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 and 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

Wildlife, livestock, improperly functioning septic systems, stormwater discharge, combined-sewer overflows, and incompletely disinfected wastewater can all 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 between the time of sampling and the availability of analytical results (19–24 hours). 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 accessing 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 toward more timely and more accurate information about recreational water quality: (1) optimization and adaptation of rapid-detection methods, and (2) predictive modeling.

Two rapid-detection methods that yield 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 estimate bacterial indicator concentrations or the probability of exceeding target concentrations. The models use water-quality characteristics (such as turbidity, water temperatures, and rapid-method results) and environmental variables (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, a beach-specific predictive model has been developed for Huntington Beach on Lake Erie that enables a "nowcast" of the current day's recreational water quality (*http://www.ohionowcast.info)*.

THE USGS 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. The OWML is equipped to conduct a variety of cultivation- and molecular-based microbiology methods, including membrane filtration, direct microscopy, polymerase chain reaction, and hybridization with gene probes. To learn more about the lab's analytical and field methods and to see results of current projects, visit *http://oh.water.usgs.gov/microbiol.html.*

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Using Multiple Lines of Evidence for Contaminant-Source Identification

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, 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. Three MST methods were used during this study—multiple antibiotic resistance (MAR) indexing of *E. coli* isolates and the presence of human-specific genetic markers within two types of bacteria, the genus *Bacteroides* and the species *Enterococcus faecium*. MAR indices were useful in distinguishing between bird feces and wastewater sources because index values were about 10 times higher in the latter. At both beaches, fecal contamination was most likely of local origin, and contamination from human and bird feces was identified.

Because further research may lead to improvements in current source-tracking methods or development of better methods, testing of source-tracking methods by the USGS is ongoing.

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 water-quality status and trends to also include the study of national priority topics to establish links between sources of contaminants, the transport of those contaminants through the hydrologic system, and the potential effects of contaminants on humans and aquatic ecosystems. 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. More information on the NAWQA Program and study-unit results can be found at *http://water.usgs.gov/nawqa/*.

Assessing the Effects of Wastewater Chemicals on Organisms 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 anti-

biotics 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.

Although the habitat in the lower reaches of Tinkers Creek in Cuyahoga County, Ohio, has the potential to support a diverse biological community, the lower reaches of the stream have not historically met Warm Water Habitat criteria established by the Ohio Environmental Protection Agency (Ohio EPA). To determine whether urban impacts (such as the discharge from wastewater-treatment plants) are limiting the ability of aquatic habitat in Tinkers Creek to support biological communities, the USGS is evaluating the presence and concentration of organic wastewater chemicals by use of recently developed polar organic chemical integrative samplers. The advantage of this type of sampler is that it accumulates organic compounds from a variety of flow conditions over time instead of "taking a single snapshot" of concentration at one point in time as typical water sampling does. The samplers were deployed for 28 days in summer 2006 in canisters made of PVC and stainless steel. Resulting data will be compared to determine whether any substantial upstream-downstream differences in biological indices and concentrations of wastewater compounds are apparent.

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 (WQS). 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 WQS. 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 WQS 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 an abandoned-mine-land reclamation site. 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 the biodiversity study determined that most of the main stem 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.

For Further Information

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