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Effects of nearshore evaporation rates on the design of seabed gallery intake systems for SWRO facilities located along the Red Sea shoreline of Saudi Arabia

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ABSTRACT

Feed water to seawater reverse osmosis desalination systems should have a constant salinity with minimal variation. Intake systems that extract water from shallow nearshore areas in arid regions can exhibit significant fluctuations in salinity caused by high rates of evaporation and lack of circulation. Such fluctuations in salinity could inhibit the design, construction, and operation of seabed gallery intake systems located in shallow nearshore areas, such as the Red Sea inner shelf. Water depths range from 0 to 2 m between the beach and the edge of the fringing reef in the optimal locations for the development of seabed gallery intakes along the coast of the Red Sea of Saudi Arabia. The evaporation rate in this area is between 2 and 3 m per year. The bottom consists of mostly a marine hardground containing a thin veneer of unlithified sediment and no significant cover of corals or seagrass. The rather barren nature of the bottom suggests that periodic hypersalinity may contribute to the formation of hardgrounds on the bottom by causing supersaturation of the seawater with calcium carbonate and may limit the growth of corals and grasses. To assess the changes in salinity, a conceptual model was developed which assumes that a shallow circulation cell develops between the shoreline and deeper water offshore. Lower salinity seawater should migrate landward to replace water loss caused by evaporation with seaward moving of high-salinity water occurring along the bottom to balance the flow with ultimate mixing before the reef tract. To test this circulation pattern, a series of sensors were deployed to continuously monitor the water temperature, conductivity, and salinity at the surface and at the bottom during several periods of high air temperature. Surprisingly, the results show very little variation in salinity, despite the very high evaporation loss. The water salinity ranged between 39,000 and 40,000 mg/L with no diurnal variations of significance. Based on the monitoring and weather station data collected nearby, it appears that the predominant strong onshore wind, particularly during the afternoon and early evening, causes near-continuous mixing of the water between the reef tract and the shoreline. Therefore, the development of seabed gallery intake systems within the shallow water between 1 and 2 m of depth is feasible based on the measured salinity which is similar to that occurring further offshore in water depths between 2 and 20 m.

Keywords: Seawater reverse osmosis; Seabed gallery intake; Nearshore circulation; Red Sea; Salinity variation

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