DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

July 2013

AWRC

Arkansas Water Resources Center Annual Technical Report FY 2012

104B funding provided by the U.S. Geological Survey through the National Institutes of Water Resources
MSC Publication 102.2012| Arkansas Water Resources Center

Arkansas Water Resources Center Annual Technical Report FY 2012

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This publication serves as the annual report to the U.S. Geological Survey regarding the projects and activities of the Arkansas Water Resources Center for FY 2012. This document provides summary information for each of the 104B projects funded: 1) Preparing drinking water utilities on Beaver Lake reservoir to meet disinfection byproduct regulations: The impact of continued nutrient enrichments; 2) Development and implementation of nutrient runoff reduction measures for poultry houses; and 3) The effect of global climate change on algal biomass and total organic carbon concentrations in Beaver Lake. This publication also summarizes the Arkansas Water Resources Center's information transfer program, student involvement, notable awards and achievements, and publications of previous 104B projects.

Keywords: Arkansas Water Resources Center, 104B Program Funding, Information Transfer, Water Quality

Introduction

The Arkansas Water Resources Center located at the University of Arkansas at Fayetteville, is part of the network of 54 water institutes established by the Water Resources Research Act of 1964. Since its formation, the Arkansas Water Resources Center (AWRC) program, in cooperation with the US Geological Survey and the National Institutes for Water Resources, has focused on helping local, state and federal agencies understand, manage and protect water resources within Arkansas. AWRC has contributed substantially to the understanding and management of water resources through scientific research and training of students. Center projects have focused on topics concerned with water quality of surface water and groundwater, especially non-point source pollution and sensitive ecosystems. AWRC helps organize research to ensure good water quality for Arkansas today and in the future.

The AWRC focuses its research on providing local, state and federal agencies with scientific data and information necessary to understand, manage, and protect water resources within Arkansas. AWRC cooperates closely with colleges, universities and other organizations in Arkansas to address the state's water and land-related issues, promote the dissemination and application of research results, and provide for the training of engineers and scientists in water resources. Each year, several research faculty participate in AWRC projects with the help of students who gain valuable experience doing environmentally related work across the state. AWRC research projects have studied irrigation and runoff, innovative domestic wastewater disposal systems, ground water modeling and land use mapping, erosion and pollution, water quality and ecosystem functions. The Center provides support to the sponsored water research by acting as a liaison between funding groups and the scientists, and then coordinates and administers grants once they are funded. Project management, reporting and water analyses are major areas of support offered to principal investigators. The AWRC has historically archived and will continue to archive reports of water resource studies funded by the 104B program or managed through the Center on its website.

In addition, the AWRC sponsors an annual water conference held in Fayetteville, Arkansas each spring, drawing over 100 researchers, students, agency personnel and interested citizens to hear about results of current research and hot topics in water resources throughout the state. Conference services and organization is an important service provided by the Center to organize specialty conferences and workshops, as well as information sessions on specific watersheds with local not-for-profit watershed groups. The AWRC also co-sponsors short courses and other water-related conferences in the state and across the region.

In addition, AWRC maintains a technical library containing over 900 titles, many of which are online. The Center staff are continuously updating the availability of reports on-line, which increases the distribution of historical research funded through the 104B program and managed by the water center. In addition, the University of Arkansas library also catalogues AWRC publications. This valuable resource is utilized by a variety of user groups including researchers, regulators, planners, lawyers and citizens.

The AWRC also maintains a modern water quality laboratory that provides water analyses for researchers, municipal facilities, and watershed stakeholders. Anyone, including farmers and other citizens can submit samples through the cooperative extension service. This laboratory is certified through the Arkansas Department of Environmental Quality for the analysis of surface and ground water.

The AWRC has a technical advisory committee made up of professionals from education institutions, environmental organizations, water supply districts, and government agencies throughout Arkansas. This committee has the opportunity to evaluate proposals submitted annually to the USGS 104B program, to recommend session topics included in the annual research conference, and to provide general advice to the AWRC Director and staff. The technical advisory committee is updated each year to find active members, which are interested in the Center's function and management of the 104B program.

Research Program Introduction

Each year, several researchers participate in 104B projects funded through the Arkansas Water Resources Center (AWRC), and these projects are completed with the help of students in water and environmentally related fields. The research projects funded through the AWRC have studied a broad range of environmental and water issues facing Arkansas, including irrigation and rainfall-runoff, innovated domestic wastewater disposal, groundwater modeling and land use mapping, erosion and nonpoint source pollution, water quality and ecosystem function. The AWRC has given priority to solid scientific research proposals submitted by the faculty to the 104B program; the intent has been to provide seed data to researchers such that larger proposals can be developed and submitted to extramural funding sources. The AWRC has funded several projects using 104B funding that have resulted in the award of extramural grants to continue the base research.

To formulate a research program relevant to state water issues, the Center works closely with state and federal agencies, and academic institutions. An advisory committee, composed of representatives from state and federal agencies, industry and academia, provides guidance for the Center. The technical advisory committee plays an important role in insuring that the water institute program (section 104) funds address current and regional issues. The priority research areas of the AWRC base program directly relate to the program objectives of the Water Resources Act, including research that fosters improvements in water supply, explores new water quality issues, and expands the understanding of water resources and water related phenomena.

In FY2012, the AWRC under the guidance of the technical advisory committee funded the following research projects: 1) "Preparing drinking water utilities on Beaver Lake reservoir to meet disinfection by product regulations: The impact of continued nutrient enrichments", Drs. Julian Fairey and Wen Zhang, University of Arkansas, Department of Civil Engineering, $32,000. 2) "Development and implementation of nutrient runoff reduction measures for poultry houses", Dr. Andrew Sharpley and Ms. Sheri Herron, University of Arkansas System Division of Agriculture, Department of Crop, Soil and Environmental Sciences, $21,000. 3) "The effect of global climate change on algal biomass and total organic carbon concentrations in Beaver Lake", Dr. Thad Scott, University of Arkansas System Division of Agriculture, Department of Crop, Soil and Environmental Sciences, $22,700.

Preparing drinking water utilities on Beaver Lake reservoir to meet disinfection byproduct regulations: The impact of continued nutrient enrichments

Basic Information

Title:	Preparing drinking water utilities on Beaver Lake reservoir to meet disinfection byproduct regulations: The impact of continued nutrient enrichments
Project Number:	2012AR355B
Start Date:	3/1/2012
End Date: Funding	2/28/2013
Source: Congressional	104B
District: Research	3rd Congressional District of Arkansas
Category: Focus	Water Quality
Category: Descriptors:	Water Quality, Nutrients, Toxic Substances
Principal Investigators:	
	Julian Fairey, Wen Zhang

Publications

There are no publications.

Arkansas Water Resources Center 104B Program Project – March 2012 through February 2013

Project Title: PREPARING DRINKING WATER UTILITIES ON BEAVER LAKE RESERVOIR TO MEET DISINFECTION BYPRODUCT REGULATIONS: THE IMPACT OF CONTINUED NUTRIENT ENRICHMENTS

Project Team: Julian L. Fairey, Department of Civil Engineering, University of Arkansas
Wen Zhang, Department of Civil Engineering, University of Arkansas

Interpretative Summary:
Beaver Lake water was enriched with primary nutrients, including inorganic carbon and phosphorus, to stimulate primary productivity. Enriched waters were chlorinated with free chlorine and disinfection byproducts (DBPs) were quantified. DBPs included the four trihalomethanes (THMs) and three haloacetonitriles (HANs). Results showed that phosphorus stimulated production of DBP precursors and exacerbated trichloromethane (increased 30 g/L on average) and dichloroacetonitrile (increased 11 g/L on average). Future experiments will evaluate DBP formation and control in waters enriched across a suite of phosphorus and nitrogen gradients.

Introduction:
Disinfection byproducts (DBPs) are formed by reactions between disinfectants (e.g., free chlorine) and dissolved organic matter (DOM), which is ubiquitous in lakes and rivers. DBPs ar e formed during chlorination of drinking water year-round, but on balance form at higher concentrations in the summer months when algal communities are more active. Continued nutrient enrichments of nitrogen (N) and phosphorus (P) are expected to increase primary productivity and shift the phytoplankton community composition to predominately cyanobacteria in both suspended and sessile growth, but these impacts on DOM properties and hence DBP formation and control remain largely unknown. The objective of this proposal is to determine the effects of nitrogen (N) and phosphorus (P) nutrient enrichments on Beaver Lake reservoir DOM quality and the subsequent impacts on DBP formation and control. The work plan consists of batch mesocosm nutrient-enrichment studies and DBP formation and control experiments. The results of this study will be of vital importance to the four DWTPs on Beaver Lake as they develop strategies to meet current and pending DBP regulations.

Methods:
Batch mesocosms were used to evaluate long-term impacts of continued nutrient enrichments of N and P, to be performed quarterly at the four DWTP intakes, again with emphasis on the growing season (May, July, August, September). Free chlorine (the predominant drinking water disinfectant in the US and worldwide) was selected as the primary disinfectant for this research project. DBP formation potential (DBPFP) tests with free chlorine were performed on the waters from the batch mesocosms in two modes: (1) before precursor removal processes (to maximize DBP formation and evaluate the impacts of algal biomass and phytoplankton community composition), and (2) after DBP-precursor removal processes. It is expected that trihalomethanes (THMs) and haloacetonitriles (HANs) will form year-round but at varying concentrations depending on the quantity and reactivity of the DOM.

Results:
One nutrient enrichment experiment was completed in spring 2013; a second experiment is ongoing and a third is planned for August 2013. Results for the completed study are presented in Figures

1 and 2. Figure 1 shows results for the four THMs as a function of CO_2 concentration in the cubicontainer headspace with no phosphorus and 100 g/L phosphorus. Regardless of the CO_2 concentration and phosphorus concentration, THMs were dominated by trichloromethane (TCM, 98-150 g/L), with detectable concentrations of dichlorobromomethane (DCBM, < 10 g/L), indicating the source waters were low in bromide. TCM formation was insensitive to the CO_2 concentration in the cubicontainer headspace, indicating that ambient CO_2 increases (550 ppm by 2050) may not exacerbate THM formation. However, phosphorus addition increased TCM by 30 g/L, on average, indicating continued P enrichment could increase formation of regulated DBPs.

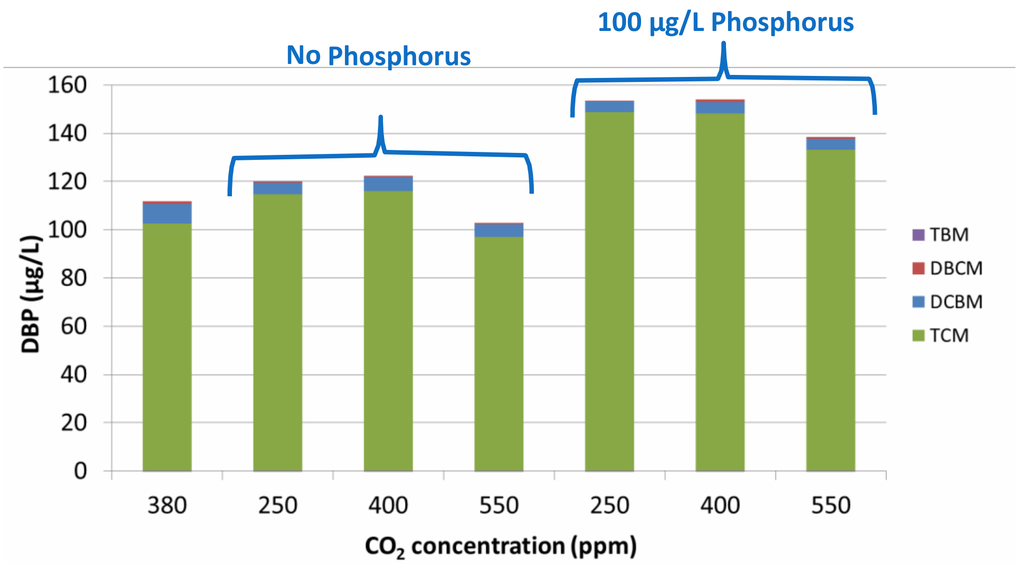


Figure 1. Disinfection byproduct concentrations for the four trihalomethanes – trichloromethane (TCM), dichlorobromomethane (DCBM), dibromochloromethane (DBCM), and tribromomethane (TBM) – as a function of CO_2 concentration in the cubicontainer headspace with no phosphorus and with 100 g/L phosphorus.

Figure 2 shows results for the three haloacetonitriles (HANs) as a function of CO_2 concentration in the cubicontainer headspace with no phosphorus and 100 g/L phosphorus. Regardless of the CO_2 concentration and phosphorus concentration, trichloroacetonitrile formed at concentrations between 5-7 g/L. Similar to the results with the THMS, HAN formation was insensitive to the CO_2 concentration in the cubicontainer headspace, indicating that ambient CO_2 increases (550 ppm by 2050). However, phosphorus addition increased dichloroacetonitrile (DCAN) formation from approximatel 5 g/L to 16 g/L, on average, indicating continued P enrichment could increase formation of non-regulated nitrogen-containing DBPs.

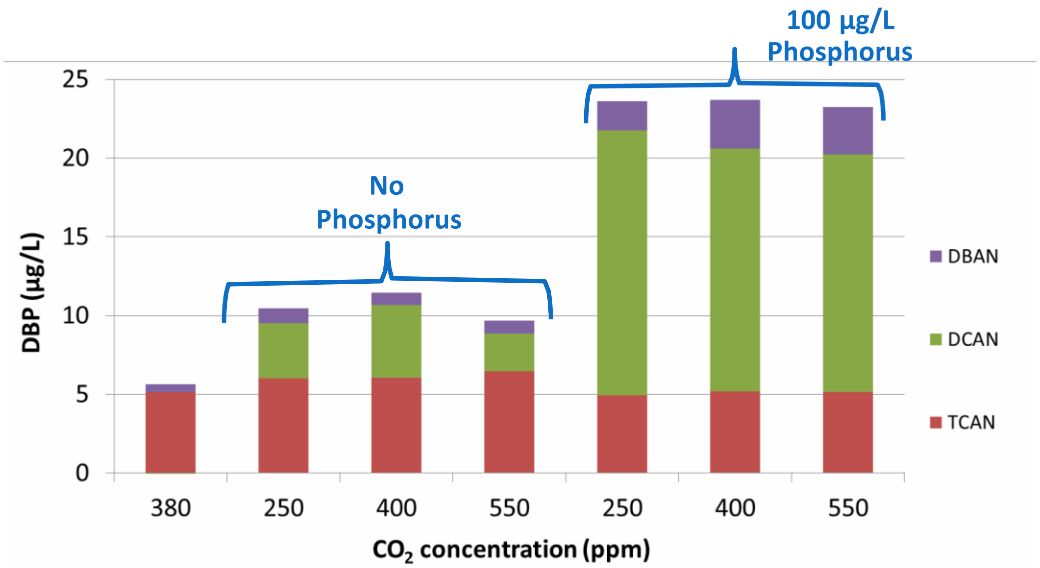


Figure 2. Disinfection byproduct concentrations for the three haloacetonitriles - dibromoacetonitrile (DBAN), dichloroacetonitrile (DCAN), and trichloroacetonitrile (TCAN) – as a function of CO_2 concentration in the cubicontainer headspace with no phosphorus and with 100 g/L phosphorus.

Conclusions: Results to date indicate that phosphorus enrichment of source waters could drive formation of THM and HAN precursors. Upcoming work will focus on gradients of primary phosphorus and nitrogen and evaluate subsequent DBP-control measures used at drinking water treatment plants.

References: None to date.

Thesis or Dissertation: None to date (Masters thesis expected August 2013).

Development and implementation of nutrient runoff reduction measures for poultry houses

Basic Information

Title:	Development and implementation of nutrient runoff reduction measures for poultry houses
Project Number:	2012AR336B
Start Date:	3/1/2012
End Date: Funding	2/28/2013
Source: Congressional	104B
District: Research	3rd Congressional District of Arkansas
Category: Focus	Water Quality
Category: Descriptors:	Agriculture, Nutrients, Water Quality
Principal Investigators:	
	Andrew Sharpley, David M. Miller

Publications

1. Herron, S., A.N. Sharpley, S. Watkins, and M. Daniels. 2012. Poultry litter management in the Illinois River Watershed of Arkansas and Oklahoma. Cooperative Extension Service, Division of Agriculture, University of Arkansas. Fact Sheet FSA 9535. 4 pages.

Arkansas Water Resources Center 104B Program Project – March 2012 through February 2013

Project Title: DEVELOPMENT AND IMPLEMENTATION OF NUTRIENT RUNOFF REDUCTION MEASURES FOR POULTRY HOUSES

Project Team: Sheri Herron, Department of Crop, Soil, and Environmental Sciences, Division of Agriculture, University of Arkansas, Fayetteville, AR 72701
Andrew Sharpley, Department of Crop, Soil, and Environmental Sciences, Division of Agriculture, University of Arkansas, Fayetteville, AR 72701
David Miller, Department of Crop, Soil, and Environmental Sciences, Division of Agriculture, University of Arkansas, Fayetteville, AR 72701
Susan Watkins, Center of Excellence for Poultry Science, Division of Agriculture, University of Arkansas, Fayetteville, AR 72701

Interpretative Summary:
This report documents progress on research to assess the potential for runoff from around poultry production areas to be enriched with phosphorus (P), what the sources of this P are, and measures that can be taken to minimize losses. Recent farm inspections by EPA has drawn attention to this issue and increased farmers' interest in developing solutions. Our results show that while the dust emitted from poultry house ventilation fans is enriched in P, it is a more soluble form than that in litter. However, by-products, locally-sourced from northwest Arkansas and previously landfilled, were found to strongly bind P and have the potential to greatly reduced P levels in runoff from poultry production facilities.

Introduction:
Arkansas is second only to Georgia in broiler poultry production (1.04 billion birds/year. The major proportion of this production is located in Northwest AR, with local (i.e., lawsuits with OK) and regional (i.e., Gulf of Mexico hypoxia) water quality issues, necessitating greater nutrient management and loss controls than in other areas. The generated poultry litter has been an invaluable source of nutrients and organic matter to area pastures for two decades. Historically, poultry litter has been land applied based on the nitrogen (N) requirements of the locally grown forage crops. This results in the application of up to four times more P than annual forage requirements, a consequent build-up of surface soil test P, and increased potential for P enrichment of runoff from pastures continually fertilized with poultry litter. In Arkansas, this has led to the designation of Nutrient Surplus Areas, which require nutrient management planning (NMP) prior to land applying any litter. The NMP process determines the risk of P loss from each field on a farm and recommends an appropriate litter application rate and Best Management Practices (BMPs) needed to minimize the risk of P loss. However, less attention has been given to nutrient loss in runoff from around the poultry production houses. The nutrients are deposited during cleanout or from ventilation fans. As a result, EPA is now looking to document the importance of this pathway and the potential need for regulations to limit stormwater runoff of nutrients. Nutrients are sorbed to particulate matter, which can exit poultry houses through ventilation fans and from the tires of skid steers tracking litter from the poultry house floor during cleanout. This dust is comprised of fine particulate portion of poultry litter and is a combination of feathers, fecal material, skin, spilled feed, mold spores, bacteria, fungus, and bedding fragments (e.g., rice hulls and wood shavings), which accumulates on the roofs of the houses and on the grassed areas below the fans. The litter that is tracked out is deposited on the concrete and gravel pads outside the house. During rainfall, particulates and nutrients can be carried away from these sources in runoff. Tracked litter differs from fan dust,

with higher moisture content and larger particulate matter. The higher moisture content of the top layer of litter, known as cake, causes it to adhere to tires and be easily tracked and is greatest during bird catching due to equipment moving in and out of the house.

This project will determine the extent to which nutrients (in particulate and dissolved forms) can be lost from around the poultry houses during rainfall-runoff and evaluate BMPs to mitigate these losses where appropriate. Specifically, the project will compare the capacity of locally sourced iron (Fe) and aluminum (Al) based by-product materials to sorb P either in fan dust or runoff from around the poultry houses. Additionally, the efficiency of other production area BMPs such as grassed filter areas, to decrease P loads in runoff, will be evaluated.

Methods:
Phosphorus sorption-desorption properties of several locally-sourced materials will be determined by equilibration with solutions of graduated P concentrations (0 - 200 mg P L^{-1}; as KH_2PO_4). The Langmuir equation will be used to obtain estimates of the P sorption maximum (P_{max}; g kg^{-1}). The locally sourced by-products tested are aluminum-based water treatment residual (WTR) from Beaver Water District, and iron filter cake (or red mud, RM) from Bekaert industrial plant, Rogers.

A channelized drainage swale between houses 2 and 3 is used for collection and treatment of runoff affected by fan dust, and tracked and spilled litter (see Map 1). Stormwater from this area flows to the grassed area in the center between the houses. Flow is then directed to a culvert running under a gravel road. An area velocity flow meter is installed in the culvert to measure runoff volume. Automatic samplers are installed at the culvert to collect runoff during each storm flow event. Samples are brought to the laboratory within 24 hours, filtered (<0.45μm), and stored at $4^{o}C$ until analysis of dissolved P and nitrate on filtered and total P, total N and suspended sediment on unfiltered runoff samples using standard EPA methods. Between houses 3 and 4 is another drainage swale that similarly flows to a culvert. This area will be used as a control, and a flow meter and automatic sampler will be installed in the culvert that captures flow impacted similarly to the area between houses 2 and 3.

Simulated rainfall – runoff, using National P Project protocols was applied to 4-1.5 m^2 plots adjacent to poultry house side vents, at 7 cm hr^{-1} until 30 min of runoff were collected. Runoff was analyzed for dissolved P, total P, nitrate, total N, and suspended solids.

Results:
Fan Dust and Poultry Litter Analysis
Analysis of poultry house fan dust shows a similar total P content to litter (about 17 g P kg^{-1}). However, the environmentally sensitive water extractable P (WEP) concentration of dust (7.0 g kg^{-1}) is greater than litter (3.0 g kg^{-1}), suggesting a potentially greater risk for P loss in surface runoff of equivalent amounts of fan dust and litter (Table 1). Studies in Kentucky show that one poultry house can emit greater than 750 kg of dust annually. This equates to about 7 kg P $year^{-1}$. In contrast, approximately 3,000 kg P are removed in litter from a poultry house (assuming an 18-month cleanout cycle). While these numbers show the amounts of P in dust are relatively small, two points need to be considered. Firstly, it has been difficult to cost-effectively control dust emissions from poultry houses without affecting in-house bird production, weight gains, and feed conversions. Secondly, EPA has been conducting on-site inspections of poultry farms in northwest Arkansas since early 2012. These inspections have focused on the area around poultry houses and to a large extent the dust emitted from house fans, mainly because it is visible during inspection.

Phosphorus Sorption Capacity of the Residual By-Product Materials

Phosphorus sorption isotherms were conducted for RM and WTR and given in Figure 1. The P sorption capacity, energy of P binding, and equilibrium P concentration of both by-products can be determined from a linearized version of this plot (Figure 2). The capacity of both by-products to sorb P from water is extremely large (109.9 and 23.8 g P kg-1 of RM and drinking WTR, respectively; Table 2) and for RM was about 200 times more than what is usually seen in soil (0.50 g P kg-1 soil; Table 2). In fact the RM has the capacity to hold more than 10% by weight of P. Also, this P is bound more tightly on by-products (particularly RM) than on soil. As a point of reference for binding energy of P, the lower this value (L mg-1; Table 2), the greater the energy with which P is bound or sorbed. Clearly, these two byproducts have the potential to sequester large amounts of P that might be in runoff water. The project is now evaluating and engineering the containment design of these by-products to efficiently remove P that may be transported in surface runoff from around production areas.

Phosphorus Transport in Rainfall – Runoff Simulation and Ditch Flow

Simulated rainfall was applied to the four 1.5 m^2 plots adjacent to each house side fan between flocks of birds. Dust accumulated on the plots, which were protected from natural rainfall during each flock, and rained on approximately every 8 weeks in 2012. The concentration of P in runoff varied with time of the year and the amount of time the fans were on during each flock. Averaged over the year, dissolved P in runoff immediately below the fans averaged 5.7 mg L^{-1} and total P 9.6 mg L^{-1} (Table 3). However, the concentration of P in runoff decreased from fan 1 to 4 over the year (9.2 and 4.4 mg L^{-1}, for plots 1 and 4, respectively), which is consistent with the fact that fan 1 (exhausting the part of the house where young birds are confined) would have birds for longer periods than fans 2, 3, 4 in decreasing order (Table 3).

By the time runoff from around all houses had reached the monitored ditches, concentrations were reduced to 2.0 mg L^{-1} dissolved P and 3.4 mg L^{-1} total P. Dilution of P-rich runoff that might occur near the fans was diluted by low P runoff from other areas and from the poultry house roofs.

Conclusions:

This study demonstrates the potential for dust emitted from poultry house fans during operation can enrich P in runoff from around the fans. However, by the time that runoff leaves the production area, in this study in a culvert under the house access road, P concentrations have decreased appreciably by dilution with low P runoff from the house roofs and other areas around the houses. While the dust contains no more P than the litter, from which much of it originates, more of the P is water soluble, increasing its potential for transport in runoff. Locally sourced by-products were found to have an extremely high capacity to sorb P, removing it from solution. The next phase of this research will evaluate how these materials can be deployed around poultry houses to minimize the potential transport of P from poultry production areas before it enters surface waters.

Table 1. Percent dry matter, total P, water extractable P (WEP), and total N of dust collected from poultry houses at three locations in northwest Arkansas and average values for litter as determined by the University of Arkansas Analytical Laboratory for 2010 through 2012.

	Dry matter, %	Total P, g kg^{-1}	Water ext. P, g kg^{-1}	Total P as WEP, %	Total N, g kg^{-1}
Dust					
Elkins	85.4	15.73	5.53	35.1	101.34
Lincoln	91.0	14.16	6.47	45.7	133.37
Savoy	87.3	17.23	7.53	43.7	81.27
Average	87.3	16.54	6.96	42.1	91.75
Litter	74.0	17.70	2.95	16.7	307.48

Table 2. P sorption properties of the residuals and an average soil.

	P sorption maximum g P kg^{-1}	Binding energy L mg^{-1}	EPC_0 mg L^{-1}
Red mud	109.9	0.00037	0.024
Water treatment residual	23.8	0.00180	0.024
Average soil	0.50	5.0	0.100

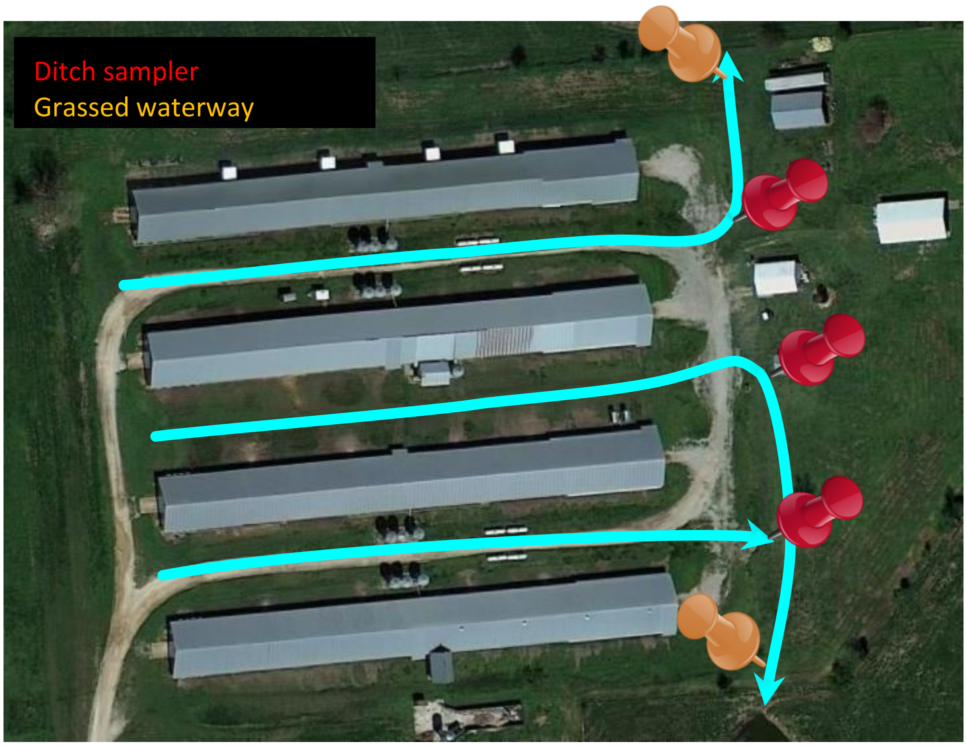
Table 3. Average P, N, and sediment concentrations of runoff from plots adjacent to the poultry house side vents and at culverts collecting runoff from of and around the houses (see Map 1).

	Dissolved P	Total P	Total Solids	Nitrate-N	Total N
	mg L^{-1}				
Plot 1	9.2	16.4	1403	43.4	74.8
Plot 2	4.7	8.8	1246	26.5	63.0
Plot 3	4.5	6.9	1393	49.4	100.9
Plot 4	4.4	6.3	882	18.9	55.5
Ditch 1	1.3	1.6	138	3.6	7.7
Ditch 2	2.8	5.2	244	6.2	10.8

Table 4. Best management practices to minimize nutrient runoff potential from poultry production facilities.

Type	Description	Action	Cost	Reduction potential
Prevent P Movement with Runoff	Roof gutters over fans	Minimizes direct runoff potential of ground immediately below fans	Low	Medium. Source still present.
	Filter Trays of residuals below fans	Binds P deposited in dust	Medium	High. P can be removed with residual.
	Larger concrete pads outside house entrance	Provides a larger area that can be scrapped clean of spillage after bird removal and house cleanout	Medium	High
Control / Reduce P Concentration in Runoff	Maintain grassed (non-grazed) waterways between houses and those directing runoff away from houses	May already exist and should be managed to maintain good grass cover	Low	Medium. Reduces runoff energy and erosive power. Uptakes and dilutes transported P.
	Aeration of land around houses	Decreases potential for runoff and may improve grass growth and cover	Low	Medium. Less runoff translates to less nutrient loss risk.
	Spread residual around houses	Binds P that may be in runoff but does not remove P from the system	Medium	Medium
Trap P in Runoff	Pond collecting house runoff	Collects nutrient rich runoff. Pond must be dredged and material used in a manner as to impair water quality	Low / high [1]	High

1 Costs are low if already exists otherwise medium or high.



Map 1. Location of poultry houses, ditch runoff, flow meters, and ISCO samplers at the Savoy farm site.

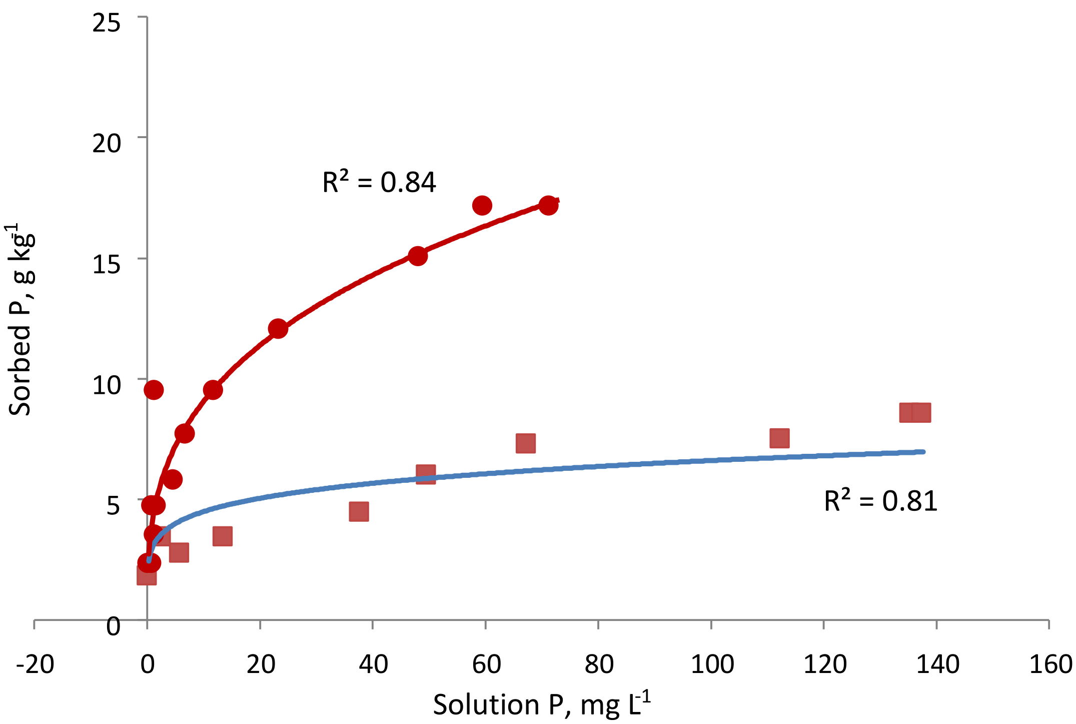
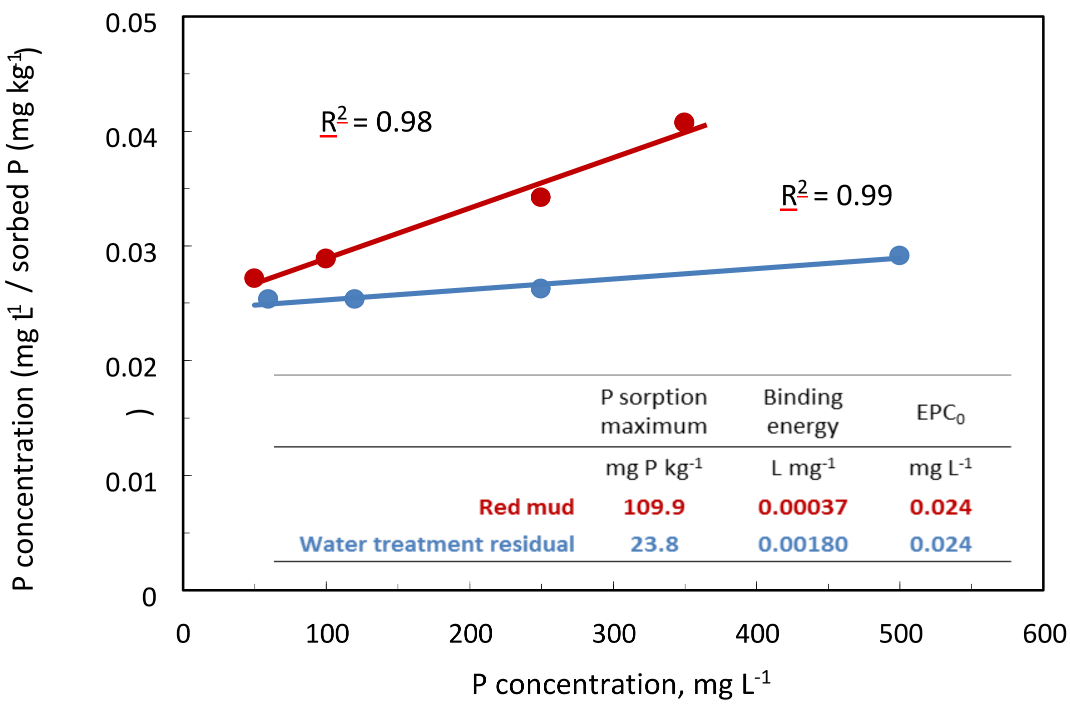


Figure 1. Phosphorus sorption isotherms for red mud and water treatment residuals.



	P sorption maximum	Binding energy	EPC_0
	mg P kg-1	L mg-1	mg L-1
Red mud	**109.9**	**0.00037**	**0.024**
Water treatment residual	**23.8**	**0.00180**	**0.024**

Figure 2. Linearized P-sorption isotherms for red mud and water treatment residuals.

The effect of global climate change on algal biomass and total organic carbon concentrations in Beaver Lake

Basic Information

Title:	The effect of global climate change on algal biomass and total organic carbon concentrations in Beaver Lake
Project Number:	2012AR337B
Start Date:	3/1/2012
End Date: Funding	2/28/2013
Source: Congressional	104B
District: Research	3rd Congressional District of Arkansas
Category: Focus	Water Quality
Category: Descriptors:	Treatment, Climatological Processes, Nutrients
Principal Investigators:	Jefferson Thad Scott

Publications

1. There are no publications.

Arkansas Water Resources Center 104B Program Project – March 2012 through February 2013

Project Title: THE EFFECT OF GLOBAL CLIMATE CHANGE ON ALGAL BIOASS AND TOTAL ORGANIC CARBON CONCENTRATIONS IN BEAVER LAKE

Project Team: Byron A .Winston, Crop, Soil, and Environmental Sciences, University of Arkansas,
Thad Scott, Crop, Soil, and Environmental Sciences, University of Arkansas

Interpretative Summary:
Climate change coupled with eutrophication could result in increased algal biomass in drinking water reservoirs and potentially enhance the production of disinfection by-products during the water purification process.

Introduction:
The Beaver Reservoir is the drinking water source for > 250,000 people in Northwest Arkansas and a major economic engine for the entire state. Therefore protecting water quality continues to be a top priority for Beaver Water District, the management authority for the reservoir. Climate change, in addition to the traditional impairers of water quality such as nutrients and sediments, has been predicted to severely deteriorate water quality by increasing nutrient supply, algal blooms and total organic carbon concentrations in lakes. However, few studies have examined these links. We designed an experiment to determine both long term trends of CO_2 in the water column and the effect of increased nutrients (phosphorus) and CO_2 concentration (expressed as pCO_2) on algal biomass measured as particulate carbon and chlorophyll a.

Methods:
Partial pressure of CO_2 over the long term (1986-2011) was modeled from pH and alkalinity data based on equations in Stumm and Morgan (1981). To determine the effect of increased phosphorus and pCO_2 a natural population of algae from Beaver Lake was grown in a semi continuous culture over a period of 13 days. The algae were grown at phosphorus (P) concentrations ranging from 0 – 100 µg/L P and at pCO_2 of 250, 400 and 550 µatm. On days 4, 7, 10 and 13 700 ml of the sample was harvested an analyzed for carbon, nitrogen, phosphorus and chlorophyll a concentration.

Results:
Long term pCO_2
Between 1986 and 2011 carbon dioxide partial pressures ranged from 2500 µatm to 300 µatm (Fig.1a, b). High values generally occurred in the fall, winter and spring with low values generally occurring in the summer. Summer pCO_2 were lower than modern day global pCO_2 average (dashed line Fig.1) of 380 µatm.

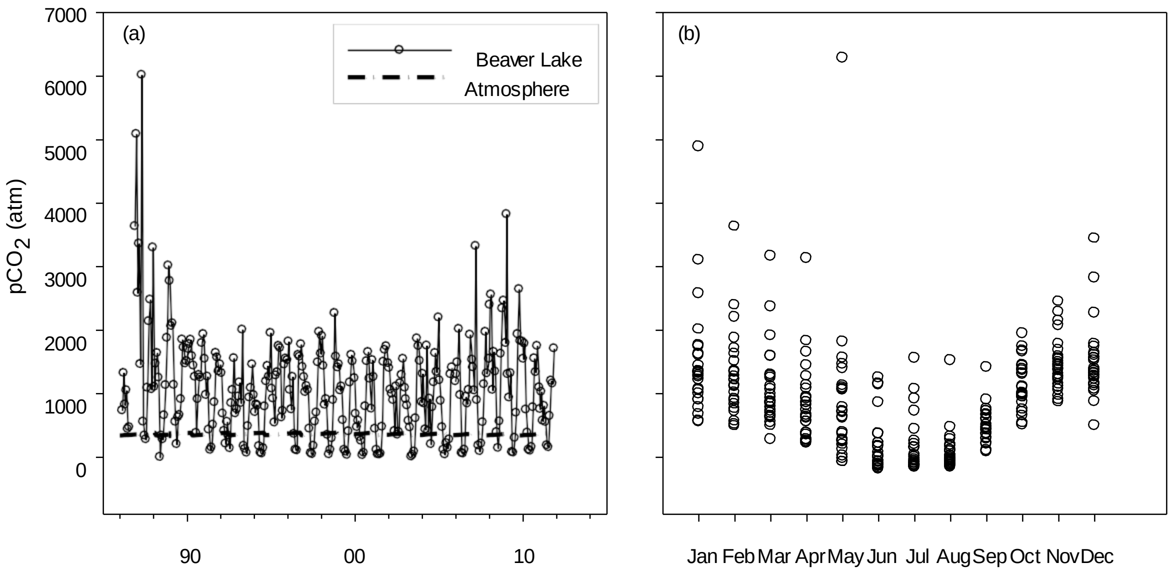


Fig.1. Modeled partial pressure of CO_2 (pCO_2) in Beaver Lake from 1986 – 2011. Values calculated from pH and alkalinity using equations of Stumm and Morgan 1981.

Particulate carbon (PC) and Chlorophyll a (Chl a)

Particulate carbon ranged from a low of 6 mg L-1 to a high value of 36 mg L-1 across all pCO2 treatments with the lowest PC in cubitainers that received no P treatments whereas highest PC occurred at P treatments of 100 µg L-1 (Fig. 2a). The greatest increases in PC generally occurred when P increased from 10 µg L-1 to 25 µg L-1 and from 25 µg L-1to 50 µg L-1. Doubling P approximately doubled PC (Fig. 2a). The doubling effect was not observed when P increased from 50 µg L-1 to 75 and 100 µg L-1 (Fig. 2a). PC was significantly correlated to P concentration irrespective of pCO2 level (Fig. 2b). Increased pCO2 had a small but measurable effect on PC concentration. For example, PC at 25 µg L-1 P and 250 µatm pCO2 was approximately 17 mg L-1 compared to 25 mg L-1 at 550 µatm pCO2 (Fig. 2).

Chlorophyll a concentrations ranged from 5 µg L-1 to 60 µg L-1 across all pCO2 levels (Fig. 3a). Similar to PC lowest chlorophyll a was measured in cubitainers receiving no P treatments whereas highest chlorophyll a occurred at P levels of a 100 µg L-1 (Fig. 3a). Chlorophyll a was positively correlated to P levels and increased significantly as P level increased (Fig. 3b). Increased pCO2 had small but measurable effects on chlorophyll a concentration. For example, chlorophyll a at 50 µg L-1 P and 250 µatm pCO2 was approximately 25 µg L-1 compared to 30 µg L-1 at 550 µatm pCO2.

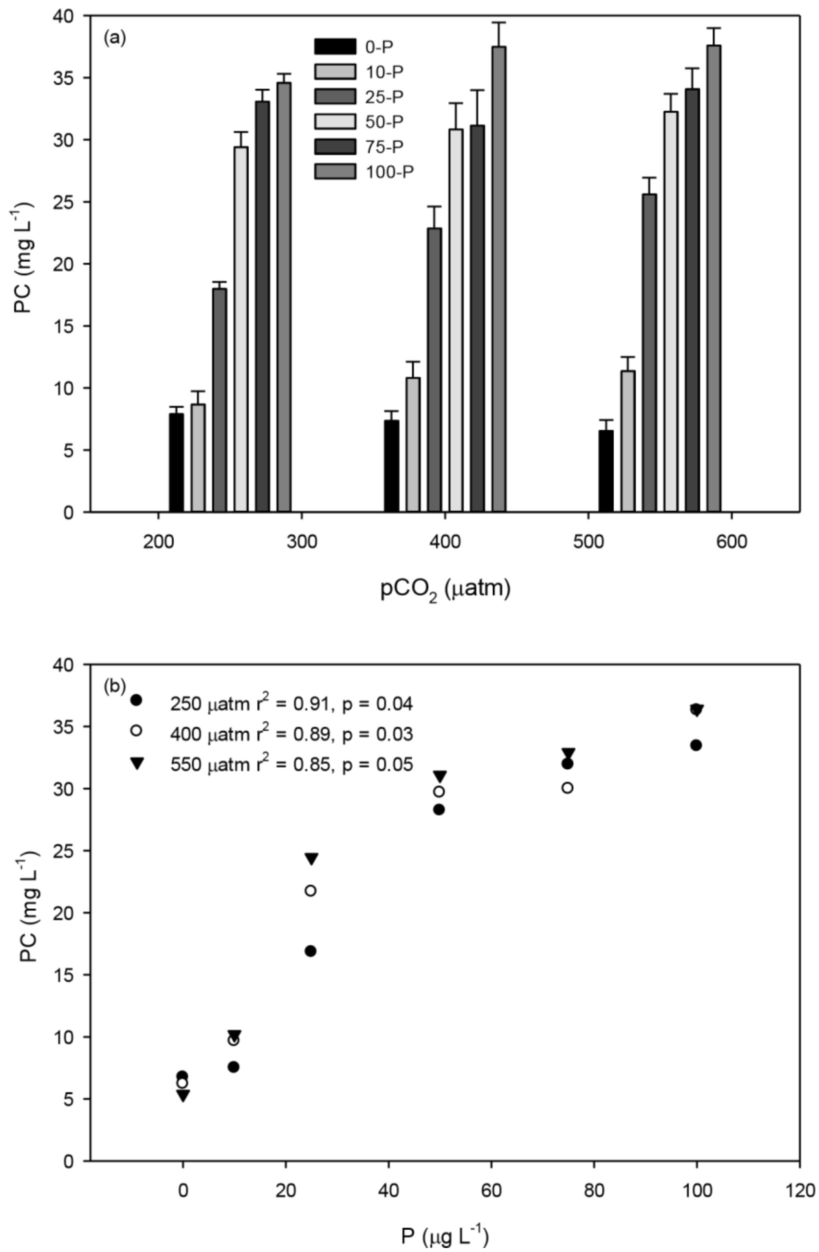


Fig. 2. Concentrations of particulate carbon (a) for algae grown at 250 µatm, 400 µatm and 550 µatm pCO_2 and at phosphorus (P) concentrations from (0 – 100 µg/L) and (b) linear regression between PC a and P concentration at various levels of pCO_2.

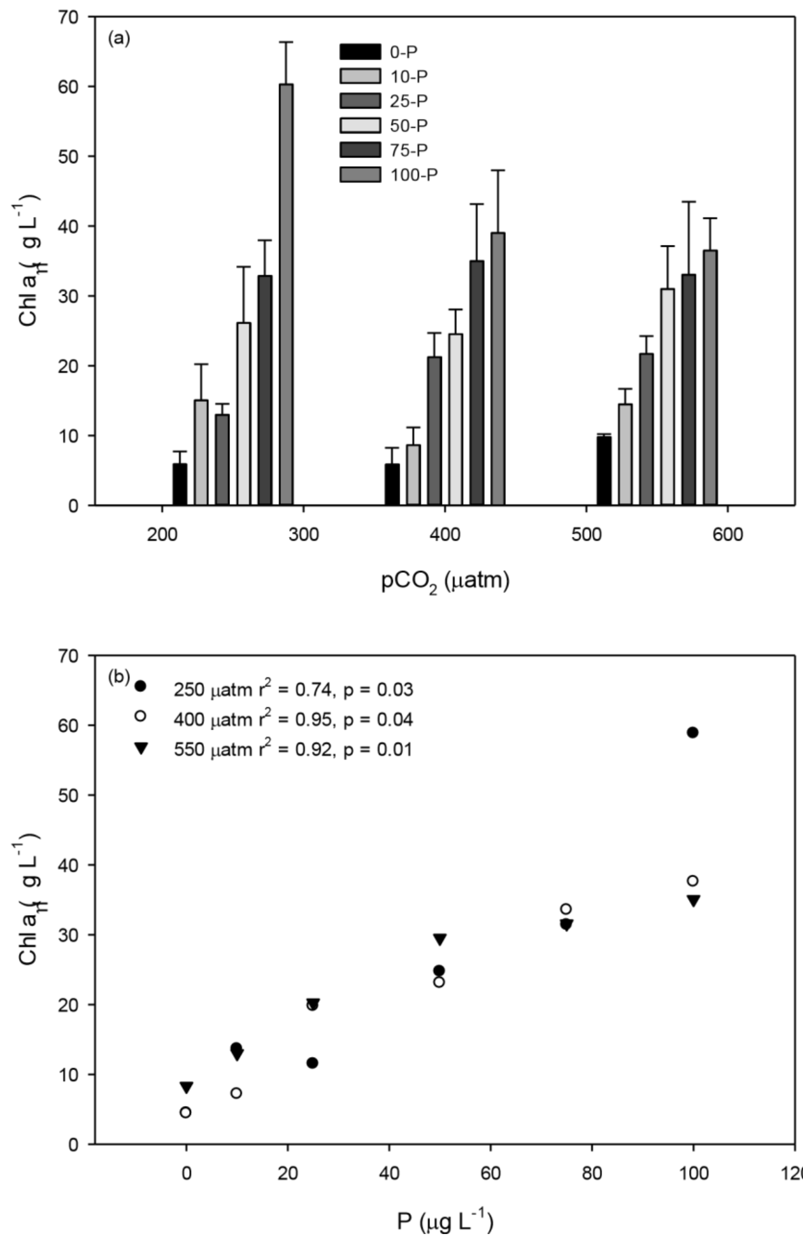


Fig. 3. Concentrations of Chl a (a) for algae grown at 250 µatm, 400 µatm and 550 µatm pCO_2 and at phosphorus (P) concentrations from (0 – 100 µg/L) and (b) linear regression between Chl a and P concentration at various levels of pCO_2.

Conclusions:

Preliminary analyses suggest that algal growth could potentially be limited by low CO_2 concentrations particular during the summer season. From a management perspective this could be beneficial since low CO_2 would serve as a natural regulator of the algal population and production of TOC. However, results from the algal growth experiments revealed that both particulate carbon (PC) and algal biomass will increase under conditions of increased pCO_2 and P concentrations. Increased algal biomass may increase water quality deterioration and place additional burdens on the water management.

Information Transfer Program Introduction

Dissemination of information is one of the main objectives of the Arkansas Water Resources Center (AWRC). AWRC sponsors an annual water conference held in Fayetteville, AR. The 2012 conference focused on the "State Water Planning Process and Reservoir Management". The conference drew approximately 130 researchers, students, agency personnel, and interested citizens from Arkansas and Oklahoma to hear about this topic and other research in water resources throughout the State. The AWRC worked closely with the consulting firm selected by the Arkansas Natural Resources Commission to revise and update the state water plan, allowing the project managers to give an overview of the process.

AWRC also co-sponsored workshops and other water related conferences in the state and region including the 24th Annual Conference of the National Agricultural Biotechnology Council in Fayetteville, AR, the 2012 Arkansas Environmental Education Association in Fayetteville, AR, the 2013 Arkansas Soil and Water Education Conference at Arkansas State University, and the 2013 National Institute of Water Resources Annual Meeting in Washington DC. The AWRC worked with the USGS Arkansas Water Science Center and the State Chapter of the American Water Resources Association to organize the 2012 Fayetteville Shale Symposium in Fort Smith, AR. This specialty conference addressed an emerging issue at the interaction of water resources and energy production, providing a holistic view of the subject from all perspectives.

The AWRC maintains a technical library containing over 900 titles, many of which are available online. This valuable resource is utilized by a variety of user groups including researchers, students, regulators, planners, lawyers and citizens. Many of the AWRC library holdings have been converted to electronic PDF format which can be accessed via the AWRC website at www.uark.edu/depts/publications.htm. AWRC is continuing to add archived documents from the library to this electronic data set, and all new titles are added when received.

AWRC maintains an active website which is updated at least quarterly (www.uark.edu/depts/awrc/). The website announces AWRC-related activities including conference announcements. The website is also home to the AWRC library listings, publications, and the AWRC Water Quality lab webpage. AWRC is also on facebook at http://www.facebook.com/pages/Arkansas-Water-Resources-Center/206554789388630. The AWRC facebook page has 83 likes and averages a weekly reach of 100 people.

Arkansas Water Resources Center Information Transfer Program

Basic Information

Title:	Arkansas Water Resources Center Information Transfer Program
Project Number:	2012AR333B
Start Date:	3/1/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	3rd Congressional District of Arkansas
Research Category:	Water Quality
Focus Category:	Education, Water Quality, Water Use
Descriptors:	
Principal Investigators:	Brian E. Haggard

Publications

1. Drake, W.M., Scott, J.T., Evans-White, M., Haggard, B.E., Sharpley, A.N., Rogers, C.W., and Grantz, E.M. 2012. The effect of periphyton stoichiometry and light on biological phosphorus immobilization and release in streams. 13:97-106
2. Haggard, B.E., Scott, J.T., and Patterson, S. 2012. Sediment phosphorus flux in an Oklahoma reservoir suggests reconsideration of watershed management planning. Lake and Reservoir Management 28(1):59-69.
3. Jarvie, H.P., Sharpley, A.N., Scott, J.T., Haggard, B.E., Bowes, M.J., and Massey, L.B. 2012. Within-river phosphorus retention: a missing piece in the watershed puzzle? Environmental Science and Technology 46:13284-13292.
4. Ludwig, A., Matlock, M., Haggard, B., and Chaubey, I. 2012. Periphyton nutrient limitation and maximum potential productivity in the Beaver Lake basin, United States. Journal of the American Water Resources Association 48(5):896-908.
5. Toland, D.C., Haggard, B.E., and Boyer, M.E. 2012. Evaluation of nutrient concentrations in runoff water from green roofs, conventional roofs, and urban streams. Transactions of the American Society of Agricultural and Biological Engineers 55(1):99-106.
6. Giovannetti, J., Massey, L., Haggard, B. and Morgan, B. 2013 Expanded Summary – Land use effects on stream nutrients at Beaver Lake Watershed, Northwest Arkansas. Journal American Water Works Association 105(1):31-32.
7. Giovannetti, J., Massey, L.B., Haggard, B.E., and R.A. Morgan. 2013. Research Article – Land use effects on stream nutrients at Beaver Lake Watershed, northwest Arkansas. Journal of the American Water Works Association 105(1):E1-E10.
8. Haggard, B.E., Scott, J.T., and S.D. Longing. 2013. Sestonic chlorophyll-a shows hierarchical structure and thresholds with nutrients across the Red River Basin, USA. Journal of Environmental Quality 42(2):437-445.
9. Jarvie, H.P., Sharpley, A.N., Withers, P.J.A., Scott, J.T., Haggard, B.E., and Neal, C. 2013. Phosphorus mitigation to control river eutrophication: murky waters, inconvenient truths, and 'post-normal' science. Journal of Environmental Quality 42(2):295-304.

10. Rogers, C.W., Sharpley, A.N., Haggard, B.E., and Scott, J.T. 2013. Phosphorus uptake and release from submerged sediments in a simulated stream channel inundated with a poultry litter source. Air, Water and Soil Pollution 224:1361 (9 pages).
11. Bailey, B.W., B.E. Haggard, and L.B. Massey. 2012. Water Quality Trends across Select 319 Monitoring Sites in Northwest Arkansas. Arkansas Water Resources Center, Fayetteville, Arkansas. MSC Publication 365. 50 pp.
12. Haggard, B.E., J.T. Scott, S.D. Longing, and J.T. Metrailer. 2012. Sestonic Chlorophyll-a and Nutrient Relationships across the Red River Basin, USA. Arkansas Water Resources Center, Fayetteville, Arkansas. MSC Publication 366. 15 pp.
13. Haggard, B.E. and J.T. Scott. Nutrient Criteria Development Mini-Workshops for USEPA Region VI States. Arkansas Water Resources Center, Fayetteville, Arkansas. MSC Publication 367. 38 pp.
14. Metrailer, J.T. 2012 Water quality trends and nutrient loads for the watershed research and education center in northwest Arkansas, 2009-2012. MS Thesis, Environmental Engineering Program, Biological and Agricultural Engineering Department, University of Arkansas, Fayetteville, Arkansas
15. Fohner, J.M. 2012. Nutrient dynamics in stormwater runoff from green roofs with varying substrate. MS Thesis, Environmental Science Program, Crop, Soil and Environmental Sciences, University of Arkansas Fayetteville, Arkansas.

Student Support

Category	Section 104B Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	23	0	0	3	26
Masters	8	0	0	2	10
Ph.D.	3	0	0	0	3
Post-Doctoral	1	0	0	0	1
Total	35	0	0	5	40

Notable Awards and Achievements

Dr. Julian Fairey received a Faculty Early Career Development, or CAREER, award from the National Science Foundation for $404,969 over five years. This will support his research to reengineer carbon nanotubes for enhanced adsorption of disinfection byproduct precursors. The 104B program provided research support to collect preliminary data for this project proposal.

Dr. Thad Scott, Assistant Professor of Environmental Water Science at the University of Arkansas, was awarded the 2012 NIWR Impact Award for his research on Denitrification, Internal Nitrogen Cycling, and Nitrogen Retention in River Impoundment Reservoirs.

Dr. Michelle Evans-White, associate professor in biological sciences at the University of Arkansas, was a 2013 NIWR Impact Award Great Plains Region Nominee.

Dr. Brian Haggard was chosen as the 2012 National Institute for Water Resources President-elect.

Dr. Brian Haggard was interviewed by KNWA on the effects of sequestration on the Arkansas Water Resources Center, in a larger piece on the University of Arkansas.

Dr. Brian Haggard was interviewed by KNWA and the Arkansas Democrat Gazette on the second statement of joint principles put forth by the states of Arkansas and Oklahoma, regarding water quality issues in the Illinois River.

Publications from Prior Years

1. 2011AR313B ("Continued Investigation of Land Use and Best Management Practices on the Strawberry River Watershed") - Articles in Refereed Scientific Journals - 1. Brueggen, T.R., Bouldin, J.L. 2012. Establishing baseline data in the subwatersheds of the Strawberry River, AR, prior to implementation of agricultural best management practices. Journal of Arkansas Academy of Science 66: 41-49.
2. 2011AR298B ("Sources and background levels of Mercury in Arkansas: A multi site paleolimnological approach") - Articles in Refereed Scientific Journals - 2. Prater, N.J.M., K.R. Brye, S. Dunn, T.S. Soerens, A.N. Sharpley, E.R. Mason, and E.E. Gbur. 2013. Effluent storage and biomat occurrence among septic system absorption field architectures in a Typic Fragiudult. Journal of Environmental Quality. In Press
3. 2012AR337B ("The effect of global climate change on algal biomass and total organic carbon concentrations in Beaver Lake") - Other Publications - 3. Grantz, E.M., A. Kogo, and J.T. Scott. 2012. Partitioning whole-lake denitrification using in situ dinitrogen gas accumulation and intact sediment core experiments. Limnology and Oceanography 57: 925-935
4. 2012AR337B ("The effect of global climate change on algal biomass and total organic carbon concentrations in Beaver Lake") - Other Publications - 4. Scott, J.T. and E.M. Grantz. 2013. N2 fixation exceeds internal nitrogen loading as a phytoplankton nutrient source in perpetually nitrogen-limited reservoirs. Freshwater Science. In-press.