WA2: Hybrid Ceramic Membrane Filtration in Water Treatment

Pilot tests at WWTP Almelo

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WP22 Hybrid ceramic membrane systems (KWR, FHNW)

• HCMS offer improved rejection of dissolved compounds and optimal control of fouling of membrane fouling (Lab-scale study in TECHNEAU).

• WP22 aims at investigate the potential of HCMS at pilot scale and to optimize the overall performance for the removal of emerging contaminants.
Hybrid Ceramic Membrane Filtration

- Coagulation-CMF
- PAC-CMF
- IX-CMF
- O3-CMF
Pilot locations

• WWTP Almelo (The Netherlands)

• WWTP Basel (Switzerland)
WWTP Almelo

- Design capacity: 5200 m³/h
- Process:
  - mechanical pre-treatment (screening, grit removal)
  - activated sludge treatment operated (sequencing-batch-reactor)
  - nutrient removal by nitrification-denitrification and simultaneous phosphorous removal by precipitation

### WWTP Almelo effluent quality (2014)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>St. dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>N total (mg/L)</td>
<td>6.19</td>
<td>4.61</td>
<td>57</td>
</tr>
<tr>
<td>P total (mg/L)</td>
<td>1.73</td>
<td>1.19</td>
<td>57</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>33.7</td>
<td>8.45</td>
<td>50</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>2.32</td>
<td>1.50</td>
<td>50</td>
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</tbody>
</table>
PAC-CMF pilot at WWTP Almelo

<table>
<thead>
<tr>
<th>Membrane area</th>
<th>2x 0,4 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal pore size</td>
<td>0,1 μm</td>
</tr>
<tr>
<td>Operation</td>
<td>dead-end</td>
</tr>
</tbody>
</table>
Experiments: (1) OMP removal (2) Operational stability
WWTP effluent + OMPs = Feed pilot plant.
Cocktail of OMPs dosed, each ≈1µg/L.
PAC dose (mg/L): 0, 15, 30, 60 [precoat mode]
BW: pressurized (5 bar) with permeate and air
CEB: BW with permeate and NaOCl

<table>
<thead>
<tr>
<th>OMPs dosed</th>
<th>µg/L</th>
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</thead>
<tbody>
<tr>
<td>metoprolol</td>
<td>0,936</td>
</tr>
<tr>
<td>gemfibrozil</td>
<td>0,953</td>
</tr>
<tr>
<td>sotalol</td>
<td>0,901</td>
</tr>
<tr>
<td>tramadol</td>
<td>0,951</td>
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<tr>
<td>carbamazepine</td>
<td>0,962</td>
</tr>
<tr>
<td>venlafaxine</td>
<td>0,881</td>
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<tr>
<td>diclofenac</td>
<td>1,027</td>
</tr>
<tr>
<td>atenolol</td>
<td>0,972</td>
</tr>
<tr>
<td>propranolol</td>
<td>0,849</td>
</tr>
<tr>
<td>trimethoprim</td>
<td>0,973</td>
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<tr>
<td>sulfamethoxazool</td>
<td>0,980</td>
</tr>
<tr>
<td>ketoprofen</td>
<td>0,999</td>
</tr>
<tr>
<td>bezafibraat</td>
<td>0,918</td>
</tr>
<tr>
<td>diatrizoic zuur</td>
<td>1,019</td>
</tr>
<tr>
<td>metronidazole</td>
<td>1,005</td>
</tr>
<tr>
<td>fenazon</td>
<td>0,996</td>
</tr>
<tr>
<td>cyclophosphamide</td>
<td>0,797</td>
</tr>
<tr>
<td>pentoxifylline</td>
<td>0,970</td>
</tr>
</tbody>
</table>

Filtration time  15 min
Filtration flux  60,80,100, 120 L/(m²·h)
BW frequency  4 times per hour
BW time  <5 sec
CEB frequency  1 time per 6 hour
Chemicals used  NaOCl (12,5 wt%)
Soaking time  5 min
Removal of OMPs

Flux=60 lmh

- Orange: with OMP spike, 15mg/L PAC
- Green: with OMP spike, 30mg/L PAC
- Blue: with OMP spike, 60mg/L PAC

Removal (%) vs. different OMPs:
- Carbamazepine
- Bezafibrate
- Atenolol
- Guanylic acid
- Gemfibrozil
- Diclofenac
- Diazoxide
- Cyclophosphamide
- Sulfamethoxazole
- Sotalol
- Propranolol
- Fenoxylamine
- Metronidazole
- Ketoprofen
- Metformine
- Metoprolol
- Venlafaxine
- Trimethoprim
- Tramadol

25.06.2015
Effect of flux on OMP removal at 30 mg/L PAC dose

- Flux=60 lmh, OMP spike, 30mg/L PAC
- Flux=100 lmh, OMP spike, 30 mg/L PAC

Removal (%)

- carbamazepine
- bezafibrate
- atenolol
- guanylylurea
- gemfibrozil
- diclofenac
- diatrizoic zuur
- sulfamethoxazol
- sotalol
- propranolol
- fenazon
- pentoxifylline
- metronidazol
- ketoprofen
- metformine
- metoprolol
- venlafaxine
- trimethoprim
- tramadol
Process stability

TMP without PAC dosing
Flux=100 L/m².h
TMP with 30mg/L PAC
Flux=100 L/m².h
Conclusions

• Removal increases with PAC dose, as expected. However, it is not proportional to PAC dose.
• Precoating PAC on membrane surface increased average TMP.
• At 30mg/L PAC, the OMP removal was similar at flux=60 lmh and 100 lmh.
• CEB with NaOCl effectively recover the TMP.
• At 30mg/L PAC dose and flux=100 lmh, HCMF process remained stable for more than 5 days.
Thanks for attention!