Session M6: Monitoring Mercury in the Environment: Data Synthesis and Integration

Room C123
10:00 – 11:30 am

0012
M6-1

A Multi-Media Synthesis of Data on Mercury in the Great Lakes Region: An Overview of Procedures and Key Findings

James Wiener[1] and David Evers[2]

[1]Univ. of Wisconsin-La Crosse, La Crosse, Wis., USA,[2]BioDiversity Research Institute, Gorham, Me., USA

We summarize key findings from a bi-national assessment of mercury in the Great Lakes region, an area with substantial aquatic resources and mercury-contaminated landscapes. During 2008-2011, a multi-institutional group of environmental scientists compiled and analyzed mercury data collected by state, provincial, federal, academic, and nonprofit monitoring and research programs. Sharing and synthesis of data were facilitated by two workshops and by funding from the Great Lakes Air Deposition Program. The geographic scope of this synthesis included the Great Lakes, Lake Champlain, the eight US states bordering the Great Lakes, and the Canadian province of Ontario. The topical scope of the synthesis included assessment of environmental mercury contamination, methylmercury exposure, ecological risks, and policy. Dated sediment cores from inland lakes show a region-wide decrease in mercury accumulation since the late 1980s, indicating that controls on local and regional emissions have reduced the atmospheric deposition of mercury across the region. Mercury levels in fish have generally declined since the 1970s, but concentrations in walleye and lake trout have increased in some areas since the late 1990s. In Wisconsin, mercury levels have increased in chicks and adults of common loons since 2000. The factors causing these recent increases in bioaccumulation have not been identified, but the observed patterns imply that changing environmental conditions have increased the microbial methylation of mercury or the concentration of methylmercury in aquatic food webs. Mean concentrations in sport fishes in many inland lakes across the region continue to exceed the USEPA methylmercury criterion (0.30 mg/g or ppm wet weight) established to protect human health. Moreover, the risks of methylmercury exposure to the region's predatory fish and fish-eating wildlife are substantial and greater than previously recognized, particularly in inland lakes. The findings from this synthesis imply that further reductions in atmospheric emissions of mercury would benefit fish and wildlife across the region and highlight the need for a comprehensive mercury-monitoring network. Project results are being communicated in special issues of scientific journals, in presentations at scientific conferences, in a semi-technical summary report for the policy community and general public, and in briefings to decision makers.

0242
M6-2

Sediment Mercury and Methylmercury Concentrations across the Coterminous United States

David Krabbenhoft[1], Michael Tate[1], John DeWild[1], Jacob Ogorek[1], Charlie Thompson[1], Keith Loftin[2], Sarah Lehmann[3], Amina Pollard[3] and Richard Mitchell[3]

[1]US Geological Survey, Middleton, Wis., USA,[2]US Geological Survey, Lawrence, Kans., USA,[3]US Environmental Protection Agency, Washington, D.C., USA

During the summer of 2007, USEPA's National Lakes Assessment surveyed the "health" of lakes and reservoirs across the lower 48 states. Lakes sampled represented six size classes and were distributed relatively uniformly across the study area. As part of this project, mercury (Hg) and methylmercury (MeHg) content of surficial (0-2 cm) sediment was assessed through the collection of intact cores from the mid-lake region (n = 1,070 lakes). In this paper, we assess the spatial distribution of total Hg and MeHg in lake sediments and their controlling mechanisms.

Total Hg concentrations show distinct sub-regional distributions, in which there are clusters of lakes with elevated concentrations. On the national scale, the primary controlling cofactor of total Hg concentration was determined to be the trophic status (defined by chlorophyll a concentration) and, to a lesser, degree proximity to known point (mining) sources. Trophic conditions affect Hg concentration because high nutrient conditions generally lead to elevated sedimentation rates, thus sediment dilution of Hg arises for eutrophic and hypertrophic lakes. There was no obvious relation to known patterns of atmospheric Hg deposition. Spatial analysis reveals the highest total Hg concentration are associated with oligotrophic conditions in New England, northern Florida, northern Wisconsin and Minnesota, and the Olympic Peninsula in Washington. Lakes in the Mississippi River basin generally exhibit lower total Hg concentration, and are associated with eutrophic and hypertrophic conditions. Nationally, 59% (95% CI = ± 2.6%) of lakes had Hg concentrations below the threshold effects concentration (TEC) of 180 ng/g (dry weight), indicating "good condition". Also, 72% of man-made lakes are in good condition versus 50% of natural lakes, which is directly related to trophic status. The spatial distribution of MeHg concentrations is very complex, exhibiting very little regional structure or obvious spatial trends. Last, MeHg

concentration shows little correspondence to the total Hg concentration (r^2= 0.27). The MeHg/total Hg ratio, which is a good indicator of net methylation activity, was generally greatest for eutrophic lakes, and peaks at 1 and 10 mg/L for total nitrogen and sulfate in water, respectively.

0275
M6-3

Informatics Approaches for Reuse and Modeling of Heterogeneous Mercury Data

Melinda Neville[1] and Kate Beard[2]

[1]Dept. of Ecology and Environmental Sciences, Univ. of Maine, Orono, Me., USA, [2]School of Computing and Information Science, Univ. of Maine, Orono, Me., USA

Maine's mercury (Hg) monitoring legacy spans three decades and many different ecosystem pools, but the diverse nature of Hg data makes comparison across studies difficult. As such, our ability to measure changes in Hg contamination in response to the regulation of Hg emissions is limited, and researchers have difficulties comparing results or utilizing the wealth of Hg data more broadly. Often, there are several methodological and contextual barriers to comparing disparate monitoring efforts, despite apparent similarities. For example, the differences in study design between sampling and monitoring projects may be in scale, duration, or intensity of sampling. Likewise the sampling methods, laboratory procedures, and reporting further complicate the evaluation of multiple monitoring efforts. Differences in climate, season, or sample matrices often preclude efforts to quantify variance among heterogeneous Hg data. For Hg contamination, there is often an assumed common understanding of some terms, assumptions about relationships, implicit, or different specification of the landscape settings, and imprecise or ambiguous spatial context specification of observation units that hinder the ability to make logical linkages between study results. Studies utilize data from varied contextual settings and characterize relationships in different ways making these relationships difficult to associate across multiple projects. These relationships and supporting data connections to these relationships can benefit from more formal definition. Domain-specific ontologies provide a way to explicitly capture knowledge about specific scientific domains, and support consistent and unambiguous representations of entities and relationships within domains. An ontology formally specifies representation of entities along with their properties and relations, and defines a common vocabulary that can be shared between researchers. In this research, we are developing ontology(ies) to facilitate disparate data integration, dissemination and comparison for Hg monitoring in freshwater ecosystems. The developed ontologies will allow Hg data to be placed in the context of the Hg biogeochemical cycle and linked to contextual characteristics of the observation settings. We will discuss the challenges of working with disparate spatiotemporal data, and the applied techniques that facilitate its use in evaluating ecosystem risk and resilience to Hg pollution.

0338
M6-4

Application and Validation of the National Descriptive Model of Mercury in Fish (NDMMF)

Mark Brigham[1], Michael Fienen[2], David Donato[3], Stephen Wente[4] and David Lorenz[1]

[1]US Geological Survey, Mounds View, Minn., USA, [2]US Geological Survey, Middleton, Wis., USA, [3]US Geological Survey, Reston, Va., USA, [4]US Environmental Protection Agency, Washington, D.C., USA

The National Descriptive Model of Mercury in Fish (NDMMF; Wente, S. P., 2004, US Geological Survey Scientific Investigation Report 2004-5199, http://pubs.usgs.gov/sir/2004/5199/) is a powerful tool for analyzing fish-mercury data sets with many observations. The NDMMF accounts for variations in fish-mercury concentrations due to species, sampled cut (for example, skin-off fillet, whole body, etc.), fish length, and event (defined as all fish samples collected at a site during a given year). The NDMMF facilitates analysis of the distribution of mercury in freshwater fish by allowing standardized comparisons among sampling events (that is, among sites and over time). We applied the NDMMF to a data set of 101,839 observations of fish-mercury concentrations compiled from numerous state, federal, and tribal monitoring programs. The data set spans the years 1967-2005, and includes data from more than 10,000 sites across 49 states in the United States. The median standard error of prediction was 10.3 percent (expressed as a percentage of concentration). The median ratio of model-predicted to measured fish-mercury concentration was 0.94, indicating low bias; the 10th and 90th percentiles of this ratio were 0.48 and 2.0, respectively, meaning that the central 80 percent of predicted values ranged from about half to twice the measured value. A leave-one-out cross-validation study was conducted to gain a better understanding of model performance in relation to different characteristics that could affect model predictions. Low bias (median residuals close to zero) was observed for most fish species (all cuts combined), and most unique species-cut combinations. In addition, low bias was observed for nearly every State represented in the data base, the exception being one state that used a high detection limit for a number of years.