Desalination and Water Purification Research Program: 2023 DWPR Research Projects

Alabama

University of Alabama: Engineering Sustainable Solvents for Brine Desalination

Reclamation Funding: $249,966 **Total Project Cost: $499,932**

The goal of this proposal is to improve the solvent performance in temperature swing solvent extraction (TSSE) for brine desalination. TSSE utilizes an organic solvent with temperature-dependent water solubility to dissolve water at a lower temperature to concentrate or crystallize the brine and the phases are separated. Then, the water-in-solvent mixture is heated to reduce water solubility and induce phase separation between the solvent and water. The solvent and de-salted water phases are separated, and the regenerated solvent can be recycled. This project addresses issues with current TSSE solvents by utilizing intertwined experimental and computational techniques to design glycerol-based solvents for TSSE.

California

Pacifica Water Solutions: Field Pilot Testing Electrically Conducting Nanofiltration and Reverse Osmosis Membranes

Reclamation Funding: $350,000 **Total Project Cost: $700,000**

This project proposes extended field testing of innovative anti-scaling and antifouling electrically conducting desalination membranes against commercial membranes to demonstrate performance through two consecutive 3-month tests in two applications - RO concentrate minimization and oil and gas produced water softening and pre-treatment. This technology seeks to significantly reduce the footprint, increase the freshwater recovery, minimize concentrate waste, and as a result decrease capital and operating cost and environmental impacts of desalination.

University of California, Riverside: Development of a Novel Vacuum-ultraviolet Photochemical System for Treatment of Nitrate and Per Fluorinated Substances from Inland Desalination Brine

Reclamation Funding: $250,000 **Total Project Cost: $390,754**

The goal of this project is to test a novel and laboratory-scale vacuum ultraviolet light-driven photochemical process for treatment of nitrate and perfluoroalkyl substances (PFASs) from inland desalination brine. The success of this project will lead to cost-effective and sustainable inland concentrate management, improve membrane system performance, and reduce operational costs, energy consumption and environmental impacts of inland desalination systems.

Colorado

Mickley & Associates: Brine Mining

Reclamation Funding: $111,500 **Total Project Cost: $234,150**

Brine mining is the extraction of useful minerals which are dissolved in brine. Source waters range from naturally occurring seawater and brackish water to industrial and municipal wastewaters. Despite this rapidly evolving consideration of brine mining, there is the lack of information available to the municipal and industrial communities on this topic. The proposed project will gather, analyze, and synthesize information from the literature, websites, and interviews to bring clarity to many issues involving brine mining, such as potential benefits, feasibility, applicable technologies, recoverable compounds, and more.

University of Colorado: Robust Surface Patterned Membranes for Membrane Distillation of High Salinity Brine with High Efficiency

Reclamation Funding: $250,000 **Total Project Cost: $396,501**

This project aims to develop scalable, robust, surface-patterned microporous membranes that are designed for a membrane distillation (MD) process to treat highly concentrated brines. The project will develop a roll-to-roll method to manufacture 8-inch wide surface-patterned microporous membranes, demonstrate long-term operation of direct contact MD process of concentrated brine with antifouling/scaling properties, and conduct technoeconomic analysis of the technology.

University of Colorado: Concentrate Minimization: Pilot Testing of Improved Static Mixer Crystallizers

Reclamation Funding: $592,703 **Total Project Cost: $756,246**

This project proposes the pilot scale testing and evaluation of improved in-line, static mixer elements conducted with real reverse osmosis desalination brine. The improved static mixer elements will be fabricated using conventional 3D printing equipment. The element shapes and the polymer materials to be used are based on prior lab studies indicating their superior performance for accelerating the desupersaturation (aka crystallization) of model brines. This project will validate laboratory results with real and variable water compositions, study the ability of the chosen static mixer element shapes and materials of construction to resist crystal deposition (scaling) themselves, and provide data at different static mixer dimensions and flow rates to support computational fluids modeling that will inform translating the technology to commercial sizes.

Indiana

Purdue University: Batch Counterflow Reverse Osmosis

Reclamation Funding: $250,000 **Total Project Cost: $465,799**

This project proposes the first batch osmotically assisted RO process, termed Batch Counterflow Reverse Osmosis (BCFRO). This process achieves exceptionally high salinities by counterflow of the brine and diluate, and high efficiencies via batch operation of a reciprocating piston-tank to make pressure follow the osmotic curve. Implementing multistage batches at higher salinities is done using the same components in one stage, requiring far fewer parts than competing approaches. This project will create the first experimental lab-scale demonstration of BCFRO and develop a fundamental understanding of fouling kinetics for the process.

Massachusetts

Tufts University: New Fouling-Resistant, Anti-Microbial Membranes for Pretreatment

Reclamation Funding: $249,994 **Total Project Cost: $407,733**

This proposal aims to develop and demonstrate ultrafiltration pretreatment membranes that resist organic fouling and biofouling through dual mechanisms, manufactured through a novel scalable manufacturing process. These membranes will feature ultra-thin, zwitterionic hydrogel selective layers that strongly resist the adsorptive fouling by organic compounds, as well as anti-microbial bio-based nanomaterials for preventing biofilm growth on the surface and improving durability. If successful, this work will lead to the development of a new membrane family that will decrease costs and energy use associated with membrane desalination and improve its reliability.

Minnesota

University of Minnesota: Crystallization Kinetics: Toward the Useful Separation of Salts in Enhanced Evaporation Systems

Reclamation Funding: $249,853 **Total Project Cost: $249,853**

This project's long-term goal is to leverage the research team's detailed understanding of the spatial and temporal temperature variation and brine evaporation behavior in enhanced evaporation systems to intentionally, and selectively, precipitate salt in distinct locations for collection and reuse. This project aims to confirm that for a given volume, concentration, and composition of brine, the solution temperature can be altered to make it either thermodynamically or kinetically favorable for a particular salt to precipitate.

New Mexico

New Mexico Institute of Mining and Technology: Advanced Hybrid Membrane Process for Simultaneous Recovery of Clean Water and Lithium from High Salinity Brines

Reclamation Funding: $249,896 **Total Project Cost: $499,792**

The objective of this project is to develop an innovative hybrid membrane process for simultaneous recovery of clean water and lithium from high-salinity brines. The proposed hybrid membrane process comprises a membrane distillation-crystallization for water recovery and lithium enrichment, and a novel titanium-based lithium ion sieve membrane for lithium recovery. If successful, the proposed project will address the challenges associated with the disposal of large volumes of high-salinity brines.

Pennsylvania

Temple University: Synergistic Integration of Electroactive Forward Osmosis and Microbial Desalination Cells for Energy-Neutral Desalination

Reclamation Funding: $250,000 **Total Project Cost: $500,972**

The goal of the proposed effort is to develop an energy-neutral desalination system by integrating electroactive forward osmosis (eFO) and microbial desalination cells (MDCs). Clean water will be recovered from the waste stream using FO, resulting in concentrated wastewater and diluted seawater. The concentrated wastewater will be used to fuel MDCs to complete the desalination of the diluted seawater. The energy recovered by the MDCs will be applied back to the eFO membrane to simultaneously mitigate fouling and enhance water recovery.

Tennessee

Vanderbilt University: Selective Removal and Degradation of PFAS via Cyclic Adsorption-electrooxidation on Conductive Functionalized Cu-MOF-aminated-GO

Reclamation Funding: $250,000 **Total Project Cost: $518,463**

This project aims to develop a fundamentally new approach to selectively remove PFAS from water and degrade it to ensure complete removal. A metal organic framework will be synthesized, characterized, and tested to selectively remove PFAS from water. Next, the electrical conductivity of the metal organic framework will be used to facilitate PFAS desorption and electro-oxidation of PFAS.

Texas

Freese and Nichols: Strategies for Gaining Pathogen Removal Credit for Reverse Osmosis in Potable Reuse in Texas (and Beyond)

Reclamation Funding: $231,710 **Total Project Cost: $539,945**

Reverse osmosis membranes can be highly effective in removing pathogens. Nonetheless, in most regulatory jurisdictions, reverse osmosis receives zero treatment credit or log removal value (LRV) for pathogen removal/ inactivation. This gap in regulatory acknowledgement becomes significant in design of treatment processes for potable reuse where additional treatment must be implemented to attain the necessary LRVs. This proposal is designed to facilitate the identification and evaluation of strategies for gaining pathogen removal credit for reverse osmosis in potable reuse in Texas and beyond.

Rice University: Ion Exchange Membranes with Tunable Monovalent Ion Permselectivity to Maximize Water Recovery in Desalination

Reclamation Funding: $250,000 **Total Project Cost: $332,842**

The proposed project aims to improve the performance of electrodialysis (ED) technologies in desalination applications. The primary objective of the research is to develop ion exchange membranes with tunable ion permeability and permselectivity, and demonstrate their ability to enhance water recovery while ensuring product water quality in ED desalination processes.

Virginia

George Mason University: Engineering Spatial Wood Carbon Scaffolds with Nanocellulose Fillers for Water Deionization

Reclamation Funding: $250,000 **Total Project Cost: $500,203**

The research goal of this proposal is to create an innovative and energy-efficient capacitive deionization (CDI) process with the help of biomass-based advanced porous structures for water desalination and purification. The research objective of this proposal is to test the hypothesis that CDI performance relies largely on pore size and 3D network and specific surface area, and engineering spatial wood carbon scaffolds with nanocellulose and post-treatment can fine-tune the pore-size at the micro/nano level. This proposed innovative approach would effectively utilize biomass to enable CDI with high/ultrahigh performance and fill current knowledge gaps in both fundamental and applications aspects.