Water Conservation Methods at the Source: A Review of Membrane Treatment Concentrate Minimization Strategies

By Jill Manning Hudkins and Jon D. Fox

The process of desalination was first used to make potable drinking water from seawater in the 1960s. Since then, the process of membrane treatment has benefited from several technological advances in membrane process design. These advances have made membrane treatment a more affordable technology for many water utilities. This is of great importance because diminishing water supply resources and increased regulatory limitations have left most water utilities with a limited number of alternatives. Technological advances in membrane treatment previously focused on reducing labor and energy associated with the membrane process.

Another arena for technical advancement, which has not received adequate attention in the municipal market to date, is the minimization of concentrate by-product. Wasting up to 20 percent of brackish water as concentrate and up to 50 percent of seawater as concentrate results in low productivity and high energy costs per volume treated. As membrane treatment facilities become larger in capacity, there will continue to be significant opportunities to conserve additional water through the minimization of concentrate.

Concentrate management for membrane treatment facilities is a significant challenge for all membrane treatment facilities because concentrate disposal is highly regulated at the state and federal level; the concentrate stream may be of significant volume (20 percent of brackish water as concentrate and up to 50 percent of seawater as concentrate); and depending on raw water quality, the concentrate stream may be laden with high concentrations of salts or other constituents that would impact disposal options.

Concentrate disposal can be accomplished by surface-water discharge, deep-well injection, reuse, or concentration methods such as evaporation. The two most common municipal practices are surface-water discharge and deep-well injection.

Blending with treated municipal or industrial wastewater for reuse or surface discharge can be a viable option. Disposal to wastewater treatment facilities is typically limited to a specific volume, based on the utilized capacity of the receiving wastewater facility. The water quality of the concentrate also must not interfere with the any discharge requirements for the wastewater treatment facilities.

Deep injection wells are widely used in the state of Florida. The location of the base of the underground source of drinking water, the confining layers, and the top of the injection zone are critical to the permitting and successful operation of a deep injection well facility due to the potential of fluid migration into drinking water supplies.

The evaluation of concentrate disposal alternatives is very site specific and, therefore, should be evaluated on a case-by-case basis. Consideration is typically given to:

- Cost
- Regulatory Acceptance
- Concentrate Quality
- Permitting and Monitoring Requirements

An important component of consideration for various concentrate disposal methods is the delivered cost of the treated water. As mentioned previously, the cost of concentrate disposal is highly dependent on method and site location. The cost also can be affected by the level of permitting or monitoring effort required. A good understanding of each of the available methods is required in order to properly evaluate each option and to estimate the cost required to dispose of the membrane concentrate or byproduct.

Regulatory requirements for concentrate disposal will vary, depending on the selected concentrate disposal method. Concentrate discharge is regulated through programs in the Clean Water Act and the Safe Drinking Water Act. Discharges to surface waters are regulated under the National Pollutant Discharge Elimination System.

The Florida Department of Environmental Protection has been granted jurisdiction from the U.S. Environmental Protection Agency for this program and has instituted more stringent guidelines to regulate these discharges. Deep-well injection is regulated by the Underground Injection Control Program.

When discussing concentrate, it is also important to remember that concentrate or treatment process byproduct will vary, based on the raw-water quality and the treatment process employed. The quality and quantity of concentrate can be determined easily once the raw-water quality of the water source is established. The quantity is easily calculated based on the system recovery, and the quality is calculated based on the raw-water quality and the expected concentration factor.

Although concentrate disposal from both MF/UF facilities, as well as from NF/RO facilities, can be one of the most challenging obstacles while planning a membrane treatment facility, the quantity and quality of the concentrate or treatment process byproducts from these processes differ greatly, as illustrated in Table 1.

Membrane Process	Water Recovery (%)	Concentrate Wasted (%)	Concentrate Quality (Concentration Factor)
MF/UF	90-95	5-10	n/a
Nanofiltration	80-85	15-20	5
Brackish RO	75-80	20-25	4
Seawater RO	45-60	40-55	2

Table 1: Quantity and Quality of Concentrate from Membrane Treatment Processes

Concentrate management can also include concentrate minimization strategies. There are several available methods available, including conventional approaches such as additional membrane treatment of concentrate, evaporation, crystallizaton, and solids production devices. Examples include brine concentrators, forced circulation crystallizers, direct contact evaporators, pulsed spray units, and air evaporators.

There are other minimization processes being researched or in development; however, even the methods listed above have limited installations at municipal facilities. The most practical implementation of concentrate minimization for municipalities is increased concentrate recovery, or reuse of the concentrate to offset other water demands.

As water supplies become more limited and the need for membrane treatment facilities increases, the management of concentrate will become more critical than ever. It is imperative that as an industry we continue to develop new ways to recover and reuse concentrate to its fullest potential as an alternative water supply. In the state of Florida, reuse of concentrate for non-potable supplies such as irrigation and the implementation of higher recovery rates through additional membrane treatment continue to show promise.

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