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Performance optimization of integrated electrochemical capacitive deionization and reverse electrodialysis model through a series pass desorption process

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Abstract

A capacitive deionization (CDI) system is one of the emerging desalination technologies used to purify brackish water. It is an electrochemical technology that uses electrically charged porous electrodes to remove salt ions from water. In this study, we developed a process model by integrating CDI with reverse electrodialysis (RED) for the production of pure water and energy. RED is a power generation technology that uses the mixing entropy of water with high and low salt concentrations. Desalination with low energy consumption and high water recovery (WR) was a design preference for this integrated electrochemical model. CDI system was optimized with a series four pass reverse current desorption (RCD) method to achieve WR of almost 96.7% that was previously 50–80% on average. Moreover, an artificial salinity gradient was also produced for RED to generate energy through this four-pass RCD method of CDI. The concentration gain ratio (CGR), WR of CDI, and power density of RED was numerically assessed with different number of desorption passes and for CDI desorption current. WR and CGR value in CDI increased to 96% and 25, respectively, with the increase of number of desorption passes to four. Two stage RED cell system is used to get energy from salinity gradient produced through CDI. Energy consumption of 1.5 kJ/l for pure water production was reduced to 0.58 kJ/l with this purposed integrated four-pass CDI-RED system. This integrated electrochemical system reduced desalination energy consumption as well reducing environmental pollution with an eco-friendly, renewable power generation method and a reduction in the CDI disposal concentration.

Keywords
Water recovery; Salinity gradient power; Electrosorption; Electrochemical process integration; Wastewater treatment