Auburn University Environmental Institute
Annual Technical Report
FY 2007

Introduction

Alabama and the Southeast are entering a new era − an era of water scarcity. The days of endless supplies of reliable, clean water are drawing to a close throughout the world. Water consumption has been outpacing population growth at global to regional scales for the past two decades, leaving a large number of people without access to adequate supplies of fresh water. Concerns regarding shortages of potable water will, in all likelihood, supersede those for petroleum in the coming decade since there are alternatives for petroleum, but not for water.

Alabama citizens depend on safe and reliable water for consumption; sanitation; power generation; production of food, fiber, energy, and other products; transportation; manufacturing and industrial processes; sustaining aquatic and terrestrial ecosystems; recreation; and tourism. However, populations and per−capita water consumption have risen dramatically in many areas of the Southeast. As a result, across the state and region, we are facing critical and increasing water quality and water quantity issues.

The Alabama Water Resources Research Institute (AWRRI) is uniquely positioned to take a leadership role in navigating our region's increasingly complex interactions with water. The Institute is in a position to serve as the catalyst for developing new and innovative approaches to water resources issues, and for capitalizing on emerging water−based economic opportunities. This multidisciplinary institute involving researchers in forestry, agriculture, biological sciences, geology, geography, and engineering has the potential to create significant economic opportunities and to assist in maintaining quality, not only of water, but life, in Alabama. We are home to a powerful array of expertise that can be used singly or in combination to address and resolve the majority of water resources issues facing our state today. AWRRI researchers are developing both the technology and management practices necessary to increase the productivity of every gallon of water that flows into our state. Their foresight will serve to protect human health as well as the integrity of our freshwater sources, forests, wetlands, and coastal estuaries. We have the capabilities to take proactive measures to not only maintain but increase the availability of clean water in our state. Using an integrated approach, AWRRI will take a crucial leadership role in developing improved water resource management strategies. We are committed to bringing about critically important, visionary changes in water management and technology necessary to protect the future of our state, region, and nation.

Examples of the Alabama Water Resources Research Institute's ongoing research in the area of water resources are included in this report. Additional information about these research efforts can be obtained by contacting our office or on the Institute's website at: www.auei.auburn.edu.

Research Program Introduction

Estimating Regional and Local Scale Surface Moisture as an Indicator of Drought Using Thermal IR Remote Sensing

Basic Information

Title:	Estimating Regional and Local Scale Surface Moisture as an Indicator of Drought Using Thermal IR Remote Sensing
Project Number:	2007AL62B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	Third
Research Category:	Climate and Hydrologic Processes
Focus Category:	Hydrology, Climatological Processes, None
Descriptors:	
Principal Investigators:	Luke J. Marzen

Publication

1. None at present time.

ESTIMATING REGIONAL AND LOCAL SCALE SURFACE MOISTURE AS AN INDICATOR OF DROUGHT USING THERMAL IR REMOTE SENSING

by

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Project Synopsis

A. Statement of Problem and Research Objectives

Problem

It is estimated that on an annual basis drought conditions occur on average in 12% of the contiguous US and cost the nation $6-8 billion US dollars (Wilhite and Svodoba, 2000). In the state of Alabama drought has caused serious problems for farming communities for the past several years and most recently in the summer of 2006. These conditions place farming communities in difficult financial situations which also substantially affects other economic sectors within the state. The drought of 2000 is estimated to have cost the state over 360 million dollars of revenue and initial estimates of the 2006 drought in Alabama indicate similar impacts. The impact of drought in the southeastern United States is going to increase in magnitude as fresh water becomes increasingly scarce and as populations grow. Fortune magazine has stated that water will have similar economic impacts in the 21st century as oil did in the 20th century. Reliable and up to date information related to surface moisture conditions could be used to forecast crop yields, assess distressed areas for allocation of disaster relief funds, and could help resource managers and government officials plan ahead for difficult financial times.

Research Objectives

In this study, the ability to monitor surface moisture conditions with remote sensing was evaluated to estimate surface moisture in the humid southeast and semi-arid west for the period of 2000-2007. Initial results in the southeast indicate that LST provides the best indicator of surface moisture. Ongoing studies were

needed to validate the results from the initial study including testing the methods in different climates. In addition, we are evaluating the methods at a more localized scale by comparing Landsat derived LST products to localized soil moisture measurements with Alabama Mesonet data. Alabama A&M, which manages the Mesonet system, and maintains the data are partners in a consortium that Dr. Marzen co-directs with Dr. J.M, Wersinger called AlabamaView and we are using data provided by A&M in joint research.

The overall goal of this proposed project is continue to evaluate and validate methods to use remotely sensed data to estimate surface moisture conditions as an indication of drought. This information will ideally provide improved forecasting and prediction of drought conditions and will be useful to resource managers to monitor the need for water which will be increasingly important as water resources become scarcer. The following objectives and tasks are being completed to meet the overall goal:

1. Collect MODIS LST and NDVI data for 2000 to 2007 for the southeastern and western United States study areas and compare these data to corresponding Crop Moisture Index data in both study areas.

2. Collect cloud-free Landsat TM data from the AlabamaView website and produce LST derived from the thermal bands. These localized datasets will be compared to Alabama Mesonet measurements of soil moisture.

3. Continue to share NDVI and LST products produced by the graduate student with user communities on the AlabamaView website in a timely manner.

4. Provide undergraduate and graduate level training in the use of remote sensing and GIS for hydro-climatology and remote sensing research.

5. Assist undergraduate and graduate students in preparing paper/poster presentations of the results of the study at the 2007 and 2008 Alabama Water Resource Conferences.

B. Methodology

For this study, MOD11 (land surface temperatures and emissivity) and MOD13 (vegetation indices) data products are compared to corresponding weather station observations for 2 week periods in the growing seasons of 2000 – 2007. MOD11 provides 1 km 8 day composites of LST and MOD13 provides 1km 16 day composites of NDVI. An additional step was necessary to produce a composite LST image that is an average over a 16 day period. This is necessary to decrease the effects of cloud contaminated pixels in the shorter 8 day period and to match the data to the 16 day NDVI composites. It is important to evaluate temporal periods that match up with ground based indices and therefore this involved the compositing of daily NDVI and LST using multi-temporal stacks to

match the remotely sensed data with the ground based indices.

LST and NDVI values have been collected and are being compared to conventional ground based drought index values that are calculated from weather stations located within regional climate divisions. The Crop Moisture Index (CMI) and Palmer Drought Severity Index (PDSI) values were collected at the climate division level for the the southeastern study area included Alabama, Georgia, Florida, South Carolina, North Carolina, and Virginia. The western study area is still being collected and is part of the 2008 continuation.

The localized study is using the thermal bands from Landsat TM data. These data are processed for geometric and radiometric corrections by the USGS Eros Data Center and are made available for download free at the AlabamaView website. This website in part was founded as a result of the initial grant funded by this program which helped to secure ongoing federal funding from the USGS and AmericaView, Inc. A Landsat derived LST has been produced and is in the process of being compared to the Alabama Mesonet soil moisture datasets which are collected every two hours. A majority of the Mesonet sites that have soil moisture probes are located in Path 20 Row 36, and Path 21 Row 36 of Landsat's reference system. There currently are 17 Landsat images stretching from 2000-2006 with more to be added this year and next. The Alabama Mesonet currently consists of eleven combination meteorological/soil profile stations and twelve soil profile stations for a total of 23 stations. With the 23 stations and 17 images we are collecting several hundred observations of Landsat derived LST values and comparing these values to soil moisture measurements taken from the Mesonet stations within two hours of the time the satellite data were collected. The localized study analysis will be conducted in summer 2008.

C. Principal Findings

The analysis indicates that a moderate to strong negative relationship exists between satellite and ground observations of surface moisture conditions suggesting that as dryer conditions occur CMI decreases and LST increases. This analysis suggests that as vegetation dries out on the surface less evapotransporation occurs and temperatures tend to increase. When taking NDVI into consideration the results are not as strong. One of the objectives of the study was to investigate a longer time period than our original 2004 project in order to test whether the analysis and methods are consistent over time. The results were not as consistent as our initial study in which we had a negative correlation between LST and CMI in all cases so we are currently in the process of evaluating why this inconsistency occurred. We believe that the exact protocol of the initial study was not followed so we are currently repeating the analysis. We requested and received continuing funds for 2008 in which we will also investigate whether thermal observations can help predict crop yields.

Development of a Cost Effective Methodology for In−field Screen Testing of Water Quality

Basic Information

Title:	Development of a Cost Effective Methodology for In−field Screen Testing of Water Quality
Project Number:	2007AL63B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	Third
Research Category:	Engineering
Focus Category:	Surface Water, Water Quality, None
Descriptors:	
Principal Investigators:	Zhongyang Cheng, Yucheng Feng, Tung−shi Huang

Publication

1. Fu, L. L., S. Q. Li, K. W. Zhang, I. H. Chen, V. A. Petrenko, Z−Y Cheng, 2007, Magnetostrictive Microcantilever as an Advanced Transducer for Biosensor, Sensors 7, 2929−2941 (ISSN 1424−8220)
2. Cheng, Z. Y., Q. M. Zhang, 2008, Field Actuated EAPs, MRS Bulletin 3 (3), 183.
3. FU, L. L., S. Q. Li, K. W. Zhang, I. H. Chen, J. M. Barbaree, Z. Y. Cheng, 2008, Detection of Bacillus Anthracis Spores in Water Using Magnetostrictive Microcantilever Biosensors, submitted to Biosensors and Bioelectronics.
4. Li, S. Q., L. L. Fu, K. W. Zhang, J. M. Barbaree, Z. Y. Cheng, 2008, Resonance Behavior of Magnetostrictive Microcantilever and its Applications as a Biosensor, submitted to Analytical Chemistry.
5. Fu, L. L., S. Q. Li, K. W. Zhang, T. S. Huang, Z. Y. Cheng, 2008, In−situ Detection of Salmonella in Water Using Magnetostrictive Microcantilever Biosensors, submitted to Biosensors and Bioelectronics.

A Cost Effective Method for Monitoring Surface Water Quality in the Field by Detecting *Escherichia coli*

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May, 2008

Synopsis

Statement of the problem and research objectives

Water quality is a critical issue around the nation due to its direct influence on public health and the economic impact as was demonstrated by the Water Resources Research Act of 1984. After the September 11 attack, water quality also became an important issue for national security. In Alabama, many families use private wells as their primary water resource. The water from these wells should be tested periodically. Otherwise, these wells may become a threat to the health of Alabamians. Alabama is rich in surface water. The quality of surface water is the key to ensuring the quality of drinking water and the safety of Agriculture products, such as vegetables for salad. The data from water quality monitoring can also be used to determine sources of pollution, which would help the local farmers use the land more efficiently. Therefore, it would be highly desirable to monitor the quality of various waters in a real-time manner. In order to monitor water quality on regular bases by a broad range of officials and citizens, the device for monitoring water quality should be cost effective and easy to use.

Due to the importance of water quality and the complexity of the problem, the US EPA has implemented many technologies for monitoring the water quality. For example, the EPA recommends *E. coli*, which is the most common form of fecal coliform bacteria, as the best indicator of health quality standards and should be, therefore, monitored accordingly. However, all the technologies recommended by EPA are laboratory-based and require trained personnel. Meaning, the water samples have to be delivered to a laboratory from various test sites within 6 hours on ice. The analysis of the water sample includes a 24-hour incubation period, which makes the analysis a time consuming process. In order to test water quality in a real-time manner, it is believed that biosensors would be a strong candidate. Many types of biosensors have been developed or are currently under development. However, to date there is no biosensor/methodology suitable for in-field screening testing of water quality.

This project was, therefore, proposed to develop a cost-effective method for monitoring water quality in a real-time manner. The methodology is suitable for in-field screen testing. The device/system to be developed is easy to operate.

The research objectives designed for the project were:

1). Immobilize antibodies against *E. coli* and *Salmonella* onto the surface of sensors in size ranging from nanometer to micrometers. The process for immobilizing antibody onto the surface of MSPs has also been established and optimized using the sensors.

2). Determining the performance and specifications of the sensors fabricated in Objective 1. The results obtained from the sensors will be compared with the current technologies.

3). Building a prototype device based on the MSP-technology suitable for in-field screen testing of water quality.

4). Developing the method for in-field screening of water quality.

5). Training both graduate and undergraduate students.

6). Submitting proposals to federal agencies.

Description of methodology

Figure 1 is the schematic illustration of the operating principle of the sensors based on magnetostriction sensor platform, where the sensor is the wireless/remote actuating and sensing using magnetic field/signal.

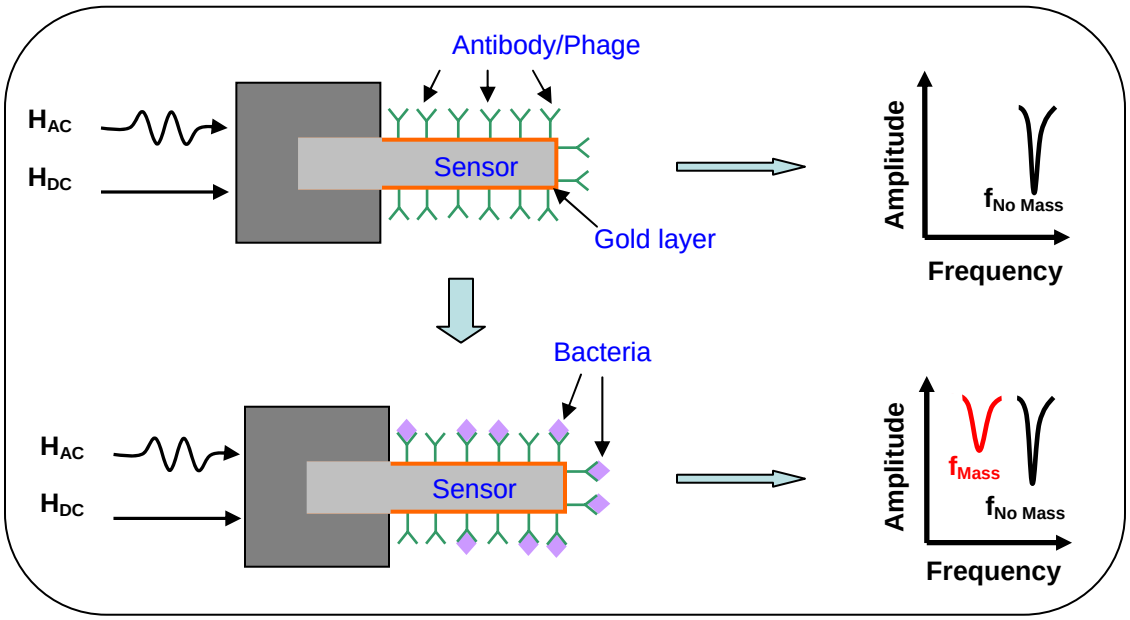

Figure 1. The schematic illustration of the operation principle of magnetostriction biosensors.

The method is based on the utilization of wireless sensor platform based on magnetostrictive materials. The advantage of the magnetostriction based sensor platform is: (1) the sensor is wireless so that there is no need for physical connections between the sensor(s) and the interrogation system; (2) the sensor provides a way to seek the target species in water sample, which is very critical for testing analyte with very low concentrations, such as the water samples for water quality tests. The sensor is a kind of acoustic-wave sensor. That is, the sensor is a mass sensor. When the target species are captured by the antibodies immobilized on its surface, the resonance frequency of the sensor would change. In the experiment, the resonance frequency of the sensor is continuously monitored so that the binding of the target species onto the sensor surface can be monitored. The resonance frequency of the sensor can be determined in seconds. Therefore, the sensor has a rapid response.

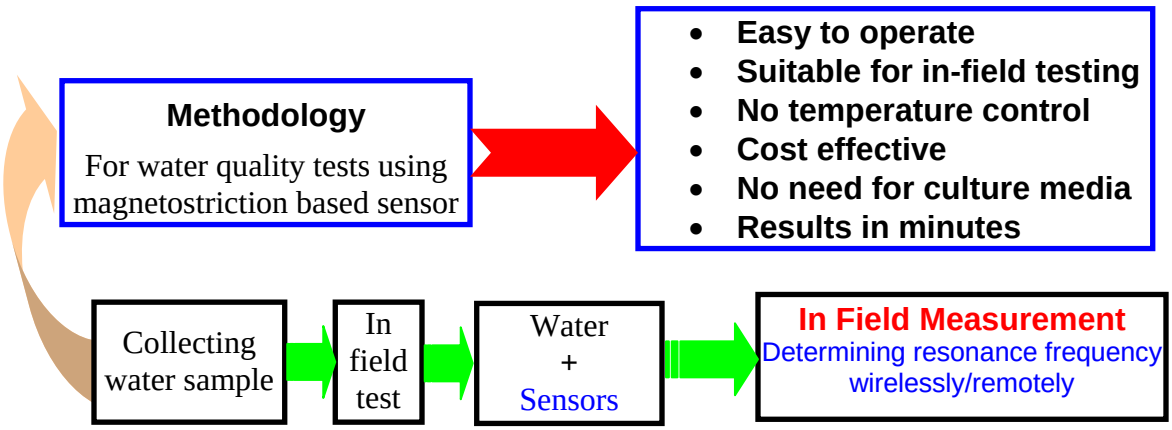

Figure 2. The procedural and the advantages of water quality test using magnetostriction based biosensor.

Principal findings and their significance

In this project, we have conducted a series of experiments. The followings are some principal findings and their significance.

(1). Immobilization of the bio-probe (antibody and phage) onto the sensor surface: We successfully immobilized the antibody against *E. coli* onto the gold coated sensor surface. The antibodies used in the experiments were special antibody designed for all *E. coli* strain. Therefore, this antibody is good for water quality test in which all strains of E. coli are used as biological index. This is the foundation of the development of magnetostriction based sensors for water quality applications. Phage against *Salmonella* was also successfully immobilized onto the sensor surface. In the method used to immobilize the antibody against *E. coli* is employing right now to immobilize the antibody against *Salmonella* onto the sensor surface.

(2). Test of magnetostrictive sensors in analyte with different concentrations: biosensors that are magnetostriction based sensor platform coated with a layer of antibody were tested in water that has *E. coli* with different concentrations. At the same time, the magnetostriction sensor coated with phage against *Salmonella* was also tested in *Salmonella* cultures with different concentrations. The test conditions used in these experiments have been studied. The optimized test condition was determined. These results are critical for the further development of the technology as a real device to be used for in-field water quality tests.

(3). Modification of the interrogation system: the interrogation system was modified to increase the signal/noise rate. A technical approach to significantly enhance the signal/noise rate was developed. The results are critical for the development of a handheld device.

An Integrated Dosing and Treatment System to Mitigate the Environmental and Health Threat From Conventional Onsite Septic Systems in the Alabama Black Belt Area

Basic Information

Title:	An Integrated Dosing and Treatment System to Mitigate the Environmental and Health Threat From Conventional Onsite Septic Systems in the Alabama Black Belt Area
Project Number:	2007AL64B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	Third
Research Category:	Engineering
Focus Category:	Management and Planning, Acid Deposition, Water Quality
Descriptors:	
Principal Investigators:	Mark P. Dougherty, John P. Fulton, C. Wesley Wood

Publication

1. He, Jiajie, Mark Dougherty, Willie Harper, Joey Shaw, Wes Wood, John Fulton, 2007, Soil Moisture Controlled Effluent Disposal by Subsurface Drip Irrigation in the Alabama Black Belt Soil Area, in The 28th Annual International Irrigation Show, The Irrigation Association, San Diego, CA., pages 136 − 146

Synopsis

Title: An integrated dosing and treatment system to mitigate the environmental and health threat from conventional onsite septic systems in the Alabama Black Belt area.

Funding period: March 1, 2007 - February 28, 2008

Investigators:
- Dr. Mark Dougherty, Assistant Professor, Auburn University, Biosystems Engineering, Auburn, AL
- Dr. Charles Wesley Wood, Professor, Auburn University, Agronomy and Soils, Auburn, AL
- Dr. John Fulton, Assistant Professor, Auburn University, Biosystems Engineering, Auburn, AL

Statement of the problem and research objectives

Conventional onsite septic systems have been widely used in the Alabama Black Belt soil area while the soils in this region are not suitable for this type of wastewater treatment method due to high clay content. This study tested the potential to use real-time drain field soil moisture content to control wastewater disposal through an SDI wastewater system so as to lower the environment impact from the wastewater and overcome several shortages of conventional onsite septic tank systems. This paper reports the results of a one-year field study on the proposed system at the Alabama Black Belt Research and Extension Station in Marion Junction, Alabama.

Explanation of the research methodology used

The field was chosen in the Alabama Black Belt Research and Extension Station in Marion Junction, Alabama. The testing soil is Vertisol (Houston clay). A 90'x 60' drain field was divided into two subplot treatments (synthetic wastewater application and clean well water application). Two capacitance soil moisture sensors were placed at 8" and 18" depth into the drain field to monitor real-time drain field soil moisture levels. The two sensors were wired into a data logger, which uses the readings to interrupt an independent irrigation controller. When either of the two sensors reads above 45% volumetric soil moisture content, the irrigation dosing system will be cut off. When either of the two sensors reads below 40% volumetric moisture content, the dosing system will be turned back on. Selected crops were alternated for summer and winter to increase water and nutrient uptake from the drain field. The system was previously tested with clean water from September 2006 to June 2007, and tested with synthetic wastewater from July 2007 until present for this report.

Principal findings and significance

Seasonal daily hydraulic dosing rates during summer were found to be four times higher than the state's recommendation. However, the system provides little or no dosing during normally wet winter season drain field saturation. Annual uptake rate of nitrogen and phosphorus is 44%, and 40%, respectively. Nitrate and phosphorus still present a potential for leaching loss, requiring further quantification of water and nutrient movement below the rooting zone. HYDRUS 2D modeling with field and field modified scenarios indicate that crop uptake is the main pathway for nutrients out of the drain field, while extensive precipitation is responsible for the majority of leaching.

Assessing the Effectiveness of Various Treatment Methods for Removing Endocrine Disrupting Compounds from Domestic Wastewater

Basic Information

Title:	Assessing the Effectiveness of Various Treatment Methods for Removing Endocrine Disrupting Compounds from Domestic Wastewater
Project Number:	2007AL65B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	Seven
Research Category:	Biological Sciences
Focus Category:	Surface Water, Water Quality, Treatment
Descriptors:	
Principal Investigators:	Robert A. Angus, Robert W. Peters

Publication

1. Poladia, N., R. W. Peters, and R. A. Angus, November 2007, Investigation of the Effectiveness of Various Treatment Methods to Remove Endocrine Disrupting Compounds from Wastewater, in 2007 Annual AIChE Meeting, Salt Lake City, UT.

Synopsis: Assessing The Effectiveness Of Various Treatment Methods For Removing Endocrine Disrupting Compounds From Domestic Wastewater

Robert Angus and Robert W. Peters

Problem and Research Objectives

In recent years, it has been determined that various synthetic and natural compounds can mimic, or interfere with the action of natural hormones and disrupt the endocrine systems of humans and wildlife. These substances, collectively referred to as endocrine-disrupting compounds (EDCs), have been linked to a variety of adverse effects in both humans and wildlife. Numerous EDCs, most of which act as estrogens, have been detected in various surface waters and ground waters.

A major source of estrogens in rivers appears to be treated wastewater effluent. Investigations worldwide have detected bioactive estrogens in waters receiving treated wastewater. Municipal wastewater is a complex mixture of natural and synthetic organic chemicals. The most powerful EDCs that are common in treated wastewater include the natural hormones 17β-estradiol (E2), its breakdown product, estrone (E1), and 17α-ethinylestradiol (EE2), the synthetic estrogen used in birth control pills. Other non-steroidal organic chemicals have been shown to possess estrogenic activity, but are much weaker than the steroid hormones. These include the degradation products of nonionic surfactants, such as alkylphenol-polyethoxylates, and plasticizers, such as bisphenol A.

Current technologies for treating municipal wastewater are only partially successful at removing EDCs. Steroid hormones are especially difficult to remove completely. They contain steroid rings that are resistant to degradation by the microorganisms used in wastewater treatment plants. Not only are steroids not efficiently removed from the waste during treatment but, those not removed are actually activated by the treatment. Steroids are excreted in human waste as biologically inactive glucuronide or sulfate conjugates, but are hydrolyzed back to the active native molecule by microbial activity in the treatment plant. As a result, both natural and synthetic estrogens and their degradation products tend to pass through wastewater treatment systems in bioactive forms and can reach concentrations in receiving waters sufficient to produce deleterious biological effects on organisms living in the waters.

Reports of EDCs in water have raised substantial concern among regulatory agencies as well as operators of wastewater treatment facilities and water purification plants. It is clear that current methods often fail to remove steroids efficiently. It would be of great benefit to the health and well being of aquatic organisms, as well as humans living downstream from wastewater treatment plants (WWTPs), if practical methods could be developed to increase the efficiency of removal of EDCs during the treatment of municipal wastewater. Treatment technologies, such as activated carbon and reverse osmosis appear to be capable of removal of many trace contaminants. However, they are costly to install and maintain. Research is needed to better understand the fate of these compounds during wastewater treatment, removal kinetics, and to develop less expensive treatment alternatives.

The research had two major objectives: (1) to investigate the effectiveness of various advanced oxidation process (AOP) techniques (used singly or in combination) in degrading the potent steroid EE2 in aqueous solution, and (2) analyzing water and sediments in rivers in the Birmingham area receiving treated wastewater to determine whether the estrogens are present in concentrations sufficient to disrupt endocrine systems of aquatic organisms in the receiving waters.

Methods

Advanced Oxidation Processes – Experiments were conducted using 1 L volumes of deionized water spiked with 1 μM 17α-ethinylestradiol (EE2, Steraloids, Inc., Newport, RI, USA). After treatment, 100 mL of the water was passed through a Varian Speck C18 10 mL column (35 mg sorbent). The columns were eluted with 5 mL HPLC grade methanol, dried under nitrogen gas, and reconstituted to a volume of 100 μL with HPLC grade methanol and subjected to HPLC analysis as described below.

Treatments are done for 5, 10, 15, and 20 minutes and consist of:

Sonication (1.4 kHz), H_2O_2 (1,000 ppm), UV (16 lamps, 5 W each), O_3 (100 ppm) and the following combinations: Sonication + H_2O_2, Sonication + O_3, Sonication + UV, UV + O_3, UV + H_2O_2, UV + O_3 + H_2O_2, and Sonication + UV + O_3 + H_2O_2.

Analysis of River Water Samples – Samples were taken from local rivers (Five Mile Creek, Cahaba River, Buck Creek) up- and downstream from wastewater treatment plants. Samples were collected in 2 L acid-washed glass jars with 15 mL of methanol added. They were immediately placed on ice and transported to the lab. In the lab, 1.0 L of each sample was passed through a series of filters (Whatman 52 [7 μm], followed by Whatman GF/A [1.6 μm], followed by Millipore RW0304700 [0.45 μm]) to remove particulates. The filtered water samples were then each passed through a Varian Bond Elut C18 solid phase extraction column (500 mg sorbent). The columns were eluted with 5 mL HPLC grade methanol, dried under nitrogen gas, and reconstituted to a volume of 100 μL with HPLC grade methanol and subjected to HPLC analysis as described below.

HPLC Analysis - For HPLC analysis, 10 μL of the reconstituted sample was injected into a Perkin-Elmer HPLC system. The column used was a Varian CP30705 Microsorb 100 C18, particle size 3 μm, 100 × 46 mm. Organic constituents of the sample were separated using a water:acetonitrile solvent gradient. The gradient started with a 1:1 water:acetonitrile mixture. The proportion of acetonitrile increased up to 100% in a linear fashion for a period of 20 min and then was held at 100% acetonitrile for a further 10 min. With this gradient, EE2 elutes from the column at about 6.2 min. Organic compounds eluting from the column were detected by UV absorbance at 225 nm.

Quantification of the amount of EE2 eluting from the HPLC column was done by comparison of the peak volume with that of a known sample containing 10 nmoles in 10 μL (1 mM solution). By passing a 1mM EE2 standard solution through a C18 column, extracting and reconstituting, as was done with all samples, it was determined that the process has a 78.5% extraction efficiency.

Findings

Advanced Oxidation Processes –

Preliminary results (Table 1) indicate that the AOPs, performed individually, are not very effective in breaking down EE2 within 20 minutes of treatment. However, combinations of treatments appear to be much more effective. As further data become available, we will model the degradation kinetics of the various treatments and compare them statistically.

Table 1. Preliminary treatment performance results.

Treatment	Mean ± std. error*
Control	6.92 ± 0.08
O_3	6.75 ± 0.23
Sonication	7.57 ± 0.02
O_3 + Sonication	6.16 ± 0.00

*nmoles per 10 μL sample after 20 min treatment.

Analysis of River Water Samples – Currently, samples have been collected from the Cahaba River and Buck Creek. Some of them appear, based on retention times, to have steroids in concentrations sufficient to affect aquatic organisms living in the rivers. Further analysis with mass spectrometry will be necessary to confirm the identities of the suspected steroids.

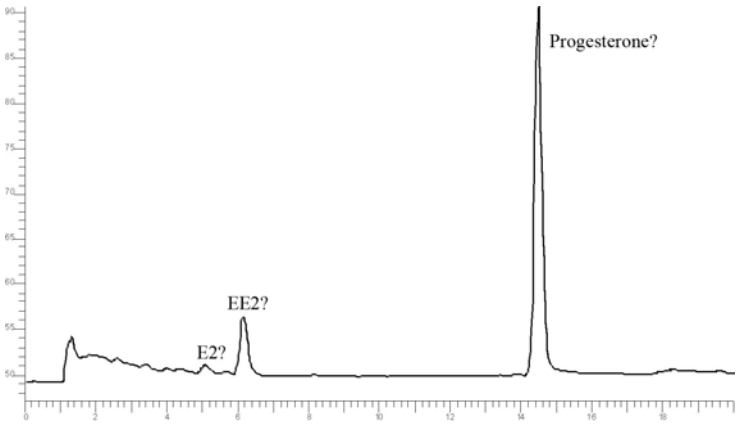

Figure 1. HPLC chromatogram of a sample of Cahaba River water collected downstream of the Riverchase WWTP in July, 2007. Peak identifications, based on retention times, are tentative. E2 = 17β-estradiol, EE2 = 17α-ethinylestradiol.

Although the project period is over, the project is not complete by any means. Numerous different AOP treatment combinations have been performed and await HPLC analysis. These will be done this summer by a graduate student in biology. Further river water samples will be collected and analyzed this summer as well. An updated report will be filed as these data are analyzed.

Information Transfer Program Introduction

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR−USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	7	0	0	0	7
Masters	4	0	0	0	4
Ph.D.	4	0	0	0	4
Post−Doc.	0	0	0	0	0
Total	15	0	0	0	15

Notable Awards and Achievements

This year we had a number of students that received recognition for their work associated with projects funded through this years program.

Two students from The University of Alabama at Birmingham presented posters at University's 2007 and 2008 Honors Expo. Both students are undergraduate students in the Department of Biology working with Dr. Robert Angus on his project "Assessing the Effectiveness of Various Treatment Methods for Removing Endocrine Disrupting Compounds from Domestic Wastewater". Titles of the posters were "Analysis of Estrogenic Activity Using Yeast Estrogen Screening (YES) presented by Jessica Edwards and "Screening Effluent of a Local Wastewater Treatment Plant for Estrogenic Compounds" presented by Patricia Jackson.

Graduate students in the Department of Materials Engineering at Auburn University received first and second place cash awards for their posters presented at the 21st Annual Alabama Water Resources Conference. The first place poster was "A Magnetostrictive Nanosensor for In−situ Microbial Monitoring" presented by K. W. Zhang. The second place poster was "Real−time Detection of Microbes Using Magnetostrictive Microcantilever Biosensors" presented by L. L. Fu.