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

Mechanical Engineering
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BACKGROUND

- Fouling layers formed during membrane filtration of activated sludge are 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.

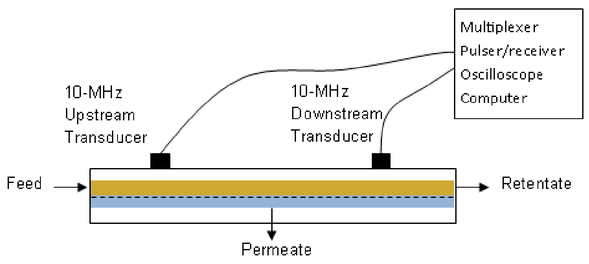
OBJECTIVES

- 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

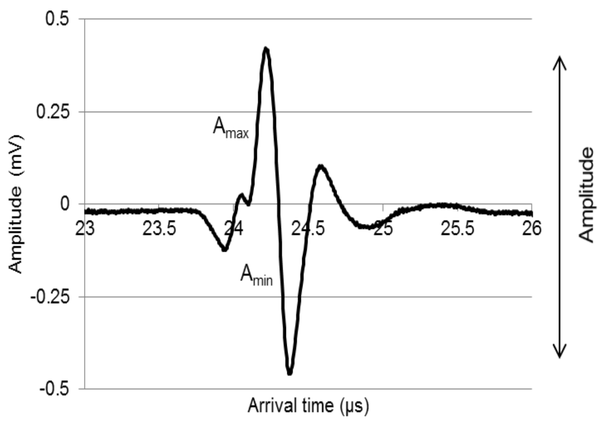
Membrane System	Compaction Phase Duration	Diluted Sludge Concentration	Crossflow Velocity
Sidestream PVDF	15 h	0.2 g/L	0.085 m/s

- **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.



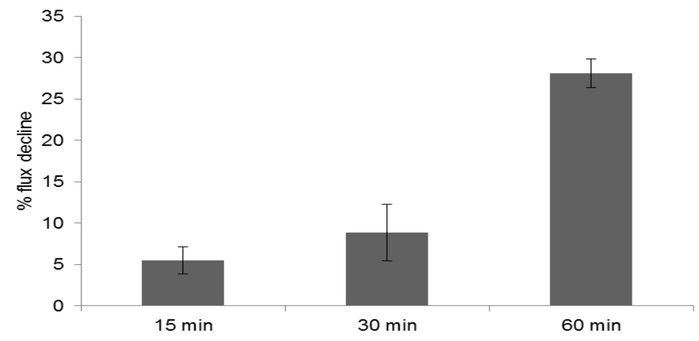
- **Constant-Pressure Experiments:**
  Constant-pressure sludge filtrations for 5 h at 15 and 25 kPa.

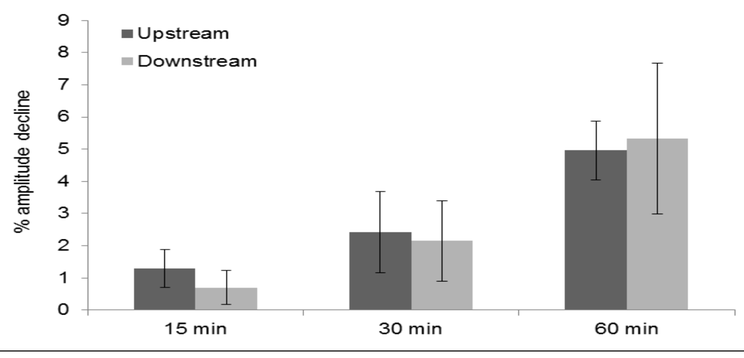
- **Pressure-Step Experiments:**
  Pressure-step experiments were performed by alternating pressures between 15 and 25 kPa.



UR RESPONSE TO SLUDGE FOULING

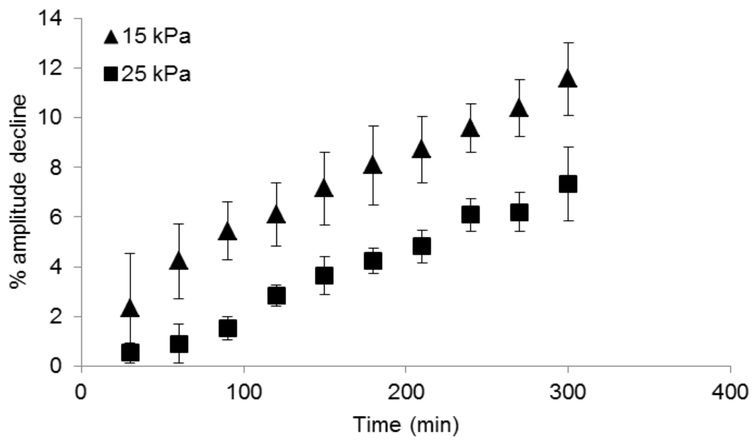
- As expected, flux decreased with increased filtration time.
- Through the membrane compaction phase with DI water, UR amplitude reached a constant level after 10-h filtration.
- With subsequent addition of sludge, UR amplitude declined significantly.
- There was no significant difference between the degree of membrane fouling near the feed inlet (upstream) and retentate outlet (downstream).
- The degree of fouling can be appropriately represented by either the flux or UR amplitude response.

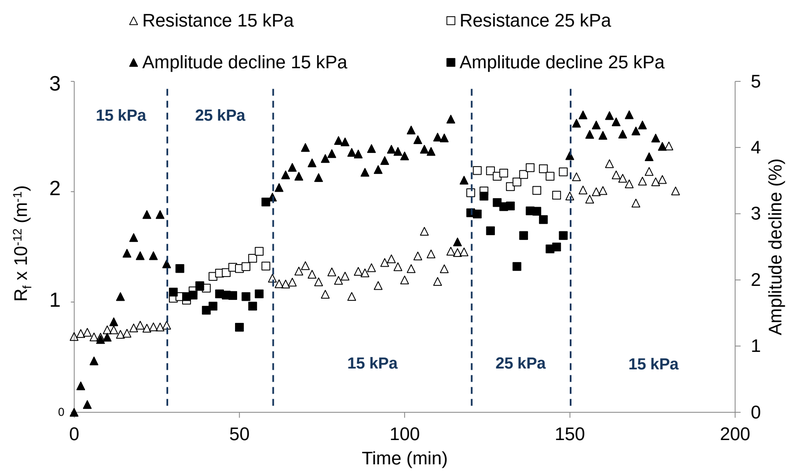




INFLUENCE OF PRESSURE

- 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., $R_{f,15kPa}$ = 1.2±0.27 x 10^{12} m^{-1} vs. $R_{f,25kPa}$ = 2.1±0.33 x 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.

ACKNOWLEDGEMENTS

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