Water Resources Institute

Annual Technical Report

FY 1999

Introduction

The University of Wisconsin Water Resources Institute (WRI), based at the University of Wisconsin-Madison, is an academic unit of the Graduate School and works with the University's Office of Research Administration, which ensures compliance with university, state, and federal guidelines. With nearly 75% of its current base budget targeted for research, the WRI is supporting 27 individual research projects that address a wide range of issues and problems. Research projects fall into the following four thematic areas: groundwater, surface water, groundwater/surface water interactions, and drinking water initiatives. Faculty, staff, and students at the University of Wisconsin System campuses at Madison, Milwaukee, Stevens Point, and Parkside, the University of Wisconsin-Extension, the Wisconsin State Laboratory of Hygiene, the U.S. Geological Survey, and individuals in private industry are participating in projects supported through the WRI. Charged with the primary mission to plan, develop and coordinate research programs that address present and emerging water- and land-related issues, the WRI has developed a broadly based statewide program of basic and applied research which has effectively confronted a spectrum of societal concerns. Institute staff, University of Wisconsin System faculty, staff, and students, public officials, state administrators, industry, and the public have come to rely on the WRI for objective, timely scientific information. The WRI ensures that this information reaches these individuals through its strong information dissemination/technology transfer program. An integral part of the WRI's total program is the training of students. Research projects have provided support and training for graduate and undergraduate students pursuing a wide range of disciplines. In May 1984, a Comprehensive Groundwater Protection Bill for Wisconsin (1983 Act 410, Wisconsin Statutes) was signed into law. One of the provisions of the bill was to include a state Groundwater Coordinating Council (GCC) appointed by the legislature and the governor. Advisory to the GCC is the Groundwater Advisory Council (GRAC), which is appointed by the Chancellor of the University of Wisconsin-Madison. Because groundwater protection is deemed a priority issue by the WRI, the GRAC serves as an important advisory committee for the WRI. The GRAC, composed of a diversity of representatives with a great deal of scientific, political and administrative experience, has helped the WRI identify current and anticipated water problems and issues and establish priorities for initiating research projects. Since July 1989 the state has provided line item funding for groundwater research to the University of Wisconsin System. This Groundwater Research Program, administered by the Water Resources Institute, currently funds 14 projects that provide a balanced program of laboratory, field, and computer modeling studies and applications designed to preserve or improve groundwater quality. The following report summarizes our institute's achievements for fiscal year 1999. In addition to describing our projects supported through U.S. Geological Survey funds, we also describe our other projects that are an integral part of our programmatic objectives.

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Use of Specific Sorbents and Rapid Bioassays for Groundwater Monitoring
Project Number	C-02
Start Date	09/01/1997
End Date	06/30/1999
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Toxic Substances
Focus Category #3	Methods
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
John M. Harkin	Professor	The University of Wisconsin	01
John M. Harkin	Professor	The University of Wisconsin	01
Ronald Crunkilton	Professor	The University of Wisconsin	02

Problem and Research Objectives

Groundwater contamination by pesticides and other organic compounds is a widespread problem in rural midwestern states, especially in areas of intensive agriculture and shallow or sandy soils. Detection of groundwater pollution using analytical methods is well documented, but its effects are not well known. To assess the acceptability of well water for human consumption, scientists usually analyze samples for chemicals such as hydrocarbons and fertilizer and pesticide residues and review toxicity testing information -- mostly on laboratory rodent species -- to estimate aggregate risks. This approach is slow, expensive and unable to account for additive, offsetting, synergistic, or antagonistic effects of mixtures of trace chemicals commonly encountered in drinking water. This problem is compounded by the fact that most contaminants exist in groundwater at concentrations below those detectable by inexpensive analytical methods. Analytical scans with state-of-the-art instrumentation needed for low level analysis are cost prohibitive for the typical groundwater user. There is a need to employ new cost effective assessment tools that directly measure potential health effects of ambient levels of contaminants in groundwater. This approach has been successfully applied to detect toxins found in surface water and written into permit compliance monitoring protocols in many states. Biomonitoring or toxicity testing is an established screening tool that can be used directly to assess the outcome of complex contaminant interactions in water samples, but this approach has yet to be applied in a systematic manner to the identification of potential hazards from exposure to groundwater pollution. Measurements of toxicity are not intended to replace chemical quantification methods. However, they can make better use of analytical time by screening samples for biological effects and using that

information to prioritize samples for more expensive chemical testing.

Methodology

Sample collection: Extensive groundwater monitoring will be accomplished at existing sites with known groundwater flow patterns and already containing numerous groundwater monitoring wells: Many wells are available from Wisconsin studies of groundwater contamination by aldicarb in the Wisconsin Central Sands area around Stevens Point, atrazine at a farm near Waunakee, a variety of pesticides at a pesticide-loading facility near Clinton, and various sites contaminated by volatile organic compounds including petroleum hydrocarbons and trichioroethylene. Appropriate sorbents with which we have prior experience include semipermeable membrane devices (SPMDs), C18 Sep-pak cartridges, and blue rayon. SPMDs will be deployed directly within each monitoring well. Lipophilic contaminants concentrate long-term in situ using SPMDs filled with synthetic triolein and the sorbates are readily extracted by dialysis against hexane. The hexane extracts are simply evaporated to dryness to produce toxicant mixtures for testing. Water concentrations of contaminants can be back-calculated from residues accumulated in the triolein, using the formula Cw = CL ML/Rsct where Cw is aqueous concentration of analyte, CL is concentration of analyte in triolein, ML is mass of lipid, Rsc is effective sampling rate in L/day, and t is SPMD exposure in days. C1g Sep-pak cartridges specifically sorb nonpolar organics of any kind from aqueous media and are currently being used in piezometers to sample contaminants in the stream bed of the Little Plover River near UW-SP. The hydraulic head in peizometers in zones of upwelling is sufficient to move water through the columns. The river, being primarily groundwater-fed and within a mostly agricultural watershed, is a prime target for pesticide contamination. Piezometers are in place at 200-foot intervals along a 6-mile length of this stream. Sorption of contaminants in the C18 cartridges occurs throughout the exposure period. The concentrated organics are eluted with a non-polar solvent. Extracts can be evaporated to dryness and reconstituted in an appropriate vehicle for bioassay or GC testing. Contaminant concentrations in water can be directly determined from the filtrate volume passed through the cartridge. Blue rayon is a relatively new concentration device used in aqueous systems. It is a specific sorbent for non-polar planar compounds with three or more fused rings. This sorbent is most appropriate for groundwater contaminated with petroleum hydrocarbons or urban runoff containing PAHs, whose toxicity can be differentiated from that of pesticide residues in subsequent bioassays. Blue rayon sorbates are simple to extract with methanolic ammonia and to concentrate to dryness under reduced pressure. Residues are dissolved in a solvent appropriate for bioassay protocols. The technique is particularly useful because no cleanup is necessary before analysis or bioassay. Chemical analysis of sorbates to elucidate constituents contributing to toxicity will be performed by GC-MS in the UW-SP's Environmental Task Force Laboratory. The volume of water to which the in-situ samplers (blue rayon and SPMDs) will be exposed, and sampled, will be determined by calculating the rate of groundwater flow through the fixed volume of the sampling device that allows for lateral flow, but not vertical flow. Since monitoring wells are in areas of well-established groundwater flow, the flow velocity within the aquifer is known through the use of bromide tracer studies or estimated from knowledge of the hydraulic conductivity and gradient. Therefore, the rate of flow through the fixed volume of the sampler over time provides the total amount of water sampled. Toxicity testing: SMP tests will be conducted at UW-Madison using protocols developed for use with an automated 96-well microtiter-plate reader. SMP are added to buffer, reaction substrates, and sorbate concentrates dissolved in an appropriate vehicle (e.g. water, alcohol/water, or DMSO/water mixtures). Reactions are monitored spectrophotometrically at 340 nm in a kinetic assay to assess the rate of reduction/oxidation of NADLH) catalyzed by electron transfer and energy coupling within the SMP as the toxicological endpoint. Reaction rates of toxicant trials are compared to rates with vehicle controls to determine the extent of redox-activity inhibition, which occurs in a reproducible dose-response fashion. With the microplate method, multiple variants of the

SMP test can be run simultaneously. Since these afford different sensitivities reliant upon various idiosyncracies of mitochondrial respiration, their use increases the likelihood of detecting toxicity compared to any single assay, especially when substance mixtures are being tested. Because of the small volume required per test, only tiny amounts of extracted toxicant are needed, so that many replicates can be conducted with any sample. Commercially available photoluminescent bacterial bioassays (Microtox/Mutatox) will be employed to assess the toxicity/mutagenicity of sample extract at UW-SP for comparison with the SMP bioassays. Both tests correlate well with whole-organism and in-vitro assays.

Principal Findings and Significance

Water samples obtained from impacted groundwater wells at the various study sites were collected, extracted, and underwent chemical analysis and bioassay procedures. In general the SMP bioassay results were predictive of contamination identified in analytic scans especialy at sites that were highly impacted, while the Microtox assay was less predictive. In part, this results from the Microtox bacteria's sensitivity to elemental sulfur present at toxic concentrations in some groundwater well extracts. This result emphasizes the importance of removing sulfur via a copper cleanup method prior to testing extracts using the Microtox assay. The SMP assay is far less sensitive to sulfur toxicity and its presence is of less concern. The bioassays, however, were not sensitive to low levels of contamination - reinforcing the argument for using SMPDs. A primary goal in this research is to conduct toxicity testing on extracts from SPMDs deployed in groundwater wells. A major obstacle to adapting the SPMD dialysates to toxicity testing is removing co-extracted triolein impurities and LDPE oligomers prior to solvent exchange to DMSO and toxicity testing. The most prevalent contaminant, methyl oleate, is typically removed using gel-permeation chromatography (GPC) conducted on HPLC. However, this method is costly, time-consuming, and not practical in many laboratory settings. An SPE cleanup method based on normal-phase separation using a silica-based restricted-access sorbent has been devised to selectively remove methyl oleate from extracts while not affecting PAH concentrations. This allows for a simple, one-step removal of co-extracted interferences, a significant advance in adapting SPMDs for use with bioassays. This advance will allow for the processing of SPMDs for use in both bioassay and analytical procedures. Results will be used to determine the suitability of the SPMDs as in-situ samplers in groundwater monitoring protocols and the use of the toxicity tests to provide a measure of chemical contamination and the potential impact of these contaminants on organism and human health.

Descriptors

Biomonitoring, Groundwater quality, Land-water interactions, Toxic substances, Trace organics, Water Chemistry, Water quality, Water quality monitoring

Articles in Refereed Scientific Journals

Gustavson, K.E., DeVita, W., Revis, A., and J.M. Harkin. 2000. A novel use of a dual-zone restricted access sorbent: Normal-phase SPE separation of methyl oleate and polynuclear aromatic hydrocarbons stemming from semipermeable membrane devices. J. Chromatogr. (accepted). Gustavson, K.E., Sonsthagen, S., Crunkilton, R.A., and J.M. Harkin. 2000. Groundwater toxicity assessment using bioassay, chemical, and TIE analyses. Environ. Toxicol. (in review). Gustavson, K.E. and J.M. Harkin. 2000. Comparison of sampling techniques and evaluation of semipermeable membrane devices (SPMDs) for monitoring polynuclear aromatic hydrocarbons (PAHs) in groundwater. Environ. Sci. Technol. (submitted).

Book Chapters

Read, H., J.M. Harkin, and K.E. Gustavson. 1998. Environmental applications with submitochondrial particles. In P.G. Wells, K.Lee, and C. Blaise, eds., Microscale Testing in Aquatic Toxicology: Advances, Techniques, and Practice. CRC Lewis Publishers, Boca Raton, FL, USA. pp. 31-52.

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Gustavson, K.E. and J.M. Harkin. 2000. Combining microscale bioassays and semipermeable membrane devices (SPMDs) for use in groundwater monitoring. Abstract. Society of Environmental Toxicology and Chemistry Midwest Chapter Annual Meeting. Bloomington, MN, April 13-14, 2000. Gustavson, K.E. and J.M. Harkin. 1999. Evaluation of groundwater toxicity using bioassay, chemical and TIE analyses. Abstract. Society of Environmental Toxicology and Chemistry, 19th Annual Meeting. Philadelphia, PA, Nov. 14-18, 1999. Gustavson, K.E. and J.M. Harkin. 1999. Use of specific sorbents and rapid bioassays for groundwater monitoring. Abstract. Ninth International Symposium on Toxicity Assessment. Pretoria, South Africa, Sept. 26 - Oct. 1, 1999. Gustavson, K.E. and J.M. Harkin. 1999. Evaluation of groundwater toxicity using bioassay, chemical and TIE analyses. Abstract. Ninth International Symposium on Toxicity Assessment. Pretoria, South Africa, Sept. 26 - Oct. 1, 1999. Gustavson, K.E. 1999. Use of long-term in-situ sorbents and rapid bioassays in groundwater monitoring. Abstract. Science To Achieve Results (STAR) Graduate Fellowship Conference. Arlington, VA, July 17-20, 1999. Sonsthagen, S., K.E. Gustavson, and R. Crunkilton. 1999. Use of in-vitro and whole-animal assays to assess groundwater contamination. Abstract. Society of Environmental Toxicology and Chemistry Midwest Chapter Annual Meeting. LaCrosse, WI, March 25-26, 1999.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Mercury Speciation and Transport in the Florida Everglades
Project Number	S-01
Start Date	03/01/1998
End Date	09/30/1999
Research Category	Water Quality
Focus Category #1	Surface Water
Focus Category #2	Groundwater
Focus Category #3	Wetlands
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
David E. Armstrong	Professor	The University of Wisconsin	01
James P. Hurley	Professional Staff	Water Resources Institute	02

Problem and Research Objectives

The various anthropogenic influences on the Florida Everglades region, such as alteration of hydrology, nutrient enrichment and contaminant inputs are of great concern to the long-term future of this unique ecosystem. Of particular importance is mercury (Hg) cycling, since recent studies have found elevated Hg levels in higher trophic levels, such as largemouth bass and the endangered Florida panther. Mercury bioaccumulation through the food chain is influenced by numerous factors, but it is apparent that bioavailability of Hg in the water column and sediments is extremely important in dictating fate and transport. In conjunction with the U.S. Geological Survey, Middleton, the Wisconsin Department of Natural Resources, the Water Chemistry Program at the University of Wisconsin-Madison, and the Water Resources Institute is examining the speciation and transport of dissolved, particulate and gaseous Hg in the upper wetlands of the Florida Everglades system.

Methodology

This research has involved obtaining a better understanding of biogeochemical cycling of total and methyl Hg in the Florida Everglades system. Our group has specifically focused on two major research areas, processes controlling transport of Hg species across interfaces (air-water, sediment-water) and processes controlling bioaccumulation through the food chain. We have developed and instituted new techniques for sampling that integrate classical "trace metal clean techniques" into our sampling protocols. Our group has designed and participated in several diel studies at selected sites in the Everglades to determine the effects of sunlight-induced processes on Hg transport and partitioning. We have cooperated with the South Florida Water Management District and the Florida Game and Freshwater Fish Commission in coordinated research. Furthermore, our multidisciplinary Aquatic Cycling of Mercury in the Florida Everglades (ACME) project has allowed our group to work with several USGS research groups in Middleton, Wisconsin, Boulder, Colorado, and Menlo Park, California.

Principal Findings and Significance

We have shown that methylation of Hg, a process typically thought to be limited to surface sediments, actively occurs in floating periphyton in many parts of the Everglades. This finding has potential management applications in that several regulatory agencies in Florida are considering developing stormwater treatment areas for nutrient removal and some designs call for periphyton-based systems. We have continued to identify and quantify photosynthetic pigments in suspended particulate matter and periphyton in the Everglades. Pigment analyses in the eutrophied northern regions of Water Conservation Area 2A has shown that pigments typical of blue-green and green algae dominate. In the southern regions where calcareous periphyton is the dominant primary producer, pigments typical of diatoms and chrysophytes dominate. We have identified the presence of a UV-blocking pigment compound in periphyton from southern portions of the Everglades. Additionally, we have observed the presence of bacteriochlorophylls, compounds characteristic of phototrophic sulfur bacteria. This is important because the presence of these microbes is usually in close proximity to sulfate reducing

bacteria, principal methylators of Hg. Results of this research will be incorporated by various regulatory agencies in Florida in a management plan for the Florida Everglades. Concurrent studies on nutrient inputs to the Everglades system will also be incorporated into a system model. The U.S. Geological Survey-sponsored project has provided a mercury cycling model that best synthesizes the results of the research. This model will allow various scenarios that aid in management decisions for Hg in the Everglades. Many of the principles developed during modeling efforts from our related work on northern Wisconsin lakes serve as the basis for the Everglades model. The Wisconsin Department of Natural Resources routinely uses the earlier model and may use the Everglades model to evaluate northern wetland cycling.

Descriptors

Mercury, Contaminant transport, Florida Everglades, Wetlands

Articles in Refereed Scientific Journals

Cleckner, L. B., P. J. Garrison, J. P. Hurley, M. L. Olson, and D. P. Krabbenhoft. 1998. Trophic transfer of methyl mercury in the northern Everglades. Biogeochem 40:347-361. Cleckner, L. B., C. C. Gilmour, J. P. Hurley, and D. P. Krabbenhoft. 1999. Mercury methylation in periphyton of the Florida Everglades. Limnol. Oceanogr. 44:1815-1825. Hurley, J. P., D. P. Krabbenhoft, L. B. Cleckner, M. L. Olson, G. Aiken, and P. J. Rawlik. 1998. System controls on aqueous mercury distribution, in the northern Everglades. Biogeochem. 40:293-310. Krabbenhoft, D. P., J. P. Hurley, G. Aiken, C. C. Gilmour, M. Marvin-DiPasquale, W. H. Orem, and R. Harris. 2000. Mercury cycling in the Florida Everglades: A mechanistic field study. Verhund. Inter. Vereinigung Limnol. (In press). Krabbenhoft, D. P., J. P. Hurley, M. L. Olson, and L. B. Cleckner. 1998. Diel variability of mercury phase and specie3s distributions in the Florida Everglades. Biogeochem. 40:311-325. Olson, M. L., L. B. Cleckner, S. A. King, J. P. Hurley, and D. P. Krabbenhoft. 1997. Resolution of matrix effects on analysis of total and methyl mercury in aqueous samples from the Florida Everglades. Fresenius J. Anal. Chem. 358:392-396.

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Monitoring and Research of Streamflow, Sediment Transport, and Water Quality in the Colorado River, Glen Canyon Dam to Lake Mead
Project Number	S-02

Start Date	03/01/1998
End Date	12/30/1999
Research Category	Water Quality
Focus Category #1	Surface Water
Focus Category #2	Sediments
Focus Category #3	Ecology
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Carl J. Bowser	Professor	The University of Wisconsin	01
Mark T. Harris	Professional Staff	US Geological Survey	02

Problem and Research Objectives

The ecosystem along the Colorado River through Grand Canyon National Park and Glen Canyon National Recreation Area has been altered by the construction of Glen Canyon Dam and the subsequent manipulation of flow to generate hydroelectricity. When Lake Powell formed behind Glen Canyon Dam, three major environmental changes occurred in the downstream river: regulation of flow has eliminated annual flooding of the river; sediment load of the main channel is now deposited in the lake, creating clear water releases from the dam; and temperature of the downstream river is colder because water released from the dam can only be drawn from the lower depths of Lake Powell. These changes have, in turn, given rise to others. The physical processes of flow, sediment transport, and water quality were identified as key factors linking dam operations to changes in the ecosystem below the dam. In cooperation with the U.S. Geological Survey (USGS), we are conducting a program of monitoring and research that is designed to detect change in key environmental variables over time. This program is designed to sufficiently understand sediment transport processes so that the system can be manipulated to more efficiently manage the limited sediment supply below the dam. The sediment supply is currently valued most for maintenance of camping beaches and backwater habitats for native fish. Specific objectives of the project are to: •Develop a monitoring and research approach that over time will differentiate short-term variation from long-term trends in sand storage in the most sediment-limited reach. •Examine the role that sediment grain size has on the measurement and prediction of sand transport through the Grand Canyon. •Compare the means of indicating the sand-storage condition of the channel and whether a small network of cross-section measurements is as reliable as other more extensive measurements. •Better understand the source of clay- and silt-sized particulates in the mainstem, their role in reducing light penetration, and, if possible, link this work to the work of other scientists who are conducting research on native fish.

Methodology

Hydrolaboratory stations have been established for five recording stations in the Glen Canyon tailwater reach extending from Lees Ferry to River Mile-11. Monitoring for pH, dissolved oxygen, temperature, and specific conductivity is done for four 48-hour periods coinciding with the two equinoxes and two solstices of the solar year. Measurements are made at 5-min intervals. Calibration of the instruments was conducted before and after the 2-day measurements to assess instrument drift. Data is downloaded to a spreadsheet form and shared among the data collection group for evaluation. During the river measurement periods, similar water parameters in the forebay of Lake Powell were measured using a "Seabird" instrument.

Principal Findings and Significance

Monitoring stations were established at five sites up river from Lees Ferry. Automated monitors were placed in the sites for four separate 48-hr monitoring periods (spring and fall equinox and summer and winter solstice). Measurements of temperature, dissolved oxygen, >pH, and specific conductivity were made at 5-min intervals over the periods of observation. Internal calibration as well as comparative calibration with similar instruments placed at Lees Ferry and at Glen Canyon Dam were used to standardize readings to a common base. Measurements were completed in spring 1999. In June 1999 project staff met to conduct a preliminary assessment of the data. Results will be published in a USGS project data report as well as in planned peer-reviewed publications. A modest renewal proposal was submitted in September to complete the data analysis and publication. Portions of the results will be presented at the fall American Geophysical Union meeting.

Descriptors

Dams, Ecosystems, Flow, Rivers, Sediment transport, Surface water, Water quality

Articles in Refereed Scientific Journals

Book Chapters

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Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	An Investigation of Mercury Levels in the Food Web of Isle Royale National Park, Michigan
Project Number	N-13
Start Date	06/18/1998
End Date	06/18/2000
Research Category	Water Quality
Focus Category #1	Surface Water
Focus Category #2	Toxic Substances
Focus Category #3	Models
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
James P. Hurley	Professional Staff	Water Resources Institute	01

Problem and Research Objectives

The goal of this project is to determine why six lakes in Isle Royale National Park have fish with Hg levels high enough to trigger health consumption advisories while fish in other lakes remain low in Hg concentration. A dual approach (Table 2) will be used on a subset of lakes (presently Sargent Lake and Richie Lake) with high and low fish Hg concentrations: Are fish Hg levels elevated due to (A) existing trophic level processes within lakes? or (B) different watershed processes and Hg inputs into the lakes? In order to determine if lakes containing fish with high Hg levels have unique trophic characteristics, the first step will be to use the heuristic capabilities of the Regional Mercury Cycling Model in lakes with existing data. Second, methyl Hg levels in biota will be measured to supplement data that is deterministic in the model. Finally, stable isotopes will be measured on biota to determine trophic length and trophic relationships within the lakes. To assess watershed processes that influence Hg accumulation in fish, Geographical Information System (GIS) data will be analyzed to determine physical characteristics of lakes and their watersheds. Factors that have been shown to be associated with elevated levels of Hg in water and fish (e.g, percent wetland influence in watershed, elevation and amount of drainage basin relative to lake volume) will be examined. Next, methyl Hg levels in the lakes including epilimnion and hypolimnetic waters, as well as feeder streams and wetlands will be measured. Finally, input of Hg from localized precipitation will be measured and compared to in-lake and watershed processes.

Methodology

Water will be collected for Hg analysis employing ultra-clean techniques as outlined in Hurley et al. (1996) and United States Environmental Protection Agency (USEPA) Method 1669. Water samples from lakes and possible wetland inputs will be collected at least twice a year. Water will be analyzed for total mercury (HgT) and methyl mercury (MeHg). Water samples will be further analyzed for MeHg associated with particles and the mass of suspended particulate matter (SPM) as well as pigment composition. Biota will monitored for Hg from the selected lakes at least twice a year. Small aquatic insects will be collected using ultra-clean techniques as outlined in Cleckner et al. (1998) while zooplankton will be sampled as in Herrin et al. (1998). Samples will be collected using non-metallic nets and sieves. Small fish will be collected using minnow traps. Collected biota will be placed into Teflon vials with site water, double-bagged, and frozen until analysis. Aquatic insects targeted for collection include those from the following orders: Ephemeroptera, Odonata, Trichoptera and Hemiptera. Zooplankton groups targeted for collection are cladocerans and copepods. Small fish collected will be cyprinids or perch (Perca flavescens). At least 12 organisms of each type will be collected at each site and date with the exception of zooplankton, where hundreds will be collected. The whole body of all biota will be homogenized. Analysis of Hg will be done on either individuals (e.g., Odonata, Hemiptera, fishes) or on composites of several individuals (e.g., Ephemeroptera, Trichoptera, zooplankton). Subsamples of biota will be dried and weighed so final concentrations can be expressed as ng×g-1 dry weight.

Principal Findings and Significance

Descriptors

Dredging, Polychlorinated biphenyls, Sediments

Articles in Refereed Scientific Journals

Book Chapters

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Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Sedimentology, Stratigraphy, and Porosity-Conductivity Relations of the Silurian Aquifer of Ozaukee County, Wisconsin
Project Number	N-01
Start Date	07/01/1999

Start Date	07/01/1998
End Date	06/30/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Models
Focus Category #3	Water Quality
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Mark T. Harris	Assistant Professor	The University of Wisconsin	01

Problem and Research Objectives

Groundwater quality has been shown to be poor in areas of near-surface fractured carbonate rock, such as in the Silurian aquifer of eastern Wisconsin. To assess the relative significance of fracture and matrix flow in this type of aquifer, the aquifer's stratigraphy, sedimentology, and porosity distribution will be integrated into a geologic model that can be combined with conductivity measurements to quantify the matrix component of the flow system. This will be compared to field tests to isolate the contributions of the fracture system. These findings will significantly improve on-going efforts to model groundwater flow within the aquifer in this region of eastern Wisconsin. In addition, the results of this study will be of value in planning ;future studies of fractured carbonate aquifers.

Methodology

Principal Findings and Significance

The sedimentologic, paleontologic, and porosity characteristics of four cores of Silurian rocks obtained in the late 1980s in Ozaukee County are being described. This information will be used to interpret the lateral distribution of sedimentary facies and porosity.

Descriptors

Aquifers, Carbonate aquifers, Groundwater, Model studies, Water quality

Articles in Refereed Scientific Journals

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Monitoring: Evaluation of the Abundance, Diversity and Activity of Methanotroph Populations in Groundwater
Project Number	N-05
Start Date	07/01/1998
End Date	06/30/2000
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Methods
Focus Category #3	Treatment
Lead Institution	Water Resources Institute

Principal Investigators

Problem and Research Objectives

Bioremediation is an emerging technology that can provide an efficient, cost-effective, and minimally invasive means to treat contaminated groundwater. In addition, biodegradation in bioreactors has the potential application to treat effluents prior to discharge in order to reduce or eliminate the release of pollutants. Methanotrophic bacteria, which occur widely in aquatic and terrestrial environments, are one of the most promising organisms for use in remediating pollution by a variety of organic contaminants. Before bioremediation can be used to clean up contaminated groundwater, however, there must be an understanding of the biological processes involved and a way of monitoring these processes. The goal of this project is to develop methods that can be used to evaluate the suibability of methanotrophic bacteria in relation to bioremediation of contaminated groundwater.

Methodology

Principal Findings and Significance

Significant progress has been made in the use of molecular methods to detect methanotrophic bacteria in groundwater. We have developed a procedure for the use of polymerase chain reaction (PCR) primers that specifically amplify a portion of a gene of methanotrophs. In addition, we have designed a simplified method for preparation of environmental samples for PCR. By using direct PCR, DNA extraction and resulting losses are avoided. A template for use in competitive PCR has been constructed and tested with laboratory strains of methanotrophs.

Descriptors

Bioremediation, Groundwater, Organic contaminants, Water quality

Articles in Refereed Scientific Journals

Book Chapters

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Water Resources Research Institute Reports

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Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	A Rational Design Approach to Permeable Reactive Walls
Project Number	N-03
Start Date	07/01/1998
End Date	06/30/2000
Research Category	Engineering
Focus Category #1	Groundwater
Focus Category #2	Water Quality
Focus Category #3	Toxic Substances
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Craig H. Benson	Associate Professor	The University of Wisconsin	01
Gerald R. Eykholt	Assistant Professor	The University of Wisconsin	02

Problem and Research Objectives

The objective of this is to assess the performance of three styles of permeable reactive barriers (PRBs) in heterogeneous aquifers and with uncertainty in composition of the barrier itself. Once the effects of these factors are understood, risk-based design models for each style of PRB are developed. Monitoring systems for each style of PRB are also evaluated and the most efficient monitoring well configuration (on a cost versus risk basis) is identified for each type of barrier. Recommendations are then made for the most reliable type of PRB and monitoring systems for a variety of field conditions. The larger scale objective of this research is to highlight the advantages of risk-based design for geo-environmental systems, and outline a method that can be used for the risk-based design of other remediation or containment technologies.

Methodology

Three types of barriers are considered in this research, a horizontal, funnel and gate, and caisson PRB. The performance of each style of PRB in aquifers that have spatially varying hydraulic conductivity is predicted using numerical models and Monte-Carlo simulations. The conceptual model for my simulations is a PRB located in the center of a three dimensional, heterogeneous aquifer. Aquifers are modeled as correlated random fields of hydraulic conductivity, and MODFLOW is used to determine a head solution under imposed boundary conditions. Next, mass transport by advection and first order reactions in the aquifer and PRB are predicted using a stream-tube model developed from PATH3D. The impact of aquifer heterogeneity on PRB performance is evaluated using a parametric study with the mean of the logarithm of hydraulic conductivity (mlnK), standard deviation of the logarithm of hydraulic conductivity (slnK), and longitudinal and lateral correlation scales (lx and ly) being varied systematically. The impact of PRB heterogeneity is also evaluated using a parametric study where the hydraulic conductivity (KP) and reactivity (kr) of the media is varied between simulations.

Principal Findings and Significance

The first half of the study was a parametric study to learn how PRBs operate under heterogeneous conditions. Spatial variability of kr and KP was found to have a minor effect on influent and effluent concentrations. Correlation scale of the aquifer hydraulic conductivity parallel to flow, which describes the length of geologic units, had a modest effect, with larger correlation scales yielding higher effluent concentrations. The log-mean (mlnK) and log-standard deviation (slnK) of aquifer hydraulic conductivity, which describe the geometric mean and spread of hydraulic conductivity, have the greatest impact on influent and effluent concentrations from a PRB. Decreasing mlnK (i.e., lowering the hydraulic conductivity) does not affect influent concentrations, but decreases median effluent concentrations and broadens the distribution of effluent concentration due to increased residence time in the PRB. Increasing slnK (i.e., increasing the range of hydraulic conductivities of the aquifer) decreases the median influent concentration and broadens the distribution of influent concentrations as a result of additional dispersion in a more heterogeneous aquifer. Larger slnK also results in higher median effluent concentrations and broader distributions of effluent concentration. Design recommendations for PRB

selection, construction, and monitoring were addressed in the second half of the study. The FGPRB was determined to be the most economical PRB design and the HFPRB the least economical design. Design of PRBs using a plug-flow model and factor of safety of two is sufficient for PRBs in aquifers with slnK < 1.0, but factors of safety greater than 10 may be needed in aquifers with slnK = 4.0. Scaling factors to be used with plug-flow models are suggested for all types of PRBs. Scaling factors are similar to factors of safety except they are functions of mlnK, slnK and correlation scale, and allow the designer to incorporate risk into PRB design. Several monitoring systems are tested and the lateral and vertical spacing between well screens that maximize the probability of detection per well screen are recommended for each type of PRB. Also, the ability of gravel zones adjacent to the influent and effluent faces of the PRB to cause more uniform residence times of groundwater in the reactive media and lower effluent concentrations is assessed. Gravel zones do yield more uniform residence times, but provide a more conductive path for groundwater flow through the reactive media, increasing effluent concentrations for all PRBs except a HFPRB in aquifers with slnK < 2.3. Given these results, recommendations for future PRB design are to place greater importance on aquifer characterization and PRB selection. The aquifer parameters slnK and mlnK strongly impact effluent concentrations. PRB design should begin with adequate aquifer characterization to choose a PRB type and scaling factor that corresponds to a low risk of failure. Then, economical monitoring systems that verify the proper operation of the PRB and have a reasonable chance of detecting higher effluent concentrations can be used. However, it is unlikely that peak concentrations (i.e., greater than the 95th percentile) will be detected even with dense monitoring.

Descriptors

Groundwater contamination, Remediation technology, Water quality

Articles in Refereed Scientific Journals

Elder, C., Benson, C., and Eykholt, G. (2000), "Effects of Heterogeneity on Influent and Effluent Concentrations from Horizontal Permeable Reactive Barriers", Submitted to Water Resources Research, June. Elder, C., Benson, C., and Eykholt, G. (2000), "Are Permeable Reactive Walls Effective in Heterogeneous Aquifers?", Submitted to Environmental Science and Technology, June. Elder, C., Benson, C., and Eykholt, G. (2000), "Selection of a PRB Type In Heterogeneous Aquifers", Submitted to Environmental Science and Technology, June. Eykholt, J., Elder, C., and Benson, C. (1999), "Effects of Aquifer Heterogeneity and Reaction Mechanism Uncertainty on a Reactive Barrier," Journal of Hazardous Materials, (68), 73-96.

Book Chapters

Dissertations

Elder, C. (2000), "Evaluation and Design of Permeable Reactive Barriers Amidst Heterogeneity," Ph.D. Dissertation, Department of Civil and Environmental Engineering, University of Wisconsin - Madison.

Water Resources Research Institute Reports

Conference Proceedings

Elder, C., Benson, C. and Eykholt, G. (2000), "Performance of Permeable Reactive Barriers Amidst Heterogeneity," Proc. of Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, May

22-25.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Groundwater Flow and Heat Transport in Wetlands: Transient Simulations and Frequency-Domain Analysis
Project Number	N-02
Start Date	07/01/1998
End Date	06/30/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Models
Focus Category #3	Wetlands
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Hector R. Bravo	Associate Professor	The University of Wisconsin	01

Problem and Research Objectives

Groundwater flow and heat transport are among the primary driving physical processes in wetland systems, but their dynamics are poorly understood. The development of a general time-dependent (or transient) model, calibrated with field observations, will provide a better understanding of the dynamics of groundwater flow and heat transport, and an estimation of the error involved in the steady-state models used to date. In addition, because heat transport and contaminant/solute transport in groundwater share significant similarities, the development of a groundwater and heat transport model will improve the understanding of nutrient/solute transport processes.

Methodology

Principal Findings and Significance

Work during the first year of the project included a systematic effort and significant progress in the

automatic calibration of a free-surface, sectional groundwater flow model of the Wilton wetlands. The model includes vertical (precipitation and evapotranspiration) flux through the water table. The parameters calibrated in the groundwater flow model are the hydraulic conductivity of the sandstone and sediment-peat layers, the vertical flux through the water table, and the lateral boundary conditions. Measurements used in the calibration process include water table elevation, vertical flux, and hydraulic gradient at the sandstone-sediment interface. The use of a known vertical flux as prior information was explored. The issues of noisy observations and uncertainty in estimated hydraulic conductivity with respect to the measurement set were investigated. Groundwater flow and heat transport were successfully modeled and calibrated in a model with steady, vertical flow and dynamically varying temperature at the upper boundary of the simulation region. Measured values of piezometric head and time-varying temperature were used to calibrate hydraulic conductivity, thermal conductivity, and heat capacity of the porous media.

Descriptors

Groundwater, Model studies, Wetlands

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	The Use of Subsurface Irrigation to Restore Degraded Groundwater-fed Wetlands
Project Number	C-03
Start Date	09/01/1998
End Date	02/28/2001
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Surface Water
Focus Category #3	Wetlands
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Kenneth W. Potter	Professor	The University of Wisconsin	01
Jean M. Bahr	Professor	The University of Wisconsin	02

Problem and Research Objectives

Aquatic ecosystems can be significantly degraded by urban development. Increased impervious areas reduce recharge, therby desiccating wetlands and springs. Groundwater extraction or drainage lowers water trables and stormwater runoff can increase flooding. Society is beginning to realize the value of wetland functions an in recent years wetland restoration is being undertaken more frequently. In an effort to develop a method for restoring groundwater-fed wetlands we are reintroducing water into a desiccated wetland via subsurface irrigation. In our test, highly treated effluent flows from the Madison Metropolitan Sewerage District (MMSD) pipeline are being introduced into the subsurface of a degraded sedge meadow bia buried perforated pipes. Our results will indicate whether or not subsurface irrigation is a viable means to restore wetlands and control reed canarygrass, an invasive wetland plant, and provide information on the importance of nutrients in wetlands restoration.

Methodology

(Please briefly describe the methods you are using.)

Principal Findings and Significance

The experimental cells that will be used to evaluate the use of subsurface irrigation to restore groundwater-fed wetlands were constructed by September 1999. At that time the water-control system was installed which regulates the water levels in the cells. Two water sources are being used: groundwater from a well that we have installed nearby and treated wastewater effluent from the Madison Metropolitan Sanitary District treatment plant at Nine Springs. Both sources are ready for use. The system was tested during the fall of 1999 and flooding experiments will beging in spring 2000.

Descriptors

Groundwater, Reed canarygrass, Restoration, Subsurface irrigation, Urbanization, Wetlands

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Subcontract from the Midwest Technology Assistance Center for Small Public Water Systems at the University of Illinois, Urbana: Coordinate Wisconsin Activities
Project Number	N-16
Start Date	10/01/1998
End Date	09/30/1999
Research Category	Social Sciences
Focus Category #1	Water Supply
Focus Category #2	Law, Institutions, and Policy
Focus Category #3	Water Quality
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Anders W. Andren	Professor	Water Resources Institute	01
James P. Hurley	Professional Staff	Water Resources Institute	02
John M. Harkin	Professor	Water Resources Institute	03
John M. Harkin	Professor	Water Resources Institute	03

Problem and Research Objectives

The Midwest Technology Assistance Center for Small Public Water Systems (MTAC) is comprised of a consortium led by the University of Illinois and the Illinois State Water Survey, in partnership with the land grant universities of Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin. MTAC serves small public water systems and public systems serving Indian Tribes. The participation of each state is led by its Water Resources Research Institute (WRRI), established under authority of the Water Resources Research Act of 1964 on the campus of the land grant university as a federal-state partnership to conduct applied research and technology transfer. This center cooperates closely with other regional technology assistance centers established by the U.S. Environmental

Protection Agency (EPA) and with other partner agencies and organizations in order to ensure efficient response to the highest priority needs of small public water systems and Indian Tribal systems in the Midwest.

Methodology

Principal Findings and Significance

Descriptors

Drinking water, Potable water supplies, Public water systems

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Macropore Flow: A Means for Enhancing Groundwater Recharge or a Potential Source of Groundwater Contamination
Project Number	B-01
Start Date	03/01/1999
End Date	02/28/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Non Point Pollution
Focus Category #3	Models
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Kenneth W. Potter	Professor	The University of Wisconsin	01
Peter J. Bosscher	Professor	The University of Wisconsin	02

Problem and Research Objectives

As urban areas expand, groundwater levels and heads decrease as a result of the combined effects of groundwater pumping and loss of groundwater recharge. In some cases these decreases constrain the use of groundwater. More commonly, they result in reduced flows to springs, streams, lakes and wetlands. Diffuse infiltration of stormwater has been proposed as a potential management strategy for mitigating groundwater depletion due to urban expansion. The idea is to carefully manage storm runoff from impervious surfaces so that as much runoff as possible sheetflows over adjacent pervious surfaces that are managed to maximize infiltration capacity. Innovative consulting firms such as Conservation Design Forum in Naperville, Illinois are beginning to apply such an approach to development projects in the upper Midwest, including the expansion of the University Research Park in Madison, Wisconsin. Successful implementation of diffuse stormwater infiltration requires identification of sites with high permeabilities. The matrix permeability of soils in the upper Midwest are generally low to moderate; however, if macropores are present, the effective permeabilities can be much higher. Hence, macropores may be critical to the effectiveness of diffuse infiltration. Exploiting macropore flow has a potential drawback - urban stormwater can be highly contaminated and macropore plow could become a source of groundwater contamination.

Methodology

This research has two principal components: infiltration testing of soils in urban/suburban greenspaces in Dane County, and modeling of infiltration of runoff from pervious surfaces. The infiltration testing has the following objectives: evaluation of the spatial variability of infiltration rates in urban greenspaces and the causes of this infiltration in urban greenspaces; development of a protocol that could be used in practice to evaluate the infiltration capacity of urban greenspaces; collection of data for use in calibrating and verifying our infiltration models. The objective of the modeling component is to quantify the potential groundwater recharge rates achievable by coupling an impervious surface to a pervious one. Infiltration Testing Our original intention was to measure infiltration rates using a standard double-ring infiltrometer and a disc permeameter/tension infiltrometer. Because of the small surface area associated with each of these methods, we decided to develop a flooding infiltrometer that could handle variable surface areas. This infiltrometer feeds water from either a point or line source of variable length and recovers it using a line sink attached to a vacuum pump. Before and after each test core, samples will be taken for laboratory measurement of water content. Initially our focus will be on applying this testing device to pervious areas that currently convey water from impervious surfaces. Modeling We are conducting two kinds of modeling experiments. One will focus on a hypothetical impervious surface connected to a pervious one. Various conditions of vegetation type, infiltration properties, length, slope, and downstream control will be evaluated. We will also model sites for which we have conducted infiltration measurements, enabling us to explore issues of model calibration and verification. The main modeling tool will be Opus, a multi-layer soil infiltration model that continuously models infiltration, water redistribution, and evapotranspiration. We will develop routing algorithms to account for the surface flow.

Principal Findings and Significance

In the first year of this 2-year project we have focused on the following: development of the flooding infiltrometer; use of a simple runoff model to evaluate the potential benefits of connecting impervious surfaces to pervious ones; and use of opus to evaluate the benefits of connecting impervious surfaces to pervious ones. Design and development of our flooding infiltrometer is nearly complete. Water is delivered by a constant head tank and recovered through a vacuum system. The configuration of the area flooded is constrained only by the flow capacities. In our preliminary evaluation of the infiltration of runoff from impervious surfaces, we applied a modified version of the Soil Conservation Service runoff equation to historical daily wet season rainfall for Madison, Wisconsin. (The wet season is defined as April 15 through October 15.) For a range of soil types (quantified through the runoff curve number) we calculated the potential reduction in runoff that would occur for various ratios of pervious to impervious areas. The potential reductions are substantial. For example, for a curve number of 70 and a ratio of pervious to impervious area of 0.2, the wet season runoff would be reduced by about 7.5 inches. We also estimated the reduction in runoff that will occur if the curve number of the pervious area is reduced. For example, for a pervious to impervious ratio of 0.2, a reduction in the curve number from 70 to 50 results in an additional decrease in runoff of about 4 inches. Preliminary runs of the Opus model have enabled us to investigate the impact of various vegetation types on grouhndwater recharge. One notable finding is that pervious surfaces receiving runoff from impervious surfaces may be more effective at increasing groundwater recharge if they are planted in turf grass rather than prairie grass. This is because of the greater evaporative losses associated with prairie grasses. Another notable finding is that in terms of groundwtaer recharge, there is an optimal ratio of pervious to impervious area. This is a result of the fact that as the pervious area is increased, water infiltrates to a lessor depth, and hence is more likely to evaporate. Both of these results will be of great practical significance in the design of infiltration practices.

Descriptors

Groundwater, Models, Runoff, Urbanization

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

DeMaster, D. W., E. B. Burmeister, and K. W. Potter. 2000. Increasing groundwater recharge by infiltrating runoff from impervious surfaces. p. 35. In: Water resources 2000 -- challenges for the new century. American Water Resources Association, Wisconsin Section Annual Meeting, Green Bay, Wisconsin. Water Resources Institute, University of Wisconsin-Madison. Potter, K. W. 2000. Stormwater infiltration: a vital component of low-impact development. Spring Technical Conference, March 23, 2000, American Society of Civil Engineers, Wisconsin Section, Madison, Wisconsin.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Hydraulic Conductivity and Specific Storage of the Maquoketa Shale
Project Number	B-02
Start Date	03/01/1999
End Date	02/28/2000
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Water Quality
Focus Category #3	Water Quality
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Herbert F. Wang	Professor	The University of Wisconsin	01
Kenneth R. Bradbury	Professor	University of Wisconsin-Extension	02
Timothy T. Eaton	Professional Staff	University of Wisconsin-Extension	03

Problem and Research Objectives

Large withdrawals of groundwater from the deep sandstone aquifer of southeastern Wisconsin have reversed the historically upward vertical hydraulic gradient so that this aquifer is now recharged from above through the overlying Maquoketa Formation, which is a regional aquitard. As urban expansion in the region continues, pumpage and downward gradients will increase and the potential for contaminants to pass through the Maquoketa into the deeper aquifer will be enhanced. At present, only estimates of the vertical hydraulic conductivity of this regional confining unit have been made from flow net analysis or computer modeling. Our objective through this research is to determine the hydrogeologic properties of the Maquoketa Formation in Waukesha County using laboratory and field data and poroelastic modeling to predict reverse well fluctuations.

Methodology

This research has involved rehabilitating one of the two existing observation wells in order to install a multilevel monitoring system similar to that which was operated successfully at the Minooka Park site during the past year. We plan to collect similar geochemical, isotopic and hydraulic data from this second installation at the Wisconsin Department of Transportation Ryan Parcel. In addition three new wells were installed nearby; one to pump from the underlying Sinnipee dolomite and the other two to use as single point observation wells. The advantage of a multiple well configuration is that it enables us to test for reverse well fluctuations as well as providing a better setup for conventional leaky aquifer

testing than a single well would allow. Using both methods produces results that are expected to corroborate each other. In addition, this combined effort has proven effective in that we made use of multilevel packer and monitoring equipment already purchased.

Principal Findings and Significance

We have completed the preliminary poroelastic modeling and laboratory measurement phase of our study of the Maquoketa shale. Modeling heads showed that a maximum reverse well fluctuation of 5 to 10 cm should occur 20 to 50 m from the pumping or injection well. Laboratory permeability measurements of vertical and horizontal hydraulic conductivity were made using the pulse decay method on 22 samples from core collected from boreholes at two locations. The vertical core-scale hydraulic conductivities ranged in value from 1.9x10-12 to 1.0x10-13 m/sec. The horizontal core-scale hydraulic conductivities ranged in value from 3.6x10-10 to 2.5x10-14 m/sec. The two measurements of horizontal hydraulic conductivity greater than 1x10-10 m/sec were anomalously high due to desiccation cracks that occurred along the bedding plane. When these values are eliminated from the data set, the geometric mean of the core scale anisotropy is nearly one.

Descriptors

Aquifers, Groundwater, Hydrogeologic parameters ----------+--------- ----------+---------

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Eaton, T. T. 2000. Geologic heterogeneity and scaling of effective hydraulic conductivity in the Maquoketa shale confining unit, southeastern Wisconsin. Ph. D. Dissertation. Department of Geology and Geophysics, University of Wisconsin-Madison. (In progress).

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Eaton, T. T., M. P. Anderson, H. F. Wang, D. Hart, and K. R. Bradbury. 2000. Importance of a sparse fracture network in a low-conductivity confining unit: Preliminary field results. Abstract. American Geophysical Union Annual Meeting, Washington, D.C. American Geophysical Union, Washington, D.C. Eaton, T. T., K. R. Bradbury, H. F. Wang, and D. Hart. 2000. Indications of vertical fracturing within the Maquoketa confining unit, southeastern Wisconsin. In: p. 2. Abstracts: Water resources 2000 -- Challenges for the new century. American Water Resources Association -- Wisconsin Section 24th Annual Meeting, Green Bay, Wisconsin. Water Resources Institute, University of Wisconsin-Madison.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Fox River Sediment Remediation Demonstration Project - Advisory and Analytical Services for Deposit N and Sediment Management Unit 56/57 Projects
Project Number	N-12
Start Date	04/20/1999
End Date	12/31/1999
Research Category	Water Quality
Focus Category #1	Surface Water
Focus Category #2	Toxic Substances
Focus Category #3	Sediments
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
James P. Hurley	Professional Staff	Water Resources Institute	01

Problem and Research Objectives

Dredging and removal of polychlorinated biphenyl (PCB) contaminated sediments is being investigated by the Wisconsin Department of Natural Resources (WDNR) as a possible remediation action for the Lower Fox River, Wisconsin. A small sediment deposit near the villages of Kimberly and Little Chute has been identified by the WDNR as a prime location for a PCB cleanup demonstration project. This project is part of a continuing program by the WDNR, U.S. Environmental Protection Agency (EPA), local paper companies (Fox River Group) and others to restore the Fox River. The WRI's role in this project will be to provide final scientific peer review of sediment remediation monitoring plans for the deposit (through establishment of the Fox River Remediation Advisory Team - FRRAT), coordinate funding transfer to the Wisconsin State Laboratory of Hygiene for PCB and ancillary analyses and distribution of final, verified data to participating parties, and prepare the final report on evaluation of the effectiveness of dredging at the deposit.

Methodology

Principal Findings and Significance

In addition to this project, a second demonstration project was initiated in late summer 1999 at sediment management unit (SMU) 56/57 in Green Bay, Wisconsin. The FRRAT will similarly provide peer review of sediment remediation monitoring plans and prepare the final report on evaluation of the effectiveness of dredging at this site.

Descriptors

Dredging, Polychlorinated biphenyls, Sediments

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Experimental Lakes Upland Flooding: Mercury Fluxes Across the Soil-Water Interface
Project Number	N-15
Start Date	05/01/1999
End Date	12/31/2000
Research Category	Water Quality
Focus Category #1	Surface Water
Focus Category #2	Toxic Substances
Focus Category #3	Floods
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
James P. Hurley	Professional Staff	Water Resources Institute	01
David P. Krabbenhoft	Professional Staff	US Geological Survey	02
Kristoffer Rolfhus	Professional Staff	The University of Wisconsin	03

Problem and Research Objectives

Watersheds exert a strong influence on the biogeochemical cycling of mercury (Hg) and land use, land cover, soil type, and glacial deposits are strong predictors of fate and transport. The Lake Superior ecosystem offers a unique opportunity to assess the fate and transport of Hg derived from its watersheds and relate these inputs and processes to in-lake cycling due to the contrasts in biology and geology within the Lake Superior Basin. In this project we are using field and laboratory studies combined with modeling to assess the importance of watershed processes in controlling the sources, transport, fate, and bioavailability of Hg in a northern temperate lake system.

Methodology

Principal Findings and Significance

Descriptors

Contaminant transport, Lake Superior, Mercury, Watersheds

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	An Investigation of Processes Influencing Elevated Fish Mercury Levels in Isle Royale National Park
Project Number	S-03
Start Date	07/01/1999

End Date	02/28/2001
Research Category	Water Quality
Focus Category #1	Surface Water
Focus Category #2	Toxic Substances
Focus Category #3	Models
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
David E. Armstrong	Professor	The University of Wisconsin	01
James P. Hurley	Professional Staff	Water Resources Institute	02

Problem and Research Objectives

Mercury (Hg) levels in fish taken from several inland lakes of Isle Royale National Park, Michigan have exceeded the Food and Drug Administration's consumption advisory level of 1 ppm. Serveral of the lakes are in close proximity to one another, raising concerns about the mechanisms influencing Hg distribution and bioaccumulation in the park's lakes and watersheds. Variations in Hg content of fish among lakes may be due to lake-specific characteristics. It is believed that most of the Hg arrives in the park from atmospheric sources (wet and dry deposition). A clear understanding of Hg transport within the Isle Royale ecosystem is needed to assess its risks because Hg contamination is deleterious to both wildlife and humans. By examining existing trophic level processes within the lakes and different watershed processes and Hg inputs to the lakes, we will investigate reasons for health consumption advisories in some lakes within the park while advisories are not required for others.

Methodology

Baseline physical and limnological data are being gathered on lakes with both high and low fish Hg (this will also provide background Hg levels in other lakes in the park). Based on this information, one lake from each category will be selected for further investigation. Every effort will be made to select two lakes with similar physical characteristics such as depth and surface area. Sampling will be completed two to three times each year between late spring and early fall, and timed so that ecologically important events such as the spring diatom bloom can be sampled. Results will be compared and constrasted for the two lakes to determine what factors are associated with the lakes that have elevated fish Hg levels. These data will be used to describe Hg accumulation in other lakes on the island.

Principal Findings and Significance

Descriptors

Aquatic systems, Fish, Isle Royale National Park, Mercury, Model studies

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Field Monitoring of Drainage and Nitrate Leaching from Managed and Unmanaged Ecosystems
Project Number	N-04
Start Date	07/01/1999
End Date	06/30/2001
Research Category	Water Quality
Focus Category #1	Agriculture
Focus Category #2	Nitrate Contamination
Focus Category #3	Groundwater
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
John M. Norman	Professor	The University of Wisconsin	01

Problem and Research Objectives

Maintaining a balance between profitable agricultural production and environmental degradation is challenging because of the ease with which nitrate moves with water through soil. The fertilization of

agricultural crops affects nitrate-leaching losses and groundwater quality. In Wisconsin 50 of 72 counties -- potentially impacting 1.5 million people -- have medium to high susceptibility for groundwater nitrate leaching from excess applications of nitrogen fertilizer. We are evaluating the influence of two agricultural management and fertilization practices on nitrogen levels in corn. A continuous data set from direct field measurements of drainage and nitrate leaching will be generated for fertilized and chisel plow and no-tillage corn and natural prairie ecosystems. These findings will advance the understanding of relationships between agricultural practices and nitrate leaching losses during the growing season and throughout frozen soil periods.

Methodology

Principal Findings and Significance

Descriptors

Agriculture, Groundwater contamination, Nitrate, Water Quality

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Remediating Groundwater Using Reactive Walls Containing Waste Foundry Sands
Project Number	N-06
Start Date	07/01/1999
End Date	06/30/2001
Research Category	Engineering
Focus Category #1	Groundwater
Focus Category #2	Treatment
Focus Category #3	Water Quality
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Craig H. Benson	Associate Professor	The University of Wisconsin	01
Gerald R. Eykholt	Assistant Professor	The University of Wisconsin	02

Problem and Research Objectives

Reactive walls (RWs) are one of the most significant developments in groundwater restoration within the last decade. They are a containment technology that uses passive remediation to remove contaminants from groundwater. After construction, RWs require no energy or maintenance and can render effluent groundwater of drinking water quality. In addition, RWs can be used to treat the most difficult and pervasive groundwater contaminants. Reactive wall technology can be more cost-effective if RWs are constructed with foundry sand, a reactive and sorptive medium that is currently being landfilled in large quantities throughout Wisconsin. We are investigating the use of waste foundry sands from gray iron foundries as reactive media for RWs. Our research will establish guidelines for assessing whether a foundry sand can be beneficially reused in RWs, set up a protocol for selecting reactive media mixtures that incorporate foundry sands, and identify correlations between index properties and transport parameters that can be used for selecting candidate sands and for preliminary design calculations.

Methodology

Principal Findings and Significance

Descriptors

Containment technology, Foundry sands, Groundwater, Reactive walls, Remediation technology, Water quality

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Time Domain Electromagnetic Induction Survey of Eastern Waukesha County and Selected Locations
Project Number	N-08
Start Date	07/01/1999
End Date	06/30/2001
Research Category	Water Quality
Focus Category #1	Methods
Focus Category #2	Models
Focus Category #3	Groundwater
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Robert Taylor	Associate Professor	The University of Wisconsin	01

Problem and Research Objectives

The Cambrian and Ordovician sandstone aquifer of eastern Wisconsin is a major source of water for municipalities and industries in this portion of the state. This aquifer has been developed heavily in the metropolitan Milwaukee area and eastern Waukesha County in response to increased urbanization. While the aquifer is a major economic resource, knowledge of its geometry and distribution of water quality is limited. We are using Time Domain Electromagnetic Induction (TEM), a proven geophysical exploration tool, to map aquifer thickness and the three-dimensional distribution of saline groundwater from the land surface. Data will be compiled into geoelectrical cross-sections that can be interpreted to reveal the location of zones of groundwater with elevated levels of total dissolved solids (TDS), areas where the aquifer is anomalously thin, and the position of the saline groundwater interface near Lake Michigan. This information will be of value to several water utilities and the Southeastern Wisconsin Regional Planning Commission and will provide a benchmark data set for future surveys to determine the direction and rate of high TDS groundwater migration.

Methodology

Principal Findings and Significance

Descriptors

Aquifers, Geophysical methods, Urban development, Water quality

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Causes of Historical Changes in Groundwater Recharge Rates in Southeastern Wisconsin
Project Number	N-11
Start Date	07/01/1999
End Date	06/30/2001
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Models
Focus Category #3	Management and Planning
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Douglas S. Cherkauer	Professor	The University of Wisconsin	01

Problem and Research Objectives

Large suburban and rural populations in southeastern Wisconsin depend on recharge-fed groundwater as their sole source of drinking water. Proper management of the groundwater resource requires the fullest possible understanding of how recharge varies spatially and through time and how it might change in climatic change scenarios. Such information is also absolutely essential input to regional and local scale groundwater models developed for resources management. Hydrograph separation provides a means to rapidly and inexpensively obtain accurate recharge measures. It also allows us to retroactively recreate historic recharge rates; rates that were not measured in the past. The objective of this project is to determine the hydrologic and climatological factors which have caused historic variation in recharge rates in southeastern Wisconsin and other regions of the state.

Methodology

Principal Findings and Significance

Descriptors

Drinking water, Groundwater, Potable water, Recharge, Urbanization, Watersheds

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Compatibility of Containment Systems with Mine Waste Liquids
Project Number	N-10
Start Date	07/01/1999
End Date	06/30/2001
Research Category	Engineering
Focus Category #1	Groundwater
Focus Category #2	Toxic Substances
Focus Category #3	Water Quality
Lead Institution	The University of Wisconsin

Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Tuncer B. Edil	Professor	The University of Wisconsin	01
Craig H. Benson	Associate Professor	The University of Wisconsin	02

Problem and Research Objectives

Metallic mining at various locations in Wisconsin has recently become an issue of great interest. Concurrently, significant concern has developed regarding the potential for environmental impacts of mining, particularly the pollution of groundwater. Mining's greatest threat to Wisconsin groundwater is pollution from drainage of mine tailings. One method to prevent groundwater contamination is to place the tailings in an engineered waste containment facility designed according to the principles used for modern municipal and industrial landfills. There is a need, however, to determine if the containment systems proposed to contain mine wastes will effectively prevent groundwater contamination. We are assessing the compatibility of landfill lining system materials and mine waste liquids to determine if the materials used for lining systems will function as intended in the presence of mine waste liquids.

Methodology

Principal Findings and Significance

Descriptors

Acid mine drainage, Groundwater, Landfill liners, Mining, Tailings, Water quality

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Development of Neural Network for Predicting Nitrate Concentration in Well Water in the Tomorrow-Waupaca Watershed
Project Number	N-09
Start Date	07/01/1999
End Date	06/30/2001
Research Category	Water Quality
Focus Category #1	Nitrate Contamination
Focus Category #2	Groundwater
Focus Category #3	Non Point Pollution
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Hangsheng (Henry) Lin	Professor	The University of Wisconsin	01
Byron Shaw	Professor	The University of Wisconsin	02

Problem and Research Objectives

Assessment of groundwater susceptibility to contamination under conditions of uncertainty is an important issue facing the state and the nation. Because of its ubiquitous nature and potential chronic health effects, nonpoint source pollution of groundwater has become a focal point for the public. We are addressing this issue by developing a new approach to predict nitrate concentration in well water from nonpoint sources in a watershed. Artificial neural network (ANN) models will be developed using a large groundwater quality database in combination with a Geographic Information System (GIS). This approach will be tested for a priority watershed in central Wisconsin and should provide insights on the factors governing groundwater quality in a watershed and on implementing best management practices (BMPs).

Methodology

We are using feedforward artificial neural network (ANN) technology to model nitrate contaminations

in surface and well water in the Tomorrow-Waupaca watershed. We then compare the accuracy and predictive power of the ANN model to standard linear regression (REG) and surface response methodology (RSREG). We wish to demonstrate the superiority of ANN modeling over standard regression techniques. Although other work has been done showing that ANN modeling yields results similar to nonlinear modeling, our approach explores important differences between the methods ignored in other studies. Specifically, other studies have focused on how well a given model can fit the data used to generate the model (e.g., the R2 value normally reported with linear regression). We are shifting the focus to how well the models can actually predict when given data not used in model creation. Another technique we are using to generate a better picture of the model's predictive power is the bootstrap method, which allows us to test our models against multiple realizations of the input data.

Principal Findings and Significance

Our preliminary results thus far are mainly for surface water nitrate contamination data gathered from 38 sub-basins in the Tomorrow-Waupaca watershed. For each model (ANN, REG, and RSREG) we used the following four independent variables for predicting stream water nitrate concentration: stream order, percent agricultural land, percent woodland, and monthly precipitation. These variables were chosen from a more extensive list using traditional statistical methods such as principle component analysis, linear model selection, and correlation matrices using the SAS statistical system. The following table summarizes our preliminary results. Internal refers to the how well each model fits the data used in its generation, while external refers to how well each model fits data not used in its generation. Internal Adjusted R2 External Adjusted R2 ANN model 0.743 0.690 REG model 0.457 0.303 RSREG model 0.747 0.315 The preliminary results show that ANN provides a much more externally consistent model than either REG or RSREG. Our preliminary investigations with the well data also showed that the ANN does better externally than any other model. Thus ANN may be a better predictive modeling tool when compared to standard regression techniques.

Descriptors

Geographic Information Systems, Groundwater, Model studies, Nitrate contamination, Nonpoint source pollution, Water quality

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Cook, R. C. 2000l Relationship between private well water, stream base flow, and land use in the Tomorrow-Waupaca River watershed. M.S. Thesis. College of Natural Resources, University of Wisconsin-Stevens Point.

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Lin, H. S., C. Jaskolski, and R. C. Cook. 2000. Development of neural network models for predicting

nitrate concentration in well water in the Tomorrow-Waupaca Watershed. Agronomy Abstract. 2000 Annual Meeting of the Soil Science Society of America, Minneapolis, Minnesota.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Admicelle-Catalyzed Reductive Dechlorination of Perchloroethylene (PCE) by Zero Valent Iron
Project Number	N-07
Start Date	07/01/1999
End Date	06/30/2001
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Methods
Focus Category #3	Toxic Substances
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Zhaohui Li	Assistant Professor	The University of Wisconsin	01

Problem and Research Objectives

Chlorinated solvents are a major groundwater contaminant at industrial sites, U.S. Department of Energy facilities, and military installations. When these toxic compounds enter the subsurface they are quite mobile and degradation or transformation by natural processes is very slow. Subsurface permeable membranes are showing promise as an efficient, cost-effective means of addressing long-term, low-concentration groundwater contamination. The membrane serves as a giant filter that allows contaminated groundwater to pass through while retaining the toxic compounds by sorption or destroy the contaminants on the barrier by reaction. Recently, the use of zero valent iron (ZVI) as degradation barriers to remediate groundwater contaminated by chlorinated solvents has attracted attention. In addition to its low materials cost and rapid degradation rate for chlorinated solvents, it has been observed that coating ZVI surfaces with a surfactant enhances degradation. We are researching this novel observation using laboratory experiments followed by model studies. This research could have far-reaching impacts on the implementation of permeable barrier technology at sites contaminated with chlorinated solvents throughout the United States.

Methodology

Laboratory batch sorption will be performed to determine the sorption maxima from different types of surfactants and from the same type of surfactant with different hydrophobic chain lengths. The zero valent iron (ZVI) surfaces will be modified to surfactant sorption maxima with cationic surfactatn having 8, 12, and 16 carbons in the tail group. The modified ZVI will be subjected to batch perchloroethylene (PCE) reduction kinetic study to determine the PCE degradation rate constant. The generation of trichloroethylene (TCE) due to the degration of PCE will be monitored with time. The aqueous chloride concentration due to degradation of chlorinated compounds will also be quantified. The PCE degradation kinetics will be studied under different initial pH and ionic strength conditions. Column study will be performed to verify the enhancement of PCE reduction catalyzed by admicelles of cationic surfactant on ZVI surfaces. The results will be simulated with current solute transport and degradation models.

Principal Findings and Significance

After a year of laboratory batch study we found that the sorption of cationic surfactant on ZVI surfaces is a function of the hydrophobicity of the surfactant. The longer the surfactant tail group, the more hydrophobic the surfactant is. Thus, the sorption maximum of hexadecyltrimethylammonium (HDTMA) (C16)on ZVI is higher than that of dodecyltrimethylammonium (DDTMA) (C12), which is higher than that of octadecyltrimethylammonium (OTA)(C8). Compared to unmodified ZVI, The rate constants of PCE reductive dechlorination increased by 15 to 20 times when ZVI was modified by HDTMA. A six to nine fold increase in rate constant was found for ZVI modified with DDTMA, while a five to seven time increase was found for ZVI modified with OTMA. The half life of PCE in the presence of unmodified ZVI was about 10 days. But under the catalysis of HDTMA, the PCE half life is reduced to 0.4 day. Rate of TCE degradation by admicelle catalyzed ZVI degradation increased by an order of magnitude compared to unmodified counterpart. Solutions with an ionic strength of 0.001, 0.01, and 0.1 M of NaCl had no effect on PCE reduction rate. PCE reduction rate was not affected by initial solution pH at 3, 5, and 7. When initial solution pH was 11, significant slowdown of PCE reduction was observed, possibly due to the inhibition of iron corrosion. From the preliminary study it can be seen that the increase in dechlorination rate would greatly enhance the performance of the ZVI barrier if surfactant could be added. On one hand, to achieve the same reduction effect in a given period of time, only fractional ZVI will be needed if catalysed by surfactant admicelle. On the other hand, if the same amount of ZVI used, under the catalysis of surfactant admicelle, the time required for reducing PCE to a limited final concentration will be dramatically reduced. The findings in this study is being used as the support document for a proposal to the U.S. Environmental Protection Agency.

Descriptors

Chlorinated solvents, Groundwater contamination, Permeable membranes, Remediation technology, Zero valent iron

Articles in Refereed Scientific Journals

Li, Z. 1998. Degradation of perchloroethylene by zero valent iron modified with cationic surfactant. Adv. Environ. Res. 2 (2): 244-250. Li, Z.,H. K. Jones, R. S. Bowman, and R. Helferich. 1999. Enhanced reduction of chromate and PCE by pelletized surfactant-modified zeolite/zero valent iron. Environ. Sci. Technol. 33:4326-4330.

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Hydrology and Biogeochemistry in the Wisconsin River Floodplain
Project Number	C-01
Start Date	09/01/1999
End Date	08/31/2001
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Hydrology
Focus Category #3	Nitrate Contamination
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Emily H. Stanley	Assistant Professor	The University of Wisconsin	01
Randall J. Hunt	Professional Staff	US Geological Survey	02

Problem and Research Objectives

Throughout the Midwest, surface and particularly groundwater concentrations of nitrate have been increasing over the past 50 years. This increase has been attributed to changing land uses, particularly intensification of agriculture. Accordingly, nonpoint source (NPS) inputs are generally viewed as a major cause of nutrient enrichment throughout much of the Midwest. There are two major consequences of this NPS pollution. First, a growing number of wells in Wisconsin have nitrate concentrations exceeding the U.S. Environmental Protection Agency's (EPA) 10 mg/liter maximum contaminant level, particularly in the southern part of the state where the combination of well-drained soils and high nitrate loading increases the risk of groundwater contamination. Second, nutrient-rich groundwater and/or the erosion of nutrient-rich particles eventually arrive in surface waters. As a result, many receiving fresh and salt water systems in the Mississippi drainage are becoming eutrophic. The best known example of this process is the expansion of the hypoxic zone in the Gulf of Mexico

following the 1993 flood. It is clear that the ecological and economic ramifications of nonpoint nutrient loading are enormous and must be addressed. In response, agencies (including, EPA, U.S. Geological Survey and the U.S. Department of Agriculture) have sponsored initiatives to improve our understanding of NPS inputs and their controls. The proposed research is directly relevant to the numerous calls for basic and applied research aimed at understanding nutrient loading in the Mississippi River basin.

Methodology

The proposed field site is a 570-ha floodplain area adjacent to the Wisconsin River between Wisconsin Dells and Portage. Piezometers and wells are already installed and information from well logs was collated. Sediments were collected with a 10-cm core, transferred to plastic bags and placed on ice for transport to the laboratory. Because of their amorphous nature, these sediments were put into wide-mouth bottles for assays of actural and potential denitrification to bracket the range of microbial activity. Groundwater samples were collected by pumping or bailing, and flood samples were collected using a series of single-stage samplers. Temperature, oxygen, and pH of surface water samples was beasured using hand-held meters in the field and probes were calibrated prior to each sampling trip. All water samples were field-filtered, stored in amber polyethylene bottles on ice, and returned to the laboratory for analysis.

Principal Findings and Significance

Descriptors

Denitrification, Ecosystems, Groundwater hydrology, Land-water interactions, Nitrogen, Rivers, Wetlands

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

West, J. L. 2000. Denitrification of the Wisconsin River floodplain. M.S. Thesis. Detrification in the Wisconsin River floodplain. Dept. of Zoology, University of Wisconsin-Madison. (In progress).

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

West, J. L., and E. H. Stanley. 2000. Denitrification in soils of the Wisconsin River floodplain: patterns and potential controls. 48th Annual Meeting. North American Benthological Society, Keystone, Colorado. (In progress).

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Development of Translators for Filterable Metals Based upon Watershed Characteristics
Project Number	C-04
Start Date	09/01/1999
End Date	08/31/2001
Research Category	Water Quality
Focus Category #1	Non Point Pollution
Focus Category #2	Toxic Substances
Focus Category #3	Models
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
David E. Armstrong	Professor	The University of Wisconsin	01
James P. Hurley	Professional Staff	Water Resources Institute	02
William C. Sonzogni	Professor	Wisconsin State Laboratory of Hygiene	03
Martin M. Shafer	Professional Staff	The University of Wisconsin	04

Problem and Research Objectives

Loading of trace metals from point and nonpoint sources poses serious concerns for the water resources of the Midwest. Stream health, as measured by biodiversity and potential to support viable populations of target species, has declined markedly in many Midwest river systems. This trend can be traced to watershed disturbances and both nonpoint and point loadings. Concern over the impacts of metals on receiving waters emphasizes the need for information on both the factors controlling export and fundamental information on metal speciation in the receiving waters.

Methodology

Our fundamental objective is to model the partitioning of a suite of trace metals to environmental solids across geochemically contrasting environments. To accomplish this we will apply two general modeling strategies to a unique and large database of reliable trace metal data: (1) multivariate regression with chemical vectors (2) multivariate analysis of environmental characteristics in a GIS-based format. The

trace metals chosen for study (As, Cd, Cr, Cu, Pb, and Zn) are all significant environmental contaminants and reactivity with inorganic ligands, particle surfaces, and functional groups on DOC are significantly different. Therefore, we will take advantage of the contrasts in aqueous speciation of these metals to probe metal specific retention and partitioning processes in the watersheds. Geochemical characteristics of the streams and associated watersheds are defined through the measurement of major ions, dissolved organic carbon (DOC), suspended particulate matter (SPM), pH, and specific conductance. The study will draw upon data for total and filterable metals that our research group has obtain for over 80 relatively homogeneous watersheds in our study area (the complete Lake Michigan basin, the complete US Lake Superior basin, and the entire State of Wisconsin). This extant data will be supplemented by additional field work designed to fill in gaps in our current database. This work will address (1) spatially significant combinations of environmental variables in under-represented ecotypes, and (2) specific combinations of DOC, SPM, and conductance missing from the current data set. GIS coverages will be assembled for regions of the Midwest incorporating our study area. The coverages will include: (1) Land Cover/Land Use (7 sub-classes; (2) Surficial Deposits - Texture (5 sub-classes); (3) Bedrock Geology (6 sub-classes); (4) Depth to Bedrock (4 sub-classes); and Stream Slope. Multivariate statistics will be applied to describe the variability in metal levels. Metal descriptors used in these analyses will include: levels of total, filterable, and particulate metal; fraction dissolved; metal-partition coefficient (Kd); and amount on particles (ug/g). The multivariate models will allow us to rank the study variables as to their influence on individual metal descriptors. Modeling in explicit support of translator development will include multivariate regressions directly on the fraction dissolved (Fd), as well as examination of fundamental factors underlying the Fd, i.e. the partition coefficient and levels and characteristics of particulate and filterable ligands. In implementing the GIS-watershed characteristic component on the study, the specific hydrologic state of each river at the time of sampling will be factored-in. We plan to focus the GIS-multivariate analyses on baseflow conditions, with a much more limited analysis at a 2-year recurring high flow condition. Regression models will be construted for the complete data set, as well as for sub-sets including: (1) similar ecotype, (2) similar environmental characteristic, (3) single basin, and (4) single watershed.

Principal Findings and Significance

Progress: Detailed GIS-based coverages of Land Use/Land Cover, Surfical Deposits, Bedrock Geology, Depth to Bedrock and Soil Characteristics, for the entire study area have been assembled. A comprehensive statistical analysis of these coverages has been performed through which the representiveness of our current site database has been evaluated. In addition, all important regions of relatively homogeneous combinations of the primary GIS-coverages have been identified. The extant trace metal data has been examined for it's ability to support robust statistics, and in the few instances where found lacking, a field sampling plan has been developed to improve the potential for statistical significance. Findings: The percentage of Wetland in a watershed is a strong predictor of both filterable metal concentrations and filterable metal export in the stream draining the watershed. This relationship is particularly strong for the species: Cd, Hg, methyl-Hg, Pb, and Zn; and is statistically more powerful in watersheds/basins with relatively low ionic strength waters. Given our observation of a highly significant relationship between Wetland percentage in the watershed and DOC levels, the implication is that DOC, either directly or indirectly, is a controlling influence on filterable metal levels and stream export. We also observe a statistically valid inverse relationship between DOC levels and the partition coefficients of certain metals (Cu, Hg, Pb, Zn), which is consistent with our modeling construct of DOC as a "dissolved" ligand in competition with functional groups on suspended particle surfaces. For total (unfiltered) metals, suficial deposit characteristics (texture and soils) appear to have the greatest influence on trace metal concentrations among all the watershed variables examined. The highest metal concentrations are observed in those watersheds producing more erodible particles, or particles with

higher metal content. Specifically, soil permeability consistently accounted for the largest fraction of the variance in unfiltered trace metal concentrations. Strong negative correlations are observed between permeability and metal levels - e.g. a decrease in soil permeability results in an increase in metal concentrations. This finding is consistent with other observations that indicate that less permeable clay regions are associated with higher metal levels, and highly permeable sand and gravel regions are associated with lower trace metal levels.

Descriptors

Trace Elements, Metals, Mathematical Models, Watershed Management, Rivers, GIS, Translators, Particle-Partitioning, Suspended Sediment, Toxic Substances, Water Quality, Geochemistry, Contaminant Transport, Organic Carbon.

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Watershed Influences on Transport, Fate and Bioavailability of Mercury in Lake Superior
Project Number	N-14
Start Date	10/01/1999
End Date	09/30/2002
Research Category	Water Quality
Focus Category #1	Toxic Substances
Focus Category #2	Surface Water
Focus Category #3	Geomorpological and Geochemical Processes
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
James P. Hurley	Professional Staff	Water Resources Institute	01
David E. Armstrong	Professor	The University of Wisconsin	02
Martin M. Shafer	Professional Staff	The University of Wisconsin	03
Richard C. Back	Associate Professor	Other	04
David P. Krabbenhoft	Professional Staff	US Geological Survey	05

Problem and Research Objectives

Loading of trace metals from point and nonpoint sources (NPS) poses serious concerns for the water resources of the Midwest. Stream health, as measured by biodiversity and potential to support viable populations of target species, has declined markedly in many Midwest river systems. This is a trend which can be traced to watershed disturbances and both point and nonpoint loadings. Concern over the impacts of metals on receiving waters emphasizes the need for information on both the factors controlling export and fundamental information on metal speciation in the receiving waters. To address this issue, metal speciation will be quantified as a function of watershed environmental characteristics and readily determined geochemical variables. In addition, model development will provide the basis for assessment and prediction of metal speciation across divergent watersheds.

Methodology

Our approach combines field and laboratory studies with modeling to assess the importance of watershed processes in controlling Hg fate and transport in Lake Superior (Figure C1). Each phase (field studies, laboratory studies, modeling efforts) is strongly linked to provide feedback for the remaining phases. Frequent interaction among project participants (group meetings, conference calls) will allow for adjustments to better assess important processes for success of objectives. Our approach builds on research conducted by our group on Lake Superior tributaries from 1995-1998 and develops new research objectives in fate and transport of Hg, including factors regulating bioavailability. Techniques developed and adapted by our group during previous projects (i.e., "clean" ultrafiltration, resin techniques, biota processing) will be supplemented by new techniques (i.e., stable isotope Hg analysis by ICP-MS; phytoplankton and zooplankton uptake experiments, "bio-reporter" work by Canadian colleagues). Modeling efforts combine efforts of ongoing GIS-based watershed yield modeling with the Dynamic Mercury Cycling Model (D-MCM) model development at Tetra Tech, Inc.

Principal Findings and Significance

The field aspects of the project began with the onset of spring melt on three study tributaries. Our group participated in a spring cruise to the open waters of Lake Superior aboard the USEPA's R/V Lake Guardian. A total of 19 sites were sampled in the lake, with six sites considered master stations for detailed phytoplankton, watercolumn and sediment sampling. Preliminary analyses suggest that offshore regions of the lake have Hg levels in the range of 0.2 to 0.4 ng/L, while sites located near urban areas can exceed 1 ng/L. A second cruise is scheduled for August 2000 and we will continue with detailed mixing zone and watershed studies.

Descriptors

Contaminant transport, Geochemistry, Mathematical models, Metals, Suspended sediment, Trace elements, Toxic substances, Water quality

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Corrosion Control in Small Public Water Systems
Project Number	N-17
Start Date	10/01/1999
End Date	09/30/2000
Research Category	Water Quality
Focus Category #1	Law, Institutions, and Policy
Focus Category #2	Water Supply
Focus Category #3	Water Quality
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Jae K. Park	Associate Professor	The University of Wisconsin	01
Abigail F. Cantor	Professional Staff	Other	02

Problem and Research Objectives

The Lead and Copper Rule, implemented in 1991, set a Maximum Contaminant Level (MCL) for soluble lead and copper concentrations in standing water samples obtained from household plumbing. Treatment options, depending upon system characteristics, can sometimes either prove costly, difficult to control or have negative secondary impacts in the system. Additionally, many small groundwater

systems have not been chlorinated in the past. Chlorine is a strong oxidizer, and as such would be expected to have a negative impact on corrosion rates. New regulations will require disinfection, and this may negatively influence corrosion rates and the concentrations of lead and copper in the drinking water. Increased corrosion of iron and associated consumer complaints are also possible. This study will address corrosion control in small public water systems, with emphasis on responding to the Lead and Copper Rule, and disinfection related problems such as red water and taste and odor complaints from consumers.

Methodology

Principal Findings and Significance

Descriptors

Drinking water, Copper, Lead, Public water systems, Potable water supplies

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	The Spatial Variability of Natural Groundwater Recharge
Project Number	C-05
Start Date	11/01/1999
End Date	09/30/2001
Research Category	Ground-water Flow and Transport
Focus Category #1	Hydrology
Focus Category #2	Management and Planning
Focus Category #3	Water Quantity
Lead Institution	The University of Wisconsin

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Mary P. Anderson	Professor	The University of Wisconsin	01
Kenneth R. Bradbury	Professor	University of Wisconsin-Extension	02
Kenneth W. Potter	Professor	The University of Wisconsin	03

Problem and Research Objectives

Understanding the distribution and rate of groundwater recharge is a basic prerequisite for effective groundwater mangement and is one of the keys to economic development in rapidly expanding urban, industrial, and agricultural regions. Recharge, defined as the entry of water into the saturated zone, is dependent on a wide variety of factors including the topography, geology, soils, vegetation, land use, precipitation, and climate. The variability and complexity make it one of the most difficult and uncertain hydrologic parameters to quantify in the evaluation of groundwater resources. Through this project we are exploring and determining the relative significance of some of the factors (e.g., climate, vegetation, topography, soils, and geology) that control groundwater recharge. In addition, we wil develop improved methods for estimating groundwater recharge rates at scales suitable for groundwater modeling and water resource planning.

Methodology

Three field techniques (temperature profiling, water level fluctuations, and lysimeters) are being used to assess the relative significance of some of the factors (topography, vegetation, soil, and geology) that control groundwater recharge to develop two improved techniques for estimating groundwater recharge at scales suitable for groundwater modeling and water resource planning. The first technique couples a water balance and parameter estimating (inverse) model. The second technique applies a modified Thornthwaite-Mather soil water balance to a three-dimensional, gridded digital elevation model (DEM) within a Geographic Information System (GIS). These improved methods will provide regulators with water resource management tools capable of providing spatially distributed estimates of the rates and distribution of groundwater recharge. In addition, these techniques might be used to evaluate the impacts of urbanization, land use changes, and climate change on the patterns and rates of recharge as well as provide inputs for the partial distribution of recharge into regional groundwater flow models. As a way of testing the methods, both techniques will be applied to a portion of the Trout Lake watershed, Vilas County, Wisconsin. Results from the methods will be compared to each other as well as to point measurements of recharge obtained from field studies within the watershed.

Principal Findings and Significance

(Please complete this section.)

Descriptors

Groundwater recharge, Groundwater hydrology, Groundwater management, Groundwater modeling, Inverse modeling, Hydrologic models, Inverse modeling, hydrologic models, Geographic information systems, Mathematical models, Resource planning, Water resource development

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

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Other Publications

Information Transfer Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Information Transfer Program
Description	Library Collection and Facilities
Start Date	03/01/1999
End Date	02/29/2000
Type	Library And Database Services
Lead Institution	Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Anders W. Andren	Professor	Water Resources Institute	01
James P. Hurley	Professional Staff	Water Resources Institute	02
Kari J. Sherman	Professional Staff	Water Resources Institute	03
JoAnn M. Savoy	Professional Staff	Water Resources Institute	04

Problem and Research Objectives

Methodology

Principal Findings and Significance

Information Transfer Program Library Collection and Facilities The Water Resources Institute Library

(WRIL) maintains a specialized collection of over 21,000 water-related publications in hard copy and microfiche, more than 35 journals, and more than 135 newsletters. The collection covers all major topics in water resources, including the water cycle, water conservation, water management, water quality and quantity, point and nonpoint water pollution sources, water law, and aquatic life. The collection is particularly strong in Wisconsin and Great Lakes water resources issues, groundwater protection, wetlands issues, and the impacts of agricultural chemicals. The Water Resources Institute Library serves Institute staff, University of Wisconsin faculty, staff, and students, Wisconsin state government, businesses, and industry, and other Wisconsin residents. The Library will lend documents to non-Wisconsin residents, but provides other services only as time and resources permit. The Library is staffed and open to the public 9 a.m. to 4:30 p.m., Monday through Friday. The entire collection is included in Madcat, the University of Wisconsin online catalog and can easily be searched by author, title, or subject heading by anyone on campus and by anyone in the world over the Internet. The collection is also available online in the CIC (Committee on Institutional Cooperation) Virtual Catalog and the Online Computer Library Center's (OCLC) WorldCat. Access to water resources indices and databases is gained through the University of Wisconsin Electronic Library, Dialog, and the many sources of information on the Internet. This unique Wisconsin resource of water-related information is one of only two such libraries established under the State Water Resources Research Institutes Program. The Library collection, electronic resources and services are built upon and the result of long-term cooperation and coordination with other University of Wisconsin and area libraries. Library staff participate in campus library groups, the Wisconsin Chapter of the Special Libraries Association, the Wisconsin Library Association, and other library organizations. Through this coordination, the librarian builds a unique collection that does not duplicate the collections of other area libraries. WRI Library contributions help make Water Resources Abstracts available online to the UW-Madison campus. In turn, the Library depends on the UW Electronic Library for access to other online water resources indices, databases and full text journals and documents. The UW General Library System partially supports WRI Library participation in MadCat, the University online catalog. The Library also cooperates with the Wisconsin Department of Natural Resources (WDNR) Library which depends on the library to collect water-related technical reports. To this end, the WDNR contributes funds each year to support the purchase of such materials. New Activities: During FY 1999, the Library expanded its Web site at http://wri.wisc.edu/library and increased the scope of its monthly "Recent Acquisitions" list. In addition to redesigning the Web site, the following new features were added: ."A Guide to Finding Water-Related Information on the Web" ."A Guide to Finding a Water-Related Job on the Web" ."A Guide to Searching MadCat for WRIL Documents" The librarian has expanded the monthly "Recent Acquisitions" list to include "Web Sites of Interest" to water resources professionals and students. In addition to the URL, an annotation is provided for each Web site. The list is now primarily sent out through email, but library staff also provide print copies for those who request it. Staff also provide back issues on the Web. Library Services: The Water Resources Institute Library offers the following services: . Loan of documents and journals through interlibrary loan, the mail, or in person. . Distribution of the monthly library newsletter, "Recent Acquisitions and Web Sites of Interest," to approximately 300 university personnel, state agency staff, researchers, consultants, libraries, private organizations and interested citizens. The newsletter is distributed by mail, email, and put on the Library Web site. . Subject searches of MadCat, Water Resources Abstracts, UW Electronic Library databases, Dialog databases, and Internet resources. . Ready reference and referral, e.g., short answers to questions. Examples include addresses, telephone numbers, bibliographic citations, etc. The Library has also instituted an e-mail reference service, AskWater. . Making the WRIL collection available in MadCat, the CIC Virtual Catalog and OCLC WorldCat. The collection can now be searched by anyone over the Internet. . A WRI Library web site at http://wri.wisc.edu/library includes information about the library and library policies, links to renew and request books, an electronic reference service (AskWater), backfiles of "Recent Acquisitions and Web Sites of Interest", links to the UW online catalog and databases, and guides to finding water-related information and jobs on the Web. . Provision

of two terminals with access to all of the resources of the UW Electronic Library, Dialog and the Internet for use by faculty, staff, students and others who come to the library. The Library also provides free printing and photocopying. . Since August, 1990 the Library has circulated and served as a depository for the reports of the WDNR Groundwater Management Program Monitoring Project. The Library has added these reports to Madcat, listed them in the Recent Acquisitions list, and provided staff to put summaries of these projects on the world wide web. Reference Services Use of the WRI Library by faculty, students, federal agencies, private consulting firms, and others interested in water has grown greatly over the last several years. Book circulation has increased more than 51% and requests for information more than 63% from FY 98 to FY 99. Since adding the collection to MadCat, the University of Wisconsin online catalog, in the summer of 1995, student use has increased significantly. During FY99, the library staff responded to 1238 requests for individual titles and subject searches. More than 691 UW-Madison faculty, staff, and students, WDNR staff, private consulting organizations, and members of the public contacted the WRIL last year. Water Resources Institute Publications Results of WRI-supported research are published in a variety of forums. Much of the WRI research ultimately appears in refereed professional journals, although results of WRI research can also be accessed as technical reports, conference proceedings and abstracts, book chapters, or as dissertations and theses. A list of all publications resulting from WRI-supported research is maintained and will be added to the WRI web site over the next year. Copies of the publications housed at the WRI are distributed upon request. A highlight during the past year was the production of the Wisconsin Water Resources Institute Program Directory. This directory provides a brief history of the Wisconsin WRI program, briefly describes all research projects supported through the WRI, and gives a general overview of the WRI program. During the next fiscal year the WRI will begin publishing a newsletter. Each issue will feature a noteworthy research project, announce recently funded research, post new and noteworthy water-related web sites, list significant acquisitions to the WRI Library, and provide a forum for announcing relevant local, regional or national water-related news. Water Resources Institute Web Site The WRI has maintained a Web site since 1995 to provide an efficient means for the transfer of water-related information. The web site was originally developed by the WRI Library on the the University of Wisconsin General Library System server; but the Web site has been greatly expanded and transferred to WRI's own on-site server. The site provides information about WRI programs and staff, water resources funding opportunities, conference information, project summaries, links to other water-related sources, and extensive information about the WRI Library. In addition, The Directory of Water Resources Personnel in Wisconsin, a comprehensive listing of more than 800 water professionals in Wisconsin, has been added to the WRI web site and is searchable by last name of expert, area of expertise, and/or research interest. The address of the WRI web site is http://www.wri.wisc.edu. Use of the web site has steadily increased from February 1999 through February 2000. MONTH USER SESSIONS Feb '99 256 Mar 1,421 Apr 549 May 1,243 Jun 1,094 Jul 939 Aug 865 Sep 975 Oct 1,458 Nov 1,815 Dec 1,582 Jan '00 1,909 Feb 2,170 Conferences, Meetings and Presentations The Wisconsin Water Resources Institute co-sponsored the American Water Resources Association -- Wisconsin Section Annual Meeting on March 23 and 24, 2000 in Green Bay, Wisconsin. This meeting provided a forum for nearly 50 papers that covered a variety of water-related subjects and were presented during six technical sessions and a poster session. This meeting is unique because it especially encourages students to present papers or posters describing their original research. Awards are presented to the student papers judged to be "best." At the meeting, the WRI librarian in cooperation with Steenbock Agricultural Library staff made a presentation on "Finding a Water-Related Job on the Web". The librarian was the 1999 Chair of the Wisconsin Library Association's Association of Special Librarians (AWSL) and involved in program planning for the annual WLA conference. In 1999, AWSL sponsored four programs and two special library tours - all well-attended and enthusiastically received - but particularly popular were the tours of the Fish Lab (USGS's Upper Midwest Environmental Sciences Center) and its library and the UW-LaCrosse Steamboat Archives.

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	N/A	1	N/A	N/A	1
Masters	2	1	N/A	N/A	3
Ph.D.	2	4	1	N/A	7
Post-Doc.	N/A	N/A	N/A	1	1
Total	4	6	1	1	12

Awards & Achievements

The University of Wisconsin System, through the Water Resources Institute, has coordinated and conducted a wide-ranging program of priority groundwater research. With nearly 75% of its base budget targeted for research,

during FY 99 the WRI supported 28 individual projects, including short-term and long-term studies of either a fundamental or an applied nature. These have provided a balanced program of laboratory, field, and computer modeling studies and applications aimed at preserving or improving groundwater and surface water quality. In addition, the projects have provided training in several disciplines for post-doctoral research associates, graduate student research assistants, and undergraduate students at the University of Wisconsin-Madison, University of Wisconsin-Milwaukee, University of Wisconsin-Parkside, and University of Wisconsin-Stevens Point. Researchers working on the project "Mercury Speciation and Transport in the Florida Everglades" have recently shown that methylation of Hg, a process typically thought to be limited to surface sediments, actively occurs in floating periphyton in many parts of the Everglades. This finding has potential management applications in that several regulatory agencies in Florida are considering developing stormwater treatment areas for nutrient removal and some designs call for periphyton-based systems. The WRI has maintained a web site since 1995 to provide an efficient means for transfer of water-related information. The web site was originally developed through the University of Wisconsin General Library System, but recently has been greatly expanded to and transferred to WRI's own on-site server. The current address for the WRI web site is http://wri.wisc.edu. Two WRI-supported students were selected to receive U.S. Environmental Protection Agency STAR (Science to Achieve Results) Graduate Fellowships. The selection process, in part, considered the students' work on the projects, "Use of Specific Sorbents and Rapid Bioassays for Groundwater Monitoring" and "Mercury Speciation and Transport in the Florida Everglades." The Ph.D. Dissertator supported by the U.S. Geological Survey-funded project, "Use of Specific Sorbents and Rapid Bioassays for Groundwater Monitoring," won the Promising Young Scientist Award at the Ninth International Symposium on Toxicity Assessment, Pretoria, South Africa, September 26 - October 1, 1999. This student also won the Outstanding Platform Presentation Award sponsored by 3M Corporation at the Society of Environmental Toxicology and Chemistry - Midwest Chapter meeting in Bloomington, April 13-14, 2000. The highly competitive and prestigious Horton Research Grant, awarded annually by the Hydrology Section of the American Geophysical Union, was won by a WRI-supported Ph.D. candidate this year. The student was selected, in part, for his work on the project, "The Spatial Variability of Natural Groundwater Recharge." Current water-related information is made easily accessible to researchers, public officials, state administrators, university students and the public through the WRI information transfer program. A list of all publications resulting from WRI-supported research is maintained and will be added to the WRI web site over the next year. Copies of the publications housed at the WRI are distributed upon request. In addition, the WRI serves as a repository for reports on all projects carried out through the Wisconsin Groundwater Coordinating Council. A highlight during the past year was the production of the Wisconsin Water Resources Institute Program Directory. This directory provides a brief history of the Wisconsin WRI program, briefly describes all research projects supported through the WRI, and gives a general overview of the WRI program. During the next fiscal year the WRI will begin publishing a newsletter. Each issue will feature a noteworthy research project, announce recently funded research, post new and noteworthy water-related web sites, list significant acquisitions to the WRI Library, and provide a forum for announcing relevant local, regional or national water-related news. During FY 1999, the WRI librarian redesigned and expanded the Library Web site at http://wri.wisc.edu/library. The following new features were added to the Web site: · "A Guide to Finding Water-Related Information on the Web" · "A Guide to Finding a Water-Related Job on the Web" · "A Guide to Searching MadCat for WRIL Documents" Last fiscal year, the librarian also increased the scope of the monthly "Recent Acquisitions" list to include new "Web Sites of Interest" to water resources professionals and students. In addition to the URL, a descriptive annotation and evaluation is provided for each Web site.

Publications from Prior Projects

Articles in Refereed Scientific Journals

Cheng, Y. S., J. L. Halsey, K. A. Fode, C. C. Remsen, and M. L. P. Collins. 1999. Detection of methantrophs in groundwater by PCR. Appl. Environ. Microbiol. 65:648-651. Cleckner, L. B., C. C. Gilmour, J. P. Hurley, and D. P. Krabbenhoft. 1998. Mercury methylation by periphyton in the Florida Everglades. Nature. (In press.) Elder, C. R., and C. H. Benson. 1999. Air channel formation, size, spacing, and tortuosity during air sparging. Ground Water Monitor. Remed. 19(3):171-181. Gustavson, K. E., A. Svenson, and J. M. Harkin. 1998. Comparison of toxicities and mechanism of action of n-alkanols in the submitochondrial particle (SMP) and the Vibrio fisheri bioluminescence (Microtox) bioassay. Environ. Toxicol. Chem. Hurley, J. P., D. P. Krabbenhoft, L. B. Cleckner, M. L. Olson, G. Aiken, and P. J. Rawlik. 1998. System controls on aqueous mercury distribution in the northern Everglades. Biogeochemistry 40:293-311. Keating, E. H., and J. M. Bahr. 1998. Using reactive solutes to constrain groundwater flow models at a site in northern Wisconsin. Water Resour. Res. 34(12):3561-3571. Keating, E. H., and J. M. Bahr. 1998. Reactive transport modeling of redox chemistry: Approaches to chemical disequilibrium and reaction rate estimation at a site in northern Wisconsin. Water Resour. Res. 34(12):3573-3584. Krabbenhoft, D. P., J. P. Hurley, G. Aiken, C. C. Gilmour, M. Marvin-DiPasquale, W. H. Orem, and R. Harris. 1999. Mercury cycling in the Florida Everglades: A mechanistic field study. Verhundlungen Internationale Vereinigung Limnologie. (In review.) Miller, L. W., and M. Anderson. 1998. Fiber-mediated titanium dioxide photocatalysis. J. Adv. Oxidation Technol. (In press.) Miller, L. W., M. Anderson, and I. Tejedor-Anderson. 1998. Titanium dioxide-coated quartz waveguides for the photocatalytic oxidation of formic acid in water. Environ. Sci. Technol. (In review.) Rosenshield, M. L., M. B. Jofre, and W. H. Karasov. 1999. Effects of polychlorinated biphenyl 126 on green frog (Rana clamitans) and leopard frog (Rana pipiens) hatching success, development, and metamorphosis. Environ. Tox. Chem. 18(11):2478-2486. Schreiber, M. E., and J. M. Bahr. 1999. Special electron acceptor variability: Implications for assessing bioremediation potential. Bioremed. J. 3(4):363-378. Schulze-Makuch, D., and D. S. Cherkauer. 1998. Variations in hydraulic conductivity with scale of measurement during aquifer tests in heterogeneous, porous carbonate rocks. Hydrogeol. J. 6(2):In press. Shi, Y., M. D. Zwolinski, M. E. Schreiber, J. M. Bahr, G. W. Sewell, and W. J. Hickey. 1999. Molecular analysis of microbial community structure in pristine and contaminated aquifers: Field and laboratory microcosm studies. Appl. Environ. Microbiol. 65(5):2143-2150. Tsay, T.-S., and J. A. Hoopes. 1998. Numerical simulation of ground water mounding and its verification by Hele-Shaw model. Comp. Geosci. 24(10):979-990. Yuan, H., J. L. P. Collins, and W. E. Antholine. 1998. Concentration of Cu, EPR-detectable Cu, and formation of cupric-ferrocyanide in membranes with pMMO. J. Inorganic Biochem. 72:179-185. Yuan, H., J. L. P. Collins, and W. E. Antholine. 1999. Type 2 Cu2+ in pMMO from Methylomicrobium album BG8. Biophys. J. 76:2223-2229.

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Schreiber, M. E., J. M. Bahr, M. Zwolinski, Y. Shi, W. J. Hickey, and K. A. Brownell. 1997. Field and laboratory studies of BTEX bioremediation under denitrifying conditions. pp. 13-18. In: In situ and on-site bioremediation. Battelle Press, Columbus, Ohio.

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Champion, G. 1998. Transient and steady-state flow models of a groundwater and lake system: Trout Lake basin, northern Wisconsin. M.S. Thesis. Department of Geology and Geophysics, University of Wisconsin-Madison. 105 pp. + appendices. Cook, R. C. 2000. Relationship between private well water,

stream base flow, and land use in the Tomorrow-Waupaca River Watershed. M.S. Thesis. College of Natural Resources, University of Wisconsin-Stevens Point. Halsey, J. L. 1998. Development of methodology for the detection of methanotrophs in groundwater. M.S. Thesis. Department of Biological Sciences, University of Wisconsin-Milwaukee. Miller, L. W. 1998. Photocatalytic oxidation of organic compounds via waveguide-supported titanium dioxide films. Ph.D. Disseration. Water Chemistry Program, University of Wisconsin-Madison. 103 pp. Schreiber, M. E. 1999. Experimental and modeling approaches to evaluating anaerobic biodegradation of petroleum-contaminated groundwater. 1999. Ph.D. Dissertation. Department of Geology and Geophysics, University of Wisconsin-Madison. 226 pp. + appendices.

Water Resources Research Institute Reports

Allran, J. W., and W. H. Karasov. 2000. Chronic effects of atrazine and nitrate on northern leopard frog (Rana pipiens) larvae exposed in the laboratory from post-hatch through metamorphosis. WRI GRR 00-01. Water Resources Institute, University of Wisconsin-Madison. 17 pp. Allran, J. W., and W. H. Karasov. 2000. Sub-acute effects of atrazine on embryos, larvae, and adults of anuran amphibians. WRI GRR 00-02. Water Resources Institute, University of Wisconsin-Madison. 17 pp. Foose, G. L., C. H. Benson, and T. B. Edil. 1999. Methods for evaluating the effectiveness of landfill liners. WRI GRR 99-02. Water Resources Institute, University of Wisconsin-Madison. 42 pp. Hickey, W. J., J. M. Harkin, G. Sabat, and P. Rose. 2000. Molecular methods for detection of sewage-borne human pathogens in soil and water. WIS WRI 00-01. Water Resources Institute, University of Wisconsin-Madison. 37 pp. Hickey, W. J., and B. N. Moran. 1999. Biostimulation of trichloroethylene degradation in contaminated aquifers. WRI GRR 99-05. Water Resources Center, University of Wisconsin-Madison. 22 pp. Hoopes, J. A., S. Rashad, Y. Majali, and T.-S. Tsay. 1999. Field evaluation of near source transport of contaminants in heterogeneous media: Estimation of flow parameters and simulation of water table elevations. WRI GRR 99-03. Water Resources Institute, University of Wisconsin-Madison. 26 pp. Hoopes, J. A., S. Rashad, Y. Majali, and T.-S. Tsay. 1999. Field evaluation of near source transport of contaminants in heterogeneous media: Numerical simulation of groundwater mounding. WRI GRR 99-04. Water Resources Center, University of Wisconsin-Madison. 22 pp. Klima, J. S., T. B. Edil, and C. H. Benson. 1999. Field assessment of monitoring and water supply well seals. WRI GRR 99-01. Water Resources Institute, University of Wisconsin-Madison. 48 pp.

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Ansari, S., and D. Cherkauer. 1998. Relation of groundwater recharge rates in southern Washington County to land use and soil type. p. 38. In: Water resources management: Changes as we approach the 21st century. American Water Resources Association - Wisconsin Section 22nd Annual Meeting. Water Resources Center, University of Wisconsin-Madison, Madison, Wisconsin. Cheng, Y. S., J. L. Halsey, P. D. Anderson, C. C. Remsen, and M. L. P. Collins. 1998. Use of PCR to detect particulate methane monooxygenase in groundwater. p. 377. In: Abstracts of the General Meeting of the American Society for Microbiology. Davis, T. S., and R. W. Taylor. 1998. An application of electrical anisotropy in hydrogeological modeling. In: Proceedings of Symposium on the Application of Geophysics to Engineering and Environmental Problems. Society for Engineering and Environmental Geophysics. Fode, K. A., C. Wimpee, C. C. Remsen, and M. L. P. Collins. 1999. Use of competitive PCR for quantification of methanotrophs in groundwater. p. 486. In: Abstracts: General Meeting of the American Society for Microbiology. Fode, K. A., C. Wimpee, C. C. Remsen, and M. L. P. Collins. 1999. Direct application of PCR to environmental samples. p. 572. In: Abstracts: General Meeting of the American Society for Microbiology. Krabbenhoft, D. P., J. P. Hurley, G. Aiken, C. C. Gilmour, M. Marvin-DiPasquale, W. H. Orem, and R. Harris. 1998. Mercury cycling in the Florida Everglades: A

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Other Publications

Cheng, Y. W., J. L. Halsey, K. A. Fode, C. C. Remsen, and M. L. P. Collins. 1999. Detection of methanotrophs in groundwater by the polymerase chain reaction. Department of Biological Sciences, University of Wisconsin-Milwaukee. Harris, M. T., J. J. Kuglitsch, R. Watkins, D. P. Hegrenes, and K. R. Waldhuetter. 1998. Early Silurian stratigraphic sequences of eastern Wisconsin, Midcontinent U.S.A. pp. 39-49. In: E. Laning, and M. Johnson (eds.). Silurian cycles: Linking of Dynamic Processes in the Atmosphere and Oceans. New York State Museum Bulletin. Harvey, R. G. 1998. A simple technique for predicting future weed problems and choosing the best management practices. pp. 37-43. In: Report of the Expert Consultation on Weed Ecology and Management. Plant Production and Protection Division, Food and Agriculture Organization of the United Nations, Rome, Italy. Muldoon, M. A., and K. R. Bradbury. 1998. Tracer study for the characterization of groundwater movement and contaminant transport in fractured dolomite. Open File Report 98-02. Wisconsin Geological and Natural History Survey, Madison, Wisconsin. 85. pp.