INTRODUCTION

Mercury (Hg) was used between 1929 and 1950 by the DuPont plant in the production of rayon acetate fiber in Waynesboro, Virginia and released into the South River. The contamination of Hg was discovered in the 1970s and remained elevated in water, soil, sediments, and biota.

The primary goal of this study is to investigate the processes that govern biogeochemical transformation and mobilization of Hg in floodplain and river bank soils at South River Mile 3.5, characterize geochemical gradients in soils and how they change over time, and to enable targeted sampling at Hg loading hot spots. The biogeochemical data will play a supporting role and be used to further develop our understanding of the processes controlling the leaching of Hg in our conceptual model.

The over-arching hypothesis was to test if leaching of bank soils is a significant source of dissolved inorganic Hg (fHg), colloidal or methyl (MeHg). Our major hypotheses are: (1) soil inundation of bank soils is due to horizontal flow through a high transmissivity gravel zone at the base of the bank, vertical drainage of precipitation, and upgradient groundwater flow; (2) drainage occurs by saturated and unsaturated processes, controlling the downward or upward movement of the capillary fringe drainage of precipitation, and upgradient groundwater flow; (2) drainage occurs by saturated and unsaturated processes, controlling the downward or upward movement of the capillary fringe.

METHODS

Soil moisture, temperature (Decagon)

Sampling and analysis of soil cores, stream water, and shallow groundwater

- Well water analysis included: MeHg, THg, SOC, total Fe, PACl, Mn, Na, Alkalinity, Ammonia-N, total P, E. coli, (DO, pH, NO3 , NO2 , PO4 )

- Soil analysis included: pH, cation exchange capacity plus exchangeable cations (K, Ca, Mg, Na), total C, total N, available nutrient analysis: ICP analysis of digestates (Fe, Mn, Al, S); ascorbate extraction of Fe and Mn, total Hg, methyl Hg and sequential extraction of Hg.

- THg was analyzed by Tekran 2500 (CWAS cold vapor atomic fluorescence spectrophotometer). For MeHg, sediments are distilled by Tekran 2700 (Mercury Extraction System) and analyzed by Tekran 2700 (GC, detector- AFS, Brewer)

RESULTS

IN-SITU SENSOR DATA

- Conductivity, water level and temperature (Solinst)

- Redox (Paleoterra)

- There is a significant redox gradient across the soil profile at both locations;

- Arrows above indicate a substantial change in soil moisture within the top 40-70 cm of Hg-rich soil followed by a drastic redox response from oxidizing (Eh ~300 mV) to very reducing conditions (Eh ~-300 mV) due to heavy rainfall and overbank flooding;

- Strong precipitation on May 8 (1) caused sharp and short redox gradient for several days. Less severe precipitation starting June 11 (2) facilitated more sustained response of the redox change, although the redox dropped to the comparative levels;

- There is a definable lag in redox response depending on soil depth;

- Steady rainfall and slow soil saturation causing the prolonged redox response in June could be more effective in Hg mobilization/Mercury production but need to be verified with the additional water sampling.

SOIL CHEMISTRY: Total Hg (dry weight, mg/kg)

- Total Hg in soils ranged from 0.1 to 1202 mg/kg and methyl Hg in soils varied from 0.1 to 57 µg/kg

Hg Sequential Extraction:

- Hg in core 2 was up to 244 mg/kg;
- Hg in core 1 was up to 760 mg/kg. It decreased sharply with depth to 0.1 mg/kg

Core 1: only one sample from 104 to 124 cm BGS (wetland soil) had 55 % of water soluble Hg (F1) above 1% of weak acid extractable Hg (F2) was in all samples; organo-complexed Hg (F3) generally increased with depth up to 52% at 152-166 cm BGS; strong-complicated Hg (F4) was the highest between 61 and 150 cm BGS; residual Hg (F5) decreased with depth from 80 to 5 %

Core 2: residual Hg (F5) is the major component in all samples (about 80%) while strong-complicated Hg (F4) increased with depth (up to 38 %).

Preliminary Water Chemistry

- Unfiltered stream surface water had up to 267 ng/L (October); MeHg ranged from 65 to 538 ng/L (shallow water) to 1202 mg/kg, dry weight;
- MeHg in core 1 was up to 750 mg/kg. It decreased sharply with depth (up to 36 %);
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- High variations in stream stage may govern the surface water - groundwater exchange affecting soil redox potential, mobility of Hg bearing minerals, mobilization, and methylation of Hg.