Sodium Chloride Removal Pilot Study: Better Tools for Reclaiming High-TDS Water Are Needed

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A common issue with reclaimed water, particularly in arid regions, is the consequence of elevated salt content. Reclaimed water often has a total dissolved solids (TDS) content of 300 to 400 mg/L greater than the drinking water source. While this can easily be accomplished with conventional dual-pass reverse osmosis (RO) plants, these are very energy-intensive. A lower-energy process that could remove the added salts, which are predominantly sodium chloride, while retaining the 'good' ions such as calcium, magnesium and sulfate, would improve the quality of the reclaimed water. This improvement in economics would in turn allow more water agencies to consider membranes for reducing the TDS in their potable sources and would promote greater use and acceptance of reclaimed water.

Our "NF/RO hybrid" two-pass membrane system proposed here uses a novel approach to using conventional treatment: a nanofiltration (NF) system with concentrate recycle in the first pass followed by RO in the second pass. Multivalent ions in the first pass are retained and blended with permeate from the second pass. Because the feed to the second pass is softened, very high overall recoveries are possible with minimal pretreatment.

This work builds on successful small-scale pilot testing. In 2014, Brown and Caldwell partnered with the City of Scottsdale to investigate the use of NF for selective removal of sodium chloride from tertiary treated reclaimed water. A 12-week pilot study of the NF process was conducted to evaluate whether adequate selective separation of multivalent and monovalent ions. Results from the pilot study were then applied to desktop computer models to simulate the second pass RO process, chemical pretreatment requirements, energy recovery potential, and concentrate treatment and disposal costs. The investigation concluded that the process could achieve the water quality objectives of preferentially removing sodium chloride, reducing chemical consumption, and reducing costs for concentrate treatment and disposal. The magnitude of the cost savings for concentrate disposal was shown to be significant. The work has been presented at multiple conferences including the 2015 AWWA/AMTA Membrane Technology Conference in Orlando, Florida; the 2015 Water Reuse and Desalination; and the 2015 WateReuse Symposium in Seattle, Washington. The work was also published in the *Summer 2015 American Membrane Technology Pretreatment Solutions Journal*.

The pilot study planned in this work will build upon the first phase pilot study to verify the long-term viability and cost and water savings the hybrid NF/RO approach can provide (compared to single-pass RO). The pilot study will:

- Demonstrate the combined NF and RO operation is a scalable system
- Investigate the hydraulic energy recovery potential on the internal concentrate recycle stream.
- Gather long-term operating data to predict long-term membrane performance (minimum 6-month operation).
- Refine membrane selection.
- Establish the performance envelope of the system.
- Investigate the fate of organic contaminants and develop strategies to incorporate this process into potable reuse flow schemes.
- Develop capital and O&M cost estimates for comparison with conventional RO desalting approaches to potable and reuse water treatment.

This research will demonstrate that this system can work successfully long-term at large pilot-scale and provide four clear benefits:

1. Selective removal of sodium chloride without removing less detrimental materials. We expect to demonstrate a restoration of the water quality to close to the raw water source ion profile.
2. Reduced mass of salts disposed in the concentrate. This can be achieved through a lower concentration of brine at the same recovery *or* a higher recovery and lower quantity of brine.
3. Lower chemical consumption for both pretreatment and post treatment—less cost and less waste.
4. Significantly lower concentrate treatment and disposal costs due to the lower mass of salts and lower concentration of limiting scale-forming compounds.