Executive Summary

WERF

Improving brine management for inland water sources

Pilot Testing of Membrane Zero Liquid Discharge for Drinking Water Systems (WERF5T10)

The Central Issue

Increasing demand for potable water has forced drinking water utilities to consider using water from lower quality sources. These sources require the use of advanced treatment technologies such as reverse osmosis (RO) or nanofiltration (NF) membranes to treat the water to a level suitable for human consumption. Membrane systems produce a brine concentrate which is challenging to dispose of. Zero liquid discharge (ZLD) is a sustainable disposal option that may represent a long-term solution to concentrate disposal for utilities that need to implement membrane treatment to produce safe water. It may also help alleviate the pressure wastewater treatment plants are under to accept membrane concentrate streams.

Context and Background

ZLD systems separate concentrate into water and solids. The water can be reused and the solids disposed of as a waste or reused in a way that no liquid waste leaves the boundary of the facility. These technologies have not been implemented in municipal applications to date due to high costs and other challenges. A multi-step screening approach was used to select concentrate minimization and ZLD technologies for testing. Based upon work completed by the Colorado Water Quality Forum's Membrane Treatment Working Group, 27 different technologies for brine minimization and disposal were identified, seven were considered for additional screen and ultimately, electrodialysis metathesis (EDM) was selected for pilot testing. EDM technology is part of a process called Zero Discharge Desalination (ZDD) developed by Dr. Tom Davis of the Center of Inland Desalination Systems at the University of Texas El Paso.

The technology was pilot tested in a "greenfield" application at La Junta, Colorado, Water Treatment Plant (WTP) during the summer of 2012. A second pilot test was conducted at the Brighton, Colorado WTP during the summer and fall of 2013. A life cycle cost estimate for the technology for the greenfield configuration was prepared using the test results from the La Junta pilot test. These costs were compared to existing dual RO technology with intermediate chemical softening. Both computer modeling and bench-level testing were used to develop the dual RO cost comparison for the La Junta WTP.

Findings and Conclusions

The technical and operational assessment found:

- Electrodialysis metathesis was an effective separation process for removing multivalent ions responsible for forming membrane scalants.
- ZDD technology met the project's water quality goals.
- ZDD demonstrated the capability to obtain high recovery.
- ZDD technology did not demonstrate the ability to maintain performance over extended periods of time.
- In its current state of development, ZDD is a complex technology that is difficult to control and operate.

Containerized nanofiltration unit in position outside the La Junta Plant (left). Interior view of the nanofiltration unit (right).

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The cost assessment of the ZDD technology at the La Junta WTP to treat the source water to SDWA requirements at a 96% recovery rate, estimated life cycle cost ranges from $2.98 to $4.60 per 1,000 gallons. The estimated life cycle cost for a full-scale plant using dual RO technology operating at 92% recovery treating La Junta source water, is between $2.13 and $3.43 per 1,000 gallons. Because of its greater recovery, the ZDD technology requires approximately 135 ac-ft/year less water than the dual RO technology to meet La Junta's potable water demands. But the cost of the water saved by the ZDD technology would not offset the differences in cost between the two alternatives at La Junta.

The technology provider for ZDD technology estimates costs for a full-scale ZDD plant to be lower than found in this study based upon expected economies of scale associated with a full-scale plant over pilot testing. Because those economies of scale could not be measured in pilot testing, actual data from the pilot testing was used to develop cost ranges for ZDD technology. Future development of ZDD technology may lower costs.

Management and Policy Implications

ZDD technology did not obtain zero discharge, but it demonstrated the ability to produce excellent water quality and obtain high recovery. ZDD technology shows good potential to reduce the volume of concentrate produced by membrane plants, but further development of the technology is needed with the goal of reducing costs, increasing reliability, and simplifying its operation.

Related WERF Research

Project Title	Research Focus
Demonstration of Membrane Zero Liquid Discharge for Drinking Water systems: A Literature Review (WERF5T10a)	Comprehensive literature review provides an overview of existing concentrate disposal options and examination of ZLD technologies that could be evaluated by pilot testing. Considered in this literature review: ■ Intermediate Treatment ■ Thermal-Based Technologies ■ Pressure Driven Membrane Technologies ■ Electric Potential Driven Membrane Technologies ■ Alternative Technologies
Survey of High Recovery and Zero Liquid Discharge Technologies for Water Utilities (03CTS17aCO)	Provides a systematic characterization of high recovery performance and costs over a range of size, salinity, and composition. An essential reference for utilities considering high recovery processing for desalination projects.
Beneficial and Non-Traditional Uses of Concentrate (03CTS17bCO)	Provides a comprehensive review and evaluation of the full range of potential beneficial and nontraditional uses of concentrate and assesses the feasibility of implementation, economic considerations, and environmental safety.
Impacts of Membrane Process Residuals on Wastewater Treatment (03CTS17cCO)	Provides utilities with two types of models for predicting the impacts of membrane concentrate loadings on the collection system and the wastewater treatment plant. Interactive Excel models allow users to predict point source impacts of the discharge of concentrates from a variety of sources such as reverse osmosis. The mass balance model examines the impacts of system-wide concentrate discharges. A useful guidance manual for any utility that handles membrane process residuals.
Regional Solutions for Concentrate Management (03CTS17dCO)	Provides an overview of concentrate disposal and management practices. Includes a decision methodology to assess not only what concentrate disposal options are technically feasible, but also what options are viable. The decision methodology is interactive software that allows users to enter site-specific data and assess options.

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