CCD series no-16: opened vs. closed circuit SWRO batch desalination for volume reduction of Silica containing effluents under super-saturation conditions

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ABSTRACT

Opened-circuit desalination (OCD) of a high salinity source (>10,000 ppm) also containing large amounts of Silica (>124 ppm) by the application of a single-element module batch apparatus under the conditions of fixed applied pressure of declined flux at low pH was reported to proceed with 80–85% recovery by a high-energy process of low permeate productivity through high super-saturation conditions of silica. The present study describes theoretical model simulations of OCD and closed-circuit desalination (CCD) processes of same feed source (10,000 ppm NaCl–125 ppm SiO₂) with different apparatus of identical single-element (SWC6-MAX) modules which execute either closed- or opened-circuit desalination under fixed pressure (47 bar) of variable flow conditions. The results of this theoretical study reveal milder batch process conditions for CCD compared with OCD manifested by longer sequence duration (23.35 instead of 15.95 min), much lower energy consumption (1.57 instead of 7.93 kWh/m³) with average TDS of permeates about the same for both processes up to ~75% batch recovery, and higher for the former process (316 instead of 316 ppm TDS) at the ultimate batch recovery of both (~83%) with same pattern also repeated for the average Silica content in permeates (6.76 instead of 3.65 ppm silica). Silica in the recycled concentrates of both CCD and OCD processes is found in the range of 125–728 ± 6 ppm) and reveals desalination under high super-saturation conditions with Silica maximum of ~5.8-fold (~580%) excess over its ordinary saturation level.

Keywords: Reverse osmosis; RO; SWRO; BWRO; Opened-circuit desalination; Closed-circuit desalination; Volume reduction of silica-containing effluents; Rescue and reuse of water from brine effluents