Removal of pesticides from aqueous solution using aquaporin FO membrane

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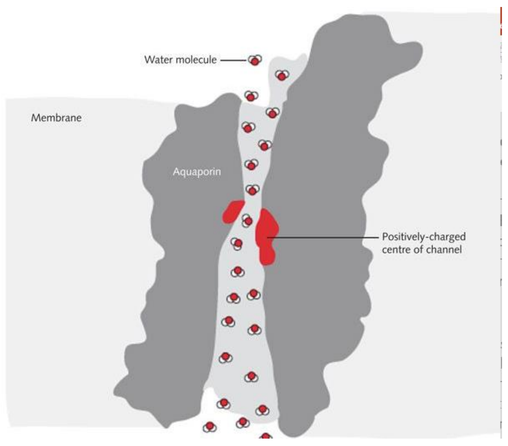
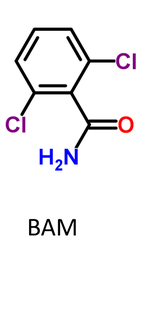
Introduction

- Forward osmosis (FO) process is known for its **decreased energy requirements** as well as **less fouling risks**.
- Finding an FO membrane offering sufficient rejection of micropollutants while maintaining a reasonable water flux has been a challenge.
- **Aquaporin membranes** by incorporating aquaporin proteins in the membrane selective layer, offers the possibility of having a high rejection without compromising water flux resulting.

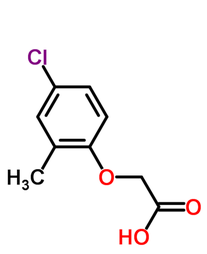


Water transport mechanism for aquaporin membrane

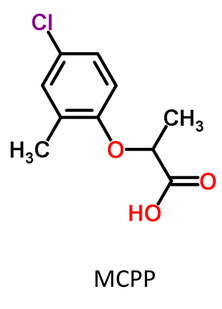
- 2-6 Dichloro-benzamide (**BAM**), 2-methyl-4-chlorophenoxyaceticacid (**MCPA**), and methylchlorophenoxypropionic acid (**MCPP**) are three frequently found pesticides in groundwater resources in Denmark.



BAM



MCPA

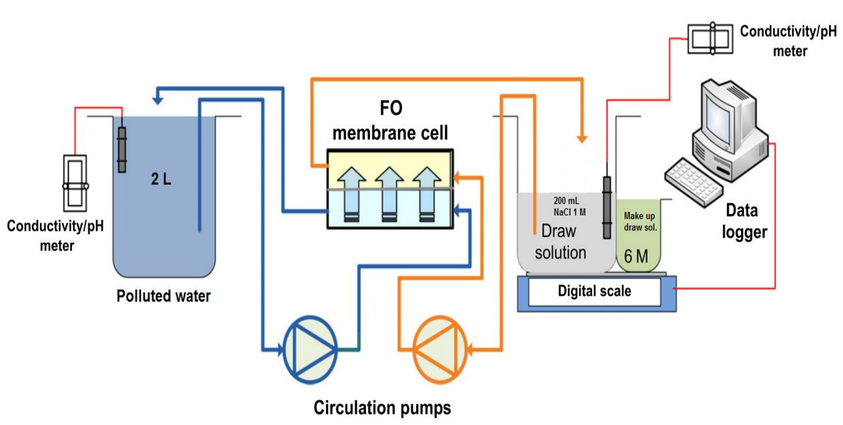


MCPP

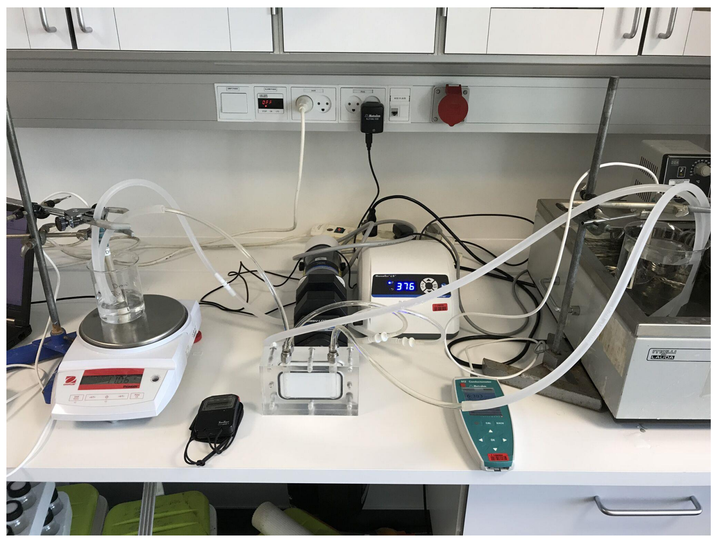
- In this study, the performance of aquaporin membrane was for the first time investigated in a conventional FO setup for removal of these pesticides.

Methods and Materials

- A flat-sheet biomimetic aquaporin membrane was provided by Aquaporin A/S, Denmark.
- a conventional cross-flow FO setup consisting of membrane cell, feed tank, draw solution tank, peristaltic pump for circulation of feed and draw solution, conductometer and a balance for reading changes in draw solution weight (See Figure 1).
- **Feed**: 2 L of Milli-Q and groundwater sample (Lerpøtvej Waterworks, DIN Forsyning, Varde) were spiked with pesticides (1 mg/L).
- **Draw solution:** 200 mL of 1M NaCl was used as draw solution.



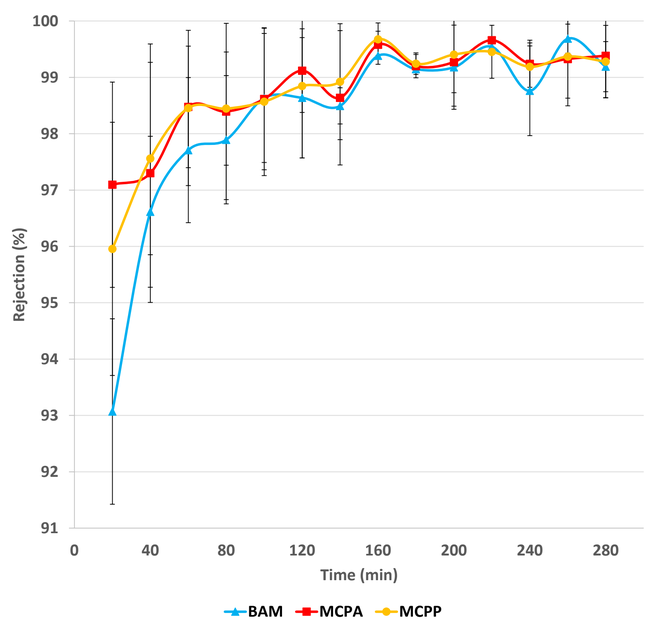
Schematic illustration of FO setup



Laboratory FO setup used for removal of pesticides

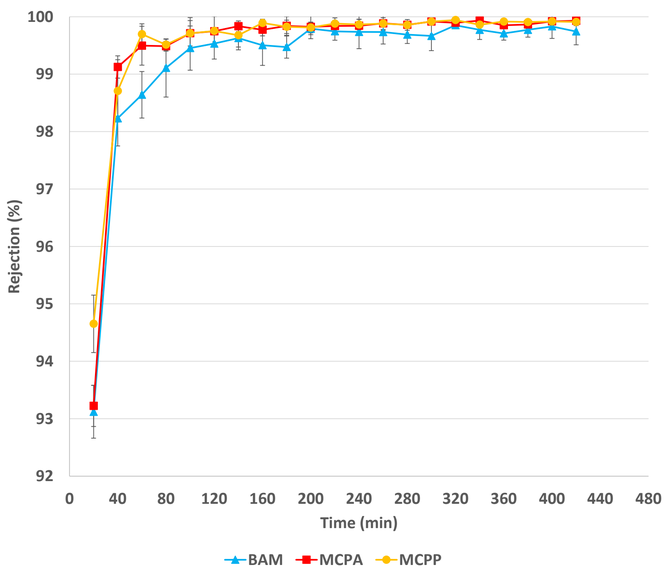
Results and Discussion

- Targeted pesticides were rejected at initial levels over 93% for BAM and up to 97% for MCPP in Milli-Q water solution.
- The rejection of pesticides increased up to approximately **99%** by the time.



Rejection of pesticides in Milli-Q water

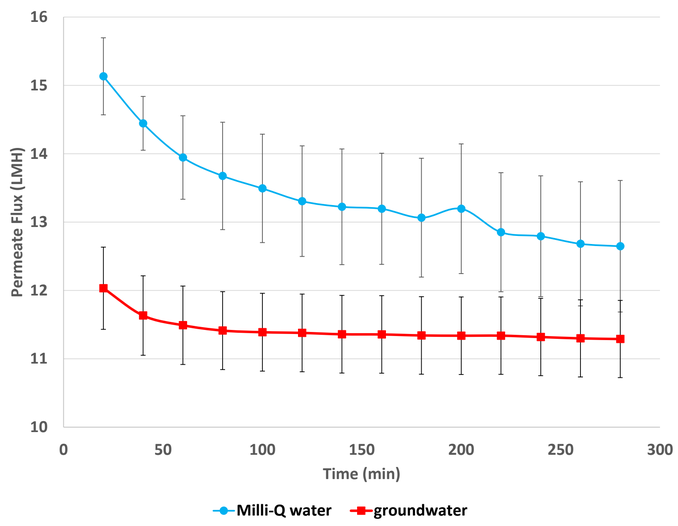
- The result is in accordance with our earlier study where the rejection of BAM by aquaporin membrane was higher than 97%, although that observation was made by a small FO system to facilitate a quick look into FO membranes.
- Rejection values of pesticides in groundwater (See Figure below) also illustrated a relatively increased values for all three pesticides when a real groundwater was used (**>99.5% rejection**).



Rejection of pesticides in groundwater

- This improvement in rejection values could be due to deposition of the other inorganic ions present in real groundwater sample.

- The permeate flux was observed to be 15 LMH for the Milli-Q water solution at the beginning and dropped down to around 13 LMH over time probably due to adsorption of solutes on the membrane.
- This increased flux compared to our earlier study, Madsen et al., (approx. 9 LMH) is suggestive of an improvement at fabrication of this biomimetic membrane.



permeate flux of Mill-Q water and groundwater solutions

- The permeate flux was lower as groundwater was used (from 12 to 11 LMH) mainly due to higher ionic strength of groundwater and possible scaling formation caused by inorganic ions.

Conclusion

- A stabilized **rejection >98%** was found for all targeted pesticides.
- The rejection of BAM in this study using a conventional FO setup was comparable with our earlier study in which a small FO setup was used suggesting that the small FO could be used for preliminary FO membrane evaluations with small FO membrane and no need to specific common FO equipment.
- A very promising permeate flux for FO process was obtained (**15 LMH**) approving higher flux hypothesis of biomimetic Aquaporin membranes.
- The pesticides rejection in real groundwater matrix was found to be relatively improved probably due to scaling resulting in a lower permeate flux.

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