

Carbon Amendment of Floodplain Soil - Pilot Studies

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Floodplain Carbon Amendment Pilot

- Study Objective:
 - Test effectiveness of carbon amendments on limiting mercury uptake by soil-dwelling ecological receptors
 - Test safety of using carbon amendments in the terrestrial environment
- Study Phases:
 - Phase I: Laboratory pilot (Completed 2014)
 - Phase II: Caged earthworms (2014-2015)
 - Phase III: Field deployment (TBD)



Laboratory Pilot: Study Objectives

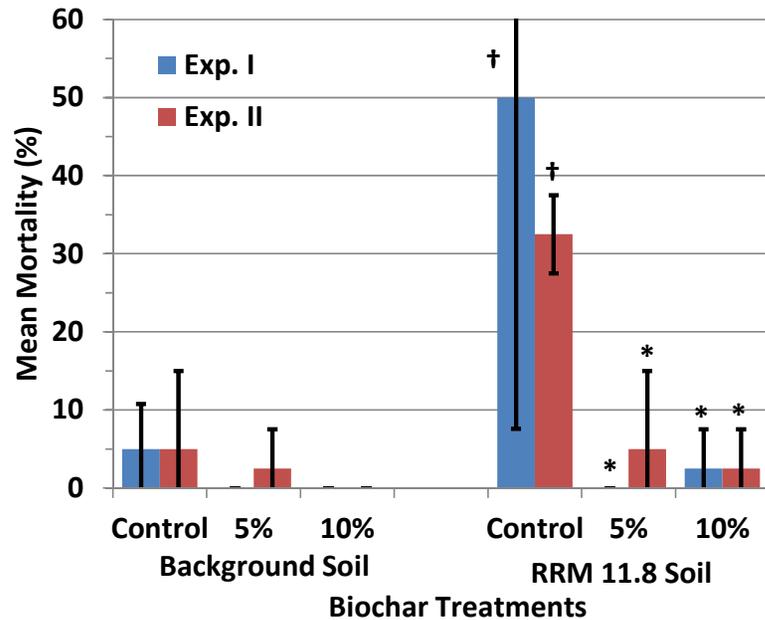
- Assess the effects of biochar on mortality, growth, and reproduction of earthworms (*Eisenia fetida*)
- Assess the effect of biochar on seed germination and shoot production in plants
- Evaluate the potential of biochar to reduce mercury uptake from floodplain soil by earthworms and plants



Laboratory Pilot: Study Design Overview

- Three biochar treatments (Cowboy Charcoal): 0% (Control), 5% and 10% by dry weight
- Two soils: RRM 11.8 soil (57 mg/kg THg) and background soil (<0.1 mg/kg THg)
- Soils sieved to < 2 mm and biochar sieved to < 1.25 cm
- Toxicity endpoints:
 - Earthworms:
 - 4 weeks: Adult mortality and weight change
 - 8 weeks: Reproduction (number of cocoons and juveniles produced)
 - Plants:
 - 3 weeks: Seedling emergence, biomass and height
- Statistical comparisons with respective controls and background controls
- Analyses of THg and methylmercury (MeHg) in earthworm and plant tissues and soils

Worm Toxicity Results - Mortality



Error bars represent Standard Deviations (Globally)

*Statistically different (at $p > 0.05$) from respective Controls

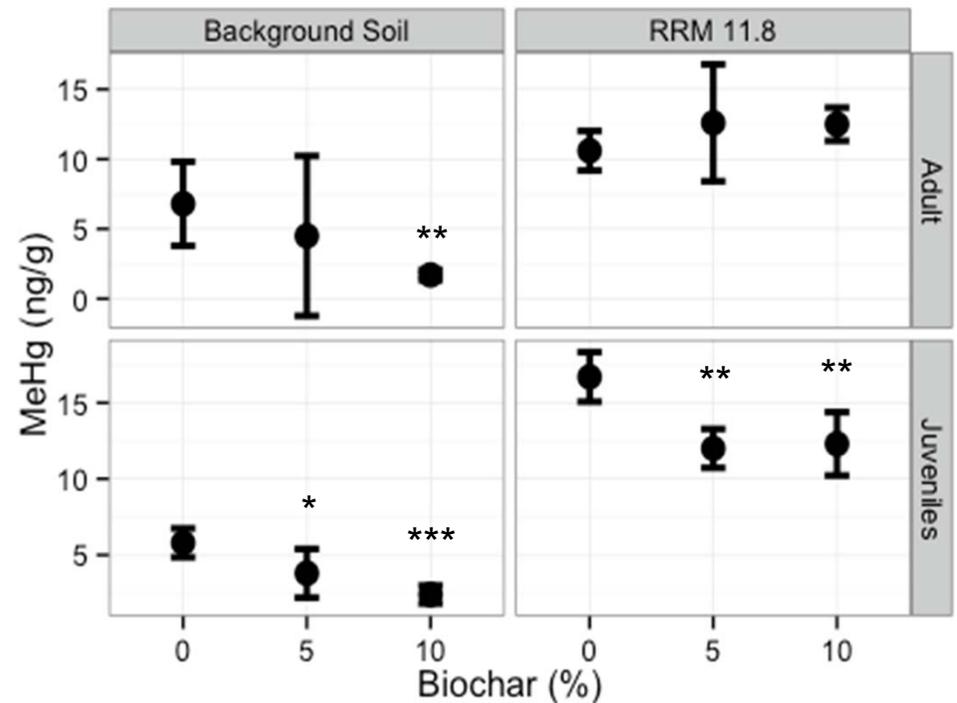
†Statistically different (at $p > 0.05$) from Control for the Background Soil

Mean Mortality:

- $> 30\%$ in controls (untreated) of RRM 11.8 soil (in Exp. I and II)
- 5% in controls of background soil (in Exp. I and II)
- $\leq 5\%$ in rest of the treatments (background and RRM 11.8 soils)
- Statistically lower in treated than in control RRM 11.8 Soils
- Comparable in treated RRM 11.8 soil and control background soil

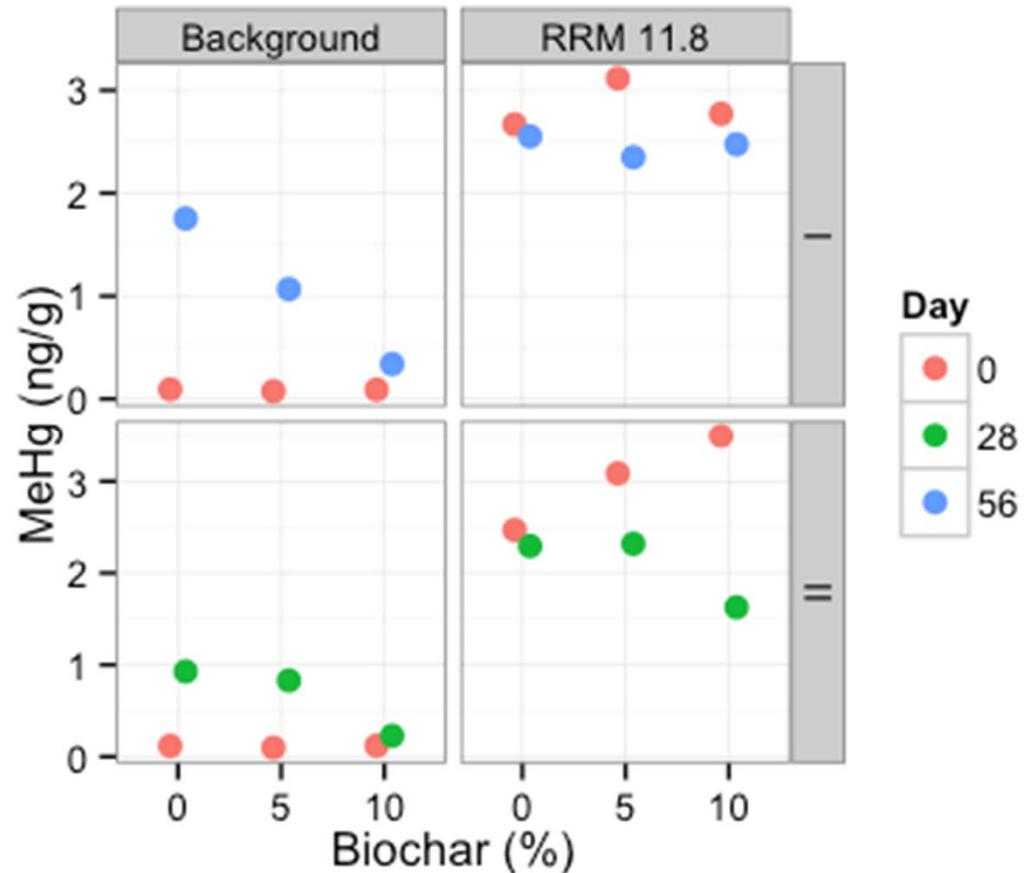
Methylmercury Concentrations Lower in Juveniles from Biochar Treatments

- In juveniles, MeHg concentrations were reduced in both 5% and 10% biochar in both soil types
- MeHg concentrations reduced in adult worms in background soil at 10% biochar
- No effect on THg or IHg concentrations



Biochar Reducing MeHg Concentrations in Soil?

- Background soils:
 - MeHg concentrations increase over the course of the exposures
 - Magnitude of increase decline with biochar concentration
- RRM 11.8 Soils
 - MeHg concentrations did not change in the 0% biochar control
 - MeHg concentrations declined by up to 50% in 5 and 10% biochar



Findings

Earthworms

- No apparent biochar-related adverse effects on adult mortality, growth, or reproduction
- Adult mortality in RRM 11.8 soils reduced to levels observed in background soil controls by
- Apparent biochar-related increases in growth of worms in RRM 11.8 soils
- **MeHg concentrations in juveniles are lower in biochar treatments**
- **MeHg concentrations in soil appear to be lowered by biochar treatment**

Plants

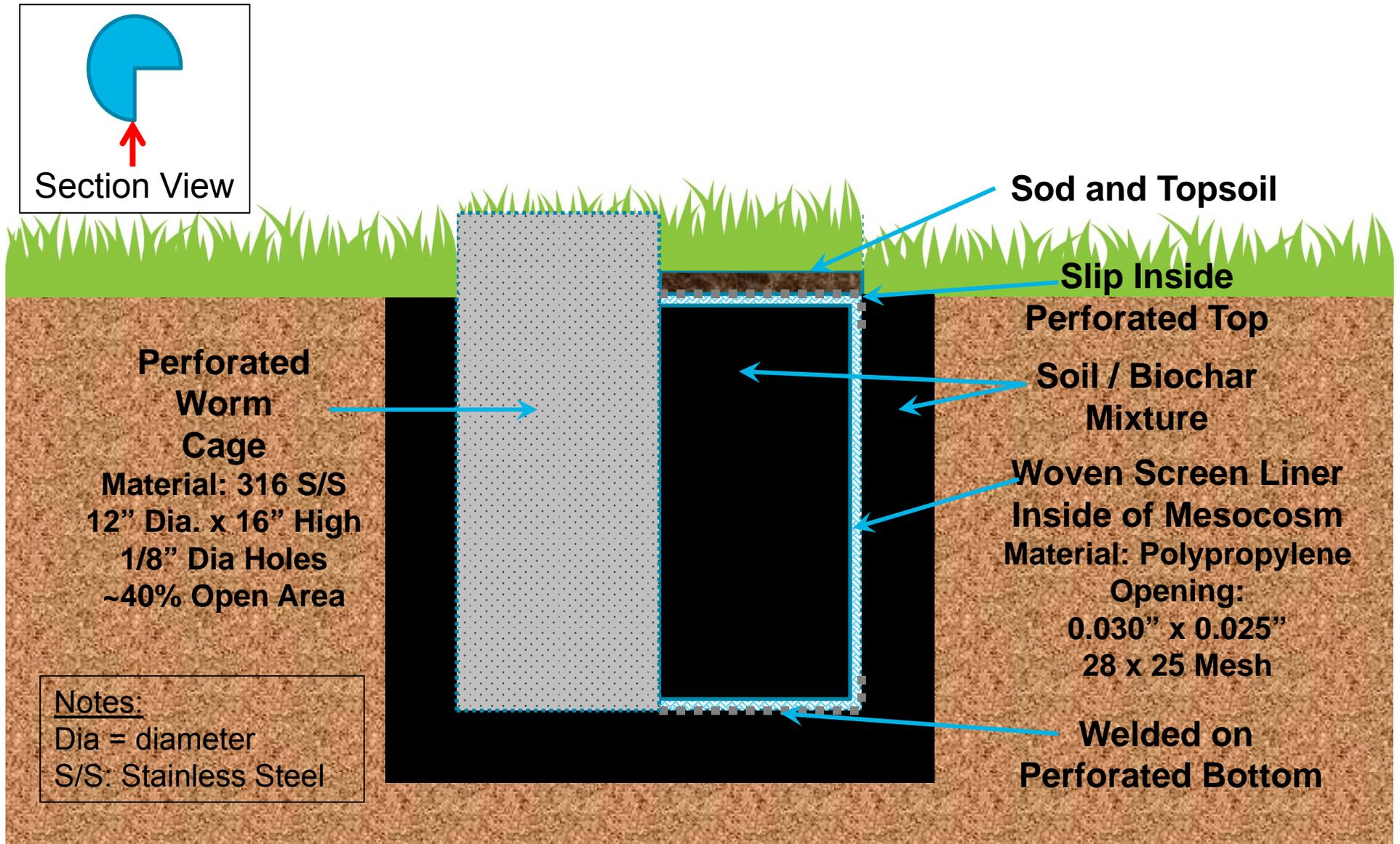
- No differences in emergence between the seedlings grown in the two controls (RRM 11.8 and Background Soils)
- No biochar-related adverse effects on emergence and growth of seedlings
- Apparent biochar-related increases in growth for wheat (mean height and biomass) and radish (mean biomass) seedlings
- MeHg concentrations higher in RRM 11.8, but not different from controls

Phase II: Field Deployment of Carbon Amendments

- Study Objective:
 - Study safety and effectiveness of carbon amendments to floodplain soil
- Study will test biochar in South River floodplain
 - Flooding and precipitation effects
- Phase II will use caged earthworms
- Focus is on juvenile earthworms



Earthworm Cage Conceptual Design



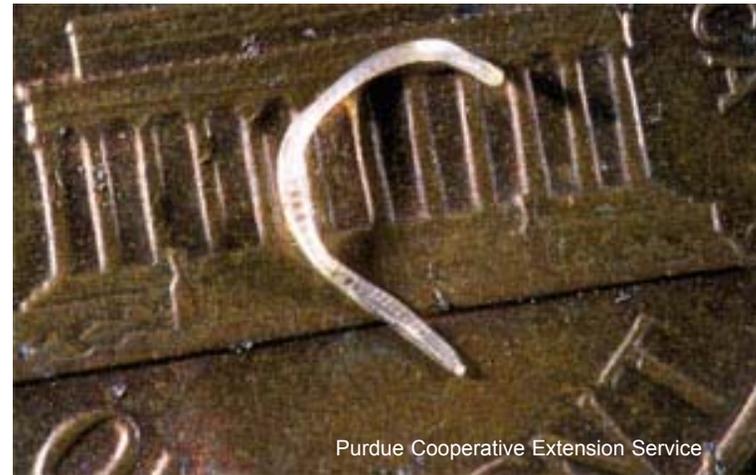
Phase II: Preliminary Study Design

- Soil will be collected and characterized¹ at Shifflet property (RRM 3.0)
- Carbon (Biochar and activated carbon) will be sieved to <1.25 cm and added to soil at 0% (control) 5% and 10% by volume
- Soil and carbon will be mixed, placed in cages, and aged for 3 months
 - Intent of cages is to ensure contact with carbon amendment and prevent earthworm avoidance of amendment
- Following aging, worms from ‘background’ areas are added to cages
- At 4 weeks, adults will be removed, weighed and measured and archived for mercury analysis
- Soil/biochar mix returned for another 4 weeks; juvenile tissue will be collected for mercury analysis

¹Metals, pesticides, herbicides, ancillary parameters

Phase II: Preliminary Study Endpoints

- Adult¹ and juvenile tissue: THg, MeHg, lipids
- Survival and growth
 - Number, length and mass of adults
- Reproduction:
 - Number of juveniles or cocoons produced
- Soil¹: THg, MeHg, organic carbon



¹Archived

Summary and Schedule

- Biochar was effective at limiting MeHg uptake by juvenile earthworms
- No negative effects of biochar were observed on earthworms or plants
- Phase II studies will extend the Phase I study design into the field – work will begin in 2015

