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CROSS-FLOW FILTRATION WITH DIFFERENT CERAMIC MEMBRANES FOR POLISHING WASTEWATER TREATMENT PLANT EFFLUENT

ALI FARSI, SOFIE H. JENSEN, PETER ROSLEV, VITTORIO BOFFA, MORTEN L. CHRISTENSEN

ICIM 2014, 8TH JULY, BRISBANE, AUSTRALIA
Outlook

- Problem and Hypothesis
- Materials and Methods
- Results and Discussion
- Conclusion
Challenge

- Micro/nano–pollutants in wastewater are a challenge to wastewater professionals. The presence of contaminants in wastewater treatment plant (WWTP) effluents may cause a severe risk for the drinking water preparation. The effluent cannot be simply discharged to environment because it contains toxic ions and organic micro-pollutants which are harmful for aquatic organism.
<table>
<thead>
<tr>
<th>Compounds</th>
<th>Examples</th>
<th>Detected in Denmark WWTP*</th>
<th>Detected in EU/US WWTP**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Contaminants from Industrial sources</td>
<td>Sulfonated organic compounds, MTBE</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>Household and personal care products</td>
<td>Sunscreen Agents</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>Acetaminophen, Ketoprofen, Ibuprofen, Diclofenac</td>
<td></td>
<td>▲</td>
</tr>
<tr>
<td>Party drugs</td>
<td>Defattening pills, Viagra, XTC</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Glyphosate</td>
<td></td>
<td>▲</td>
</tr>
<tr>
<td>Metal Ions</td>
<td>Cu, Pb, Zn, Cd, Cr, Hg</td>
<td>▲</td>
<td>▲</td>
</tr>
</tbody>
</table>

*Punktkilder 2012, Miljøministeriet, [www.nst.dk](http://www.nst.dk) (in Danish).
Hypothesis

- A possible strategy to avoid this is to polish the effluent by membrane processes.
Materials and Methods

- **Sample.** The samples were taken from Aalborg WWTP which is located in the west of Aalborg city, Denmark.

- **Filtration.** The effluent was pumped at 6 bar to a cross-flow filtration.

- **Membranes.** Various monotube active layers such as on macroporous α-alumina support (~100nm) were used.

- **Analysis.** The total ions and specified toxic ions rejections were measured using conductivity measurements respectively. The type and the molecular size of removed organic compounds were determined using pH, full spectrum UV and size exclusion HPLC. Inorganic N-compound rejections were calculated by N-autoanalyzer. Bioassays were done with Daphnia magna method.

- **MBR.** The MBR Pilot plant is already working in the WWTP site.
<table>
<thead>
<tr>
<th>Material</th>
<th>Type</th>
<th>Nominal Main Pore size</th>
</tr>
</thead>
<tbody>
<tr>
<td>α-alumina</td>
<td>MF- Macroporous</td>
<td>~100nm</td>
</tr>
<tr>
<td>TiO₂</td>
<td>UF- Mesoporous</td>
<td>15 nm</td>
</tr>
<tr>
<td>γ-alumina</td>
<td>NF- Mesoporous</td>
<td>5 nm</td>
</tr>
<tr>
<td>TiO₂</td>
<td>NF- Microporous</td>
<td>1 nm</td>
</tr>
<tr>
<td>Hybrid silica</td>
<td>RO- Microporous</td>
<td>&lt;1nm</td>
</tr>
</tbody>
</table>

Before the test
Size: 1.022 mm

Water, after 21 days
Size: 3.132 mm ($A_0$)

Sample after 21 days
Size: 3.8 mm ($A_1$)
Abs. vs. Wave Length [nm]

- Effluent
- MBR
- Alpha alumina
- Mesoporous TiO2
- gamma alumina
- Microporous TiO2
- Hybrid Silica
<table>
<thead>
<tr>
<th>Peak</th>
<th>MW (KDa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>90</td>
</tr>
<tr>
<td>C</td>
<td>85</td>
</tr>
<tr>
<td>D</td>
<td>90</td>
</tr>
<tr>
<td>E</td>
<td>40</td>
</tr>
</tbody>
</table>
Hybsi active layer (<1nm, RO) could remove most of inorganic ions and organic molecules and increase the water quality up to drinkable water. But its permeability is very low (0.03 LMH/B).

α-alumina (>100 nm, MF) did not show a better performance for removing organic compounds and ions rejections.

Mesoporous TiO₂ (15nm, UF), γ-alumina (5 nm, NF) and microporous TiO₂ (1nm, NF) could remove most of the aromatic organic compounds more than MBR but their ion rejections are not obvious (less than 10%).

Chromatography results showed that MBR could remove a range of organic components (around 90 KDa) even better than NF ceramic membrane.

MBR shows a better performance in competition with all ceramic membrane to remove N-compounds.

Bioassays with Daphnia magna suggested that effluent polishing with γ-alumina membrane reduced toxicity of the treated water better than MBR and even TiO₂ micro porous membrane.

Our study showed that γ-alumina is the optimized membrane for this application.
TIPS OF DAY:

“EXPERIMENTAL DESIGN IS FUNDAMENTAL FOR THE DEVELOPMENT OF NEW MEMBRANE APPLICATION”

THANK YOU FOR YOUR ATTENTION.