Biochemical Characterization of Microphyte Composition in Relation to Se Biogeochemistry and Bioavailability

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Principal Investigators:
Teresa W-M. Fan
Department of Land, Air, and Water Resources
UC Davis
(530) 752-1450
twfan@ucdavis.edu

Jack Meeks
Microbiology - Division of Biological Sciences
UC Davis
(530) 752-3346
jcmeeks@ucdavis.edu

Executive Summary:
The project proposed here is one part of a larger, Joint Research effort proposed for selenium (Se) ecotoxicity remediation in evaporation basins. Our focus on evaporation basins has several major endorsements: (a) it is a proven, economical means by which to dispose of waste agricultural water and contain the salt; (b) it is a "no discharge" technology for the disposal of water since it is terminal, thus capable of avoiding almost all aspects of the Total Maximum Daily Load (TMDL) regulations; (c) historically, its principal detracting feature has been Se toxicity to migratory waterfowl, yet in recent years, basin management schemes have significantly reduced this risk; (d) most recently, we have obtained field-scale evidence that remediation through a combination of foodchain breakage with natural volatilization may be possible. This last is the topic of the Joint Research project.

In the San Joaquin Valley agricultural drainage waters, the utmost issue with selenium is toxicity to top predators such as aquatic birds, which receive their selenium primarily through their diet, such as aquatic invertebrates and fish. The research shows that waterborne selenium concentration is not always a reliable predictor of selenium content in aquatic organisms (Skorupa and Ohlendorf, 1991; Bowie et a., 1996) or observed toxicity (e.g. Reash et al., 1997). It is now clear that selenium "biogeochemistry" - that is, how selenium chemically transforms both inside and out of organisms - plays a pivotal role in determining the ecotoxic risk at particular sites (EPA Office of Water, 1998). Consequently, there has been scientific consensus that tissue or protein-bound selenium concentrations are possibly better markers of ecotoxic risk (EPA Office of Water, 1998). There is additional scientific consensus that sediments harbor key pools of Se for ecotoxic effects (EPA Office of Water, 1998).

Thus, selenium biogeochemistry is where the solution must be sought for the best chance at selenium remediation. These processes must be evaluated for any remediation effort and may even be exploited to mitigate Se ecotoxic problems. These concepts form the foundation of the proposed projects at the Tulare Lake Drainage District (TLDD) evaporation basin and at the Lost Hills Water District's (LHWD) evaporation basin site. This is in contrast to most projects in the San Joaquin Valley, which keyed on simple, but unfortunately unreliable, indicators such as waterborne Se concentration.

The overarching objectives of the joint project, "Mitigating Selenium Ecotoxic Risk by Combining Foodchain Breakage with Natural Remediation", which involves the PIs listed above in separate but linked projects, plus cooperators at Novalek, DWR, TLDD, and LHWD, are keyed around the foodchain system in TLDD and LHWD evaporation ponds, which include:

- Evaluating the efficacy of reducing Se risk resulting from intensive commercial harvest of brine shrimp (Artemia franciscana) and other macroinvertebrates in TLDD and LHWD basins.

- Assessing effects of fertilizer inputs on algal dynamics for optimizing the harvest of brine shrimp and other macroinvertebrates as well as Se volatilization so that total and bioavailable Se are reduced in TLDD and LHWD basins.
- Evaluating ecotoxic status in different basins of widely varying salinity and other conditions, so that general factors leading to reduced ecotoxic risk can be discerned.

Objectives

As stated above, the overall objectives of the joint remediation research are keyed around the microphyte-macroinvertebrate foodchain in evaporation basins: (1) reduction of quantity of food items through aggregation and harvesting of algae, brine shrimp and other invertebrates; (2) reduction of total Se or bioavailable Se in the food through biogeochemical channeling to Se volatilization before reaching food item invertebrates; (3) combinations of 1 and 2.

For this portion of the project, our objectives will be:

1. To complement the microscopic analysis of microphyte community by the project of Rejmankova with biochemical characterization including pigment and 16S RNA profiling;
2. To measure Se volatilization activity in relation to microphyte compositions;
3. To assess Se ecotoxic status via proteinaceous Se and Se-Met in microphytes-macroinvertebrates foodchain;
4. To conduct convenient algal Se bioavailability test for water, sediment, and various fractions of sediment (generated by the projects of Higashi and Gao) to ascertain the bioavailable Se status;
5. To correlate 1-4 to nutrient manipulation and brine shrimp production and harvest to see if reduction of total Se, particularly bioavailable Se can be optimized.

These objectives will be attained by investigating the in situ test enclosure systems proposed by Rejmankova, and existing TLDD and LHWD evaporation basins where Dr. Rofen is manipulating brine shrimp production. In addition, a cooperative arrangement has been made among DWR, LHWD, and Fan/Higashi to build experimental evaporation basins (Cooper, 1998) so that important parameters (e.g. water depth, salinity, nutrient input) of the basin can be better controlled for testing the concept outlined above. We will conduct the proposed research in these test basins when they become available.