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Water Quality and Ecology

The Nation's water resources are the basis for life and our economic vitality. These resources support a complex web of human activities as well as fishery and wildlife needs. Demands for clean and abundant water for drinking, recreation, farming, and industry are rising; and as a result, the American public is concerned about the condition and sustainability of its water resources.

The USGS has been investigating the quality of Ohio's streams and ground water since the 1940s. In recent decades, USGS scientists have also used ecological studies (studies of plant and animal communities and their habitat) as important indicators of water quality because the health of aquatic organisms reflects exposure to the quality of water in streams over an extended period of time. Water-quality and ecology studies are done in cooperation with local and State governments, universities, and with other Federal agencies so that science-based decisions regarding water-resources management and planning can be made. Some of the ways in which USGS water-quality and ecology information can be used are described in this fact sheet.

Assessing Recreational Water Quality

Various factors—wildlife and livestock in streams, improperly functioning septic systems, stormwater discharge, combined-sewer overflows, and incompletely disinfected wastewater—can contribute to water quality that is unsafe for recreational use. Currently, swim advisories or beach closings are issued by beach or park managers on the basis of standards for concentrations of fecal indicator bacteria, such as *E. coli*. Concentrations of indicator bacteria may change significantly between the time of sampling and the availability of analytical results (19–24 hours later). This time lag can lead to beach advisories that cause unwarranted loss of valuable recreation access or permit swimming when conditions present an unacceptable level of risk. More timely methods for assessing recreational water quality are needed so that more accurate short-term information is available than that resulting from traditional monitoring methods.

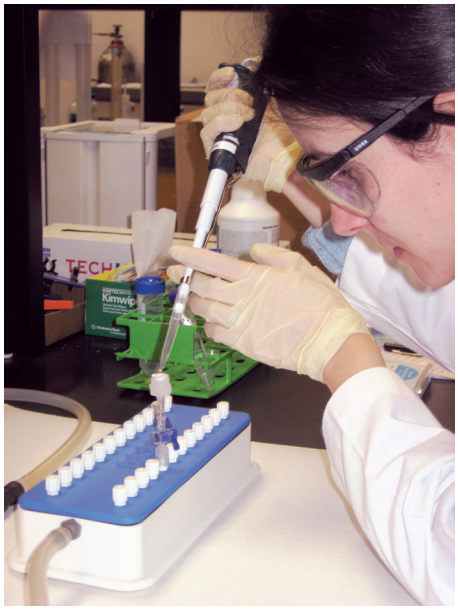
The USGS Ohio Water Science Center (WSC) is currently working on two different approaches to provide more timely and accurate information about recreational water quality: (1) optimization and adaptation of rapid-detection methods, and (2) predictive modeling.

Two rapid-detection methods that provide fecal indicator bacteria concentrations within 1–3 hours are being tested by USGS personnel for use with recreational waters in Ohio. The tests will be used to determine how well the rapid results correlate with results obtained using standard analytical methods.

The predictive models being developed in Ohio use water-quality characteristics (such as turbidity, water temperature, and rapid-method results) and environmental data (such rainfall and wave height) as surrogates for concentrations of fecal-indicator bacteria. The surrogates must be easily measured or available as real-time data. Real-time forecasting may help resolve the delayed notification problems inherent with the present approach to recreational-water-quality monitoring. To date, beach-specific predictive models have been developed for Huntington and Edgewater beaches on Lake Erie. The predictive models enable a "nowcast" of the current day's recreational water quality at each beach (*http://www.ohionowcast.info*).

THE OHIO WATER MICROBIOLOGY LABORATORY

The USGS Ohio Water Microbiology Laboratory (OWML) is a state-of-the art microbiology facility located in Columbus. OWML is involved in investigations of processes that affect microorganisms in the environment and testing of new methods to improve detection of microorganisms in water and sediments. To learn more about the lab's analytical and field methods and to see results of current projects, visit *http://oh.water.usgs.gov/micro_index.htm.*



Identifying the Sources of Microbial Contamination

When a community finds that water it relies on for drinking or recreation contains *E. coli*, residents and officials naturally want to find the cause and fix it—quickly. Often, however, the source of contamination is not obvious. Is the problem stemming from leaking septic systems, wastewater-treatment-plant discharges, cattle in the stream, concentrated animal feeding operations (CAFOs), or wildlife?

USGS studies to date indicate that following multiple lines of inquiry can be an effective approach in searching for sources of contamination. Multiple source-tracking tools were used to identify sources of fecal contamination at two Ohio beaches—Edgewater and Lakeshore. These tools included identifying spatial patterns of *E. coli* concentrations in each area, determining weather patterns that caused elevated *E. coli*, and applying microbial source tracking (MST) techniques to specific sites. MST tools are also being used to identify the relative contributions of contaminants from CAFOs, septic systems, wildlife, and wastewater on water quality within the Portage River Watershed. Investigators are testing for the presence of human- and bovine-specific molecular MST markers of the bacterium *Bacteroides* in source and environmental water samples.

Defining Contaminant Distribution and Trends

The USGS National Water-Quality Assessment (NAWQA) Program was designed to describe the status and trends in the quality of the Nation's surface- and ground-water resources and to provide a sound, scientific understanding of the primary factors affecting the quality of these resources. Two of the more than 50 NAWQA "study units" (which include parts of major river basins, aquifer systems, and coastal drainages) are partly within Ohio—the Lake Erie-Lake St. Clair Drainages and the Great and Little Miami River Basins.

Across the Nation, the NAWQA Program found that pesticides are frequently present in streams and ground water. Although rarely found at concentrations likely to affect humans, pesticides occur in many streams at concentrations that may have effects on aquatic life or fish-eating wildlife. PCBs and other organochlorine insecticides, the use of which was canceled or restricted in the 1970s and 1980s, continue to persist in fish tissue and streambed sediments. Rural, agricultural areas are not the only places affected; insecticides commonly used by homeowners on lawns and gardens are frequently detected in samples from small urban streams.

Ground-water studies nationwide concluded that, although evidence is found of human activities affecting ground-water quality, most samples from domestic wells meet health-related drinking-water standards.

In 2001, the NAWQA Program in Ohio evolved from its focus solely on describing observed water-quality to examining processes that affect water quality. In the Great and Little Miami River Basins, processes being evaluated include the effects of nutrient enrichment on streams; the sources, transport, and fate of agricultural chemicals; and the transport of contaminants to water-supply wells.

In the Lake Erie-Lake St. Clair Drainages, samples of raw (untreated) water from the Maumee River at a water treatment plant intake and the finished (treated) water prior to distribution were collected as part of a drinking-water source water-quality assessment study. Samples were analyzed for about 280 manufactured chemicals such as solvents, refrigerants and propellants, personal-care and domestic-use products, disinfection byproducts, pesticides, and pesticide degradates to gain a better understanding of the occurrence of these chemicals in water and to identify patterns in their occurrence before and after treatment. The USGS is also conducting a detailed ground-water study of the fate and transport of nutrients along a regional flow path in the glacial aquifer in the Lake Erie-Lake St. Clair Drainages area.

More information on the NAWQA Program and study-unit results can be found at *http://water.usgs.gov/nawqa/*.

Assessing the Presence of Wastewater Chemicals in Streams

A recent study by the USGS showed that a broad range of organic chemicals in wastewater are entering U.S. streams. (See *http://toxics.usgs.gov/pubs/FS-027-02.)* These include human and veterinary antibiotics and other drugs, natural and synthetic hormones, detergent metabolites, plasticizers, insecticides, and fire retardants. New analytical methods for these wastewater-related organic chemicals were

developed by USGS laboratories. Little is known, however, about health effects on aquatic organisms exposed to low levels of these chemicals in streams or to mixtures of these chemicals.

The USGS evaluated the occurrence and distribution of organic wastewater chemicals in the Tinkers Creek watershed in northeastern Ohio, using passive samplers, such as the polar organic chemical integrative sampler (POCIS) and semipermeable membrane device (SPMD). Unlike traditional sampling methods that "take a single snapshot" of concentration at one point in time, these types of samplers are staked in the stream and accumulate organic compounds over a variety of flow conditions for several weeks. The samplers were deployed for 28 days both upstream and downstream from seven wastewater-treatment-plants (WWTPs). A total of 12 antibiotics, 20 pharmaceuticals, and 41 wastewater compounds were detected in water at one or more sites. It was common to have more of these compounds detected in samples downstream of the WWTPs than in samples collected upstream from a WWTP.

Modeling Scenarios for Reduction of Contaminant Loads

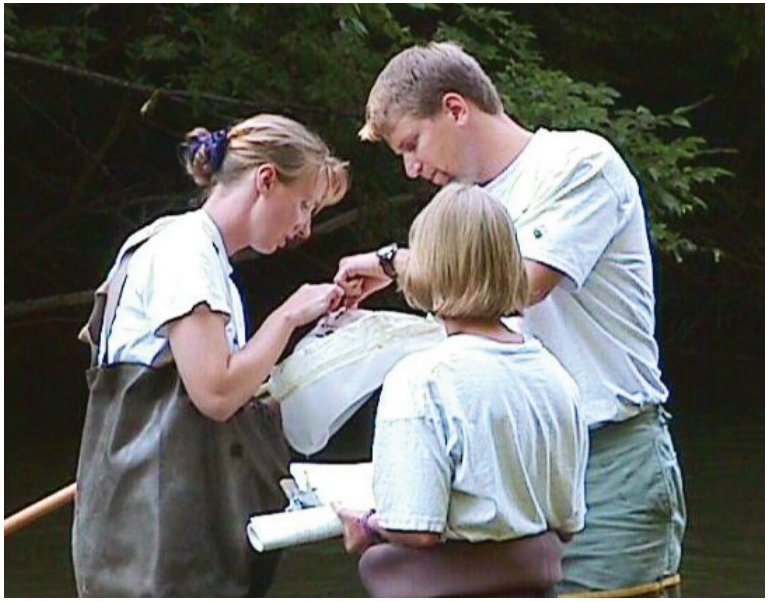
Stream waters of the Mad River watershed are used for recreation, agriculture, industrial water supply, and support of aquatic life. However, long-term availability of water for some of these uses is threatened because several segments of the Mad River and its tributaries are not in compliance with Ohio Water Quality Standards. An extensive evaluation of the Mad River watershed by the Ohio EPA found that, throughout the watershed, ambient-water-quality standards for fecal coliform bacteria are exceeded. Other causes of impairment to specific stream segments include nutrient and organic enrichment

from agricultural activities, urban runoff, or wastewater-treatment plants. To quantify loads and concentrations of nitrate (a nutrient) and fecal coliform in the Mad River watershed and to estimate these concentrations over a range of hydrologic conditions, the USGS used a watershed model called Hydrological Simulation Program—Fortran (HSPF). After calibrating the model to reflect existing conditions, the model was modified to create scenarios that simulated loads of fecal coliform and nitrate after selected sources were either reduced or eliminated. Such information will serve as a basis for water-resource-management decisions in the watershed, as the Ohio EPA establishes the Total Maximum Daily Load of nitrate and fecal coliform that the stream can receive from all sources and still meet Ohio Water Quality Standards. Subsequently, appropriate remediation and restoration methods can be chosen that will reduce loads by the specified amount, with the ultimate goal of reaching full attainment of biological and chemical water quality standards within each stream segment.

Quantifying Reduction of Acid Mine Drainage

The USGS has recently used two methods to evaluate the effectiveness of measures for reducing acid mine drainage. The first method involved installation of automated water-quality samplers at streamgages on Little Raccoon Creek and Sunday Creek in southeastern Ohio. The automated samplers regularly measured and recorded pH, temperature, specific conductance, dissolved-oxygen concentration, and turbidity. In addition, bimonthly water-quality samples were manually collected and analyzed for concentrations of dissolved and total manganese, iron, aluminum, and dissolved sulfate. Chemical characteristics before and after reclamation projects can be compared to evaluate the effectiveness of the remediation measures.

A second method has been to evaluate changes in biodiversity of aquatic organisms over time following reclamation. A biodiversity study involving fish, macroinvertebrates, and habitat was done in Rush Creek watershed in Perry County, an area that contains several abandoned-mine-land reclamation sites. Although fish and macroinvertebrate communities and stream habitat failed to attain Warm Water Habitat criteria at all of the water-quality sites on Rush Creek and a biodiversity study determined that most of the mainstem within the study area is currently uninhabitable to macroinvertebrates and fish, the quality and quantity of organisms



collected by the USGS showed improvement when compared to similar, previous studies by the Ohio EPA.

Mapping Wetlands

The USGS Ohio Water Science Center has mapped wetlands at various scales. A recent regional-scale project was the creation of the Great Lakes Coastal Wetlands Inventory. Digital coastal wetland data from several sources were integrated to create a single geographic data base. Because several different classification systems had been used in the original studies, all wetlands in the geographic data base were reclassified using a single, hydrogeomorphic classification. This dataset, a collaborative effort between Canada and the United States, provides a standard reference for the Great Lakes wetland community and will serve as the framework for long-term monitoring of coastal wetlands.

On a local scale, the USGS inventoried potential wetlands in training areas on Ravenna Training and Logistics Site to aid the Ohio Army National Guard in its goal to conserve biological diversity on its facilities. Potential wetlands were mapped through use of geographic information system (GIS) data layers compiled from existing sources, such as data layers of wetland-plant communities, hydric soils, the National Wetlands Inventory, and aerial photography. Areas identified as likely wetlands according to the GIS spatial analysis were further corroborated by field inspection for the presence of hydrophytic (water-loving) vegetation and evidence of wetland hydrology, such as standing water and moss growth on trees.

Integrating Watershed and Transportation Planning

Decision-support systems are interactive computer-based applications that assist researchers or managers in making decisions. To aid transportation planning in the greater Cleveland area, the USGS and the Cuyahoga Remedial Action Plan have developed a computer-based decision support system that will address various transportation issues that could impact numerous environmentally sensitive areas, historic sites, and tourist venues. Transportation planning is commonly based on political boundaries; however, watersheds are a more meaningful boundary in which to evaluate and remediate stressors to the natural environment.

The primary goal of the GIS-based decision support system was to provide environmental information about the study area and affected watersheds in a visual and tabular form. A suite of potential Best Management Practices (BMPs) were included, based on the chosen transportation project type. The BMPs raise awareness of the types of things that can be done to avoid, minimize, or mitigate negative effects of the transportation project to the environment. In addition, fact sheets and Web links to pertinent watershed and transportation topics were included. The decision support system is geared towards the non-GIS professional, and the aim is to provide access to this environmental data and information to a large group of people early in the planning process.

Additional Information

To learn more about USGS projects in Ohio or USGS information products, please visit

http://oh.water.usgs.gov/

or contact

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