# Arkansas Water Resources Center

**Submitted to the U.S. Geological Survey**

# ANNUAL TECHNICAL REPORT

# FISCAL YEAR 2007

**For the Period**

**03/01/07-02/28/08**

**Publication No. MSC-102.2007**

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# Arkansas Water Resources Center
# Annual Technical Report
# FY 2007

# Introduction

State Wide Mission: The Arkansas Water Resources Center (AWRC) has a statewide mission to plan and conduct water resource research. AWRC cooperates closely with colleges, universities and other organizations in Arkansas to address the state's water and land−related problems, promote the dissemination and application of research results and provide for the training of scientists in water resources. Through the years, projects have included irrigation, ground water modeling, non−point source pollution, quality of ground water and surface water, efficient septic tank design and ecosystem assessment. These projects have been funded by a variety of federal, state, local and tribal sources.

Support Provided: The Center acts as a liaison between funding groups and the scientists, and then coordinates and administers grants once they are funded. Accounting, reporting and water analyses are major areas of support offered to principal investigators.

Technology Transfer: AWRC sponsors an annual water conference held in Fayetteville, Arkansas each spring, drawing an average 100 researchers, students, agency personnel and interested citizens to hear about results of current research and hot topics in water resources throughout the state. AWRC also co−sponsors short courses and other water−related conferences in the state and region. In addition, AWRC maintains a technical library containing over 900 titles, many of which are on−line. This valuable resource is utilized by a variety of user groups including researchers, regulators, planners, lawyers and citizens.

AWRC Water Quality Laboratory: The Center maintains a modern water quality laboratory that provides water analyses for researchers, farmers and others who submit samples through the Cooperative Extension Service and the Department of Housing and Urban Development.

Critical Needs and Proposed Projects: The following water research topics are currently important in Arkansas:

1. Non−point source contamination (nutrients and pesticides), 2. development of methods for determination of total maximum daily loads (TMDLs). 3. declining groundwater levels, especially in eastern Arkansas, 4. saline ground water contamination, 5. development of efficient septic systems, 6. wetlands identification and enhancement, 7. flood forecasting and flood control, and 8. ecosystem sustainability.

The objectives of the Arkansas Water Resources Center are to enhance research and educational outreach related to:

1. The physical, chemical, and biological characteristics of streams, reservoirs, and aquifers, 2. quantification of the trophic levels and associated parameters in lentil and lotic ecosystems (e.g., modeling, energy transfer, production), 3. determination of the impact of natural and synthetic chemicals on water quality, 4. development of analytical techniques and protocols for assessing water quality (e.g., quality control, quality assurance, microbiological, indicator species), and 5. development of mechanisms for improving the quality and quantity of water supplies.

The objectives of the Arkansas Water Resources Center and the topics important to Arkansas are being addressed by the projects administered by the Center. The Arkansas Water Resources Center currently administers about 50 projects with about 85% of these related to non−point source contamination and TMDL development. The funds provided under the USGS 104B program support basic "seed" grants to provide preliminary data for preparation of larger collaborative projects. Each of the four proposals funded this year under the USGS 104B program address one or more of the priority research topics. One of the four research projects submitted address issues of non−point source nutrient loading of the shallow karst aquifer resulting from application of animal manures as fertilizer, with a goal of understanding mechanisms of phosphorus cycling as water recharges the aquifer. Partitioning of phosphate load will be investigated based on isotopic signature of oxygen, which may lead to a mechanism to better assign loading rates allowing for more focused management practices. One project focuses on non−point source sediment loading into Beaver Reservoir, associated algal biomass production and the organic compounds produced. Organic compounds produced in very low concentrations may result in taste and odor problems for drinking water extracted from the Reservoir. The project goal is to identify the source and mechanism of algal production and associated Geosmin and MIB production so effective management strategies can be developed to minimize the impact. This is important because Beaver Reservoir supplies water to over 300,000 people in northwest Arkansas, greater than 12% of the States population. The third project focuses on arsenic mobilization in transport in the alluvial aquifer of eastern Arkansas, a significant source of drinking water in the region. The fourth project investigates the mobility of nutrients and trace metals from in runoff and leachate from poultry litter amended soils. This is important in terms of developing effective management practices to minimize nutrient and trace element loading to area streams, lakes, and groundwater.

Management: The Arkansas Water Resources Center has a Technical Advisory Committee (TAC) composed of representatives of the state/federal water resources agencies, academia, industry and private groups. A subset of the TAC reviews and ranks proposals submitted to the Center for funding, and provides general advice for the Centers operation. The Center assists agencies and other groups in forming research teams to address the states priority water resources research topics and facilitates academic researchers with links to appropriate agencies/organizations for funding their research. Once these scientists have been funded the Center coordinates and administers the grants allowing the researchers to concentrate on providing a quality product. Support is provided to researchers in the form of accounting, reporting and water analysis (through the AWRC Water Quality Laboratory). The Centers training and information dissemination programs are intricately involved with the research projects. Typically about 50 students are trained through participation in research projects and also at the AWRC Water Quality Laboratory. Information dissemination occurs via publication of journal articles, reports, presentations at professional meetings, and the organization of conferences and short courses.

# Research Program Introduction

AWRC has contributed substantially to Arkansas water resources via research and training of students. In 2007, projects passed through the Center which included funding from a variety of organizations including 1)USGS 104B program, 2)U.S.G.S., 3)U.S.D.A., 4) NSF, 5) NRCS, 6)Arkansas Natural Resources Commission, 7)Arkansas Department of Environmental Quality, 8)Upper White River Basin Foundation, 9)Walton Family Foundation, 10)Beaver Water District, 11)Environmental Protection Agency, 12)Santee Sioux Nation. These projects involved training of 26 students made up of 7 undergraduates, 12 master's and 7 Ph.D. candidates.

# Long−term runoff water quality in response to natural rainfall as affected by poultry litter application rate

## Basic Information

| | |
|---|---|
| **Title:** | Long−term runoff water quality in response to natural rainfall as affected by poultry litter application rate |
| **Project Number:** | 2007AR162B |
| **Start Date:** | 3/1/2007 |
| **End Date:** | 12/31/2008 |
| **Funding Source:** | 104B |
| **Congressional District:** | 3 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Non Point Pollution, Water Quantity, Surface Water |
| **Descriptors:** | |
| **Principal Investigators:** | Kristofor R. Brye |

## Publication


1. Menjoulet, B.C. 2007. Nutrient and metal runoff from broiler litter−amended tall fescue in response to natural precipitation. M.S. thesis. Univ. of Arkansas, 130p.
2. Menjoulet, B.C., K.R. Brye, A.L. Pirani, B.E. Haggard, and E.E. Gbur. In Review, Runoff Water Quality from Broiler−Litter−Amended Tall Fescue in Response to Natural Precipitation in the Ozark Highlands. J. Environ. Qual.
3. Pirani, A.L. K.R. Brye, B.E. Haggard, T.C. Daniel, and J.D. Mattice, 2007, Broiler litter rate effects on nutrient leaching from soil under pasture vegetation in the Ozark Highlands. Soil Sci. 172:1001−1018.

2007 USGS 104 B Project Report for "Long-term runoff water quality in response to natural rainfall as affected by poultry litter application rate"

Summary of project goals and objectives, and findings

The goals and objective of this research project were to continuously monitor runoff and solute losses in runoff, specifically soluble metals (i.e., As, Cd, Cr, Cu, Fe, Mn, Ni, Se, and Zn) and plant nutrients (Ca, Mg, Na, K, P, $NH_4$-N, $NO_3$-N), from tall fescue pasture soil amended with varying rates of poultry litter over a multi-year period.

Runoff differed ($P < 0.05$) among litter treatments during only two of 16 3-mo seasons, but did not differ during any individual annual period or cumulatively over the 4-yr study duration. Seasonal and annual flow-weighted mean (FWM) nutrient and metal concentration differences occurred, but were variable and inconsistent throughout the study. However, during eight of 16 3-mo seasons, FWM As concentrations from all litter treatments exceeded the maximum contaminant level for drinking water (0.01 mg As/L). Annual nutrient runoff losses of DOC, NO3-N, NH4-N, P, Ca, K, Mg, and Na did not differ among litter treatments during any annual period. Four-year FWM Fe concentrations and runoff losses were greater ($P < 0.05$) from the high- than from the low-litter treatment and unamended control, and the 4-yr FWM P concentration from the low-litter treatment (3.0 mg/L) was greater than that from the unamended control (1.8 mg/L). Since seasonal and annual precipitation are known to be quite variable, evaluating runoff water quality response to natural precipitation over a long enough time period to encompass natural temporal variability is key to ascertaining the most representative long-term impacts of surface-applied soil amendments like broiler litter.

Student support/involvement

This project supported research activities for 1 M.S. graduate student who completed their degree in September 2007. This field project also served as an educational tool for ~12 other graduate students.

# Source of Geosmin and MIB in drinking water: Identifying the source and mechanisms of taste and odor compounds at Beaver Reservoir, northwest Arkansas

## Basic Information

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|---|---|
| **Title:** | Source of Geosmin and MIB in drinking water: Identifying the source and mechanisms of taste and odor compounds at Beaver Reservoir, northwest Arkansas |
| **Project Number:** | 2007AR164B |
| **Start Date:** | 3/1/2007 |
| **End Date:** | 12/31/2008 |
| **Funding Source:** | 104B |
| **Congressional District:** | 3 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Management and Planning, Non Point Pollution, Toxic Substances |
| **Descriptors:** | |
| **Principal Investigators:** | Sonja Hausmann, Stephen K. Boss, Ralph K. K Davis |

## Publication


1. Winston, Byron, Sonja Hausmann and Ralph Davis, 2007, Taste and Odor in NW Arkansas Drinking Water, poster, 2007 Annual Arkansas Water Resources Center Conference Abtracts on CD, Arkansas Water Resources Center, Fayetteville, Arkansas, April 2007.
2. Winston, Byron, Sonja Hausmann, Ralph Davis, Bob Morgan, Reed Green, 2007, Taste and Odor in NW Arkansas drinking water, poster, 30th Congress of the International Association of Theoretical and Applied Limnology, SIL Montreal, August 2007.
3. Winston, Byron, Sonja Hausmann and Ralph Davis, 2007, Taste and Odor in NW Arkansas Drinking Water, poster, Annual Conference of the National Association of Black Geologists and Geophysicists (NABGG), Phoenix, AZ, September 2007.
4. Arkansas Democrat Gazette,2007, Yucky water, September 17, 2007 (newspaper article).
5. Arkansas Democrat Gazette,2007, Beaver Lake: Water quality under microscope, September 9, 2007 http://nwanews.com/adg/News/200926/ (newspaper article).

# Report for 2007 USGS 104 B project: "Source of Geosmin and MIB in drinking water: Identifying the source andmechanisms of taste and odor compounds at Beaver Reservoir, northwest Arkansas"

PIs: S. Hausmann, R. K. Davis, S.K. Boss,

## Problem and Research Objectives

Eradicating musty-earthy taste and odor from drinking water is a major challenge for water managers and municipalities in Arkansas, the U.S and around the world. The taste threshold of MIB is 5 ng $L^{-1}$. Each fall citizens of NW Arkansas suffer from foul tasting drinking water caused by Geosmin and 2-Methylisoborneol (MIB), which prompts major complaints to the Beaver Water District (personal communication Robert Morgan from Beaver Water District). Each Fall from 2002 to 2007, 20 to 240 ng $L^{-1}$ MIB were measured at Beaver Reservoir, the region's primary source of potable water. This problem is pervasive, reported in Asia, Europe and other countries, and is projected to increase as populations increase The northwest Arkansas Metropolitan Statistical Area is among the most rapidly developing in the United States with an approximate 50% increase between 1990 and 2000. Upstream of the water intake are large areas of urban sprawl and lakeshore development that are not connected to the municipal sewer systems and may contribute nutrients to the reservoir. Additionally, effluents from treated municipal sewage and non-point sources from animal feeding operations, also contribute nutrients to the reservoir. However, the TP concentrations of the effluents of the Noland Waste Water Treatment plant are only 0.4 mg $L^{-1}$, which is much lower than the guidelines given by EPA. Several studies have shown that the two most common products responsible for bad taste and odor are Geosmin and MIB, produced by cyanobacteria. The assertion is that the increasing population with potential contribution of nutrients will exacerbate the MIB and Geosmin problem in the drinking water because nutrient loading of the reservoir drives algal blooms.

The **objectives** of the project were

1) Determine the sources of MIB and Geosmin production at Beaver Reservoir. Efforts will focus on determining whether cyanobacteria or actinomycetes are the primary organisms responsible for taste and odor episodes.
2) Identify the species abundance and concentration and correlate to MIB and Geosmin concentration.
3) Determine the water quality (physical and chemical) conditions conducive to the production of Geosmin and MIB.

## Methodology

From March to October 2007 water samples were collected biweekly at three study sites: Beaver Reservoir at Lowell, War Eagle Arm and White River Arm. After having identified the depth of the cyanobacteria growth using an in situ optical fluorometer, 1 Liter water samples for microscopic analysis were collected with a Van Dorn bottle. All samples for microscopic analysis were preserved with formaldehyde at collection. The concentration of phytoplankton was determined by adding an aliquot of a known concentration of beads with a diameter of 6 µm.

Identification of algae was attained through microscopic analysis with a phase contrast microscope and oil immersion. Identification was photographically documented. *Actinomycetes* were isolated and enumerated from the same water samples on selective chitin agar.

Total dissolved solids, major ions and inorganic nutrients were analyzed from the same sample. Geosmin and MIB were analyzed only from one study site. In addition, physical parameters such as pH, temperature, dissolved oxygen and conductance were measured in 1 meter intervals in collaboration with the Beaver Water District to determine physical profiles for the Reservoir at the intake region. Statistically significant species and environment relation were tested using multivariate statistics.

## Student support/involvement

The project financed a research assistant ship and tuition for the PhD student Byron Winston. Mister Winston is part of a minority group. He participated in all the fieldwork together with the Beaver Water District. Minster Winston concentrated the algae, cultivated *Actinomycetes* and identified the algae. He presented the project at one regional, one national and one international scientific meeting.

## Principal Findings and Significance

The study yielded important information on the species and environmental dynamics at all three sites at Beaver Reservoir (Fig. 1). This study revealed two distinct algal communities influenced by two distinct sets of environmental conditions at all three sites. This might explain the observation that Geosmin is detected first then followed by MIB. Statistically only nitrite explained significantly the seasonal distribution of algae.

At the first study site Beaver Reservoir at Lowell the increase of Geosmin preceded the peak of MIB (Fig. 1). The production of MIB was influenced by a different set of environmental parameters and algal community composition than the smaller Geosmin peak in early summer. The algal community comprising of *Asterionella formosa, Chrysoccocus* sp. and *Cylindrospermopsis raciborskii* were significantly related to higher production of MIB. *Cylindrospermopsis raciborskii* is a hepatotoxin producer, and *Asterionella* and *Chrysoccocus* species are known taste and odor producers. The relative abundance of these taxa increased at the end of August during lower nitrite concentrations, higher alkalinity and higher turbidity.

In the War Eagle Arm (WEA) the toxin producer *Cylindrospermopsis* sp. occurred with 45% one week earlier than at the intake. It is not known as a MIB/Geosmin producer. Its occurrence was related to lower nitrite concentrations (Fig. 1). Towards the end of August, the increasing abundance of benthic diatoms *Navicula* and *Achnanthes* species indicated a lower lake level. This raises important questions about the controlling factors on the species distribution and composition and the possible production of MIB and Geosmin. War Eagle Arm had the highest TP concentrations of all three study sites.

As observed in the other two sites nitrite and alkalinity were negatively correlated in the White River Arm. *Raphidiopsis curvata*, which has no nitrogen fixing heterocysts, occurred during high nitrite concentration, but could have been *Cylindrospermopsis* with out heterocysts. *Raphidiopsis curvata,* occurred with 30% abundance at the end of May together with the green algae *Chlamydomonas* (20%), which is a known odor and taste producer. Unlike the two other sites, *Fragilaria crotonensis* was not among the dominant species.

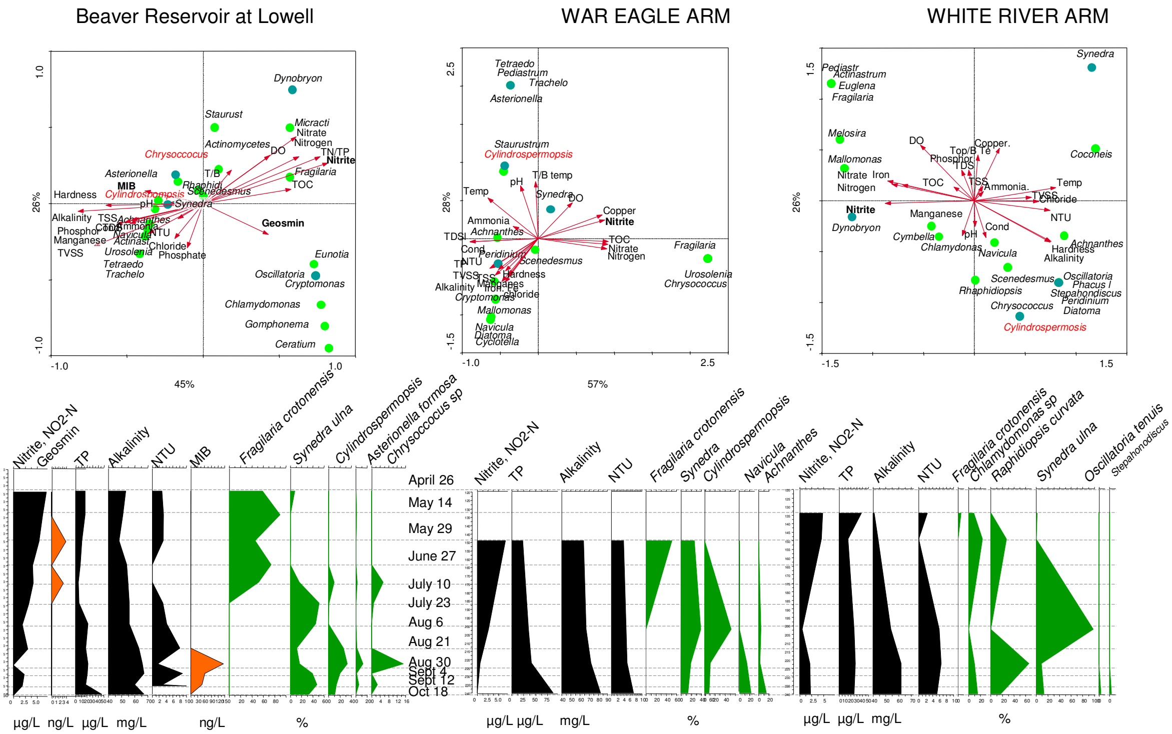


Fig. 1: Species-environment bi-plots of the three study sites. The angle between the arrows gives information about the correlation of environmental variables. The lengths of the arrows represent the importance of each environmental variable for the distribution of taxa. Bottom: Relative abundances of the most important species and water chemistry.

# Continuous Water−Quality Monitoring and Potential Phosphorus Source Identification with Oxygen Isotopes

## Basic Information

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|---|---|
| **Title:** | Continuous Water−Quality Monitoring and Potential Phosphorus Source Identification with Oxygen Isotopes |
| **Project Number:** | 2007AR171B |
| **Start Date:** | 3/1/2007 |
| **End Date:** | 12/31/2008 |
| **Funding Source:** | 104B |
| **Congressional District:** | 3 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Water Quality, Surface Water, Non Point Pollution |
| **Descriptors:** | |
| **Principal Investigators:** | Brian E Haggard, Phil D Hays |

## Publication

## Characterization of Nitrate Processing and Transport in the Interflow Zone of a Mantled Karst Watershed

### Problem and Research Objectives:

Animal production and associated on-land application of animal manures in karst watersheds pose a substantial threat to water quality because of thin soils, rapid infiltration, a predominance of conduit flow, and minimal opportunity for processing of nutrients such as nitrate. Balanced nutrient application presupposes an understanding of biogeochemical processes and controls on nitrate transport and cycling in karst. This research focused on investigation of these processes and controls in the interflow zone - an intermediate zone between the focused-flow and diffuse-flow soil zones in karst with an increased residence time and a potential for microbial remediation of nitrate.

### Methodology:

A hydrologic conceptual model was established through a dye tracer experiment of a study site situated in mantled karst of the Ozark Highlands at the University of Arkansas Savoy Experimental Watershed. Chicken litter was applied to the study area. Dissolved organic carbon concentrations and bioavailability, concentrations of reactive (nitrate) versus conservative (chloride) constituents, and nitrate isotopic composition were determined for soil (diffuse), interflow, and focused flow zones under low flow and high flow conditions.

### Principal Findings and Significance:

Data indicated considerable short-circuiting or bypass of dissolved species past the soil zone, but that a majority of flow spends some residence time in the interflow zone. Nitrate mass balance data also indicated that nearly 40 percent of nitrate moving through the interflow zone may have been microbially processed. The level of processing was highly variable and dependent upon flow-path and hydrologic conditions. Bioavailability of dissolved organic carbon in the interflow zone was elevated relative to the focused-flow zone under high-flow conditions, providing a needed substrate for nitrate processing in this zone. Nitrate flowing out of the interflow zone was isotopically depleted relative to modeled values that would be expected if denitrification didn't occur. Results suggest the interflow zone is a potentially important zone for nitrate attenuation in karst settings.

Based on the gathered data, the following experiments were designed and are scheduled to be conducted in 2008/2009, to further elucidate nitrate processing and attenuation in the interflow zone: 1) A quantitative dye tracer test to establish hydrologic connectivity and solute travel times along the interflow zone flow-paths, and to verify the existence of macropore-flow as an important mechanism for rapid water and solute transport in the interflow zone. 2) Nitrate mass balance and nitrate stable isotope analyses to identify denitrification in the interflow zone; and dissolved inorganic carbon concentration and $\delta13C$ isotopic composition analyses to quantify microbially (denitrification) produced CO2. 3) Dissolved dinitrogen analysis to quantify denitrification along the interflow zone flow-paths.

# Metal Mobilization, Especially Arsenic, in the Alluvial Aquifer in Response to Water Level Fluctuations Measured by Field and Laboratory Column Data

## Basic Information

| | |
|---|---|
| **Title:** | Metal Mobilization, Especially Arsenic, in the Alluvial Aquifer in Response to Water Level Fluctuations Measured by Field and Laboratory Column Data |
| **Project Number:** | 2007AR173B |
| **Start Date:** | 3/1/2007 |
| **End Date:** | 12/31/2008 |
| **Funding Source:** | 104B |
| **Congressional District:** | 3 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Hydrogeochemistry, Geochemical Processes, Water Quality |
| **Descriptors:** | |
| **Principal Investigators:** | Kenneth F. Steele |

## Publication


1. Kim, B., 2008, Hydrochemical Evolution of Ground Water in an Intesively Pumpled Alluvial Aquifer. Ph.D. Dissertation, Environmental Dynamics and Department of Geosciences, University of Arkansas, Fayetteville, Arakansas, 238p.
2. Kim, B., K.F. Steele, R.K. Davis, M.U. Sharif, T. Kresse and F. Fazio, 2007, TI: Arsenic Release Mechanism in an Intensively Irrigated Agricultural Region of the Alluvial Aquifer, Eastern Arkansas, USA Eos Trans. American Geophysical Union, 88(52).
3. Sharif, M.U., 2007, Hyrogeochemical Evolution of Arsenic in Groundwater: Sources and Sinks in the Mississippi River Alluvial Aquifer Southeastern Arkansas, USA. Ph.D. Dissertation, University of Arkansas, Fayetteville, Arkansas. 367p.

Metal Mobilization, Especially Arsenic, in the Alluvial Aquifer in Response to Water Level Fluctuations Measured by Field and Laboratory Column Data

Burmshik Kim, Kenneth F. Steele, Ralph K. Davis, Salah U. Sharif, Timothy M. Kresse

Abstract

A simple column experiment was designed and conducted for investigating the chemical evolution of ground-water chemistry related to ground-water level fluctuation. Disaggregated sediments from the boreholes of monitoring wells were packed in 6-in inner diameter, 2-ft length acrylic columns. The thickness of the sediment layers were proportional to the sediment profile in terms of lithology and thickness in the field. Ground water was collected and passed through a pre-treatment column that was packed with sediments which would produce a reducing environment similar to field conditions. These column experiments were collaborated by field data. The results of the column experiments indicate that investigation of geochemical evolution and the impact of ground-water level fluctuation on metal mobilization can be evaluated by simple laboratory column experiments.

Key Worlds: column experiment, ground water, geochemical evolution, ground-water fluctuation.

## INTRODUCTION

Patrick et al. (1973) provided a simple system for controlling redox potential and pH in soil suspensions. Redox potential (ORP) was controlled by oxygen in the air, and the system achieved a strong reducing environment (ORP of about -250 mV). Redox conditions related to water quality control (Bilek, 2006), soil-water interaction, including metal release mechanisms and heavy metal transport simultation in ground water (Dragun, 1993; Camobreco, 1996; Bang, 2002; Chuan et al., 1995; Sadiq et al., 1983; Wilkin et al., 2003; Fulekar and Dave, 1991), and biodegradation of organic matter (Davis et al., 2003) were studied by column experiments.

Schlieker et al. (2001a; 2001b) investigated the influence of advective transport on redox fronts under various flow velocities using column experiments and modeled reaction mechanism between water and sediments numerically. Horner et al. (2007) studied transport and reaction models with PHREEQC for simulating bank filtration from column experiments. Considering the previous research, column experiments are very useful for investigating the influence of redox changes on metal mobilization mechanisms caused by water-level fluctuation. The difficulty of charactering the field environment (e.g., heterogeneity of aquifer materials), and rapid transition of oxidation-reduction potential during sampling and transportation of ground water for physicochemical parameter analysis limit the acquisition of representative aquifer material. Considering limitations of the data acquisition methodology (e.g., immediate chemical analysis after sampling, and frequent *in-situ* physicochemical parameter measurement), the best tool for investigating ground-water evolution is a simple but elaborately designed laboratory-scale column test. Although laboratory column tests can not simulate all of the field conditions perfectly, these tests provide the best method for chemical data acquisition . Therefore, the goals of this research are to provide information for column design and to recommend adequate column experimental data for investigating the impact of ground-water level fluctuation on metal mobilization mechanism in an alluvial aquifer.

## EXPERIMENTAL DESIGN

### Columns and Sediment

Disaggregated sediment collected from boreholes of monitoring wells were packed in 0.5 ft diameter, 2-ft long acrylic columns. The sediment layers corresponded to the sediment profile of lithology and thickness in the field. Each sediment layer was sieved with mesh No.10 sieve (2 mm opening) to remove gravel and homogenize each stacked layer before filling the column. Three columns (One pretreatment and two redox ) with the same sediment constituents were prepared. Each column was well packed with sediments by vibrating and gently pressing on the sediment.

Feed Water

An important issue for the construction of column tests was how to obtain feed water for the tests. The available feed water sources were:

1) artificial ground water with composition based on chemical analysis of field collected ground water,

2) rain water or surface water collected at the research site,

3) deionized water,

4) field collected ground water.

Artificial ground-water constituents (e.g., chelated metals, and ionic strength) can not perfectly represent field conditions, in part because of heterogeneity. Rain water or surface water at the research site could simulate vertical and horizontal recharge but as previously noted representative recharge water does not exist because of heterogenic hydrogeology. Deionized water can be used as recharge water without any pre-treatment, but this alters the initial sediment-water chemistry, and and is therefore not valid for comparison of the column test results with observed field conditions. Field collected ground water is the most appropriate water to simulate actual fluctuation condition and sediment - water interactions in the aquifer. The biggest problem related to using field collected ground water is that it is easily oxidized during transportation to the laboratory. However, this problem can be overcome by using a pre-treatment column to develop a reducing environment in field collected ground water (Table 1.).

Table 1. Feeding water sources for column experiments

| Water Sources | Compositions[1)] | Investigation[2)] | Accessibility[3)] | Other Problems |
|---|---|---|---|---|
| Artificial Ground water* | Acceptable | Good | Good | Chelating or other Unwanted Reaction |
| Rain Water / Surface Water** | Acceptable | Acceptable | Bad | pH, ORP, Organic Matter |
| Deionized Water | Bad | Acceptable | Good | Loss of Cation Exchange Capacity, Metals |
| Field Collected Ground Water*** | Good | Good | Acceptable | ORP |

1) The similarity of compositions with actual ground-water constituents

2) Easy to investigate reaction mechanisms

3) Easy to obtain the water

* Artificially created water compositions with chemicals

** Obtaining the recharge water for the alluvial aquifer at the research site

*** Obtaining from the monitoring wells

Design

After considering the previously discussed feed water sources, ground water collected from a monitoring well in the field was used as feed water for the column studies. Field collected water was passed through a pre-treatment column, packed with field collected sediments in the same way as the primary experimental columns, to develop a reducing environment that mimics observed field conditions. The regenerated, reduced ground water was distributed to three main test columns. The three main test columns were two water-level fluctuation columns (oxic and anoxic water-level fluctuation columns) for simulating water-level fluctuation, and a continuous flow column, which remained fully water saturated for comparison to water-level fluctuation columns. The two water-level fluctuation columns periodically received feed water to maintain sediment saturation, and were pumped to dewatering sediments, as well as during water sample collection. Water sample collection dates were based on the fluctuation simulation schedule (Table 2.). The continuous flow column remained fully saturated and water passed through the column continuously without de-watering. For the continuous flow column, water samples were collect from the over fill water container.

Redox Issues

One of the most important parameters for the column tests is oxygen. Field measurement of alluvial aquifer ground water revealed that dissolved oxygen in ground water was less than 0.1 mg/L, which indicates the environment is anoxic. To simulate this field environment, oxygen was controlled for the column experiments. A nitrogen shielding box was installed for isolating the system from the air (Figure 1 and Figure 2). Also, all columns were purged with nitrogen gas before adding feed water in order to remove oxygen in the pore spaces in the sediment. In order to see the effect of oxygen intrusion into the alluvial aquifer caused by intensive pumping, the air hole for one column was connected to atmosphere (oxic column) directly, and the air hole of the other column connected to an oxygen absorbent solution (anoxic column). The two columns were tested for water-level fluctuation simulation of oxic and anoxic conditions. Consequently, the oxic water-level fluctuation column was allowed contact with the atmosphere for oxygen transfer during water-level fluctuation. The anoxic water-level fluctuation column had air passed through the oxygen absorbent solution thus creating reducing conditions during water-level fluctuation. The continuous flow column was a closed system maintaining reducing condition continuously.


(a) Column experimental setup. (1): Continuous flow column, (2): Pre-treatment column, (3): Oxic water-level fluctuation column, (4) Anoxic water-level fluctuation column


(b) Outside shielding box filled with nitrogen gas 99.9%.

Figure 1. Column experiment design.

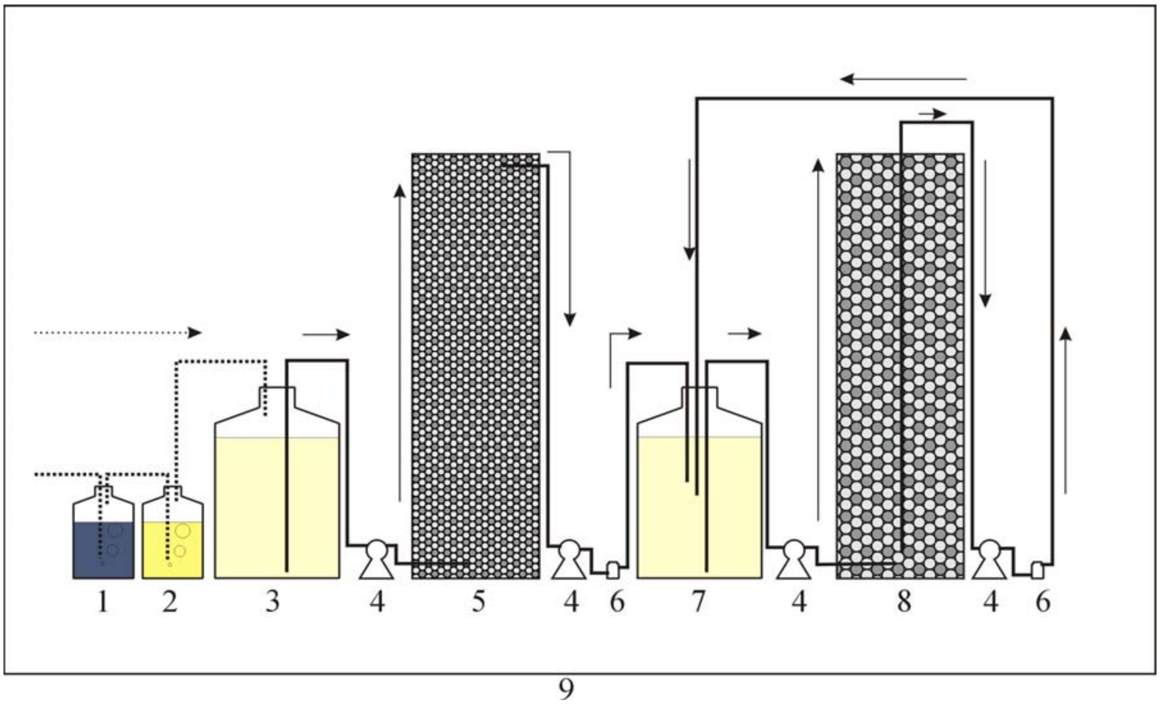


Figure 2. Water flow diagram for column studies. Arcrilic tubing was used to make the columns. (1) Pyrogallol 6 % in KOH 30 % alkaline solution medium for absorbing oxygen, (2) 15 % ascorbic acid solution for absorbing oxidants, (3) Raw ground water tank, (4) Peristaltic pump, (5) Pre-treatment column, (6) Effluent bottle for sampling and measurements, (7) Storage container, (8) Main test columns comprised of two water-level fluctuation simulation columns and one continuous flow column. Two types of flow direction were tested for the main columns. The inner diameter of the columns is about 6 in and height is 2 feet. (9) Nitrogen shielding box to keep air out. Dotted arrow line indicates air flow, and solid arrow lines indicate water flow.

Flow direction is another essential factor in determining geochemical evolution. The alluvial aquifer is recharged mainly by horizontal from adjacent recharge areas including surface water capture,, and to a lesser degree by vertical infiltration. The first experiment was conducted utilizing up-welling flow to avoid trapping air in the sediment column, as well as simulating recharge (Direction 1 for oxic, anoxic and continuous flow, and Direction 3 for pre-treatment column (Figure 3). For the fluctuation simulations, water from the pre-treatment column was fed into the oxic and anoxic columns until there was sufficient saturation at the bottom of the column for a sample to be pumped for collection. For simulating vertical infiltration, as well as to allow sufficient interaction between water and the silt sediment, a second experiment was conducted by utilizing Direction 2 (for oxic, and anoxic columns) and Direction 3 (for continuous flow and pre-treatment columns) (Figure 3).

Table 2. Water-level fluctuation in the columns and sampling plan schedules.

| Test set[1)] and column type | | Feeding (Recharge) | Saturation | Effluent (Pumping) | De-watering | Repeat | Sampling |
|---|---|---|---|---|---|---|---|
| 1 | Oxic* | 48 hours | 5 days | 48 hours | 5 days | 6 cycles | Every cycle (at effluent) |
| | Anoxic** | 48 hours | 5 days | 48 hours | 5 days | 6 cycles | |
| | Continuous Flow*** | Continuously saturated and periodically circulation of water in the system. Flow direction was Direction 1 | | | | | Same with oxic/anoxic |
| 2 | Oxic* | 48 hours | 12 days | 48 hours | 5 days | 3 cycles | Every cycle (at effluent) |
| | Anoxic** | 48 hours | 12 days | 48 hours | 5 days | 3 cycles | |
| | Continuous Flow*** | Continuously saturated and periodically circulation of water in the system. Flow direction was Direction 3. | | | | | Same with oxic/anoxic |

1) Test set 1 and 2 are different for flow direction and saturation time.

* Oxic: Oxic water-level fluctuation column

** Anoxic: Anoxic water-level fluctuation column

*** Continuous Flow: Continuous flow column

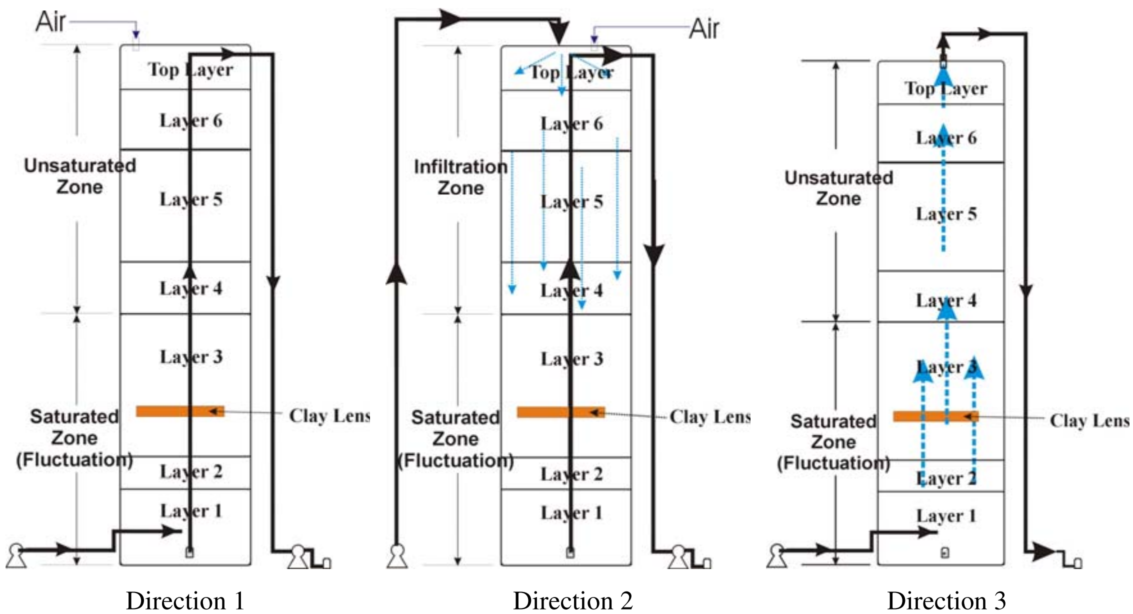


Figure 3. Water flow directions for anoxic, oxic and continuous flow columns. Direction (1) was the flow direction for oxic column, anoxic column, and continuous flow column test set number 1. Direction (2) was the flow direction for oxic column and anoxic column test set number 2. Direction (3) was the flow direction for continuous flow column test set number 2, and pre-treatment column. For the test set numbers, see Table 2.

## Result and Discussion

In order to test the chemical stability of the column experiment, a pre-test column was constructed with the column under continuous up-welling ground-water flow. *In-situ* monitoring of specific conductance, redox potential (Eh), temperature, dissolved oxygen, and pH was conducted (Figure 4). The parameters were stable within 125 hours for the continuous up-welling water flow (flow direction #1 in Figure 3). After stabilization, the system was run continuously. Although some oxygen intruded the system (near the 125 hour point as shown on Figure 4), redox potential was re-stabilized within 24 hours. Redox potential values indicated that the system maintained a reducing environment due to utilization of the Pyrogallol dissolved in potassium hydroxide solution (see Figure 2 for detail).

Pyrogallol solution has been used as an effective oxygen absorbent solution since 1920s (Nicol, 1929; Williams et al., 1952). As previously described, ground water was oxidized after collection in the field. Before using this water in the column experiment, the water was regenerated by passing it through the pre-treatment column resulting in development of reducing conditions. In general, physico-chemical characteristics of the regenerated water were in the range of field measured parameters. For example, bicarbonate calculated from alkalinity. values ranged from 248.8 to 333.2 mg/L, and from 32 to 442 mg/L, and iron ranged from 0.2 to 6.6 mg/L, and from non-detect at <0.015 mg/L to 41.4 mg/L, in regenerated water and in field collected water, respectively (Arkansas Department of Environmental Quality Water Division, 2001).

Based on simple observations regenerated water had higher arsenic, iron, manganese, total phosphorus (TP), and phosphate concentrations than experimental water samples, whereas experimental water had higher calcium, chloride, magnesium, potassium, sodium, and sulfate concentrations than regenerated water samples. It was observed that regenerated water had lower ORP (i.e., more reducing conditions) than experimental water. These results indicated that some trace metals and nutrients including arsenic, iron and phosphorus, were adsorbed on the sediment and/or co-precipitated (Zhu et al., 2003) resulting in a decrease in concentrations. The adsorption depends on ORP and other physico-chemical parameters, including ionic strength, pH, and other competing ions. Examples of competing ions for arsencic are silica in the main test columns. However, major cations and anions (calcium, magnesium, potassium, sodium, chloride, and sulfate) concentrations in some samples increased after passing through the main test columns. The concentrations of major cations and anions in some samples ranged from 10 to 500 % higher than concentrations for the regenerated water. It is hypothesized that dissolution of some minerals and chemicals such as calcite, pyrite ,nutrients and iron oxyhydroxide increased the concentrations of ions associated with these minerals.

The results indicated that the reducing environment was stable during the experiments and the reproduced redox conditions and other physco-chemical parameters of alluvial aquifer were within the concentration variation ranges from the field. Consequently, the simple column experiments are adequate for the simulation of the impact of ground-water level fluctuation in an alluvial aquifer.

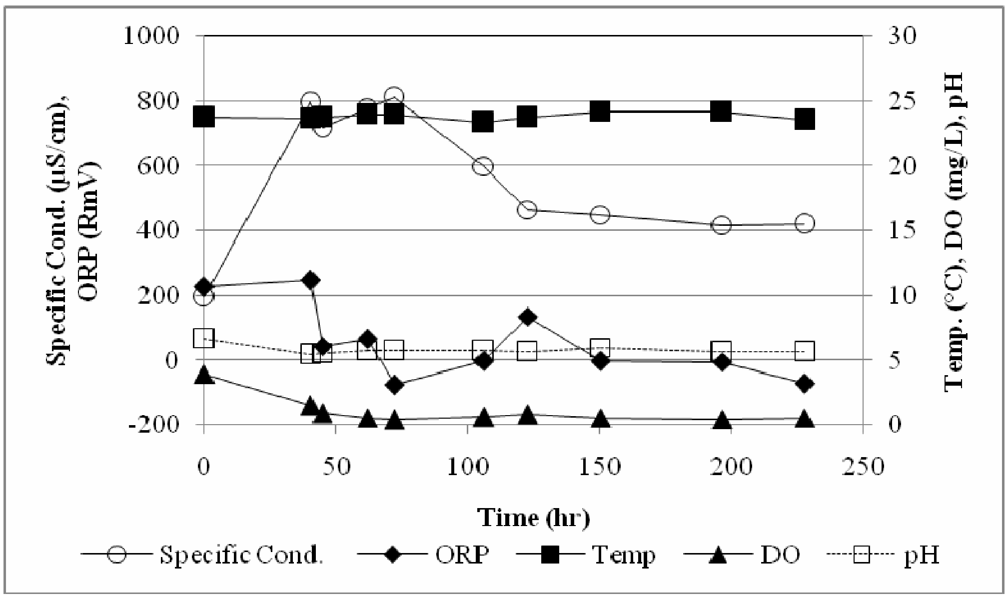


Figure 4. Parameter monitoring for system stability test. A column with field collected sediments was run under continuous up-welling ground-water flow. The ground-water flow rate was about 2 L/day. The monitored parameters are specific conductance in µS/cm, oxidation reduction potential (ORP) in mili-volt relative to hydrogen cell (RmV), temperature in °C, dissolved oxygen (DO) in mg/L, and pH. The parameters were measured *in-situ* with meters.

## CONCLUSIONS

A simple column experimental set was designed for simulating ground-water level fluctuation and for investigating the impact of the fluctuation on ground-water evolution. The result indicated that acrylic columns filled with field collected sediments can successfully reproduce the field redox environments and the data can be used for geochemical modeling or graphical analysis for investigating geochemical evolution in an alluvial aquifer.

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# Information Transfer Program Introduction

AWRC sponsors an annual water conference held in Fayetteville each spring, drawing in about 100 researchers, students, agency personnel and interested citizens to hear about results of current research and hot topics in water resources throughout the state. AWRC also co−sponsors short courses and other water−related conferences in the state and region. The 2007 Conference featured 20 oral presentations and 12 posters during the one and one−half day conference. In addition, AWRC maintains a technical library containing over 900 titles, many of which are on−line. This valuable resource is utilized by a variety of user groups including researchers, regulators, planners, lawyers and citizens. Many AWRC publications have been converted to electronic pdf format which can be accessed via our web site at http://www.uark.edu/depts/awrc. Click the "Publications" link on the left−hand side of the page to view these publications.

# 2007 Arkansas Water Resources Center Conference

## Basic Information

| | |
|---|---|
| **Title:** | 2007 Arkansas Water Resources Center Conference |
| **Project Number:** | 2007AR206B |
| **Start Date:** | 7/1/2006 |
| **End Date:** | 4/30/2007 |
| **Funding Source:** | 104B |
| **Congressional District:** | 3 |
| **Research Category:** | Not Applicable |
| **Focus Category:** | Water Supply, Water Quality, Non Point Pollution |
| **Descriptors:** | Annual Water Resources Conference |
| **Principal Investigators:** | , Ralph K. Davis |

## Publication


1. Davis, R.K., 2007, 2007 Annual Arkansas Water Resources Center Conference, April 24 and April 25, 2007, University of Arkansas Center for Continuing Education, Fayetteville, AR, Conference Agenda and Abstracts on−line at http://www.uark.edu/depts/awrc/Publications/2007%20AWRC%20CONFERENCE/Trifold07IA.pdf.

## 2007 Arkansas Water Resources Center Conference

### Tuesday, April 24
**7:15am to 5:30pm**

**Registration and Continental Breakfast......................7:15 am**

**Ralph K. Davis, Director, Arkansas Water Resources Center Welcome and Introductions..........................................8:10 am**

**PRESENTATIONS**
***Denotes Speaker**

***Session Moderator**:* J. Van Brahana, Professor, Geosciences, University of Arkansas, Fayetteville

**Utilizing Water Treatment Residuals for Reducing Phosphorus Runoff from Biosolids**, *Moore, Jr., P.A., Soils Scientist, USDA-ARS, Parker, D., McGoodwin, Williams and Yates, Inc., Klineman, P., USDA/ARS, Sharpley, A., Professor, Crop, Soil and Environmental Sciences, UA, Williams, R., Professor, Civil Engineering, UA and Young, R., Director, Arkansas Natural Resources Commission …….…….... **8:15 am**

**Watershed Remediation: Considering Co-Benefits and Tradeoffs**, *Sharpley, A., Professor, Crop, Soil and Environmental Sciences, UA ……………………….….**8:40 am**

**Earthworms as Ecoengineers in the Restoration of Oil and Brine-Impacted Soils Following Remediation**, *Thoma, G., Professor, Chemical Engineering, UA, Alahari, N., Sublette, K., Jennings, E., Professors, Center for Applied Biogeosciences, University of Tulsa, Wolf, D., Professor, Crop, Soil and Environmental Sciences, UA, Kathleen Duncan, Professor, University of Oklahoma, Tim Todd, Professor, University of Kansas, Mac A. Callaham, Jr., USDA-Forest Service ….**9:05 am**

**Long-Term Perspective on Central Texas Climate**, *Cleaveland, M., Geosciences, UA …………………….**9:30 am**

**Break …………………………………….……9:55 – 10:20am**

**Modeling Ground-Water Flow Within the Ozark Plateaus Aquifer System**, * Czarnecki, J.B., Ph.D., Hydrologist, U.S. Geological Survey Arkansas Water Sciences Center ..**10:25 am**

**Selected Trace and Major Element Concentrations of Beaver Lake Sediment Cores,** *Patton, J. A., USEPA Doctoral Fellow, Environmental Dynamics, UA and Boss, S.K., Director, Environmental Dynamics Program, UA ………………**10:50 am**

**Migration of Landfill Contaminants in a Tilted Block Mantled Karst Setting in Northwestern Arkansas**, *Bolyard, S., Geosciences, UA and Hydrologist, U.S. Geological Survey Arkansas Water Science …………..…………………**11:15 am**

**Lunch (Provided) and Poster Session**
**Tuesday, April 24..………..11:40 – 2:30 pm**
***See back page for poster titles**

***Session Moderator**:* Phil Hays, Adjunct Professor, Geosciences, University of Arkansas, Fayetteville

**Characterization of a Karst Spring in North-Central Arkansas**, *Scheiderer, R.M., Hydrologist, USGS Arkansas Water Science Center and Galloway, J.M., Hydrologist, USGS Arkansas Water Science Center ………………………**2:35 pm**

**Extent of Aquifers and Confining Units in Arkansas: A Web Based Stratigraphic Database**, *Clark, B.R., Scheiderer, R.M.., Hydrologists, U.S. Geological Survey Arkansas Water Science Center and Bryson, J.R., Hydrologist, U.S. Geological Survey Mississippi Water Science Center ………………………**3:00 pm**

**Break ………………………………………3:25 pm – 3:45 pm**

**Distribution and Variability of Redox Zones Controlling Spatial Variability of Arsenic in the Mississippi River Valley Alluvial Aquifer, Southeastern Arkansas**, *Sharif, M.U., Doctoral Fellow, Environmental Dynamics, UA, Davis, R.K., Arkansas Water Resources Center and Geosciences, Steele, K.F., Geosciences, Kim, B., Doctoral Candidate, Environmental Dynamics, UA, Kresse, T.M. and Fazio, J.A., Geologists, Arkansas Department of Environmental Quality ……..**3:50 pm**

**Water-Quality and Biological Assessment of the Middle Fork of the Saline River, 2003-2006**, *Galloway, J.M., Hydrologist, USGS Arkansas Water Science Center, Shelby, E., Water Use and Resource Specialist, Arkansas Department of Environmental Quality, Petersen, J.C., Hydrologist, USGS Arkansas Water Science Center and Green, R.W., Assistant Director, USGS Arkansas Water Science Center ………………………**4:15 pm**

**The Effects of Land-Use Change on Water Quality and Speleogenesous in Ozark Cave Systems – A Paired Cave Study of Civil War and Copperhead Cave, Northwestern Arkansas**, Gillip, J.A.* and Hays, P.D., Ph.D., Hydrologists, U.S. Geogical Survey Arkansas Water Science Center and Geosciences UA ……………………………………**4:40 pm**

### Wednesday, April 25
**7:15am to Noon**

Session Moderator: Marty Matlock, PhD, PE, CSE, Associate Professor of Ecological Engineering, UA

**Registration and Continental Breakfast ..................... 7:15 am**

**Net Changes in Stream Antibiotic Concentrations Downstream from Effluent Discharges**, Haggard, B.*, Professor, Biological and Agricultural Engineering UA ………… ....................................................................................... **8:10 am**

**Antibiotic Resistance in Aquatic Bacteria Downstream from Effluent Discharge**, Savin, M.*, Professor, Crops, Soils and Environmental Sciences UA …………….……………**8:35 am**

**Distribution and Occurrence of Indicator Fecal Bacteria in Stillwater Creek, Cow Creek and Boomer Creek,** Deng, S.*, Professor, Oklahoma State University ........................... **9:00 am**

**Point Source Ozonation to Minimize Antibiotic Resistance,** Osborn, S.*,, Professor, Biological and Agricultural Engineering UA.................................................................................. **9:25 am**

**Break ……………………………………9:50 am – 10:10 am**

**Sustainable Water Resources in Arkansas**, Boss, S.K.*, Director, Environmental Dynamics and Geosciences UA …………………………….……………………**10:15 am**

**Water Resources Sustainability in Northwest Arkansas**, Morgan, R.*, Environmental Director, Beaver Water District …………………………………………………..**10:40 am**

**Green Infrastructure Design**, Luoni, S.*, Director, Community Design Center UA …………………………………**11:05 am**

**Sustainable Growth in Northwest Arkansas**,Collins, J., Ph.D., Endeavor Consulting, Inc.……………………………**11:30 am**

## POSTERS

**Development of a Bacterial Source Tracking and Apportionment Methodology Using DNA Micro-arrays and Luminex Micro-beads, and its Application in the Ozark Plateau**, Alkendi, Ruwaya, Environmental Dynamics Program, Ralph Davis, Arkansas Water Resources Center and Department of Geosciences, Greg Thoma, Chemical Engineering, Jin-Woo Kim, Biological and Agricultural Entgineering, University of Arkansas, Fayetteville, AR

**Spatial Variations in Net Uptake [or Release] of Antibiotics in Effluent Dominated Streams**, Bartsch, L.D., Graduate Assistant, Environmental Engineering, UA, Haggard, .E., Associate Professor, Biological and Agricultural Engineering, UA, Galloway, J.M., Water Quality Specialist, U.S. Geological Survey Arkansas Water Science Center.

**Multiproxy Reconstruction of the Paleofloods in the Mississippi River Delta**, Ruchi Bhattacharya and Sonja Hausmann, Department of Geosciences, University of Arkansas, Fayetteville, AR, rbhattac@uark.edu

**Detailed Geologic Map for Forum Quadrangle, Arkansas Including a Karst Inventory**, Johnson, Ty Charles, Davis, Ralph k., Brahana, J. Van, and Zachry, Doy L., Department of Geosciences, University of Arkansas, Fayetteville, AR

**Beaver Lake Watershed Atlas: Community Resource for Protecting and Preserving the Watershed**, Stephanie Shepherd, Environmental Dynamics Program, UA, Ralph Davis, Arkansas Water Resources Center and Department of Geosciences, UA, Jack Cothren, Center for Advanced Spatial Technologies and the Department of Geosciences, UA

**Stream Sediment Phosphorus Equilibrium Concentrations Below a Rural Effluent Discharge**, R.J. Stoner, Crop, Soil and Environmental Sciences and B.E. Haggard, Biological and Agricultural Engineering Department, University of Arkansas, Fayetteville, AR 72701

**Underground Injection Control Program in Arkansas and Drinking Water Protection**, Laura Stuart, P.G., Geologist Water Division, Arkansas Department of Environmental Quality.

**Taste and Odor in NW Arkansas Drinking Water**, Byron Winston, Sonja Hausmann, Ralph Davis, Department of Geosciences, University of Arkansas, Beaver Water District, Reed Green, U.S.G.S. Water Sciences Center, Little Rock, AR

**WELCOME TO THE**

**2007 ARKANSAS WATER RESOURCES CONFERENCE**

**April 24 & 25, 2007**
***at the***

**Center for Continuing Education**
**and the**
**Fayetteville Cosmopolitan**
70 North East Avenue
Fayetteville, Arkansas

# Student Support

| Student Support | | | | | |
|---|---|---|---|---|---|
| **Category** | **Section 104 Base Grant** | **Section 104 NCGP Award** | **NIWR−USGS Internship** | **Supplemental Awards** | **Total** |
| **Undergraduate** | 4 | 0 | 0 | 4 | 8 |
| **Masters** | 4 | 0 | 0 | 2 | 6 |
| **Ph.D.** | 4 | 0 | 0 | 2 | 6 |
| **Post−Doc.** | 0 | 0 | 0 | 0 | 0 |
| **Total** | 12 | 0 | 0 | 8 | 20 |

# Notable Awards and Achievements

Establishing Effective Partnerships A partnership between the Upper White River Basin Foundation and the Arkansas Water Resources Center is a bi−state dual University partnership with a goal of minimizing cross boarder conflicts and resolving water quality concerns within the Upper White River watershed. AWRC is working closely with a regional watershed group (Upper White River Basin Foundation, Branson, Missouri), and Missouri State University to provide basic geographic spatial data and water quality data for the watershed on which sound environmental management decisions can be based. Our close relationship with this group has led to additional interaction with another newly formed Watershed Advisory group for the Illinois River Basin in Northwest Arkansas. We have been selected as one of the primary entities to collect, compile, interpret, and report on water quality in the Illinois River basin. This is significant because it shows that the data provided through the AWRC research teams is considered to be sound, reliable, and unbiased. Maintaining this type of independent credibility provides a valuable asset in terms of dispute resolution on both water quantity and water quality concerns in these trans−boundary waters.

USGS 104 B funds were leveraged through a partnership with the Arkansas Department of Environmental Quality and additional University resources to investigate arsenic release and mobilization mechanisms in the Mississippi River Valley alluvial aquifer in eastern Arkansas. This is important because a high percentage of small public water systems and most of the domestic users in the region rely on this aquifer as a source of potable water. The research supported two Ph.D. students at the University of Arkansas and has resulted in the publication of papers in the Journal of Hydrology and the Journal of Contaminant Hydrology, with an additional three papers in preparation. The results were also presented at the Geological Society of America Annual meeting in 2006 and 2007, and the American Geophysical Union in 2007.

Collaborative Multidisciplinary Interagency Research Programs

The Arkansas Water Resource Center in conjunction with a multidisciplinary team have leveraged funding provided by the USGS 104 B program over several years to supplement infrastructure and provide basic and applied research at the Savoy Experimental Watershed, Northwest Arkansas. The Savoy Experimental Watershed (SEW) is an approximately 1,250 hectare University of Arkansas property managed by the UA Department of Animal Sciences. Cooperation between the Colleges of Agriculture, Engineering and Arts and Sciences has provided access to this valuable site for basic and applied research related to assessing methods to minimize environmental impacts from animal agriculture and other sources of nutrient and bacterial loading to the environment. The facility is located about 24 km west of the University of Arkansas campus in northwest Arkansas. It was selected because it is representative of mantled−karst aquifers throughout northwest Arkansas, the Ozarks and much of the remaining 20% of the United States dominated by karst topography. Ongoing research at the site has facilitated development of a fully instrumented site that allows investigation of the integrated transport of surface applied nutrients and bacteria through primary pathways to their ultimate discharge into major streams. USGS 104 B funds have been provided through AWRC to several researchers utilizing SEW over the last several years with a goal of providing seed data, creating the basis for preparation of proposals to other entities. This includes investigation of transport and storage of E. coli bacteria in streams and aquifers of Northwest Arkansas. Results of this project were recently published in the Journal of the American Water Resources Association (Davis et al. 2005) and Applied Biochemistry and Biotechnology (2008). The initial state and Federal funds provided via the Arkansas Science and Technology Authority and the USGS 104 B program provided initial data sets which were then used as the basis for a proposal to the National Science Foundation which was awarded for continued research in this area.

Dr. Phil Hays who holds a joint appointment with the USGS and the University of Arkansas, and Dr. Susan Ziegler, UA Department of Biological Sciences are conducting an interdisciplinary study with USGS, USDA, and the UA Departments of Geosciences and Biological Sciences to define biogeochemical processes occurring in karst, and how nitrogen transport and utilization is controlled by the interplay of biological and hydrological inputs to the complex systems. Additional funds provided by the USGS 104 B program have augmented this project providing resources to investigate nitrogen processing in a Karst Soil Catena. Results of their work was published by Defaw et al. (2005), and more recently presented at the Geological Society of America and American Geophysical Union annual meetings.

Dr. J. Van Brahana, Geosciences at UA, utilized seed funds provided under the USGS 104 B program in conjunction with funding from US EPA, USDA, Arkansas Department of Environmental Quality, and others to establish a fully instrumented facility at SEW with a main goal of understanding nutrient (nitrogen and phosphorus) fate in strongly linked surface subsurface karst agricultural watersheds, which is critical to development of effective management strategies to protect human health and minimize adverse effects of phosphorus on river and lake systems. Their team has published several papers related to the site including several papers in the proceedings of the USGS Karst Interest Group (Brahana et al, 2005; and Laincz et al, 2005) and also presented findings at the Annual Meeting of the Geological Society of America in 2006 and 2007.

Leaders in Non−Point Source Water−Quality Monitoring

Dr. Brian Haggard, UA Biological and Agricultural Engineering (2006) published an article on the "Effect of Reduced Effluent Phosphorus Concentrations at the Illinois River, Northwest Arkansas" in the Journal of Environmental Quality, and a second paper along with Dr. Thomas Soerens, UA Civil Engineering (2006) on Sediment Phosphorus Release at a Small impoundment on the Illinois River, Arkansas and Oklahoma, USA as a direct result of funding provided through the USGS 104 B program. This extends the work of other researchers across campus who are monitoring nutrient loading in surface systems that enter our drinking water supplies resulting in increased algal production and associated bacterial related taste and odor problems within area reservoirs. Dr. Sonja Hausmann and her team are investigating the occurrence and distribution of bacteria in Beaver Lake and impoundment serving about 350,000 people in northwest Arkansas. They are focusing on the relationship between algal toxins including Geosmin and MIB and the dominant algal community causing these compounds to be released into the water.

Cutting Edge Research

Dr. Mary Savin, UA Crops, Soils and Environmental Sciences used 104 B funds to investigate antibiotic resistance in fecal indicator bacteria in the vicinity of municipal waste water discharge to streams. Understanding the occurrence and distribution of indicators of fecal contamination as recommended by U. S. EPA is essential to microbial source tracking and identification of public health risk. Additionally, to identify if streams receiving effluent from a point source are increasing in antibiotic resistance downstream from that point source will enable regulators to develop preventive strategies to protect water quality in streams receiving wastewater discharge. Their initial findings indicate that a portion of bacteria in the effluent were resistant to select antibiotics. The data provided by the seed grant provided through the USGS 104 B program will provide the basis for development of a larger research proposal to continue this critical area of research. Dr. Brian Haggard conducted separate but related research on the occurrence of antibiotics in select Ozark streams, looking specifically at the transport, degradation, and residence time of antibiotics below waster water treatment discharge points. Both areas of research will help us better understand anthropogenic impacts to aquatic ecosystems, and long−term sustainability under our current waste water treatment and discharge policies. Dr. Savin presented her initial findings in April 2008 at the AWRC Annual Water Resources Conference, and at the Annual Meeting South Central Branch American Society for Microbiology in 2007.

# Publications from Prior Years

1. 2005AR93G ("Arsenic Release and Mobilization in the Mississippi River Valley Alluvial Aquifer Related to Drinking Water Standards") − Articles in Refereed Scientific Journals − Sharif, M.U., R. K. Davis, K. F. Steele, B. Kim, P. Hays, T. M. Kresse, and J.A. Fazio, 2008, Inverse geochemical modeling of groundwater evolution with emphasis on arsenic in the Mississippi River Valley alluvial aquifer, Arkansas (USA). Journal of Hydrology, v. 350, Issue 1−2, pp. 41−55.
2. 2005AR93G ("Arsenic Release and Mobilization in the Mississippi River Valley Alluvial Aquifer Related to Drinking Water Standards") − Articles in Refereed Scientific Journals − Sharif, M.U., R. K. Davis, K. F. Steele, B. Kim, T. M. Kresse, P.D. Hays and J.A. Fazio, In Press, Distribution and Variability of Redox Zones as Control of Spatial Variability of Arsenic in the Mississippi River Valley Alluvial Aquifer, Southeastern Arkansas, USA. Journal of Contaminant Hydrology. Expected Publication Summer 2008.
3. 2006AR122B ("Sediment Characterization in Three Coves − Beaver Reservoir, Arkansas") − Dissertations − Patton, J.A., 2008, Comparative Sedimentation in Three Coves, Beaver Reservoir, Northwest Arkansas, Ph.D.) Dissertation, Environmental Dynamics, University of Arkansas, Fayetteville, AR, completed May 2008.
4. 2006AR122B ("Sediment Characterization in Three Coves − Beaver Reservoir, Arkansas") − Conference Proceedings − Patton, J.A. and Boss, S.K., 2007, Selected Trace and Major Element Concentrations of Beaver Lake Sediment Cores: Arkansas Water Resources Center Annual Conference, 24−25 April 2007, Fayetteville, AR.
5. 2006AR122B ("Sediment Characterization in Three Coves − Beaver Reservoir, Arkansas") − Conference Proceedings − Patton, J.A. and Boss, S.K., 2007, Differentiating Watershed−derived Sediments from a Drinking Water Treatment Residuals (DWTRs) Deposit: Geological Society of America Annual Meeting Abstracts with Programs, v.39.
6. 2006AR122B ("Sediment Characterization in Three Coves − Beaver Reservoir, Arkansas") − Conference Proceedings − Boss, S.K. and Patton, J.C., 2006, Sedimentation in Beaver Lake: An Ozark Mystery?: Arkansas Water Resources Center Annual Conference, 18 – 19 April 2006, University of Arkansas, Fayetteville, AR.
7. 1999AR ("Tagged Bacterial Tracers in Mantled Karst Aquifers") − Articles in Refereed Scientific Journals − Tiong−Ee Ting, Gregory J. Thoma , Robert R. Beitle Jr., Ralph K. Davis, Rugkiat Perkins, Khursheed Karim and Hui−Min Liu, 2008, A Simple Substrate Feeding Strategy using a pH Control Trigger in Fed−Batch Fermentation. Applied Biochemistry and Biotechnology 149:89–98.
8. 2003AR47B ("Antibiotic resistance and the relationship between enzyme activity and P in runoff from poultry litter amended soil") − Articles in Refereed Scientific Journals − Tomlinson, P. J., M. C. Savin, and P. A. Moore, Jr. 2008. Phosphatase activities in soil after repeated untreated and alum−treated poultry litter applications. Biol. Fertil. Soils 44:613−622.
9. 2006AR131B ("Occurrence and antibiotic resistance in fecal indicator bacteria upstream and downstream of wastewater treatment plants in northwest Arkansas") − Conference Proceedings − Akiyama T., and Savin, M. C. 2007. Antibiotic−resistant bacteria in a stream receiving wastewater treatment plant effluent. In Annual Meeting South Central Branch American Society for Microbiology, November 2−3, 2007, University of Arkansas at Little Rock, AR.
10. 2006AR131B ("Occurrence and antibiotic resistance in fecal indicator bacteria upstream and downstream of wastewater treatment plants in northwest Arkansas") − Conference Proceedings − Akiyama T., and Savin, M. C. 2008. Antibiotic−resistant Escherichia coli in a Northwest Arkansas stream receiving wastewater treatment plant effluent. [Online] In 108th General Meeting of Am. Soc. Microbiol., June 1−5, 2008. Available at http://www.abstractsonline.com/viewer/viewAbstractPrintFriendly.asp
11. 2006AR131B ("Occurrence and antibiotic resistance in fecal indicator bacteria upstream and downstream of wastewater treatment plants in northwest Arkansas") − Conference Proceedings −

Akiyama T., and Savin, M. C. 2008. Multi−drug resistant Escherichia coli in an effluent−driven stream. In Gamma Sigma Delta, The Honor Society of Agriculture, Arkansas Chapter Student Competition, February 25, 2008, University of Arkansas, Fayetteville, AR.

12. 2003AR50B ("Evaluating the Influence of Lake Francis on Phosphorus Concentrations and Transport at the Illinois River") − Articles in Refereed Scientific Journals − Haggard, B. and T. Soerens, 2006, Sediment phosphorus release at a small impoundment on the Illinois River, Arkansas and Oklahoma, USA, Ecological Engineering 28 (2006)280–287.