Floodplain Pilot Laboratory Study: Technical Briefing Paper

This briefing paper summarizes the objectives, study approach, and preliminary findings of the South River Floodplain Pilot Laboratory Study. Study findings from the soil sampling and characterization efforts are summarized below. The information reviewed and presented herein are not comprehensive; additional details regarding the scope of work and methodologies are documented in URS (2013).

Introduction

Remedial options are currently being evaluated for their ability to reduce the mercury bioavailability to South River floodplain soil biota. One option involves amending the floodplain soils with physical and chemical controls to decrease mercury bioavailability in soils. The Floodplain Pilot Laboratory Study was planned in 2013 to assess the viability and efficacy of a soil amendment remedial option (URS, 2013). The first component includes collection of soil samples for laboratory studies and soil characterizations for potential future usage. The second component includes laboratory analyses to assess the efficacy of biochar as a potential remedial option via its effect on soil mercury toxicity and uptake by earthworms and plants.

References

- ✓ Office of Economic Cooperation and Development (OECD). 2004. Test 222: OECD Guideline for the Testing of Chemicals. Earthworm Reproduction Test (Eisenia fetida/Eisenia andrei). Adopted 23-November-2004.
- ✓ Office of Economic Cooperation and Development (OECD). 2006. Test 208: OECD Guideline for the Testing of Chemicals. Terrestrial Plant Test: Seedling Emergence and Seedling Growth Test. Adopted 19-July-2004.
- ✓ University of Waterloo. 2013. South River Program Scope of Work
- ✓ US EPA. 2013. Ecological Soil Screening Levels (Eco-SSLs). Accessed at: http://www.epa.gov/ecotox/ecossl/index.html
- ✓ URS Corporation. 2013. Scope of Work for Floodplain

Objectives

The purpose of the study is to test the efficacy of a soil biochar amendment in limiting the mercury bioavailability (and hence toxicity) toward biological receptors. Specific objectives are to evaluate biochar's:

- Potential to reduce mercury uptake by earthworms and plants from floodplain soil;
- Effects on mortality, weight change, and reproduction of earthworms;
- Effects on seed germination and shoot production in plants;
- Effects on potential bioavailability of mercury in soil to other ecological receptor; and
- Effects on mercury methylation in soil.

Soil Sample Collection and Characterization

Soil samples were collected on August 20, 2013 from two locations at the Augusta Forestry Center: one location to serve as the low total mercury (THg) control soil (0.03 mg/kg), and the other with higher THg as the high THg test soil (57 mg/kg) in the planned laboratory studies and other future investigations.

Each soil sample was sieved through 0.5 inch steel screen, homogenized, subsampled, and sent to laboratories. Following homogenization, soils were subsampled and transferred for analyses and testing as follows:

- One composite sample for Lancaster Laboratories (Lancaster Labs) to analyze for grain size, total organic carbon (TOC), metals, pesticides, herbicides, and nutrients;
- Three replicate samples (from the left, right, and center of the homogenized soil) for Lancaster Labs to analyze THg; One 50 g aliquot for each discrete samples were frozen for potential methyl mercury (MeHg) analysis;
- Two gallons of soil for University of Waterloo to investigate the effects of biochar on mercury speciation, stability, and release in the soil;
- 15 gallons of soil (and two gallons of biochar) for Wildlife International to conduct earthworm and plant toxicity tests with biochar amendments; and
- The remaining soil was placed in clean 5-gallon buckets and stored at the SRST office in Waynesboro for future use.

Laboratory Soil Testing

University of Waterloo will investigate soil mercury speciation and stability, and the biochar's effects on mercury release from soils. Further details of the investigation proposed by University of Waterloo are described in their scope of work (University of Waterloo, 2013).

Laboratory Toxicity Testing

Wildlife International (Easton, MD) will conduct the toxicity tests for the earthworm (*Eisenia fetida*) and three plant species, wheat (*Triticum* spp.), soybeans (*Glycine max)* and radish (*Raphanus sativus*). Procedures for both the earthworm and plant toxicity tests are briefly summarized below and each will follow the standard protocols developed by the Office of Economic Cooperation and Development (OECD): OECD Test No. 222, Earthworm Reproduction Test (*Eisenia fetida/Eisenia andrei*) (OECD, 2004) and OECD Test No. 208, Terrestrial Plant Test: Seedling Emergence and Seedling Growth Test (OECD, 2006).

Toxicities will be tested on the two soils with three biochar amendments: 0% (control), 5% and 10% biochar in soils (on dry weight basis), i.e., altogether six soils. Cowboy charcoal, a biochar derived from hardwood, will be used to amend the soils. Tests will be conducted in soils sieved to < 2 mm and amended with biochar sieved to < 1.25 cm.

Additionally, worms and plants used in the toxicity studies will be collected at appropriate stages and sent to CEBAM Analytical, Inc. (CEBAM) for analyses of tissue THg and MeHg concentrations and test soils will be collected and sent to Lancaster Labs for analyses of THg and MeHg as well.

Earthworm Reproduction Test

Adult earthworms will be exposed to six groups of soils (two soils each at 0, 5, and 10% biochar). Four replicates for each group will be tested. Test duration will be eight (8) weeks. Adult mortality and growth (weight change) will be determined after 4 weeks. The adults are then removed from the soils and reproductive effects (number of offspring) assessed following another 4 weeks.

Terrestrial Plant Test

Seeds for each plant species (wheat, soybeans, and radish) will be planted in the soil groups and grown for 14 to 21 days, after which seedling emergence and plant growth endpoints (shoot weight and height) will be determined.

In addition to determining toxicities (via emergence and growth endpoints), the following plant (shoot) material and test soils will be collected at the end of the toxicity tests to determine THg and MeHg concentrations:

- Two composite samples for each plant species will be prepared from the six replicate samples, i.e., a total of 36 composite samples (= 3 species x 2 composites x 6 groups).
- Two aliquots of 50 g soil (dry weight) from two replicates in each soil group for each species, i.e., a total of 36 samples (= 2 replicates x 6 groups x 3 species)

Soil Characterization Results

Available soil characterization results for soil samples collected on August 20, 2013 are presented in Tables 1 and 2 and Figure 1 and summarized below:

- Homogenized soil shows very similar THg concentrations (mean ± standard deviation) in the three replicate samples (Table 1): THg = 0.05 ± 0.01 µg/g (dry weight) for the low THg control soil samples and 57.4 ± 0.3µg/g (dry weight) for the high THg test soil samples.
- Full characterization results for the low THg control and high THg test soils (Table 2) show that:
    - Pesticides, herbicides, and PCBs are generally not detected in both soils; Concentrations are either below the corresponding method detection limits (MDLs) or between the MDLs and limits of quantitation (LOQs).
    - Several metals concentrations (beryllium, cadmium, chromium, cobalt, copper, manganese, nickel, selenium, silver, and zinc) appear to be elevated in the high THg test soil (> 3-fold) compared to the low THg control soil. But concentrations of only cobalt, copper, manganese, selenium, and zinc in the high THg test soil marginally exceed their corresponding Ecological Soil Screening Levels (Eco-SSLs) for terrestrial plants and/or invertebrates.
    - THg concentration is > 750-fold higher in the high THg test soil [60.1 µg/g (dry weight)] than in the low THg control soil (0.08 µg/g (dry weight)].
    - Rest of inorganics (bromine, chloride, fluoride, nitrate, nitrite, and sulfate) and nutrients [Total Kjeldahl Nitrogen (TKN) and Total Phosphorous] appear to have similar concentrations in the low THg control soil and the high THg test soil.

- TOC content (and consequently the moisture content) is slightly greater in the high THg test soils (TOC = 2.87% and moisture = 22.4%) compared to the low THg control soil (TOC = 0.97% and moisture = 15.1%).

- Figure 1 shows the grain size distributions in the low THg control soil and the high THg control soil; the distributions are very similar in both soils.

Summary of Preliminary Findings

Preliminary findings from the South River Floodplain Pilot Study are as follows:

- The high THg test soil has higher concentrations of several metals (including mercury) than the low THg control soil; however, the observed levels of these non-mercury metals are generally below or near the available Ecological Soil Screening Levels (Eco-SSLs) for plants and invertebrates. Additionally, the THg is considerably higher in the high THg test soil than in the low THg control soil. Therefore, the rest of metals are not expected to significantly interfere with the planned earthworm and plant studies to investigate mercury toxicity and uptake.

- Apart from the slight (but likely inconsequential) differences in several metals concentrations, the low THg control soil and the high THg test soils have remarkably different THg concentrations, but similar characteristics in other respects (e.g., both are likely not impacted by herbicides, pesticides, and PCBs and both have similar grain size distributions) that are desired for the planned earthworm and plant studies.

Figure 1
Soil Grain Size Distributions
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