Hg Contamination at Oak Ridge and Site Biogeochemical Processes

Oak Ridge National Laboratory – ERSP Science Focus Area

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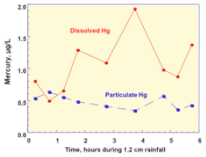
Mercury Contamination at the Oak Ridge Y-12 Site

Approximately 11,400 metric tons of mercury were shipped to the Oak Ridge Y-12 Plant in the early 1950's for use in isotopic enrichment of lithium. About 3% of that mercury was lost to the environment, 2/3 of which contaminated soil and rock under the facility. That subsurface elemental Hg continues to act as a source of dissolved Hg in groundwater that eventually contaminates surface waters draining the site. Smaller amounts of mercury were handled at the other Oak Ridge facilities, with similar results. Inorganic mercury is converted to methylmercury by microorganisms at the groundwater-surface water interface, and that methylmercury accumulates in fish to levels posing risks to consumers.

Remedial efforts initiated in the 1980's focused on identifying and eliminating point sources of mercury. Among actions completed to date are: filling and capping New Hope Pond and eventually bypassing its replacement, treatment of building sump waters (groundwater),cleaning, relining, and replacement of subsurface storm and process drains, stabilizing contaminated streambanks, and building a treatment system for contaminated spring water. These and other actions reduced waterborne mercury export from the site from over 100 g/d in 1985 to approximately 10 g/d at the present time. Mercury in East Fork Poplar Creek (EFPC) now approaches 200 ng/L, the interim cleanup goal.

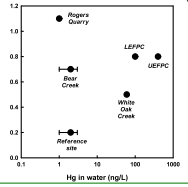
Mercury in storm drain discharge versus time during rain

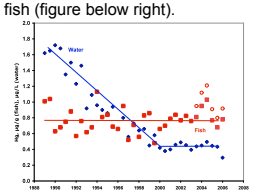


Non-point sources of Hg: (i) **Storm-drain network**: Hg-enriched groundwater infiltrates the storm-drain system (see figures above left). Increased dissolved [Hg] in response to rainfall indicates the presence of a reservoir of dissolved Hg in close hydrologic proximity to the storm drain system. (ii) **Metallic Hg in the streambed** generates dissolved Hg(0) and Hg(II) that sorb to sediments and infiltrate surface flow. A 200 m reach (figure, above right) accounts for ~25% of Hg flux in the creek. [Hg] in interstitial streambed water is > 30 µg/L, sediment [Hg] is > 400 ppm. (iii) [Hg] in the **solution cavity network** underlying EFPC is > 20 µg/L [Hg] in a spring fed by this system was typically 2 - 10 µg/L. A treatment system completed in 2005 effectively removes Hg from the spring water, but ~ 20% of the spring flow is not captured by the system.

Dye injected into a Hg-contaminated solution cavity 700 m upstream emerges from a spring.

Examples of paradoxical Hg behavior Oak Ridge Sites: (i) Hg concentrations in fish are not related to [Hg] in water (figure below left), (ii) Groundwater-derived mercury at Y-12 has greater affinity for particulates than 'natural' (background) mercury, (iii) Methylmercury concentration in EFPC is inversely related to the concentration of dissolved inorganic Hg, its precursor, (iv) Although Hg concentrations in water have decreased, there has been no accompanying decrease in fish (figure below right).

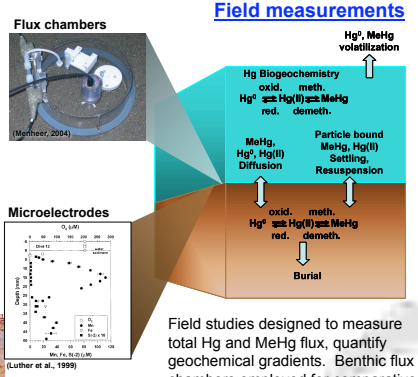




Site Biogeochemical Processes and Microcosm Studies (SFA Task 1)

The objective of Task 1 is to delineate key biogeochemical parameters to provide an improved understanding of the chemical and microbiological field processes influencing Hg transformations at a selected site on the UEFPC. Field work will include measurements of Hg species, Hg and MeHg fluxes, and benthic flux chambers for field measurements and manipulations. Field work will inform and be complemented by controlled laboratory microcosm experiments. This work will provide new insights into the biogeochemical controls on Hg transformations and fluxes.

Field measurements

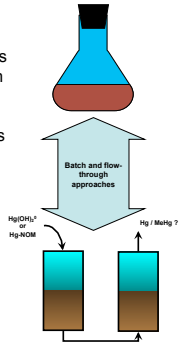


Field studies designed to measure total Hg and MeHg flux, quantify geochemical gradients. Benthic flux chambers employed for comparative studies and controlled manipulations

Critical understanding of Hg flux, biogeochemical controls

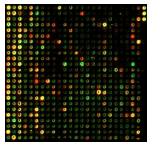
Complementary laboratory microcosms

Experiments investigate biogeochemical controls on Hg transformation, e.g.: Are sulfate reducers the primary Hg methylators in this hardwater, freshwater system (MoO_4^{2-} addition; vary SO_4^{2-} concentration, etc.)? How does Hg methylation vary with form (aqueous species) of Hg entering system?



Critical understanding of biogeochemical controls on net methylation in sediment-water systems.

Microbial Community Structure



(Oregaard and Sørensen. 2007)

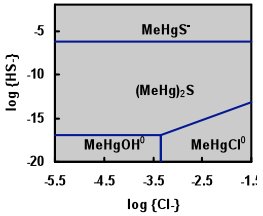
Relationships among community structure, geochemical conditions, and MeHg production in sediments using (i) Functional gene arrays (developed under complementary Task 3), and (ii) 16S rRNA gene clone library analysis.

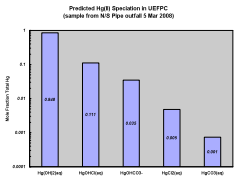
Community analysis related to net methylation and demethylation activity

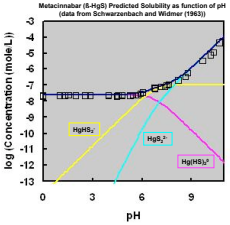
Geochemical modeling

Relationships among predicted aqueous species concentrations and methylation/ demethylation activity and microbial community structure.

Integration of geochemical and microbiological observations, infer processes, identify critical parameters for study







For more information please contact Scott Brooks (brookssc@ornl.gov). This research is funded by the U.S. Department of Energy's Office of Science, Biological and Environmental Research, Environmental Remediation Sciences Program. Oak Ridge National Laboratory is managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract DE-AC05-00OR22725.