

Pilot-Scale Assessment of Urea as a Chemical Cleaning Agent for Biofouling Control in Spiral-Wound Reverse Osmosis Membrane Elements

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Figure S1: Automated RO pilot installation equipped with two single 8-inch module pressure vessels, designed to measure key performance indicators in real time.



Figure S2: Fouling on the inlet and outlet ends of spiral-wound membrane modules after 2.5 years of operation at the DECO water treatment plant.



Figure S3: Unwound control membrane module (uncleaned) after membrane autopsy. Visual observations showed that the bulk of the fouling is present on (A) the inlet side rather than the middle or outlet of the module, and (B) the spacer surface rather than the membrane surface.

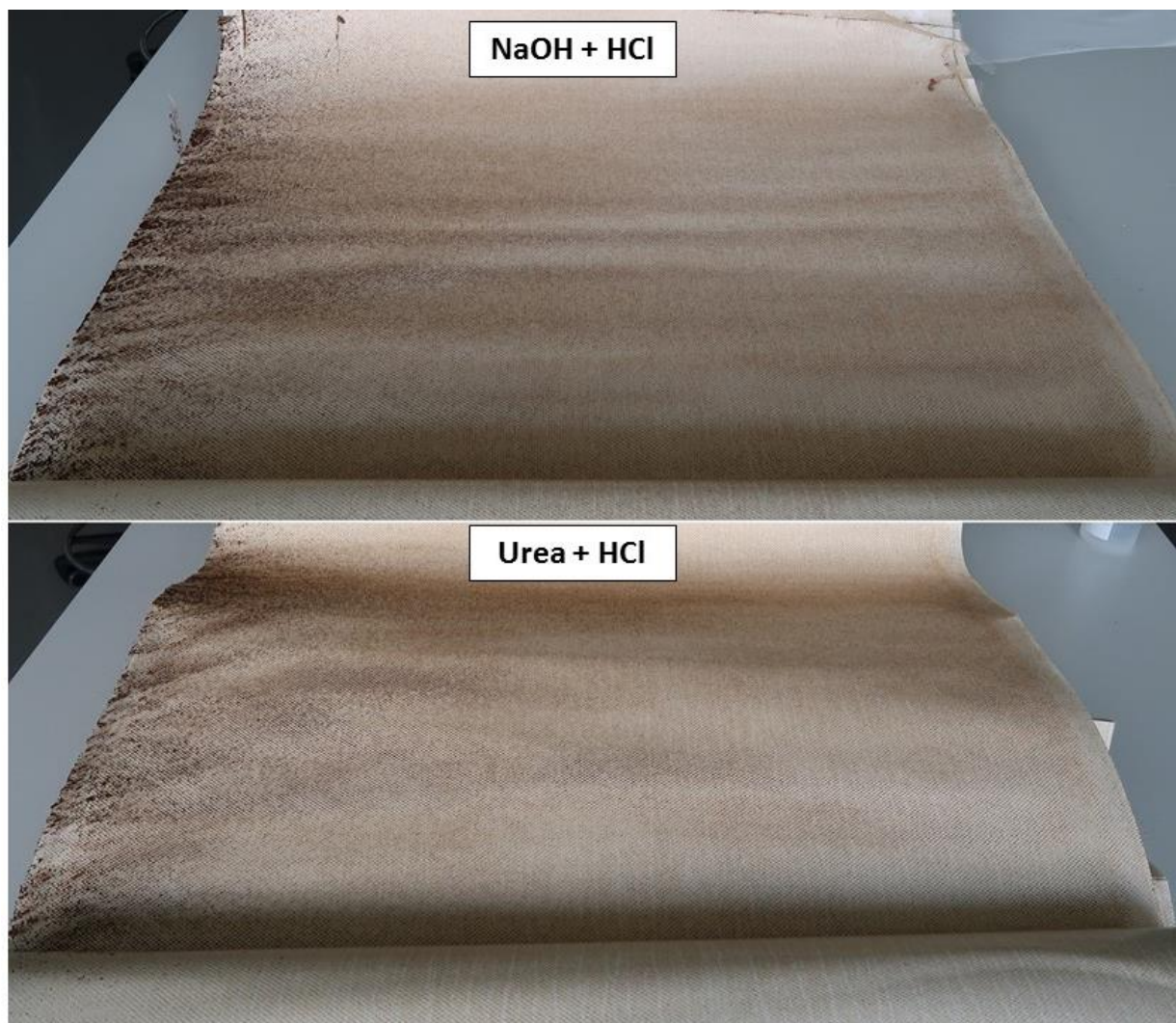
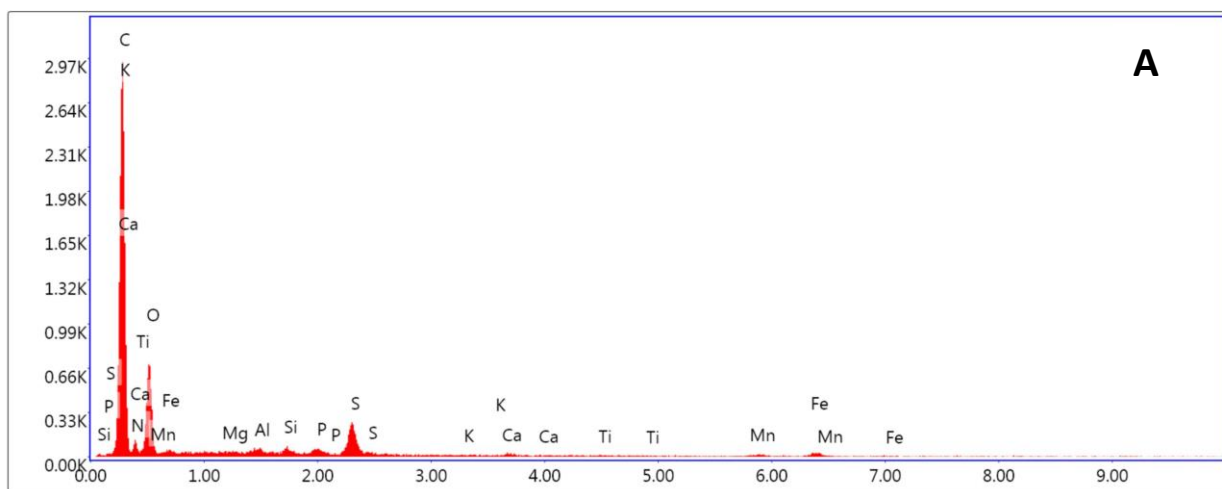


Figure S4: Visual comparison of the membrane/spacer surface of cleaned membrane modules.



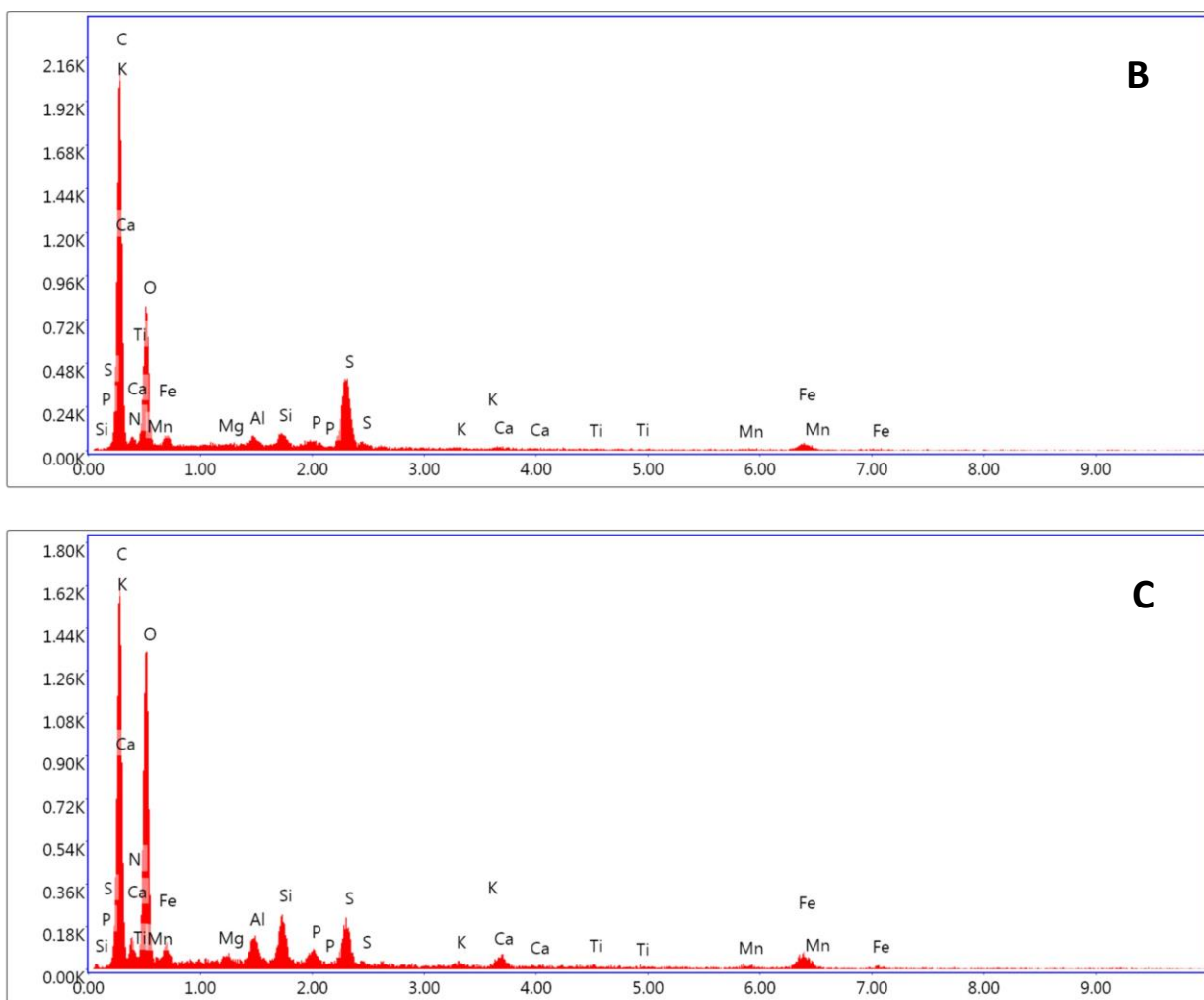


Figure S5: Energy dispersive x-ray spectra of (A) Control module uncleaned, (B) Reference module cleaned with NaOH + HCl and (C) Test module cleaned with Urea + HCl. The EDX spectra show that C, N, O and S dominate the elemental composition, thereby confirming the presence of organic fouling and biofouling. Scaling or inorganic fouling may be very minor contributors to overall fouling of the membrane modules since elements like Al, Ca and Fe were present only in trace concentrations.