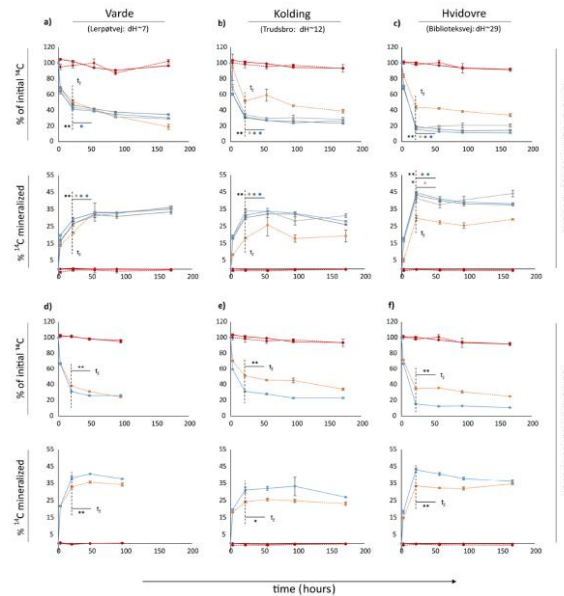
## LAB SCALE RESEARCH

### Membrane selection

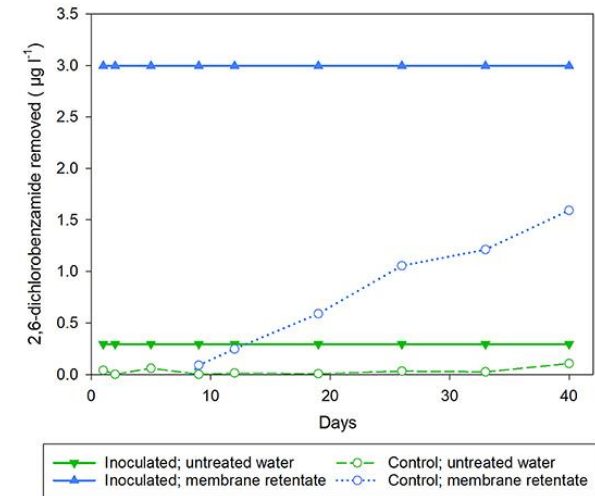


Fini et al. (2019)

### Batch studies

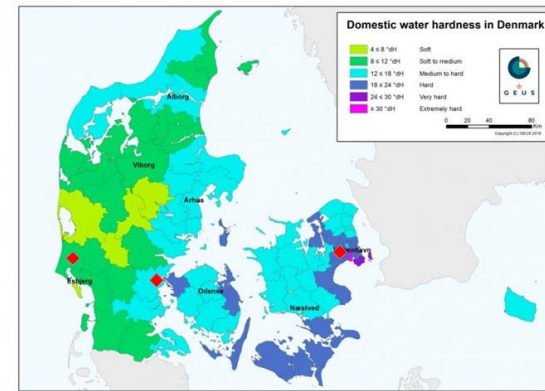


### Column studies

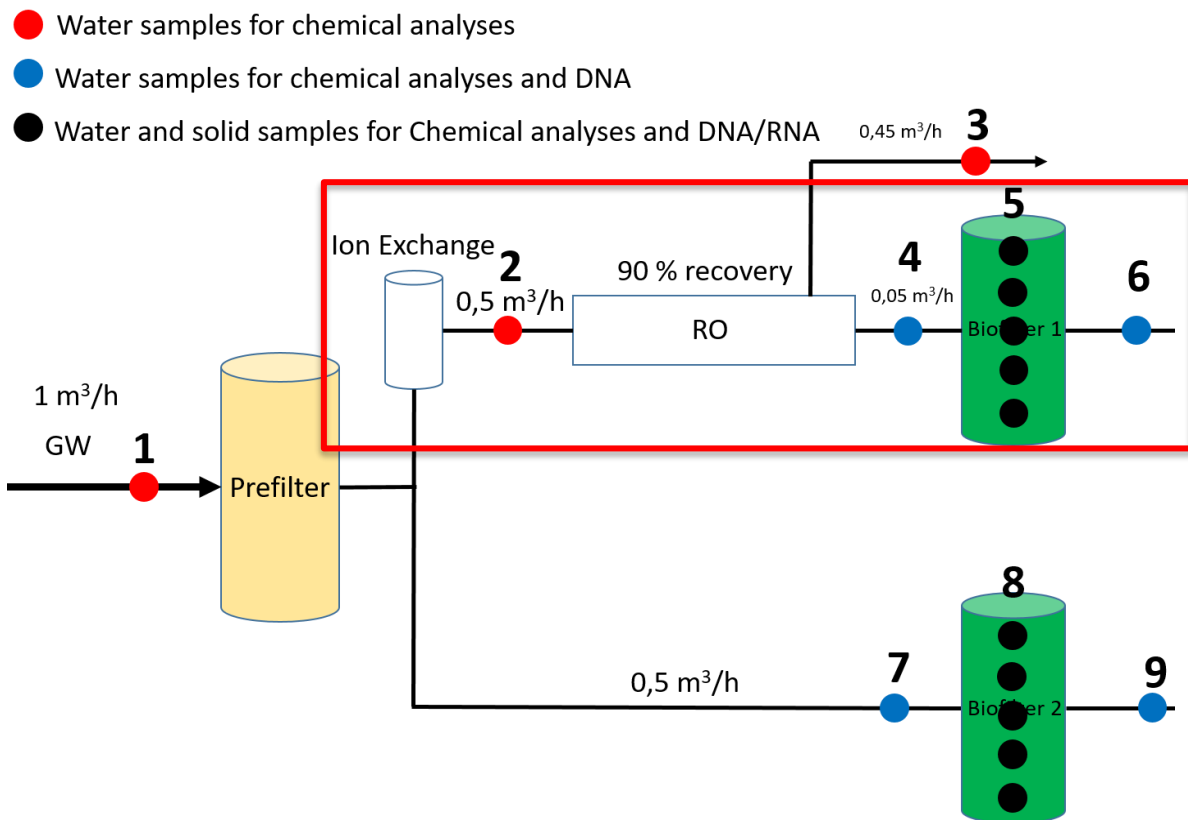


Ellegaard-Jensen et al. (2020)

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.

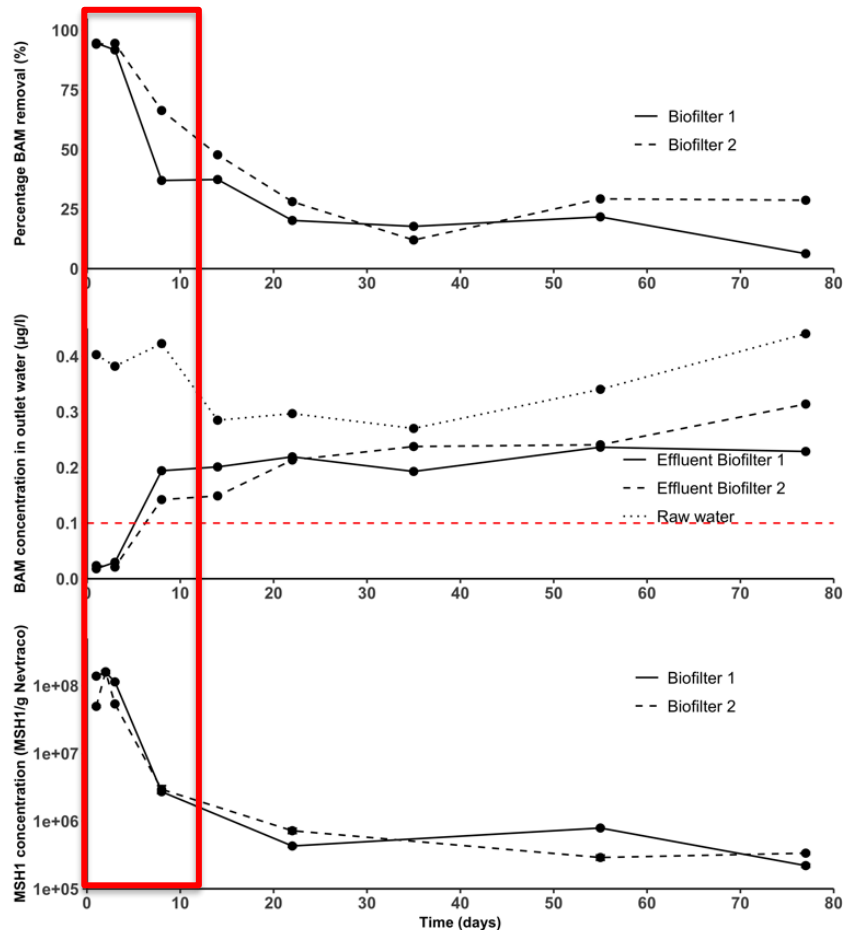


## PILOT TESTING



## 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

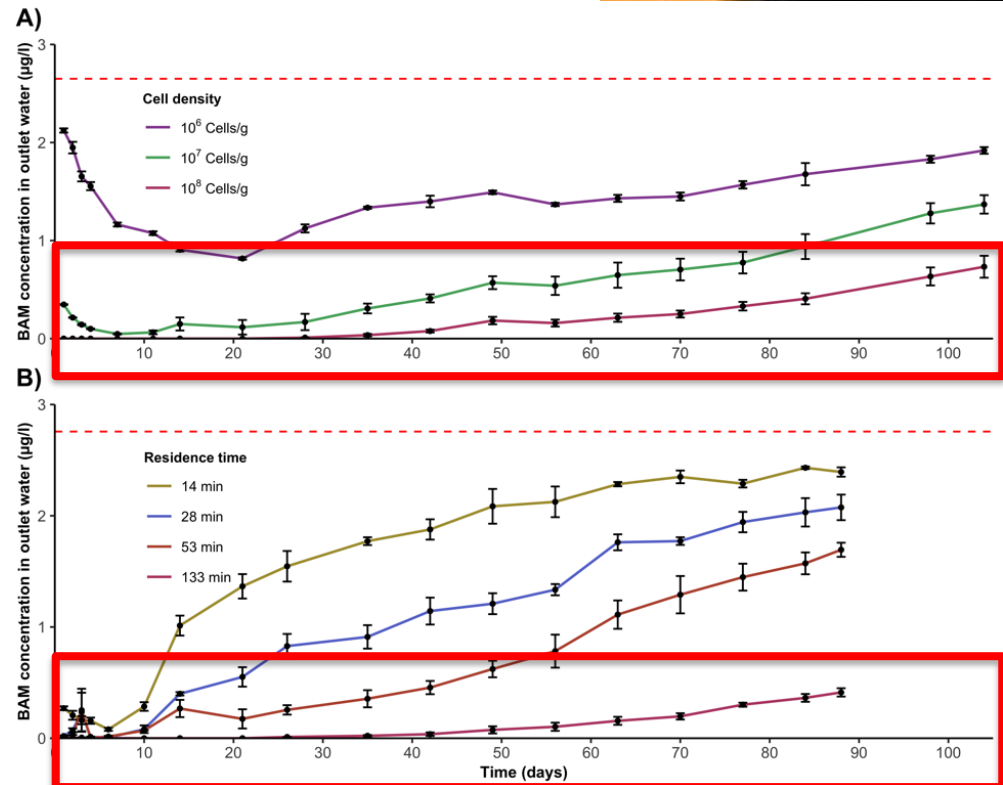
### Residence time:

14 min (Top Yellow)

28 min (Blue)

53 min (Brown)

**133 min (Bottom Pink)**





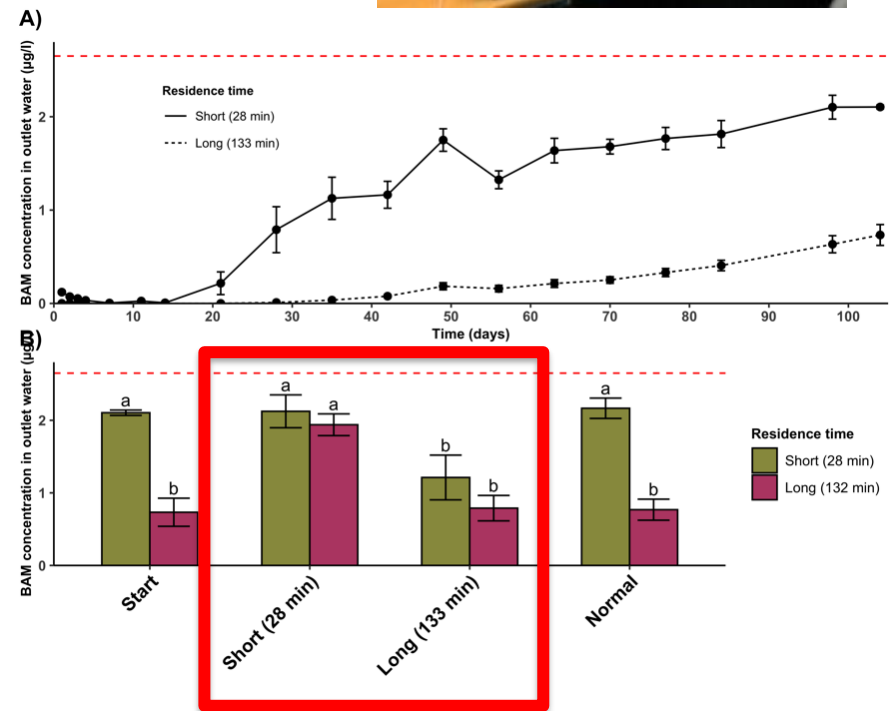
## LAB – CHANGE IN RESIDENCE TIMES

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.

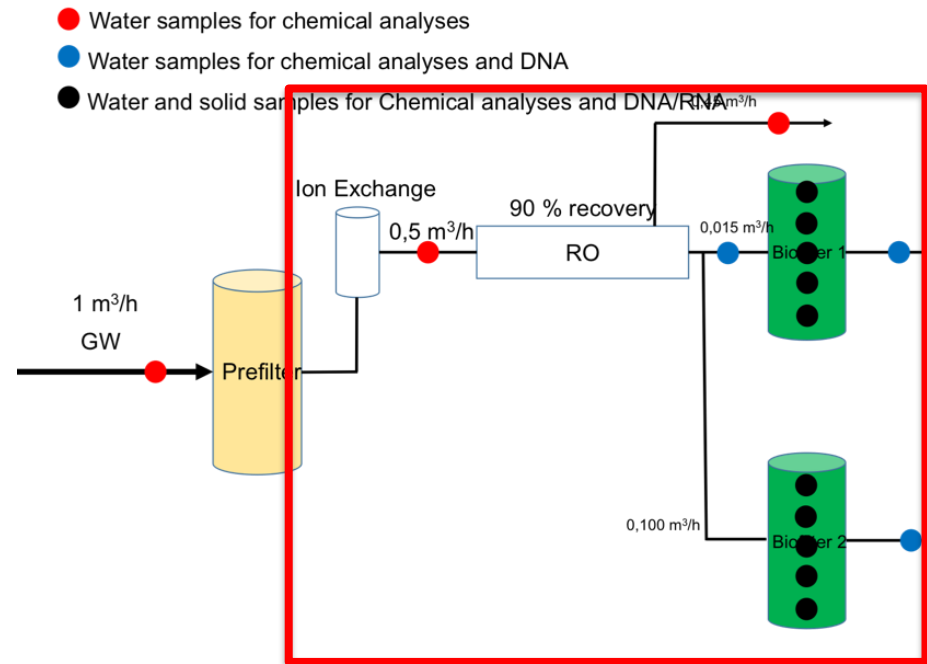


## 2. PILOT – TESTING RESIDENCE TIME

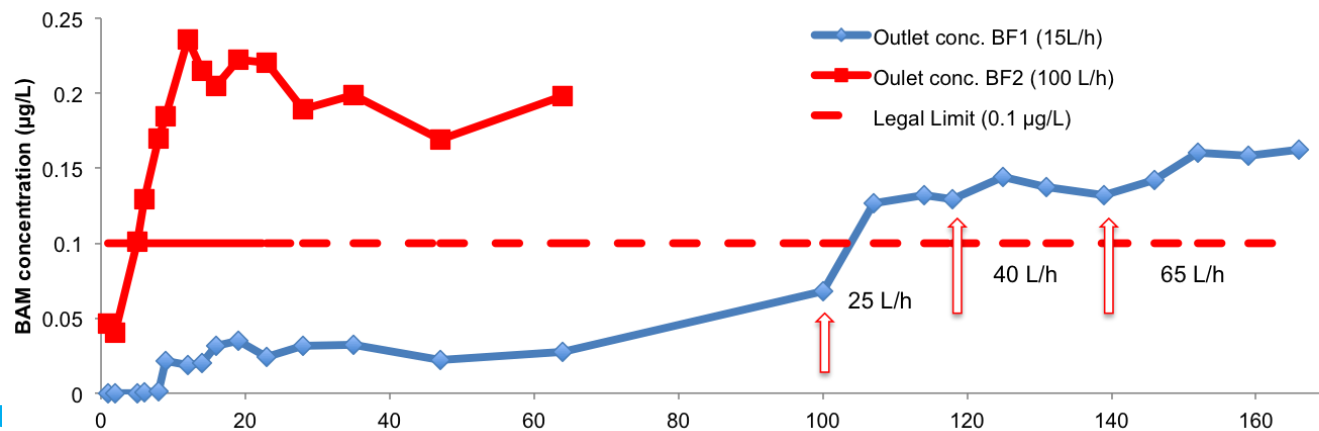
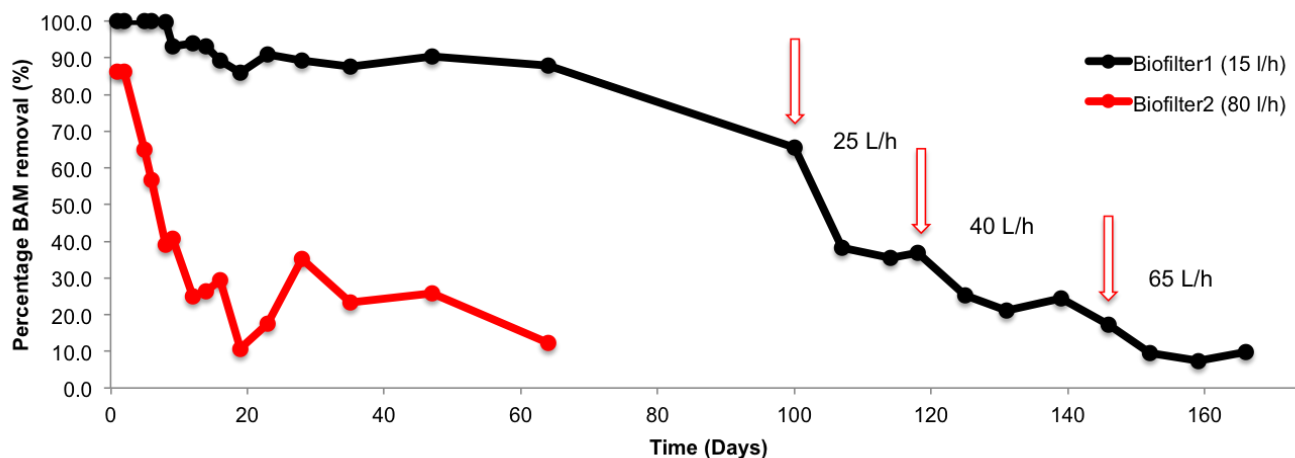
Change the design to test only residence time on the pilot waterwork.

Membrane retentate on both filters.

~133 vs. 22 min



## 2. PILOT – TEST OF RESIDENCE TIME







## 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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**SILHORKO**  
REN VANDBEHANDLING



DIN  
FORSYNING

**TREFOR**



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## NY BIOTEKNOLOGI SKAL FJERNE PESTICIDER FRA DRIKKEVAND

Forfatterne



Henrik Tøskker Madsen  
er adjunkt, Sektion for  
Bæredygtig bioteknologi,  
Institut for Kemi og  
Biovidenskab, Åalborg  
Universitet.  
htm@bio.aau.dk



Jens Muff er lektor,  
Sektion for Kemiteknologi,  
Institut for Kemi og  
Biovidenskab, Åalborg  
Universitet.  
jm@bio.aau.dk



Lea Ellegaard-Jensen  
er forsker, Sektion for  
Mikrobiel økologi og  
bioteknologi, Institut for  
Miljøvidenskab, Aarhus  
Universitet.  
lees@rnv.au.dk

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 for 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.

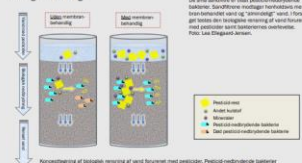
I Danmark overvåges tilstanden af grund- og drikkevand af GEUS (De Nationale Geologiske Undersøgelser for Danmark og Grønland), og her finder man typisk pesticider i omkring 40 % af grundvandsindtagene samt omkring 25 % af prøverne fra vandværkerne. Overvågningen begynde i starten af 90'erne, og

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 nylige fund af stoffet desphenylchloridazon illustrerer, at der stadig kan gemme sig pesticider, som vi ikke har opdaget endnu.

I Danmark har vi principielt en



Biologisk rensning



Forurening af biologisk rensning af vand forurenet med pesticider. Pesticid-opsamlende bakterier opsamlende på pesticider. Bakterier, der renses i membranen, opsamlende vand, opsamlende mere rensning til et opsamlende bakterierne, andre. Illustration: Lea Ellegaard-Jensen.

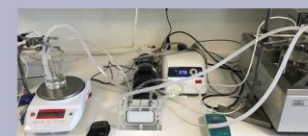
været muligt at holde bakterierne i live over længere tid. Det er sandsynligt, at disse bakterier (med næsten) vandet til disse bakterier, som også vil kunne renses i de opsamlende bakterier og andre indvandringsbakterier i særlig grad.

**Membraner**  
**Bakteriegrupper**  
For at overkomme begrensningen for de to metoder er bioteknologi, Aarhus Universitet, GEUS og en række industrielle partnere

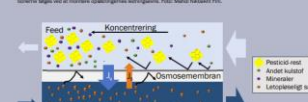
har gjort sammen i et nyt projekt, MEM2BIO, hvor vi kombinerer de to teknologier. Det pesticid-opsamlende vand filteres med membraner, hvorefter bakterier i den opsamlende af koncentrationer pesticider samt en strøm af rent vand. Det pesticid-opsamlende vand sendes til et specialiseret sætfilter, hvor de pesticid-opsamlende bakterier er placeret. Disse filterer nu godt af de høje koncentrationer i det rene mængde vand og nedbryder pesticiderne til vand og CO<sub>2</sub>. To ind-

deksede det pesticid-opsamlende filter, så det rene vand, så det endelige drikkevand til den endelige membranenrensningsproces. Der vil være en række teknologiske udfordringer, som projekter skal løse. For membranerne handler det om, hvordan grundvandet kan koncentrationen af pesticider uden at bryde ned bakterierne, som kan udfælde på membranen, og, samt hvordan membranen og

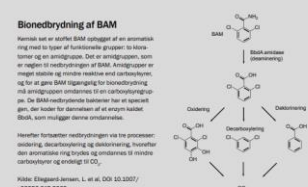
14 AKTUEL NATURVIDENSKAB | NR. 1 | 2018



Biologisk rensning af vand forurenet med pesticider. Pesticid-opsamlende bakterier opsamlende på pesticider. Bakterier, der renses i membranen, opsamlende vand, opsamlende mere rensning til et opsamlende bakterierne, andre. Illustration: Lea Ellegaard-Jensen.



Forurening af biologisk rensning af vand forurenet med pesticider. Pesticid-opsamlende bakterier opsamlende på pesticider. Bakterier, der renses i membranen, opsamlende vand, opsamlende mere rensning til et opsamlende bakterierne, andre. Illustration: Lea Ellegaard-Jensen.



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## CONTACT INFO

Jens Muff,  
Aalborg University  
Denmark  
jm@bio.aau.dk  
+45 9940 3564

<https://vbn.aau.dk/en/persons/106008>



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