Algal Community Assessment Under Different Nutrient and Grazing Intensity Regimes: Selenium Volatilization and Ecotoxic Risk

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Executive Summary:
Overview of the Joint Project
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 and Approach for this Proposal

The proposed project is designed to assess effects of grazing by brine shrimp (Artemia franciscana) and other macroinvertebrates in combination with nutrient additions on microphyte community structure in TLDD and LHWD basins. The main objective of this part of our multi-project joint research effort is to characterize the extent microphyte communities and evaluate the effect of grazing as well as effect of nutrient input on the changes in population dynamics of individual components of these microphyte communities. Ultimately, we would like to modulate microphyte communities in two aspects: 1) create conditions that are most favorable for microphytes that contribute most to the volatilization process, and 2) at the same time create conditions that would provide enough microphyte food for brine shrimp production.

We propose to use both observation and experiments in the field to confirm or reject the following hypotheses:

- H1: Brine shrimp production increases with overall microphyte productivity.
- H2: Overall microphyte primary production increases with addition of nutrients.
- H3: The microphyte species composition is affected more by grazing ("top down" effect), ("bottom up" effect).

For the field observations, we will:

1. Monitor the microphyte composition and primary production (PP) indicators in basins;
2. Correlate the changes in microphyte composition and PP with water/nutrient chemistry data (projects of Gao/Dahlgren and Higashi/Flocchini) and the date on brine shrimp harvest;
3. Correlate the changes in the microphyte composition with 16S DNA and pigment analyses of the microphytes (project of Fan/Meeks);
4. Correlate the changes in microphyte composition with Se volatilization and BCFs in the algae (project of Fan/Meeks).

For the field experiment, we will conduct short-term, in situ enclosure experiments in both TLDD and LHWD basins to evaluate:

1. The responses of microphyte communities to factorial combinations of brine shrimp presence/absence, nitrogen, phosphorus, combined N and P, and chicken manure additions in terms of species composition and growth response (e.g., PP, chlorophyll a);
2. Relate these responses to Se Volatilization (project of Fan/Meeks) and detritus chemistry (projects of Gao/Dahlgren and Higashi/Flocchini);
3. Correlate the microphyte composition with Se BCFs in the algae (project of Fan/Meeks).