

Proceedings and Summary Report

Workshop on the Fate, Transport, and Transformation of Mercury in Aquatic and Terrestrial Environments



Proceedings and Summary Report

Workshop on the Fate, Transport, and Transformation of Mercury in Aquatic and Terrestrial Environments

May 8 – 10, 2001
West Palm Beach, Florida

National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

Toxic Substances Hydrology Program
Office of Water Quality
United States Geological Survey
Reston, VA 20192

NOTICE

This document was compiled from presentations and open discussion at a U.S. Environmental Protection Agency (USEPA) Workshop on the Fate, Transport, and Transformation of Mercury in Aquatic and Terrestrial Environments held in West Palm Beach, Florida. The agenda and speaker/poster abstracts are presented in the appendices. Information presented herein does not necessarily represent the views of USEPA, nor is it specifically tied to reference materials. In many cases, the information presented is the opinion of the speaker, generated by his or her background and operations experience.

FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threaten human health and the environment. The focus of the Laboratory's research program is on methods, and their cost-effectiveness, for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL's research provides solutions to environmental problems by developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director
National Risk Management Research Laboratory

This page left intentionally blank.

TABLE OF CONTENTS

Section		Page Number
NOTICE		ii
FOREWORD		iii
TABLE OF CONTENTS		v
ACRONYMS		ix
ACKNOWLEDGMENTS		xi
SECTION 1	INTRODUCTION	1
SECTION 2	SCOPE AND OBJECTIVE OF THE WORKSHOP	3
SECTION 3	SUMMARY OF THE PLENARY SESSION	5
3.1	Plenary Session	5
3.1.1	USEPA’s Mercury Research Strategy — <i>Douglas W. Grosse, USEPA, National Risk Management Research Laboratory (NRMRL)</i>	5
3.1.2	USGS/USEPA Mercury Roundtable: Enhancing Interagency Collaborations — <i>Sarah Gerould, USGS</i>	6
3.1.3	State of Florida/Mercury Science Program — <i>Tom Atkeson, Florida Department of Environmental Protection (DEP)</i>	7
3.1.4	USEPA STAR Program — <i>Bill Stelz, USEPA, National Center For Environmental Research (NCER)</i>	8
3.1.5	Electric Power Research Institute — <i>Leonard Levin, EPRI</i>	8
3.1.6	National Wildlife Federation (NWF) Great Lakes Natural Resource Center — <i>Mike Murray, NWF</i>	10
3.2	Keynote Speakers	11
3.2.1	Atmospheric Deposition Overview — <i>Gerald Keeler, University of Michigan</i>	11
3.2.2	Historic Perspectives on Mercury — <i>Don Porcella, Environmental Science & Management</i>	14
SECTION 4	SUMMARY OF THE TECHNICAL SESSIONS	17
4.1	Session A: Mercury and Methylmercury Transport in the Environment	17
4.1.1	Determination of the Sediment-Water Exchange of Mercury and Methylmercury: Approaches, Limitations, Observations — <i>G. Gill, Texas A&M University</i>	17
4.1.2	Mercury and Methylmercury Accumulation in Lake Sediment: What Can We Infer from Dated Cores? — <i>D. Engstrom, Science Museum of Minnesota</i>	17
4.1.3	An Overview of Mercury Cycling in the Boreal Ecosystem — <i>V. St. Louis, University of Alberta</i>	18
4.1.4	Is the Arctic a Missing Sink for Mercury? New Measurements of Depletion Events, Deposition and Speciation in Air and Snow at Point Barrow, Alaska — <i>Steven E. Lindberg, Oak Ridge National Laboratory</i>	19
4.1.5	Putting into Perspective Mercury Emissions from Geologic Sources — <i>M. Sexauer Gustin, University of Nevada-Reno</i>	19
4.1.6	Mercury Cycling in the Boreal Forest: Insights from Models, Experiments, and Isotopes — <i>B. Branfireun, University of Toronto at Mississauga</i>	20
4.2	Session B: Bioaccumulation of Mercury in Aquatic Food Webs	21

Section		Page Number
4.2.1	Evolution of a Contaminant Problem: Mercury in Freshwater Fish — <i>J. Wiener, University of Wisconsin-La Crosse</i>	21
4.2.2	Projecting the Population-Level Effects of Mercury on the Common Loon in the Northeast — <i>D. Evers, BioDiversity Research Institute</i>	22
4.2.3	USGS National Pilot Study of Contamination of Aquatic Ecosystems Along Multiple Gradients: Bioaccumulation in Fish — <i>W. Brumbaugh, National Pilot Study of Mercury</i>	22
4.2.4	Interactions of Trophic Position and Habitat with Mercury Bioaccumulation in Florida Everglades Largemouth Bass (<i>Micropterus salmoides</i>) — <i>T. Lange, Florida Fish and Wildlife Conservation Commission</i>	23
4.2.5	Bioaccumulation of Mercury in the Everglades: Patterns in the Foodweb — <i>J. Trexler, Florida International University</i>	24
4.2.6	Effects of Rainbow Smelt Invasion on Mercury Concentrations of Predatory Fish of Northwestern Ontario and Manitoba, Canada — <i>R. Bodaly, Department of Fisheries and Oceans, Freshwater Institute, Canada</i>	24
4.3	Session C: STAR Program Review	25
4.3.1	Formation/Transport of Methylmercury in Ecosystems and Watersheds	25
4.3.1.1	Watershed Influences on the Transport, Fate, and Bioavailability of Mercury in Lake Superior — <i>J. Hurley, University of Wisconsin</i>	25
4.3.1.2	Factors Controlling Methylmercury Production in Sediments and Fate in Aquatic Systems — <i>R. Mason, University of Maryland</i>	26
4.3.1.3	Response of Methylmercury Production and Accumulation to Changes in Mercury Loading: A Whole-Ecosystem Mercury Loading Study — <i>C. Gilmour, The Academy of Natural Sciences, Estuarine Research Center</i>	26
4.3.1.4	Methylmercury Sources to Lakes in Forested Watersheds: Has Enhanced Methylation Increased Mercury in Fish Relative to Atmospheric Deposition? — <i>J. Jeremiason, Minnesota Pollution Control Agency</i>	27
4.3.2	Biogeochemical Controls on Mercury Methylation/Demethylation Rates	29
4.3.2.1	Photochemistry of Mercury in Saginaw Bay Watershed, Michigan: Annual USEPA STAR Project Meeting — <i>J. Nriagu, University of Michigan</i>	29
4.3.2.2	Chemical and Biological Control of Mercury Cycling in Upland, Wetland and Lake Ecosystems in the Northeastern United States — <i>C. Driscoll, Syracuse University</i>	29
4.3.3	Physical and Chemical Processes Affecting Mercury Cycling	30
4.3.3.1	Processes Controlling the Chemical/Isotopic Speciation and Distribution of Mercury from Contaminated Mine Sites — <i>G. Brown, Stanford University</i>	30
4.3.3.2	Microbiological and Physiochemical Aspects of Mercury Cycling in the Coastal/Estuarine Waters of Long Island Sound and Its River-Seawater Mixing Zones — <i>W. Fitzgerald, University of Connecticut</i>	31

Section		Page Number
4.3.3.3	Redox Transformation of Mercury — <i>F. Morel, Princeton University</i>	32
4.3.3.4	Assessing the Role of Plants in the Biogeochemical Cycle of Mercury — <i>M. Gustin, University of Nevada</i>	32
4.3.3.5	Mercury and Methylmercury Burdens in Sediments, Water, and Biota of VT and NH Lakes, and Trends in Paleolimnology-Inferred Mercury Deposition to VT and NH — <i>N. Kamman, VT Department of Environmental Conservation</i>	33
4.3.3.6	Mercury in Fish and Sediments of Clear Lake, California: Defining the Problem and Developing Cleanup Options through the USEPA Superfund Program — <i>E. Mange</i>	33
4.4	Session D: Managing Mercury Contamination in Aquatic/Terrestrial Systems	35
4.4.1	An Assessment of the Ecological and Human Health Impacts of Mercury in the Bay-Delta Watershed: A CALFED Study — <i>C. Foe, Central Valley Regional Water Quality Control Board</i>	35
4.4.2	An Evaluation of USEPA's Bioaccumulation Factor for Mercury: A Regulated Industry Perspective — <i>R. Reash, American Electric Power</i>	36
4.4.3	Methylmercury in Terrestrial Ecosystems: Summary of Swedish Research — <i>J. Munthe, IVL Swedish Environmental Research Institute</i>	36
4.4.4	Interfacing Process-Level Research and Ecosystem-Level Management Questions: Aquatic Cycling of Mercury in the Everglades Phase II — <i>D. Krabbenhoft, U.S. Geological Survey</i>	36
4.4.5	Modeling Mercury Fate in Seven Georgia Watersheds — <i>R. Ambrose, Jr., USEPA</i>	37
4.4.6	Fitting into the North American Mercury Emissions Reduction Priority — <i>L. Trip, Environment Canada</i>	38
4.5	Session E: Methylmercury Production in the Environment	39
4.5.1	Overview of Microbial Methylmercury Production and Degradation: What Do We Know? What Don't We Know? — <i>C. Gilmour, The Academy of Natural Sciences</i>	39
4.5.2	Environmental Controls on Methylmercury Production and Degradation in Florida Everglades Sediment — <i>M. Marvin-DiPasquale, U.S. Geological Survey</i>	39
4.5.3	Group VI Anions and Mercury Transformation within the S-cycle in the Carson River System, Nevada — <i>J.C. Bonzongo, University of Florida</i>	40
4.5.4	A Bacterial Biosensor for Aquatic Hg(II) Speciation and Bioavailability — <i>P. Barrocas, Florida State University</i>	40
4.5.5	Facilitated Uptake of Mercury at Trace Concentrations by <i>Escherichia coli</i> and <i>Vibrio anguillarum</i> — <i>G. Golding, University of Manitoba</i>	41
4.5.6	Mercury Transport and Transformation in the Wider Idrija Region and the Gulf of Trieste — <i>M. Horvat, Institute Jozef Stefan</i>	42

Section		Page Number
4.5.7	The Everglades Mercury Cycling Model: Development and Application to Two Marsh Sites in the Florida Everglades — <i>R. Harris, Tetra Tech, Inc.</i>	42
4.6	Combined Session	43
4.6.1	Landscape Patterns of Mercury Contamination Across the Everglades Ecosystem — <i>J. Stober, USEPA Region 4 and K. Thornton, FTN Associates Ltd.</i>	43
4.6.2	Use of Path Analysis to Integrate the Effects of Multiple Stressors on Mercury Contamination in the Everglades Ecosystem — <i>K. Thornton, FTN Associates Ltd. and J. Stober, USEPA Region 4</i>	44
4.6.3	METAALICUS: A Study to Determine the Relationship Between Mercury Deposition and Methylmercury Concentrations of Fish — <i>J. Rudd, Department of Fisheries and Oceans Canada and R. Harris, Tetra Tech Inc.</i>	44
SECTION 5	SUMMARY OF THE PANEL DISCUSSIONS	47
5.1	Mercury And Methylmercury Transport in The Environment — <i>D. Krabbenhoft</i>	47
5.1.1	What We Know	47
5.1.2	What We Don't Know	48
5.1.3	Open Discussion	49
5.2	Methylmercury Production in The Environment — <i>C. Gilmour</i>	50
5.2.1	What We Know	50
5.2.2	What We Don't Know	50
5.2.3	Open Discussion	50
5.3	STAR Program Review — <i>J. Hurley</i>	52
5.3.1	What We Know	52
5.3.2	What We Don't Know	52
5.3.3	Open Discussion	53
5.4	Management of Mercury Contamination in Aquatic/Terrestrial Systems — <i>Luke Trip</i>	53
5.4.1	What We Know	53
5.4.2	What We Think We Know	53
5.4.3	What We Don't Know	54
5.4.4	Open Discussion	54
5.5	Bioaccumulation of Mercury in Aquatic Food Webs — <i>Jim Wiener</i>	55
5.5.1	What We Know	55
5.5.2	What We Don't Know	56
5.5.3	Open Discussion	57
FIELD TRIP TO THE EVERGLADES		57
APPENDIX A	WORKSHOP AGENDA	A-1
APPENDIX B	SPEAKER ABSTRACTS	B-1
APPENDIX C	POSTER ABSTRACTS	C-1

ACRONYMS

ACME	Aquatic Cycling of Mercury in the Everglades
AMD	Acid Mine Drainage
ATSDR	Agency for Toxic Substances and Disease Registry
AVS	Acid-volatile sulfide
BAF	Bioaccumulation Factor
CEC	Commission for Environmental Cooperation
CEM	Continuous Emissions Monitoring
CRS	Carson River System
CV-AFS	Cold-Vapor Atomic Fluorescence Spectrometry
CWA	Clean Water Act
DGM	Dissolved Gaseous Mercury
DEP	Department of Environmental Protection
D-MCM	Dynamic Mercury Cycling Model
DOC	Dissolved Organic Carbon
E-MCM	Everglades Mercury Cycling Model
Eh	Redox potential
EMAP	Environmental Monitoring and Assessment Program
ELA	Experimental Lakes Area
ENRP	Everglades Nutrient Removal Project
USEPA	United States Environmental Protection Agency
EPG	Electric Power Generation
EPRI	Electric Power Research Institute
FDA	Food and Drug Administration
GEM	Gaseous Elemental Mercury
GIS	Geographic Information System
ICP	Inductively Coupled Plasma
LFG	Landfill Gas
LIF	Laser Induced Fluorescence
LIS	Long Island Sound
MARB	Mobile-Alabama River Basin
MAWLTS	Mercury in Adirondack Wetlands Lakes and Terrestrial Systems
MCL	Maximum Contaminant Level
MDE	Mercury Depletion Events
MDN	Mercury Deposition Network
MeHg	Methylmercury (monomethylmercury)
METAALICUS	Mercury Experiment To Assess Atmospheric Loading In Canada and the United States
NADP	National Atmospheric Deposition Program

NARAP	North American Regional Action Plan
NAWQA	National Water Quality Assessment
NCER	National Center For Environmental Research
NRMRL	National Risk Management Research Laboratory
NWF	National Wildlife Federation
OC	Organic Carbon
ORD	Office of Research and Development (USEPA)
ORNL	Oak Ridge National Laboratory
PBT	Persistent, bioaccumulative and toxic [chemicals]
POC	Particulate Organic Carbon
RARE	Regional Applied Research Effort
RELMAP	Regional Lagrangian Model of Air Pollution
RGM	Reactive Gaseous Mercury
SBMM	Sulphur Bank Mercury Mine
SFWMD	South Florida Water Management District
SoFAMMS	South Florida Atmospheric Mercury Monitoring Study
SRB	Sulfate-Reducing Bacteria
STA	Stormwater Treatment Area
STAR	Science to Achieve Results [Program]
SUVA	Specific Ultra-Violet Absorbance
THg	Total Mercury
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TP	Total Particulates
TRV	Toxicity Reference Value
USGS	United States Geological Survey
WASP5	Water Quality Analysis Simulation Program
WCA	Water Conservation Area (Everglades)
WCS	Watershed Characterization System
WTF	Waste Treatment Facility
XAFS	X-Ray Absorption Fine Structure
XRD	X-Ray Diffraction

ACKNOWLEDGMENTS

Several people contributed to developing and conducting this workshop. The Organizing Committee, chaired by Scott Minamyer of the USEPA's National Risk Management Research Laboratory, included the following individuals:

Rochelle Araujo	USEPA ORD National Exposure Research Laboratory-Athens
Thomas Atkeson	Florida Department of Environmental Protection and the South Florida Mercury Science Program
Marilyn Engle	USEPA Office of International Affairs
David Krabbenhoft	USGS, Water Resources Division, Toxics Program
Arnie Kuzmack	USEPA Office of Water, Office of Science and Technology
Leonard Levin	Electric Power Research Institute
Michael Murray	National Wildlife Federation
Paul Randall	USEPA ORD National Risk Management Research Laboratory
William Stelz	USEPA ORD National Center for Environmental Research, Quality Assurance and the STAR Program
Jerry Stober	USEPA Region 4, Science and Ecosystem Support Division

Lisa Kulujian, Alina Martin, Evelyn Hartzell, Lisa Mahoney, and Marc Fuentebella of the Science Applications International Corporation (SAIC) provided workshop logistical support.

David Krabbenhoft and Scott Minamyer provided technical guidance for this report which was prepared by Evelyn Hartzell of SAIC.

This page left intentionally blank.