

SERAFM: Ecological Risk Assessment Tool for Evaluating Wildlife Exposure Risk Associated with Mercury-Contaminated Sediment in Lake and River Systems



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INTRODUCTION

Mercury (Hg) is an important environmental pollutant because of its suspected neurotoxicity and is classified as a priority pollutant by the United States Environmental Protection Agency (USEPA) (USEPA, 1997). The primary pathway of mercury exposure to humans and wildlife is via ingestion of mercury-contaminated fish.

Under CERCLA and RCRA, remediation goals for sites with mercury contamination: **are not** typically developed for surface water, **are** often developed for sediment.

However, fish do not demonstrate a strong correlation with concentrations in sediment but rather with methyl-mercury concentration in water (Brumbaugh, 2001).

So Region 1 asked us: *How can one develop a remediation goal for mercury in sediment when the sediment mercury concentration may be a poor predictor of mercury exposure to biota?*

2003 ERASC Request #10 from Region 1

In 2003, NERL-ERD (Athens, GA) received a request through the Ecological Risk Assessment Support Center (ERASC) from Region 1.

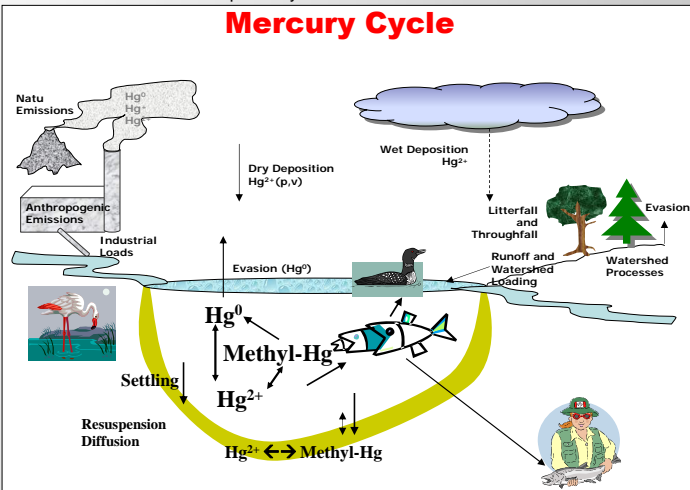
In response ORD/NERL/ERD:

Developed an easy-to-use, straight-forward model to assist in deriving a remediation goal.

and thus SERAFM was born.

SERAFM is the Spreadsheet-based Ecological Risk Assessment for the Fate of Mercury. We wrote and designed this model to be used as a stand-alone, risk assessment tool for mercury contaminated ecosystems.

- Process-based, Steady-state
- Spreadsheet Framework
 - transparent
 - series of linked modules, each kept on separate sheet
 - results linked sequentially



REFERENCES

Brumbaugh, W.G., D.P. Krabbenhoft, D.R. Helsel, J.G. Wiener, and K.R. Echols. 2001. A National Pilot Study of Mercury Contamination of Aquatic Ecosystems Along Multiple Gradients: Bioaccumulation in Fish. USGS/BRD/BSR-2001-0009, iii+25pp.

USEPA. 1997. Mercury Study Report to Congress. EPA-452/R-97-005, Office of Air Quality Planning and Standards United States Environmental Protection Agency, Washington.

SERAFM Inputs		
Watershed Characteristics		
Watershed Location (East or West)	Value	Units
Watershed Area (in Combining Area)	1,000,000	m2
Percent Deposition	20%	---
Percent Wetland	20%	---
Percent Riparian	40%	---
% with Heavy Contaminated Soil	1%	---
Percent Upland	30%	---
Lake Area	10,000,000	m2
Equilibrium Depth	3	m
Hydroperiod Depth	10	m
Annual Hydroperiod	60	days
Hydrologic Residence Time	0.5	yr
Inflow	6.00E+07	m3/yr
Outflow	6.00E+07	m3/yr
Water pH	7	---
Equilibrium Water Temp	20	C
Hydroperiod Water Temp	4	C
Air Temp	20	C
Annual Precipitation	102	mm/yr
DOC Equilibrium	10	mg/L
DOC Hydroperiod	20	mg/L
Color (in PCU)	0	PCU
Trophic Status	Eutrophic	---
Inflow Mercury Concentration:		
Hg0	0	ug/m3
HgII	0	ug/m3
Methyl	0	ug/m3
Total Mercury Concentration in Contaminated Sediment, by weight	10	ug/g
Known Mercury in Contaminated Soil:		
Cu/Hg	0	ug/m3
Cu/HgII	0	ug/m3
Cu/Methyl	0	ug/m3
Required Hazard Index for Sensitive Indicators	1	---

SERAFM Modules

- ▶ Atmospheric Deposition
- ▶ Watershed Erosion
- ▶ Equilibrium Partitioning
- ▶ Water Body Mercury Calculations
- ▶ Contaminated Sediment
- ▶ Background Conditions
- ▶ Watershed Runoff
- ▶ Water Body Solids Balance
- ▶ Mercury Speciation
- ▶ Remediation Goal
- ▶ Wildlife Risk Calculations

Calculates Exposure Concentrations

Exposure Concentrations					
		Contaminated Sediment	Units	Cleaned Sediment	Required Cleanup Levels
Epilimnion	Hg0 Filtered	10.46	ng/L	0.07	0.06
	HgII Filtered	22.21	ng/L	0.15	0.13
	Methyl Filtered	3.02	ng/L	0.01	0.00
	HgT Filtered	35.69	ng/L	0.23	0.19
Hypolimnion	Hg0 Unfiltered	10.46	ng/L	0.07	0.06
	HgII Unfiltered	88.28	ng/L	0.60	0.50
	Methyl Unfiltered	14.41	ng/L	0.03	0.01
	HgT Unfiltered	113.14	ng/L	0.70	0.57
Hydroperiod	Hg0 Filtered	3.95	ng/L	0.01	0.01
	HgII Filtered	26.71	ng/L	0.09	0.08
	Methyl Filtered	9.26	ng/L	0.01	0.00
	HgT Filtered	39.92	ng/L	0.12	0.07
Sediment	Hg0 Unfiltered	3.95	ng/L	0.01	0.01
	HgII Unfiltered	152.74	ng/L	0.63	0.43
	Methyl Unfiltered	27.52	ng/L	0.05	0.01
	HgT Unfiltered	224.12	ng/L	0.70	0.45
Fish	Hg0 porewater	3.95	ng/L	0.01	0.0050
	HgII porewater	79.39	ng/L	0.09	-0.0019
	Methyl porewater	18.87	ng/L	0.02	0.0015
	HgT porewater	102.12	ng/L	0.12	0.0085
Human	Hg0 bulk	0.00	ug/g	0.00	0.00
	HgII bulk	7.69	ug/g	0.00	0.00
	Methyl bulk	2.31	ug/g	0.00	0.00
	HgT bulk, dry	10.00	ug/g	0.01	0.00
Fish	Trophic Level 3	23.05	ug/g	0.04	0.02
	Trophic Level 4	97.98	ug/g	0.18	0.07
NI		3231.99		5.36	2.06
Sensitive Indicator	Tree Swallow			Tree Swallow	Tree Swallow
Target C. and		0.000	ug/g		

Identifies Sensitive Species

Calculates Wildlife Hazard Indices

Human and Wildlife Exposure Risk Results			
Wildlife	Hazard Index		Clean Up Level
	Contaminated	Cleaned	
Mink	280.54	0.52	0.20
Otter	391.97	0.70	0.27
Kingfisher	886.71	1.58	0.61
Loon	354.68	0.63	0.24
Osprey	354.68	0.63	0.24
Eagle	290.11	0.52	0.20
Tree Swallow	3231.99	5.36	2.06
Hooded Merganser	550.09	0.95	0.33
Wood Duck	244.64	0.38	0.14
Human			
Man	27.64	0.01	0.02
Woman	99.49	0.04	0.07
Adult	30.80	0.01	0.02
Child	143.71	0.06	0.10
Native American	275.28	0.12	0.19



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