

Overview

The U.S. Geological Survey (USGS) project for monitoring mercury in Indiana streams was done in cooperation with the Indiana Department of Environmental Management (IDEM). The monitoring provided data about total and methylmercury concentrations in the major watersheds of Indiana. The data can be used to assess changes resulting from rules and educational programs to reduce mercury in Indiana's environment. The partnership between USGS and IDEM supported interpretation of mercury data from stream monitoring in 2002–2006 and in 2007–2009.

Risks to Humans and Wildlife from Mercury in Indiana's Fish

Aquatic ecosystems receive mercury from atmospheric deposition and through wastewater discharge. The State of Indiana has designated mercury a "bioaccumulative chemical of concern" (Indiana Administrative Code, 2007). Low concentrations of inorganic mercury in aquatic ecosystems can be converted to organic methylmercury by microorganisms. Methylmercury is highly absorbable and concentrations accumulate and magnify in food webs. The greatest concentrations arise in fish and in fish-eating mammals and birds at the top of the food web. Methylmercury is a potent neurotoxin and potential endocrine disruptor which can slow nervous-system and cognitive development in humans and wildlife. Methylmercury can interfere with reproduction in vertebrates and has been linked to congenital birth defects, increased risk of heart attack, renal damage, and blood pressure dysfunction (National Research Council, 2000).



Mercury has been detected in nearly all fish-tissue samples collected in Indiana since 1983 (Indiana Assessment Information Management System, 2008, unpublished data). Concentrations of mercury in some tissue samples from fish caught in Indiana waters have prompted State health officials to issue advisories that warn about human consumption of these fish (Indiana State Department of Health, 2008). The Indiana annual fish consumption advisories are based on a safe exposure limit of 0.1 µg/kg and the concentrations of methylmercury in fish-tissue samples collected throughout the state. These advisories recognize a greater risk to some members of the population. The advisories can be summarized generally with the following statements. If safety is unknown, women (pregnant, breast-feeding, or planning pregnancy) and children less than 15 years of age may assume that one meal of Indiana sport fish per month is safe. Women and children in this group should not eat any large carp, flathead catfish, walleye, sauger, or striped bass. Adult men and women not in the previous group may assume that one meal of Indiana sport fish per week is safe; however, some Indiana rivers and streams have "do not eat" advisories for all fish.



As of 2008, fish-consumption advisories for mercury were listed as the cause for impaired beneficial use designations for 324 water bodies in 268 hydrologic units¹ in Indiana (fig. 1). These water bodies include: 287 stream reaches, 3 reaches of the Ohio River bordering Indiana, 8 reservoirs, 19 lakes, and all of Lake Michigan in Indiana (Indiana Department of Environmental Management, 2008). Each year, some 833,000 resident anglers 16 years and older spend 15.5 million days and \$469 million for fishing as recreation. An estimated 286,000 more resident anglers were 6 to 15 years old (U.S. Department of the Interior, 2003). Based on these numbers, fish-consumption advisories affect approximately 1 of 6 Indiana residents.²

¹ The Indiana Department of Environmental Management (2008) lists the 14-digit hydrologic unit code for the impaired water bodies. These hydrologic units are described in DeBroka and others (1999) as "an area of land upstream from a specific point on a stream that is defined by a hydrologic boundary. The boundary includes all of the source area that could contribute surface-water runoff directly or indirectly to the designated outlet point."

² The sum of 833,000 Indiana resident anglers over 16 years in age and an estimated 286,000 resident anglers 6 to 15 years in age is approximately 1 million Indiana anglers out of 6.4 million Indiana residents (Indiana Business Research Center, 2009).

Mercury Reduction Efforts in Indiana

Indiana mercury reduction efforts were elevated to an agency-wide priority in 1997. Focusing on children's health issues and the widespread occurrence of mercury in water and fish, IDEM has worked in regulatory and non-regulatory ways to prevent additional mercury from being released into the environment and to clean up mercury contamination. The Indiana Water-Quality Standards for mercury in water list three criteria. Statewide, the chronic aquatic criterion for mercury is 12 nanograms per liter (ng/L) to protect aquatic life from chronic toxic effects (Indiana Administrative Code, 2007). For water in Indiana in the Great Lakes system, the water-quality criterion for mercury (including methylmercury) is 1.8 ng/L to protect human health from possible non-cancer effects resulting from consumption of aquatic organisms (Indiana Administrative Code, 2007). Also for water in Indiana in the Great Lakes system, the water-quality criterion for mercury (including methylmercury) is 1.3 ng/L to protect avian and mammalian wildlife populations from adverse effects which may result from consumption of aquatic organisms (Indiana Administrative Code, 2007).



The Need for Monitoring Mercury in Streams in Indiana

Monitoring data are needed to determine the geographic distribution and temporal trends in mercury levels in Indiana's streams resulting from:

- (a) implementation of state programs to prevent water pollution from mercury—the Streamlined Mercury Variance and Total Maximum Daily Load for wastewater discharges;
- (b) state implementation of federal rules for air pollution control that affect mercury emissions; and
- (c) state rules and educational programs to remove mercury from schools, homes, hospitals, dental offices, auto salvage, and their associated waste disposal to the water or the land.

Monitoring for Mercury in Streams in Indiana

The USGS collected water samples on a seasonal schedule from 25 locations on Indiana streams from August 2004 through September 2006. IDEM collected grab samples of water from 24 of these 25 locations, 3 to 4 times a year, from February 2002 through February 2004. All these water samples were analyzed for total mercury and methylmercury and most of the samples were collected near USGS streamflow gages so that total mercury and methylmercury loads could be computed. These 4 years of mercury monitoring in Indiana streams were summarized and interpreted by Risch and others (2010). Monitoring continued using a revised network from February 2007 through September 2009, described in the section Monitoring Stations.

Objectives for Monitoring of Mercury in Streams in Indiana

- Determine long-term trends of mercury in water of the major watersheds of Indiana.
- Identify factors that explain differences in levels among the major watersheds of Indiana.
- Relate mercury in water to mercury in fish of the major watersheds in Indiana.
- Design and operate a monitoring network to support these first three objectives.
- Communicate and interpret the results from the monitoring project.



Monitoring Stations

The 2007–2009 statewide network of 25 monitoring stations (fig. 2) included the major watersheds of Indiana. Stations are at USGS streamflow gages at confluences of contributing and integrating stream basins for the major watersheds. The network included stations with mercury data for 2002–2006 and stations near Indiana's atmospheric mercury deposition-monitoring stations. Analytical data and sample information from the monitoring program are archived in the USGS National Water Information System.



Water-Sample Collection and Analysis for Low-Level Mercury

The project involved low-level mercury sampling, analysis, reporting, and data management for a statewide network of 25 monitoring stations in Indiana. Sampling, analysis, and quality control for the monitoring program follow a Quality-Assurance Program Plan. Measures were taken to avoid, to detect, and to quantify unintentional mercury in samples because the concentrations of interest typically were less than 30 ng/L.

Sampling was done on a quarterly schedule using ultra-clean protocols, isokinetic samplers, and stream width and depth-integrating techniques (U.S. Geological Survey, 1998). Water samples were analyzed for particulate and dissolved mercury and particulate and dissolved methylmercury at the USGS Mercury Research Laboratory using low level methods equivalent to EPA Methods 1631 and 1630 (U.S. Environmental Protection Agency, 1999 and 1998, Olson and DeWild, 1997; DeWild, Olson, and Olund, 2002). Additional monitoring constituents included sulfate, organic carbon, and suspended sediment analyzed at USGS laboratories, along with field measurements of the water-quality properties pH, specific conductance, dissolved oxygen, turbidity, and water temperature.

References

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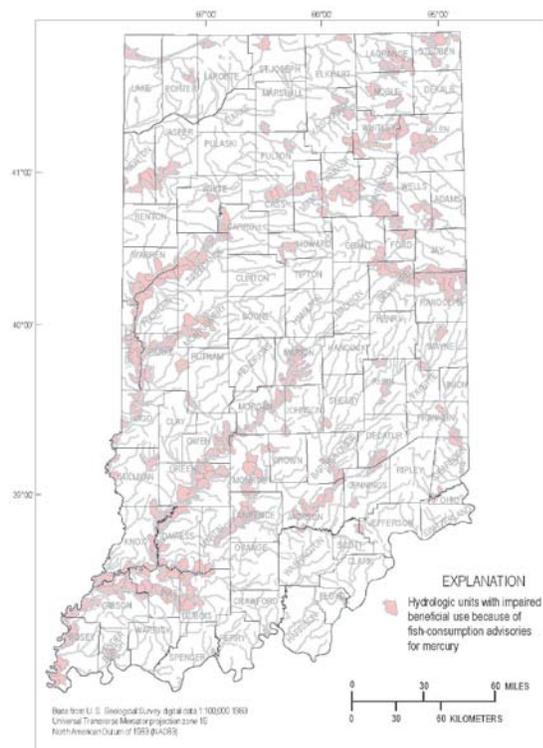


Figure 1. Hydrologic units in Indiana with water bodies impaired because of fish-consumption advisories for mercury (from information in Indiana Department of Environmental Management, 2008).

For more information,
contact the USGS project chief:
Martin Risch (mrrisch@usgs.gov)
317-290-3333 x.163



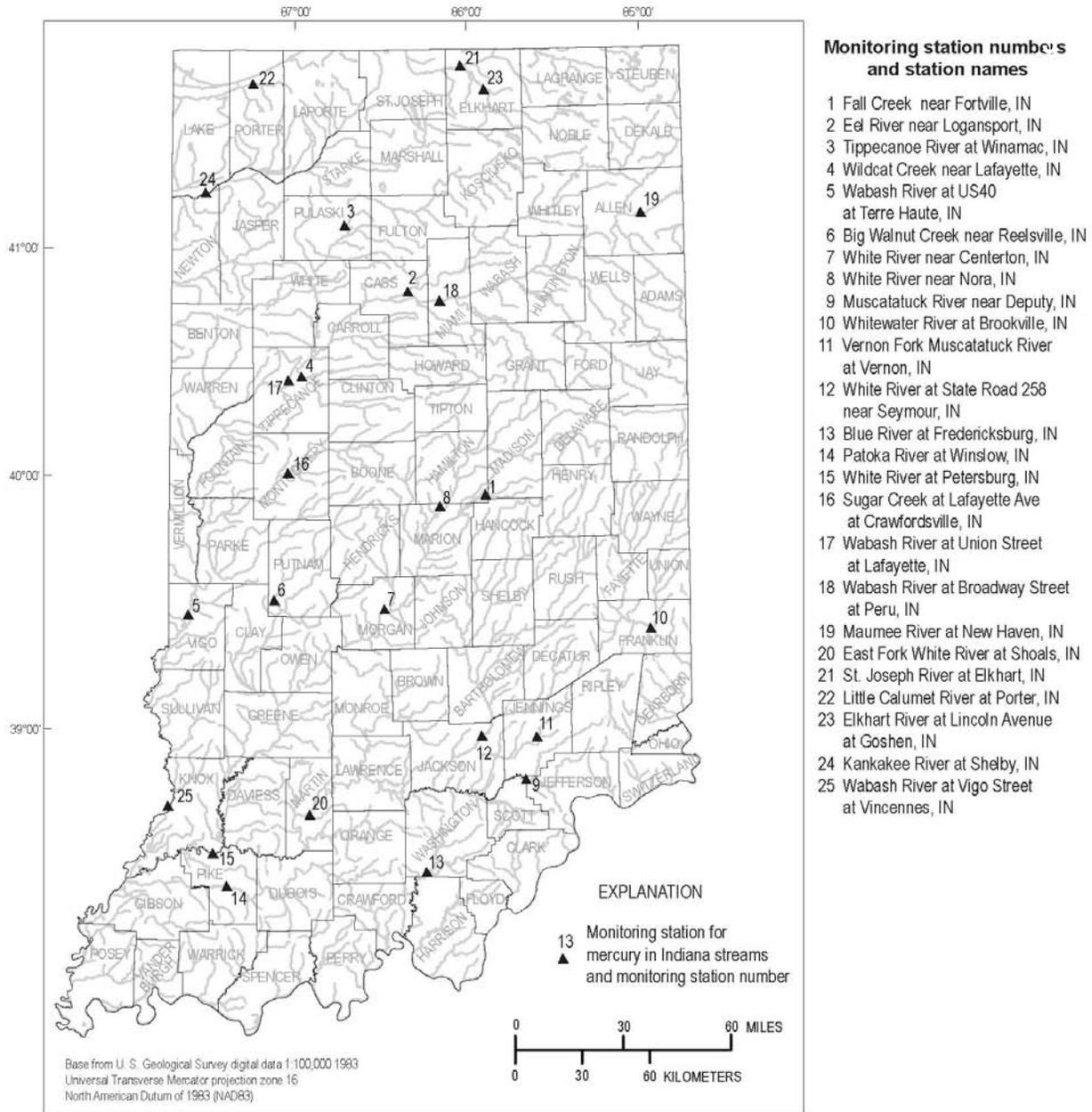


Figure 2. Statewide network for monitoring mercury in Indiana streams, 2007-2009.