

Performance Optimization of Low Resistance Ion Exchange Membranes in an Electrodialysis–Evaporator Hybrid System for Reject Brine Treatment in Kuwait Desalination Plants

Bader S. Al-Anzi *

Environment Science, College of Life Sciences, Kuwait University, Kuwait City, Kuwait

Maryam K. Awadh

Environment Science, College of Life Sciences, Kuwait University, Kuwait City, Kuwait

Zainab A. Aljaser

Environment Science, College of Life Sciences, Kuwait University, Kuwait City, Kuwait

Amy Magdalene Paul

Environment Science, College of Life Sciences, Kuwait University, Kuwait City, Kuwait

Abstract

This study aims to mitigate the environmental impacts of brine discharge generated from desalination plants. A pilot-scale electrodialysis–evaporator hybrid system was implemented as a cost-effective approach for treating reject brine. The electrodialysis unit employed a low-resistance membrane (LRM) to enhance salt production and low-salinity water recovery. The system consisted of an electrodialyzer with 25 cell pairs, incorporating monovalent selective anion exchange membranes (AEMs) and monovalent selective cation exchange membranes (CEMs), along with a neutral cell positioned at the cathode to limit fouling caused by the accumulation of divalent ions such as Ca^{2+} and K^+ .

The system was evaluated under varying operating conditions, including current densities ranging from 300 to 500 A/m^2 and flow rates of 400 and 450 L/h . The results demonstrated that the low-resistance membrane achieved higher water recovery, reduced energy consumption, and more efficient monovalent ion removal compared to the high-resistance membrane. However, the permselectivity of the LRM for monovalent cations decreased with increasing current density, whereas the performance of the high-resistance membrane was less sensitive to current density variations. Furthermore, the inclusion of a neutral cell effectively minimized divalent ion accumulation on the inner cathode membrane.

Keywords

Brine discharge, electrodialysis, density, resistance, recovery.