Evaluating Cost Effectiveness of Treating Unconventional Water Resources for Agriculture Use

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Table of Contents

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ABR's collaboration on assembling and running the experimental setup utilizing ABR's patented electromembrane cell.

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Fellow intern Sarah Buzby-Rynders.

Executive Summary

Higher cost of conventional water treatment technologies has forced local oilfield operators to dispose high quality (total dissolved solids < 2000 parts per million) oilfield-produced water instead of treating it for agricultural uses. 94,000 acre-ft of water is annually disposed by local oil industry, which is continually facing regulatory constraints related to ongoing underground disposal operations.

ABR's electrochemical membrane separation process is a waste water treatment process as well as resource reuse process. ABR can recover valuable by-products such as hydrochloric acid, caustic soda or magnesium and calcium hydroxide through electro hydrolysis.

Project Objectives

The project objective entails the designing and construction of laboratory scale testing system involving ABR's patented electrochemical membrane separation technology. The goal is to test the usefulness and efficacy of ABR's technology based water treatment strategy in treatment of associated water of varies competency and tedious values. To obtain treated water of pre-specified chemical composition, especially the one that will meet agriculture irrigation water management standards set by local water districts. Also, to provide necessary information and data to local oil industry for initiating field scale pilot testing. Help both oil and agriculture industries in adding a sustainable, but alternate source of irrigational water, while combating the management challenges related to underground disposal of associated water in an environmentally friendly and cost effective manner.

Project Approach

Conducted literature research on emerging water treatment technologies and collected relevant data on various water treatment methods and the water crisis facing the state of California. This was done to gain an understanding of the issues and available solutions. Multiple experiments were performed on various lab equipment to better prepare for the project and to understand the functions of the different tools utilized in the lab. Synthetic brines were created with varying compositions and water analysis was performed. A pH meter was used to measure the pH of the brine. HI38074 Boron chemical test kit was used to measures boron in water by titration with boric acid. Total water hardness mainly caused by Calcium and Magnesium ions were measured using total hardness test strips.

Before the construction of the ABR system could be done, required parts for assembly were ordered through usplastic.com suggested by ABR Process Development. Numerous schematics were drawn to gain an understanding of the parts and connections necessary for set up. Communication through email and Skype with the engineer for ABR Processes Cameron was established. Cameron verified the progress, answered questions as well as assisted with the lab ABR system set-up.

To test the efficiency of ABR's technology, a synthetic brine of 100,000ppm of NaCl was ran through the system at 200cc/min for a 20minute period. Samples were collected for pH, electrical conductivity (EC), and compositional analysis, however, analysis results were pending at the time of report submission.

Experimental Setup

The feed tank is connected to a pump which is connected to a regulator to control the flow rate. A flow rate of 200cc/min was set. This is connected to the catholyte IN pumping the feedwater into the cell. For initially testing of the ABR system, the designated feedwater is 10% (100,000ppm) sodium chloride (NaCl) solution prepared in the lab. The brine passes through the cell creating hydrogen gas (H2) and exits from the catholyte OUT, going back into the feed tank. The hydrogen gas then rises through tubing from the feed tank. A second tank designated as the electrolyte tank is filled with 5% hydrochloric acid (HCl) and is set at a flow rate of 200cc/min. This 5% HCl solution passes though the cell in a comparable manner as the NaCl. The solution enters the cell though the anolyte IN and exiting though the anolyte OUT. Due to the corrosive nature of chlorine gas and hydrochloric acid a highly chemical resistant tubing is used and a non-contact pump to avoid corrosion. As the HCl solution passes though the cell chlorine gas(Cl2) is produced which rises out of the electrolyte tank mixing with the H2 gas. This mixture enters the HCl reactor forming HCl vapors. For the reaction to take place the HCl reactor is filled with activated carbon and wrapped with heating tape, which is set to a temperature between 120-200°C (248-392°F). These vapors enter an Erlenmeyer flask filled with deionized (DI) water forming HCl solution. To encourage the flow through the HCl reactor into the DI water a venturi tube with a pump is hooked up to the flask creating suction. A third tube is inserted into the flask for sampling purposes. To start the reaction electric current of a minimum of 36 Amperes must be supplied, therefore the system is hooked up to an external power supply. The designated current for initially testing is 39amps. Please refer to the appendices for schematics and pictures of the experimental lab set up.

Project Outcomes

The design and construction of laboratory scale testing system of the ABR's system was completed. Initial testing of ABR's electrochemical membrane separation technology were performed. Certain parameters were chosen and tested to assure the system was functioning. A flowrate of 200cc/min was chosen for the feedwater and the 5% hydrochloric acid solution. An electric current supply of 39amps were selected. To avoid leakage Teflon tape was placed on each connecting point. The system was running and appeared to be performing as expected mechanically.

Three samples were collected to be analyzed, feedwater, treated water, and HCl solution. The samples from feedwater and the treated water are being tested for pH, electrical conductivity and TDS. The HCl solution sample is tested for concentration of chlorine ions. The HCl solution is a valuable resource and can be commercialized, as well as re-used in the system to make 5% HCl brine.

Currently, oil-field produced water disposal cost is around $0.5/bbl. The ABR technology can certainly treat the oil-field produced water at a cost less than the current water disposal costs. With production of value added chemical such as HCl, treatment of oil-field produced water can be made more lucrative to local oil companies that use HCl in their oil-field operations. In the beginning, the treated water can be used for growing non-edible cash crops like guar

The testing of pH levels is an important part of this system, precipitates start forming and drop out of the solution once the solution has reached a certain pH level. When the chloride ions get pulled out the pH level increases. Magnesium hydroxide tends to precipitate at pH level of 9 or greater and calcium carbonate at pH levels of 11-12.

The process of learning laboratory skills and the importance of research to create a solid foundation for future experiments were acquired. One of the lessons learned was that it is time consuming to set a solid foundation.

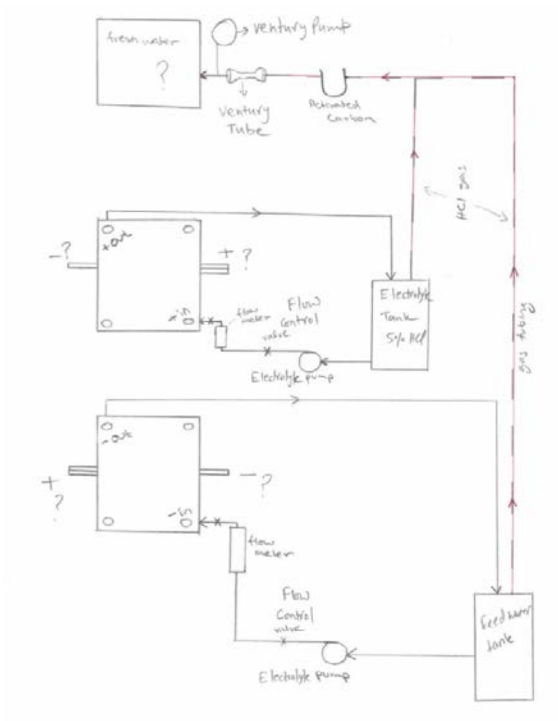
Conclusion

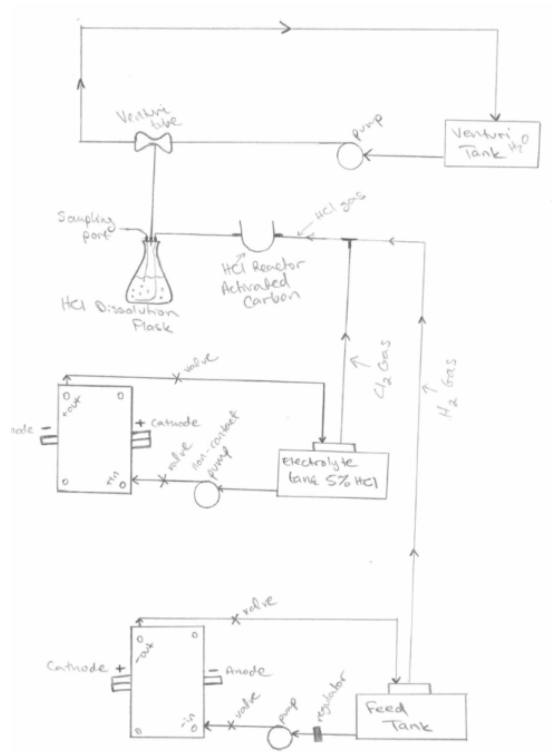
Future work focus is to run experiments and optimize the process by changing variables, such as the current supplied and flow rates. Also, to analyze the efficiency of the system by running controlled experiments to reach a salt concentration of 2000ppm or less from the initial 100,000ppm. This will help determine the optimal conditions for the system to operate under. Future work should also focus on providing information and data to local oil industry for initiating field scale pilot testing. As well as aid oil and agriculture industries in adding a sustainable alternate source of irrigational water in an environmentally friendly and cost effective manner.

This experiential learning internship has had a great deal of impact on my career goals and plans. I have become very passionate on aiding and solving the water crisis facing our state and am considering a career in an environment such as the USDA where my knowledge and skills could further be put to use.

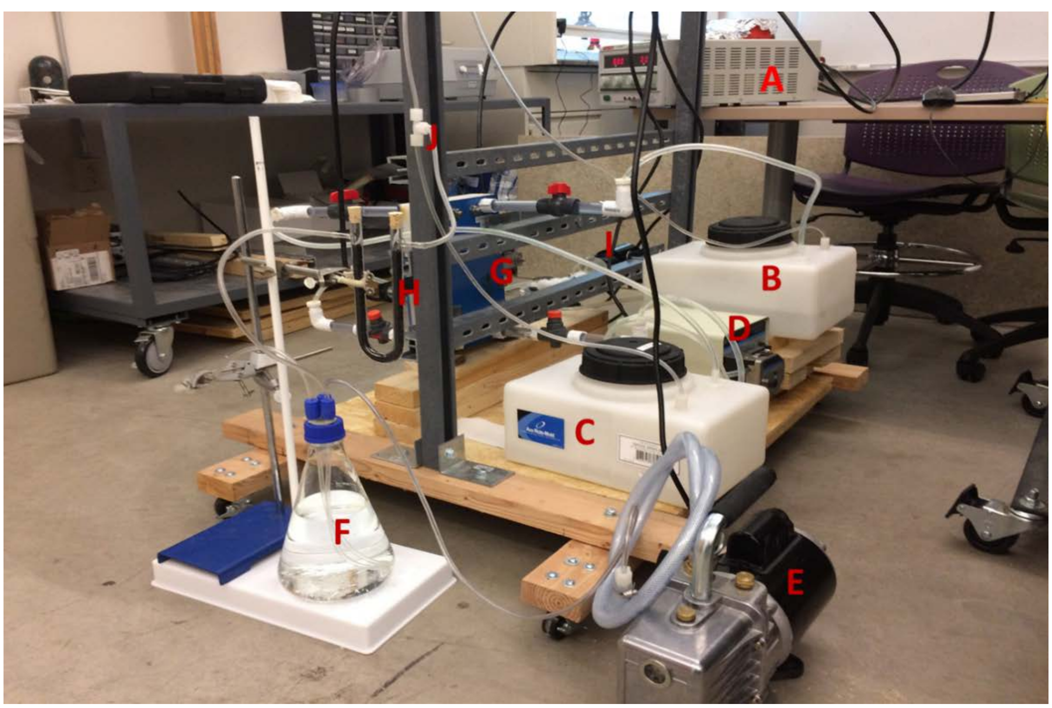
Appendices

Schematics of Experimental Setup





Experimental Setup



A: Power Supply (DC)

B: Feed Water (Catholyte) Tank

C: Anolyte (5% HCl) Supply Tank

D: Anolyte Pump

E: Vacuum Pump

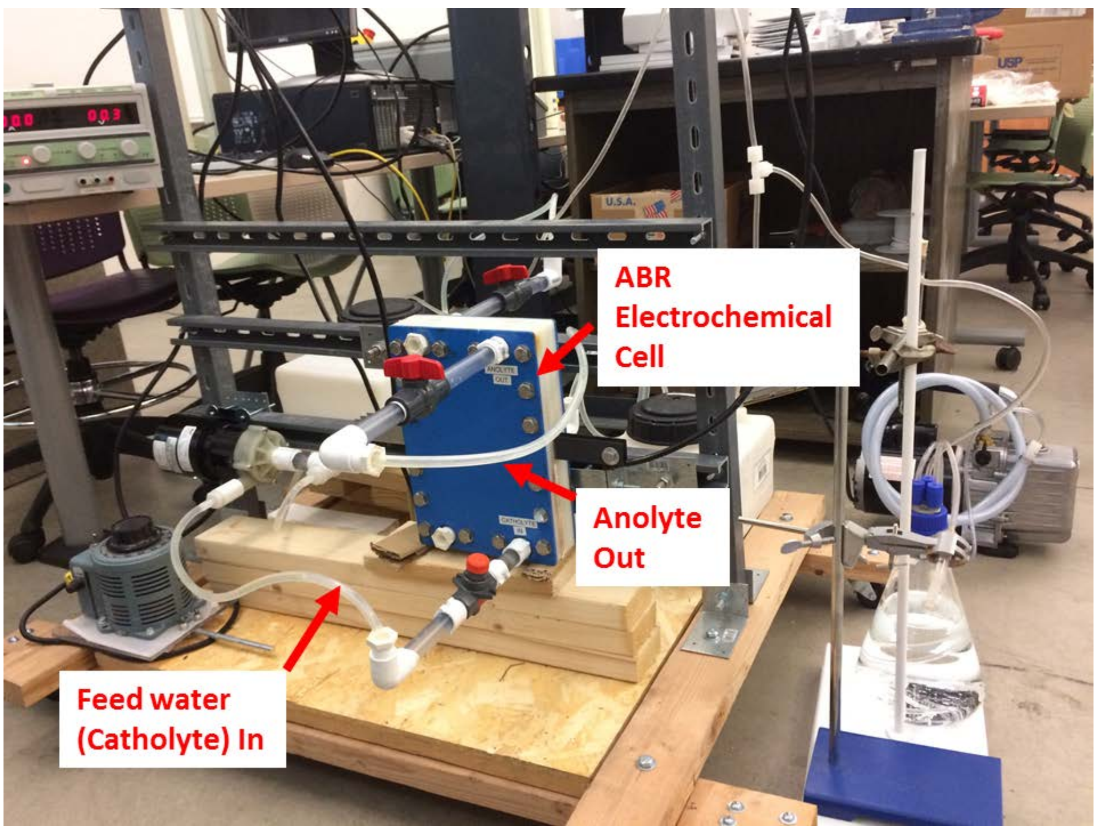
F: HCl Gas Dissolution Flask

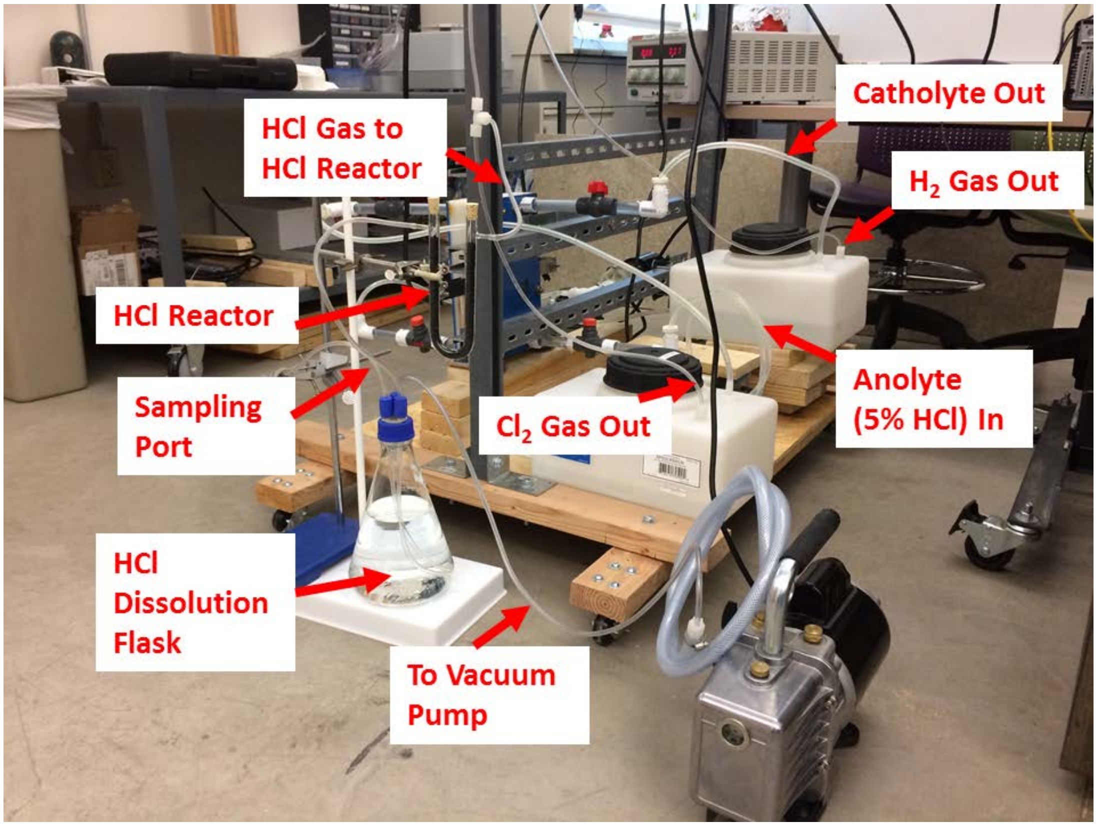
G: ABR Electrochemical Cell

H: HCl Reactor

I: Feed Water Pump

J: H_2 and Cl_2 Gas Junction




HCl Gas to HCl Reactor
Catholyte Out
H_2 Gas Out
HCl Reactor
Anolyte (5% HCl) In
Sampling Port
Cl_2 Gas Out
HCl Dissolution Flask
To Vacuum Pump

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