

Construction of a Bioreactor for On-site Bioremediation of Selenium Oxyanions in Agricultural Drainage Water

PRINCIPAL INVESTIGATOR:

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EXECUTIVE SUMMARY:

Environmental pollution caused by selenium (Se) contamination of agricultural drainage water is a serious problem in western USA. Due to the high solubility, mobility and toxicity of selenate and selenite, these ions can cause serious harmful effects in the aquatic ecosystems. Death and deformation of wildlife and waterfowl as a result of bioaccumulation of Se have been observed throughout the San Joaquin Valley, California. Research is ongoing to study the ways of removing Se oxyanions from agricultural drainage water. Although much has been learned, the goal of finding a practical, cost-effective technology for treating Se-contaminated water has not yet been accomplished. Thus, this proposal involves the development and construction of a bioreactor system for removing toxic, mobile Se oxyanions (selenate [SeO_4^{2-}] and selenite [SeO_3^{2-}]) from agricultural drainage water. Anionic Se species are biologically detoxified and precipitated as elemental selenium (Se^0), which can be easily removed from solution through physical means. In this process, SeO_4^{2-} and SeO_3^{2-} serve as alternate terminal electron acceptors in bacterial respiration in the presence of a suitable carbon substrate as oxygen becomes limiting. With our expertise in isolation and characterization of Se-reducing organisms, we propose to develop an effective and economical bioreactor system for remedial treatment of Se-contaminated agricultural wastewater. To achieve these goals, we will conduct microcosm experiments to evaluate and compare SeO_4^{2-} and SeO_3^{2-} reduction in agricultural drainage water by several Se-respiring bacterial monocultures in our laboratory (e.g. *E. cloacae* Strain SLD1a-1, *Thauera selanatis*, *Stenotrophomonas maltophilia*, etc). One or two isolates will be selected for testing of a laboratory model bioreactor to assess the rates of SeO_4^{2-} and SeO_3^{2-} removal from drainage water as well as to test filtration systems for Se^0 removal. The removal of alternate electron acceptors such as nitrate (NO_3^-) will also be assessed along with SeO_4^{2-} and SeO_3^{2-} removal. We will also assay biotransformations of selenium oxyanions to Se^0 by cell-free extracts and immobilized cell-free SeO_4^{2-} / SeO_4^{2-} reductases of selected SeO_4^{2-} reducing bacteria using the bioreactor approach developed for whole cells. We will construct and evaluate two pilot scale bioreactor systems for SeO_4^{2-} and SeO_3^{2-} removal in drainage water from the San Joaquin Valley, CA and optimize reactor parameters for maximal SeO_4^{2-} and SeO_3^{2-} removal. One bioreactor will be a fixed film system and the second bioreactor will be a free film system for biocatalyst attachment. Relationships with the industry may be sought to assist in the bioreactor construction, and possibly hardware selection. The best reactor system will be selected for future field scale demonstration of economic removal of SeO_4^{2-} and SeO_3^{2-} from drainage water in the San Joaquin Valley, CA. In summary, this study is expected to provide the following critical information: (1) through comparison of existing isolates (and possibly new ones), a SeO_4^{2-} reducing bacterial isolate will be selected with respect to its efficiency in reducing Se in actual agricultural drainage water, and suitability for use in bioreactor technology, (2) an inexpensive carbon substrate (electron donor) will be identified, (3) an efficient bioreactor system for field-scale treatment of SeO_4^{2-} -impacted drainage water will be developed, (4) provide a rapid molecular tool for monitoring SeO_4^{2-} reducing bacterium within the reactor, its effluent and in drainage water in the field. We demonstrate for the first time, SeO_4^{2-} and SeO_3^{2-} removal in actual drainage water by immobilized enzyme bioreactors. The use of cell free enzymes can avert the need for post-reaction treatment of biomass. This work is expected to provide an effective and economical technique for treating SeO_4^{2-} and SeO_3^{2-} -impacted drainage water prior to discharge into the environment. The major advantages of using bioreactor technology are that it is cost effective, conversion of toxic oxyanions to insoluble Se^0 is rapid, Se^0 is innocuous and recyclable, and Se is sequestered in an easily manageable waste stream. The proposed study is novel to previous studies on selenate/selenite bioremediation.