Biological Treatment of Irrigation Drainage for Selenium Removal

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RESEARCH OBJECTIVES

Much of the subsurface agricultural drainage in the western San Joaquin Valley (SJV) is contaminated with selenate (50–1200 mg/L as Se) and nitrate (20–120 mg/L as N), in addition to high total dissolved solids and boron. This water is currently either discharged to sloughs that drain into the San Joaquin River and then to the San Joaquin Delta, or it is evaporated in terminal ponds. These means of disposal are problematic, since Se is a teratogen that bioaccumulates in the aquatic food web, and nitrate contaminates groundwater supplies and promotes eutrophication of surface waters. Nitrate also interferes with the reduction and removal of selenate SeO_4^{-2}, the most abundant form of Se found in western SJV drainage. Our objective is to develop reliable and economical treatment methods to remove these contaminants.

APPROACH—PILOT FACILITY

We have developed the algal-bacterial selenium removal (ABSR) Process to remove nitrate and selenium from drainage. A 75 m^3/day pilot-scale ABSR Facility has been used to study the mechanisms and rates of selenium and nitrate removal (Figure 1). Subsurface drainage is dosed with a carbon and energy source for bacteria (usually animal feed-grade molasses) and then injected into a baffled and covered anoxic reduction pond. In the reduction pond, bacteria denitrify and reduce selenate to selenite, elemental Se, and bacterial-associated organic Se. Much of the reduced Se settles in the pond. Settled bacterial biomass in the reduction pond undergoes anaerobic decomposition, so that the volume of solid residues increases very slowly. Removal of the selenium-containing solids should not be required for many years, possibly not even decades.

ACCOMPLISHMENTS

Selenium Removal

Over two years, the ABSR Facility at Panoche, California, removed 95% of the influent nitrogen load and 80% of the influent soluble selenium load. The addition of physical-chemical flotation and filtration processes to remove particulate Se has increased total Se removal to 87%. Dozens of bacterial species have been isolated from the ABSR Facility and identified by 16S rRNA sequencing, including the prevalent *Acinetobacter Johnson* II/genospecies 7, *Pseudomonas mendocina*, and *Xanthomonas maltophilia*. Pure cultures of several of these bacteria have been proven to reduce selenite in the laboratory.

Brine Treatment

Planned "zero discharge" drainage management in the SJV will create brines that require treatment. The high salt concentration of brines may inhibit bacterial Se reduction. We have found that denitrification and selenate reduction are unaffected by NaCl concentrations augmented up to 22 g/L. Higher concentrations and other potential inhibitors such as sulfate will be studied during 2003–2004.

SIGNIFICANCE OF FINDINGS

With the ABSR facility at the Panoche Drainage District, we have demonstrated a promising, cost-effective process that will be used in planning full-scale facilities to remove nitrate and selenium from irrigation drainage.

RELATED PUBLICATION

Green, F.B., T.J. Lundquist, N.W.T. Quinn, M.A. Zárate, I.X. Zubieta, and W.J. Oswald, Selenium and nitrate removal from agricultural drainage using the AIWPS® Technology. Fifth International Water Association Specialist Conference on Waste Stabilization Ponds, Pond Technology for the New Millennium, Auckland, New Zealand, April 2–5, 2002; Water Science and Technology, 2003 (in press).

ACKNOWLEDGMENTS

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Figure 1. One of two pilot ABSR Systems at the Panoche Drainage District, San Joaquin Valley, California.