DELTA SCIENCE FELLOW 2020

Delta Stewardship Council
Delta Science Program

Sea Grant California

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WHY THIS RESEARCH MATTERS

Mercury pollution in the San Francisco Bay-Delta is deep-rooted, dating back to the California Gold Rush. Elevated levels of methylmercury–a dangerous form of the chemical that gets concentrated as it moves up the food web–have been seen in fish and birds, including sport fish. To protect wildlife and human health, resource managers need to understand the biogeochemical pathways that mercury undergoes in the environment, and how environmental conditions influence the formation of methylmercury.

Simulating methylmercury production and transport at the sediment-water interface to improve the water quality in the Delta

Managed wetlands in the Yolo Bypass are of particular interest because they are an important source of methylmercury to the Delta. Credit: Stefanie Helmrich

PROJECT

The aim of this project was to improve basic knowledge of mercury cycling and aid management of net methylmercury production in the delta by developing a kinetic-thermodynamic reaction model that describes and quantifies mercury cycling in delta sediments. The model was used to assess uncertainties and estimate methylation and demethylation rates — the processes by which methylmercury is produced and breaks down. In addition, the project examined coupling of mercury cycling with cycling of iron, sulfur, and manganese.

RESULTS

Methylation and demethylation rates in the environment depend on a number of factors, making it difficult to interpret field and laboratory data. This project assessed over 40 published studies on methylation and demethylation rates, applying them to the reaction model to assess uncertainties and the relative importance of processes. The analysis found that demethylation rates had more uncertainties than methylation rates and that simulated MeHg concentrations were more sensitive to demethylation than methylation rates. Simulations also highlighted the influence of major elements including sulfur and iron on methylmercury production. Previous research believed that less methylmercury is produced when more sulfide is present, because it makes mercury unavailable to form the more toxic methylmercury. The simulations showed that the opposite is true: more sulfide makes mercury more available and can lead to increased methylmercury production.

MANAGEMENT APPLICATIONS

In order to reduce methylmercury in delta freshwater environments, a working understanding of biogeochemical processes affecting net methylmercury production is necessary. The model developed through this project can supply basic knowledge that is necessary to plan management practices. Findings showed surprising control mechanisms and buffering effects that are difficult to glean from laboratory and field data.

Additionally, insights from this project on uncertainties and limitations of currently available data for mercury methylation and methylmercury demethylation rates point to future areas of research that are of interest for management. This research was presented to USGS and they are interested to apply the model to field data.

Cache Creek Settling Basin (shown above) and agricultural wetlands in the Yolo Bypass (shown below) are hotspots for methylmercury production and export methylmercury to the Delta. Credit: Stefanie Helmrich

SELECT PUBLICATIONS AND PRESENTATIONS

Helmrich S., Vlassopoulos D., Alpers C., O'Day P. (2018). Critical review of mercury methylation and demethylation rate laws for biogeochemical reaction modeling. Goldschmidt. Boston, MA. August 2018.

Helmrich S., Vlassopoulos D., Alpers C., O'Day P. (2018). Simulation of biogeochemical processes driving methylmercury production in different sediment habitats of the Delta and its tributaries. 10th Biennial Bay-Delta Science Conference. Sacramento, CA. September 2018.

Helmrich S., Vlassopoulos D., Alpers C., O'Day P (2019). Simulation of mercury methylation and demethylation coupled to oxidation-reduction reactions in sediments of Delta tributaries. Annual meeting of the California Water & Environmental Modeling Forum. Folsom, CA. April 2019.

Helmrich S., Vlassopoulos D., Alpers C., O'Day P (2019). Development of a kinetic-thermodynamic model to simulate the mercury cycle in freshwater sediments. American Chemical Society Fall National Meeting. San Diego, CA. August 2019

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This publication is sponsored by a grant from the Delta Science Program, part of the Delta Stewardship Council, and is based on research findings from project R/SF-91. The views expressed herein are those of the authors and do not necessarily reflect the views of the Delta Stewardship Council or any of its sub-programs. This document is available in PDF on the California Sea Grant website: caseagrant.ucsd.edu
California Sea Grant, Scripps Institution of Oceanography, University of California, San Diego,
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