RECLAMATION Managing Water in the West

June 2012
Research and Development Office
Bulletin 2012-23

The Knowledge Stream
Research Update

San Joaquin Selenium Solutions: From Research to Reality

Research provided innovative alternatives to address selenium in irrigation drainage

Bottom Line

The biotreatment pilots provided data for feasibility-level designs and cost estimates of full-scale biotreatment plants to remove selenium in the San Joaquin Valley.

Faster, Better, Cheaper

The pilot-scale testing showed that this technology can successfully remove selenium to below 10 micrograms per liter (µg/L) from the DP-25 drainage water significantly faster than other competing technologies.

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Collaborators

- **San Luis Unit Irrigation Districts**
- **California Department of Water Resources**
- **Other Reclamation Programs**

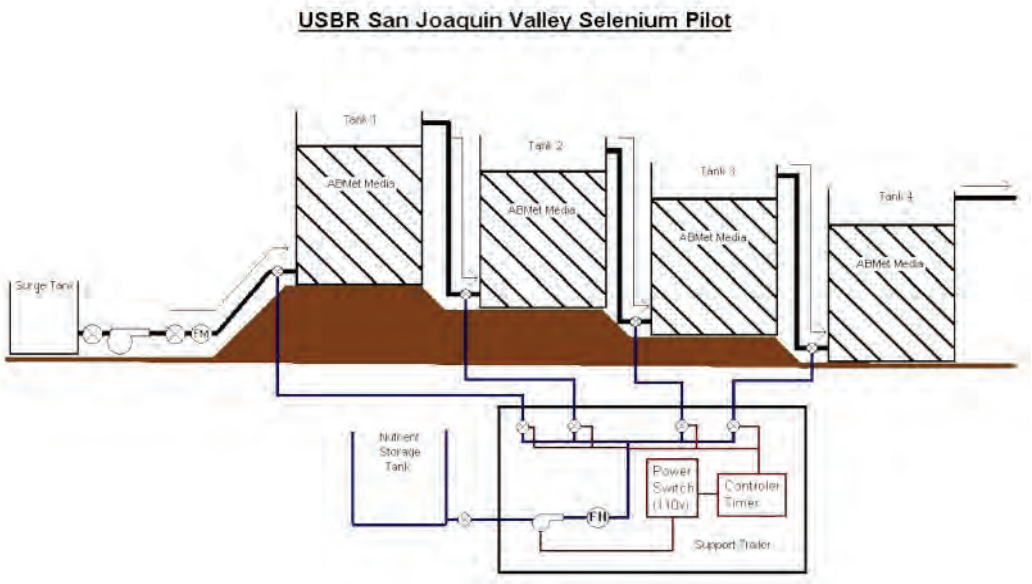
Problem

Selenium concentrations in irrigation drainage can lead to serious environmental problems. High selenium concentrations transported via the San Luis Drain into the Kesterson National Wildlife Refuge were linked to reproductive problems, deaths, and deformities of waterfowl. These findings led to closing the San Luis Drain and the Kesterson Reservoir in 1985. Currently, irrigation districts in the San Luis Unit, including the Panoche Drainage District and Westlands Water District in the San Joaquin Valley near Firebaugh, California, have drainage effluents containing elevated levels of selenium. The search continues for viable and long-term ways to dispose of or treat this effluent.

Solution

This Science and Technology Program research project supported a patrnership among Reclamation's Technical Service Center and Mid-Pacific Region with the San Luis Unit irrigation districts and the California Department of Water Resources. We contracted with Applied Biosciences (now part of Zenon Membranes Solutions, a division of GE Water) to conduct pilot studies at Panoche Drainage District and Westlands Water District (at Red Rock Ranch) to determine the cost and performance of the Advanced Biological Metals Removal Process (ABMet®) technology to remove selenium from agricultural drain water. Applied Biosciences initiated a pilot-scale study to test the removal of selenium from the district's drainage water. The initial testing was from June to October 2003.

The biotreatment technology used micro-organisms to reduce dissolved selenium to insoluble elemental selenium, which is removed from the water in the bioreactor tanks.



Schematic for the San Joaquin Valley Selenium Pilot Plant.

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The tanks are filled with granular activated carbon (GAC) media, which provides a surface area for the microbes to attach to and come into contact with the dissolved selenium. The reduced selenium is retained and accumulates within the biological film and GAC media until the tanks are backwashed weekly at a high flow rate.

The selenium biotreatment pilot consisted of two bioreactor tanks operating in series, with a capacity of 1-3 gallons per minute (gpm) to treat raw drainage or concentrate from reverse osmosis treatment. The bioreactor pilots operated periodically in phases from June 2003 until September 2006. During each phase of operation, Reclamation and the contractor (Zenon-GE) made modifications to the pilot equipment and operations in response to observed flow and performance. These modifications included design and operational changes to all facets of the system including tanks, plumbing, nutrient dosage, flow distribution, instrumentation, pumps, backwashing flow rate and frequency, data acquisition, etc. The modifications resulted in greater process control, more stable operation, and improved selenium removal performance. Both pilots operated for about 3 months after the final equipment modifications.

Results

Data collected in the biotreatment pilot studies were used to develop designs and cost estimates for full-scale treatment plants. Design assumptions derived from the pilot studies included:

- Selenium can be removed to 10 µg/L or less within about 6 hours of residence time in the bioreactors.
- Downward flow through the bioreactor tanks is required to avoid gas binding in the GAC media.
- Two-stage bioreactor design: Stage 1 bioreactor is designed to remove nitrate, and the Stage 2 bioreactor is designed to remove selenium.
- Weekly backwash of bioreactors is required to remove accumulated biosolids and avoid flow blockage.

A feasibility-level design was developed for three biotreatment plants in the San Joaquin Valley by Zenon-GE. The design inflows and influent concentrations represent the concentrate flow from a co-located reverse osmosis treatment plant.

The heart of the full-scale selenium treatment plant is the Zenon ABMet® biotreatment train. A train consists of two bioreactors operating in series. Each train will treat a maximum feed flow of 285 gpm. Each bioreactor tank will be constructed of reinforced concrete approximately 40 feet long x 16 feet wide x 32 feet high and contain a 22-foot bed of GAC media.

The biotreatment plant will include a feedwater tank, bioreactor trains, and a post-treatment oxidation tank(s) to convert any residual selenium in the effluent back to its oxidized soluble form. The backwash system will include a backwash water storage tank and backwash clarifier(s). Ancillary systems include nutrient feed and sludge dewatering. One of the more important of these ancillary systems is the nutrient that is used as a carbon source for the micro-organisms in the bioreactors. Since the molasses-based nutrient is quite viscous and injected into the bioreactors at periodic intervals, the nutrient system is designed to maintain continuous flow circulation through the plant.

"This is an excellent example of some of the many ways Reclamation and innovators can approach seemingly intractable problems and provide a larger suite of potential solutions for decisionmakers rather than being limited to off-the-shelf solutions. This project shows the research process of problem identification, testing of conventional alternatives and research of new and unproved techniques, followed by pilot-scale testing, extensive internal and external technical review, and now demonstration leading to full-scale implementation."

Kevin Price,
Advanced Water Treatment Research Coordinator

More Information

San Luis Drainage Feature Re-evaluation Feasibility Report. Appendix E: Selenium Biotreatment Pilot Reports
www.usbr.gov/mp/sccao/sld/docs/sldfr_report/Appendices/AppE-Final.pdf