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Brackish water desalination in RO–single pass EDR system

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ABSTRACT

Electrodialysis reversal (EDR) treatment of inland brackish water reverse osmosis concentrate was examined. The resistance to $CaSO_4$ and $CaCO_3$ scaling in our single-pass and low residence time EDR is better than in the one that was originally developed by Ionics. Our approach is as follows. The RO concentrate of $CaSO_4$ and $CaCO_3$ content being close to the saturation level (or slightly supersaturated) is concentrated by EDR 4–5 times. This enables the concentrate volume to decrease and, probably, its disposal cost to the same extent. Assuming brackish water composition as follows (mg/L): Mg^{2+} — 95.4; Ca^{2+} — 208.4; Cl^- — 1166; SO_4^{2-} — 868.8; HCO_3^- — 170.8; NO_3^- — 179.8 and 60% RO recovery, concentrate composition was calculated using Dow Chemical Co. RO system analysis (ROSA) software. Simulated RO concentrate containing (mg/L): Mg^{2+} — 237.7; Ca^{2+} — 519.2; Cl^- — 2886; SO_4^{2-} — 2164; HCO_3^- — 414.4; NO_3^- — 424.3 was then treated in a laboratory EDR stand at 79.1% diluate recovery. The analysis of EDR stack voltage drop vs. EDR process time curves showed that scaling did not occur despite 358.9% calcium sulfate saturation level and 2.29 Langelier Index value. The overall RO–EDR water recovery was equal to 91.6% despite the high scaling potential of investigated water. The expected cost of EDR was found to be promising, especially as compared to evaporation. E.g. the RCC vapor compression evaporation (turned out to be useful for treatment of $CaSO_4$ containing brine) energy consumption was equal to ca. 20 kWh/m^3 while our EDR laboratory test showed the demand (in similar salinity range) of ca. 3 kWh/m^3 at the estimated unit EDR cost \$0.30/m^3. EDR has especially high potential in the case of waters containing calcium sulfate and calcium bicarbonate as dominant solutes. Thus, $CaSO_4$ and $CaCO_3$ may be crystallized in the EDR concentrate and disposed. This will allow zero-discharge technology to develop.

Keywords: Brackish water desalination; RO concentrate disposal; EDR; RO–EDR hybrid system

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