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PREDICTING ENVIRONMENTAL CONCENTRATIONS OF AIRBORNE POLLUTANTS IN TERRESTRIAL RECEPTORS: THE CASE OF MERCURY

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EXTENDED ABSTRACT

This work is a modeling analysis of airborne mercury fate in catchments, which are important receptors in terms of exposure to mercury. Mercury is introduced into watersheds by atmospheric deposition and point source loadings. Atmospheric mercury deposition monitoring and source attribution data are used along with simulation models previously developed by the authors to estimate the contributions of Hg to the terrestrial and aquatic components of a catchment from local, regional and global sources. The study focuses on estimating the total maximum daily loads (TMDLs) for mercury as required by the Clean Water Act and associated regulations in the Ochlockonee watershed in Georgia, USA. Different software tools were used: a mercury version of the Water Characterization System (WCS), a GIS-based modeling system, to calculate surficial soil mercury concentrations over time using a mass balance on pervious watershed grids; the Mercury Delivery Spreadsheet (MDS) for calculating the fraction of mercury from the landscape that is lost in the watershed's tributary system due to reduction of divalent mercury to gaseous elemental mercury in the upper soil surface; and the mercury version of the general dynamic mass balance model WASP5 which uses as inputs the speciated mercury loadings delivered from the watershed and from point sources, and calculates total and methyl mercury concentrations in both water and sediment segments of the considered watershed. A check of simulation results against survey data gathered during very dry conditions in June, 2000 showed reasonable agreement. Relative errors were found to be 18% and -13% for methyl and total mercury in the sediments, respectively and -22% and 20% in the water, respectively. Model results are further examined in the context of implications for managing atmospheric emission sources of mercury in the Ochlockonee watershed. Results revealed that approximately a 90% reduction of mercury from all sources is needed to bring the predicted maximum concentration down to the target concentration. Moreover, mercury loading sensitivities were investigated to evaluate parameters controlling the predicted mercury loading flux, including weather variability and landscape characteristics. For both total mercury and methyl mercury in runoff, weather variability and soil loss rate were found to be the most sensitive parameters. Predicted methyl mercury runoff flux was also found to be sensitive to the processes of methylation and demethylation. Based on the results obtained from the simulations presented in this study, we conclude that the models and the modeling strategy used in the present work can be useful management tools. They are well suited for use in linked atmospheric-hydrologic mercury modeling studies for assessing loadings of mercury to the atmosphere that are protective of environmental quality in watersheds.

Key words: airborne mercury, terrestrial receptors, methyl mercury, hydrologic transport