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Influence of reservoir water level fluctuations on sediment methylmercury concentrations downstream of the historical Black Butte mercury mine, OR

C.S. Eckley[a,*], T.P. Luxton[b], J.L. McKernan[b], J. Goetz[b], J. Goulet[a]

[a] US Environmental Protection Agency, Region-10, 1200 6th Ave, Seattle, WA 98101, USA
[b] US Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, 26 West Martin Luther King Drive, Cincinnati, OH 45268, USA

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ABSTRACT

Mercury (Hg) is a pollutant of global concern due to its ability to accumulate as methylmercury (MeHg) in biota. Mercury is methylated by anaerobic microorganisms such as sulfate reducing bacteria (SRB) in water and sediment. Throughout North America, reservoirs tend to have elevated methylmercury (MeHg) concentrations compared to natural lakes and rivers. This impact is most pronounced in newly created reservoirs where methylation is fueled by the decomposition of flooded organic material, which can release Hg and enhance microbial activity. Much less is known about the longer-term water-level management impacts on Hg cycling in older reservoirs. The objective of our study was to understand the role of on-going water-level fluctuations on sediment MeHg concentrations and sulfur speciation within a reservoir 75 years after initial impoundment. The study was performed at the Cottage Grove Reservoir located 15 km downstream of the historical Black Butte Hg mine. For 8 months each year, the water level is lowered resulting in roughly half of the reservoir's sediment being exposed to the atmosphere. Water samples from the inflow, water-column, outflow, and sediment were collected seasonally over a year for total-Hg, MeHg, and several ancillary parameters. The results showed that conditions in the reservoir were favorable to methylation with a much higher %MeHg observed in the outflowing water (34%) compared to the inflow (7%) during the late-summer. An anoxic hypolimnion did not develop in the reservoir indicating that methylation was predominantly occurring in the sediments. In the sediments subjected to seasonal inundation, MeHg production was highest in the top 2 cm of the sediments and declined with depth. The seasonally inundated sediments also had significantly higher methylation activity than the permanently inundated area of the reservoir. Oxidizing conditions in the sediments during periods of exposure to air resulted in an increase in sulfate concentrations which likely stimulated SRB methylation following the raising of the water levels. In contrast, the sulfur in the permanently inundated sediments was all in a reduced form (sulfide) and sulfate remained below detection throughout the year. Overall, our results indicate that reservoir water level fluctuations can affect sediment redox conditions and enhance MeHg production. This process can result in a continued elevation of MeHg concentrations in older reservoirs after the initial impact of landscape flooding has subsided.

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1. Introduction

Methylmercury (MeHg) is a more toxic form of Hg that can bioaccumulate in fish and fish consumers. The amount of MeHg produced within an ecosystem is dependent upon the activity and abundance of microorganisms that can methylate Hg as well as the bioavailability of inorganic Hg to these organisms (Hsu-Kim et al., 2013; Ullrich et al., 2001). It is well established that sulfate reducing bacteria (SRB) are important producers of MeHg (Berman and Bartha, 1986; Compeau and Bartha, 1985; Gilmour et al., 1992) and more recently iron reducing bacteria (IRB) have also been shown to methylate Hg (Fleming et al., 2006; Kerin et al., 2006). The productivity of methylating bacteria is related to the extent of anoxic conditions, availability of a labile organic carbon source, and the concentration of sulfate or other electron acceptors such as ferric iron (Hsu-Kim et al., 2013; Kerin et al., 2006; Ullrich et al., 2001). The activity of SRB and IRB is

* Corresponding author.
E-mail address: eckley.chris@epa.gov (C.S. Eckley).

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