BUREAU OF RECLAMATION

Desalination and Water Purification Research Program: 2024 DWPR Research Projects

Arizona

Arizona State University: Nanobubbles as a Chemical-Free Fouling and Scale Control Strategy for Reverse Osmosis

Reclamation Funding: $209,708 **Total Project Cost: $424,479**

Despite its effectiveness, reverse osmosis (RO) faces a critical challenge: membrane fouling. Scaling results from inorganic mineral ion precipitation, while biofouling involves living microorganisms adhering to the membrane. This project proposes a chemical-free solution using gas nanobubbles (NBs) for scaling and biofouling control during brackish water desalination. To establish NBs as a competitive solution, several research questions must be addressed, including (1) the impact of water matrix composition on bubble attributes, (2) the influence of bubble size and gas type on fouling prevention, and (3) the cost-effectiveness compared to conventional methods. This project aims to fill these knowledge gaps by evaluating bubble generation in different water matrices, determining the ideal gas and bubble size for fouling prevention, and demonstrating cost-effectiveness at a pilot scale. The ultimate goal is to unravel mechanisms and identify the most effective bubble type for preventing and cleaning membrane fouling.

Colorado

Mickley & Associates LLC: Updated Survey of U.S. Municipal Desalination Plants

Reclamation Funding: $117,700 **Total Project Cost: $235,400**

This project aims to identify and gather detailed information about U.S. municipal desalination facilities that have been built since 2017 and will be built through 2024. An estimated 50 to 70 such facilities will be involved. The proposed survey will include concentrate disposal practices, a full characterization of the treatment process, source water, reason for treatment, changes in operation since startup, and operational challenges encountered. In addition to documenting newer facilities, the proposed project will also determine that status of facilities included in past surveys – as several older facilities are no longer operating. The project will gather and communicate information on the status, trends, and practices of municipal desalination in the

U.S. – information necessary in the consideration and planning of new desalination facilities as well as in the maintenance and refinement of practices in existing facilities.

University of Colorado: Advancing Water Reuse Through Improved Diagnostic Tools for Corrosion Control

Reclamation Funding: $250,000 **Total Project Cost: $339,133**

Whether it is implemented as direct or indirect potable reuse, recycling water alters the water chemistry compared to the sources used prior to reuse. Changes in water chemistry can increase corrosion in distribution systems. For utilities with cast iron pipes, corrosion destabilizes the iron scale layers leading to discolored or "red water" events. Since iron scales act as a sink for other trace metals, discolored water events can mobilize toxic metals, such as chromium, arsenic, or uranium. This project will develop a new method for proactively assessing the presence of toxic metal release and the susceptibility of release due to changing water conditions. Current methods are limited, because they do not link the presence of a toxic metal to the likelihood of release into potable water. Scale analyses digest samples using aggressive acids and cannot distinguish to which reactive iron phases the toxic metals were originally associated. Similarly, coupon and pipe loop studies with representative waters are typically not paired with a comprehensive analysis method that can explain why metals were or were not released. The project seeks to develop a better understanding of why and minimize the release of hazardous products into distribution systems due to water reuse.

Massachusetts

Harmony Desalination Corporation: Field Pilot Testing a Batch RO Process Using Electrically Conducting Reverse Osmosis Membranes

Reclamation Funding: $390,871 **Total Project Cost: $781,742**

This project proposes extended field testing of a high recovery batch reverse osmosis process (Batch RO) using innovative anti-scaling and antifouling electrically conducting membranes (Active RO) in comparison with conventional RO membranes (Passive RO). The goal is to demonstrate Active RO's performance through a 6-month test at an oil and gas produced water site in California with a high total dissolved solids brackish groundwater with significant mineral scaling potential as the feed source. Such applications have challenging chemistries with propensity for various degrees of mineral scaling and organic fouling which current commercial membrane cannot sustainably address without significant amount of pre-treatment, limited recovery and consequently a very high cost. Each of Batch RO and Active RO technologies can significantly reduce the footprint, increase the freshwater recovery, minimize concentrate waste, and as a result, reduce capital and operating costs and environmental impacts of desalination, and enable cost effective resource recovery from mineral rich unconventional water resources, with the latter being an emerging trend in desalination industry.

New Jersey

New Jersey Institute of Technology: Enhanced Coagulation for the Removal of Per- and Polyfluoroalkyl Substances (PFAS) using Hydrophobic Ion Pairing Approach

Reclamation Funding: $249,940 **Total Project Cost: $396,971**

Coagulation and flocculation processes are commonly employed for water and wastewater treatment across the United States but perform poorly in the removal of per-and polyfluoroalkyl substances (PFAS). PFAS removal during coagulation/flocculation process can be improved by increasing the hydrophobic interactions of PFAS molecules with the flocs. This project proposes to utilize hydrophobic ion-pairing (HIP) as a pretreatment to enhance the removal of both short-chain and long-chain PFAS during coagulation/flocculation process. HIP is a concept by which an ion pair complex is made through the interaction of a hydrophilic ion of interest with a hydrophobic counter-ion, making the overall molecule hydrophobic. In the case of PFAS, the project proposes to add a cationic HIP additive to the contaminated source water, to enhance the hydrophobic interaction of PFAS with flocs and entrapment of hemi-micelles/micelles of PFAS complex within the flocs. The overall goal of this proposed project is to optimize the type, dosage, and operating conditions of the enhanced coagulation/flocculation system for the removal of PFAS mixtures.

New Jersey Institute of Technology: Field-Effect Transistor Nanosensors for Testing Per- and polyfluoroalkyl Substances Impacted Water and Air

Reclamation Funding: $250,000 **Total Project Cost: $500,334**

Among different emerging nano-enabled sensing techniques, electronic sensors based on the field-effect transistor (FET) geometry have potential for per-/poly-fluoroalkyl substances (PFAS) detection and quantification with high sensitivity and selectivity. Moreover, FET sensors have low fabrication cost and high potential for on-chip integration. This project will fabricate novel FET sensors, systematically examine the sensing performance, device stability, and reusability when probing PFAS in synthetic water and air samples, and conduct a field demonstration of the PFAS FET sensors. The project outcomes will be measured by the potentials of the developed sensors to help reducing public exposure to PFAS, improving PFAS pollutant control and subsequent environmental and human health improvements.

New Mexico

New Mexico State University: Brine 2030: Enhanced Water Recovery with Mineral Valorization for Sustainable Cement Production

Reclamation Funding: $250,000 **Total Project Cost: $312,514**

This project seeks to address two seemingly disparate problems: brine management and greenhouse gas emissions from cement manufacturing. Over the last decade, saline wastewaters other than seawater and brackish groundwater, including agricultural tile drainage, power plant cooling tower blowdown water, reverse osmosis brines, and oil and gas produced waters have received increasing interest because desalinating these waters could augment freshwater sources for landlocked communities. These alternative waters contain elevated concentrations of sparingly soluble salts that prevent high recovery using conventional approaches. At the same time, the manufacturing of Portland cement – the most widely used cement in the world – generates 7 to 8% of the global carbon dioxide (CO2) emissions each year. This project proposes to address brine management challenges by selectively precipitating out calcium hydroxide, thereby softening the water and enabling high recovery, and using this calcium hydroxide as a main ingredient for creating a non-Portland-based cement.

Texas

Texas State University: Pilot Photobioreactor Development for Scalant Removal and Enhanced Water Recovery from Brackish Reverse Osmosis Concentrate

Reclamation Funding: $250,000 **Total Project Cost: $399,234**

Reverse osmosis (RO)-based treatment of brackish water and treated wastewater is one of the key solutions for solving the global challenge of water scarcity due to population growth and climate change. However, 15% to 25% of the feed water becomes waste stream, called RO concentrate (ROC) or brine, presenting a disposal issue, especially critical for inland communities. Higher water recovery is limited by membrane scaling due to silica, phosphate, and hardness metals, such as calcium, associated with the brine. The project team has developed a new photobiological process that utilizes the biology of brackish diatoms and natural sunlight to remove these scalants, enables additional freshwater recovery from treated ROC using secondary RO, reduces the concentrate volume to less than 5%, absorbs carbon dioxide, and produces beneficial algal bioresources. This project seeks to demonstrate continuous pilot photobioreactor operation using sunlight and reduction of the reactor footprint.