RESEARCH BRIEF
Start Date: October 2023 | Duration: 24 months

NAWI
National Alliance for Water Innovation

Development of a Flow-through Intensified ELectroDialysis (FIELD) System to Manage Inland Reverse Osmosis Concentrate

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Challenge

Inland desalination of wastewater and brackish water can generate reverse osmosis concentrate (ROC) with elevated levels of hazardous contaminants, such as ppb-level heavy metals (e.g., Ni^{2+}, Cu^{2+}, Hg^{2+}, Cd^{2+}, Pb^{2+}, and Mn^{2+}) and sub-ppb-level trace organics of emerging concern (e.g., PFAS). These hazardous contaminants prevent inland ROC from a direct environmental discharge, requiring further contaminant elimination or bulk separation to remove all contaminants from the ROC. Unfortunately, limited cost-effective and energy-efficient treatment schema currently exists to achieve simultaneous water recovery, total dissolved solids (TDS) removal, selective metal separation, and efficient organics degradation in inland ROC.

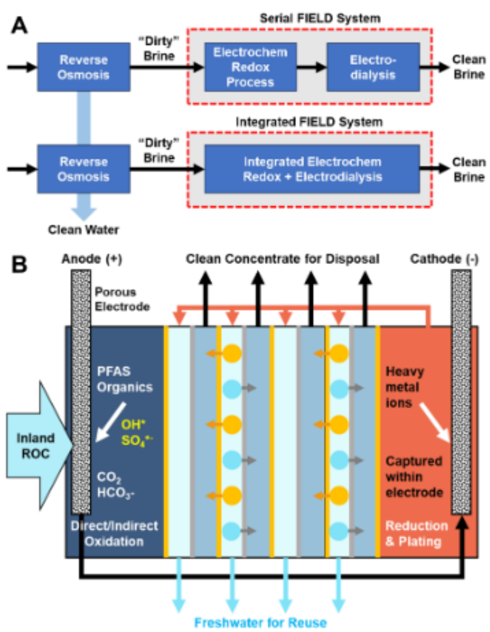

Figure 1. Schematic of FIELD system in a flow-through operation. (A) Serial and integrated FIELD system schema to purify RO brine. (B) A zoom-in of an integrated FIELD system with an electrochemical redox process to oxidize organics and reduce metal ions and an electrodialysis process to separate salts.

RESEARCH PARTNERS

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Research Approach

To promote inland desalination, our collaborative project brings together theoretical material scientists, electrochemical scientists and engineers, environmental engineers, energy research organizations, and at-stake inland municipalities to develop a Flow-through Intensified ELectro-Dialysis (FIELD) System. Such a FIELD system strategically combines flow-through electrochemical redox processes with a commercial electrodialysis to degrade recalcitrant organics, capture diluted heavy metals, extract non-hazardous dissolved salts into a "clean concentrate" for potential environmental discharge, and produce freshwater for beneficial reuse (Figure 1).

Impact

We envision that advancement in these key performance metrics will significantly improve pipe parity when sourcing freshwater from brackish water and municipal wastewater. Specific impact of the proposed FIELD system include: (i) reduced levelized cost of water as the FIELD system consumes minimum spent materials while generating "clean brine" to lower waste management cost, (ii) enhanced energy performance using similar amount of electrons to complete multiple tasks (i.e. electrooxidation, electroplating, and electrodialysis), (iii) high-efficiency water treatment to remove >90% of PFAS, heavy metals, and TDS while recovering >90% of reusable water, (iv) improved externalities with >90% reduction of waste stream volume and contaminants of emerging health concern, (v) outstanding process adaptability to accept variable input water matrices with ppb levels of contaminants while producing consistent effluent water quality, (vi) desirable reliability and availability with high resiliency to quickly recover from performance disruption through in-situ cleaning and/or self-regeneration, (vii) strong compatibility with existing RO-based inland desalination infrastructure and distributed electric power, and eventually (viii) promoting a sustainable water economy as this multi-purpose FIELD system can be adapted to water recovery in other PRIMA sectors at reduced physical and carbon footprints (e.g. ,GHG emissions).

This work was supported by the National Alliance for Water Innovation (NAWI), funded by the U.S. Department of Energy, Energy Efficiency and Renewable Energy Office, Industrial Efficiency and Decarbonization Office.

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