Matrix Effects on the Removal of Pharmaceuticals from Wastewater through Filtration with Multi-Channel Mixed-Matrix Membranes

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Content

Introduction

- Water pollution
- Fourth treatment step
- Multi-channel Mixed-matrix Membranes

Methods

- Membrane production
- Removal of Micropollutants
- Matrix Effects

Results

- Characteristics of MCMMM
- pH effects on removal efficiency
- Wastewater matrix effects on removal efficiency

Summary and Outlook

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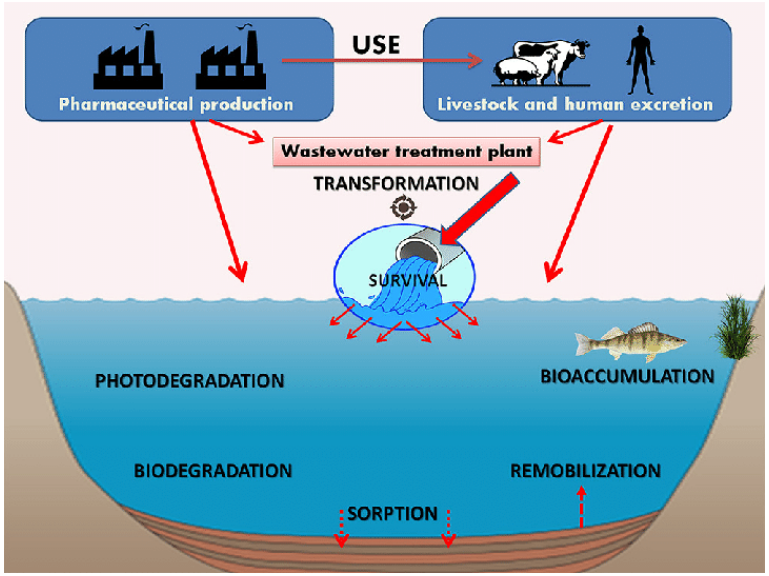
Summary and Outlook

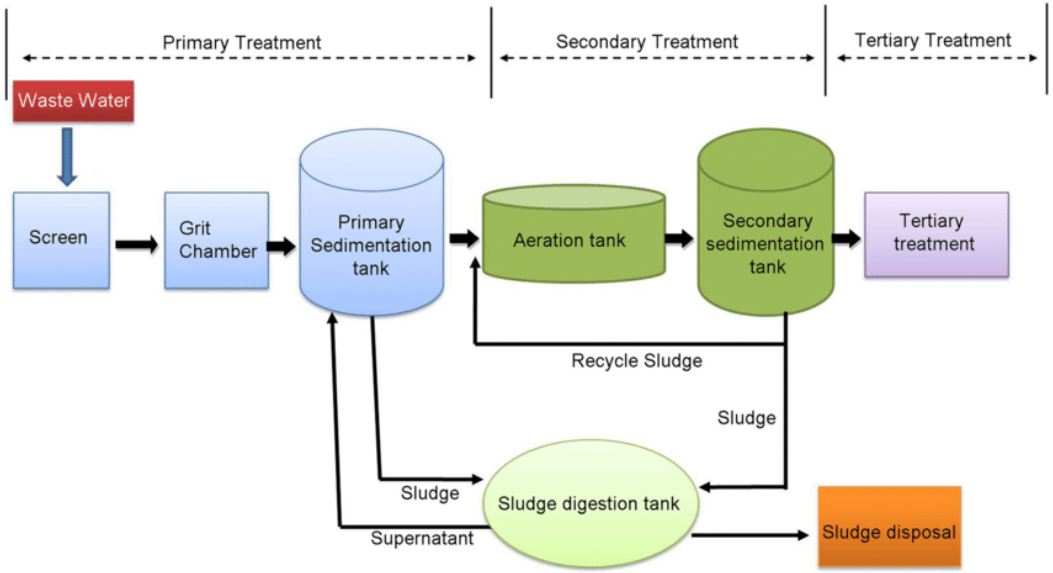
Water pollution through micropollutants worldwide

- Micropollutants: pharmaceuticals, personal care products, hormones, industrial chemicals etc.
- Released into the environment through waste water treatment plants
- Insufficiently removed → Accumulation in the environment



Rzymski, Piotr & Drewek, Agnieszka & Klimaszyk, Piotr. (2017). Pharmaceutical pollution of aquatic environment: an emerging and enormous challenge. Limnological Review. 17. 97-107. 10.1515/limre-2017-0010. [1]

Fourth treatment step: Status quo

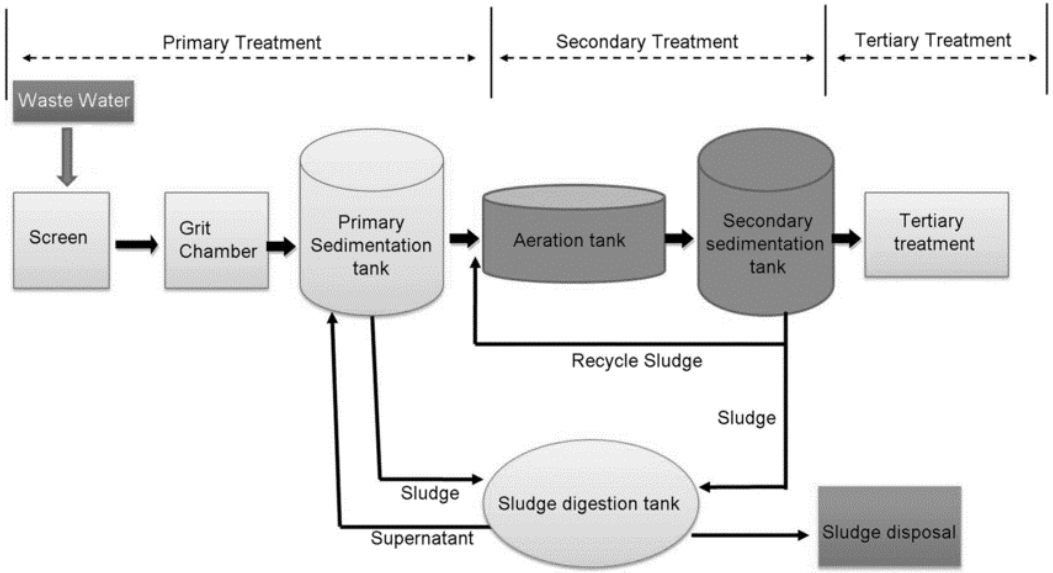


Chauhan, Jaspal & Kumar, Sudhir. (2020). Wastewater ferti-irrigation: an eco-technology for sustainable agriculture. Sustainable Water Resources Management. 6. 10.1007/s40899-020-00389-5. [2]

Fourth treatment step

- Adsorption
- Filtration
- Ozonation

Fourth treatment step: Status quo



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Fourth treatment steps applied in Switzerland since 2016

- **Adsorption**
- Filtration
- **Ozonation**

Fourth treatment step: Perspective

- **Combined Treatment strategies:**
- **One-step and multi step methods**
- **Combination of Filtration and Adsorption**

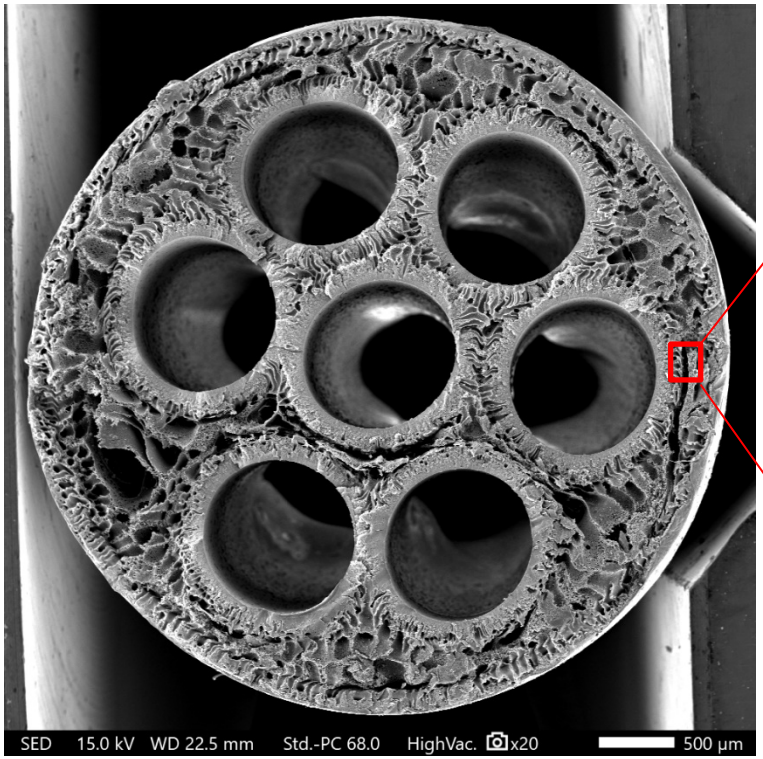
Drawbacks Adsorption (Powdered activated carbon):
- Low selectivity
- High temperature for regeneration
- Needs downstream filtration

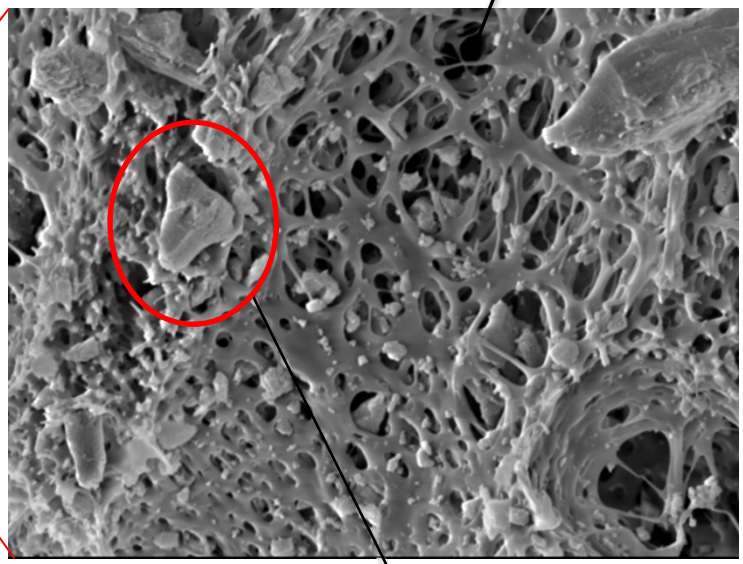
Drawbacks Filtration:
- Higher Energy demand for small pore sizes
- High pressures
- Fouling → Backwashing necessary

→ Multi-channel Mixed-Matrix Membranes

Multi-Channel Mixed-Matrix Membranen

- Combination of Filtration and Adsorption
- Powdered activated carbon particles embedded in polyethersulfone matrix

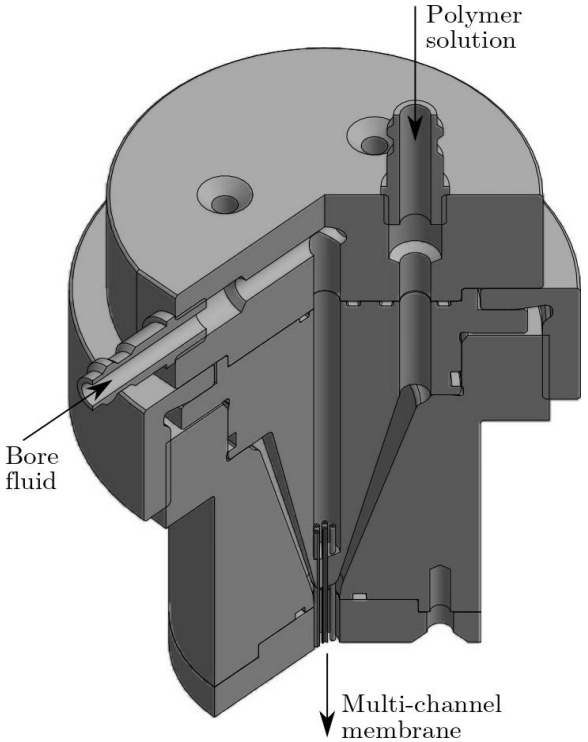




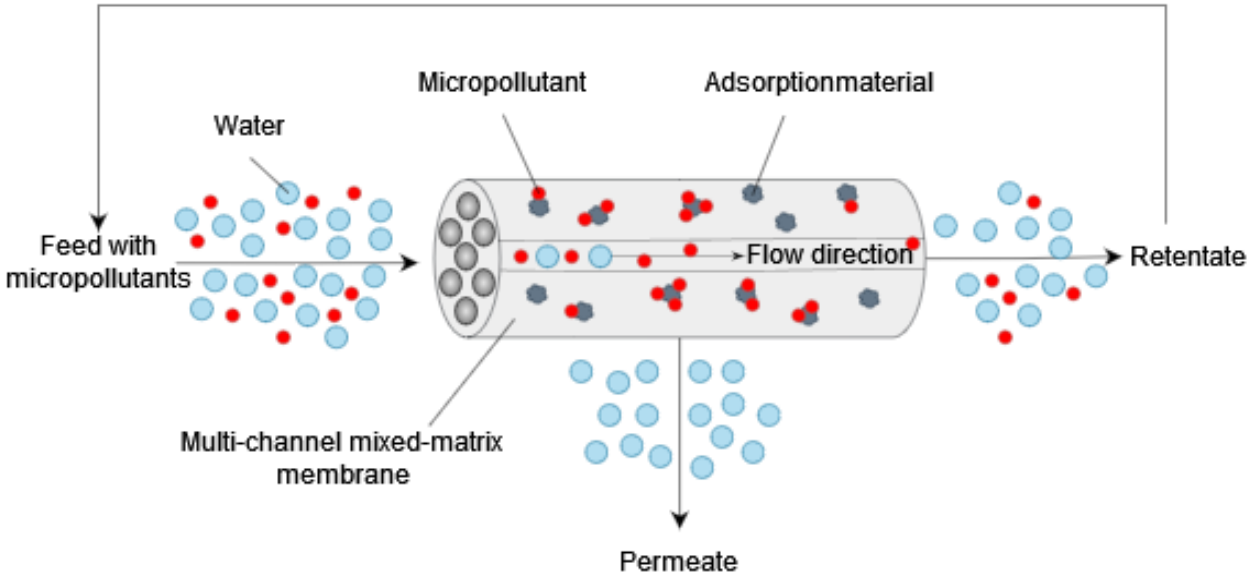
Content

Membrane production

- Polymeric solution
  - Polyethersulfone
  - 1,2-Propandiol
  - Polyvinylpyrrolidon
  - *N,N*-Dimethylacetamid
- Non-solvent induced phase separation
- Spinneret designed with seven channels
- Production of Multi-channel Mixed-matrix Membranes (MCMMM) with embedded powdered activated carbon particles



Removal of Micropollutants and Regeneration



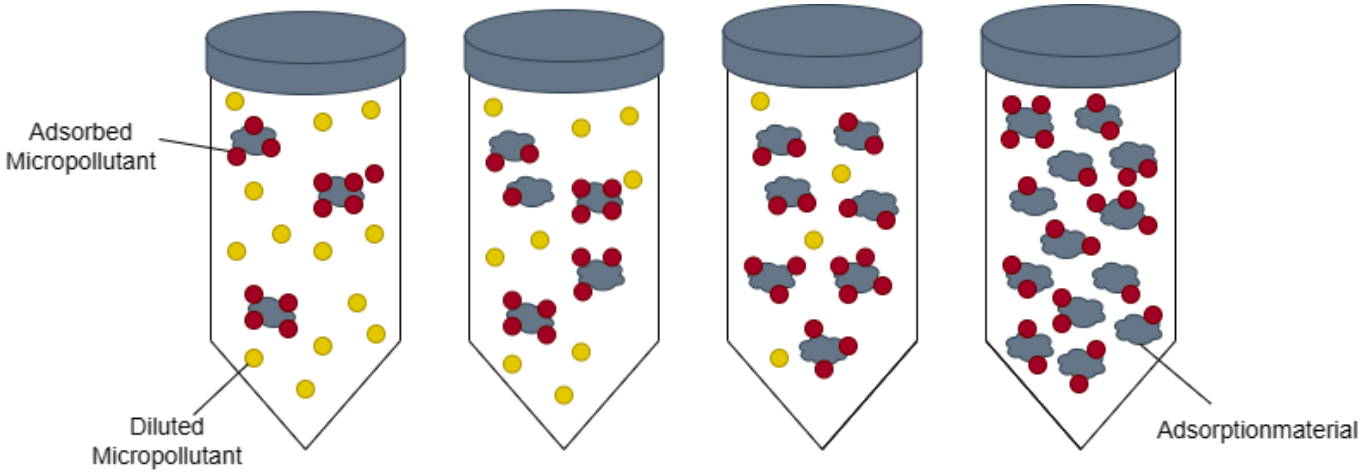
Reference Substances

- Carbamazepine
- Diclofenac
- Paracetamol

Regeneration

- 75 % ethanol in water
- 7 wt-% PAK in MCMMM
- 15 mg/L pharmaceuticals

Evaluation of Matrix-effects



pH

- Acidic 3.14
- Neutral 7.0
- Alkaline 11.67

Matrix wastewater

- Chemical Oxygen Demand (COD)
- pH-Value
- Conductivity

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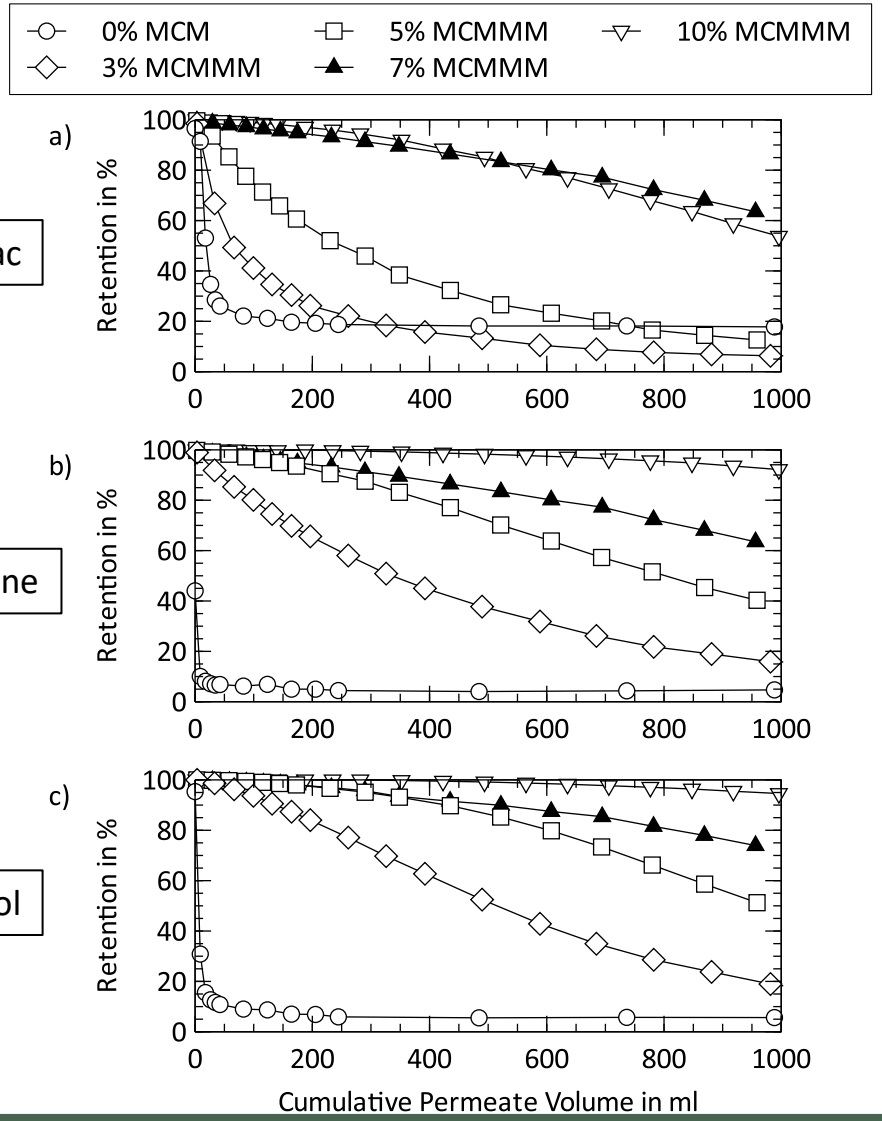
Micropollutant removal from Tap water

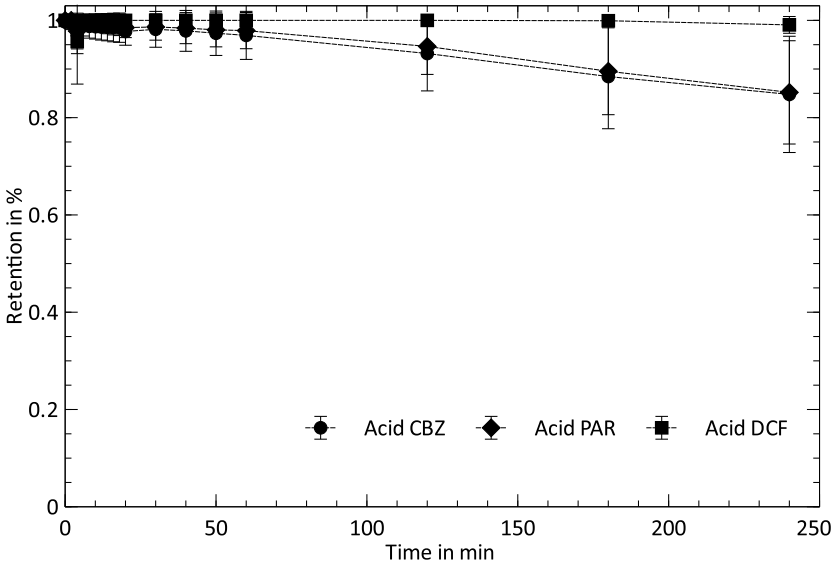
Filtration parameter:

- Flow: 40 L/h
- Transmembrane pressure (TMP): 1 bar
- Temperature: 20 °C
- Concentration: 15 mg/L pharmaceuticals
- Filtration volume: 1 L

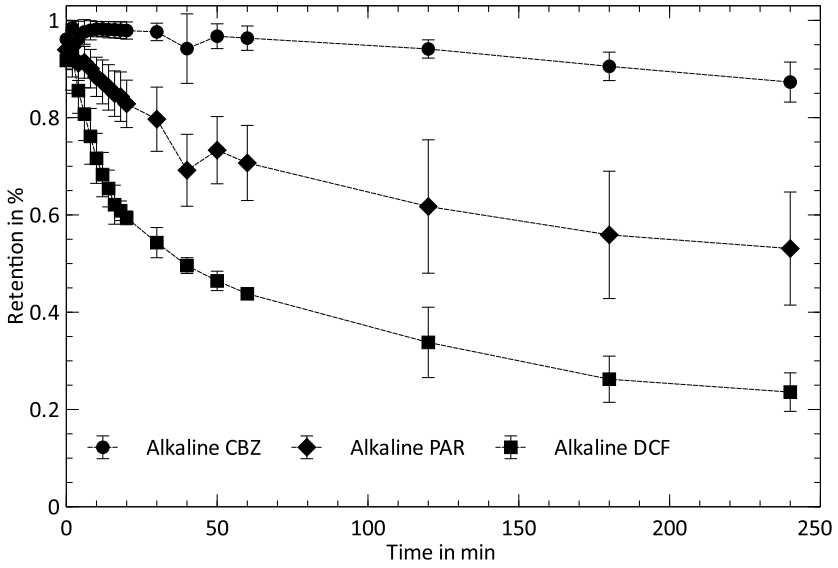


Micropollutant removal at different pH

Acidic (pH=3.17)



Alkaline (pH=11.67)



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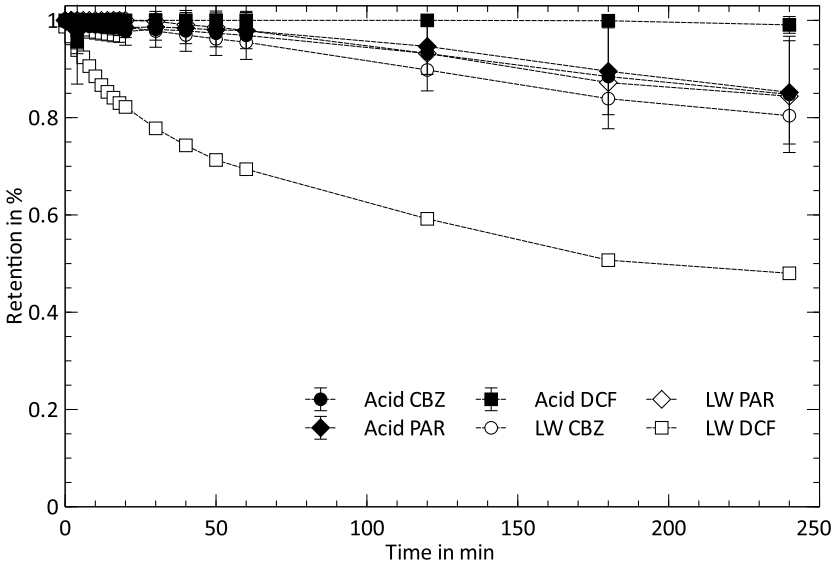
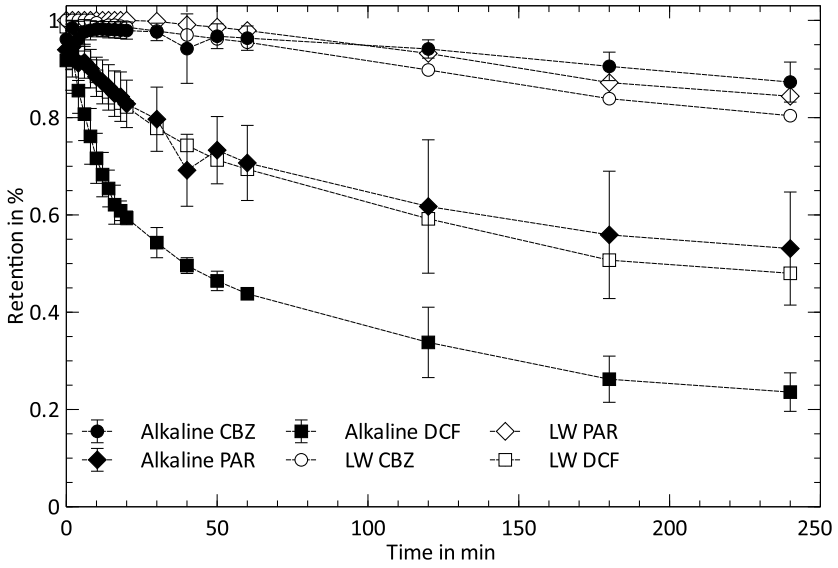
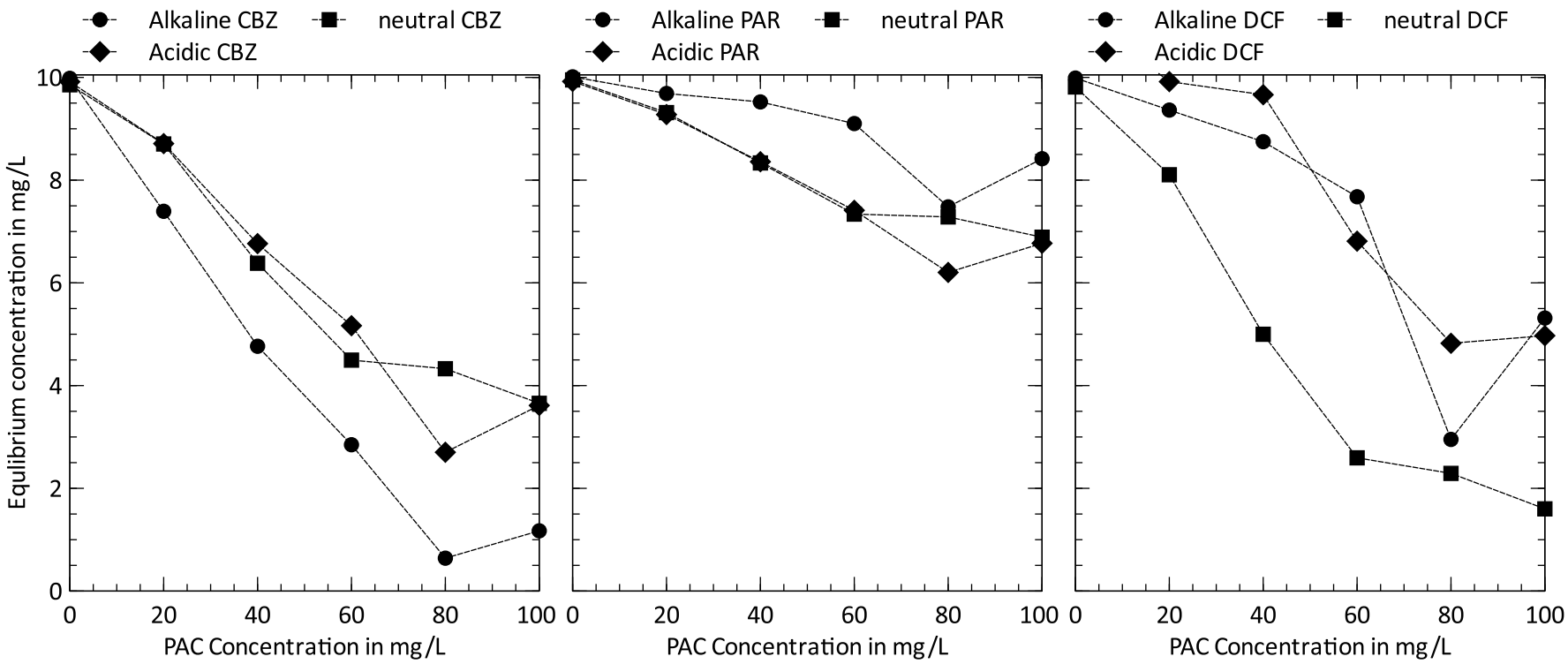


Alkaline (pH=11.67)



Adsorption at different pH

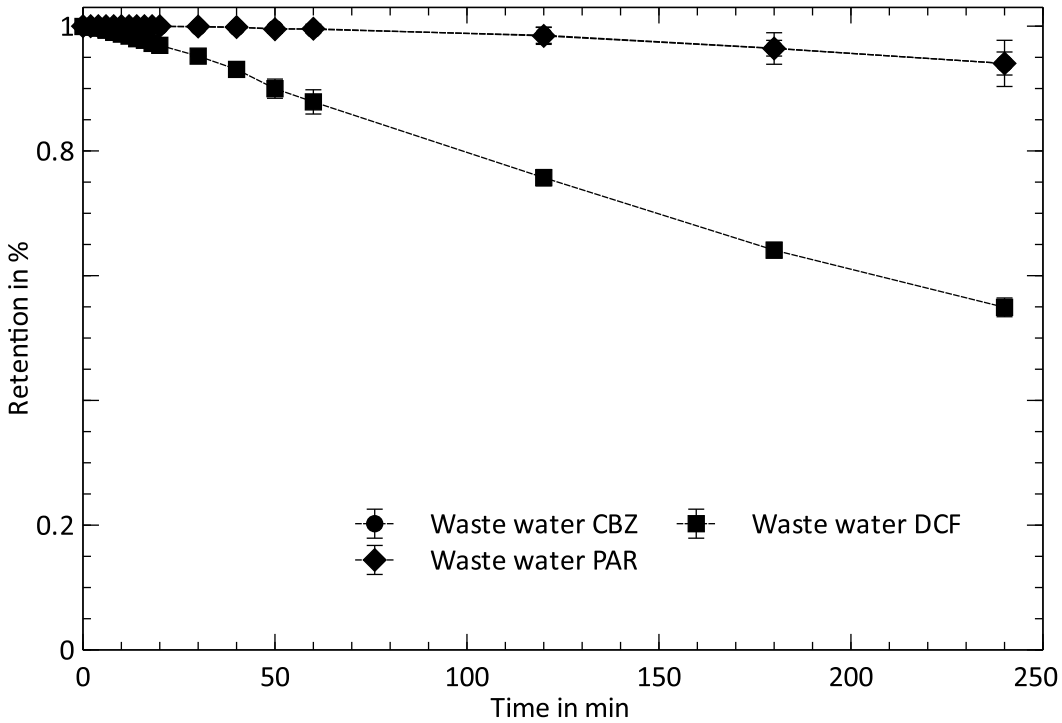


Adsorption over 24 h, starting concentration 10 mg/L competitive, T=25 °C

Micropollutant Removal from Waste Water Matrix

Waste water:

- CSD: 19.6 mg/L
- Conductivity: 770 µS/cm
- pH: 7.13



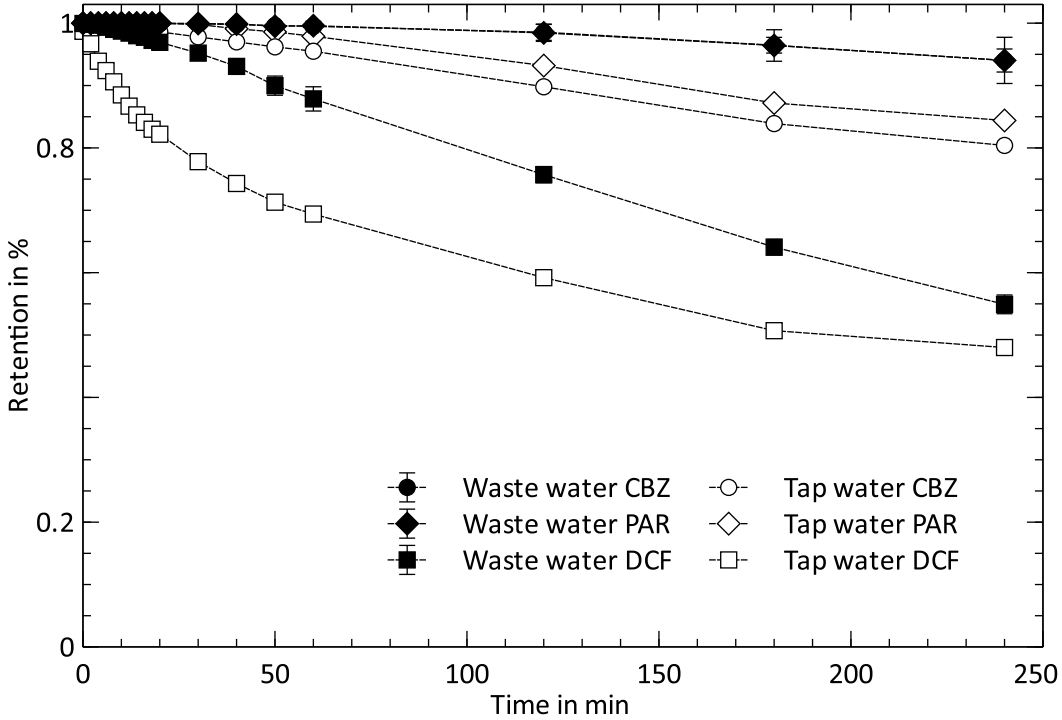
Micropollutant Removal from Waste Water Matrix

Waste water:

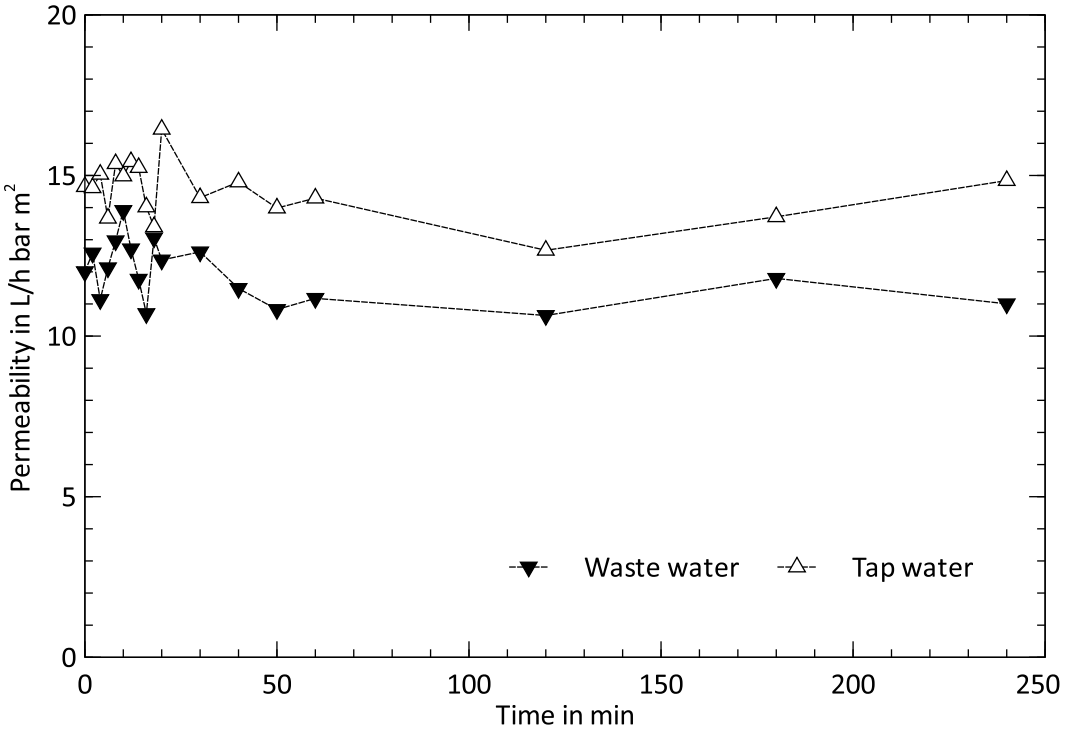
- COD: 19.6 mg/L
- Conductivity: 770 µS/cm
- pH: 7.13

Tap water:

- COD: <15 mg/L
- Conductivity: 4.7 µS/cm
- pH: 8.024



Permeability Tap Water vs. Waste Water



Active filtration area: 66 cm^2 for 7 channel MCMMM

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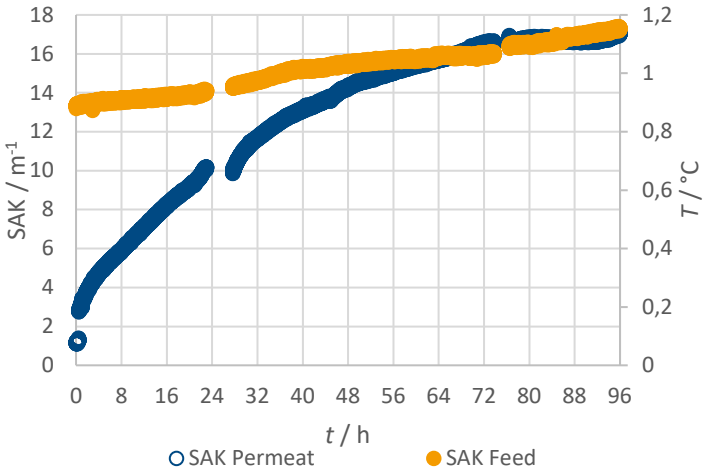
Summary

- Efficient Removal of the target pharmaceuticals from tap water
- Influence of pH on removal rate is high
- Diclofenac shows highest difference between acidic and alkaline pH
- Adsorption experiments support the findings → not a full explanation for the results
- Waste water matrix has little effects on removal rate over 4 h
- Permeability is slightly effected by the waste water matrix

- **Results are promising for the application in pilot scale at the waste water treatment plant**

Outlook

- Upscaling from Laboratory to Pilot scale (Modules)
- Detailed characterization of pH influence
- Zeta potential measurements
- First ‘Long-term’ experiments of 1 week successful



Thank you for your attention!

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Further questions: jana.marx@mci.edu

Quellen

1. Rzymski, Piotr & Drewek, Agnieszka & Klimaszyk, Piotr. (2017). Pharmaceutical pollution of aquatic environment: an emerging and enormous challenge. Limnological Review. 17. 97-107. 10.1515/limre-2017-0010.
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