483c Biological Sulfate Reduction of Reverse Osmosis Brine Concentrate:

Masoud Samee, Jaeyong Jung, Atosa Vahdati, Varadarajan Ravindran, Mark D. Williams, and Massoud Pirbazari

The University of Southern California, in conjunction with the Desalination Research and Innovation Partnership—a consortium of California utilities and universities—is developing innovative and cost-effective technologies for large-scale desalination of brackish water supplies. Reverse Osmosis (RO) was chosen for its proven reliability and potential for large-scale application. Prior research has shown that RO recovery is constrained by precipitation of sparingly soluble inorganic minerals such as calcium carbonate (CaCO3), calcium sulfate (CaSO4), barium sulfate (BaSO4) and strontium sulfate (SrSO4). Inorganic mineral precipitation may be controlled at lower recoveries by using antiscalants or by controlling feed water pH, however, at higher recoveries (>85 percent) antiscalants may not be effective and pH control does not effectively prevent precipitation of sulfate containing minerals onto RO membranes. Thus, water production goals (95 percent or greater) cannot be cost-effectively achieved without, at some point, lowering levels of sparingly soluble mineral component ions (e.g., calcium or sulfate ions, i.e. Ca++ or SO4=). While several treatment options exist (i.e., pretreatment or post treatment), post-treatment, after a primary RO process, offers several benefits: (1) flow volumes are substantially reduced, (2) ions are concentrated to saturation or supersaturated levels and, consequently, may be removed at higher efficiencies, and (3) the primary RO process, which would recover most of the water, would not be affected by process changes or upsets in a post-treatment strategy.

This project will evaluate a new technology to recover reverse osmosis (RO) concentrate produced from desalting high-sulfate waters. The process uses biological sulfate reduction (BSR) to lower sulfate concentration, which concomitantly lowers saturation levels of sparingly soluble mineral salts. This research will focus on evaluating biological kinetics and pertinent operating variables in the BSR reactor.

An electron donor (e.g., ethanol, hydrogen, or acetate) is first added to the primary RO concentrate; sulfate is then biochemically reduced to sulfide in a fluidized-bed, biological reactor. The BSR reaction is favorable under anaerobic conditions when an adequate carbon source (electron donor) is present. Effluent from the BSR reactor is subsequently acidified and sparged to strip reduced sulfur (as H2S) and aqueous CO2 from solution. Hydrogen sulfide, and other reduced sulfur species in the off gas, must be neutralized (i.e., oxidized back to sulfate) prior to off gas discharge. Finally, biological solids are removed in a filtration step and the process stream is subsequently sent to a secondary RO process where approximately 70 percent of the water is recovered as a low-total dissolved solids (low-TDS) product.

This study utilized the information from batch reactor and chemostat studies, and further evaluated several variables on the fluidized bed adsorber reactor (FBAR) performance including influent sulfate concentration, the carbon-to-sulfur (C/S) ratio, and pH. The FBAR performance was evaluated by varying the influent sulfate concentrations from 700 mg/L to 1100 mg/L; the pH was varied from 6.5 to 7.5, and the C/S ratio from 0.8 to 1.2. To determine sulfate removal efficiency, sulfate concentrations in the FBAR effluent were periodically measured. Additionally, the study compared the sulfate removal efficiencies of the FBAR system using ethanol and acetate as carbon sources. The pH of the FBAR system was carefully monitored and maintained at the desired level by a pH controller connected to reservoirs containing hydrochloric acid and sodium hydroxide solutions. Sulfate reduction and removal efficiencies as high as 86-91% could be achieved at high influent sulfate concentrations of about 1100 mg/L. Furthermore, the experiments compared the performances of granular activated carbon (GAC) and sand as FBAR packing media. The general observation was that GAC performed better than sand, and the superiority of GAC was more apparent when the brine concentrate contained heavy metals and organic constituents that would potentially inhibit microbial activity. The effluent from the FBAR system contained hydrogen sulfide and odorous compounds that were products of biological sulfate reduction. The FBAR effluent gases were directed to a biofiltration unit containing GAC as packing media for purification. The hydrogen sulfide concentrations in the FBAR effluent gas stream, and in the biofilter effluent were periodically measured. It was observed that the biofilter was efficient in hydrogen sulfide transformation to sulfate as well as odor control.