A hybrid hollow fiber nanofiltration process for organic micropollutant removal from wastewater

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Twente membranes

The Netherlands

17.5 million people

Background

If you combine the mass of all pharmaceutical residues, what is the amount of pharmaceutical residues that ends up in surface waters in the Netherlands, expressed as
pills of ibuprofen/person/year?

190 t/year (RIVM)

17.5 million people

200 mg ibuprofen/pill

54 pills/person/year

RIVM report 2020-0088

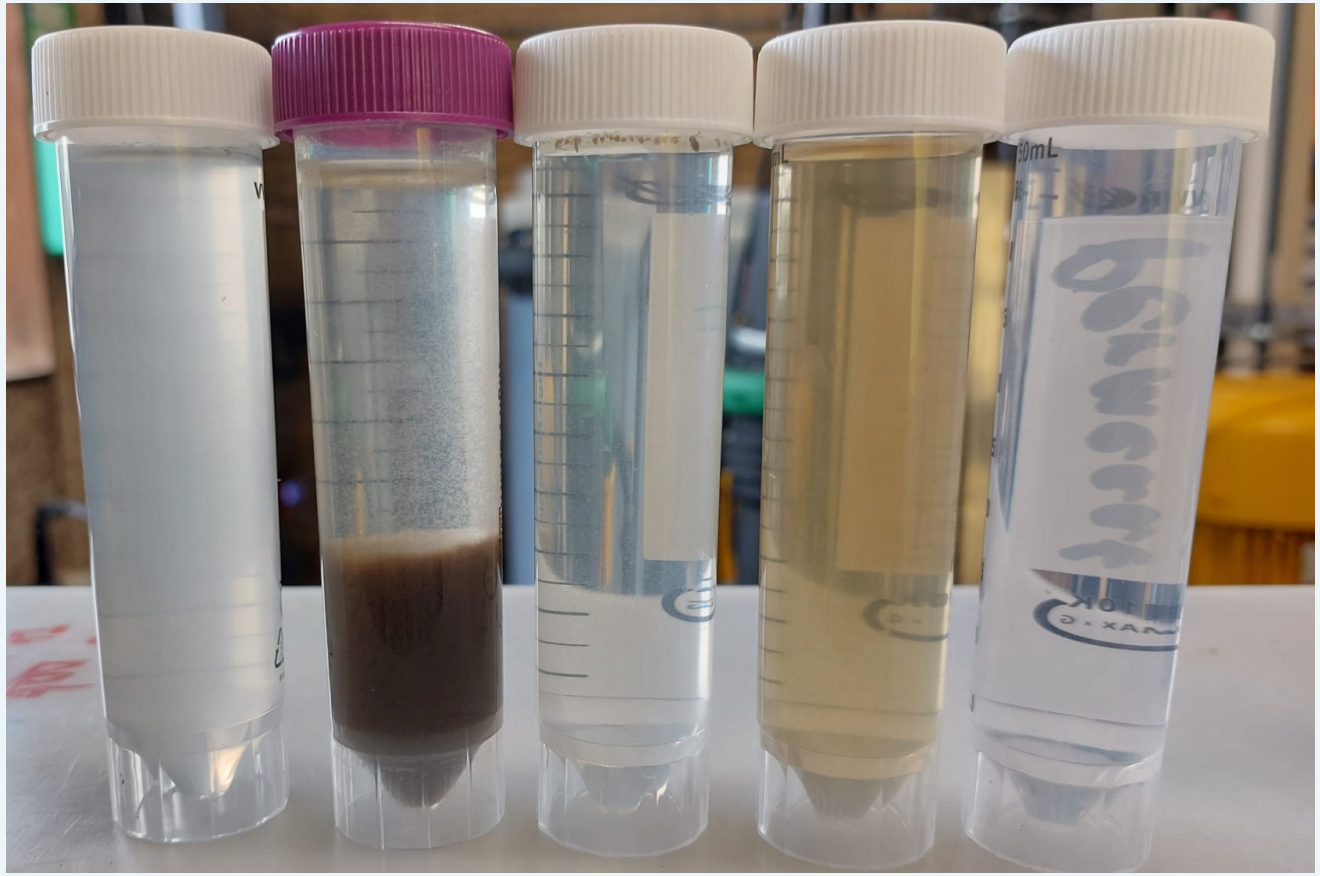
Potential solution

Pilot plant

Inflow of 1 m^3/h
Miniature version of full-sc

Total membrane area 90 m^2
Hollow fiber dNF40 membrane by NX Filtration
Freedom in process conditions/staging
Automated hydraulic and chemical cleaning
Only screen filter as pre-treatment

Process steps



Pre-settled Influent

Effluent

Permeate

Bioreactor

Concentrate

Research goals

Test feasibility of concentrate recirculation for

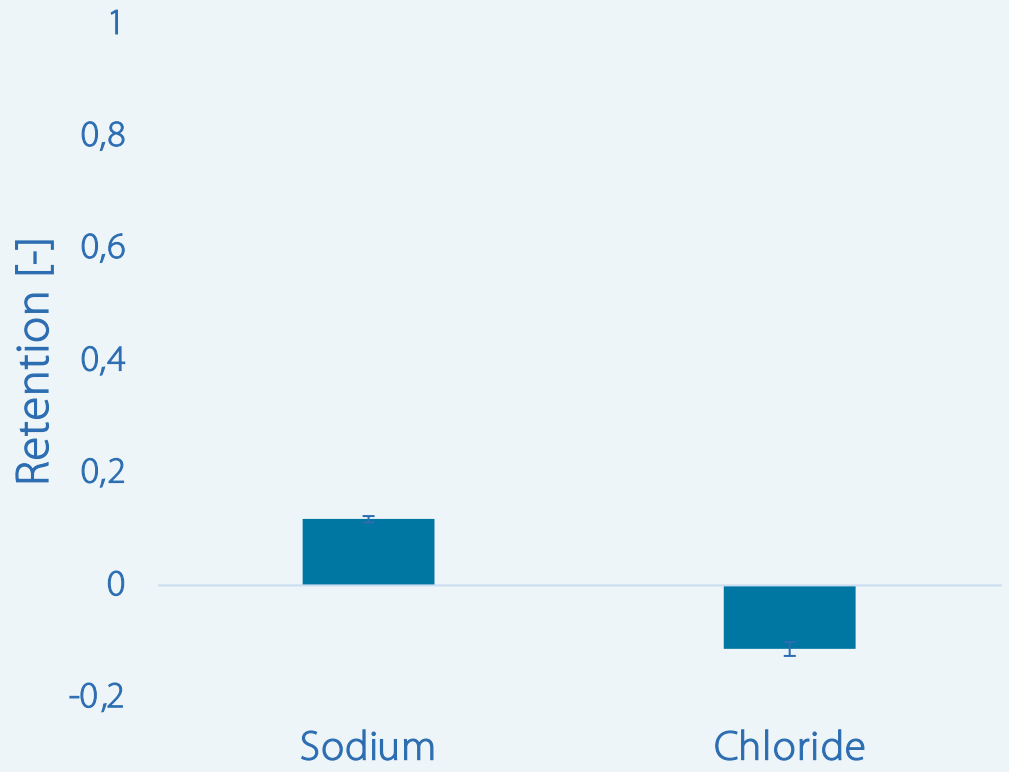
- Zero-liquid discharge
- OMP removal

Subtopics:

- Determine performance without concentrate recirculation for different process conditions
- Initiate recirculation of concentrate and monitor effects on accumulation/removal of ions and OMPs

Retention: ions

Flux of 11 LMH
Crossflow of 0.4 m/s
80% recovery



Low monovalent ion retention

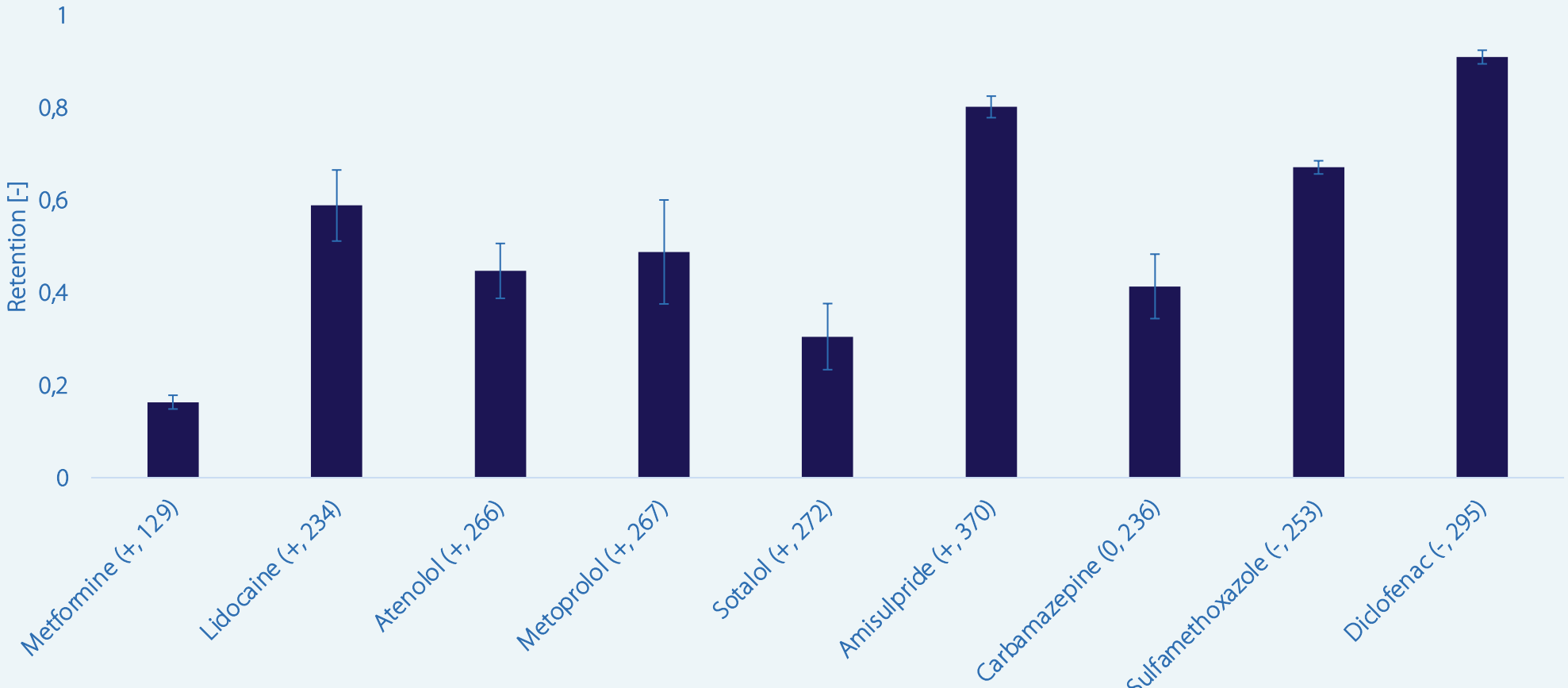
Limited accumulation when recirculating

High (negative) multivalent ion retention

More accumulation

Retention: OMPs

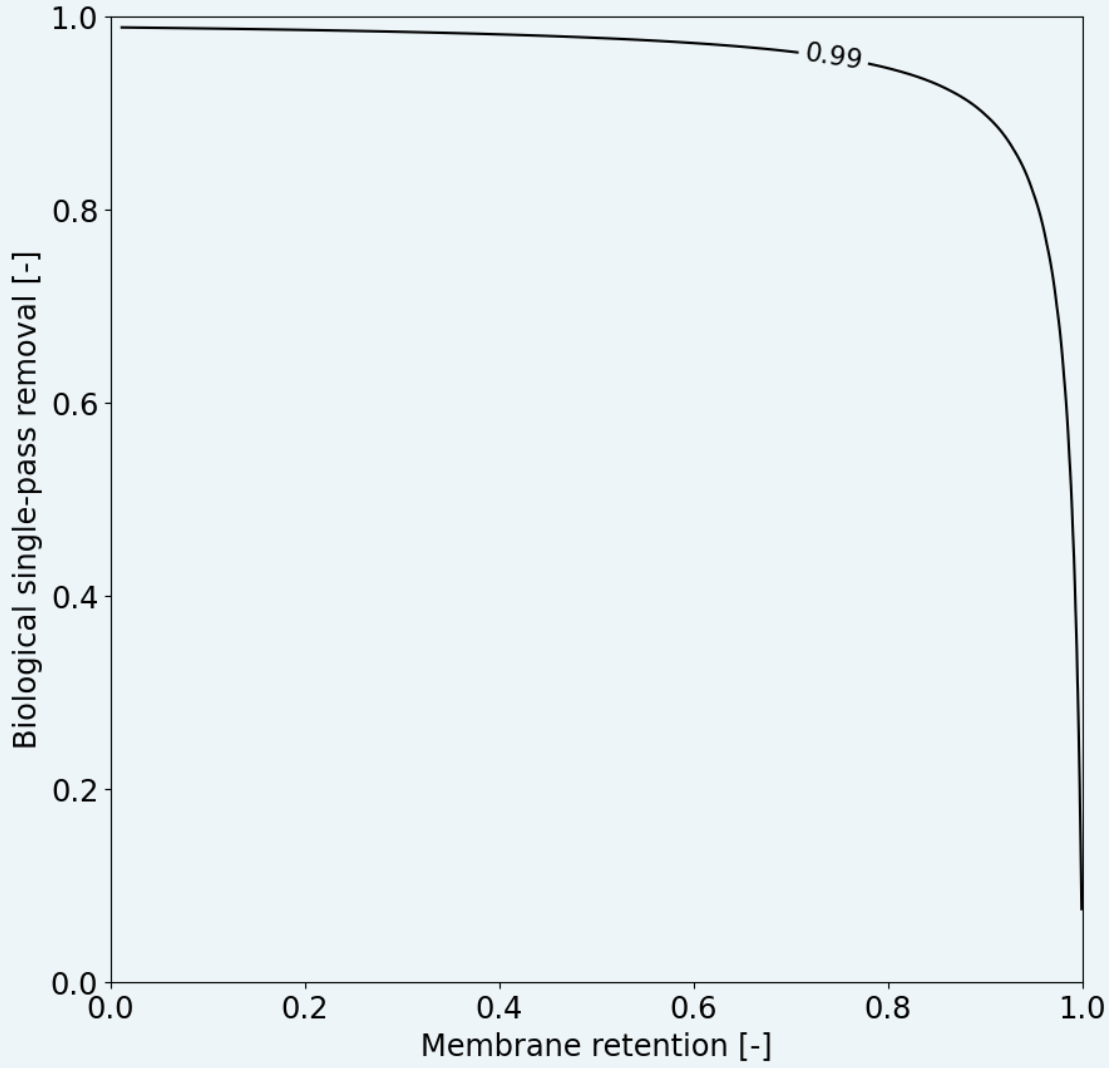
Flux of 11 LMH
Crossflow of 0.4 m/s
80% recovery



Retention affected by molecular weight and charge
Depends on target components

Total removal with concentrate recirculation

- Based on:
  - Measured biological removal without concentrate recirculation
  - NF retention
  - First order degradation kinetics
- Lines indicate predicted total removal



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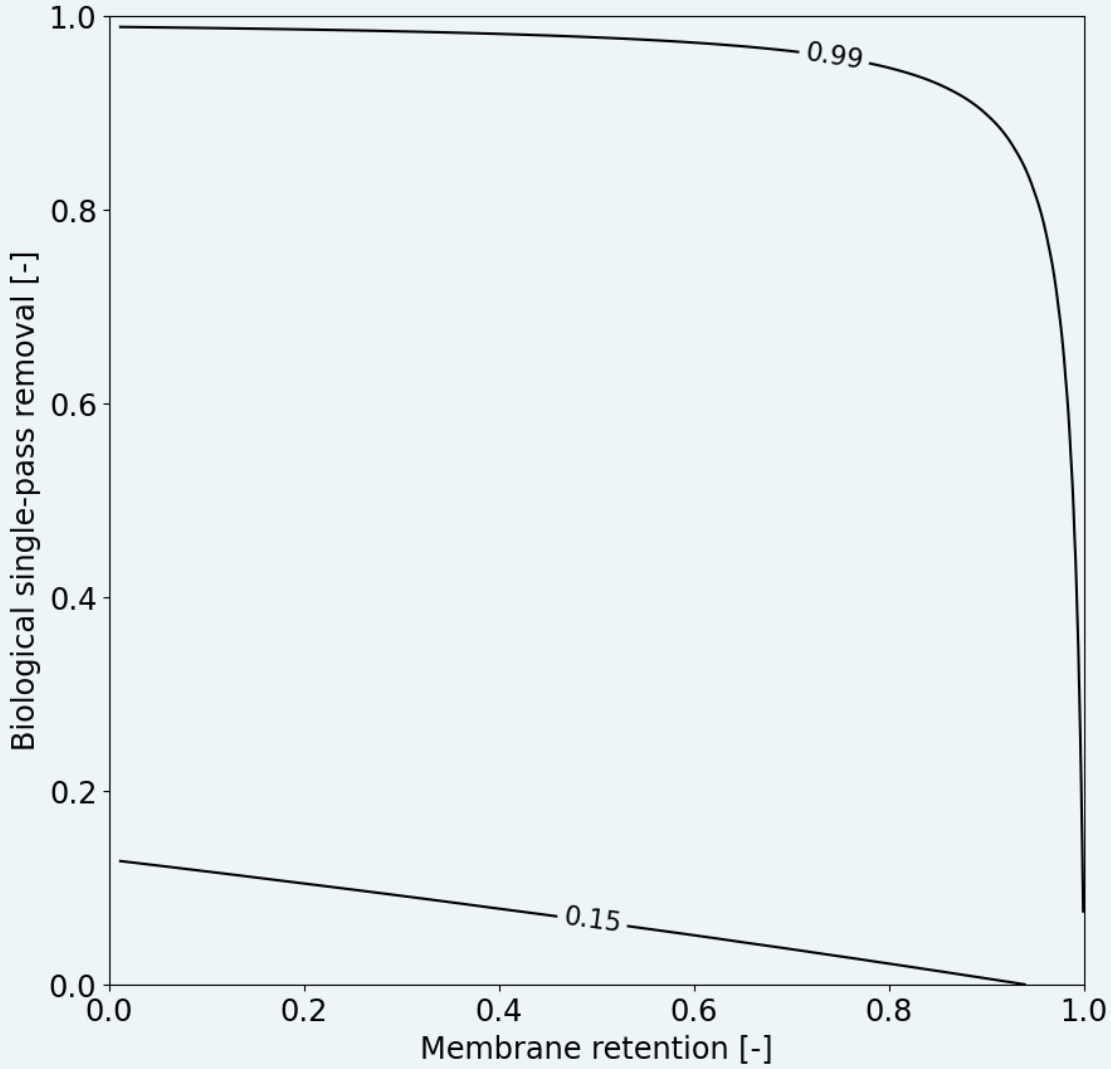

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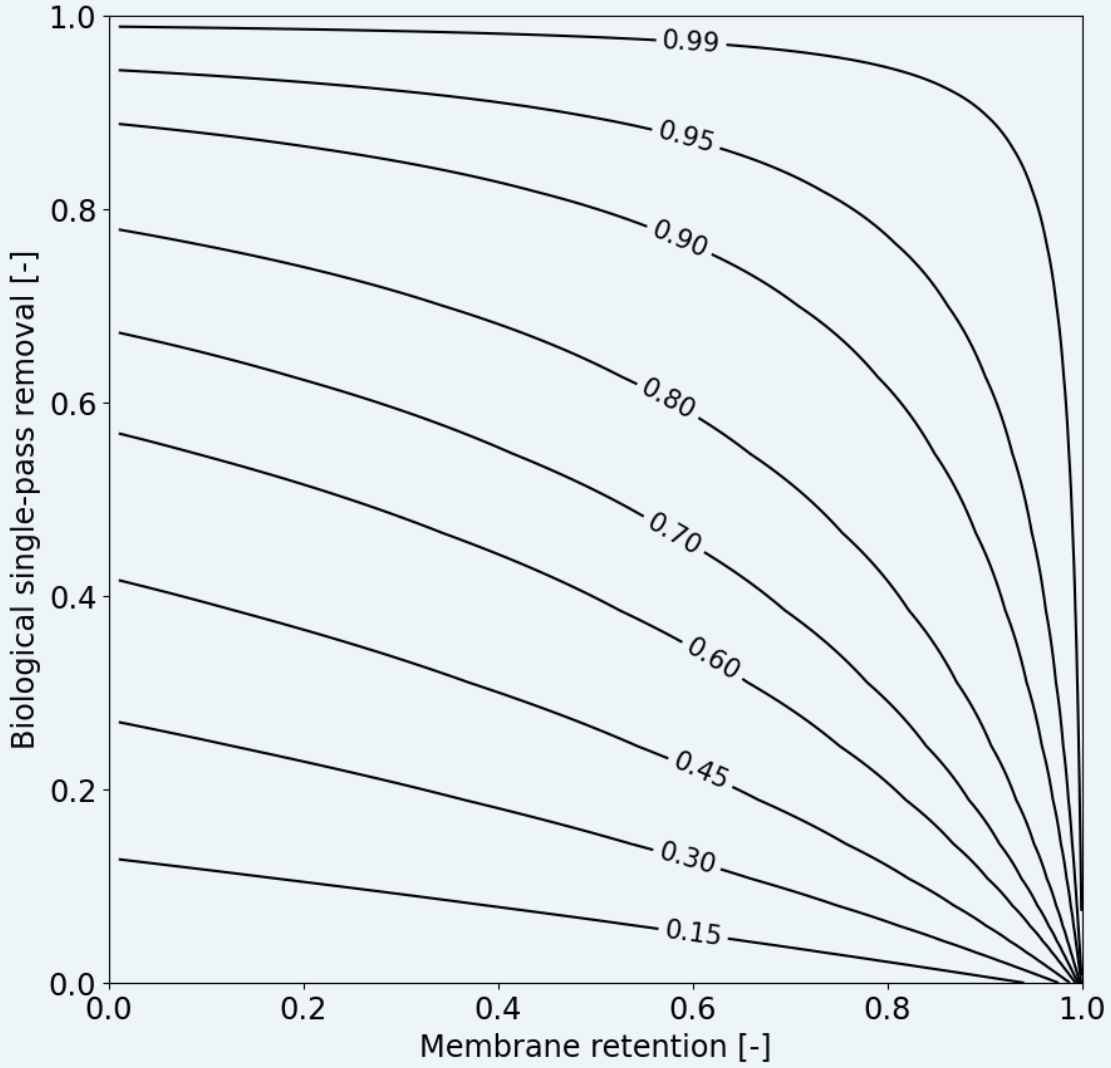
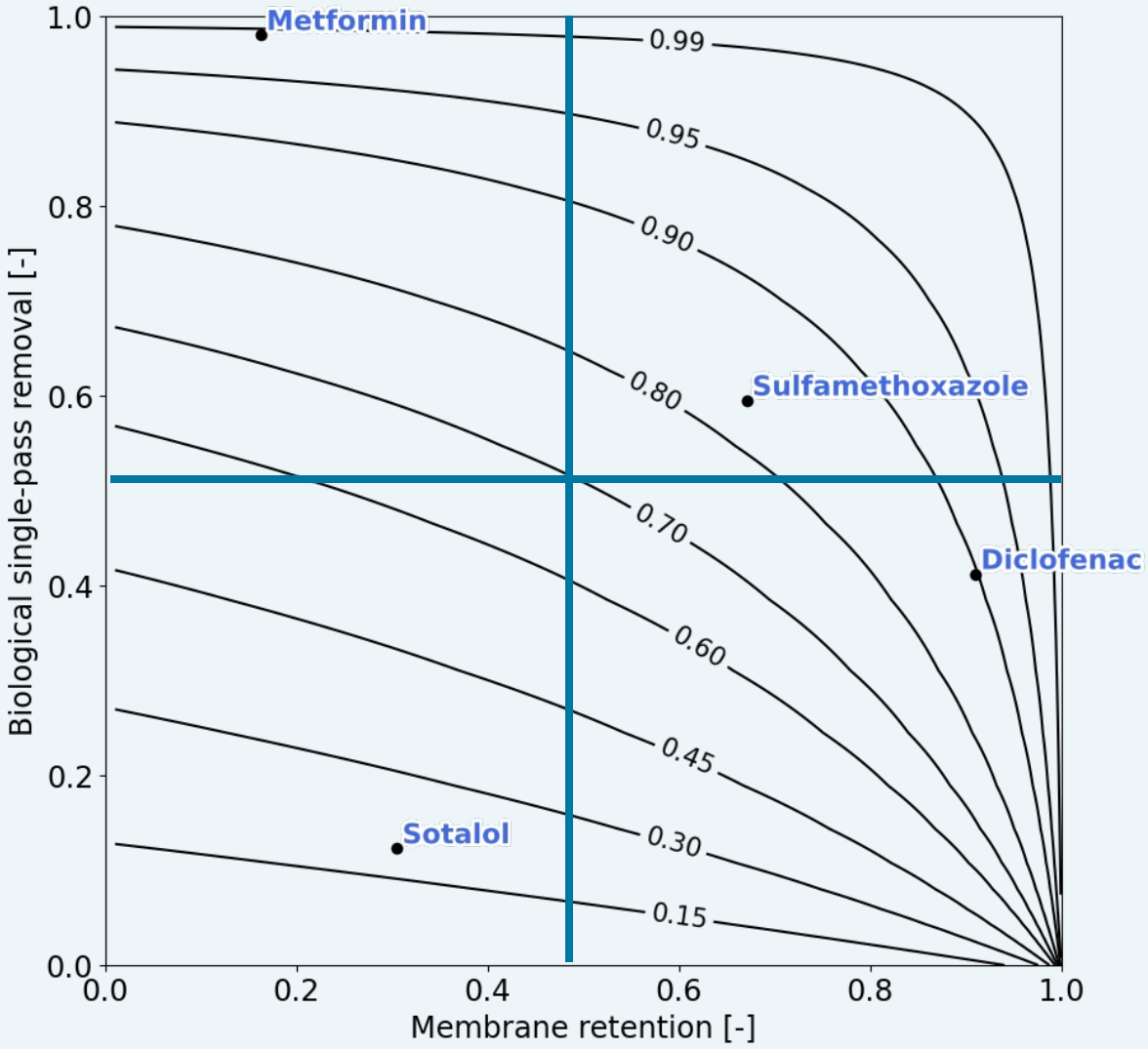


Total removal with concentrate recirculation

- Based on:
  - Measured biological removal without concentrate recirculation
  - NF retention
  - First order degradation kinetics
- Lines indicate predicted total removal
  - In four quadrants

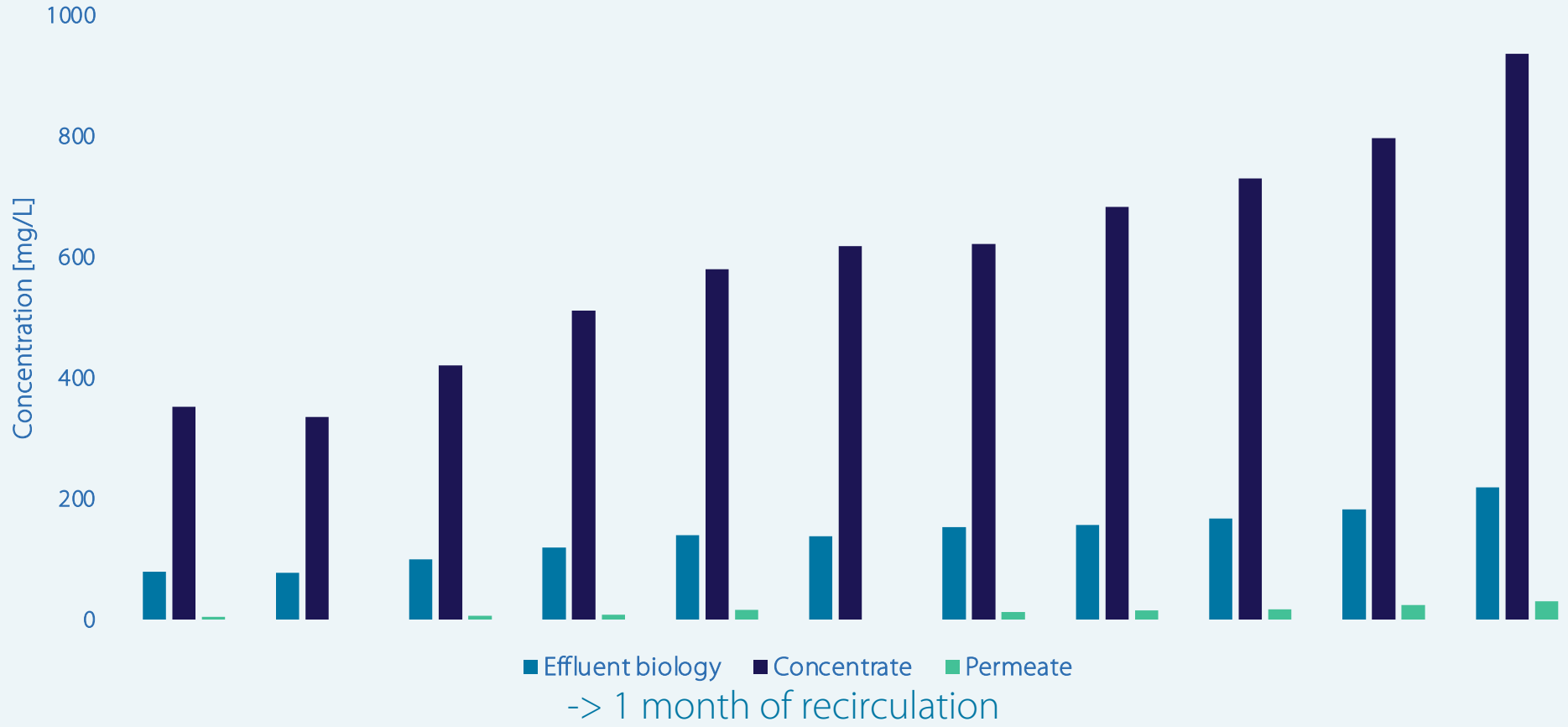


Let's find out in practice!

- Mild NF conditions:
  - Flux of 11 LMH
  - Crossflow of 0.4 m/s
  - 80% recovery

Sulfate concentration

Flux of 11 LMH
Crossflow of 0.4 m/s
80% recovery

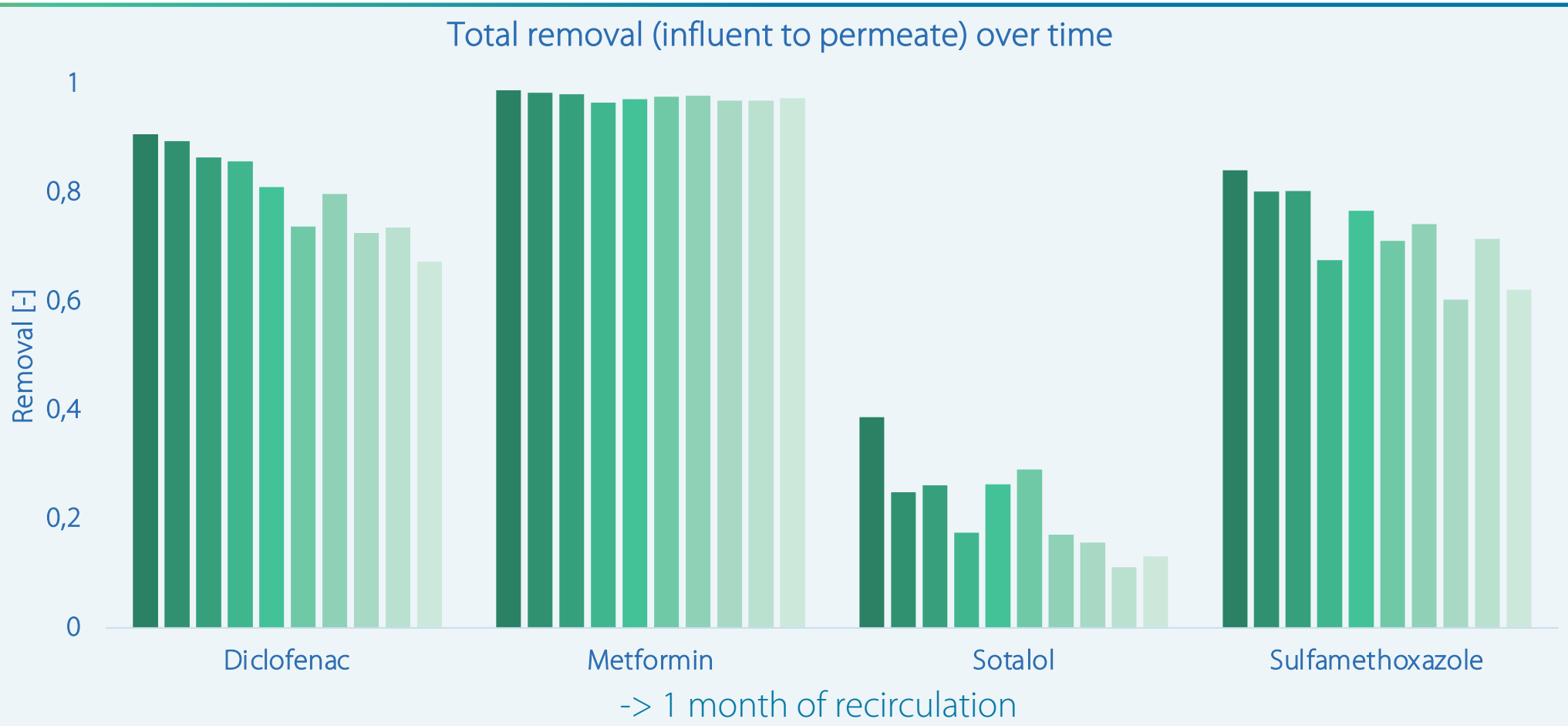


-> 1 month of recirculation

High accumulation of sulfate visible

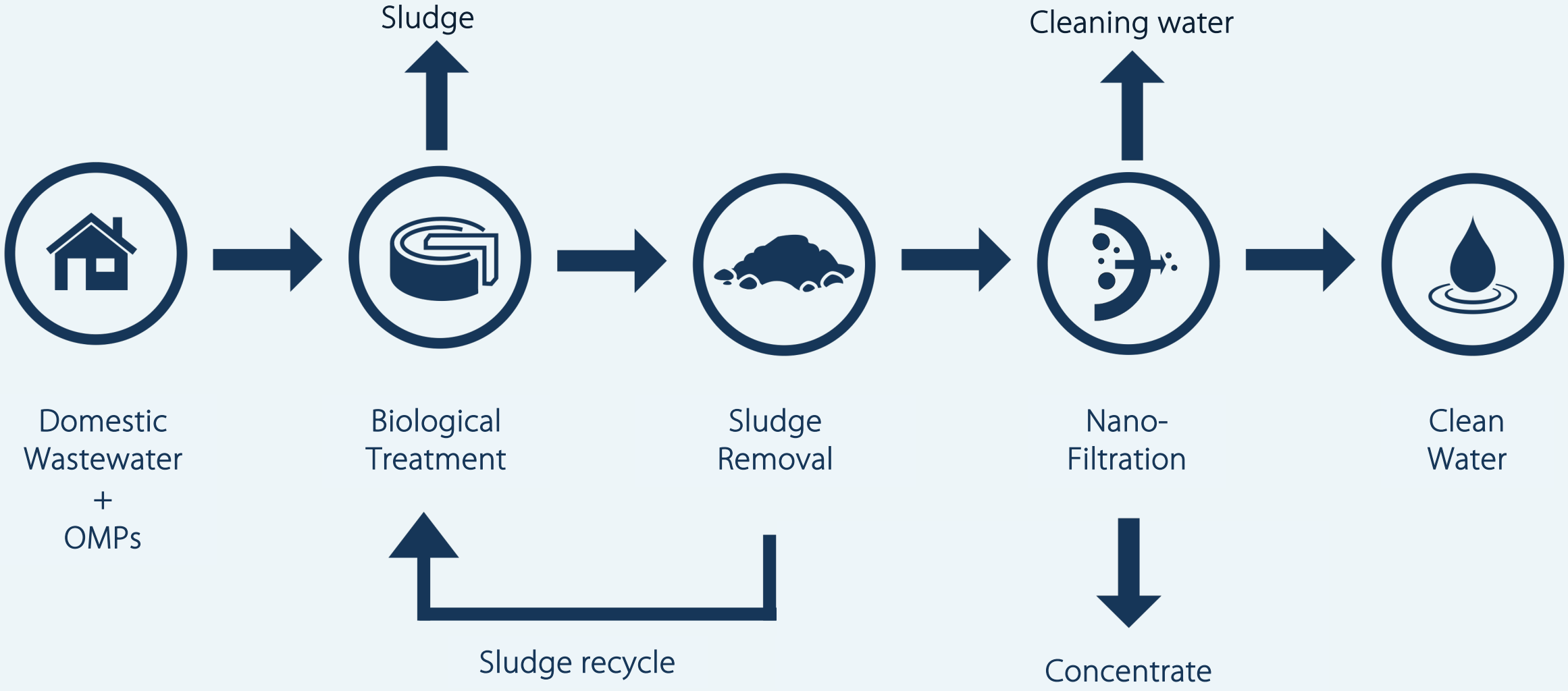
OMP removal since recirculation

Flux of 11 LMH
Crossflow of 0.4 m/s
80% recovery



Compared to no concentrate recirculation, slight decrease in total removal for some OMPs as expected
OMPs accumulate, so the output of biology contains more OMPs, which also end up in permeate
Long term effects most important but still unknown

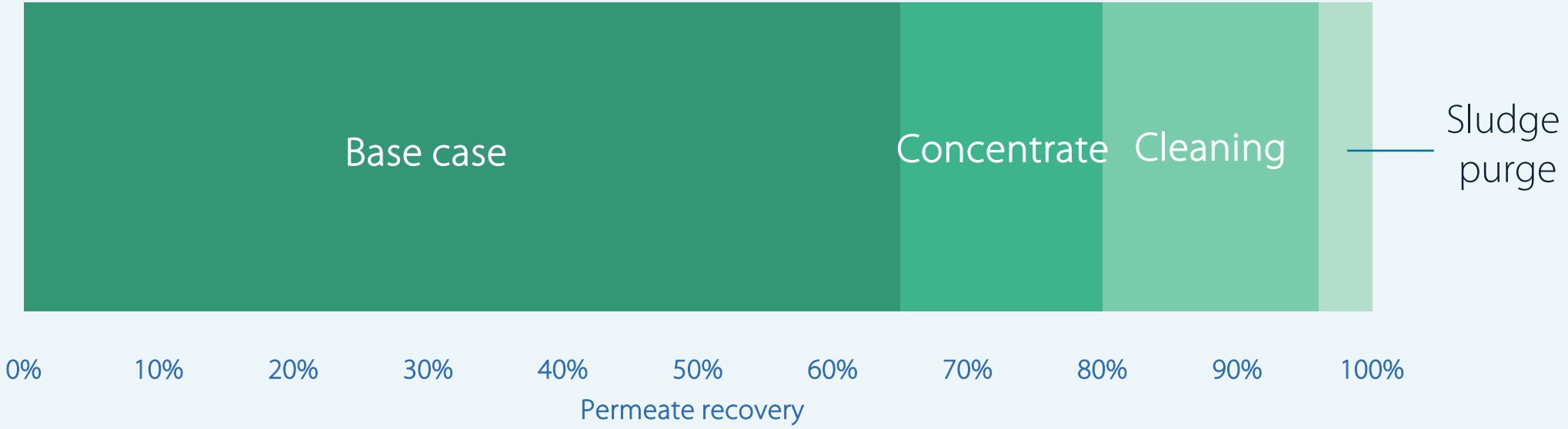
How much water do we still lose on the way?



Estimated permeate recovery

m^3 permeate/m^3 influent bio

Largest part of accumulation is still to come, and will make it more representative for full-scale treatment plant



Summary

- A hybrid process with biology and NF concentrate recirculation can substantially remove OMPs
- Recirculation of concentrate is initiated, showing expected accumulation of multivalent ions and OMPs

- Next steps will include to decrease loss of water on the way
- Time will tell if biology can adapt to higher concentrations and improve removal of OMPs

Acknowledgements

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