Technology Brief

Treatment of Brackish Desalination Plant Concentrate and Seawater

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Disposal of concentrate (brine) from brackish water reverse osmosis (BWRO) desalination plants (brackish desalters) is usually one of the key limiting factors associated with the wider implementation of inland brackish water desalination. Currently, in many locations brackish water concentrate from inland desalters is disposed most often by either deep well injection into high-salinity aquifers, or it is conveyed using a regional interceptor pipeline to a wastewater treatment plant (WWTP) and discharged to the ocean using the treatment plant's ocean outfall.

The first disposal method (i.e., disposal to a deep saline aquifer) is often limited by the capacity of this aquifer and is very dependent on the availability of such an aquifer in the vicinity of the brackish desalter. The second approach (i.e., disposal through the outfall of existing WWTP) is also relatively costly and more importantly, it occupies outfall capacity and thereby, it indirectly limits the treatment capacity of the host WWTP. Both alternatives treat brine from inland desalters as a waste and involve significant expenditures for the disposal of this brine.

An innovative alternative approach for integrated regional concentrate management is to convey brine generated from one or more inland desalters to a coastal seawater reverse osmosis (SWRO) desalination plant, blend this brine with seawater collected from the ocean, and then desalinate this blend in the seawater desalination plant (1).

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The key components of such regional concentrate management system are shown on Figure 1 and include: 1. inland brackish water desalination plants; 2. regional brine interceptor/collector; and 3. centralized coastal seawater desalination plant. The purpose of the regional brine collector is to convey the concentrate from the inland desalters to the regional seawater desalination plant, where this concentrate is used as supplemental feedwater to the source seawater used for desalination.

Although Figure 1 presents a combination of seawater desalination plant co-located with a coastal power generation plant, this approach could be used for SWRO plants with conventional intakes and outfalls as well. Use of concentrate from brackish water desalination plants as feedwater to a seawater desalination plant is mutually beneficial for both plants.

Suitable discharge. Usually, inland brackish water desalination plant capacity is limited by lack of suitable discharge locations for the plant concentrate. If the seawater desalination plant can accept brackish water desalination plant concentrate and process it, the brackish plant capacity could be increased beyond the threshold driven by brine discharge limitations, and the desalination plant source salinity could be reduced at the same time.

This regional concentrate management approach has a number of benefits. Brine from inland desalters using brackish groundwater sources typically does not contain pathogens (bacteria, *Giardia*, *Cryptosporidium*, among others) and therefore, it could be a safe and suitable source of water for seawater desalination. As a result, rather than being disposed as a waste product to the ocean or to deep aquifers, brackish water concentrate could be reused for drinking water production.

Brine from inland desalters usually has an order-of-magnitude lower total dissolved solids (TDS) concentration than seawater (i.e., 2,000 to 5,000 milligrams per liter (mg/L) versus 33,500

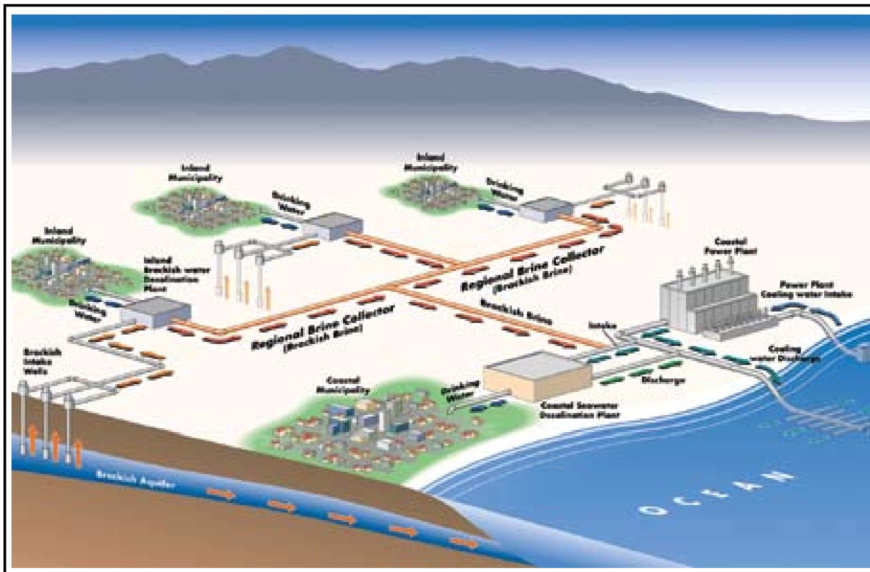

Figure 1. Integrated inland desalter brine disposal and seawater desalination.

to 35,000 mg/L). As a result, the mixing of brine and seawater will reduce the overall salinity of the source water fed to the seawater desalination plant, and therefore, it will decrease the total amount of energy needed to desalinate seawater.

Typically, brine from inland desalters contains antiscalants, which would allow to reduce or to completely eliminate the expenditures for addition of such chemicals at the seawater desalination plant and will increase seawater recovery. This benefit in turn would result in increased overall recovery of the desalination plant (i.e., more fresh water would be produced from the same amount of feedwater). Lower recovery in turn would yield lower unit production costs. For example, if 25% to 30% of the source water of SWRO plant operating on seawater of salinity concentration of 35,000 mg/L is replaced with brackish water concentrate of salinity less than or equal to 5,000 mg/L, than the total SWRO plant recovery can be increased from 45% up to 60% or 65%, which would significantly enhance the plant's overall production capacity.

By replacing some of the source seawater with brine from inland desalters, the total amount of new seawater that needs to be collected for the desalination plant operations will be reduced proportionally, which would lower the overall impingement and entrainment of marine organisms associated with collection of ocean water for seawater desalination.

Because of using this approach, brackish water desalter brine would be put to beneficial use, rather than being a disposal burden, as it is today. Instead, it would become a valuable resource, which would reduce the operational costs of the brackish water desalters, and at the same time it would enhance the affordability of seawater desalination. In addition, diverting brine from exiting WWTP ocean outfalls will enhance the available outfall capacity, and thereby could decrease wastewater treatment and disposal costs, especially if the WWTP capacity is limited by outfall discharge capacity availability. Operating SWRO plants at higher recovery as a result of integrated brine management would also yield reduction of the overall discharge volume and salinity of the SWRO plants. Such a change would also be environmentally beneficial.

Constraint to concentrate management approach. One of the key constraints of the practical use of this regional concentrate management approach is the fact that brackish water desalination plant concentrate may exhibit whole effluent toxicity because of the ion imbalance of the brackish concentrate, which may impact the ability of the seawater desalination plant to discharge its concentrate. The main factor that governs the brackish brine toxicity is the ratio of the concentration of one or more key ions (calcium, magnesium, fluoride, strontium, sodium, chloride, potassium, sulfates, and bicarbonates) in the brackish brine and the TDS concentration of the brine (ion/TDS ratio) (1). If the ion/TDS ratio for one or more of these key ions contained in the brackish brine is above a certain threshold value, the brine exhibits toxicity. If the ion/TDS ratio is lowered below a certain level by either removing the ion from the brine solution by precipitation or absorption or increasing the brine salinity, the brackish brine becomes nontoxic.

For example, if a standard whole effluent toxicity test organisms (mycid shrimp) is exposed to brackish desalter brine that contains calcium ion of 500 mg/L, and has a TDS concentration of 10,000 mg/L (i.e., an ion/TDS ratio of (500 mg/L)/(10,000 mg/L) = 0.05), the brine causes mortality of 100% of the test organisms (2).

However, when the brine TDS concentration is increased to 20,000 mg/L at the same calcium ion concentration (500 mg/L), the testing organisms survive (i.e., the increase in brine TDS concentration renders the same brackish brine non-toxic by decreasing the ion/TDS ratio below the threshold value for calcium ion of 0.05). Using this principle, brackish brine can be detoxified cost-effectively by mixing it with seawater or higher-salinity concentrate generated during seawater desalination with RO membranes in a certain mixing ratio. This mixing ratio depends on a number of factors, including the TDS concentrations of the brackish brine and the seawater, and the concentration of the major ions in the brackish water brine. The maximum ratio of brackish water concentrate to seawater that does not render the regional seawater desalination plant concentrate toxic can be established by pilot testing.

Summary and Conclusions

Integrated treatment of brackish water desalination plant concentrate with source water for SWRO can yield significant benefits, including: operation of the RO system at higher recovery and enhancement of plant production capacity; mitigation of potential toxicity of the brackish inland desalter; reduction of impingement and entrainment caused by the seawater intake operations by lowering the total volume of source water collected for SWRO desalination; and converting a water that is normally disposed (e.g., brackish desalter brine) into useful and valuable side-stream that can be reused to produce fresh drinking water.

References

1. Voutchkov, N. "Desalination System and Method for Integrated Treatment of Brackish Water Concentrate and Seawater, U.S. Patent No. 8,206,589 B2 (June 25, 2012).
2. Mickley, M.C. "Major Ion Toxicity in Membrane Concentrate", AWWA Research Foundation, Denver, Colo. (2000).

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