Water Resources Research Center

Annual Technical Report

FY 2000

Introduction

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 Missouri's 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 Center's 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 2000 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. Five proposals were submitted for regional competition. Of those five, three were funded; one of which was a continuation from last year.

UNIVERSITY OF MISSOURI FACULTY ADVISORY COMMITTEE

Mike Chippendale University of Missouri - Columbia 1-29 Agriculture Building Columbia, MO 65211

Dr. Patrick Osbourne University of Missouri - St. Louis 224 Research Building St. Louis, MO 63121

David Yourtee Associate Professor Pharmacy and Medicine MED M3-115 Kansas City Campus

STATE OF MISSOURI ADVISORY COMMITTEE MEMBERS

Dr. Russell Rhodes Southwest Missouri State University 901 South National Springfield, MO 65802

Jim Barks 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 65102

Jim Czarneszki Fisheries & Wildlife Department of Conservation 1110 South College Ave. Columbia, MO 65201

Scott Totten MO Department of Natural Resources PO Box 176 Jefferson City, MO 65102

Research Program

PROGRAM GOALS AND PRIORITIES

The Missouri Water Resources Research Center's goals are: 1) establish active research programs to aid in understanding and solving Missouri's and the nation's 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 it's 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 Missouri's 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 Center's Advisory Committee to determine its importance in solving Missouri's and the nation's water problems.

Basic Information

Title:	Development of a Simple Combustion Process for Disposal of Waste from Livestock Operations
Project Number:	USDI-1434-HQ-96GR-02680-04
Start Date:	3/1/1999
End Date:	8/31/2001
Research Category:	Water Quality
Focus Category:	Treatment, Non Point Pollution, Agriculture
Descriptors:	Animal Waste, Wastewater, Agriculture, Waste Disposal, Pollution Control, Treatment
Lead Institute:	Water Resources Research Center
Principal Investigators:	Virgil Flanigan, Shubhender Kapila

Publication

Progress Report (01)

Development of a Simple Combustion Process for Disposal of Waste from Livestock Operations

Project No: **USDI-1434-HQ-96GR-02680-04**
Development of a Simple Combustion Process for Disposal of Waste from Livestock Operations
PI: Virgil Flanigan and Shubhen Kapila

Project Period: March 1, 1999 – February 28, 2001

Description:

The project was initiated in March 1999. The first four months were spent on design and fabrication of the combustor. The combustor has now been built and installed at the Center for Environmental Science and Technology at the University of Missouri-Rolla.

The optimization and evaluation of the burner configuration will be carried out in the next three months. This will be followed up with trial degradation of simulated waste. These evaluations will include chemical and biological measurements to ascertain degradation efficiencies of odiferous chemicals, pathogens, pesticides, residual antibiotics and metabolites. The analytical methodologies required for the measurements are being validated.

We are planning to carry out a trial with farm waste streams during the summer and fall 2000. A complete project report will be submitted by March 2001.

Basic Information

Title:	Developing a Model for Watershed Management through Determining Watershed Conditions Required by the Endangered Topeka Shiner
Project Number:	USDI-1434-HQ-96GR-02680-04
Start Date:	3/1/1999
End Date:	2/28/2001
Research Category:	Water Quality
Focus Category:	Conservation, Wetlands, Ecology
Descriptors:	Watershed, Topeka Shiner, Land-use, Bonne Femme Creek, Turkey Creek, Bass Creek, Cyprinid, Agriculture
Lead Institute:	Water Resources Research Center
Principal Investigators:	Douglas Noltie, Charles Nilon

Publication

Progress Report (02)

Developing a Model for Watershed Management through Determining Watershed Conditions Required by the Endangered Topeka Shiner

Project No: USDI-1434-HQ-96GR-02680-04
Developing a Model for Watershed Management through Determining Watershed Conditions Required by the Endangered Topeka Shiner
PI: Doug Noltie

Description of Species

The Topeka Shiner is a cyprinid (minnow) species native to the Midwestern United States that has been extirpated in up to 88% of its former range. In Missouri, a decline has been found in all but one stream.

The Study Site

The Bonne Femme Creek Watershed, including Turkey and Bass Creeks, is typical of many Midwestern drainages. The watershed includes preserved natural areas, but it is predominately agricultural and is experiencing increasing urbanization. Similar patterns of urban degradation and corresponding declines in fish species have been found throughout the Midwest.

We chose the Bonne Femme watershed to identify land-use changes that are either:

· sufficiently benign as to be compatible with Topeka Shiner population maintenance, or

· sufficiently detrimental that extirpations have occurred.

Objectives

1) Collect and analyze historical and current land-use and current habitat information at sites in the Bonne Femme Creek watershed where Topeka Shiner populations have been extirpated (Turkey Creek) or still exist (Bass Creek).

2) Determine whether historical changes in land-use, land cover, and riparian zone characteristics are correlated with the presence or absence of Topeka Shiner populations in these watersheds.

3) Conduct an assessment of landowner attitudes toward participation in specific land recovery (as outlined by the Missouri Department of Conservation's Topeka Shiner Action Plan).

4) Develop conceptual and analytical models for these watersheds that describe and define correlations between land cover, water quantity and quality, and Topeka Shiner presence and absence.

Preliminary Results

Thus far we have concentrated on creating our land cover and land-use databases. Even so, some interesting contradictions between predicted land cover associations and Topeka Shiner presence and absence has already come to light:

1) Even though agriculture is considered to have a negative impact on Topeka Shiners, agricultural land cover has decreased in both watersheds.

2) Even though an increase in forest cover is considered to improve Topeka Shiner habitat, both of our watersheds have become increasingly forested.

3) The watershed with the greatest amount of urbanization is the one which Topeka Shiners are present (Bass Creek).

4) The watershed with the greatest number of roads is also the one in which Topeka Shiners are present.

Yet as predicted, the watershed with the most rapid urban development and with the greater increase in the number of ponds is the one in which its Topeka Shiner populations have been extirpated (Turkey Creek).

Basic Information

Title:	Measurement of Waterborne Pathogens in Wetland Treatment Systems
Project Number:	USDI-1434-HQ-96GR-02680-03
Start Date:	3/1/1999
End Date:	2/28/2001
Research Category:	Water Quality
Focus Category:	Wetlands, Water Quality, Methods
Descriptors:	Waterborne Pathogens, Bacteria, E. coli, Giardia, Cryptosporidium, Biomonitoring, Land-Water Interactions, Model Studies, Wastewater, Wetlands, Water Quality, Water Quality Monitoring
Lead Institute:	Water Resources Research Center
Principal Investigators:	John Jones, Jeanne Erickson

Publication

Progress Report (03)
Measurement of Waterborne Pathogens in Wetland Treatment Systems

Project No: USDI-1434-HQ-96GR-02680-03
Measurement of Waterborne Pathogens in Wetland Treatment Systems
PI: Jack Jones & Jeanne Erickson

Objectives

The overall objective of this project was to develop a rapid, sensitive, quantitative PCR-based assay for the identification and enumeration of microbes, that would provide a convenient method for quantification of microbes, including potential pathogens, found in environmental water samples.

Results

In order to reduce costs in the development stage of our assay, we focused solely on coliforms, and used CsCl-purified E. coli DNA template to work out the PCR assays in which lacZ and uidA DNA fragments were amplified to identify and quantify total and fecal coliforms, respectively.

Successful development of this PCR assay included the following elements:

- ➢ Concentration of microorganisms from environmental water samples in a way that allows archiving of microbes for further molecular characterization in the future.
- ➢ Purification of DNA templates from concentrated microbes, to the degree that inhibitors of PCR are removed and PCR amplification can proceed.

- Design of specific DNA primer pairs that amplify specific DNA fragments indicative of total or fecal coliforms.
- Optimization of the PCR conditions such that a unique PCR product is formed, and the products are ~ proportional to the initial template concentration over ~ 1-2 orders magnitude difference in the initial template copy number.
- Sensitive visualization of the PCR product using agarose gel electrophoresis and estimation of the concentration of coliforms in the environmental water sample.

The assay is highly sensitive. We can detect as few as one copy (one genome equivalent) of E. coli DNA present in the initial PCR reaction, and can visualize the product on ethidium-bromide-stained gels without further amplification of signal. We routinely distinguish standards that include 4, 40, or 400 copies of initial E. coli template DNA.

Purification of DNA templates from environmental water samples has been the most challenging part of the assay development. The methods must be fairly rapid, allow for quantitative recovery of template, and eliminate inhibitor to the extent that appropriate volumes, needed to see a positive signal, can be assayed. The most effective method provided a 10 x to 100 x purification with respect to inhibitor, depending on the source of water and the levels of inhibitors present.

New Developments

In January 2000 we purchased a new instrument (LightCycler, Roche Diagnostics Inc.) capable of monitoring fluorescence signals from each PCR reaction at the end of each cycle of PCR amplification. This allows us to monitor the kinetics of accumulation of PCR product, and hence provides a much more accurate and reproducible quantification of initial template copy number. Preliminary experiments suggest this instrument is sensitive enough to detect small copy number, and is quite accurate. We expect use of the LightCycler to decrease the assay time, and improve data acquisition and analysis.

Lab Personnel involved in PCR Project

Technician	Steve Hart

Students

Graduate	Angela Sell, (MS, Fisheries and Wildlife)
	Charissa Nonhoff (Ph.D., Biochemistry)
Undergraduate	Katya Korostash (Biochemistry)
	Josh Fitzmaurice (Biochemistry)

Meetings Attended

International Symposium on Waterborne Pathogens (Milwaukee, WI, August 1999)

Jeanne Erickson and Angela Sell

Poster Presentations

"PCR-based technique for monitoring waterborne-microbes"

Angela Sell, Jack Jones, Mark Milanick and Jeanne Erickson

(Presented at Intl. Symposium on Waterborne Pathogens, August 1999)

Basic Information

Title:	Influence of Solids on Hydraulic and Treatment Properties of Submerged Flow Wetlands
Project Number:	USDI-1434-HQ-96GR-02680-02
Start Date:	3/1/1999
End Date:	2/28/2001
Research Category:	Water Quality
Focus Category:	Waste Water, Wetlands, Water Quality
Descriptors:	Wetlands, Wastewater treatment, hydraulics, solids accumulation
Lead Institute:	Water Resources Research Center
Principal Investigators:	Allen Thompson

Publication

Progress Report (04)

Influence of Solids on Hydraulic and Treatment Properties of Submerged Flow Wetlands

Project No: USDI-1434-HQ-96GR-02680-02
Influence of Solids on Hydraulic and Treatment Properties of Submerged Flow Wetlands.
PI: Allen Thompson

The majority of presently constructed submerged-flow wetlands (SF) have experiences water mounding problems that are caused by clogging of pore spaces with solids, biofilm, and plant root growth. Solids buildup is larger near the inlet of the bed, causing the potential for bed clogging. In an attempt to quantify solids buildup, an experimental design was set up combining three vegetated and three non-vegetated submerged-flow wetland beds (3m x 1m x 0.5m) operated in a semi-continuous-flow mode, which were fed every eight hours, with a 5-day residence time. BOD5 and TSS removals throughout the two-year operating period were high 9up to 98%) for both vegetated and non-vegetated wetlands and tended to follow seasonal variations. The presence of vegetation showed a small degree of process enhancement for the reduction of biodegradable organic matter and suspended solids within the SF environment. The annual average mass removal for ammonia nitrogen in vegetated wetlands beds was 3.3 kg $ha^{-1}d^{-1}$ (up to 95%). The nitrification process in vegetated wetlands beds was much more pronounced than non-vegetated beds (only up to38% removal). The lack of measurable dissolved oxygen in the non-vegetated wetlands likely restricted the nitrification process.

The soluble phosphorus reduction varied from month to month, ranging from 27% to 100% in vegetated wetland beds and from no removal to 66% in non-vegetated beds. The soluble phosphorus reduction in vegetated beds was much higher than non-vegetated beds depending upon seasonal variations of plant growth.

The particle size spectrum at the inlet always peaked before the outlet, showing a net longitudinal size spectrum shift, which generally tended to decrease over time in response to the continuous solids loadings and internal processes of solids decomposition and regeneration within the plant-rooting media. The process of solids deposition in the SF substrate matrix was characterized by a rapid decline of particulate mass over the length of the bed, with more than 75% of the pore solids attenuated within the first of the bed length for both vegetated and non-vegetated wetland beds after two years of operation. The total solids depositions in the vegetated and non-vegetated wetland media were determined to be, respectively, 2.39 kg m^{-2} and 2.78 kg m^{-2} after two years of system operation. Net accumulations of pore solids were significantly higher ($P < 0.05$) in the non-vegetated wetland beds than in the vegetated wetland beds. A solids buildup model was developed using the mass balance approach to predict the dynamics of solids depositions and void blockages in the wetland media. Internal generation dominated the system over decomposition throughout the operation in both vegetated and non-vegetated wetlands. This led to an overall solids buildup in the wetland media. The estimated average operating value for G-D (generation – decomposition) for total pore solids depositions was 2.66 mm yr^{-1} for vegetated wetland media and 4.44 mm yr^{-1} for non-

vegetated wetlands. From the increasing trend of G-D over time for pore organic accumulations, it was revealed that the system experienced the domination of internally and externally generated organics coupled with less biological decomposition, potentially leading to logging of the wetland media due to excessive solids buildup. It is concluded that in a long run, the solids buildup would significantly influence the system hydraulics as the majority of solids are deposited within the first 1/3 bed length.

Basic Information

Title:	Eutrophication in the White River watershed: Data synthesis and dynamics of planktonic communities
Project Number:	USDI-1434-HQ-96GR-02680-04
Start Date:	3/1/1999
End Date:	2/28/2001
Research Category:	Water Quality
Focus Category:	None, None, None
Descriptors:	
Lead Institute:	Water Resources Research Center
Principal Investigators:	John Havel, Russell Rhodes

Publication

Progress Report (05)

Eutrophication in the White River watershed: Data synthesis and dynamics of planktonic communities

Project No: **USDI-1434-HQ-96GR-02680-04**
Eutrophication in the White River watershed: Data synthesis and dynamics of planktonic communities
PI: John E. Havel and Russell G. Rhodes

Project Period: March 1, 1999 – February 28, 2001

Objective:

This project investigated effects of eutrophication on upper White River lakes. This project had two principal components: 1) synthesis of existing data and ongoing projects in the upper White River, and 2) surveys and sample analyses from Bull Shoals Lake. This report provides a brief summary of outcomes from this study. Further details are available through the BSFS web site: http://www.cnas.smsu.edu/bullshoals/Default.htm.

Description:

The first project is the ongoing design and maintenance of the James River Basin Partnership (JRBP), a not-for-profit group whose mission is to protect and improve water quality of the James River basin. The BSFS Data Manager authored this website: http://www.cnas.smsu.edu/JRBP/default.htm. In addition, a JRBP "listserve" was set up to facilitate communication among researchers in the area.

The second project was the use of Geographic Information Systems (GIS) to construct detailed maps for the Bryant Creek Watershed Atlas (BCWA). The BCWA is a educational web site for school children and is operated by teachers in the Bryant Creek

watershed area. These maps will be used on their web site as the primary maps for the area. The web site follows:

http://www.watersheds.org/blue/index.htm

The third project is the ongoing effort to facilitate communication among principal investigators of aquatic research in the White River Basin. This project has been approached by participating in the White River Basin Water Quality Forum and by creating the White River Basin web site (web site above). During the second Water Quality Forum (November 2000), we co-organized a scientific symposium, with 19 contributed talks and posters. Abstracts can be viewed at the following web site:

http://www.cnas.smsu.edu/bullshoals/WhiteRiverBasin/White%20River%20Forum/WhiteRiverForum2000.htm.

Presentations:

Dickerson, Michael R., John E. Havel, and Russell G. Rhodes. 2000. A web-based database on the upper White River Watershed. White River Forum II, November 2000, Mountain Home, Arkansas. Poster presentation.

Havel, John E., Kristin Pattinson, and Russell G. Rhodes. 2000a. Eutrophication in the upper White River lakes: preliminary analysis of Bull Shoals Lake. White River Forum II, Novermber 2000, Mountain Home, Arkansas. Oral presentation.

Havel, John E., K. Pattinson, and R. G. Rhodes. 2000b. Eutrophication in the upper White River lakes: preliminary analysis of Bull Shoals Lake. Great Plains Limnology Conference, November 2000, Lawrence, Kansas. Oral presentation.

Basic Information

Title:	Spectral Induced Polarization (SIP) Estimation of the Hydraulic Conductivity of Unconsolidated Sediments in Missouri
Project Number:	USDI-1434-HQ-96GR-02680-03
Start Date:	3/1/1999
End Date:	2/28/2001
Research Category:	Water Quality
Focus Category:	None, None, None
Descriptors:	
Lead Institute:	Water Resources Research Center
Principal Investigators:	Lee Slater

Publication

Progress Report (06)

Spectral Induced Polarization (SIP) Estimation of the Hydraulic Conductivity of Unconsolidated Sediments in Missouri

Project No: **USDI-1434-HQ-96GR-02680-03**
Spectral Induced Polarization (SIP) Estimation of the Hydraulic Conductivity of Unconsolidated Sediments in Missouri
PI: Lee D. Slater

Project Period: March 1, 1999 – February 28, 2001

Objective:

The objective of the study was to investigate the relationship between electrical and hydrogeological properties of unconsolidated sediments. In particular, an electrical method for the estimation of saturated hydraulic conductivity (*K*) was targeted.

Primary findings:

The key finding of the work is that SIP measurements are closely correlated with the effective grain size of the tested unconsolidated sediments. Consequently, it is possible to formulate a simple model for electrical estimation of hydraulic conductivity based on a Hazen-type grain size model. The K estimation model appears appropriate for a wide range of unconsolidated materials. However, it performed poorly for glacial tills, which I attribute to a broad grain size distribution for these materials. Interestingly, porosity is poorly correlated with K in these materials.

Further work:

This work initiated laboratory SIP studies in the new UMKC Geophysics Laboratory. The link between SIP measurements and hydraulic parameters is being further investigated. The study indicates that materials with a broad grain size distribution require a more sophisticated K prediction model than that utilized in this work. I am currently investigating whether the shape of the SIP response in between 0.1-1000 Hz can be used to extract information on the grain size distribution. If so, it will be possible to formulate a more general electrical model for K estimation of unconsolidated sediments.

Dan Glaser is now conducting research on the application of the developed laboratory models in the field. A fieldsite was identified and instrumented with electrode arrays placed in boreholes. The boreholes were drilled by Burns & McDonnell Engineers, with electrode arrays installed at no charge. Two arrays were installed to a depth of 80 feet in unconsolidated sediments of the Kansas River Valley. I hope to image the electrical properties of the in situ sediments between the boreholes. These measurements will be used to obtain a prediction of the K distribution between these boreholes. Dan Glaser will submit a second paper, describing this work.

Broader benefits of this work:

This work will form the core of an MS thesis in Urban Environmental Geology, to be submitted by Dan Glaser in 2002. Dan has benefited from exposure to laboratory and field methods for measurements of electrical and hydraulic properties. An undergraduate intern student, Isaiah Utne, has also worked on this project and developed useful laboratory skills. He will present an undergraduate research poster partly based on this work at the first UMKC Undergraduate Research Experiences exhibition (May 3, 2001)

Results of this project have already been submitted for rigorous peer review (see Part II). However, at least one more paper is expected. Dan Glaser is responsible for the production of this second article, which will deal with field application of the developed electrical models.

Information Transfer Program

INFORMATION TRANSFER ACTITIVES

During the past year, the Center has either initiated or supported the following information transfer activity:

1. Dr. Clevenger participated on the following state and national committees: National Association of Water Institute Directors; Universities Council on Water Resources; Advisory Committee of the National Water-Quality Assessment Program - Ozark Plateaus; Mississippi Embayment National Water Quality Assessment Liaison Committee; and the Missouri Quality Coordinating Committee.

USGS Summer Intern Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	3	0	0	0	0
Masters	2	0	0	0	0
Ph.D.	3	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	0	0	0	0	0

Notable Awards and Achievements

None

Publications from Prior Projects