U.S. Department of the Interior
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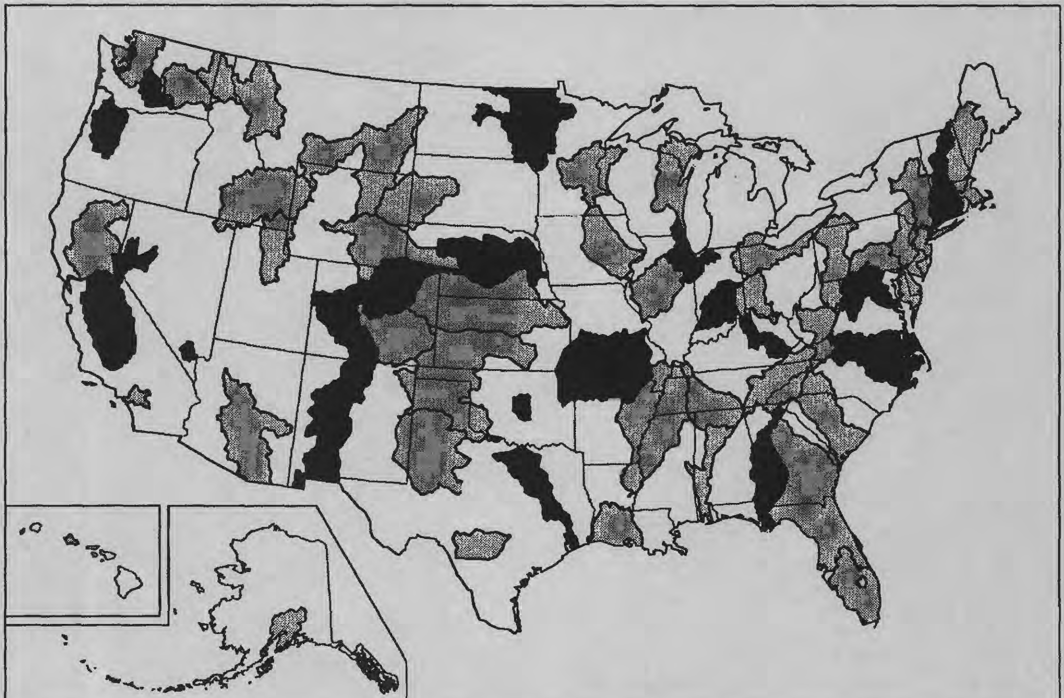
U.S. GEOLOGICAL SURVEY
National Water-Quality Assessment Program

Proceedings Abstracts

American Water Resources Association's Symposium on the National Water-Quality Assessment (NAWQA) Program --

November 7-9, 1994, Chicago, Illinois



U.S. GEOLOGICAL SURVEY
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Edited by Stephen K. Sorenson

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U.S. DEPARTMENT OF THE INTERIOR

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AN INTRODUCTION TO THE U.S. GEOLOGICAL SURVEY'S NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

P. Patrick Leahy, Barbara J. Ryan, and A. Ivan Johnson

The Nation needs accurate and timely information about the quality of its water resources so that it can make scientifically based decisions and policy at all governmental levels. During the past two decades, Federal, State, and local governments have made significant commitments to the protection and enhancement of water quality. In spite of these investments, information is not available to answer some rather fundamental questions to the satisfaction of the scientific, regulatory, and management communities, and the public. Some example questions include:

• Are national water quality goals being met? How effective have past actions been?

• How should limited financial resources be allocated among competing water-quality problems? For example, what is the extent of various types of nonpoint-source contamination, and how does nonpoint-source contamination compare to various types of point-source contamination?

• Can regulations be targeted to specific water-quality constituents in particularly sensitive hydrologic settings? Policy makers and regulators have mandated national bans or reductions on the use of selected chemicals which may have over protected water resources in some areas while under protecting water resources in other areas.

• What natural and human-induced constituents in water are most prevalent in the different hydrologic, geologic, climatic, and land-use settings that comprise the Nation? This information is needed to identify (1) potentially harmful substances in need of regulation; (2) additional research needs relative to toxicity, human exposure, and drinking-water treatability; and (3) sensitive environmental settings which may require unique monitoring designs and requirements.

A critical factor in understanding water quality is the ability to make comparisons among different locations through time. Nationally consistent and comparable information is needed to make valid regional and national statements about current water-quality conditions and changes in these conditions. Existing programs designed to report on the status of the Nation's water resources have not always provided meaningful results because of a lack of consistency. In many instances, there are consistency problems because field and laboratory procedures and methods are not uniform and comparable among Federal, state, and local agencies and often change through time; sites are purposefully located to investigate a specific water-quality problem that is not representative of the surrounding area; long-term sampling is lacking and trends are difficult to detect; data are lacking on potentially toxic constituents such as trace elements, pesticides, and other organic constiuents of concern; and most studies have not been of an interdisciplinary nature that involve comprehensive use of physical, chemical, and biological data nor have these studies been integrated to assess the interaction of the various resources on observed or predicted water-quality conditions.

Recently, as part of the continuing national debate concerning reauthorization of the Clean Water Act, there has been renewed interest at the Federal, State, and local level in the development and implementation of watershed-based management strategies. The key to this approach is the development of information on physical, chemical, and biological conditions, and responses of individual watersheds to both natural and human-induced changes. This information will allow managers and policy makers at all levels to better define the most effective control strategy for the most critical water-quality problems affecting a particular watershed. It is important that watershed information be comprehensive and include all components of the hydrologic cycle including the interaction of the quantity and quality of ground water, surface water, and atmospheric inputs. Watershed information should be multidisciplinary and include information on water, sediment, biota, and aquatic and terrestrial habitats. In most watersheds in the Nation, comprehensive and integrated information of this type is lacking. Where information is available, it has seldom been compiled or analyzed with the objective of understanding the interaction of all components of the hydrologic system and using this information to support the development, implementation, and evaluation of water-resource management actions.

The U.S. Geological Survey's National Water Quality Assessment (NAWQA) program that began in 1991 is designed to support these information needs. The design concepts being implemented nationally in the NAWQA program are based in part on a pilot effort that began in 1986. The long-term goals of the NAWQA program are to describe the status and trends in the quality of a large, representative part of the Nation's surface-water

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and ground-water resources and to provide a sound, scientific understanding of the primary natural and human factors affecting the quality of these resources. In meeting these goals, the program will produce a wealth of information useful for the development of watershed management strategies.

The NAWQA program is designed to integrate water-quality information at different spatial scales. The program consists of two major components - study-unit investigations and national synthesis activities.

The first component, the study-unit investigations, are the principal building block of the NAWQA program. They are integrated resource investigations of a hydrologic system that include parts of most major river basins and large aquifers in the United States. A total of 60 study areas comprise the program. They are regional in scale incorporating about 60 to 70 percent of the Nation's water use and population served by public water supply.

To make the program manageable, intensive assessment activities in each of the study units will be conducted on a rotational rather than a continuous basis. One-third of the study units will be studied intensively at a given time. The first set of studies began assessment in 1991; the second set of 20 began on October 1, 1993; and the remaining studies are scheduled to begin in 1997. For each study unit three- to four-year periods of intensive data collection and analysis will be alternated with six- to seven-year periods during which the assessment activities will be less intensive.

In the initial assessment period in each study unit, the existing water-quality conditions and the factors that influence these conditions are described through characterization of the environmental setting, analysis of existing data, and the collection of additional data to fill information. NAWQA is multidiciplinary and assessments are based on converging lines of evidence provided by physical, chemical, biological, and habitat information collected, compiled, and analyzed as part of the program. Subsequent intensive assessment periods will focus on improving our understanding of the resource and assessing changes that are occurring through time.

Long-term assessment activities in the study units are a key attribute of the program - not only to define trends - but also to refine an evolving understanding of water quality in each of the study units. This understanding will be achieved in two steps - analyzing and interpreting long-term data sets on the chemical and biological characteristics of the water resource and defining their relation to carefully compiled data on physical hydrology and changes in land use and management practices within the study units.

The NAWQA program will focus on integrating results from the study-unit investigations with results from other programs to provide information at multi-study unit and national scales. The national synthesis or second component of the program will address specific water-quality issues that are of concern in many areas of the Nation. A framework has been established to assure consistency in approach to each study - in field and laboratory methods, in water-quality measurements, and in supporting data requirements.

Initial synthesis efforts focus on pesticides and nutrients. Specific questions related to pesticides and nutrients that are being addressed by the program include:

- What are the occurrences and concentrations of pesticides and nutrients in selected river basins and aquifer systems nationwide?

- What is the relation of pesticide and nutrient concentrations in surface and ground water to natural factors, changes in hydrologic conditions, pesticide and fertilizer use, chemical properties, and land-management practices?

The abstracts presented in this volume are summaries of presentations presented at the Symposium on the NAWQA Program as part of the 30th Annual Conference of the American Water Resources Association held in Chicago, Ill. on November 7-9, 1994. The abstracts represent a cross section of preliminary findings from 19 study-unit investigations located throughout the Nation. In addition, several papers provide a regional or national analyses of data on the occurrence and distribution of pesticides and nutrients in surface water and ground water resources. Most of the findings presented are based on a compilation of existing water-quality data from Federal, State, and local sources complemented by new data collected as part of the NAWQA Program. The symposium is divided into 4 main themes -- nutrients, pesticides, trace elements and radionuclides, and ecology.

The NAWQA Program is continuing to produce assessment information that will be released in publications suitable for a wide array of technical and non-technical users of water-quality information. For additional information on the NAWQA Program contact: Chief, NAWQA Program, U.S. Geological Survey, 413 National Center, Reston, Virginia 22092, Tel. (703) 648-5012, Fax (703) 648-5722, email TThompsn@qvarsa.er.usgs.gov.

OVERVIEW OF THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

William G. Wilber and P. Patrick Leahy[1]

The U.S. Geological Survey's National Water-Quality Assessment Program is designed to: (1) provide a nationally consistent description of current water-quality conditions for a large, representative part of the Nation's surface- and ground-water resources, (2) define long-term trends (or lack of trends) in water quality, and (3) identify, describe, and explain, as possible, the major factors that affect observed water-quality. This information, obtained on a continuing basis, is being made available to water managers, policy makers, and the public to provide an improved scientific basis for evaluating the effects of alternative land- and water-management practices and for developing future water-quality policies. The program has two major work elements--(1) integrated assessments of the physical hydrology, aquatic chemistry, and biology of 60 large river basins and aquifer systems, referred to as study units and (2) national synthesis projects focused on water-quality topics of regional and national interest. The first two national synthesis topics are focused on pesticides and nutrients. Investigations of the first two sets of 20 study-unit investigations were started in 1991 and 1994, respectively. The final set of 20 study-unit investigations is scheduled to begin in 1997. The first cycle of investigations covering all 60 study units will be completed in 2002.

[1] U.S. Geological Survey, 413 National Center, 12201 Sunrise Valley Drive, Reston, VA 22092

A NATIONWIDE STRATEGY TO IMPROVE WATER QUALITY IN THE UNITED STATES

David A. Rickert[1] *and Elizabeth Jester-Fellows*[2]

In order to better characterize the condition of our water resources, fill existing information gaps in State and Federal water resource monitoring programs, and improve the availability of information for decision making at all levels of government, the U.S. Geological Survey and the U.S. Environmental Protection Agency, in concert with eight other Federal agencies and ten States and tribes, have established an Intergovernmental Task Force on Monitoring Water Quality (ITFM). The ITFM is developing a nationwide strategy for water monitoring to better meet the objectives of various monitoring activities, integrate existing monitoring efforts, make more efficient use of available resources, distribute information more effectively, and provide comparable data and consistent reporting of water-quality status and trends. In its first year, the ITFM recommended the general outline for a national strategy to include Federal, Regional, State and Tribal agencies, as well as local and private organizations. In its second year, the ITFM provided "building block" products to use in implementing the national strategy. Now, in its third year, the ITFM is detailing how to implement an integrated, voluntary, nationwide strategy for water-quality monitoring that includes institutional collaboration, environmental indicators, comparable monitoring and laboratory methods, data management and sharing, assessment and reporting, and cost information. ITFM will seek wide public review of its recommendations.

[1] U.S. Geological Survey, 412 National Center, Reston, VA 22092
[2] U.S. Environmental Protection Agency (4503F), 401 M Street, SW, Washington, DC 20460

A NATIONAL LOOK AT NUTRIENTS

Dennis R. Helsel[1], Pixie A. Hamilton[2], David K. Mueller[3], and Kerie J. Hitt[1]

The National Water Quality Assessment program of the U. S. Geological Survey has compiled and interpreted existing information for surface and ground waters of 20 large areas across the Nation. Some noteworthy patterns in nutrient concentrations emerge from analyses of these data.

Nitrate in ground water shows distinct regional patterns, related primarily to surface applications of nutrients and to ease of transport to the subsurface. High concentrations are not identical with areas previously labeled as "vulnerable". Concentrations in surface waters are generally high in different locations than for ground water, with the differences related to the ability of soils to transmit water. Stream concentrations are correlated with several natural and human factors. Trends in nutrient concentrations over the past 10 years are evident in several parts of the Nation. Decreasing ammonia concentrations and increasing nitrate concentrations are evident in streams within many urban and suburban areas. Data sufficient to measure trends in ground-water concentrations are rare. Where data are available, patterns of nitrate seem to directly follow yearly changes in use of nitrogen fertilizers.

These limited findings begin to indicate geographic regions and conditions where ground and surface waters are most at risk from nutrient enrichment. With this information, water-resource managers can begin to prioritize areas for prevention and control strategies.

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[2]U.S. Geological Survey, 3600 West Broad Street, Room 606, Richmond, VA 23230
[3]U.S. Geological Survey, Bldg. 53, Denver Federal Center, MS 415, Box 25046, Lakewood, CO 80225

CONCENTRATIONS, TRENDS, AND LOADS OF NITROGEN AND PHOSPHORUS IN THE CONNECTICUT, HOUSATONIC, AND THAMES RIVER BASINS, 1972-92

Elaine C. Todd Trench[1] and Marc J. Zimmerman[2]

The U.S. Geological Survey collected nutrient data in 119 drainage basins, most of which contain mixed urban, agricultural, and forested land. The data were evaluated for water years 1972-92. Median total nitrogen concentrations ranged from 0.31 to 4.2 mg/L (milligrams per liter). Nitrate concentrations exceeded background levels in many streams, but were well below the U.S. Environmental Protection Agency's Maximum Contaminant Level for drinking water (10 mg/L). Median total phosphorus concentrations ranged from 0.01 to 0.8 mg/L. Streams in densely populated urban basins with major point-source discharges had the highest nutrient concentrations. Trend analysis (18 stations) showed increases in concentrations of total nitrite-plus-nitrate (5 stations), and decreases in total ammonia (11 stations), total phosphorus (13 stations), and dissolved phosphorus (12 stations) during 1980-92. Annual nutrient loads were estimated for six basins 21 to 9,660 mi^2 in size. Total nitrogen loads ranged from 600 to 6,900 kg/mi^2; total phosphorus loads ranged from 20 to 700 kg/mi^2. Urbanized basins yielded 3 to 5 times as much nitrogen and 6 to 20 times as much phosphorus as forested basins. Intensity of urbanization, as well as the number, size, and location of point-source discharges, appeared to have a greater effect on nutrient load than did the overall percentage of urban land.

[1]U.S. Geological Survey, 450 Main St., Room 525, Hartford, CT 06103
[2]U.S. Geological Survey, 28 Lord Road, Suite 280, Marlborough, MA 01752

AN ASSESSMENT OF THE INCREASING NITRATE TREND IN THE LOWER SAN JOAQUIN RIVER, CALIFORNIA

Charles R. Kratzer[1]

A highly significant, flow-adjusted, statistical trend ($p<0.01$) of increasing nitrate concentration in the lower San Joaquin River since 1950 can be attributed to several sources, including tile drainage, runoff from fertilizer application, wastewater treatment plant effluent, and runoff from dairies. Nitrate in the tile drainage is primarily native. The relative contributions of these sources were evaluated by limited estimates of nitrate load in sources and trends in phosphorus and ammonia concentrations in the lower San Joaquin River. Tile drainage and runoff affected by fertilizer application are relatively high in nitrate, whereas wastewater treatment plant effluent and runoff from dairies are relatively high in nitrate, phosphorus, and ammonia.

The source of the nitrate increase during the 1950s is indeterminate, although all potential sources, except tile drainage, increased substantially. During the 1960s, phosphorus concentrations in the lower San Joaquin River decreased, and the nitrate increase in the river was due to increases in runoff affected by fertilizer application and tile drainage. Since 1970, phosphorus and ammonia concentrations in the river have remained relatively low and stable. Nitrate in runoff affected by fertilizer applications decreased during the early 1970s, then stabilized at mid-1960s levels. Nitrate loads to the river from tile drainage increased steadily and were the primary cause of the increase in concentrations in the river since 1970.

[1]U.S. Geological Survey, 2800 Cottage Way, Sacramento, CA 95825

FACTORS AFFECTING NUTRIENT CONCENTRATIONS IN THE WHITE RIVER BASIN, INDIANA

Jeffrey D. Martin, Jeffrey W. Frey, and Charles G. Crawford[1]

Nutrient concentrations in rivers and streams in the White River basin are affected by land use, agricultural practices, seasonal changes in nutrient uptake, point-source discharges, and variations in precipitation and runoff. Median concentrations of dissolved nitrate and phosphorus were 0.66 and 0.02 milligrams per liter, respectively, in a small urban watershed, but median concentrations were 1.5 to 10 times greater for nitrate and 1.5 to 3 times greater for phosphorus in six small agricultural watersheds. The lowest nutrient concentrations in the small agricultural watersheds were measured in a watershed where conservation tillage was extensively used. Median concentrations of ammonia and nitrite were more than 2 times and more than 5 times greater, respectively, in an agricultural watershed affected by waste from farm animals than in the other small agricultural watersheds. Nitrate concentrations were highest during the winter and spring when vegetation was dormant and uptake was reduced. High nitrate concentrations in late spring in some agricultural watersheds seem to correspond to the application and runoff of nitrogen fertilizers. Nondetectable concentrations of nitrate, ammonia, and phosphorus in the White River during extreme summer low flows were caused by nutrient uptake during periods of intense algal productivity.

[1] U.S. Geological Survey, 5957 Lakeside Boulevard, Indianapolis, IN, 46278

COMPARISON OF SURFACE- AND GROUND-WATER NUTRIENT CONCENTRATIONS BETWEEN URBAN AND AGRICULTURAL LAND-USE SETTINGS, SOUTH PLATTE RIVER BASIN, COLORADO

Breton W. Bruce, David W. Litke, Robert A. Kimbrough, and P. B. McMahon[1]

Nutrient concentrations in surface and ground water in the South Platte River Basin show statistically significant differences between urban and agricultural land-use settings. Concentrations in surface water were determined from 20 monthly samples obtained at the mouth of streams that discharge from individual small urban and agricultural basins. Concentrations in ground water were determined from samples collected from 30 randomly selected alluvial wells in each land-use setting.

The median concentration of dissolved nitrate, as nitrogen, in surface water was 3.0 milligrams per liter (mg/L) in the urban setting and 6.6 mg/L in the agricultural setting. The median concentration of dissolved phosphorus, as phosphorus, in surface water was 0.28 mg/L in the urban setting and 0.16 mg/L in the agricultural setting. For ground water, the median concentrations for nitrate were 2.1 mg/L in the urban setting and 7.0 mg/L in the agricultural setting, and the median concentrations of phosphorus were 0.02 mg/L in the urban setting and 0.2 mg/L in the agricultural setting.

In both land-use settings, nitrate was the predominant nitrogen species in surface water, except during storm events when organic nitrogen concentrations increased and nitrate concentrations decreased. Ground water contributed substantially to nitrate concentrations in surface-water, but the nitrate contribution from ground-water varied seasonally and was smaller than expected because of partial denitrification in anaerobic streambed sediments.

[1] U.S. Geological Survey, Bldg. 53, Denver Federal Center, MS 415, Box 25046, Lakewood, CO 80225

ESTIMATES OF NONPOINT AND POINT SOURCES OF NUTRIENTS IN NAWQA BASINS: WHAT CAN THEY TELL US?

Larry J. Puckett[1]

Estimates of nonpoint and point sources of nitrogen and phosphorus were evaluated for 113 watersheds located in the U.S. Geological Survey's National Water-Quality Assessment Program (NAWQA) study units. The relative proportions of nitrogen and phosphorus originating from nonpoint sources such as fertilizer, manure, atmospheric deposition; and point sources such as sewage and industrial discharges, vary with climate, hydrologic conditions, land use, population, and physiography based on the evaluation. Fertilizer sources are greater in agricultural areas of the west, midwest, and south than in other parts of the nation. Animal manure contributes large quantities of nutrients in the south and parts of the northeast. Atmospheric deposition of nitrogen is generally greatest in areas of greatest precipitation, such as the northeast. Point sources (sewage and industrial) of nitrogen and phosphorus generally are predominant in watersheds near cities, where they may account for a large part of the nutrients in streams. Because no single nonpoint source is dominant everywhere, approaches to the control of contamination from nutrients must vary throughout the nation. Watershed-based approaches to understanding nonpoint and point sources of contamination, such as those used in NAWQA studies, will aid water-quality and environmental managers in the development of methods to reduce nitrogen and phosphorus pollution.

[1] U.S. Geological Survey, 12201 Sunrise Valley Drive, MS 413, Reston, VA 22092

NUTRIENT CONCENTRATIONS NEAR THE WATER TABLE OF THE SHEYENNE DELTA AQUIFER BENEATH CROPLAND AREAS—PRELIMINARY RESULTS FROM A RED RIVER OF THE NORTH BASIN LAND-USE STUDY

Tim K. Cowdery[1]

The U.S. Geological Survey is studying the effects of agriculture on water quality in the Sheyenne Delta aquifer in southeastern North Dakota. This study is part of a larger effort to evaluate the water quality in shallow aquifers within the Red River of the North drainage basin as part of the National Water-Quality Assessment program. The aquifer is a near-shore deltaic facies deposit composed of interbedded fine to medium sands and silts up to 120 feet thick. The main agricultural commodities produced in the area are corn and sunflowers. Lesser amounts of soybeans, small grains, potatoes, and beef are also produced. These crops are commonly irrigated with water from the surficial aquifer. The heavy rains during 1993 raised the water table to within one to two feet of the land surface in many areas. Historical ground-water nitrate concentrations from the aquifer range from less than 0.1 to 11 mg/L nitrate as nitrogen (NO_3-N). After the 1993 recharge, these concentrations ranged from less than 0.01 to 4.3 mg/L NO_3-N. These data suggest that this intense recharge substantially diluted the concentration of nutrients from agricultural activity in the area.

[1] U.S. Geological Survey, 2280 Woodale Drive, Mounds View, MN, 55112

NITRATE AND ATRAZINE IN SURFACE WATERS OF THE UPPER-MIDWESTERN UNITED STATES: AN EXAMPLE OF REGIONAL SYNTHESIS

David K. Mueller[1], *Barbara C. Ruddy*[1], *and William A. Battaglin*[2]

The National Water Quality Assessment (NAWQA) Program will sample water in 60 Study Units in the United States. Because it is not economically feasible to collect and analyze water samples everywhere contamination is suspected to occur, the NAWQA Program includes a National Synthesis component, one of the goals of which is to extrapolate information from the Study Units to estimate water-quality conditions over broad regions of the country. As a prototype for regional synthesis, water-quality data from a synoptic-sampling program in the Upper Midwest were analyzed to determine whether land use and other watershed characteristics could be used to estimate downstream water quality. Nitrate and atrazine concentrations were measured in water samples from 132 stream sites in 10 states during 5 synoptic surveys in 1989-90. Based on these data, logistic regression models were calibrated to relate the concentrations of these contaminants to characteristics of the watersheds upstream from the sampling sites. Results of the regression analysis indicate that watershed characteristics related to downstream nitrate concentrations include streamflow, crop cover, fertilizer use, soil drainage, population density, and climate. Characteristics determined to be related to downstream atrazine concentrations include streamflow, crop cover, time since planting, and climate. Predictions of nitrate and atrazine concentrations derived using these models were about 80-percent accurate. Many of the watershed characteristics included in the models can be determined from digital geographic-information-system (GIS) maps that are available for the United States. From these digital maps, data were compiled for characteristics of 294 watersheds, and the logistic models then were used to estimate concentrations of nitrate and atrazine throughout the upper-midwestern region.

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NATIONAL STUDY DESIGN FOR ASSESSING PESTICIDES IN STREAMS AND GROUND WATER

Robert J. Gilliom[1]

Concern about pesticides in the Nation's streams and ground water is one of the highest priority issues under study as part of the National Water Quality Assessment program. The national study design is based upon the use of a consistent study approach and sampling strategy in all 60 study units to assess the occurrence and levels of a broad range of pesticides in streams and shallow ground water associated with specific land-use and hydrologic settings. Land-use and hydrologic settings are chosen for study based upon a combination of local priorities in each study unit and national priorities for representing particular settings because of their regional extent or national importance. As a basis for national-level design, agricultural and urban land-use settings in all study units are classified in relation to national patterns in such factors as major crops and urban development densities. The land-use classifications, combined with hydrologic features, support a comparative assessment among occurrences and levels of pesticides in different settings. Major streams and aquifers affected by multiple settings are also assessed. Initial results from eight of the first 20 study units show contrasts and similarities in pesticides present in streams and ground water in different settings of the Nation and indicate how patterns will be interpreted in relation to present knowledge of pesticide use practices and the behavior of pesticides in particular hydrologic environments.

[1]U.S. Geological Survey, WRD, 2800 Cottage Way, Sacramento, CA 95825

INPUTS OF THE DORMANT ORCHARD PESTICIDE, DIAZINON, TO THE SAN JOAQUIN RIVER, CALIFORNIA

Joseph L. Domagalski and Neil M. Dubrovsky[1]

The organophosphate pesticide, diazinon, is applied as a spray to dormant almond and stone-fruit orchards in the San Joaquin Valley, California, during late December through January. A storm on the evening of February 7 and morning of February 8, 1993, with more than an inch and one-half of rain, produced runoff in the San Joaquin Valley and adjacent Coast Ranges. Two distinct pulses of pesticide inputs to the San Joaquin River resulted from contrasts between the soil texture and hydrology of the eastern and western valley. The fine soil texture and small size of the western tributary basins resulted in rapid runoff. Diazinon concentrations at Orestimba Creek peaked (3.8 micrograms per liter) within hours of the end of rainfall and then decreased because of a combination of dilution with pesticide-free runoff from the nearby Coast Ranges and decreasing concentration in the agricultural runoff. Data for the Merced River, a large eastern tributary, are sparse but suggest that peak concentrations occurred at least a day after those at Orestimba Creek. This may be attributable to well-drained soils and poorly integrated surface-water drainage networks that dominate the eastern valley, and the larger size of the Merced River basin.

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ASSESSMENT OF TRIAZINE HERBICIDES IN STREAMS IN NORTH CAROLINA AND VIRGINIA BY AN ENZYME-LINKED IMMUNOSORBENT ASSAY

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Approximately 418,000 pounds of triazine herbicides are applied annually to control weeds in crops grown in the Albemarle-Pamlico Sound drainage basin, located in North Carolina and Virginia. An enzyme-linked immunosorbent assay was used to detect concentrations of total triazine herbicides in streams draining into Albemarle-Pamlico Sound. Water samples were collected in May and June during the application of triazine herbicides and in early September during low streamflows at approximately 40 sites on streams in the Coastal Plain and Piedmont Physiographic Provinces. Triazine concentrations exceeded 0.2 μg/L (micrograms per liter) in 67 percent of the water samples collected in June, and 13 percent of the water samples exceeded 0.2 μg/L in September during low streamflows. The enzyme-linked immunosorbent assay for total triazine herbicides provides a low-cost and rapid analytical method for screening water samples prior to sending them to a laboratory and for semiquantitatively assessing seasonal concentrations of triazine herbicides in streams throughout a large region.

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INFLUENCE OF LANDUSE, WEATHER, AND WATERSHED CHARACTERISTICS ON PESTICIDE CONCENTRATIONS IN THE WHITE RIVER BASIN, INDIANA

Charles G. Crawford and Jeffrey D. Martin[1]

Samples for determination of pesticide concentrations in stream water were collected during 1991–93 from two small agricultural subbasins (60-100 square miles), one small urban subbasin (17 square miles), and a site near the mouth of the White River basin (11,300 square miles). Samples were collected once or twice weekly during the growing season (May–September) and once or twice monthly the rest of the year. Herbicides associated with corn and soybean production were found in highest concentrations during periods of runoff in late spring. Small rainfall events resulted in extremely high concentrations (100 micrograms per liter of atrazine, 200 micrograms per liter of cyanazine) when they occurred shortly after herbicide application. Peak herbicide concentrations were about 10 times greater in the smaller agricultural subbasin with permeable soils than in the subbasin with low-permeability soils on glacial till. The highest atrazine concentrations found in the White River near the mouth of the basin were about 10 micrograms per liter. Other pesticides, such as diazinon, were found in highest concentrations in the urban subbasin (1.1 micrograms per liter maximum concentration), but in low concentrations in the agricultural subbasins. Trace amounts of diazinon were found near the mouth of the basin, corresponding to the temporal pattern observed in the urban subbasin.

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OCCURRENCE OF PESTICIDES IN NESTED WATERSHEDS IN VIRGINIA AND WEST VIRGINIA

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Pesticide monitoring in nested agricultural watersheds indicates that the occurrence of pesticides is scale dependent in the Shenandoah River Valley. The Muddy Creek site (14.2 square miles) contributes to the much larger watershed of the Shenandoah River site (3,040 square miles). Atrazine, deethylatrazine, simazine, and metolachlor were detected throughout the sampling period (March 1993 - April 1994) at both sites, with highest concentrations in runoff from spring storms. Alachlor and cyanazine were detected at both sites, but only during spring application. Prometone, an herbicide with widespread nonagricultural use, was detected in less than half of the samples from the Muddy Creek site, but in higher concentrations and in all samples from the Shenandoah River site. Eleven additional pesticides were detected at concentrations near or below the analytical reporting level at the Muddy Creek site, whereas only two additional pesticides were detected at the Shenandoah River site. Many pesticides are used in the Shenandoah River Valley but only those pesticides with extensive use are frequently detected in the Shenandoah River. Many additional pesticides, however, might be detectable only in small watersheds such as Muddy Creek because of less extensive use and lower application rates.

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INTEGRATED ASSESSMENT OF PESTICIDES IN A SUBURBAN WATERSHED, ARLINGTON, TEXAS

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An integrated assessment of pesticides was conducted during 1993 with the collection of water, benthic invertebrate, and bed-sediment samples from Rush Creek and four ground-water samples in a watershed between Dallas and Fort Worth, Texas. The use of pesticides in the suburban watershed is mostly to maintain landscapes of residences, businesses, parks, and along roads. Other uses are for control of termites, fire ants, and other insects around residences and businesses. Common herbicides used are glyphosate, dicamba, diquat, 2-4,D, oxyfluorfen, atrazine, and triazine. Common insecticides used are diazinon, carbaryl, chlorphrifos, and malathion. Of the 17 different pesticides detected in water samples from Rush Creek, 7 were detected in more than 75 percent of the samples. Diazinon and atrizine were the most commonly detected pesticides and had the largest concentrations (2.3 and 2.0 micrograms per liter, respectively). The other frequently detected pesticides included simazine, prometon, chlorpyrifos, metolachlor, and carbaryl. Diuron was detected in tissue analysis of clams (*corbicula*). Pesticides were not detected in the bed-sediment samples. Water samples from three monitoring wells (less than 40 feet deep) and an irrigation well (100 feet deep) had no detectable concentrations of pesticides.

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OCCURRENCE AND DISTRIBUTION OF PESTICIDES IN GROUND WATER OF THE OZARK PLATEAUS OF ARKANSAS, KANSAS, MISSOURI, AND OKLAHOMA

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Pesticides were detected in 28 ground-water samples collected in the Ozark Plateaus in parts of Arkansas, Missouri, Kansas, and Oklahoma. A total of 100 ground-water samples were collected and analyzed for 88 pesticides and metabolites during 1993. These water samples were collected from 50 shallow domestic wells and 50 springs that tap the Springfield Plateau or Ozark aquifers. Pesticides were detected in 19 water samples from springs and in 9 water samples from wells. Pesticides were detected in 16 water samples from the Springfield Plateau aquifer and in 12 water samples from the Ozark aquifer.

A total of 14 pesticides were detected, with a maximum of 4 pesticides detected in any one sample. Maximum concentrations ranged from 0.002 micrograms per liter for DCPA to 0.23 micrograms per liter for tebuthiuron. The most commonly detected pesticides were atrazine (14 detections), prometon (11 detections), and tebuthiuron (6 detections). P,P' DDE, a metabolite of DDT, was detected in water samples from three wells and one spring. The remaining pesticides were detected in less than four samples. The occurrence and distribution of these pesticides probably is related to their chemical properties, local land use, and site characteristics, which could affect the susceptibility of ground water to surface contamination.

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RELATION OF PESTICIDES IN GROUND WATER TO LAND USE IN CONNECTICUT, MASSACHUSETTS, AND VERMONT

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During 1978-93, State and Federal agencies reported 40 pesticides or metabolites in ground water in the Connecticut, Housatonic, and Thames Rivers NAWQA study unit; most of the pesticides were associated with agricultural land use. Ethylene dibromide, formerly used on tobacco fields, was detected in water from 23 percent of 2,781 wells in central Connecticut and Massachusetts. Atrazine, simazine, and metolachlor were detected in water from 41 of 79 wells in corn fields in Connecticut and Vermont. Historical data on pesticides in ground water from other agricultural areas in the study unit, and from urban and forested areas, were limited. In 1993, water samples from 52 wells installed in unconsolidated sand and gravel aquifers were analyzed for a broad suite of pesticides to evaluate the relation of shallow ground-water quality to land use. Preliminary results indicate that water from 83 percent of the 23 wells in agricultural areas contained 1 or more of 16 pesticides, most commonly atrazine (detected in samples from 74 percent of the wells). Water from 54 percent of 13 urban wells contained 1 or more of 7 pesticides, most commonly prometon (detected in samples from 31 percent of the wells). Water from 44 percent of 16 wells in forested areas contained 1 or more of 5 pesticides, most commonly carbaryl (detected in samples from 19 percent of the wells).

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PESTICIDES IN SHALLOW GROUND WATER UNDERLYING AGRICULTURAL AREAS OF THE SAN LUIS VALLEY, COLORADO

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The San Luis Valley, in south-central Colorado, is a high (approximately 7,500 feet above sea level) agricultural area near the headwaters of the Rio Grande. The water table in the valley's unconfined aquifer is shallow, ranging from 3 to 35 feet below land surface, and is recharged primarily by irrigation water diverted from the Rio Grande. Soils are mostly sand and gravel, with numerous cobbles. Approximately 1,950 center-pivot sprinklers are used to irrigate potatoes, barley, wheat, alfalfa, and vegetables. Pesticides are applied by various methods, including chemigation, surface application, and aerial application, but at lower rates than comparable agricultural areas in the southwestern United States. In the summer of 1993, 35 shallow monitoring wells were installed in the agricultural area where irrigation wells pump water from the unconfined aquifer. Water samples were taken from the top 10 feet of the aquifer. Four pesticides--metolachlor, metribuzin, prometon, and p,p' DDE--were detected at or slightly above the method detection level in water from 5 of the 35 wells. Pesticide detection may have been influenced by the timing of the sampling, which was near the end of the growing season.

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GEOCHEMICAL PROCESSES THAT FAVOR MOBILIZATION OF ARSENIC, CHROMIUM, SELENIUM, AND URANIUM IN THE CENTRAL OKLAHOMA AQUIFER

Jamie L. Schlottmann[1], Elwin L. Mosier[2], and George N. Breit[3]

Dissolved arsenic, chromium, selenium, and uranium concentrations in the Central Oklahoma aquifer locally exceed established or proposed drinking-water standards. These high concentrations are the result of natural conditions within the Permian red-bed sandstones and mudstones. Mineralogical and sequential chemical-extraction analyses of aquifer rocks indicate that the elements enter the ground water by oxidation, pH-related desorption from ferric oxides, and dissolution. Most of the ground water contains measurable dissolved oxygen, indicating oxic conditions. The oxic conditions cause the elements to be in their relatively soluble highest oxidation states. Local, slightly reducing conditions indicated by dissolved ammonium, excessive dissolved iron, or less than 1 milligram per liter dissolved oxygen, favor reduced forms of chromium and selenium that are relatively insoluble. High arsenic, chromium, and selenium concentrations are limited to water with pH values above 8.5, 8.3, and 6.9, respectively, as a result of pH-related desorption. Dissolved uranium concentration is related to the activity of dissolved carbonate ions because of uranyl-carbonate complex formation, which favors uranium dissolution and desorption. The high pH and carbonate-ion activity are a result of dolomite dissolution and exchange of dissolved calcium and magnesium for sodium in mixed-layer clay minerals.

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SOURCES OF DISSOLVED ARSENIC, CHROMIUM, SELENIUM, AND URANIUM IN PERMIAN ROCKS OF THE CENTRAL OKLAHOMA AQUIFER

George N. Breit[1], Elwin L. Mosier[2], and Jamie L. Schlottmann[3]

Natural conditions within the Central Oklahoma aquifer produce concentrations of dissolved arsenic, chromium, selenium, and uranium that exceed established and proposed drinking-water standards. The high concentrations exist even though the concentrations of these elements in the Permian sandstones and mudstones that form most of the aquifer are similar to values typical of sedimentary rocks. To identify sources of these elements within the aquifer, rock samples from test-hole cores were analyzed mineralogically and chemically.

High concentrations of arsenic, chromium, selenium, and uranium were found in solids disseminated among the major rock-forming minerals. Arsenic was detected in some ferric oxyhydroxides and rare grains of residual pyrite. Chromium is locally abundant in ferric oxyhydroxides and clay minerals. Selenium forms clausthalite (PbSe) and native selenium. Metatyuyamunite (Ca(UO2)2(VO4)2•H2O), a uranium titanate, and a uranium silicate were recognized uranium-rich solids.

Rock samples were treated with chemical reagents to simulate the natural processes of desorption, mineral dissolution, and oxidation believed to be active in the aquifer. Results indicate that arsenic, selenium, and uranium are released by desorption from iron oxides, selenium is mobilized by oxidation, and chromium and uranium are added to the ground water partly through mineral dissolution.

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DISTRIBUTION AND SOURCES OF URANIUM IN GROUND WATER IN THE CARSON RIVER BASIN, WESTERN NEVADA AND EASTERN CALIFORNIA, U.S.A.

James M. Thomas, Alan H. Welch, and Linda S. Gunderson

The Carson River basin is an internally drained basin within the semi-arid northern Basin and Range physiographic province. Uranium concentration in ground water ranges three orders of magnitude as a result of a variety of geochemical conditions and the impact of man's activities. The hydrologic and geochemical conditions present in the Carson River basin are similar to other areas in the arid west. In the upper part of the Carson River basin, dissolved uranium activity in ground water is generally less than 10 picocuries per liter (pCi/L). Uranium is released by weathering of granitic and acidic volcanic rocks within the Sierra Nevada batholith and sedimentary deposits in the basins derived largely from these rocks. Results of alpha radiography indicate that uranium and its alpha-emitting progeny in the ground water are deposited on mineral coatings and fine-grained sediment, some of which are transported by fluvial processes. Uranium released by weathering is also adsorbed by sedimentary organic matter. Thus, uranium is transported as solutes and on sediments within the basin. The highest measured uranium activity in ground water is in shallow ground water in the downstream end of the Carson River basin, where concentration locally exceeds 300 pCi/L. The shallow aquifer matrix consists, in part, of sediments derived from the upper parts of the basin that have uranium-bearing coatings. As a result of a rise in the water table due to local irrigation, uranium is being released from the sediments into the ground water. The release of uranium appears to be produced by the reaction of iron and manganese oxide coatings with sedimentary organic matter. This reaction releases uranium from these phases and produces anoxic, but low, sulfide water.

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MULTISCALE APPROACHES TO EVALUATING REGIONAL CHEMICAL PROCESSES AND TRACE-ELEMENT DISTRIBUTION

Neil M. Dubrovsky and John M. Neil[1]

From 1985 through 1989, a three-tiered study design was used to determine the distribution and geochemical processes affecting selenium concentrations in the regional aquifer of the San Joaquin Valley, California. First, 273 production wells were sampled valley-wide to describe the selenium distribution in the regional aquifers. Second, monitoring wells were installed along ground-water flow lines from the Coast Range to the valley trough in critical subregions in the western San Joaquin Valley. Third, a specific site was investigated to evaluate selenium mobility in chemically reduced parts of a regional aquifer. Selenium concentrations in the production wells rarely exceeded 10 micrograms per liter; in contrast, data from the monitoring wells showed that leaching by irrigation water produced a zone of recently recharged ground water with selenium concentrations greater than 100 micrograms per liter in the upper 30 to 60 meters of the aquifer. The site-specific data showed that selenium is removed from downward-moving shallow ground water by microbially-mediated reduction to insoluble species. Selenium therefore is not mobile in the reducing conditions that predominate in the most productive zone of the regional aquifer in the western San Joaquin Valley.

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EFFECTS OF LAND USE ON THE OCCURRENCE AND DISTRIBUTION OF SELECTED TRACE ELEMENTS IN THE KENTUCKY RIVER BASIN, KENTUCKY

Kim H. Haag[1] *and Stephen D. Porter*[2]

The occurrence and distribution of metals and other trace elements in water and sediment in the Kentucky River Basin, Kentucky, were investigated by the U.S. Geological Survey during 1987-90. Highest concentrations of antimony, arsenic, molybdenum, selenium, strontium, uranium, and vanadium in streambed sediments were generally correlated with bedrock geology and lithology in the basin. Concentrations of barium, chromium, and lithium in streambed sediments were highest in streams that received brine discharges from oil-production areas. Highest concentrations of lead and zinc in streambed sediments were generally associated with urban stormwater runoff, municipal and industrial point-source discharges, and landfills. Significant upward trends in the concentrations of aluminium, iron, and manganese were indicated at one or more sampling sites that received drainage from coal-mine areas. Estimated mean annual loads and yields for most metals and other trace elements were correlated to the transport of suspended sediment. Water-quality criteria established by the U.S. Environmental Protection Agency and the State of Kentucky for concentrations of aluminium, beryllium, cadmium, chromium, copper, iron, manganese, nickel, silver, and zinc were exceeded in filtered water samples at one or more fixed sampling sites in the Kentucky River Basin.

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GEOCHEMICAL CHARACTERIZATION OF STREAMBEDSEDIMENT IN THE UPPER ILLNOIS RIVER BASIN

John A. Colman[1] and Richard F. Sanzolone[2]

Geochemistry of fine-fraction streambed sediments collected from the upper Illinois River basin was surveyed in the fall of 1987 as part of the U.S. Geological Survey National Water-Quality Assessment pilot projects. The survey included 567 samples analyzed for 46 elements. Three distinctive distribution patterns were found for seven U.S. Environmental Protection Agency priority pollutants surveyed, as well as for boron and phosphorus: (1) enrichment of elements in the Chicago urban area and in streams draining the urban area relative to rural areas, (2) enrichment in main stems relative to tributaries, and (3) enrichment in low-order streams at high-population-density sites relative to low-population-density sites. Significant differences in background concentrations, as measured by samples from low-order streams, were observed among five subbasins in the study area. Uncertain geochemical correspondence between low-order, background sites and high-order, generally metal enriched sites prevented determination of background levels that would be appropriate for high-order sites. The within-sample ratio of enriched elements was variable within the Chicago area but was constant in the Illinois River downstream from Chicago. Element ratios imply a composite fine-fraction sediment in the Illinois River of 35-40 percent Des Plaines River origin and 60-65 percent Kankakee River origin.

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EFFECT OF GEOLOGY AND HUMAN ACTIVITIES ON THE DISTRIBUTION OF TRACE ELEMENTS IN WATER, SEDIMENT, AND AQUATIC BIOTA, YAKIMA RIVER BASIN, WASHINGTON, 1987-91

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Distributions of many trace elements in aquatic media in the Yakima River Basin result from geologic sources in forested landscapes of the High Cascades and from human activities in agricultural and urban areas. The High Cascades might be classified as "pristine", yet the effect of geologic sources in some areas results in concentrations of (1) arsenic, chromium, and nickel in streambed sediment which are nearly 4 to as much as 13 times higher than their respective median concentrations in agricultural and urban areas, and (2) selenium in whole sculpin which are 3 times higher than the median concentration in the Basin--similar patterns exist for trace elements in suspended sediment. Geologically-derived arsenic, chromium, mercury, and nickel concentrations in the main stem, although still high, decrease by about a factor of 3, by mixing with element-poor streambed sediment eroded from agricultural lands in the Upper Basin. In the Mid and Lower Valley, however, the effect of geology is dampened, and human activities increase concentrations of arsenic, cadmium, copper, lead, mercury, selenium, and zinc in sediment and (or) aquatic biota. Lead concentrations in streambed sediment and caddisflies, respectively, are 2 and 15 times higher in urban and agricultural areas than in areas minimally influenced by human activity.

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EFFECTS OF MINING ON WATER QUALITY IN THE UPPER COLORADO RIVER BASIN

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Acid mine drainage is a critical water-quality issue in the Upper Colorado River Basin. Twenty-seven streams in the basin have been identified as having substantial amounts of metals contributed by mines from complex ore metal deposits. Precipitation of hydrous metal oxides in two stream reaches greatly decreased the abundance of periphyton and benthic invertebrates. Concentrations of cadmium and lead exceeded Colorado State aquatic-life standards in 23 of the identified streams, and zinc and copper concentrations exceeded aquatic-life standards in 17 streams. Mercury, silver, manganese, nickel, gold, aluminum, and iron exceeded aquatic-life standards in three streams. The effect of mines on fisheries ranged from no noticeable effect to complete depletion of fish populations. Generally, fish populations were minimal in mine-affected stream reaches, and the species distribution, number, and size of fish were limited by metals concentrations. Manganese concentrations exceeded agricultural and drinking-water standards in 7 streams, and concentrations of cadmium, copper, zinc, lead, and iron exceeded these standards in three streams. Further investigations on the status, trends, fate, and transport of metals in these streams and their effect on biota are needed.

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RELATIONSHIPS BETWEEN LAND USE AND TRACE-ELEMENT CONCENTRATIONS IN BED SEDIMENT OF THE WILLAMETTE BASIN, OREGON, 1992-93

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Concentrations of 15 trace elements in the <62-µm fraction of bed sediment from 47 sites in the Willamette Basin were evaluated as part of the National Water-Quality Assessment (NAWQA) Program and two related projects. All studies used NAWQA sample collection, processing, and analysis protocols. The sites represent forested watersheds, watersheds with municipal and industrial point sources, and watersheds receiving nonpoint-source contributions from urban, agricultural, and mined areas. As, Cd, Pb, Hg, Ag, and Zn concentrations were elevated in bed sediment from urban basins. For example, median Pb concentrations in urban basins were three to eight times those from basins with forested, agricultural, or mixed land use. Median Mn concentrations were greatest in agricultural basins, and the highest Se concentrations typically were found in forested basins. Maximum Hg and elevated Cu concentrations occurred downstream from historic mining activities. Concentrations of Sb, Co, Cr, Fe, Ni, and V were not obviously related to land use. Of the 15 trace elements considered, eight (As, Co, Cu, Fe, Pb, Mn, Hg, Zn) exceeded the corresponding 95th percentiles for concentrations in western U.S. soils, four (Cr, Ni, Se, V) were about equal to their respective 95th-percentile concentrations in western U.S. soils, and three (Sb, Cd, Ag) had no distribution statistics from western U.S. soils for comparison.

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OCCURRENCE OF MERCURY IN BED SEDIMENTS AND AQUATIC BIOTA IN WESTERN REGION NAWQA STUDY UNITS

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As part of the U.S. Geological Survey's National Water-Quality Assessment Program, 100 sites have been sampled for mercury in bed sediments and aquatic biota in six major drainage basins in five western states. In addition to stream-bed sediments, tissue mercury concentrations were assessed for eleven species of fish and seven species of aquatic invertebrates. Sediments and biota were collected from riverine locations encompassing a wide range of water-quality conditions, including relatively undisturbed headwater reaches to locations impacted by metal-mining activities. Overall, the median sediment mercury concentration was 0.06 ug/g dry wt., with 20% of the sites exceeding the Lowest Effect Level for mercury in sediments of 0.2 ug/g dry wt. recommended by the Canadian Environmental Ministry for the protection of aquatic life. The highest median tissue level of mercury occurred in fish (0.20 ug/g dry wt.), with lower median concentrations in the Asiatic clam Corbicula fluminea (0.17 ug/g dry wt.), and Hydropsychid caddisfly larvae (0.06 ug/g dry wt.). Mercury levels in aquatic biota were positively correlated with sediment mercury concentrations (R2=0.62; P=<.001), and, in general, assessment of fish tissue provided the best spatial characterization of mercury occurrence among drainage basins.

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BIOLOGICAL COMPONENTS OF THE NATIONAL WATER-QUALITY ASSESSMENT (NAWQA) PROGRAM

Martin E. Gurtz[1]

The U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program uses a multidisciplinary approach that integrates physical, chemical, and biological data to assess water quality in the Nation's streams and rivers. Biological community sampling, physical habitat characterization, and tissue studies are conducted, along with appropriate hydrologic and chemical data-collection activities, at fixed sites and synoptic survey sampling locations as part of each study-unit investigation. The NAWQA Program has developed nationally consistent biological sampling methods so that results can be compared across different river basins and geographic regions. These methods are described in a series of published protocols that build on scientific understanding from multiple disciplines, including aquatic community ecology, geomorphology, botany, and ecotoxicology. The protocols provide consistent methods for (1) sampling and processing aquatic organisms to analyze tissues for organic and inorganic contaminants; (2) collecting samples of algal, benthic invertebrate, and fish communities; (3) characterizing instream and riparian habitat; and (4) processing invertebrate samples and assuring the quality of the data. Development of these protocols has been enhanced through communication with scientists from universities and other agencies.

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BENTHIC-MACROINVERTEBRATE COMMUNITIES AND WATER QUALITY IN AGRICULTURAL AND URBAN SUBBASINS IN THE GREAT VALLEY CARBONATE SUBUNIT OF THE POTOMAC RIVER BASIN

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Ecological surveys were conducted in the late summer of 1993 at 25 stream sites, as part of a synoptic sampling that related water quality to ecology and land use in the carbonate region of the Great Valley of the Potomac River Basin. The surveys included habitat assessments and benthic-macroinvertebrate sampling. Water samples were analyzed for physical properties, nutrients, major ions, and pesticides.

The Great Valley carbonate subunit encompasses about 2,500 square miles, or about 17 percent of the Potomac River basin. Drainage areas for the 25 sampling sites range from 3.6 to 20 square miles. Eighteen of the 25 drainage areas are dominated by agricultural land use, and the other 7 are strongly affected by local urban areas.

Sampling reaches at each site included two representatives of each geomorphic channel unit present in the stream segment--riffle, run, or pool. Composite benthic-macroinvertebrate samples were collected from the richest-targeted habitat, usually a riffle. Habitat assessment consisted of geomorphic characterizations of the channel, bank, and flood plain. Ecological conditions were described using community structure information, including taxa richness, diversity, functional feeding groups, and mode of existence.

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STREAM MACROINVERTEBRATE COMMUNITIES IN WATERSHEDS WITH DIFFERENT LAND USE CHARACTERISTICS IN THE APALACHICOLA-CHATTAHOOCHEE-FLINT RIVER BASIN

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Benthic macroinvertebrate communities are being assessed as indicators of water-quality in the Apalachicola-Chattahoochee-Flint River basin of Florida, Alabama, and Georgia as part of the National Water Quality Program. Non-point source influences on water-quality in 20 watersheds representing silviculture, poultry agriculture, row-crop agriculture, suburban and urban land uses are being studied in the Apalachicola-Chattahoochee-Flint River basin. Four watersheds are associated with each of these land use categories. The watersheds, which range in size from 15 to 86 square miles, do not have permitted point source discharges. Benthic invertebrate commonties were sampled to assess the cumulative effect of upstream influences on water-quality in each of these basins. It is hypothesized that species richness and diversity (1) are similar among watersheds within land use categories, and (2) decrease with increasing land disturbance and urbanization. Qualitative samples of benthic macroinvertebrates were collected in each watershed in June 1993 using a 210 um aquatic net, and composited from all habitat types present within a stream reach of at least 150 m in length. Dissolved oxygen concentration, pH, alkalinity, specific conductance, water temperature, and discharge were measured at the time of sample collection. In addition, water samples were collected to determine the concentrations of ammonia; nitrite, nitrate, orthophosphate, total phosphorus, dissolved and suspended organic carbon, and suspended sediment. In-stream (depth, velocity, substrate characteristics) and riparian habitat assessments were also conducted. Sampling was repeated in June 1994 and will be repeated in June 1995 to assess short-term trends in benthic invertebrate communities.

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USING MULTIPLE LINES OF EVIDENCE TO ASSESS WATER QUALITY IN THE SOUTH PLATTE RIVER BASIN

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Ecological surveys of invertebrate communities, physical and chemical variables, and contaminants in fish tissue and bed sediment were used to assess water quality in the South Platte River Basin. Invertebrate communities were sampled and physical and chemical measurements were taken basinwide during summer 1992. Ordination of sites based on taxonomic structure of the invertebrate community was done using detrended correspondence analysis, and sites were divided into four groups: mountains, plains/tributary, plains/braided channel, and plains/downstream from point source. Differences among site groups were related to physical (gradient, channel width, temperature) and chemical (conductivity, nutrient concentrations) attributes of the sites and their associated land use. The number of taxa was greater in mountain sites (25) compared to all plains sites (<18) and lowest in plains/downstream from point-source sites (11). Whole fish and fine-grained bed sediment were analyzed for organochlorine compounds. Total DDT (T-DDT) and total chlordane (T-Chlor) concentrations were greater in fish tissue (mean = 274 μg/kg T-DDT; 54 μg/kg T-Chlor) than in bed sediment (mean = 5 μg/kg T-DDT; 2 μg/kg T-Chlor) and both varied with land use (T-DDT highest in agriculture; T-Chlor highest in urban). Integration of results from the ecological surveys, physical and chemical variables, and contaminants in fish tissue and bed sediment indicate that water quality is related to land-use practices in the South Platte River Basin.

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RELATION OF FISH COMMUNITIES TO PHYSICAL AND CHEMICAL VARIABLES AT NINE STREAM SITES IN THE PLATTE RIVER BASIN

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Species composition of fish communities was related to selected physical and chemical variables at nine sites in the Platte River basin from North Platte, Nebraska downstream to the confluence with the Missouri River near Omaha, Nebraska. The multivariate data included abundances for 36 fish species, characteristics of the nine drainages, site-specific habitat and water-quality characteristics measured during the 1993 water year. Land-use variables were calculated for the entire drainage area at sites draining less than 4,000 km2, and for the lower 4,000 km2 of larger drainages. Canonical correspondence analysis was used to relate environmental characteristics to species data. This method restricts the number of environmental variables to be less than the number of samples. To reduce the number of variables a correlation matrix of 37 variables was examined. Many variables such as concentrations of four herbicides, nutrients, and dissolved organic carbon were highly correlated with each other and with the percentage of the drainage area in cropland. Six variables selected for analysis were: percentage of drainage area in cropland, maximum water temperature, minimum suspended sediment concentration, channel slope, time since a flow of 99 percent exceedance, and the ratio of stream width to depth. These variables explained 64 percent of the variability in species data. Ordination of the fish community data showed that larger river sites which typically had more fish species than smaller sites were grouped together. Two sites draining areas with more than 90 percent cropland were grouped together. Another drainage dominated by cropland was isolated in the ordination. This site had the fewest fish species (4) and lowest total abundance (43). A site in the Nebraska Sandhills, predominantly herbaceous rangeland, also was isolated in the ordination.

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PHYSICAL HABITAT AND FISH COMMUNITY STRUCTURE IN THE TRINITY RIVER BASIN, TEXAS

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Determinants of fish community structure that often are overlooked in water-quality-monitoring programs include measures of channel form and hydraulic stress, particularly in partially channelized and flow-regulated systems such as the Trinity River Basin. Fish species richness and diversity were derived for twenty-eight sites in the basin and compared to basin and reach-level hydraulic parameters such as mean annual discharge, coefficient of variation of mean annual discharge, basin area, ratio of discharge to basin area, mean channel width, and the ratio of bank height to channel width. Mean annual discharge, coefficient of variation of mean annual discharge, and the ratio of discharge to basin area had the highest loadings on the first principal component of a prinicipal components analysis that accounted for 66 percent of the variation among sites. As a measure of flow variability, the coefficient of variation of mean annual discharge had a significant negative correlation with fish species diversity (r_s =-0.900, $p < 0.05$). An increased understanding of the relations between fish community structure and physical habitat can provide water-resource managers with information that is important in generating policies regarding water-quality conditions in natural and regulated streams.

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RESPONSES OF FISH AND MACROINVERTEBRATE COMMUNITIES TO VARIATIONS IN HABITAT AND WATER QUALITY IN STREAMS OF THE SAN JOAQUIN VALLEY, CALIFORNIA

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The San Joaquin-Tulare Basins study unit of the U.S. Geological Survey's National Water Quality Assessment Program includes 28,500 square miles in central California. In 1993, 13 stations were sampled ranging from relatively pristine sites in the Sierra Nevada to a small creek used as an agricultural drain. A total of 31 species of fish were captured; ten were native to California and 21 were introduced. Multivariate analyses identified three major groups of co-occurring species, one composed of native fishes and the other two of introduced fishes. The abundance of one introduced species group, characterized by minnows, was positively associated with increased specific conductance, hardness, pH, and nutrients. This group also was positively associated with streams of fine substrate and little instream cover. The native species group was negatively associated with both sets of variables. The other group of introduced species, characterized by bass and sunfish, was positively associated with stream discharge, depth, and width but was not related to water quality. Macroinvertebrates, especially insects, were most diverse at the Sierra Nevada sites. The diversity of mayflies, caddisflies, and stoneflies was especially low on the valley floor. Both fishes and macroinvertebrates were useful indicators of water quality and habitat conditions.

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MULTIVARATE ANALYSES OF RELATIONS BETWEEN FISH COMMUNITY STRUCTURE AND ENVIRONMENTAL CONDITIOINS IN SELECTED ILLINOIS BASINS, 1982-84

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As part of the U.S. Geological Survey's National Water-Quality Assessment Program study of the upper Illinois River Basin, detrended correspondence analysis (DCA), principal components analysis (PCA), and the Illinois Department of Conservation's alternate index of biotic integrity (AIBI) were used to analyze existing fish community, water-quality, streambed-sediment quality, and habitat data. The AIBI is an adaptation of Karr's index of biotic integrity (IBI).

Results of the analyses indicate that fish community structure was more strongly related to water-quality and streambed-sediment quality than to habitat conditions. Streams in the agricultural Fox River Basin had the smallest concentrations of chemical constituents associated with urban runoff and point-source discharges, similar DCA scores, the highest AIBI scores, and relatively diverse fish communities, including several intolerant species. Streams in the more heavily urbanized Des Plaines and DuPage River Basins had higher concentrations of constituents associated with urban runoff and point-source discharges, lower AIBI scores, and fish communities with fewer, more tolerant species.

Results of analyses that used DCA were in close agreement with analyses that used the AIBI. This indicates that multivariate methods such as DCA are useful tools for regional water-quality assessments. Multivariate methods are also useful in designing, testing, and validating multi-metric indices.

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DISTRIBUTION OF BENTHIC ALGAE IN THE YAKIMA RIVER BASIN, WASHINGTON, IN RELATION TO GEOLOGY, LAND USE, AND OTHER ENVIRONMENTAL FACTORS

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Benthic-algal distributions in the Yakima River basin were examined in relation to geology, land use, water chemistry, and stream habitat using indicator-species classification (TWINSPAN) and canonical correspondence analysis (CCA). Algal assemblages identified by classification were each associated with a narrow range of chemical-constituent concentrations. In the Cascade Range, where timber harvesting and grazing are the dominant land uses, differences in community structure (CCA site scores) and concentrations of major ions (Ca and Mg) and nutrients (P, Si, and inorganic N) varied with dominant rock type of the basin. Differences in community structure in agricultural areas of the Columbia Plateau were based primarily on the degree of enrichment in dissolved solids, inorganic N, and solute P originating in irrigation-return flows and subsurface drainage. Habitat characteristics correlated with community structure included reach altitude, turbidity, embeddedness (Columbia Plateau), large woody-debris density (Cascade Range), and composition/density of the riparian vegetation. Algal biomass correlated with composition/density of the riparian vegetation but not with measured chemical-constituent concentrations. Nitrogen limitation in streams of the Cascade Range favored nitrogen-fixing bluegreen algae and diatoms with endosymbiotic bluegreens. Benthic-algal composition in the Yakima River ranged from oligotrophic species in segments unaffected by irrigation-return flows to eutrophic species in the extensively-irrigated lower basin.

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