Mercury Modeling Case Studies in NY/NJ Harbor

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We have developed a mercury modeling component as part of a larger effort to simulate the fate and transport of contaminants in the New York and New Jersey harbor and nearby water bodies. The project was funded by the Port Authority of New York and New Jersey under subcontract agreement with the Hudson River Foundation on behalf of the New York/New Jersey Harbor Estuary Contaminant Assessment and Reduction Program (CARP), and used modeling components previously developed for New York City Department of Environmental Protection as part of the System-Wide Eutrophication Model (SWEM). The project goals include understanding the transport and dynamics of contaminants in the harbor area including biogeochemical transformations and accumulation in biota and biotic food webs. The models can then be used to predict future water quality conditions, and the impact that management actions (or inactions) may have on those conditions.

The mercury model was developed to take advantage of previous model development, including hydrodynamic, eutrophication, sediment transport, and sediment flux components. A model domain was developed from upstream boundaries in the Hudson River (approximately 150 miles upstream from the tip of Manhattan), and an oceanic boundary well beyond the harbor area. The model domain also extended upstream into several New Jersey rivers and incorporated all of Long Island Sound.

Mercury loads were developed for water years ranging from 1994 to 2002 and quantified inputs from storm water, combined sewer overflows, wastewater treatment plants, nearby landfills, atmospheric inputs, and upstream river flows. Three forms of mercury were included in the model system including elemental divalent, and methylmercury forms. Appropriate transformations for each of these forms were also incorporated. For example, the chemical speciation for divalent mercury in the water column and sediments included the calculated distribution between particulate organic matter, dissolved organic matter, and various inorganic forms. Sulfide complexes were among the most important inorganic forms. Mercury in the sediments was also allowed to bind to acid volatile sulfide (AVS) when this mineral phase was present. Chemical speciation was also used to determine the distribution of methylmercury, and included dissolved and particulate organic forms as well as several inorganic complexes.

One of the most important components of the modeling effort was to predict the formation of methylmercury. Methylmercury production was related to both sulfate reduction kinetics and the bioavailability of divalent mercury in the sediments. Bioavailable mercury species, for the purposes of determining methylation rates, were limited to neutrally charged inorganic species. Model simulations were compared with measured mercury and methylmercury concentrations in both the water column and sediments, along selected spatial transects Simulations showed that the model could reproduce the major seasonal and spatial trends evident in monitoring data of mercury and methylmercury concentrations in sediments and waters in the model domain. Both sulfate reduction rates and bioavailablilty based on detailed chemical speciation were important for determining the predicted methylmercury kinetics.