# A COUPLED MONITORING NETWORK TO CONDUCT AN ASSESSMENT OF MERCURY TRANSFORMATION AND MOBILIZATION IN FLOODPLAIN SOILS: SOUTH RIVER, VIRGINIA

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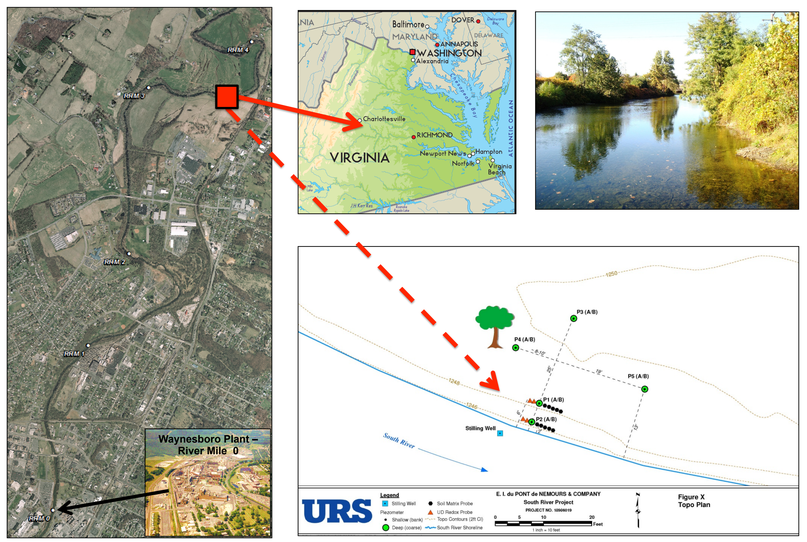
## INTRODUCTION

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 (IHg), colloidal or methyl (MeHg). Our major hypotheses are: (1) soil inundation of bank soils is due to horizontal flow through a highly transmissive gravel zone at the base of the bank, vertical drainage of precipitation, and upgradient groundwater flow; (2) drainage occurs predominantly through gravel zone wetting an organic rich soil; and (3) hydraulics facilitate the downward or upward movement of the capillary fringe affecting soil redox potential, abiotic and biotic mineral dissolution, and leaching of inorganic Hg into dissolved/colloidal phases that are either directly transported to the river or methylated within the saturated zone of the bank and subsequently released.

## RESEARCH AREA

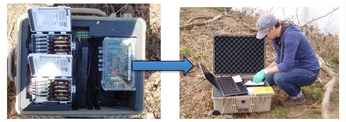



## METHODS


*Conductivity, water level and temperature (Solinst)*

*Redox (Paleoterra)*

*Soil moisture, temperature (Decagon)*

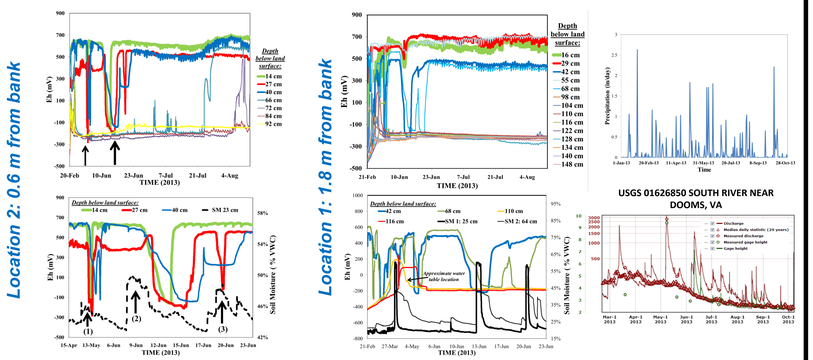



- Sampling and analysis of soil cores, stream water, and shallow groundwater
- Well water analysis included: MeHg, THg, DOC, total Fe, Fe(II), Mn, Na, Alkalinity, Ammonia-N, total P, $\delta 18O$, $\delta D$,$SO_4^{2-}$, $Cl^-$, $NO_3^-$, $NO_2^-$, $PO_4^{3-}$)
- Soil analysis included: pH; cation exchange capacity plus exchangeable cations (K, Ca, Mg, Na); total C, total N; particle size analysis; ICP analysis of digestates (Fe, Mn, Al, S, Si); ascorbate extraction of Fe and Mn, total Hg, methyl Hg and sequential extraction of Hg.

*THg was analyzed by Tekran 2600 (CVAFS cold vapor atomic fluorescence spectrophotometer). For MeHg, sediments are distilled by Tekran 2750 (Methyl Mercury Distillation System) and analyzed by Tekran 2700 (GC column, detector-AFS, Tenax trap)*

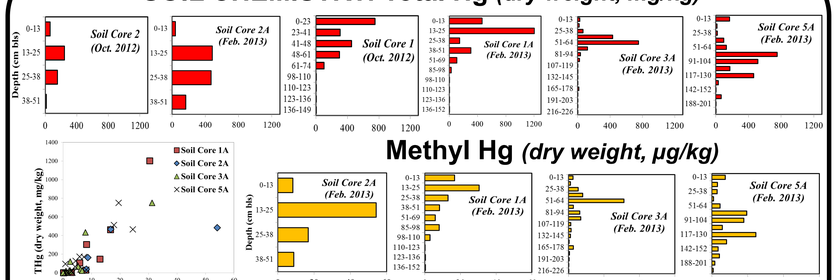
## RESULTS

### *IN-SITU* SENSOR DATA



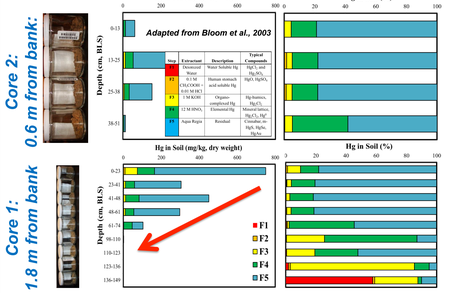

- There is a significant redox gradient across the soil profile at both locations;
- Arrows above indicate a substantial change in soil moisture within the top 40-70 cm of Hg-rich soil followed by a drastic redox response from oxidizing (Eh ≈+600 mV) to very reducing conditions (Eh ≈-300 mV) due to heavy 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 defined 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/MeHg production but need to be verified with the additional water sampling.

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



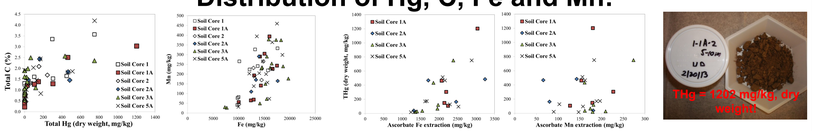

- Total Hg in soils ranged from 0.1 to 1202 mg/kg and methyl Hg in soils varied from 0.1 to 57 µg/kg;

### Hg Sequential Extraction:



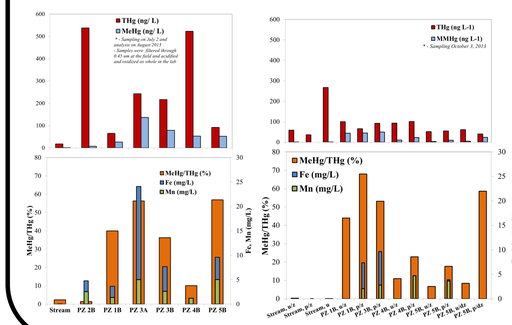

- Hg in core 2 was up to 244 mg/kg;
- Hg in core 1 was up to 750 mg/kg. It decreased sharply with depth to 0.1 mg/kg;
- Core 1: only one sample from 136-149 cm BGS (wetland soil) had 58 % of water soluble Hg (*F1*); about 1% of weak acid extractable Hg (*F2*) was in all samples; organo-complexed Hg (*F3*) generally increased with depth (up to 82% at 123-136 cm BGS); strong- complexed Hg (*F4*) was the highest between 61 and 110 cm BGS (up to 61%); 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-complexed Hg (*F4*) increased with depth (up to 36 %);

### Distribution of Hg, C, Fe and Mn:




- The highest concentration of total Hg was associated with total C and ascorbate Fe extraction (Fe oxides)
- There is a significant correlation between total Fe and Mn with the highest values reaching about 20,000 and 460 mg/kg;
- The particle size analysis showed that textural class changed from sand to sandy loam and loamy sand

### PRELIMINARY WATER CHEMISTRY




- Well water samples were filtered at the site and either preserved with acid or unpreserved. Stream water samples were collected as filtered unpreserved/preserved and unfiltered;
- Sampling of wells in July and October 2013 showed that THg ranged from 65 to 538 ng/L (July) and from 40 to 100 ng/L (October). Unfiltered stream surface water had up to 267 ng/L of THg (October);
- MeHg ranged from 7.7 to 137 ng/L (shallow well 3A) in July and from 3.5 to 49 ng/L (deep well 3B) in October. Stream surface water had < 0.2 ng/L of MeHg;
- MeHg/THg (%) in each well changed between 1 - 57 % (July) and 6.7 – 68 % (October). The highest values were in 1B, 3A, 3B and 5B;
- High variations in stream stage may govern the surface water - groundwater exchange affecting soil redox potential, stability of Hg-bearing minerals, mobilization, and methylation of Hg.