Control of Mercury Methylation in Wetlands through Iron Addition

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To improve aquatic habitat in the San Francisco Bay and other critical habitats, significant effort is being directed to the restoration of wetlands. However, wetland restoration can exacerbate mercury bioaccumulation in fish and wildlife by providing an environment that is conducive to mercury methylation. This project is investigating the addition of iron to wetland sediments as a potential landscape-scale approach to decreasing methylmercury production.

Methylmercury (MeHg) is a potent neurontoxin that can be detrimental to both human health and wildlife, and its formation in the anoxic sediments of wetlands has led to mercury contamination in aquatic ecosystems. Elevated levels of mercury, which exist primarily as MeHg in biota, are responsible for over 75% of the fish consumption advisories issued in the United States. Mercury is of special concern in California due to elevated concentrations caused by historical mining practices. The primary objective of this research project is to develop a novel method of restoring and constructing wetlands that will minimize MeHg production in wetland sediments without sacrificing natural habitat potential.

Since the 1780's, California has lost an estimated 91% of its wetland acreage, and it has only been over the past few decades that policy and management decisions have been made to reverse this trend (e.g., the proposed restoration of over 15,000 acres of tidal salt marsh around South San Francisco Bay). Wetlands are extremely important ecosystems to California as they serve as essential habitat for a variety of wildlife species, including the federally endangered California clapper rail, offer flood protection, and improve water quality. However, high levels of MeHg production often occur in wetlands, and as a result, the restoration of these essential habitats may exacerbate the mercury problems that already exist within the food web.

This project is investigating a potential method of reducing net mercury methylation rates through the addition of iron to wetland sediments. After iron addition, the concentration of dissolved sulfide decreases through the formation of $FeS_{(s)}$. Sulfate-reducing bacteria also produce less MeHg because the concentration of dissolved, bioavailable mercury decreases as sulfide concentrations decrease. In a previous research project, we showed that iron addition decreases net MeHg production in pure cultures of sulfate-reducing bacteria and in wetland sediment slurry systems. We are now investigating the efficacy of iron addition under conditions that more closely approximate those encountered in wetlands by using laboratory microcosms collected from a tidally influenced estuarine wetland in San Francisco Bay.

Over the past year, we completed a laboratory microcosm experiment using tidal wetland sediments that started in spring 2008. We found significant reductions in methylmercury concentrations exported in the surface water from the medium and high iron dose groups (amended with 360 and 720 g-Fe/m^2, respectively) relative to the unamended control. At the end of the experiment, we sampled sediment cores from the microcosms to assess the formation of iron-sulfur minerals between the different amendment groups. We found evidence of enhanced production of acid-volatile sulfur (ie, $FeS_{(s)}$) and pyrite (ie, $FeS_{2(s)}$) in the iron-amended microcosms, which could have further implications for reducing methylmercury output as these minerals can be important sorption sites for inorganic mercury. We also conducted a second microcosm experiment using the same laboratory microcosm system with intact sediment cores containing live wetland plants (pickleweed), which supported the results of the sediment-only experiment.

This project demonstrated that the addition of ferrous iron to tidal wetland sediments has the potential to provide a practical landscape-scale control that could be implemented during tidal wetland construction and restoration projects throughout California. However, further research is needed to determine the efficacy of an iron amendment under in-situ field conditions, as well as in a variety of tidal wetland types, before this technique can be applied successfully.

Professional Presentations

Ulrich, Patrick and David Sedlak, Decrease in net mercury methylation following an iron amendment to wetland microcosms, San Francisco Estuary Institute Regional Monitoring Program Mercury Coordination Meeting, Oakland, CA, February 2009

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