RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Ceramic and Polymeric Membranes

Comparing performance and cleaning of ceramic and polymeric membranes

Bottom Line

This research identified how and why ceramic membrane performance differs from polymeric membrane performance and used a techno-economic model to compare the life-cycle cost differences between membranes made from the two materials.

Better, Faster, Cheaper

Ceramic membranes, due to their numerous benefits, including longer operational life and cleaning efficiency, may be a more cost-effective approach—even though they have a higher capital cost.

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Collaborators

University of Colorado

Potential future researcher explores the Denver Water Treatment Engineering and Research Laboratory where we compare ceramic and polymeric membranes.

Problem

Improved water treatment technologies help to increase the water supply to areas of the West where demands may soon exceed supplies. Effectively using treatment technologies like microfiltration (MF) and ultrafiltration (UF) are easier to operate, take up less space, and require less maintenance than conventional water treatment technologies like media filtration and coagulation/flocculation/sedimentation. MF and UF are best used to remove suspended solids, *Giardia* and *Cryptosporidium,* and to reduce turbidity. They are also used as a pretreatment to desalination technologies such as nanofiltration and reverse osmosis. MF and UF processes use membranes that can be made of polymeric or ceramic materials. Membrane material properties, the characteristics of the source waters to be treated, and the operational conditions of the membrane process affect the degree to which contaminants are removed and the product water recovery.

As there are no standard sizes and configurations for low-pressure membranes, each manufacturer has adapted their technology to meet customer needs. However, there is little guidance in the industry to help membrane users select the most efficient low-pressure membranes for various applications. Polymeric membranes have dominated the market for low pressure membrane systems for the past 20 years. Yet, ceramic membranes have many benefits, including longer operational life and cleaning efficiency, and may be a more cost-effective approach—even though they have a higher capital cost.

Solution

This Reclamation Science and Technology Program research project compared two types of MF and UF membranes: ceramic and polymeric. We conducted laboratory experiments to quantify differences in the fouling propensity for an alumina ceramic and a polyethersulfone (PES) polymeric UF membrane. To increase the certainty that observed differences in flux behavior, rejection, and cleaning efficiency resulted from the materials and not various uses, we tested both types of membranes under comparable conditions. These tests used the Peclet number (Pe) to compare the same mass of foulant per unit area under the same hydrodynamic conditions.

This research project also developed and demonstrated a data-driven, techno-economic model to describe the life-cycle costs for a hypothetical membrane plant using these ceramic or polymeric membranes. The data-driven cost model is a novel tool that can be used to compare the performance and cost differences and to identify the technical and economic lever points that dictate which membrane system is more cost effective. Additionally, this model allows for the comparison of different materials based on a number of other important factors such as labor, operations and maintenance, replacement costs, energy input, power consumption, chemical usage, and source water recovery.

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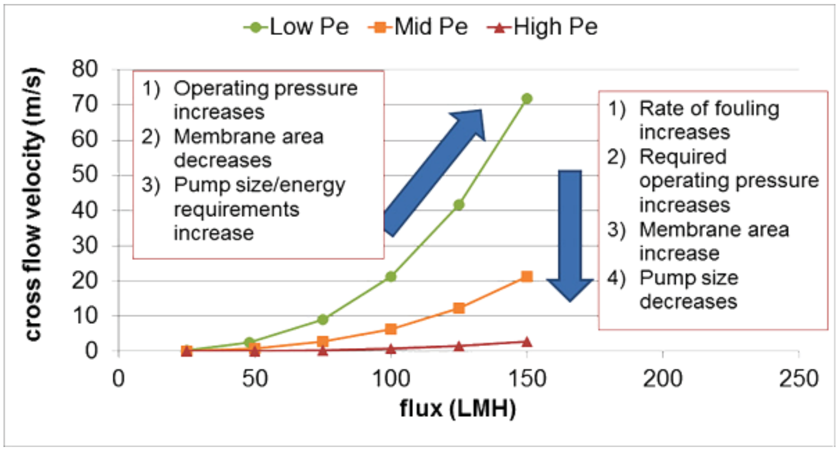
For the analysis conducted, the alumina membrane is cost competitive with the PES membrane:

- When harsh operating conditions or feed quality limit polymeric membrane life to less than 3 years,
- If the ceramic membrane is operated with a fouling rate >2.5 times that of the polymeric membrane, and
- The ceramic membrane material cost is ≤ $250 per square meter.



Graph illustrating the value of considering performance and operational factors in cost calculations.

"More research is needed to minimize the cost [of low-pressure membrane systems] by reducing membrane fouling and optimizing membrane design and operation"

National Research Council, 2008

More Information

Science and Technology Program research project:

www.usbr.gov/research/projects/detail.cfm?id=4141

Future Plans

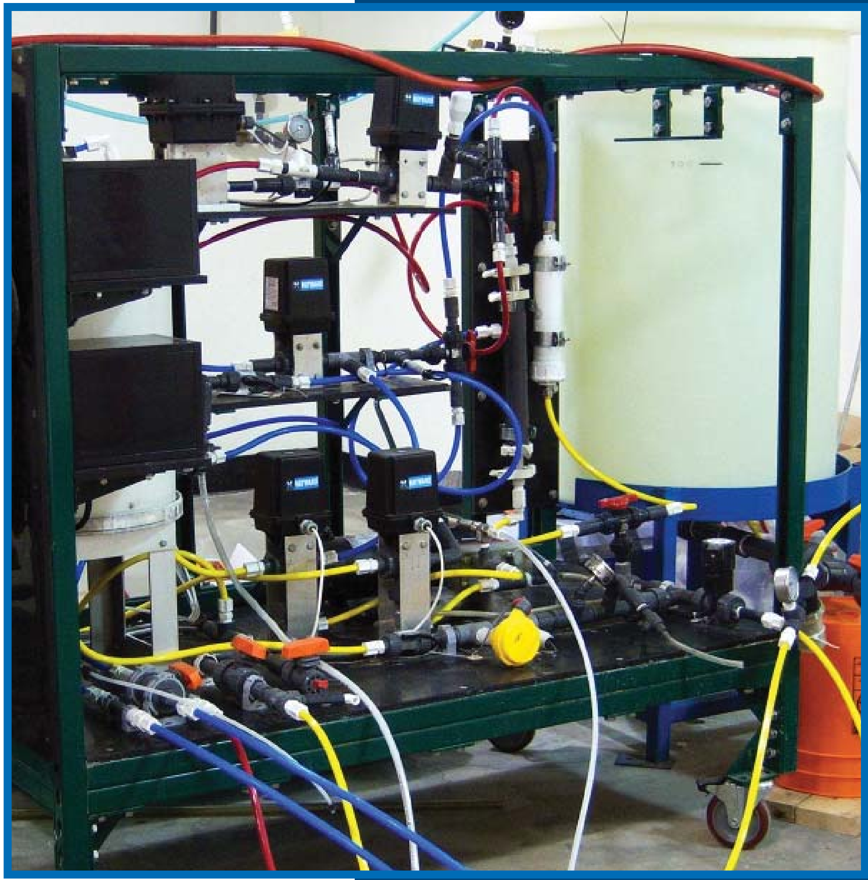
This work will help identify areas where future research efforts should be focused. Future steps include:

1. Experimental

- Describe performance in terms of membrane material properties, solute properties, and hydrodynamics.
- Compare ceramic to polymeric membranes in a pilot test.
- Use Pe to scale laboratory results to full-size modules and to investigate economic impact of varying different operating conditions.

2. Cost Modeling

- Update cost correlations based on most recent MF and UF knowledgebase from the American Water Works Association.
- Incorporate long-term cleaning and backwash inefficiencies into cost model.
- Use optimization algorithm to determine optimal operating conditions to minimize total plant cost.



Laboratory-scale testing facility for polymeric and ceramic membranes.