Biomimetic aquaporin forward osmosis membrane for removal of frequently found pesticides from danish groundwater network

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BIOMIMETIC AQUAPORIN FORWARD OSMOSIS MEMBRANE FOR REMOVAL OF FREQUENTLY FOUND PESTICIDES FROM DANISH GROUNDWATER NETWORK

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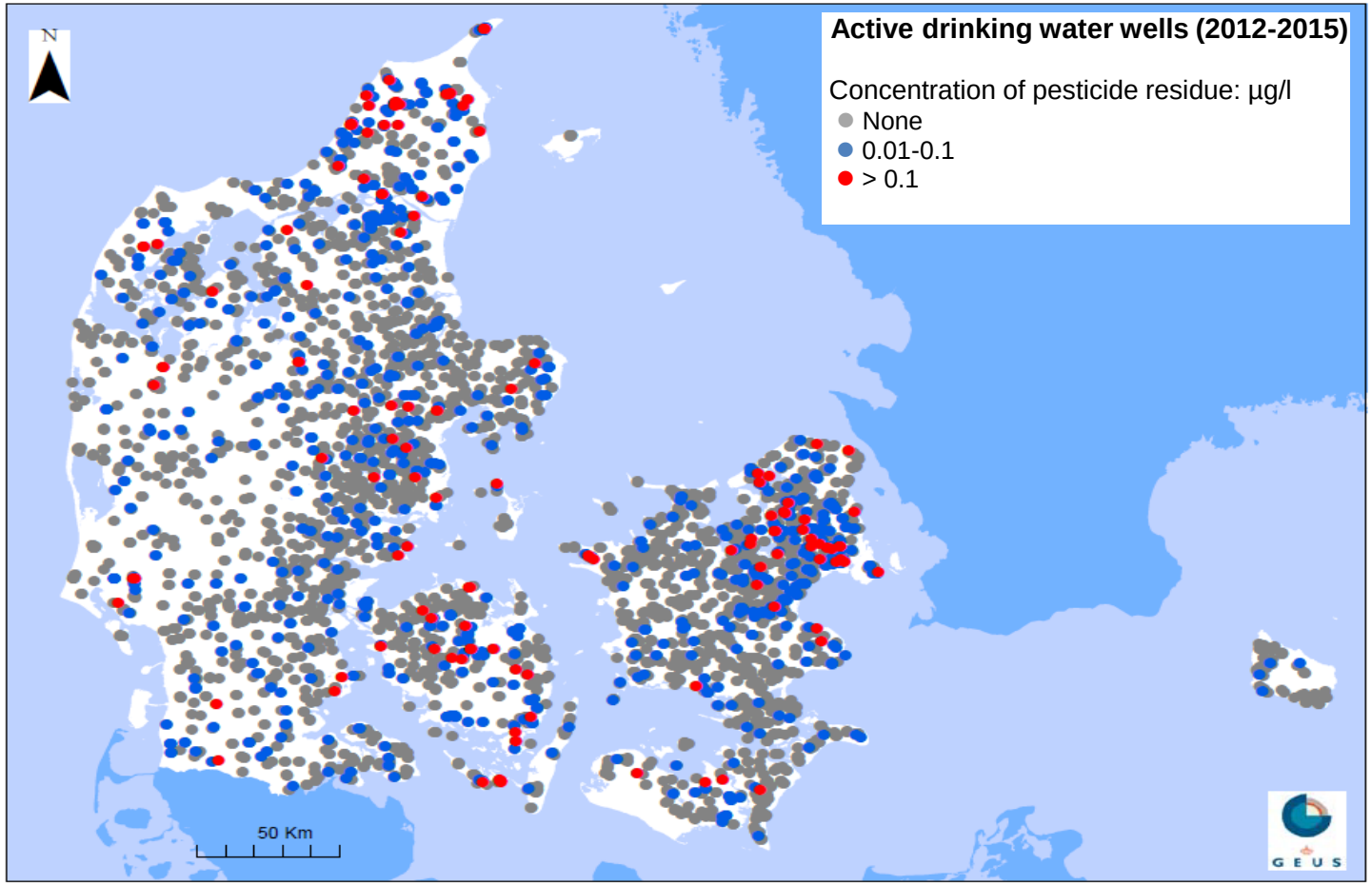
Introduction

Map of pesticide contamination



- Found in 27% of active DW wells
- > 0.1 µg/L in 3.6%
- 130 wells were closed within 1993-2009

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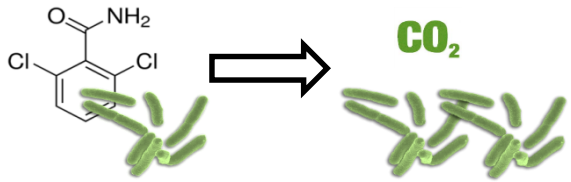
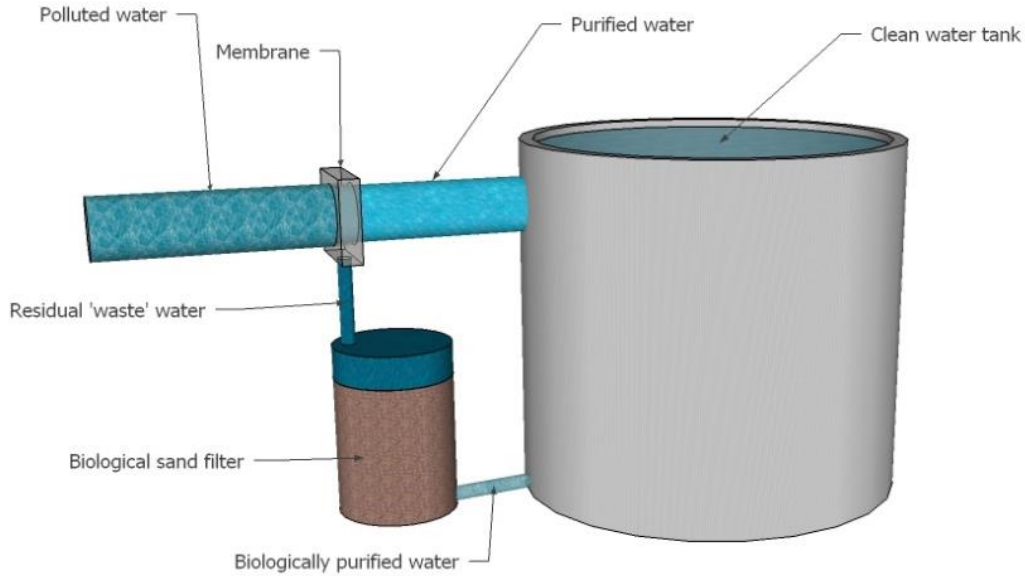
Water teatment

Membrane separation:
~ 90% ultra pure water
~ 10% residual ‘waste’ water with high concentration of pollutants, carbon, minerals etc.

Biofilter:
Added specific pesticide degrader organisms to sand filters





Ellegaard-Jensen et al. 2017

Mineralization
Treated concentrate is mixed with permeate

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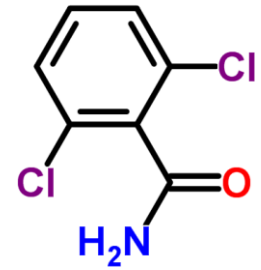
Studied pesticides

1. BAM (2-6 Dichlorobenzamide)

   MW: 190.028 g/mol

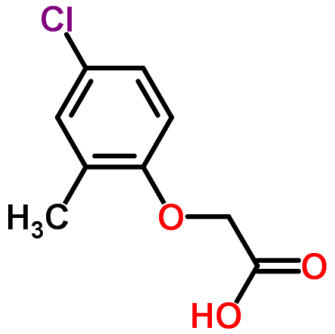
   transformation product of Dichlobenil



In 2015, Found in 16% of sampled wells of which 9.4% was above 0.1 µg/L.

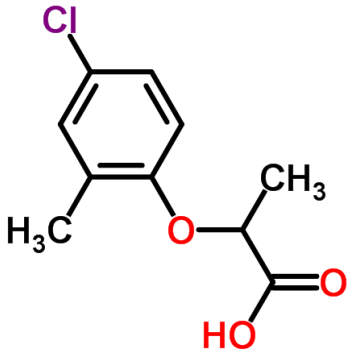
2. MCPA (2-methyl-4-chlorophenoxyacetic acid)

   MW: 200.62 g/mol



3. MCPP (methylchlorophenoxypropionic acid)

   MW: 214.65 g/mol



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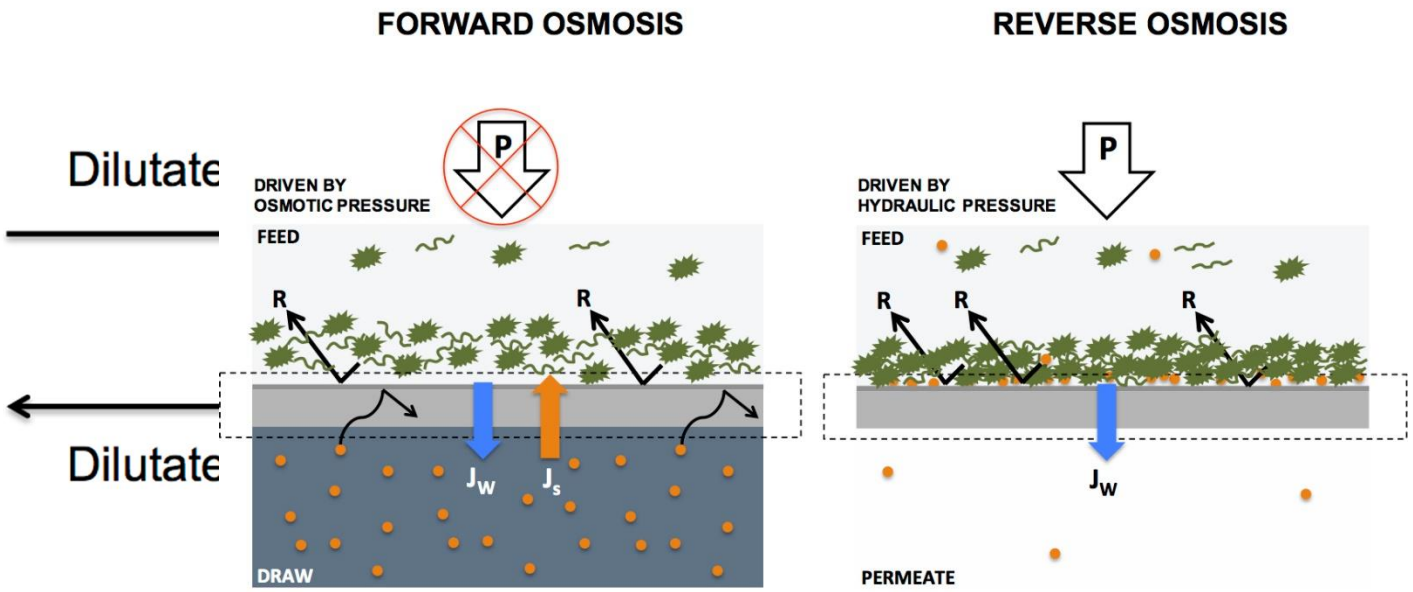
Forward Osmosis

Advantages of FO process

- Less energy requireme
- Less risk of fouling/sca



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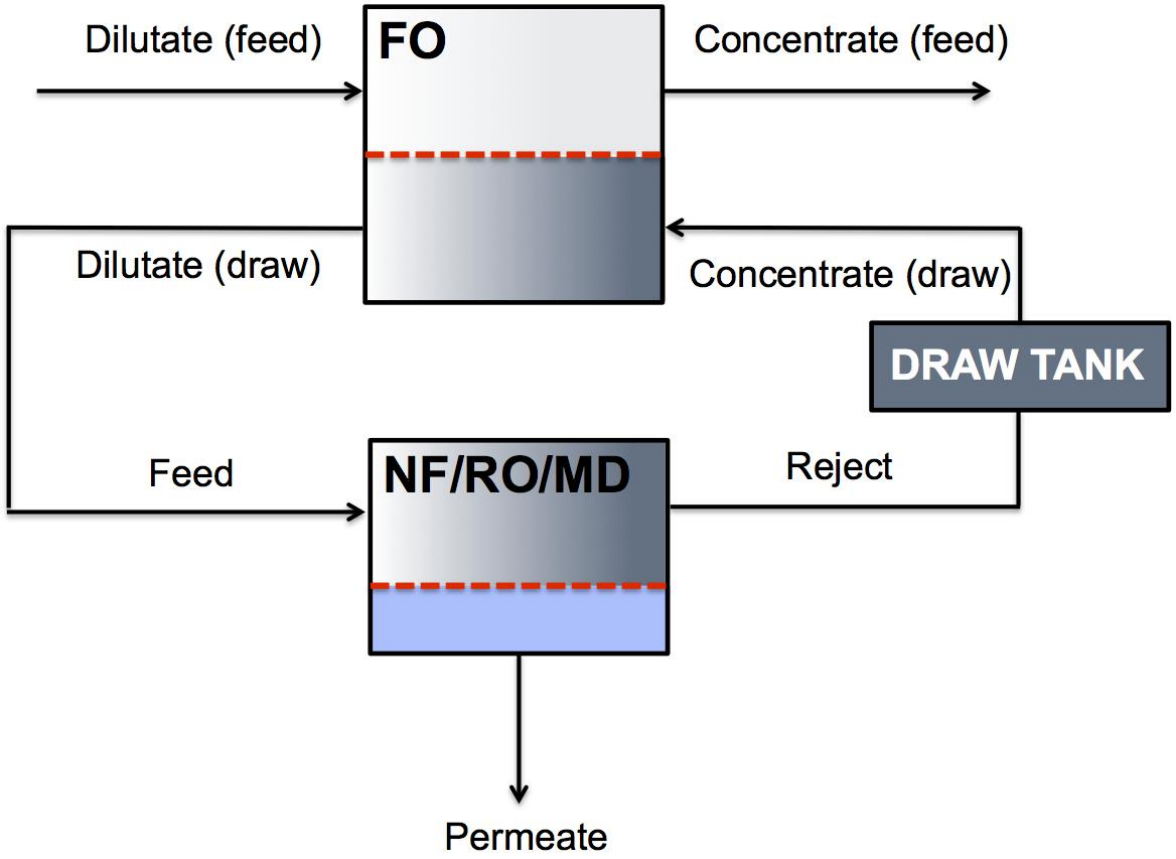
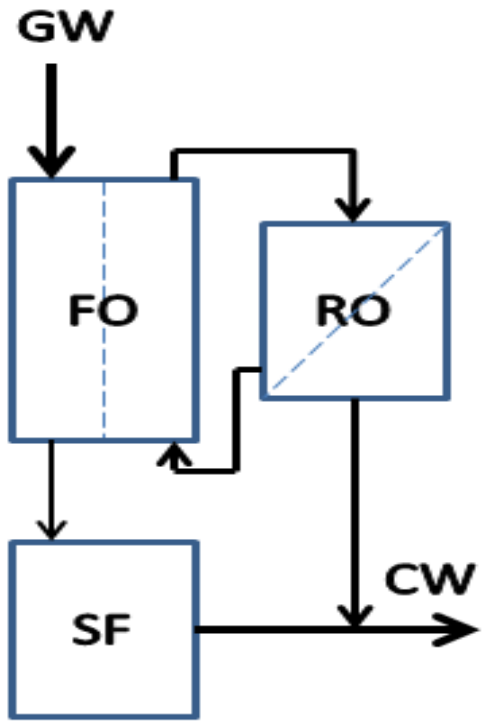
Use of FO in MEM2BIO project





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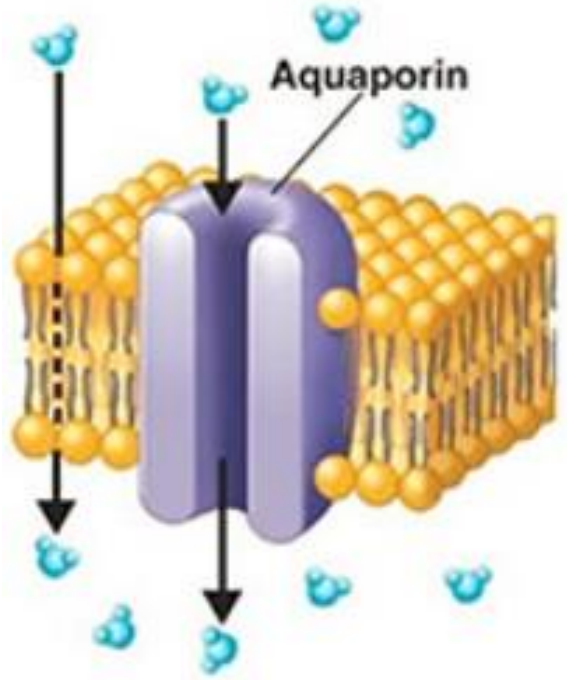
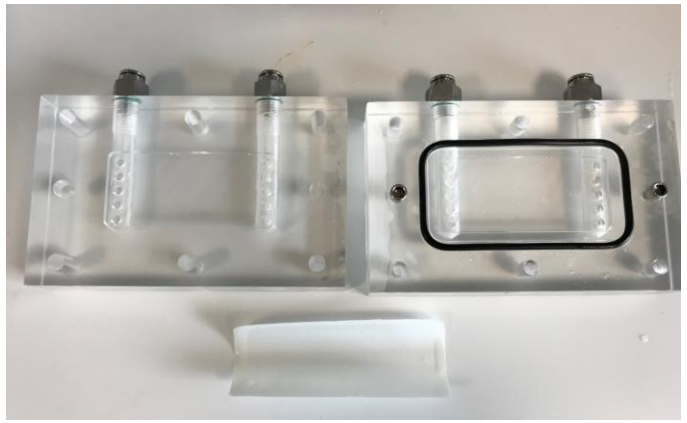
Aquaporin FO membrane



- Incorporated aquaporin proteins in the membrane
- Higher permeability compared to traditional FO membranes



34 cm^2

2.3 m^2

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FO setups

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Membrane characterization

Parameter	Value
NaCl rejection in RO (%)	99.4 ± 0.2
Pure water permeate flux (LMH)	15.2 ± 0.6
Reverse salt flux (g m^{-2} h^{-1})	5.6 ± 0.5 (1.7 ± 0.4 by HF)
Water permeability, A (L m^{-2} h^{-1} bar)	3.0 ± 0.2
Salt permeability, B (L m^{-2} h^{-1})	0.1 ± 0.03
Membrane structural parameter, S (µm)	305 ± 43
Contact angle (˚)	28.6 ± 3.4
Zeta potential at pH=5.3 (mV)	- 21 ± 2

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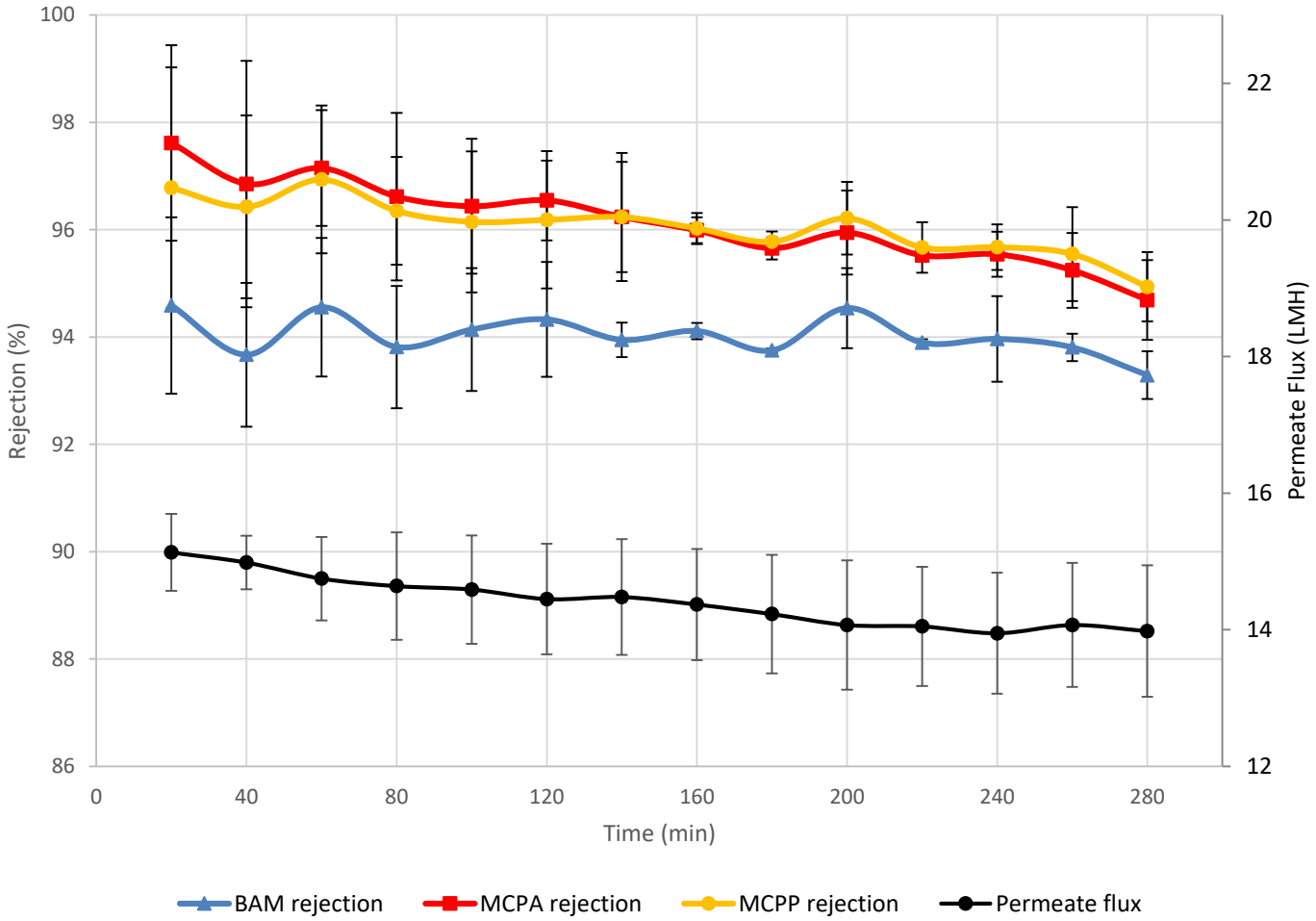
Pesticides rejection in pure water

- Feed 2 L, 1 mg/L
- Draw 200 mL, 1 M NaCl
- Flat sheet membrane



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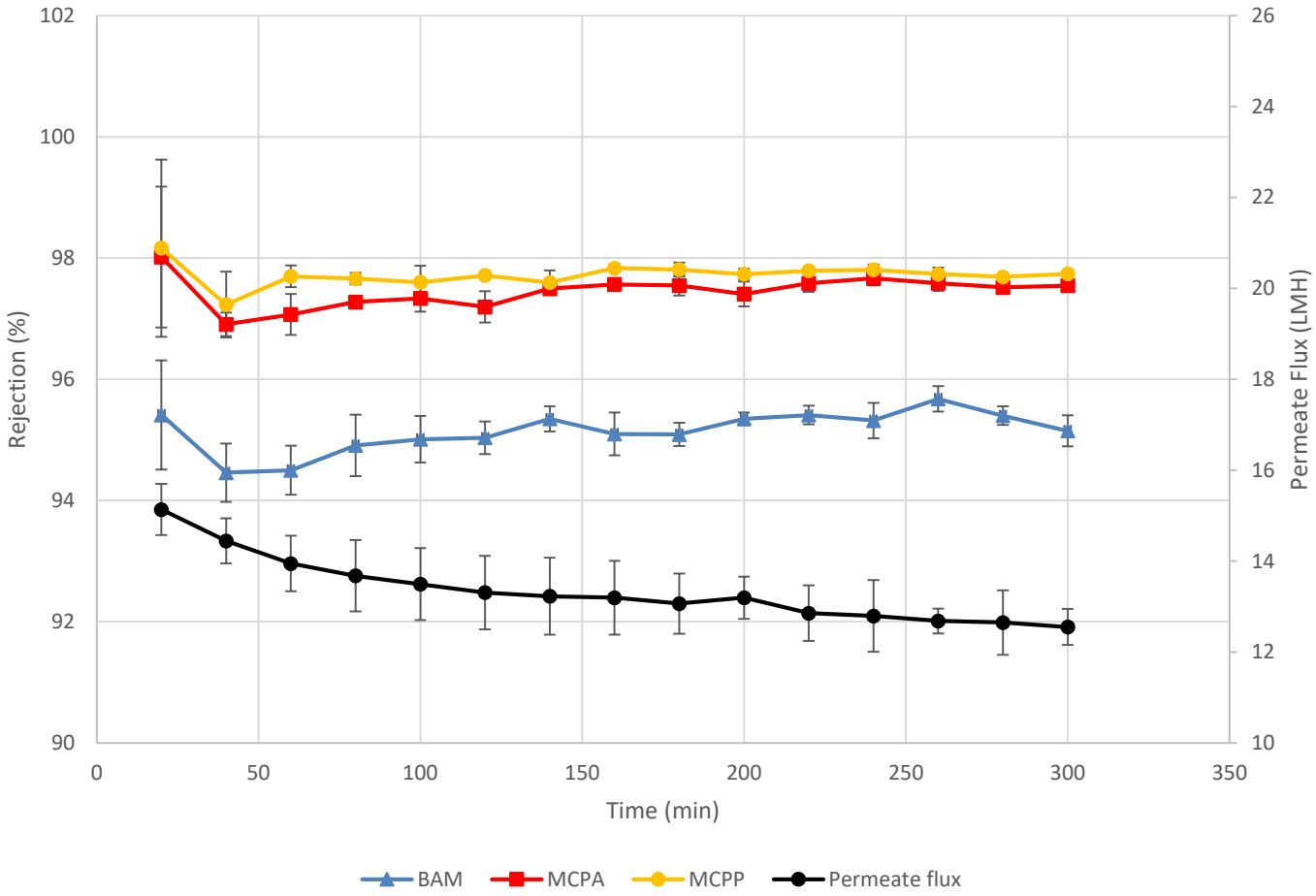
Pesticides rejection in Varde water

- Feed 2 L, 1 mg/L
- Draw 200 mL, 1 M NaCl
- Flat sheet membrane



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Pesticides rejection by different setups

	BAM (%)	MCPA (%)	MCPP (%)	Pure water permeate Flux (LMH)
Hollow fiber	98.1	98.6	98.9	15.8
Flat sheet	93.3	94.7	94.9	15.2
Small FO compartment	97.2	-	-	9.4

H. Madsen et. al., Journal of Membrane Science 476 (2015) 469–474

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Future work

- Use of the other water samples from Kolding and Hvidovre.
- Use of the other draw solutes: Glucose and Sodium acetate
- Study of effect of recovery on the membrane performance.
- Production of concentrates for biological treatment using different draw solutes
- Comparison of RO and FO in terms of scaling propensity
- Combination of FO and RO as an integrated membrane process.

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