Carbon Amendment of Floodplain Soil - Pilot Studies

South River, Waynesboro, VA
7 October 2014

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 (2015)

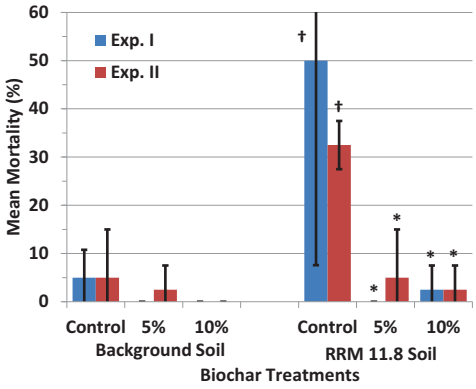
Laboratory Pilot: Study Objectives

- 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



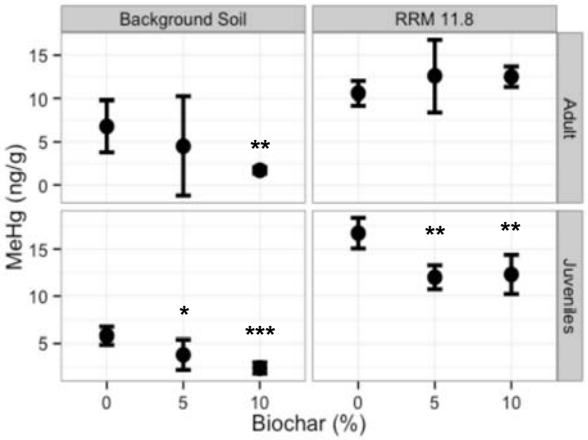
Error bars represent Standard Deviations (Globally)
*Statistically different (at p > 0.05) from respective Controls
†Statistically different (at p > 0.05) from Control for the Background Soil

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)
- ≤ 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

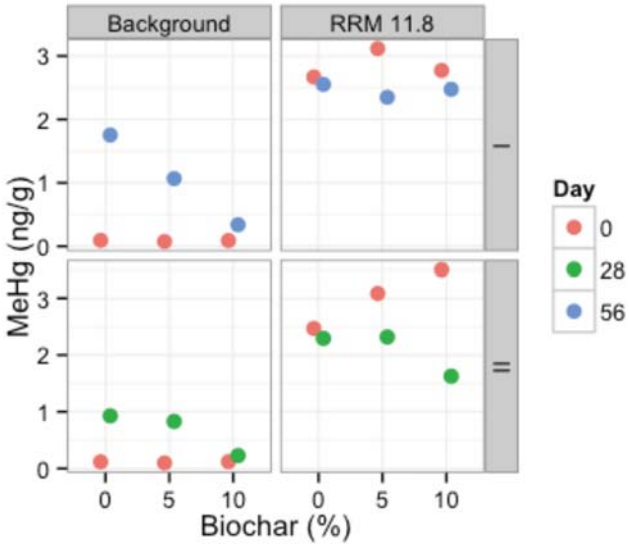
Methylmercury Concentrations Lower in Juveniles from Biochar Treatments

- 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



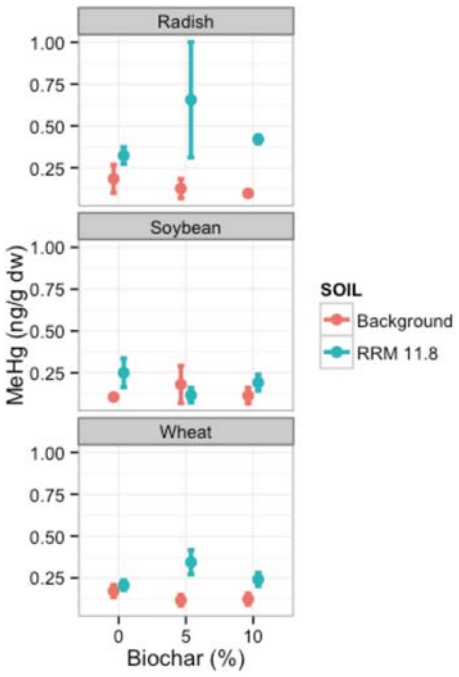
Biochar Reducing MeHg Concentrations in Soil?

- Background soils:
  - MeHg concentrations increase over the course of the exposures
  - Magnitude of increase declines 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



Biochar Reducing MeHg Concentrations in Plants?

- Higher MeHg in radish and wheat from RRM 11.8 soils than background
- No differences (α = 0.05) between 5 and 10% biochar and controls
- No effect on THg concentrations



Findings – Laboratory Pilot

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 adults reduced in biochar treatments, but only in background soils
- MeHg concentrations in soil appear to be lowered by biochar treatments

Findings – Laboratory Pilot

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
- Phase II will use caged earthworms
- Study will test biochar and activated carbon in several locations in the South River floodplain

Phase II: Earthworm Cages

- Cages are pipe screened at top and bottom to prevent worm escape
- Intent of cages is to ensure contact with carbon amendment and prevent earthworm avoidance of amendment
- Soil and carbon will be mixed, placed in cages, and aged over winter
- In spring, worms from 'background' areas are added to cages and sampled at 4 and 8 weeks

Phase II: Preliminary Study Design

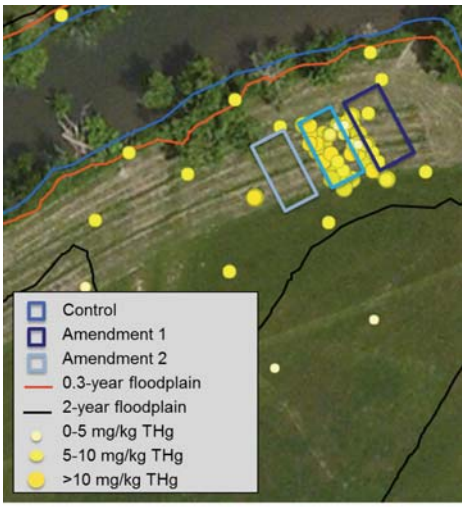
- Soil will be collected and characterized at the following locations:
  - Shifflet (RRM 3.0)
  - Wertman (RRM 8.7)
  - Augusta Forestry Center (RRM 11.8)
- Carbon (Biochar and activated carbon) will be sieved to <1.25 cm and added to soil at 5% by volume
  - Control with no carbon source
- Two sets of cages will be deployed, with three replicates each
- Soil and carbon will be aged over winter in the cages
- Beginning in spring 2015, one set collected at four weeks, one at 8 weeks

Phase II: Preliminary Study Endpoints

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

Phase III: Field Application

- Tentative study design:
  - Conducted at AFC
  - Biochar and activated carbon
  - Till carbon into soil to 7-12”
  - Age one winter
  - Collect resident earthworms and other invertebrates (e.g., predatory mite, collembolans, enchytraeid worms, spiders)



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 2014
- Phase III may evaluate potential reductions in mercury uptake in resident invertebrates in field setting