

Application of Redox Mediators to Accelerate Removal of Selenium from Agricultural Drainage Water

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Executive Summary

Irrigation in certain parts of the San Joaquin Valley, California has produced high selenium (Se) drainage water causing deformities in aquatic waterfowl. To protect waterfowl, Se in agricultural drainage water must be removed or reduced before it is disposed into aquatic systems. Although Se bioremediation has been studied for the last 20 years, so far no treatment technology has proven economically feasible to remove Se from drainage water in the field.

In the aquatic system, Se(VI) can be used in microbial respiration as a terminal electron acceptor for growth and metabolism. Because of the insolubility of Se(0) in aquatic systems, bacterial reduction of Se(VI) to Se(0) is considered to be a useful technique for removing Se from agricultural drainage water. Cost and efficiency are two important factors considered in the remediation of Se-contaminated agricultural drainage water. In our previous study, we isolated several Se(VI)-reducing bacteria from rice straw and agricultural drainage water which are capable of using inexpensive molasses to reduce Se(VI) in drainage water. In order to increase reduction efficiency of Se(VI) in drainage water, redox mediators (e.g. quinones) might be a better selection for accelerating Se(VI) reduction to Se(0). The redox active quinone moieties of humic substances have been recently shown to play important roles as electron carriers which stimulate the reductive biotransformation of azo dyes, nitroaromatics, and polyhalogenated contaminants by shunting electrons between an external electron donor and contaminants. Our previous test shown that application of a redox mediator (anthraquinone disulfonate) can also accelerate Se(VI) reduction to Se(0).

We propose to use redox mediators to accelerate the removal of Se from Se-contaminated agricultural drainage water in a biotreatment system. Through a series of experiments, we will obtain a better combination of a Se(VI)-reducing bacterium and a nitrate reducer with a better quinone for accelerating Se(VI) reduction to Se(0) by screening three Se(VI) reducing bacteria with a nitrate reducer and four quinones. By oxidative and adsorptive pretreatments, we will increase the immobilized surface quinone content of activated carbon to enhance bacterial reduction of Se(VI) to Se(0). Finally, We will use immobilized surface quinone on activated carbon in a flow-through system to accelerate the removal of Se from drainage water. After completing the proposed study, we will design a pilot-scale bioreactor to remediate Se-contaminated agricultural drainage water.