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Nanofiltration and low energy reverse osmosis for rejection of radioactive isotopes and heavy metal cations from drinking water sources

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ABSTRACT

While nanofiltration (NF) and low energy reverse osmosis (LERO) have only moderate rejection for monovalent salts, they have been shown to be highly effective in water dehardening and in removal of polyvalent contaminant ion species. The present work is a part of a long-term investigation of the treatment of contaminated ground waters and certain grades of industrial waste waters for rejection of radioactive isotopes and heavy metal cations (HMC) and for determination of efficient and environmentally safe waste disposal methods. In fact several technical challenges remain with regards to the efficiency and cost of conventional methods for removal of certain contaminants, NF is thought to offer higher efficiency and lead to lower cost. Separation of radium (Ra^{2+} 226 and Ra^{2+} 228), uranium 238 (UO_2^{2+} or its carbonate complex anions at pH 7.5 to 8, $UO_2(CO_3)_2^{2-}$/ $UO_2(CO_3)_3^{4-}$, Cd^{2+}, Cu^{2+}, Hg^{2+} and other cations from mixture salt solutions was investigated as a function of water composition and concentration by NF and LERO. Results were compared to those of separation by conventional methods of chemical precipitation, softening with the hot lime method (HLM), coagulation, and separation by chelating ion-exchange resins (IERs) determined under the same conditions. Membrane methods gave higher rejection of radionuclides and HMCs ranging from 92% to 99%. Contaminant concentration in permeate water was lowered than the maximum contaminant level (MCL) of the US Environmental Protection Agency at system recoveries which attained 90%. In case of separation by IERs a loss of process efficiency which attained 24% was observed in view of interference with separation of similar valency ions such as Ca^{2+} and SO_4^{2-}. The higher the efficiency of the resin to retain the radionuclide, the more its regeneration was difficult, resulting in a higher volume of contaminated spent solution. With NF and LERO, on the other hand, parallel rejection of polyvalent ions did not practically impact that of radionuclides or HMCs, and membranes do not require regeneration. Results of rejection of radionuclides and HMCs showed several significant advantages of membrane methods over that by IER, coagulation, chemical precipitation, and softening. These are the absence of chemical dosing specific to rejection, absence of sludge formation which is contaminated and requires disposal, mechanism does not include slow steps like settling, no need of subsequent filtration or of expensive installations, and the ability to realize parallel water desalination. The study will extend to the evaluation of the waste disposal alternatives. In view of the concentration of the contaminants in the waste stream, selection of environmentally safe disposal methods will be determined.

Keywords: Nanofiltration; Low energy reverse osmosis; HMC removal; Radionuclides removal

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