# Fate of Selenium in Constructed Wetlands Treating Agricultural Drainage Water: Role of Sediment Se Deposition and Se Volatilization

Norman Terry
Project 00-017

## *Executive Summary*

Monitoring studies from May 1997 to August 1999 have shown that the TLDD wetland is capable of removing substantial amounts (up to 80% mass removal in some cases) of Se from agricultural drainage water. The concentration of Se in drainage water entering the wetland cells was 16 to 22.5 ppb, which, after passage through the wetland cells, was reduce to concentrations as low as 5 ppb in some instances. The data show that the wetland cells are becoming more efficient in removing Se with each successive year. The results also showed that the vegetated wetland cells were more efficient in removing Se than the unvegetated cell. Although there was significant variation in the amount of Se accumulated by different wetland plant species, the amount of Se in the standing plant biomass represents only a small proportion (<5%) of the Se sequestered by each wetland cell. Rates of Se volatilization varied significantly from cell to cell and over time with up to ~50% of the Se input into the rabbitfoot grass cell being removed by volatilization in June 1998.

Large amounts of Se may be immobilized in the sediments in the form of elemental and organically bound Se. One might expect that, given this immobilization of Se in the sediments, the sediments should constitute a large sink for the incoming Se. However, direct determination of sediment Se concentrations support the view that Se concentrations in the upper layers of the sediments have not changed significantly with time from May 97 to August 99. Thus, there appears to be no direct evidence that the sediments are accumulating Se. To obtain an accurate mass balance, we need to explain why the sediment Se concentrations do not change over time and we need to obtain an accurate estimation of the accumulation of Se in the sediment; in particular, we need to determine 1) whether Se is deposited in localized regions of the sediments that are not being accounted for the current sampling protocol, and 2) whether Se volatilization is a much larger component of the Se mass balance than we have hitherto ascertained (and therefore could account for the fact that Se concentrations in sediment do not increase over time).

Our objectives are: 1) To develop accurate mass balances for water and Se in selected wetland cells (jointly with UCD and DWR), with special emphasis on the compartmentalization of Se in the sediments; 2) To determine the mechanism of Se deposition in the sediments by providing a spatial resolution of the changes in Se concentration and speciation, and relating them to the microscale environmental conditions, with respect to distance from root and sediment surfaces (jointly with UCD); and 3) To determine whether Se is volatilized at enhanced rates from natural, open (unenclosed) sediment surfaces, compared to volatilization from an enclosed sediment surface (as in volatilization chamber).

With regard to Objective 1, we will sample sediments, surface water, and pore water from Cells 1, 3, 5, 7 and 9 of the TLDD wetland at Corcoran every two months for the 2-year period. The sampling plan for sediment cores will be modified from our previous study to include the following layers, fallen litter layer, organic matter layer, 1 cm layers for the top 5 cm, and then every 10 cm up to a depth of 25 cm. Because the sediment sampling protocol will include localized regions where Se may be accumulated (e.g., the sediment surface, rhizosphere, fallen litter), this monitoring study will determine more accurately the changes in Se concentrations in sediment, pore water, and surface water over time. In addition, we will collect rhizosphere sediment (sediment attached to the roots). To determine how much Se is lost to the atmosphere, we will also measure the rates of Se volatilization from each of the cells once every two months. In order to obtain mass balances, these results will be analyzed together with the water balance, and Se concentrations in inlet and outlet waters (to be done by the Tanji Lab). With regard to Objective 2, we will conduct a thorough study of the mechanism of Se deposition in the sediments, i.e., to determine where and in what forms Se is accumulating, as well as the environmental conditions controlling the speciation of Se in the localized regions surrounding the roots and at the sediment surface. Thus, we will determine how total Se concentrations change spatially with respect to distance from root and sediment surfaces in large sediment cores (up to 1 meter depth). Shoots and roots of rabbitfoot grass and the different sediment regions will be separated from each other, and we will measure pH, dissolved oxygen, redox potential and microbial biomass changes in the different regions. Furthermore, we will conduct x-ray absorption spectroscopy to determine the chemical form of Se in the different samples, which will provide some ecotoxicological information. With regard to Objective 3, we will Se volatilization rates at 4 different times of the year in mesocosms. Sediment will be collected from the unvegetated cell and filled into six mesocosms. These mesocosms will be static (no flow-through) systems. Three of the mesocosms will be enclosed with Plexiglas volatilization chambers, and volatile Se measurements will be made every 24 hours for 1 week. The other three mesocosms will be unenclosed. We will measure Se in the sediment and water in the mesocosms. Se volatilization in the unenclosed mesocosm will be calculated by difference. This information will enable the development of a math model by the Tanji Lab (UCD) for wetland engineering design and performance evaluation necessary for scaling up to large operating systems.