Oklahoma Water Research Institute

Annual Technical Report

FY 1999

Introduction

The Environmental Institute at Oklahoma State University has as its mission to serve as a center for stimulation and promotion of interdisciplinary research, graduate education, and public education relating to understanding, protecting, utilizing, and sustaining the natural environment. The University Center for Water Research (UCWR) is an integral part of the Institute's research effort, and is responsible for developing and coordinating water research funded through two programs: ¨ Oklahoma Water Resources Research Institute (OWRRI) funded by the U.S. Department of the Interior through the U. S. Geological Survey ¨ Water Research Center (WRC) funded by the State of Oklahoma.

The primary objective of the UCWR is the promotion of research of water related issues that are not only of national and regional concern, but also address the needs of Oklahoma.

The federally supported Oklahoma Water Resources Research Institute is one of 54 Water Resources Research Institutes funded under Section 104 of the Water Resources Research Act. In FY 1999, the $68,178 base grant to the OWRRI was directed to support one research project and water research administration and development activities as well as the information transfer program. A synopsis of the research project is included in this report. Administration and development activities included the Director's travel to regional and national NIWR meetings and salary support for the Coordinator to compensate for time devoted to the program. A portion of the Institute's Technical Writer position was supported to edit the OWRRI newsletter. Printing and mailing costs for the Institute newsletter and other announcements were also covered.

Additionally, the OWRRI continued to oversee one Regional Competive Grant program award. This project, awarded in FY 1997 to the University of Oklahoma and Texas A&M University, investigates geochemical and microbiological influences on biodegradation of pollutants in the subsurface. A synopsis of this project is included in this report.

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Geochemical and Microbiological Influences on Terminal Electron Accepting Processes and Its Relation to the Biodegradation of Pollutants in the Subsurface: A Study of an Aquifer Contaminated by Landfill Leachate
Project Number	C-02

Number	
Start Date	09/01/1997
End Date	02/01/2001
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Hydrogeochemistry
Focus Category #3	Toxic Substances
Lead Institution	Oklahoma Water Research Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Joseph M. Suflita	Professor	University of Oklahoma, Dpt. of Botany and Microbiology	01
Ethan Grossman	Professor	Texas A&M University, Dpt. of Geology and Geophysics	02
Luis Cifuentes	Professor	Texas A&M University, Dpt. of Oceanography	03

Problem and Research Objectives

Accurate predictions concerning the fate of pollutants in the environment depends upon precise observations of a number of ecological parameters. Subsurface microorganisms can play a central role in the destruction of contaminants within aquifers. The geochemical makeup of an aquifer can influence the biological activity of these organisms that can in turn, have an effect on geochemistry.

The work performed by implementation of this proposal has been to determine the presence and distribution of microbial processes that are occurring in the aquifer and to assess the impact of these processes on the quality of the groundwater. This project has been addressed in a variety of ways that include on-site field measurements and observations as well as laboratory experimentation and analyses. The findings are certainly not restricted to the Norman landfill. Many of our results will be useful to other investigators who are working in related areas at other field sites.

Methodology

This project involves the measurement of dissolved hydrogen gas in the groundwater that underlies the landfill. We are investigating the usefulness of hydrogen as an indicator of the dominant microbial processes that could be occurring at the site. Information concerning the three-dimensional distribution of microbial processes is required in order to accurately describe a subsurface ecosystem and predict the

rate of biodegradation of pollutant chemicals. Moreover, microbial activity often changes with time. Dissolved hydrogen measurements made over time may be a useful indicator of the dynamics of microbial communities in soil. If hydrogen can be used to make this description, then the task of characterizing the environment is greatly simplified. Traditionally, this characterization involves obtaining sediment cores that are used in laboratory experiments that can incur a significant expense while often requiring long incubation times and tedious sampling. Groundwater sampling for hydrogen is much simpler and cost effective in that no sediment is required. Water can be pumped from wells that have been installed at the site of interest and can then be removed after hydrogen monitoring is complete, resulting in minimal disturbance to the environment.

A thorough understanding of an aquifer environment requires information concerning the rates of the various microbial processes that are occurring. We have employed an experimental procedure termed a push-pull test in an effort to quantitate the rates of hydrogen and sulfate consumption at the landfill. Briefly, the push-pull test involves the removal of groundwater, which is stored in a carboy, while chemicals of interest, including a conservative tracer are added after which the solution is reinjected into the formation. As samples are removed over time, the concentration of tracer and analyte will decrease due to microbial consumption and/or dilution. The degree of tracer loss due to dilution is applied to the concentration curve of the analyte. In this way, the decrease in analyte concentration that is due to dilution can be estimated. Any time-dependent decrease of the chemical of interest over and above that which can be attributed to dilution is then recognized as being due to microbial consumption and a rate is estimated based upon that measure.

A feature of natural systems that often complicates the estimation of rate processes at any site is the non-uniform distribution of microbial activity. We have recently removed cores of sediment from several locations downgradient from the landfill and are currently studying the two-dimensional distribution of sulfate reducing activity in incubations of this material. The spatial distribution of sulfate reduction activity can be visualized based on a direct imaging procedure that we have developed. Radioactive sulfate is applied to the face of a core sample; the sulfate is reduced by the resident microflora yielding radioactive sulfide, which precipitates on the soil particles. The unreacted sulfate is washed away leaving only sulfide, which can be examined qualitatively, and quantitatively using a specialized autoradiography instrument. This procedure allows for direct viewing of the distribution of microbial activity in a minimally disturbed sample giving the researcher an accurate representation of how the processes occur in the field. Following this type of assessment, we will send the samples to our colleagues at the USGS office in Denver, CO, who will analyze for various sulfur-containing minerals in the same sediments. In addition to these data, USGS workers in Reston, VA, obtained water samples at several locations along the vertical depth of each core. From this collaboration, we will have water and solid phase chemical profiles as well as information concerning in situ sulfate reducing activity at numerous locations. This work will not only describe the distribution of activity at the site but will enhance our understanding of the factors responsible for the distribution of sulfate reduction at the landfill and other sites.

Principal Findings and Significance

Hydrogen measurements indicate that various bacterial processes are dominant at different locations within the field site. In fact, significant differences in hydrogen values were measured at different depths within the same well. In addition, we have found that dissolved hydrogen values change over time. We have monitored hydrogen levels at 35 different locations, taking a measurement approximately every six weeks for almost one year. Results suggest that the dominant microbial process is not constant over time, but changes with seasonal patterns, possibly as a function of groundwater temperature. Our work

has shown that the concentration of hydrogen in groundwater can indeed be a useful indicator. However, under some environmental conditions its usefulness is limited and needs to be considered in concert with other groundwater geochemical measurements. Future work in this area will further define the usefulness of dissolved hydrogen measurements and provide an additional tool for site characterization to workers in several disciplines including microbiology, geochemistry and various engineering sciences. Direct rate measurements made in the laboratory suggest that sulfate reduction and methanogenesis are the most important microbial reactions at the aquifer locations. At one location, the hydrogen values measured in the field agree with the laboratory experiments in predicting sulfate reduction as a dominant process. In another area of the aquifer, the hydrogen suggests that iron reduction is the dominant reaction but laboratory rate measurements could not confirm this prediction. This finding implies that caution is necessary in the interpretation of dissolved hydrogen data and that other methods should be employed, in addition to hydrogen measurements, in efforts to accurately map the distribution of microbially catalyzed redox reactions. Sulfate reduction rates based on the push-pull test method were found to be approximately 5 mM/day. This value is in good agreement with laboratory based methods that employed material from the same location. Our rate estimates are also similar to rates measured at other sites. This finding confirms the integrity of the laboratory-based analyses and provides yet another method to estimate sulfate consumption activity. The advantage of the push-pull test is similar to that of dissolved hydrogen in that soil and expensive laboratory incubations are not necessary. The degradation rate of higher molecular weight molecules in aquifers impinges on the rate and extent of hydrogen removal from the system. Therefore, accurate measurements of hydrogen consumption rates in soil are required for the precise definition of fate processes in groundwater environments. We used the push-pull test method discussed above to measure the hydrogen consumption rate at a particularly well-studied location at the Norman landfill. Our estimates included kinetic estimates of the Km as well as measures of the maximum rate. We compared our values with those determined from other sites and found similar kinetic properties existed at different locations, suggesting that the hydrogen consuming capacity at the Norman landfill may be representative of other field sites. In addition to determining the dominant microbial processes that are occurring at a site, the factors that limit the activity of the microorganisms also need to be investigated. We have found that sulfate reduction is an important process at the landfill and our experimental evidence has suggested that the sulfate concentration in the aquifer is maintained at a level which limits the rate of sulfate reduction. Sulfate-reducing bacteria are widely distributed in many environments and have the capacity to degrade compounds that are metabolized slowly or not at all under other conditions. At some sites it may be necessary to know what limits the activity of these organisms in order to maximize their biodegradative capacity.

Descriptors

AQUIFER CHARACTERISTICS, ANAEROBIC TREATMENT, BIODEGRADATION, GEOCHEMISTRY, GROUND WATER QUALITY, POLLUTANTS, MICROBIOLOGY, TOXIC SUBSTANCES

Articles in Refereed Scientific Journals

Cozzarelli, I. M., J. M. Suflita, G. A. Ulrich, Harris, S. H., Scholl, M. A., Schlottman, J. L. and Christenson, S. Geochemical and Microbiological Methods for Evaluating Anaerobic Processes in an Aquifer Contaminated by Landfill Leachate. Submitted. 1434HQ-96-GR-02692-02

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Documentation and Dissemination of Geospatial Data in Oklahoma Educational Institutions
Project Number	01
Start Date	03/01/1999
End Date	02/28/2000
Research Category	Not Applicable
Focus Category #1	Education
Focus Category #2	Management and Planning
Focus Category #3	None
Lead Institution	Oklahoma State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Jayne M. Salisbury	Research Associate	Oklahoma State University	01

Problem and Research Objectives

There are many geospatial data related to water resources being created in Oklahoma. Few, however, are being documented in compliance with the Federal Geographic Data Committee "Content Standards for Digital Geospatial Metadata" (FGDC-STD-01-1998, Federal Geographic Data Committee, Washington, D.C.) This is the standard require to be used by all federal agencies. The State of Oklahoma has also adopted the standards, and anyone, though not associated with federal or state agencies, who received federal or state funding to create digital geospatial data is required to comply with the standards for data documentation.

The object of the project was to develop training curriculum for teaching why and how to create metadata to higher education students in GIS, Remote Sensing, and Surveying classes. Other funding grants focus on government agencies, and Native Americans. This project focused on students as the next generation of digital data producers emerging into the professional work arena.

Methodology

A 50-minute lecture in PowerPoint format was developed for presentation in classrooms. In addition, we modified the federal standards report to include term and field definitions, domain types, and examples. Other handouts we prepared were of useful URLs for metadata tutorials and tools. These and other fact sheets from the FGDC were provided to the students and instructor. Appropriate departments, chairpersons, and instructors at five colleges and universities were contacted: East Central University, Ada Northeastern State University, Tahlequah Oklahoma State University, Stillwater Southeastern Oklahoma State University, Durant University of Oklahoma, Norman

Principal Findings and Significance

More publicity and training of instructors is needed to promote this training exercise. One school no longer has GIS or other geospatial courses (Durant). One was not teaching any such courses this past academic year but may be in the future (Tahlequah). The instructor at one could not alter his course schedule to accommodate an extra lecture on metadata but will try to do so this coming academic year (Ada). At another school, dates were arranged but had to be cancelled (Norman). At one school/department the instructor was very willing to allow us to give the metadata lecture and asked us to do so again in his second semester course (Stillwater).

In this course at OSU, Stillwater, about 60 undergraduate and graduate students were taught metadata standards and sources of more information and help tools in the fall and spring semesters. The instructor for this course was the most familiar with metadata content and the value of metadata.

Some changes in the lecture presentation have been made on basis of student and instructor comments. A lab exercise component has also been developed wherein students have hands-on experience creating metadata and using the Internet to download software tools and search/retrieve data via metadata.

We hope to continue the classroom training in the coming academic year, 2000-2001. Publicity and support will be sought from the Oklahoma Consortium of Geographers (COG), the Oklahoma Alliance for Geographic Education (OKAGE), and the Geography Section of the Oklahoma Academy of Science (OAS). The P.I. is Vice Chair of Geography in AOS and a member of COG. Other schools and departments that teach geospatial courses are now known and have requested to be included: University of Central Oklahoma at Edmond, and Southwestern Oklahoma State at Weatherford.

Descriptors

Data Documentation:Geographic Information Systems; Remote Sensing; Data Storage and Retrieval

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Salisbury, Jayne M., Al Tongco, Chin-Chih Chang, and Lang Hsieh. 2000. "Metadata teaching materials for higher education classrooms." URL: http://www.seic.okstate.edu.

Information Transfer Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Prism
Description	Bimonthly newsletter of the Environmental Institute, including the OWRRI
Start Date	
End Date	
Type	Newsletter
Lead Institution	Oklahoma Water Research Institute

Principal Investigators

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Technical Reports and General Publications
Description	Listing of technical reports and other publications generated by the OWRRI and Environmental Institute. Available in print or on Institute web site.
Start Date	
End Date	
Type	Publications
Lead Institution	Oklahoma Water Research Institute

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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	N/A	N/A	N/A	N/A
Masters	2	N/A	N/A	N/A	2

Ph.D.	2	2	N/A	N/A	4
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	4	2	N/A	N/A	6

Awards & Achievements

Achievements Seminars: Techniques in Geophysics and Applications to Groundwater F. Peter Haeni, Chief USGS Geophysical Applications and Support March 23, 2000 Hydrologic and Geochemical Research at the Norman, OK Landfill Site Scott Christenson, Hydrologist USGS Geological Survey District Office, Oklahoma City, OK November 16, 1999

Publications from Prior Projects

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications