Water Resources Research Center
Annual Technical Report
FY 2002

Introduction

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WATER PROBLEMS AND ISSUES OF MISSOURI

The water problems and issues in the State of Missouri can be separated into three general areas: 1) water quality, 2) water quantity, and 3) water policy. Each of Missouris specific problems usually requires knowledge in these three areas.

Water Quality: News media attention to the occurrence of pesticides in drinking water in the Midwest has raised a serious public concern over the quality of Missouri drinking water and how it can be protected. With the large agricultural activity in the state, non-point source pollution is of major interest. Because of several hazardous waste super-fund sites, hazardous waste is still of a concern to the public. The Centers research has been to evaluate the quality of current waste sources and improve the methods to protect them. Areas of research for the past ten years have included (but are not limited to): erosion, non-point pollution, reclamation of strip mine areas, hazardous waste disposal, acid precipitation, anthropogenic effects on aquatic ecosystems and wetlands.

Water Quantity: Missouri has a history of either inadequate amounts of rainfall, or spring floods. Because of the 1987-1989 drought years, and the flood of 93 and 95, water quantity has become a major topic of concern. Research is needed to better understand droughts and flood conditions. Water Policy: Policies and programs need to be formulated that will ensure continued availability of water, as new demands are place on Missouri water. The social and economic costs may no longer be held at acceptable levels if water becomes a major issue in cities and rural areas. Past droughts and the possible lowering of the Missouri River have raised serious questions over states rights to water and priority uses. Research areas in this program have included drought planning, legal aspects, perception and values, economic analysis, recreation, land/water use policy and legislation, and long-term effects of policy decision.

COOPERATIVE ARRANGEMENTS

The following individuals have participated in the selection and development of our 2002 research program. They have been active advisory committee members, participating in research meetings and assisting with their expertise in the area of water research, and at Center research meetings. Six proposals were submitted for state competition. Of those six, four were funded.

UNIVERSITY OF MISSOURI FACULTY ADVISORY COMMITTEE

Craig Adams University of Missouri-Columbia I-29 Agriculture Building Columbia, MO Mike Chippendale University of Missouri - Columbia 1-29 Agriculture Building Columbia, MO 65211 Dr. John Gardner Associate Dean of Research & Outreach College of Agriculture, Food & Natural Resources 2-44 Ag Building Columbia, MO Dr. Patrick Osbourne University of Missouri - St. Louis 224 Research Building St. Louis, MO 63121 Dr. Jerry Richardson University of Missouri-Kansas City 00126 RHFH 574 Kansas City, MO

STATE OF MISSOURI ADVISORY COMMITTEE MEMBERS

Dr. John Madras Department of Natural Resources Water and Pollution Control PO Box 176 Jefferson City, MO 65102 Dr. Steve Mellis Agricultural Engineering Extension 227 Agricultural Engineering University of Missouri-Columbia Columbia, MO 65201 Dr. Russell Rhodes Southwest Missouri State University 901 South National Springfield, MO 65802 U.S. Geological Survey 1400 Independence Road Rolla, MO 65401 Steve McIntosh Water Resources Program Department of Natural Resources PO Box 176 Jefferson City, MO Hamed Mubarak 205 Jefferson Street Jefferson City, MO 65101 City, MO 65102 Jim Czarneszki Fisheries & Wildlife Department of Conservation 1110 South College Ave. Columbia, MO 65201 Becky Shannon MO Department of Natural Resources PO Box 176 Jefferson City, MO 65102

Research Program

PROGRAM GOALS AND PRIORITIES

The Missouri Water Resources Research Centers goals are: 1) establish active research programs to aid in understanding and solving Missouris and the nations water problems; 2) provide educational opportunities in research for students with an interest in water resources and related fields; and 3) be actively dedicated to the dissemination of water related information, using all aspects of the media.

With these goals, the Center is able to mobilize the best faculty expertise in the state to examine specific water resources problems. The Center is familiar with research needs and activities, and its goals are to help researchers avoid duplicate efforts and to serve as a link between the research community and potential users of research results - such as industries, planning commissions, and state agencies.

Because of Missouris economy revolves around its water resources, the director and principal investigators have worked closely with the state in addressing their problems by providing research data which are necessary in order to solve present and future water problems. Each of the research projects forwarded for regional competition has undergone a thorough evaluation process by the Water Centers Advisory Committee to determine its importance in solving Missouris and the nations water problems.

Research Program

Web-Based Tool for Implementing Adaptive Management in the Missouri River System

Basic Information

Title:	Web-Based Tool for Implementing Adaptive Management in the Missouri River System
Project Number:	2002MO1B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	Missouri 9th
Research Category:	None
Focus Category:	Management and Planning, Models, Water Quality
Descriptors:	None
Principal Investigators:	Tony Prato

Publication

Web-Based Tool for Implementing Adaptive Management in the Missouri River System

Tony Prato
Professor and Director
Missouri River Institute

The study involved adaptive management for the Missouri River Ecosystem with the assistance of a graduate student (Jiahui Yan). Our results indicate that adaptive management for the Missouri River Ecosystem is feasible, but would be difficult. The research led to an article entitled *Adaptive Management of Large Rivers with Special Reference to the Missouri River*, which will be published in the Journal of the American Water Resources Association. Progress was made on the creation of an adaptive management working group for the Missouri River Ecosystem that will include, scientists, river managers, recreation and navigation groups, and other stakeholders. I participated in a panel session on adaptive management at the 7th Annual Missouri River Natural Resources Conference. A short survey was administered at the conference to determine the attitudes of participants regarding adaptive management. Results, which are on the CARES website (http://www.cares.missouri.edu), indicate that those participating in the panel session were favorable toward implementing adaptive management for the Missouri River Ecosystem. I wrote a sub-proposal entitled Socioeconomic Indicators and Their Links to Ecological Indicators for Great Rivers that was included in a larger $6 million proposal entitled CESERS: Indicators of Ecosystem Function, which was submitted to EPA by The University of Kansas. The proposal was not funded, but may be re-submitted later this year.

Development of Wax-Rich Grout for Borehole Sealing

Basic Information

Title:	Development of Wax-Rich Grout for Borehole Sealing
Project Number:	2002MO3B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	Missouri 8th
Research Category:	None
Focus Category:	Water Quality, Groundwater, None
Descriptors:	None
Principal Investigators:	Mike Whitworth

Publication

Summary Report: Development of a wax/glass grout for sealing boreholes

T. M. Whitworth
Associate Professor
Dept. of Geological and Petroleum Engineering
University of Missouri-Rolla

Steve Knobbe
Design Engineer
Geoprobe Systems
Salina, KS 67401

Paraffin wax and silt-sized glass have a number of physical properties that make them well suited for use as a heated, injectable mixture. Paraffin wax has a very small polymer chain size, a low viscosity, and is waterproof and inexpensive. Glass provides strength and increases the density of the mixture. This combination can seal rock and soil in the subsurface both above and below the water table, significantly decreasing the hydraulic conductivity.

Our experiments demonstrated that melted paraffin wax and silt-sized glass mixtures cannot penetrate into all types of subsurface material. Hydrated clays and silt are not effectively penetrated by the wax-based grout mixtures because of the small grain size. Pressure injection of the hot, liquid grout may result in a deformation of the hydrated clay or silt as the wax is forced out of the perforated tube, resulting in some forced penetration into the clay or silt. In addition, if there are interconnected spaces within the clay or silt, the grout mixtures can flow through and seal these voids.

Unconsolidated materials such as sands have a much larger grain size than the clays, which allows the wax to flow around and seal the grains. As a general rule, our experiments show that a wax-based grout does not seal any material with a grain size smaller than sand. The wax grout mixtures are also well suited for sealing interconnected fractures in both hard rock, such as dolomite, and soft rock, such as shale.

These experiments were conducted where samples were exposed to wet and dry conditions, simulating areas at and above the water table, respectively. Success was highly variable since some injections were able to seal all of the samples in a wet trial while not successfully sealing others in the accompanying dry trial. The opposite was also found to be true. A sample would typically fail due to inadequate grout volume.

Evaluation of the physical parameters of the paraffin wax and silt-sized glass show that grout mixtures can be created that are both lighter and heavier than water, thus controlling the buoyancy of the mixture in water. Testing shows that shear strength of the grout increases with an increase in the volume of clay-sized glass in the mixture.

The wax-glass mixture is not without its problems. The mixture is not always successful at sealing all of the void spaces within the soil or rock, and organic chemicals and microbes may degrade the mixture over time. However, it may be useful for sealing rock fractures and permeable sands.

A follow-up proposal (total budget $400,000) has been submitted to NIOSH and proposes to test the ability of wax grout mixtures to seal fractures in mines and prevent water influx. A paper describing the results of this research is also in preparation and will be submitted to a peer-reviewed journal before the end of the summer.

Microbial Influences on Geophysical Signatures: A Proxy for the Understanding and the Monitoring

Basic Information

Title:	Microbial Influences on Geophysical Signatures: A Proxy for the Understanding and the Monitoring
Project Number:	2002MO5B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	Missouri 8th
Research Category:	None
Focus Category:	Geochemical Processes, Methods, Groundwater
Descriptors:	None
Principal Investigators:	Estella Atekwana

Publication

Title: Microbial Influences on Geophysical Signatures: A Proxy for the Understanding and the Monitoring of
Natural Attenuation.
Name: Estella Atekwana (UMR) and Lee D. Slater (UMKC)

Pollutants such as organic chemicals, heavy metals, and radionuclides remain a major problem of environmental concern by posing a threat to global groundwater resources. Currently, the number of hazardous waste sites in the US where ground water may be contaminated is estimated at 300,000-400,000 (Benkin et al., 2001). The remediation of such sites has become an area of high priority for many agencieswithin the US government (e.g., EPA, DOE, DOD, etc.). The EPA Office of Emergency and Remedial Response has compiled a National Priorities List (NPL) of seriously contaminated sites across the US (US EPA, 2001). Twenty-two NPL Sites are currently listed in Missouri. Current EPA regulations relating to NPL sites mandate a remedial investigation/feasibility study (RI/FS) with possible follow up remedial design, remedial action and operations and maintenance (O&M) procedures. The financial obligation of the State depends on ownership of the NPL. For publicly owned and publicly operated sites the State is responsible for at least 50% of the RI/FS, remedial design/action and first year O&M costs. For privately operated sites the State responsibility is 10% of remedial design/action and 10% of first year O&M costs. The EPA estimated average total cost per site is $1.3 m for RI/FS, $1.5 m for remedial design, $25 m for remedial action and $3.77 m for O&M procedures. The Missouri Department of Natural Resources Hazardous Waste Management Program (MDNR-HWMP) is responsible for preliminary assessments, site investigations, feasibility studies, remedial investigations and short/long term remedial action at contaminated sites in Missouri. In 1999 the MDNR-HWMP Hazardous waste remedial fund received $1.7 m, rising to $2.6 m in 2000 (Missouri State Government, 2001).

The high costs of engineered cleanup systems and their disappointing performance have spurred research in the development of more efficient, inexpensive and innovative methodologies to address the problem of contaminated soils. Over the past several years, natural attenuation (microbial mediated degradation) has become increasingly accepted as a remedial alternative for many contaminated soils, partly because of their relatively lower costs. However, the implementation of natural attenuation as a remedial strategy at a site often requires a demonstration that natural attenuation is occurring through several lines of evidence. One such line of evidence is the demonstration of the potential for intrinsic bioremediation. Because biodegradation is expected to cause predictive changes in groundwater chemistry, traditional methods for assessing an area for the potential of intrinsic bioremediation have relied heavily on extensive sampling and analyses of groundwater for intermediates of biological hydrocarbon metabolism, depletion of terminal electron acceptors, and assessment of microbial communities capable of metabolizing the hydrocarbons. Such investigations are very costly and increase the cost of remediation. Additionally, the above traditional techniques rely heavily on direct sampling methodologies for obtaining soil and water for site characterization.

Such direct sampling provides adequate data to interpret degradation activities at specific subsurface locations, but are flawed in several respects: 1) wells screened at a given depth can sample water (and any signals of bacterial activity) only at that specific point in space and time; 2) the determination of suitable sampling frequencies, sampling locations and subsurface interval for characterization is difficult and are arbitrary; 3) more frequent groundwater sampling and analyses translate to extremely high clean up costs; 4) it is difficult to use direct sampling techniques to span the entire spatial and temporal scales associated with biodegradation and provide in situ, real time monitoring of these and other dynamic subsurface environmental processes.

Biogeochemical processes occurring at contaminated sites are currently only partially understood because they occur within dynamic systems where the geochemical and hydrogeological conditions can change with time

and location in the subsurface, and also because of the very sparse spatial and temporal sampling regiments often used to assess them. Non-invasive methods that adequately characterize and quantify the nature and fate of these contaminants ***are lacking.*** Thus, the need for research and development of more cost-effective methodologies that can serve as a surrogate for pore water and soils sampling and analysis to assess subsurface degradational processes and to monitor the cleanup of contaminated soils is critical. Such methodologies would have tremendous potential to reduce cleanup costs and reduce health risks to humans and the environment.

Geophysical methods have a tremendous potential for rapid, non-intrusive evaluation of spill sites, delineating the lateral and vertical extent of the impacted media. However, the potential changes in geoelectrical response to biogeochemical modifications of the subsurface impacted media resulting from microbial NAPL degradation have never been investigated. Although controlled spill and short-term laboratory experiments have provided valuable insights into the potential for geophysical detection of hydrocarbon contaminants these studies do not take into account the extent to which resident microbial communities modify NAPLs to different physical and chemical states, causing changes in the physical properties of the impacted media. The current project is therefore, **a first attempt** at investigating how biogeochemical processes associated with microbial LNAPL degradation affect geophysical properties of soils and groundwater at NAPL contaminated sites. Such information is critical for the interpretation of geophysical data from contaminated sites and is fundamental to the development of robust geophysical models that can describe these systems. Advances in the understanding of these relationships will provide the foundation necessary for the development of non-invasive geophysical techniques for studying coupled biogeochemical processes at contaminated sites. This work, while oriented toward LNAPL contaminant sites, will have significant implications for understanding any other classes of contaminant plumes (e.g., dense non-aqueous phase liquids (DNAPL), radio nuclides, and heavy metals) which exhibit electrical conductivity different from their surroundings, and which change electrical properties in space and time. Furthermore, we believe that the information derived from this study will foster the development of geophysical techniques as an **independent measure or proxy** for intrinsic biodegradation of contaminants in the subsurface, leading to cheaper clean up costs.

This study is considered the initial step in the development of an electrical method for in situ monitoring of NAPL biodegradation. Following the results of this study, down-borehole and field scale measurements are anticipated. This would incorporate both an element of instrumentation development as well as site characterization. The application of the method at NPL sites in Missouri is envisaged. We plan to use the preliminary results obtained in this study to aggressively seek funding for a much larger field-based study from the US Department of Energy and/or the US Environmental Protection Agency, as well as the National Science Foundation.

Student involvement

The primary student involvement is in the form of two full-time graduate (Masters and PhD) students dedicated to this project. Student responsibility includes data collection, analysis and interpretation. Student presentation of the results of the project at an international conference is expected. Both students will develop MS theses and PhD dissertation from this work. We will also recruit an undergraduate research student to participate in this project. Through these ***mentoring*** activities we expect to provide students with ***hands-on*** experience in the conduction of scientific research addressing both basic and applied science issues.

Status

The Water Center has given this project a six-month no-cost extension to finish collecting and submit further data.

Microbial Influences on Geophysical Signatures

Basic Information

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Project Number:	2002MO6B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	Missouri 9th
Research Category:	None
Focus Category:	Geochemical Processes, Methods, Groundwater
Descriptors:	None
Principal Investigators:	Lee Slater

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Information Transfer Program

USGS Summer Intern Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	0	0	0	0	0
Masters	4	0	0	0	4
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	4	0	0	0	4

Notable Awards and Achievements

Not Applicable

Publications from Prior Projects