Bioaccumulation and Biotransformations of Organic Material-Borne Selenium in Mosquitofish

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Executive Summary:

Selenium (Se) contamination of wetlands receiving drainage water from seleniferous soils occurs throughout the western United States. Bioaccumulation and biotransformations of Se in organisms living in these wetlands creates serious hazards to fish and waterfowl. It has become clear that dietary Se, rather than water-borne Se, is the major contributor to the toxic levels for top predatory aquatic and aquatic-dependent organisms. Therefore, natural dietary Se needs to be studied in order to evaluate the ecotoxicity of Se in wetland systems.

A wetland system is a complex aggregate of water, sediment and various types of organic materials such as plants, algae, microorganisms and insects. Dissolved Se entering the wetland in natural and agricultural drainage water reacts with this aggregate, causing Se accumulation in wetland systems. Wetland sediment, a sink of wetland organic materials, is the largest reservoir of Se, accounting for more than 90% of total Se in wetland systems. Se associated with organic materials accounts for about 50% of the total Se in wetland sediment. Of the total Se present in the tissues of aquatic food chain organisms, 50-91% is in the organic form. Organic forms of Se generally are more toxic than selenite and selenate and bioaccumulate more rapidly.

Considering these important characteristics of Se-containing organic materials, such as their high Se concentration per mass, their high availability as a major dietary food source to top predatory aquatic and aquatic-dependent organisms, and the high amounts of organic Se, the seleniferous detritus (organic material-borne Se) deposited in the sediment and suspended in the water column may be a dietary food source subject to bioaccumulation by the top predatory aquatic and aquatic-dependent organisms.

Therefore, Se species in these organic materials may be a reliable indicator of Se bioaccumulation to top predatory aquatic and aquatic-dependent organisms.

We have developed a series of methods to determine Se species in various environmental samples, including a method to determine Se(VI), Se(IV), and organic Se in water and water extracts, and sequential and parallel extraction techniques to determine Se(VI), Se(IV), organic Se, Se(0), organic material related Se, and residue Se in sediment. We have used an ion exchange resin to separate Se(VI), Se(IV), non-amino acid organic Se, and amino acid Se in plant extracts, and a purge-trap technique to determine Se-methylselenomethionine (MSemet), dimethylselenide (DMSe), dimethyldiselenide (DMDSe), and dimethylselenoxide (DMSeO), and dimethylselenoniopropionate (DMSeP) in sediments. On the basis of these valuable techniques, we will develop a method to determine Se species in wetland organic materials.

We propose to investigate the bioaccumulation and biotransformations of organic material-borne Se in mosquitofish. Mosquitofish has often been used in Se ecotoxicity studies. We will develop a method that combines a series of extraction and purge-trap techniques with high performance liquid chromatography (HPLC), microwave (MW) and hydride generation atomic absorption spectrometry (HGAAS) to determine Se species in organic materials and mosquitofish. We will monitor the bioaccumulation and transformations of water-borne Se species (selenate, selenite, and different organic Se compounds) in sediment organic materials in a series of experiments. After harvesting Se-rich organic materials, we will determine bioaccumulation and transformations of organic material-borne Se in mosquitofish under various conditions. At the end of this project, we will examine whether organic material-borne Se can be used as a criterion to evaluate Se ecotoxicity in an aquatic system. This information should help scientists to better understand the pathway of Se transfer from water-borne Se to organic material-borne Se to freshwater fish in a natural setting.