Transformation of Selenium in Tulare Lake Evaporation Ponds

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Project Summary

Selenium (se) contamination in California's wetlands has been studied for more than 15 years since the discovery of irrigation-induced Se poisoning of waterfowl in Kesterson Reservoir, California. A concern about Se accumulation in Tulare Lake evaporation ponds, California has greatly increased during the last several years.

A wetland system is a complex aggregate of water, sediment and various types of organic material. Dissolved Se entering the wetland in natural and agricultural drainage water reacts with this aggregate through a series of adsorption, reduction, and transformation processes, causing Se accumulation in wetlands. Selenium can be removed from Se-contaminated wetlands by methylation/volatilization. The rates of Se methylation/volatilization are dependent on the Se species present, microbial activity, and various environmental conditions. Cooke and Bruland (1987) estimated that about 30% of the Se entering a wetland is naturally removed through Se volatilization (Fan et al.). (Evaporation Ponds Technical Committee, 1999) found that as high as 70% of dissolved Se was transformed to volatile Se in several species of microalgae isolated from Tulare Lake evaporation ponds.

The pathway for methylation of inorganic Se in a wetland generally involves a reduction of selenate to selenite and/or selenide, followed by an assimilation process to organic Se (non-dimethlselenonium compounds) such as selenomethionine. Through the binding of methyl groups, organic Se is converted to non-volatile dimethylselenonium compounds such as methylselenomethionine, and finally, non-volatile dimethylselenonium compounds yield dimethylselenide and dimethyldiselenide which can volatilize into the atmosphere. Because of the difficulties in determination of Se species in wetland systems, little attention has been made in studying the limiting steps for the methylation of inorganic Se to volatile Se, and if we can accelerate this process by biochemical alterations, it may be possible that the rate of Se methylation/volatilization can be much higher than what Cooke and Bruland (1987) and Fan et al. (1999) measured in their studies, and Se methylation/volatilization can be an effective technique for removing Se form Se-contaminated wetlands.

Tulare Lake is located in the western San Joaquin Valley, California and is a Se-impacted wetland. Our previous work found that up to 305 of the total Se in the Tulare water column was dimethylselnonium compounds, indicating that Se methylation/volatilization in the Tulare evaporation ponds may take place at a much faster rate than that in other wetland systems in the western United States. In order to reduce Se accumulation and accelerate the removal of Se through methylation/volatilization in these evaporation ponds, a better understanding of the transformation processes of inorganic Se to volatile Se compounds in this wetland system is needed.

We propose to investigate the biotransformation of Se in Tulare Lake evaporation ponds. In the first year, we will use a combination of different instruments (GC, HPLC and HGAAS) to develop a series of speciation methods with our early developed purging/trapping and ion exchange resin techniques to differentiate Se species in the Tulare evaporation pond water and sediment. In the second year, we will perform laboratory experiments on the transformation pathway of inorganic Se and non-volatile organic compounds to volatile Se compounds from the evaporation pond water and sediment. We will monitor Se transformation processes, and determine the rate limiting methylation reactions of inorganic Se to volatile Se compounds. At the end of this project, we will obtain information on the natural biotransformation pathway of Se in Tulare Lake evaporation ponds and provide suggestions to increase the transformation rate of inorganic Se to volatile Se. This information should help wetland managers and scientists to better understand how to increase the removal of Se from Se-contaminated wetlands through Se methylation/volatilization.