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Ultrasonic Reflectometry for Monitoring the Effect of Pressure on Sludge Fouling of MF Membranes

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BACKGROUND

• Fouling of MF membranes with activated sludge is compressible, which significantly reduces membrane performance [1].
• Surprisingly little information has been reported regarding the dynamics of such highly compressible fouling layers.
• Ultrasonic reflectometry (UR) is now a well-established technique that has been successfully used to quantify membrane fouling [2] by calcium sulfate [3], yeast [4], proteins [5] and biofilm [6] among other foulants.

OBJECTIVES

• Based on the advantages of real-time measurement [7], utilize UR for characterization of the fouling dynamics of municipal activated sludge on microfiltration (MF) membranes.
• Quantify the effect of pressure on the sludge fouling layer.

METHODOLOGY

<table>
<thead>
<tr>
<th>Membrane System</th>
<th>Compaction Phase Duration</th>
<th>Diluted Sludge Concentration</th>
<th>Crossflow Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidestream PVDF</td>
<td>15 h</td>
<td>0.2 g/L</td>
<td>0.085 m/s</td>
</tr>
</tbody>
</table>

• Time-Series Experiments: Constant-pressure sludge filtrations at 15 kPa for 15, 30 and 60 min to correlate the change in UR amplitude to the degree of fouling.
• Constant-Pressure Experiments: Constant-pressure sludge filtrations for 5 h at 15 and 25 kPa.
• Pressure-Step Experiments: Pressure-step experiments were performed by alternating pressures between 15 and 25 kPa.

INFLUENCE OF PRESSURE

• UR results show that the reduction of amplitude is higher for the fouling layer formed at 15 than 25 kPa, although the fouling layer resistance is lower, i.e., $R_{15kPa} = 1.210.27 \times 10^{12}$ m$^{-1}$ vs. $R_{25kPa} = 2.10.33 \times 10^{12}$ m$^{-1}$.
• Pressure-step experiments show a similar trend where an increase in pressure generates higher hydraulic resistance and lower UR amplitude reduction.
• As pressure is released, cake resistance decreases and the UR amplitude reduction increases.

SIGNIFICANT FINDINGS

• Fouling of MF membranes with activated sludge was successfully monitored using ultrasonic reflectometry.
• At lower pressure, UR amplitude reduction is higher but fouling layer resistance is lower.
• Lower-pressure UR behavior is due to formation of a less-compacted fouling layer that provides better impedance matching, which in turn translates to higher signal attenuation layer as compared to that at high pressure.
• Pressure-step experiments indicate that the cake compression is partly reversible with cake swelling after the release of pressure.

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REFERENCES