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Field Validation of a Laboratory Pilot Demonstrating the Ability of Biochar to Reduce Mercury Bioavailability in Floodplain Soils

B. Reese and S. Thakali (AECOM, Conshohocken, PA) | R.G. Stahl, Jr. and R. Landis (E.I. du Pont de Nemours and Company, Newark, DE) | J. Flanders (Former AECOM, Conshohocken, PA)

ABSTRACT

Mercury (Hg) was used in the manufacturing process at a facility in Waynesboro, Virginia between 1929 and 1950. In the course of the manufacturing process, mercury was released and subsequently migrated into surface water, sediments, soils, and biota of the South River. As a result, these historic mercury releases from the facility have accumulated in depositional areas along the river and floodplain.

Biochar ('Cowboy' charcoal) amendment is an option to be considered in remediation of mercury-impacted soils. An initial laboratory pilot study (Phase I) was performed with positive results in reducing methylmercury (MeHg) in juvenile earthworms (*Eisenia fetida*), with no adverse effects on earthworms or plants. The field pilot (Phase II) aims to validate the phase I results, *in situ*, as well as investigate additional parameters.

PHASE I - LABORATORY PILOT

Figure 1. Mortality in Adult Earthworms

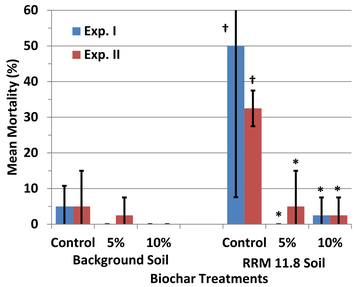
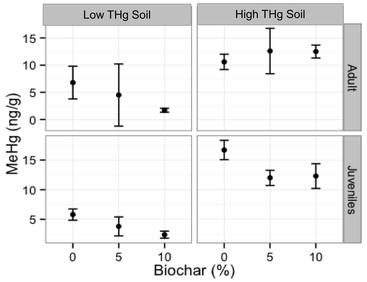


Figure 2. Mercury Concentration in Earthworms



Phase I was a bench-scale test of the effectiveness and safety of biochar in reducing bioavailability of Hg to terrestrial invertebrates.

- Low Hg (Background) and high Hg (RRM 11.8) soil treated with no biochar (control), 5% biochar and 10% biochar (by weight)
- Toxicity tests were run and treatments were analyzed for adverse effects and Hg uptake in adult and juvenile earthworms (*E. fetida*) and plants (wheat [*Triticum aestivum*], soybeans [*Glycine max*] and radish [*Raphanus sativus*])
- Results for *E. fetida* showed a reduction in mortality in biochar-amended high Hg soils (Figure 1) as well as reduced methylmercury (MeHg) uptake in juvenile earthworms (Figure 2)

PHASE II - FIELD PILOT

Objectives

- The intent of Phase II (Field Pilot) is to validate the Phase I results
- Assess potential efficacy of biochar in reducing MeHg bioaccumulation in juvenile *Lumbricus terrestris* (soil-dwelling earthworms)
- Monitor effects on *L. terrestris* survival, growth, and reproduction
- Demonstrate progress toward innovative remedial strategies

Figure 3. Exposure Mesocosm Schematic

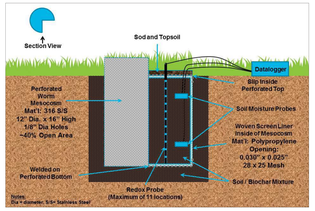


Figure 4. Amended soil in exposure mesocosm

Mesocosm Design and Deployment

- Exposure mesocosm (cage) design
  - 16 inches high, 12-inch diameter, perforated stainless steel (Figure 3)
- High Hg soils were amended
  - 0% (control), 5% and 10% saturated (wet) and unsaturated (dry) biochar
  - Amended soils placed in exposure cages, and deployed *in situ* at the field location (Figure 3 and Figure 4)
- Four cages deployed for each treatment
  - Three exposure replicates and one replicate for monitoring real-time soil redox potential and percent moisture (Figure 3)
- Amended soils left idle for three months to allow for adequate aging
- Fifteen (15) background-level adult earthworms were added to each cage (Figure 5)

Figure 5. Earthworm Deployment:
A) Background-level adult earthworms; B) Earthworms deployed in cage; C) Closed cage

PHASE II - FIELD PILOT *(continued)*

Sampling and Results

- After a 7-week exposure period, adult and juvenile earthworms were sampled (Figure 6) for tissue analysis, survival, growth, and reproduction, soils were sampled for Hg analysis
- Generally, low numbers of surviving adult and juvenile earthworms were observed in each cage, among all treatments (0-2 adults per cage; 0-3 juveniles per cage) (Table 1)

Figure 6. Week 7 Sampling:
A) Exposure cage array; B) Amended soil retrieved; C) Juvenile earthworms; D) Adult earthworm

Table 1. Week 7 Sampling- Observed Earthworms

Replicate	Age Class	Week 7- No. Organisms Observed (Sampled)				
		Control	5% (Dry)	10% (Dry)	5% (Wet)	10% (Wet)
A	Adult	1	Redox and % Moisture Monitoring	1	0	1
	Juvenile	0		3	0	0
B	Adult	1	2	1	1	Redox and % Moisture Monitoring
	Juvenile	1	3	3	1	
C	Adult	0	0	1	Redox and % Moisture Monitoring	1
	Juvenile	1	2	0		1
D	Adult	Redox and % Moisture Monitoring	1	Redox and % Moisture Monitoring	1	1
	Juvenile		2		1	0
TOTAL	**Adult**	**2**	**3**	**3**	**2**	**3**
	Juvenile	**2**	**7**	**6**	**2**	**1**

PRELIMINARY RESULTS

The sampling yields of adult and juvenile earthworms were generally low among all five amendment treatments [0% (control), 5%, and 10% saturated (wet) and unsaturated (dry) biochar], indicating that it is unlikely that the biochar had an adverse effect on earthworm survival, growth, and reproduction. Work is still in progress; it is expected that the juvenile earthworms will show similar results to Phase I (Laboratory Pilot), with a reduction in MeHg in tissue (Phase II analytical results are pending).

The work described in this poster has been performed in conjunction with the South River Science Team (SRST), a multi-stakeholder group including representatives from local, state and federal governments, academia, environmental groups and DuPont. The SRST is a collaborative team created to provide input into the watershed-level, risk-based assessment framework to address mercury in the system. www.southriversciencteam.org