Monovalent Selective Electrodialysis for Improved Irrigation

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ABSTRACT

Countries in the Mediterranean basin and Middle East with significant proportions of their national water use supplied by seawater desalination are increasingly re-using this water after its urban use for irrigation. Given that the ionic composition of desalinated seawater is inappropriate for irrigation because of the high sodium adsorption ratio (SAR) and the lack of essential minerals (calcium, magnesium, and sulfate), brackish water is often added back into the desalinated seawater to provide these minerals. However the chloride added back with the minerals increases plant irrigation water consumption. Monovalent ED can potentially solve this problem. Three types of commercial monovalent selective ion exchange membranes (MIEM) (Neosepta CMS/ACS by Astom Co., Selemion CSO/ASA by Asahi Glass, and MVK/MVA by PCCell) were tested in experiments focused on ED performance under various operating conditions of current density and feed ionic strength. Membrane permselectivity was compared by means of separation efficiency of different pairs of ions namely Cl versus SO_4, and Na versus Ca and Mg.

All monovalent selective anion exchange membranes tested showed excellent selectivity for sulfate over chloride. Monovalent selective cation exchange membranes worked less well at the lower conductivities typical of brackish water, with only CSO membrane showing significant monovalent permselectivity ($P_d^m > 1$) at conductivities < 4.5 dS/m. Highest monovalent cation selectivity was obtained using the CSO/ASA membranes (See Figures 1 and 2) after special regeneration treatment. This resulted in reducing the SAR of treated well water from 12.3 to 2.4.

Bell peppers were irrigated in lysimeters with monovalent selective ED desalinated brackish water mixed with RO and compared with brackish water mixed with RO permeate. The plant yield was significantly improved (by 31%) by using monovalent selective ED, while less RO permeate was required (see Table 1). The salt load was also significantly reduced (by 25%).

Table 1: Results of lysimeter experiment growing bell peppers with waters blended with RO permeate

	SED/RO 1:1 MIX	GW/RO 1:3 MIX
Total plant mass (g)	186 (+/- 23)	142 (+/- 24)
Salt load, g/m^2	177	236

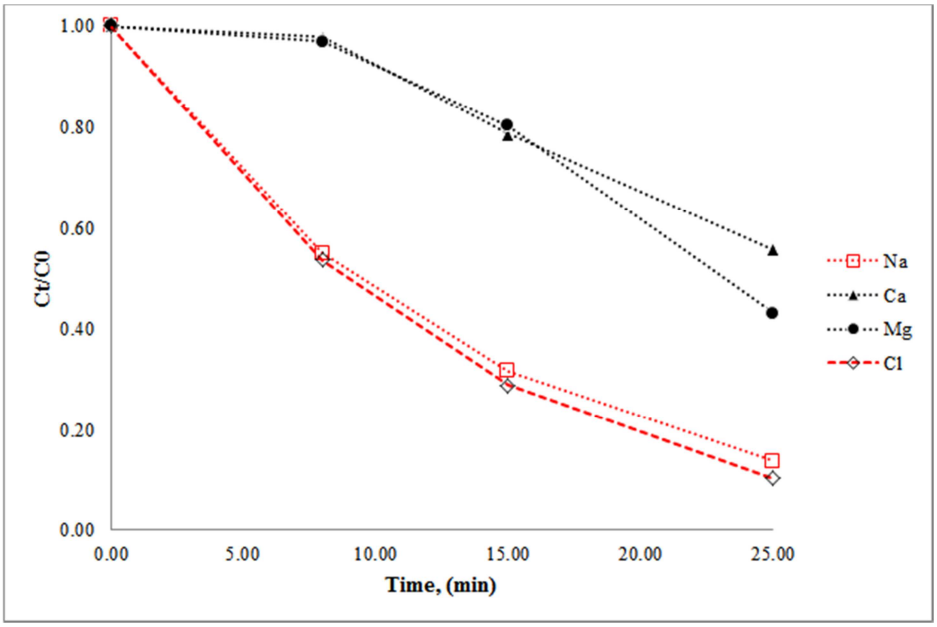


Figure 1: ED run with Mashabe Sade Well water. ED stack equipped with 0.2 m^2 of CSO/ASA membrane.

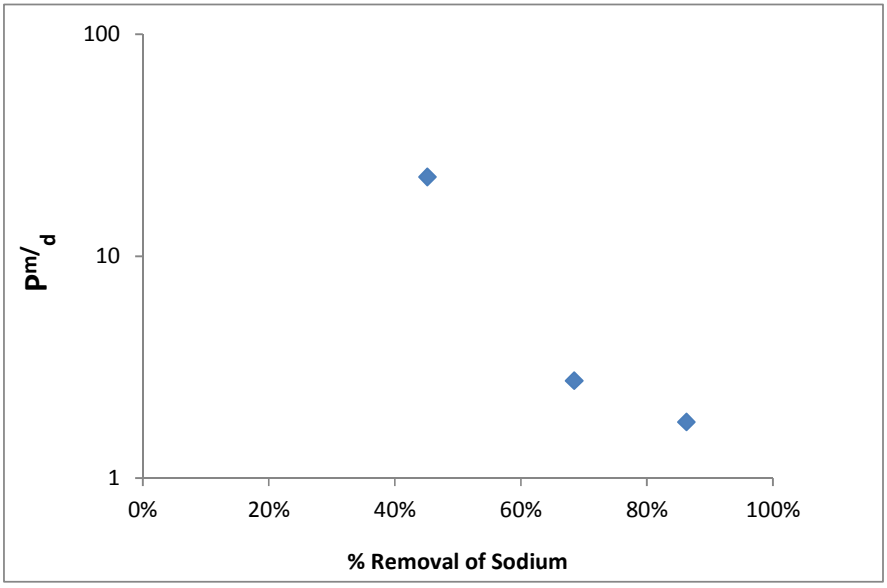


Figure 2: Relative selectivity of monovalent over divalent cations $P_d^m = \frac{t_m}{t_d}\frac{C_d}{C_m} = \frac{J_m}{J_d}\frac{C_d}{C_m}$ in treating brackish well water