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Batch and Dynamic Investigations on Magnesium Separation by Ion Exchange Adsorption: Performance and Cost Evaluation

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Abstract : Ion exchange adsorption has a long standing history of success for seawater softening and selective ion removal from saline sources. Strong, weak and mixed types ion exchange systems could be designed and optimized for target separation. In this paper, different types of adsorbents comprising zeolite 13X and kaolin, in addition to, poly acrylate/zeolite (AZ), poly acrylate/kaolin (AK) and stand-alone poly acrylate (A) hydrogel types were prepared via microwave (M) and ultrasonic (U) irradiation techniques. They were characterized using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM). The developed adsorbents were evaluated on bench scale level and based on assessment results, a composite bed has been formulated for performance evaluation in pilot scale column investigations. Owing to the hydrogel nature of the partially crosslinked poly acrylate, the developed adsorbents manifested a swelling capacity of about 50 g/g. The pilot trials have been carried out using magnesium enriched Red Seawater to simulate Red Seawater desalination brine. Batch studies indicated varying uptake efficiencies, where Mg adsorption decreases according to the following prepared hydrogel types AU>AM>AKM>AKU>AZM>AZU, being 108, 107, 78, 69, 66 and 63 mg/g, respectively. Composite bed adsorbent tested in the up-flow mode column studies indicated good performance for Mg uptake. For an operating cycle of 12 h, the maximum uptake during the loading cycle approached 92.5-100 mg/g, which is comparable to the performance of some commercial resins. Different regenerants have been explored to maximize regeneration and minimize the quantity of regenerants including 15% NaCl, 0.1 M HCl and sodium carbonate. Best results were obtained by acidified sodium chloride solution. In conclusion, developed cation exchange adsorbents comprising clay or zeolite support indicated adequate performance for Mg recovery under saline environment. Column design operated at the up-flow mode (approaching expanded bed) is appropriate for such type of separation. Preliminary cost indicators for Mg recovery via ion exchange have been developed and analyzed.

Keywords : batch and dynamic magnesium separation, seawater, polyacrylate hydrogel, cost evaluation
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