RESEARCH BRIEF
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NAWI National Alliance for Water Innovation

NAWI 3.19 Reverse Osmosis with Virtual Curtain to Achieve Minimal Liquid Discharge

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Challenge

Currently, there is a technical and economic challenge of treating brackish, impaired waters having high scaling potential which currently require the use of cost- and energy-intensive thermal desalination technologies to achieve minimum- (or zero-) liquid discharge (MLD or ZLD) to treat reverse osmosis (RO) concentrates (brines). RO is recognized as the most cost-effective process for desalinating impaired water supplies. However, for most waters, the presence of sparingly soluble solutes (scalants) limits RO efficiency (water recovery) due to mineral precipitation to well below theoretical maximums (e.g., concentrate salinity corresponding to maximum membrane osmotic pressure).

Research Approach

The overall objective of this project is the successful coupling and integration of RO with Commonwealth Scientific and Industrial Research Organization's (CSIRO's) patented Virtual Curtain (VC) process to maximize water recovery and minimize concentrate volume by allowing RO to operate at its osmotic pressure limit. The VC process uses the in-situ formation of hydrotalcite (HTC, Cheng et al., 2014, 2021; Douglas 2014) to remove, through adsorption, ion-exchange, and co-precipitation, key RO membrane scalants including silica and alkaline earth metal salts (e.g., calcium and magnesium). By applying the VC process to the treatment of brackish RO concentrates, scaling potential is significantly reduced, allowing for further treatment by RO to maximize overall water recovery. In this research, submerged ceramic membrane filtration will be used to remove the HTC solids, providing a high-quality water suitable for direct treatment using a second seawater RO step. The seawater RO unit will be used to determine the maximum recovery that can be achieved prior to the onset of mineral precipitation with the goal of achieving >97% overall recovery. Bench testing will be conducted initially to optimize variables for HTC formation (chemical concentrations, pH, reaction time) with two different brackish waters (surface and ground); followed by pilot testing of the overall process as shown in Figure 1.

Impact

The major outcome of this project will be a significant reduction in thermal brine concentrator capital (CAPEX) and operating costs (OPEX), enabling Minimal Liquid Discharge (MLD) or Zero Liquid Discharge (ZLD). VC reduces the scaling potential of impaired water through in situ HTC mineral-based co-precipitation of recovery-limiting solutes (silica, alkaline earth metal salts) more efficiently and economically than chemically or operationally intensive methods such as high-pH lime softening and ion exchange. By eliminating conventional precipitation/clarification with gravity filters, in-line precipitation with VC followed by CMF for solids clarification provides a simplified, scalable process for MLD or ZLD. This approach can be applied to small-scale desalination of challenging water supplies. RO/VC integration will enable a transformative step in water recovery, supporting more cost-effective treatment of traditional and non-traditional impaired sources.

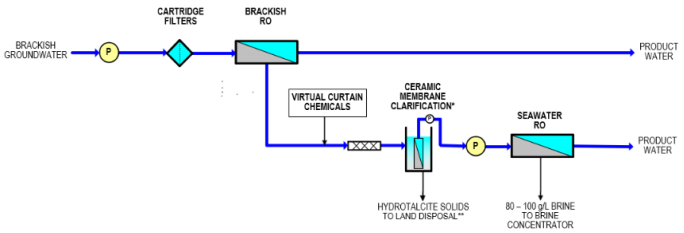

Figure 1. CCRO-VC Treatment for Processing Brackish Groundwater

RESEARCH PARTNERS

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