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MERCURY IN ABIOTIC MATRICES OF CLEAR LAKE, CALIFORNIA: HUMAN HEALTH AND ECOTOXICOLOGICAL IMPLICATIONS

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Abstract. Mercury (Hg) from Hg mining at Clear Lake, California, USA, has contaminated water and sediments for over 130 years and has the potential to affect human and environmental health. With total mercury (TotHg) concentrations up to 438 mg/kg (dry mass) in surficial sediments and up to 399 ng/L in lake water, Clear Lake is one of the most Hg-contaminated lakes worldwide. Particulate Hg in surface water near the mine ranges from 10 000 to 64 000 ng/g; TotHg declines exponentially with distance from the Sulphur Bank Mercury Mine. From 1992 to 1998, no significant long-term trends for TotHg or methylmercury (MeHg) in sediments or water were observed, but peaks of both TotHg and MeHg occurred following a 1995 flooding event. Sediments and water exhibit summer/fall maxima and winter/spring minima for MeHg, but not TotHg. Sediment TotHg has not declined significantly a decade after remediation in 1992. At the mine site, aqueous TotHg reached 374 000 ng/L in unfiltered groundwater. Pore water sulfate in sediments varies seasonally from 112 mg/L in summer/fall (when Hg methylation is highest) to 3300 mg/L in winter. While TotHg is exceptionally high in both sediments and water, MeHg is substantially lower than would be expected based on the bulk Hg loading to the lake and in comparison with other sites worldwide.

Total mercury in Clear Lake water does not exceed the Safe Drinking Water Act criteria, but it sometimes greatly exceeds human health criteria established by the Great Lakes Initiative, U.S. Environmental Protection Agency water quality guidelines, and the California Toxics Rule criterion. Methylmercury concentrations exceed the Great Lakes Initiative criterion for MeHg in water at some sites only during summer/fall.

Relative to ecological health, Clear Lake sediments greatly exceed the National Oceanic and Atmospheric Administration's benthic fauna Sediment Quality Guidelines for toxic effects, as well as the more concensus-based Threshold Effects Concentration criteria. Based on these criteria, Hg-contaminated sediments and water from Clear Lake are predicted to have some lethal and sublethal effects on specific resident aquatic species. However, based on unique physical and chemical characteristics of the Clear Lake environment, MeHg toxicity may be significantly less than anticipated from the large inorganic Hg loading.

Key words: acid mine drainage; Clear Lake, California, USA; ecotoxicology; human health; mercury; methylmercury; mining; sediment quality criteria; Sulphur Bank Mercury Mine; water quality criteria.

INTRODUCTION

This evaluation of mercury (Hg) in the abiotic compartments of Clear Lake, California, USA, is one component of a larger ecosystem-level study that traces the origin and pathways of Hg from the ore body at an abandonded Hg mine through the abiotic (sediment and water) matrices to lower trophic level species (benthic invertebrates and plankton) and to higher trophic level species (e.g., fish, birds, and mammals). In addition to describing the spatial and temporal variability of Hg in the abiotic compartments of the ecosystem, this paper provides Hg data in sediments and water that are used in numerous other papers to elucidate the manner in which Hg is transformed, transported, bioaccumulated, and stored in this system.

Mercury has been identified as a significant threat to human and environmental health. Typically, Hg exists in very low concentrations in the environment, but in some regions, especially those altered by human activities (e.g., Hg, gold, and silver mining sites, chloralkali plants), it can occur at relatively high concentrations. Considerable research has focused on Hg contamination from atmospheric sources, but much less has addressed

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