Special Issue

Mercury Cycling and Bioaccumulation in a Mine-dominated Aquatic Ecosystem: Clear Lake, California[1]

This assemblage of 16 reports represents the culmination of ca. 15 years of investigation on mercury (Hg) cycling and bioaccumulation at Clear Lake, California, site of the abandoned Sulphur Bank Mercury Mine (a USEPA Superfund Site since 1990) and one of the most Hg-contaminated lakes in the world. Hg cycling studies in this mine-dominated ecosystem provide a valuable contrast to other studies on Hg contamination in that the Hg source material (primarily cinnabar and metacinnabar, HgS) differs chemically from Hg source material in other studies that focus primarily on Hg derived from atmospheric deposition or industrial point sources. Thus, Hg cycling and bioaccumulation at Clear Lake differ greatly from processes described at non-mine-dominated sites as reflected in both the production of toxic methylmercury (MeHg) and the bioaccumulation of Hg in lower and higher trophic level species.

A holistic ecosystem approach was taken to examine the behavior of Hg within this mine-dominated lacustrine system. Collectively, this Special Issue represents an integrated set of interdisciplinary studies on the sources, transport, transformation, cycling, and fate of Hg in Clear Lake including studies on: chemistry, geology, environmental engineering, biology, microbiology, physiology, limnology, ecology, and ecotoxicology. This integration is evidenced throughout the volume by the linkage of data and results among the many different studies. In addition, these studies elucidate the influence of natural vs. anthropogenic processes as drivers in the production and bioaccumulation of toxic MeHg in prehistoric, historical, and modern time frames, and provide an evaluation of the actual and potential health effects of Hg to wildlife and humans in this system. Finally, these studies also provide quantitative data for use by managers and regulators who strive to minimize the effects of Hg on both humans and other species.

In the second paper of this issue, Suchanek et al. provide historical information and common background data on both the lake and the mine that are used throughout this Special Issue. This collection of studies on the source, characterization, transport, and fate of Hg in this system includes: (1) data on the origin of Hg from the ore body and the flow of acid mine drainage from the mine site to the lake, (2) an identification of those physical processes that transport mine-derived Hg from the mine site to the lake and throughout the aquatic system, (3) a description of the physical and biological factors that are correlated with or promote the production of toxic MeHg in this system, (4) documentation of the spatial and temporal variability of total Hg (TotHg) and MeHg in the abiotic compartments, lower trophic (invertebrate) compartments, and fish, (5) an elucidation of the transfer of Hg through a complex aquatic trophic system influenced by many alien fish species, (6) an analysis of the influence of an alien fish species on the bioaccumulation of Hg to higher trophic levels, and (7) an account of the factors that influence the uptake and bioaccumulation of Hg in piscivorous osprey and grebes. These data are compared with results of comparable studies at other contaminated and non-contaminated sites worldwide.

Hg loading into Clear Lake was further traced to historical (1800s) and prehistoric (to ca. 3000 years before present) periods through sediment coring and the use of dating methodologies including ^{14}C, ^{210}Pb, and in situ depositional horizons of the legacy pesticide DDD (dichlorodiphenyl-dichloroethane). These results provide clear evidence of the influence of open-pit mining (as opposed to shaft mining) practices on driving increased Hg loading to the lake and elucidate the stable nature of TotHg and MeHg deposited by both natural and anthropogenically driven processes over periods ranging from hundreds to thousands of years. They also provide evidence of other anthropogenic stressors and natural processes that influence sediment chemistry in this system.

A summary of the pathways through which Hg flows from the ore body to individual organisms and through Clear Lake's aquatic ecosystem to higher trophic levels, as well as a synthesis of the

[1] Reprints of this 296-page Special Issue are available for $20.00 each, either as PDF files or as hard copy. Prepayment is required. Order reprints from the Ecological Society of America, Attention: Reprint Department, 1990 M Street, N.W., Suite 700, Washington, D.C. 20036 (esaHQ@esa.org).

responsible geochemical processes, is provided by Suchanek et al. in the second paper of this Special Issue. The contributors to this issue hope that this assemblage of papers will facilitate the application of sound science to the analysis and remediation of Hg-contaminated mine sites.

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In Memory

This publication is dedicated to Ken McElroy (1975–2001), who loved the lake and loved life. Ken contributed greatly to ecological studies at the UC–Davis Clear Lake Environmental Research Center during 2000–2001 and was an inspiration, both personally and academically, to all who knew him.