South River Science Team
Remedial Options Program (ROP)
Work Group Update

March 14, 2012

South River Science Team Qtrly Meeting

NR Grosso

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South River Science Team - ROPs Work Group

VA DEQ
- Don Kain
- Calvin Jordan

USEPA Region 3
- Mike Jacobi
- Joel Hennessy
- Mark Chappell (USACE-ERDC)

Consultants and Int. Parties
- Dick Jensen
- Bob Luce
- Ralph Turner
- Reed Harris
- Gary Bigham
- Scott Brooks

Academia
- Robert Brent
- Carol Ptacek
- Mike Newman
- Jim Pizzuto
- Cindy Gilmour

DuPont
- Erin Mack
- Jim Dyer
- Mike Liberati
- Rich Landis
- Bill Berti
- Nancy Grosso

URS
- Ceil Mancini
- J.R. Flanders
- Jen Badner
- Josh Collins

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South River Science Team
ROPs Work Group

Purpose: Review, evaluate and test promising remedial approaches to address mercury in the South River – including engineering and treatment options

Recent Meetings

- February 8, 2012
- March 13, 2012

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ROPs Current and Upcoming Activities

Field (URS)

- *Amendment Pilot Implementation and Monitoring
- Bank Stabilization Pilot Monitoring
- Bank Sampling Program – Hg loading estimate verification
- River Substrate Mapping

Laboratory

- *University of Waterloo (Ptacek et al.)
- *Smithsonian Environmental Research Institute (Gilmour et al.)
- Proposals in preparation
  - James Madison University (Brent)
  - DuPont Haskell Global Research Laboratory (Berti)

* Reviewed today

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Pond Pilot - Carbon Amendment

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Pond Pilot – Carbon Amendment

Objectives

1. Assess efficacy of biochar in reducing mercury in physical media and in biota
2. Assess potential unintended effects on benthic macroinvertebrates
3. Notes challenges to deployment, distribution and maintenance

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Pond – physical characteristics

- Located at ~RRM 9
- ~50’ X120’
- Water depth 2’ to 5.5’ @ deepest point
- Cobble/ gravel bottom some fines around perimeter

Carbon Amendment Pond Pilot

Barrier installed – two cells

Biochar saturated

Week of 2011 July 8 - Deployed

Carbon Amendment Pond Pilot

Success Criteria

1. Addition of carbon amendment – reduction of Hg and MeHg concentrations in pore water and benthic invertebrates by 50% compared to control
2. Benthic community structure (richness and distribution) does not differ between control and amended cells

Monitoring: seven events post deployment: weeks July 18 through Nov 28, 2011

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Carbon Amendment Pond Pilot - Results

Sediments

No significant difference control and amended (IHg and MeHg)

Pore Water

IHg and MeHg somewhat lower in amended cell

Filtered Surface Water

Significantly lower IHg and MeHg in amended

Benthic Invertebrates

Snails and Mayfly in amended cell showed significantly less MeHg. Chironomids to a lesser extent.

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% IHg Reduction

Between Control and Amended Cells

Media	Baseline	Week 1	Week 2	Week 4	Week 8	Week 12	Week 16	Week 20
	IHg	IHg	IHg	IHg	IHg	IHg	IHg	IHg
Sediment (THg)	52	10	17	-115	59	-121	22	90
Pore Water	-28	-268	59	53	49	69	12	34
Surface Water (Filtered)	-3	66	75	37	37	40	50	46
Snails	27			-42	64	63	71	91
Chironomids	-450			87	62	31	48	59
Caenis	40			61	32	45	56	83

	% Reduction ≥ 50%

$$\% \text{ Reduction} = \frac{(Control - Amendment)}{Control} \times 100$$

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% MeHg Reduction

Between Control and Amended Cells

Media	Baseline	Week 1	Week 2	Week 4	Week 8	Week 12	Week 16	Week 20
	MeHg	MeHg	MeHg	MeHg	MeHg	MeHg	MeHg	MeHg
Sediment (THg)	36	20	59	35	74	29	66	-453
Pore Water	50	56	24	67	29	-1	63	35
Surface Water (Filtered)	24	76	67	73	70	71	78	74
Snails	-2			54	62	81	78	67
Chironomids	3			84	92	79	-82	28
Caenis	52			56	86	65	80	75

	% Reduction ≥ 50%

$$\% \text{ Reduction} = \frac{(Control - Amendment)}{Control} \times 100$$

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Carbon Amendment Pond Pilot – Next Steps

Continue Monitoring in 2012

- Four events
- Target temperatures greater than 12^{o}C for highest seasonal MeHg concentrations
- Include other biota for example
  - Tadpoles in spring (if possible)
  - Young of year fish (e.g. sunfish)
- Core sediment where appropriate for vertical profile of biochar

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DuPont Mercury Remediation Studies

Evaluation of carbon amendments for remediation of Hg and MeHg exposure and bioaccumulation in sediments

A 12-week microcosm study of sediments from South River and Wertman's Pond

Summer/Fall 2011

Cynthia Gilmour, Fritz Riedel, Ally Bullock, Georgia Riedel
Smithsonian Environmental Research Center (SERC)

Upal Ghosh and Seokjoon Kwon
Univ. Maryland Baltimore County

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SERC Study Objectives:

1) Test the relative effectiveness of activated carbon vs. biochar in the South River system

2) Examine the effectiveness of carbons over time

3) Check the observation that MeHg concentrations in carbon-amended sediments may increase, and how that impacts exposure and bioaccumulation

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SERC Study Design

12-week (86 d) microcosm study
- Including 14-day *Lumbriculus* bioaccumulation study over days 72-86

Two test sediments:

South River RRM ~3.9

Wertman's Pond #2 (South River floodplain pond)

Three treatments:
- Control – no amendment
- Activated Carbon
- Biochar (Cowboy charcoal)

3 replicate microcosms per treatment

2 sites X 3 treatments X triplicates =

18 microcosms


09/22/2011

SERC: Summary of South River Results

Concentrations relative to un-amended control, Day 86

		Porewater		Worms		Sediment	
		THg	MeHg	THg	MeHg	THg	MeHg
South River	AC	0.2	0.3	0.4	0.25	1.8	7
	Biochar	0.5	0.25	0.7	0.4	1.6	7
Wertman's	AC	0.55	0.2	0.4	0.2	0.6	10
	Biochar	0.5	0.2	0.8	0.2	0.6	4

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SERC Summary

- Carbon amendments effectively decreased inorganic Hg and MeHg uptake by worms
- % MeHg reduction in mesocosms is comparable to results found in the Amendment Pilot
- But MeHg concentrations increased significantly over time in carbon-amended sediments

Next step: develop hypotheses to explain increased MeHg concentrations in treated sediment

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University of Waterloo - Ptacek et al.

Study Objectives

- Characterize solid-phase forms of Hg and geochemical associations in riverbank and floodplain sediments
- Identify geochemical mechanisms leading to the release and transport of Hg from sediment
- Evaluate methods to limit Hg release

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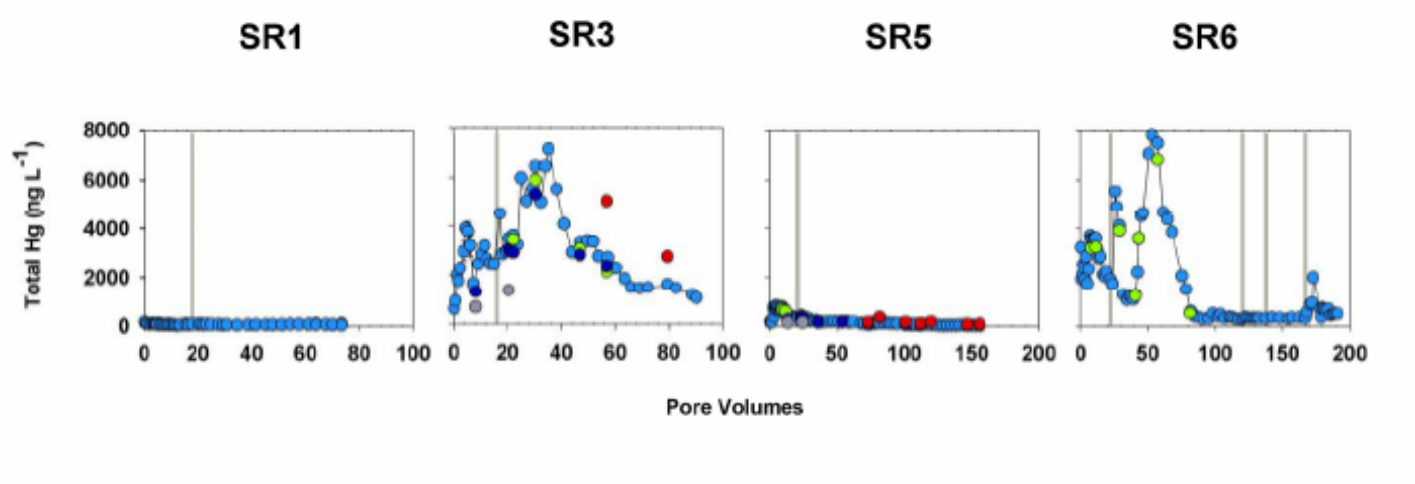
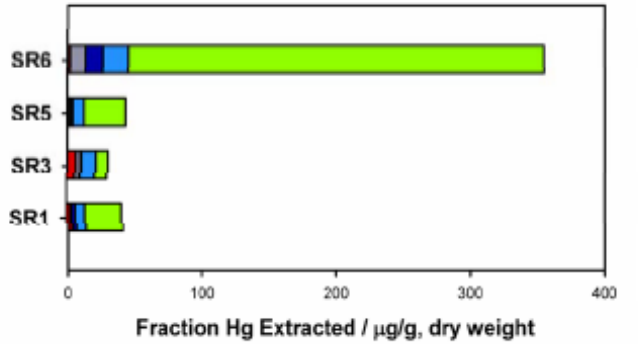
University of Waterloo

Characterization





	Target Hg Species
F1	Water soluble ($HgCl_2$, $HgSO_4$)
F2	'Human stomach acid' soluble ($HgSO_4$, HgO, adsorbed Hg)
F3	Organo-chelated (chelated Hg, Hg_2Cl_2)
F4	Elemental Hg (Hg^0, thiol-bound Hg, amalgam Hg)
F5	Mercuric sulfide (HgS, HgSe, HgAu)

- Mercury species distribution is different for different samples
- Most of the Hg is tightly bound to solids – but leachate still contains significant Hg concentration
- Soils can leach even after 10s of pore water flushes

University of Waterloo - Testing Treatments

- Several biochars tested for effectiveness in lowering Hg in spiked South River water
- All chars were relatively effective in reducing Hg in water
- Higher temperature biochars released less undesirable constituents (DOC and sulfate)
- “Cowboy Charcoal” brand used for pond pilot based on Waterloo results

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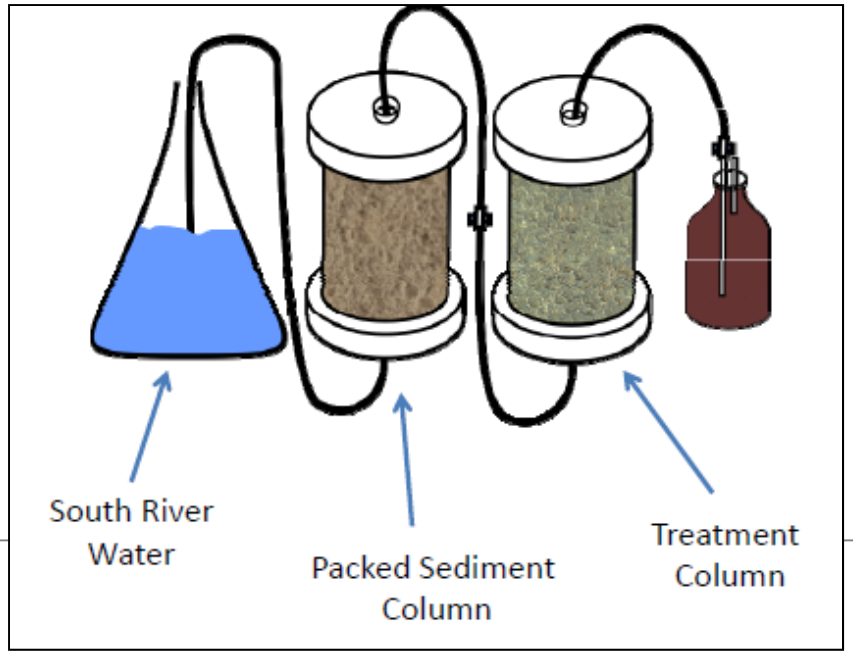
University of Waterloo – Treatment Column Studies

- Saturate soils from RRM 0.1 were leached
- Effluent then treated with Cowboy Charcoal
- THg concentrations decreased by 99% (initially reduced from ~15,000 ng/L to ~90 ng/L)



University of Waterloo – Current Activities

- Variably saturated soil columns
- Testing the effects of alternately wetted and dried soils and sediments on Hg release and MeHg concentrations
- Simulating rainwater and river stage fluctuations /bank soil inundation

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Next Meeting – June

- Working Meeting
  - Develop short term (2 year) and an outline for a long term plan
  - Implement within an adaptive management framework
- Updates on field and studies (possibly webmeetings)

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Additional Slides

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SERC RESULTS – Bioaccumulation

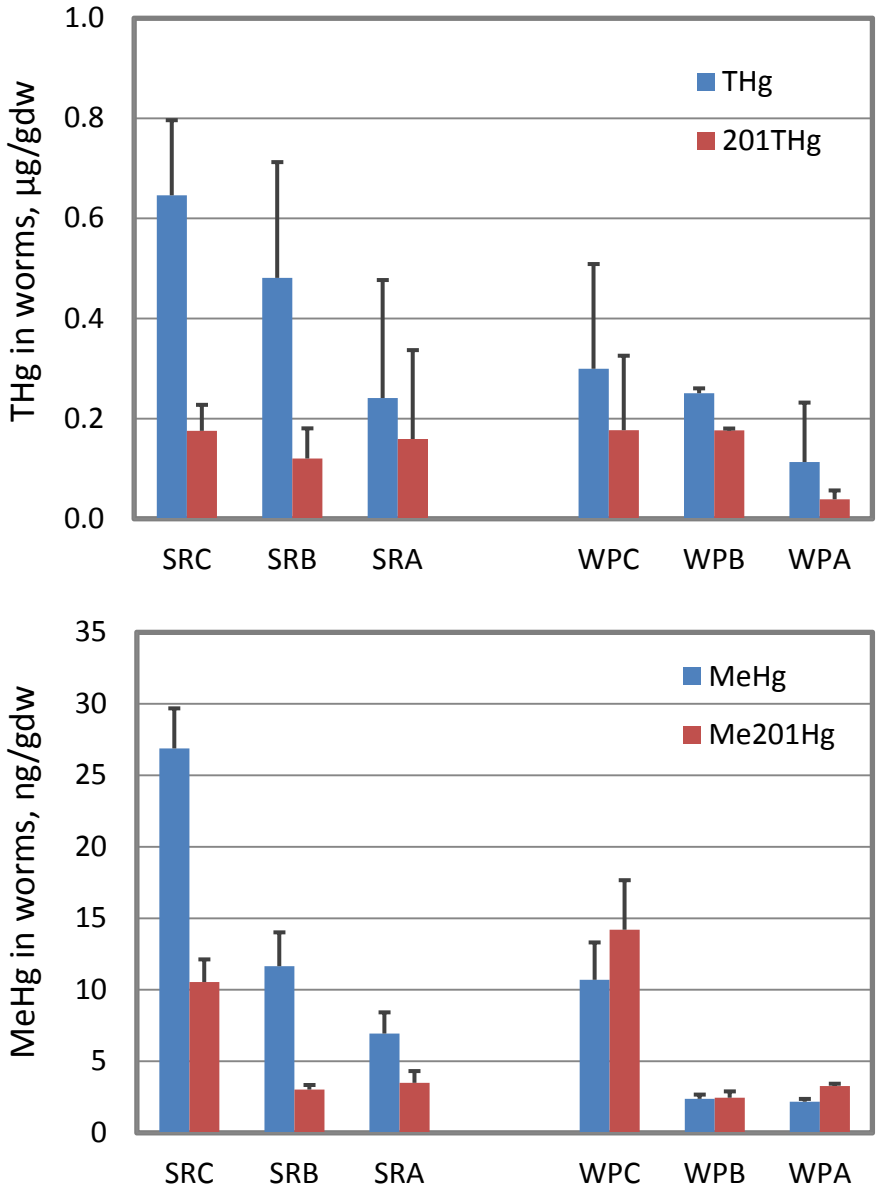
Carbon amendments effectively decreased inorganic Hg and MeHg uptake by worms

Activated carbon was more effective in reducing worm Hg and MeHg concentrations than Cowboy charcoal

SRC: South River sediments Control
SRB: South River sediments Biochar (Cowboy)
SRC: South River sediments Activated Carbon

WPC: Wertman Pond sediments Control
WPB: Wertman Pond sediments Biochar (Cowboy)
WPA: Wertman Pond sediments Activated Carbon

Hg and MeHg in *Lumbriculus*
14-day exposure, microcosm day 72-86



SERC RESULTS – Sediment MeHg

MeHg concentrations increased significantly over time in carbon-amended sediments

The effect was more dramatic with the ^{201}Hg spike