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Concentration of seawater reverse osmosis brines using electrodialysis for a zero discharge system

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Reverse osmosis (RO) and multi-stage flash (MSF) are the most worldwide used desalination technologies. The decision for a certain technology is influenced by several factors such as feed water salinity, required product quality available area, energy cost, local demand for electricity, etc.[1] Reverse osmosis (RO) is the currently most used membrane technology for seawater desalination in Europe due to its lower energy consumption compared to other desalting technologies [2].Up to 40-50% of the treated seawater in RO process is rejected as high salinity brine with all the chemicals used in the process. The main drawback of this desalting technology is then the disposal of the rejected brine, which is generally drained back into the sea due to economic reasons. Other methods such as dilution with seawater or with other streams have been studied [3,4] but are not commonly applied because of their extra cost.

The direct RO brine disposal into the sea generates environmental impacts in the reception point such as diminishing the amount of flora and creating salinity, temperature and alkalinity gradients. Seawater RO brines have been identified as an alternative to common NaCl sources for the chlor-alkali industry due to its high NaCl content. This reuse could be beneficial both in terms of reducing the environmental impact of these brines disposal (thus promoting zero desalination discharge system) and creating synergies between the two industries.

Reuses of RO brine to produce solid salts have been widely reviewed by Kim [5], Van der Bruggen et al.[6], Perez et al.[7], nevertheless SWRO reject reuse in other industries have not been completely studied because sea disposal is an easier and cheaper way to get rid of the reject. Different studies can be found on the valorization of by-products from RO reject through different concentration-precipitation systems to obtain salts, which are commonly known as ZLD (zero liquid discharge) [8]. Zero Desalination Discharge (ZDD) was also developed to recover salts from SWRO brine [9]. However, direct liquid reuse of the brine has not been reported.

Chlor-alkali industries demand purified and saturated NaCl brine. SWRO brine should be concentrated and purified from polivalent ions in order to be reused in this industry. Electrodialysis (ED) has been evaluated as preliminary step of NaCl concentration for these brines in order to meet the chlor-alkali requeriments.

An ED pilot plant of 500L/h with 100 membranes was installed in the desalination plant of Barcelona and is currently being operated in order to optimize the NaCl concentrated brine produced. Experimental results showed that ED was an effective concentration technology. Parameters such as temperature, current density, production overflow and energy consumption have been studied to determine the optimal operation point for the ED pilot plant, which was determined at 0.5kA/m2 at 28C (0.16 kA/m2 energy consumption and 244 g/L NaCl obtained). Moreover, as the membranes used (Neosepta CIMS and ACS) were mainly selective for univalent ions, polyvalent ions were partially removed from the brine, benefiting its reuse. Concentration Factor (CF) was calculated in every experiment with the relation between final and initial concentration.

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