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Editorial

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Brine Discharge: One Size Does Not Fit All

Investments in seawater desalination and water recycling are increasing as drought-prone areas of the world struggle to provide adequate quantities of potable water (see Bruce Logan's recent Editorial). While providing potable water is clearly a necessity for civilization, from an ecotoxicology perspective there are potential risks that need to be considered more fully if desalination and water recycling systems are to be ecologically sustainable.

In 2008, the U.S. National Research Council convened a panel that evaluated ecological issues related to desalination and highlighted the relatively few data sets available that have examined before and after treatment strategies and facility impacts on ecological systems, particularly in coastal settings. A similar panel convened by the State of California also concluded that significant complexities exist with regard to the ecological effects of desalination and water reuse. Two uncertainties that were consistently expressed in the panels were that (1) brines differed dramatically and should not be considered one entity and (2) the site of discharge has a significant impact on the relative risk of the discharge.

The age-old question with reverse osmosis (RO) treatment has always been what to do with the brine. The first issue that needs to be addressed with regard to brine discharge is the source of water used for filtration. For example, the primary constituents of brine from ocean desalination are ionic and would not be considered to be acutely toxic at discharge concentrations. However, to maintain consistent flow through the filtration membranes, antifouling chemicals such as chloramines are used to clean membranes.

With few exceptions, antifouling agents represent limited risks to ecological systems upon discharge in oceanic desalination. However, if other source water such as municipal wastewater is used, a much different risk scenario can occur. Secondary or tertiary treated wastewater can undergo membrane filtration prior to potable water reuse. Given that chloramines are continually used during the RO process, the formation of unique halogenated byproducts due to elevated bromide from domestic wastewater may take place. For example, low concentrations of hydrophilic pharmaceutical or personal care micropollutants from treated wastewater could conceivably be halogenated in this type of brine and concentrated at concentrations 4−6-fold higher than in wastewater. Brominated and chlorinated micropollutants have been observed in effluents where brine is derived from secondary treated wastewater. The creation of halogenated byproducts presents relatively unique risks to biota associated with RO concentrate discharge especially if the blended discharge is chlorinated for disinfection a second time prior to final discharge. Halogenation of hydrophilic water-soluble micropollutants dramatically alters the fate and effects of the parent compound by increasing the hydrophobicity such that the halogenated derivatives likely partition out of the water column into sediments or biota. While the concentrations of these compounds in the water column are not likely to be an issue in open ocean discharge due to dilution (see below), constant exposure (also known as pseudopersistence) and deposition within sediments may be a concern for the now-hydrophobic derivatives. Very limited research has been conducted in this area and represents a clear uncertainty with regard to risks associated with this type of brine.

To limit the potential effects of brines (or RO concentrates) on receiving waters, the concentrates are usually blended with wastewater prior to discharge. However, in regions where water recycling is occurring, the amount of wastewater that is available for blending may be limited. For example, in many cases throughout California, wastewater discharge volume has significantly decreased, in some cases up to 50% over the past 5 years. Several wastewater treatment plants have goals to be "water free" within the next two decades. Consequently, with smaller volumes of water for blending, concentrates will likely not be diluted prior to discharge.

Because of limitations in dilution by wastewater blending, the site of discharge is probably the most significant variable with regard to evaluating the risks of brine or RO concentrate to ecological systems. Sites and dilution can vary tremendously. Open ocean discharge provides an up to 1000-fold dilution and limited toxicological risk in the water column. In contrast, shallow water bays or sounds provide less dilution and in some cases limited efflux of the discharge to the open ocean. The distribution of brine below the halocline within embayments may establish hypoxic/anoxic conditions at the overlying water/sediment interface. Such a case may occur in Cockburn Sound just south of Perth in Western Australia. Enhanced brine discharge to limited flux embayments coupled with climate change-induced sea level rise (i.e., hypersalinity) and continued freshwater removal for recycling of municipal wastewater may exacerbate salinity regimes within sensitive waterways. For example, the spring salinity of Suisun Bay within San Francisco Bay has increased more than 10 parts per thousand over the past four decades. The combination of hypersaline water with other climate change outcomes such as increased temperature may have significant impacts on estuarine algal blooms or on migratory species (i.e., salmonids) and may alter responses to other contaminants or stressors such as urban pesticides or impervious surface runoff. While National Pollutant Discharge Elimination System (NPDES) permits in the United States require acute toxicity tests and standards of 1−3 parts per thousand have been proposed for discharge, there is still considerable uncertainty with regard to chronic impacts of concentrates and unknown disinfection byproducts on biota.

While human health is clearly a significant concern with regard to adequate water supplies, ecological impacts particularly in endangered species warrant additional investigation and accurate assessments of risk. Water sustainability is a targeted philosophy with regard to water distribution in geographical areas such as California and Australia. Con-

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sequently, impacts on both ecological and human health need to have equal parametrization in "site-specific" assessments when conducting risk–benefit analyses for emerging technologies. In addition, technologies that can limit impacts of brine/concentrate discharge are also necessary. Alternatives include utilization of nonhalogenated oxidants for disinfection or membrane antibiofouling, and wetland treatment of the final effluent. If we can stop using chlorine for either pre- or post-treatment of concentrates, the ecological risks of RO concentrates will likely be diminished and allow sustainable use of saltwater and wastewater for consumption.

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Notes

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