Optically-Based Quantification of Concentrations and Fluxes of Mercury and Methylmercury in South River, Virginia (USA)

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Background/Objectives. Historical releases of mercury to the South River (Virginia, USA) and mobilization of mercury from secondary sources (e.g., riverbed and riverbank sediments) is contributing to the redistribution of mercury to the water column. Accumulation of mercury in aquatic systems poses significant health risks to humans and wildlife due to methylation processes, which typically occur in near-surface sediments, and the consequences of methylmercury exposure (direct toxicity and neurological and autoimmune effects) and its bioaccumulation through the food web. In order to effectively remediate the South River, it is necessary to understand specific mechanisms for mercury contamination and transport in the system. The goal of this study was to determine the efficacy of a high temporal resolution OPTically-based In-situ Characterization System (OPTICS) to better understand the exchange of mercury and methylmercury to the water column and to quantify mass fluxes of mercury and methyl mercury in the river.

Approach/Activities. An OPTICS study was implemented in the South River between 31 March and 17 May 2016 to derive high temporal resolution variability of mercury and methylmercury concentrations from in situ field measurements of optical and water quality parameters. OPTICS is based on the principal that chemical contaminants are often associated with specific substances in the water column, e.g., organic detritus, suspended sediment, and dissolved organic carbon. Therefore, since optical parameters can characterize the biogeochemistry of natural waters and its substances (particle concentration, composition, and size distribution), optical measurements have the potential to quantify concentrations of chemical contaminants. Optically-based chemical characterization methods have been shown to be effective for determining concentrations of unfiltered, filtered, and particulate mercury and methylmercury, and unfiltered polychlorinated biphenyls.

Results/Lessons Learned. OPTICS provided robust, high frequency determinations of mercury and methylmercury concentrations in the context of water quality, physical forcing processes, and biogeochemical variability. Importantly, continuous chemical concentration data enabled resolution of processes important to contaminant transport including quantification of mass loadings to the South River. The results of monitoring showed a steady increase in dissolved methylmercury as water temperatures rose, consistent with increased microbiological activity. Storm flow and diel cycling were identified as important mechanisms by which secondary sources of particle-bound mercury and methylmercury in bottom sediment and fine-grained channel margin deposits are redistributed to the water column and transported with water flow in the South River. The calculation of mass fluxes of these chemical contaminants enabled quantification of contaminant solids loading to the South River due to these mechanisms. It was determined that diel cycling contributed average daily mass loadings of 0.01 kg of particulate mercury and 1.9E-05 kg of particulate methylmercury, which accounted for up to 13% and 16% of total mass loading over the period of the OPTICS study. The remaining 87% and 84% loading of particulate mercury and methylmercury was attributed to high storm flow following a series of precipitation events in late April and early May 2016. These results will contribute to South River design and implementation of remediation efforts to reduce mercury levels in the river and, ultimately, revise fish consumption advisories.