Auburn University Environmental Institute
Annual Technical Report
FY 2005

Introduction

Although Alabama is a humid state with approximately 50 inches of annual rainfall, its distribution, rapid urbanization, and threats to water quality, cause important problems for assuring an adequate high quality water supply. Because infrastructure is constructed based on this level of rainfall and existing demands, seasonal shortages and unexpected levels of growth can impose important limits on the liklihood that water supply will meet demands. Flooding and drought are possible in the same year. Unfortunately, during the summer, water demands peak at the same time that supplies are at their lowest levels. there is no snow pack that in effect stores winter rainfall for use later in the year as occurs in much of the west. Urbanization typically takes place in coastal areas or rural areas that have difficulty with water supply infrastructure. Thus, Alabama and the Southeast are humid, but the challenges to water management are quite serious. This USGS supported research program is quite useful in facilitating innovative solutions that augment water users' ability to deal with these confounding issues.

Management and development of our State's water resources largely determine the quality of life for present and future Alabamians. Decisions are being made concerning inter-related water resources needs - municipal, environmental, recreational, and agricultural. Wastewater disposal; contaminant remediation; flood and drought management; recreation areas for fishing, boating, swimming; and fish/wildlife habitat present persistent, long term challenges for water resources managers and users in the State. However, current decision making is often based on use of outdated, pooly understood information and technology and limited opportunity for stakeholder input. In making the decisions concerning the management and development of our State's water resources, many factors (environmental, economic, and social) need to be taken into account.

The Alabama Water Resources Research Institute has established an effective partnership of state and federal agencies and water managers with higher education that uses newly developed knowledge about water science, engineering, and policy to meet the emerging challenges to protect, manage, and sustain the State's water resources as a vital asset. Through this partnership scientific based information is provided that allows those who establish regulations and set policies to meet the emerging challenges to protect those assets.

This report, with the descriptions of each of the research projects supported in the Institute's program this year, provides examples of the problems and the talent available to work on solutions for these problems. Not only do these projects target specific water problems, but they also mobilize expertise, in the form of both student and faculty, to address future water-related problems.

Partnerships play a vital role in building coalitions needed to keep the public informed of the value of earth science issues and ensure support for state and federal programs. Information management is the key to making objective science available in rich, creative, and meaningful ways. To get across what needs to be communicated to those who should know it requires a high degree of skill, tact, and sensitivity. We need to change a cultural mindset that has not previously recognized the importance of making science relevant, understandable, and even entertaining.

In an effort to meet these needs the AWRRI sponsors and annual water conference held in Orange Beach, Alabama each fall, drawing in approximately 175-200 researchers, students, state and federal agency personnel, and interested citizens to hear about results of research and topics in water resources throughout the state. The AWRRI also co-sponsors other conferences and workshops in the state related to water issues.

Research Program

Spatial Dynamics of Runoff-Contributing Areas for Effective Management of Phosphorus from Land-Applied Poultry Litter

Basic Information

Title:	Spatial Dynamics of Runoff-Contributing Areas for Effective Management of Phosphorus from Land-Applied Poultry Litter
Project Number:	2005AL36B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	Third
Research Category:	Water Quality
Focus Category:	Hydrology, Non Point Pollution, Agriculture
Descriptors:	
Principal Investigators:	Puneet Srivastava, Prabhakar T. Clement, Kyung Yoo

Publication

1. Sen, S.; P. Srivastave, K. Yoo, P. Clement, 2005, Hydrologically Active Areas for Effective Management of Phosphorus From Land-applied Poultry Litter in 2005 Annual Alabama Water Resources Conference Proceedings, Alabama Water Resources Research Institute, Auburn, AL.
2. Sen, S.; P. Srivastava, K. Yoo, J. Shaw, and M. Kang, 2006, Characterizing Hydrologically Active Areas for Effective Management of Phosphorus Loss in Surface Runoff in Annual International Meeting of the American Society of Agricultural and Biological Engineers, American Society of Agricultural and Biological Engineers, Portland, OR.

Project Synopsis
for the
Water Resources Research Institute Program
under
Section 104, Water Resources Research Act of 1984
to the
Alabama Water Resources Research Institute

Project Title

SPATIAL DYNAMICS OF RUNOFF-CONTRIBUTING AREAS FOR EFFECTIVE MANAGEMENT OF PHOSPHORUS FROM LAND-APPLIED POULTRY LITTER

by

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Statement of Problem and Research Objectives

Alabama's agricultural economy depends on poultry production. Confined poultry production, however, results in massive amounts of litter and associated phosphorus (P). Land application of litter to pastures, as a cheap alternative to commercial fertilizer, has resulted in excessive buildup of P in soils of major poultry producing counties (e.g., Cullman, Marshall, Dekalb, and Blount) of Alabama. While P is an essential nutrient for plant growth, runoff of P can accelerate eutrophication resulting in severe impairment of waterbodies that support aquatic, recreational and drinking water uses. Because of excessive buildup of P in soils and the resulting threat to our water quality, recent years have seen the development of a P-index in major poultry producing states of the country. Alabama's P-index suggests applying litter based on agronomic P requirement rather than agronomic nitrogen (N) requirement to those fields that have mid- or higher-field vulnerability ratings. Since poultry litter has a high P to N ratio, this recommendation has resulted in a great imbalance in the amount of poultry litter produced and the area available for litter application.

Current P management practices, however, treat an entire field as one homogeneous unit. The underlying assumption is that an entire field contributes to overland flow. Several studies have shown that overland flow is generated from well-defined and often identifiable portions of a watershed. Extrapolating based on the results of these studies, we contend that areas within those fields might be suitable for poultry litter application at a higher rate because probability of these areas generating runoff is extremely low. Through an intensively-instrumented field study we are identifying those areas (i.e., hydrologically active areas (HAAs)) in the Sand Mountain region of Alabama where major Poultry producing counties are located. Since the primary mechanism of P transport is overland flow, we believe that consideration of hydrologic controls and identification of HAAs are critical for effective management of P. Also, since most of the litter management occurs at a hillslope scale, understanding the hydrologic controls at that scale is fundamental to reducing water quality impacts. Specific objectives of our proposed research were to:

1. Delineate spatial and temporal distribution of HAAs and identify surface runoff generation mechanism (infiltration excess vs. saturation excess) using distributed sensors., and
2. Relate the spatial and temporal variability of HAAs and runoff generation mechanism to static and dynamic watershed hydrologic characteristics.

Methodology

The study is being conducted on a 0.3 ha hillslope at the Sand Mountain Research and Extension Station, DeKalb County, Alabama. The Sand Mountain Research and Extension Center is one of the outlying units of Alabama Agricultural Experiment Stations. The hillslope represents a typical pasture in the Sand Mountain Region of Northern Alabama. The site was extensively surveyed using a Real-Time Kinematic GPS unit to generate detailed topography data. The study is on a Hartsells soil (fine-loamy, siliceous, subactive, thermic Typic Hapludults). The Hartsells series consists of moderately deep, well-drained, moderately permeable soils that are formed of loamy material from acid sandstone containing thin strata of shale or siltstone. These soils are on nearly level to moderately steep ridges and upper slopes of hills and mountains. The hillslope was intensively instrumented using surface and subsurface sensors, rain gage, H-flume and shallow wells. In particular, surface and subsurface runoff sensors (Figure 1) at 27 points were installed. The surface runoff sensors are miniature v-notch weir made of 2-mm thick galvanized sheet metal with a sensor pin and ground pin set 2 cm apart and 3 cm away from the v-notch and located on the upslope side of the sensor. The subsurface sensors, installed up to 60 cm depth, record the fluctuation in water table near the surface. The subsurface and surface sensors are powered using 12-volt DC batteries. All sensors are connected to a series of multiplexers and dataloggers (model CR10X Campbell Scientific, Inc.). A tipping bucket rain gage measures the rainfall intensity at 5-min intervals. Two shallow water wells were installed to monitor the depth of water table. One well is located near the upslope end

Figure 1. Instrumented hillslope with surface and subsurface sensors (detailed view on the right), H-flume, rain gage, and shallow wells at the Sand Mountain Research and Extension Center, Crossville, Dekalb County, Alabama.

of the hillslope, while the other is located near the downslope end of the hillslope. The site was instrumented such that the hillslope drains to a point where an H-flume records the overland flow from the entire instrumented hillslope. All 27 surface and subsurface sensors were installed in pair to study the interaction between the water table and overland flow for the characterization of HAAs and runoff generation mechanisms.

Rain gage triggers surface and subsurface sensors and pressure transducers (in shallow wells and H-flume) and prompts data collection during rainfall event and two hours after rainfall event has seized. Rainfall, water table level, and occurrence of overland flow at surface and subsurface sensors are collected at 5-min interval. The data collection began in January 2006 and so far data for more than 5 rainfall events have been collected. Since we are still in the process of collecting data to meet our objectives, we present results from a rainfall event to demonstrate the kinds of data we are collecting. In addition, we describe our plan for relate the spatial and temporal variability of HAAs and runoff generation mechanism to static and dynamic watershed hydrologic characteristics. Even though the project period ended in April of 2006, we are continuing our project with support from other sources to meet our objectives.

Results

Figure 2 below shows an example of the kinds of data we are collecting. As an example, the figure shows a rainfall event that started at 11:30 PM on January 28, 2006 and continued for over 4 hrs. The top figure shows three distinct HAAs (detected by surface sensors) after 3 hr 20 min of rainfall; the subsurface sensors suggested that the water table was below the surface at that time. After 3 hr 35 min of rainfall, the mechanism of overland flow appears to have changed from infiltration excess flow to saturation excess overland flow at some HAAs. Note that the overland generated at these locations did not reach the outlet of the sub-watershed where an H-flume has been installed to estimate the amount of overland flow. The cumulative rainfall for this event was more than 0.5 in. The preliminary data collected for 5 storm events suggest that the mechanism of runoff generation at this site is mostly infiltration excess. Also, it appears that the HAAs start from the same locations for every storm event and expand depending on the characteristics of the rainfall event. Even though the Hartsells series soil, on which this watershed is located, is moderately deep and well-drained, it appears that there are locations within the hillslope where the hydraulic conductivity is low. This difference in hydraulic conductivity might be the reason that some areas on the hillslope generate infiltration access runoff where as other areas do not generate any runoff. We plan to confirm this observation by collecting soil hydraulic conductivity data using an air permeameter. In addition, we plan to use EM38 to characterize the spatial variability in soils characteristics. These two datasets together will help explain the reason for infiltration excess runoff from a few locations.

The approximate average depth of sandstone layer at the site is about 100 cm and the sandstone layer seems to be a bit porous. Because of this characteristic, it also appears that there is quite a bit of subsurface flow at the site. We plan to install moisture sensors and continue to collect data from this site for at least one and a half more years. In addition, we also plan to instrument another sub-watershed next to this watershed. Once sufficient field data has been collected, we will confirm these preliminary observations. If these preliminary observations are found to be true, the study would suggest that (1) the mechanism of runoff generation at Sand Mountain pastures are mostly infiltration excess, (2) the location of HAAs can be identified using air permeameter and EM38, and (3) subsurface flows are significant part of total flow out of a hillslope.

We will attempt to generalize the findings of the field data through HYDRUS 2D or 3D modeling and geostatistics (to meet objective 2 of this study). Also, once we understand the hydrologic and geomorphic characteristics of these two sub-watersheds, we will test various litter management prescriptions and determine a prescription that lets a farmer maximize the amount of applied-litter, while providing the best water quality protection possible. This kind of detailed data collection is crucial for science-based decision making and for increasing the acceptability of Federal and State regulations.

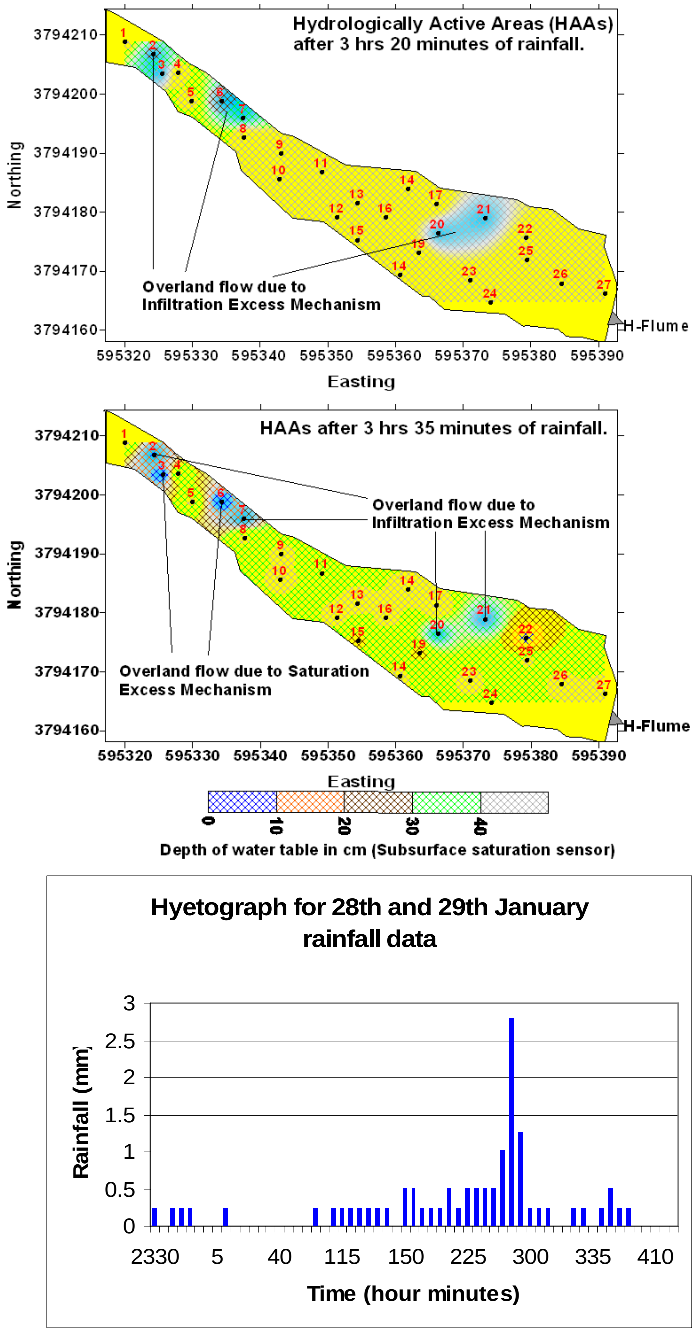

Figure 2. Hydrologically Active Areas (HAAs) as determined by surface and subsurface sensors in a sub-watershed located at the Sand Mountain Research and Extension Center, Crossville, DeKalb County, Alabama. The top and the middle figures were generated for two different times (3 hr 20 min and 3 hr 35 min) after the rainfall began. Note that both infiltration excess and saturation excess overland flow generation mechanisms appear to be present during this storm event.

Development and Application of an Innovative Nanotechnology for In-situ Remediation of Mercury-Contaminated Alabama Soils and Sediments

Basic Information

Title:	Development and Application of an Innovative Nanotechnology for In-situ Remediation of Mercury-Contaminated Alabama Soils and Sediments
Project Number:	2005AL37B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	Third
Research Category:	Engineering
Focus Category:	Non Point Pollution, Sediments, None
Descriptors:	
Principal Investigators:	Willie F. Harper, Mark O. Barnett, Dongye Zhao

Publication

1. Xiong, Z., D. Zhao, and M. Barnett, 2006, Immobilization of Mercury From Water and Soils by Stabilized Iron Sulfide Nanoparticles in American Chemistry Society National Meeting Proceedings, American Chemistry Society, San Francisco, CA

PROJECT SYNOPSIS

TITLE: *DEVELOPMENT AND APPLICATION OF AN INNOVATIVE NANOTECHNOLOGY FOR IN-INTU REMEDIATION OF Hg-CONTAMINATED ALABAMA SOILS AND SEDIMENTS*

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Problem statement and research objectives

Mercury (Hg) is one of the most pervasive and bio-accumulative contaminants. The annual anthropogenic Hg emitted in the U.S. totals 158 metric tons, of which ~33.3% are deposited in the homeland. In addition, the global reservoir adds ~35 tons of Hg annually to the U.S. territory. When mercury enters water and sediments, it can undergo a number of complex chemical and biological speciation and transformation processes, of which Hg methylation has been the primary environmental concern. Methylated mercury (or methylmercury, MeHg) can accumulate along the aquatic food chain, reaching its apex in predatory fish, where concentrations may be up to one million times higher than in the water column.

Triggered by the toxicity and bioaccumulation concerns, the U.S. Environmental Protection Agency (EPA) has identified Hg as one if its twelve priority persistent bio-accumulative toxins (PBTs). As of 2003, EPA, FDA (Food and Drug Administration) and 45 states have issued ~3089 fish consumption advisories, of which ~80% are, at least in part, associated with Hg poison. Because of the heavy Hg hit, 100% of the Gulf coast line is covered by the advisories. In recent years, Hg at concentrations 10-20 times higher than the safe level of 0.5 ppb was widely detected in various popular fish such as largemouth bass in the estuaries near the Mobile Bay. In response, the State of Alabama has issued a number of Hg advisories, which essentially banned the consumption of fish in 17 south Alabama streams or bays.

This research aims to develop an environmentally benign, cost-effective process for effective immobilization/containment of mercury in water and soils and inhibition/elimination of Hg methylation from affected Alabama sources. A novel class of metal sulfide nanoparticles (FeS and MnS) will be prepared, characterized for *in situ* immobilization of Hg in water and estuarine sediments. The specific objectives are to:

(1) Develop a new class of stabilized, highly dispersive metal sulfide (MeS) nanoparticles, which uses select low-cost and environmentally friendly polysaccharides such as starch and cellulose as a stabilizer;

(2) Test the long-term feasibility of applying the new metal sulfide nanoparticles to in situ immobilization of Hg in estuarine sediments and for inhibition of Hg methylation; and
(3) Develop an innovative technology based on the new nanoparticles for in situ remediation of Hg contaminated marine sediments.

Research Methodology

The research was carried out by executing the following five tasks:

Task 1: Synthesis of FeS nanoparticles. Task 1 is designed to test the hypothesis that FeS nanoparticles of desired physical-chemical characteristics (size, dispersibility, mobility and Hg reactivity) can be prepared with the aid of low cost and environmentally friendly starch or cellulose as a capping agent. The FeS nanoparticles were prepared with the following 3 steps.

Step 1. Prepare a dilute starch- or cellulose-Fe solution containing 0~0.5% (w/w) of a starch or cellulose and 0.1-1 M Fe^{2+} and adjust pH to 8-9.

⇓ ← System under vacuum and non-magnetic stirring

Step 2. Vary the stabilizer-to-Fe molar ratio and/or types of the stabilizer for preparing particles of desired size and dispersibility.

⇓ ← System under vacuum and non-magnetic stirring

Step 3. Add stoichiometric amounts of Na_2S solution into the above solution and allow for reaction for 20 minutes under vacuum and at room temperature.

Task 2: Physical characterization. The particle size distribution and surface area of FeS nanoparticles were characterized by TEM (Zeiss EM10 transmission electron microscope, Zeiss, Thornwood, NJ, operated at 25 and 40 kV) and DLS (Nicomp 380 Submicron Particle Sizer, PSS, Santa Barbara, CA, operated at a measurement angle of 90^o with Internal He-Ne laser, wavelength 633 nm).

Task 3: Batch equilibrium. Mercury removal by FeS nanoparticles in water solution was carried out with 25 ml Teflon vials. Removal of Hg^{2+} in water (50 µg/L Hg^{2+}) was tested at various concentrations of FeS (0.5~60 mg/L) nanoparticles.

Task 4: Soil mobility of nanoparticles. Nanoparticle solutions of 0.2 g/L FeS were passed through a glass column filled with a sandy soil under gravity. The soil column has a bed volume of 2.5 ml, a soil porosity of 0.37 and a pore volume of 0.93 ml. Total iron in the effluent was measured using an Atomic Adsorption Spectroscopy (Varian 220FS).

Task 5: Mercury immobilization. A clay loam sediment was loaded with 318 mg/g Hg^{2+}. Then the Hg-loaded sediment was treated with various concentrations of FeS (solid:suspension = 1g:20ml). A Toxicity Characteristic Leaching Procedure (TCLP) was used to test the leachability of the FeS-treated or untreated Hg-loaded sediments. Hg in water or TCLP liquid was analyzed following EPA method 245.1 (Cold Vapor AAS).

Principal findings and significance

The major findings are summarized as follows:

(1) The freshly prepared FeS nanoparticles were characterized with TEM and DLS. While the non-stabilized FeS particles appear as bulky dendritic flocs, the CMC-stabilized FeS appear as discrete nanoscale particles with a mean diameter of 45±20 nm (standard deviation) and a surface area of 28.4 m^2/g.
(2) The CMC-stabilized FeS nanoparticles can pass through a sandy soil column by gravity. Total iron measured in the effluent shows that stabilized FeS nanoparticles breakthrough occurred at 4.2 pore volumes. A comparison test indicated that non-stabilized FeS particles were completely intercepted at the top of the soil bed. The results imply that stabilized FeS nanoparticles can be used in an in-situ remediation/immobilization process by injecting the nanoparticle suspension in Hg-contaminated soil/sediment, solid waste or water/groundwater.
(3) The stabilized FeS nanoparticles remove efficiently mercury from water. The addition of ~10 mg/L starch-stabilized FeS can nearly completely remove/immobilize 48 μg/L Hg from water at neutral pH.
(4) The stabilized FeS nanoparticles can greatly reduce mercury leachability from Hg-contaminated soils. The experimental results indicate that treating Hg-laden sediment using 22.2 mg/L starch-capped FeS suspension can reduce the TCLP (Toxic Characteristic Leaching Procedure) leachability of Hg by over 95%. These observations strongly suggest that application of the FeS nanoparticles can substantially reduce the biological availability, hence methylation, of Hg in water and soils/sediments.

Detection of E. coli in Source Water Using a Novel Biosensor

Basic Information

Title:	Detection of E. coli in Source Water Using a Novel Biosensor
Project Number:	2005AL39B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	Third
Research Category:	Water Quality
Focus Category:	Surface Water, Management and Planning, Water Quality
Descriptors:	
Principal Investigators:	Zhongyang Cheng, Tung-shi Huang, Dongye Zhao

Publication

1. Li, Suiqiong; Lisa Orona, Zhimin Li, Z. Y. Cheng, 2006, Biosensor Based on Magnetostrictive Microcantilevers as Sensor Platform, Virtual Journal of Nonascle Science and Technology Applied Physics Letters 88, 073507.
2. Cheng, Z. Y., 2005, Applications of Smart Materials in the Development of High Performance Biosensors in Materials and Devices for Smart Systems, Materials Research Society, Boston, MA, Vol. 888, V10.6.1
3. Li, Suiqiong; Lisa Orona, Z. Y. Cheng, 2005, Electrosynthesis of Magnetostrictive Nanosensor Array in Nanoparticles and Nanostructures in Sensors and Catalysis, Materials Research Society, Boston, MA, Vol. 900E, 08.4.1

Final Project Report

Project Title: Development of a Cost Effective Methodology for in-field screening TEST of water quality

Sponsor: U. S. Geological Survey through the Alabama Water Resources Research Institute)

Duration: 03/01/2005 to 02/28/2006

PI: Zhongyang Cheng
Co-PIs: Tung-shi Huang and Dongye Zhao

Statement of the problem and research objectives

Continuously monitoring the quality of various waters is highly needed for safe drinking water practice and smart agriculture. The biological quality of water, which represents the presence and concentration of microorganisms in the water, is an important part of the task. The types of microorganisms in water can be a great number. Therefore, EPA recommends *E. coli*, which comes from human and animal wastes and is the most common form of fecal coliform, as the best indicator of health quality standards and are monitoring accordingly. By observing *E. coli* bacteria, the increase or decrease of many pathogenic bacteria can be estimated. Additionally, the presence of *E.coli* in a body of water may indicate that more harmful bacteria, viruses, or other microorganisms have contaminated that body of water.

In Alabama, there are families using private wells as their primary water resource. Therefore, a device, which can be used by individuals without training for monitoring the quality of the water from the well in a real-time manner, is highly desirable. Alabama is rich in source water, such as Lake Martin and many rivers/creeks. The quality of source water is the key to ensure the quality of drinking water. Therefore, monitoring the quality of source water would be very critical. Additionally, the data from water quality monitoring is very critical to determine the source of pollution and would help local farmers use the land more efficient. Therefore, an inexpensive biosensor/technology that is suitable for field testing is urgently needed for monitoring quality of source water in a real-time manner.

Due to the importance of water quality and the complexity of the problem, the EPA has implemented many technologies for monitoring water quality. However, all the technologies recommended by EPA are laboratory-based. That is, the water samples have to be delivered to a laboratory from the sources. The current EPA recommended technologies require the water samples to be delivered to a laboratory within 6 hours on ice. More importantly, the analysis of the water samples requires trained personnel and includes a 24-hour incubation period, which makes the analysis a time consuming process. In order to test the 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 under development. However, there is yet no biosensor suitable for in-field screening of water quality.

This project was designed to develop a new device/methodology of monitoring water quality by detecting the concentration of *E. coli* in the water in a real-time manner. The device to be developed is based on the magnetostrictive particle (MSP) technology recently developed by the Principal Investigator. The device is ideal for in-field screening.

Research Methodology

The methodology is based on the newly developed MSP (magnetostrictive particle) technology. The MSP technology is an acoustic wave device. The MSP is a wireless sensor platform with a sensitivity much better (100 times) than the state-of-the-art microcantilevers. More importantly, the MSPs work well in liquid including water. The MSP is coated with antibodies against *E. coli* on its surface. The antibody as a bio-probe captures the target bacteria, *E. coli*. The capture of target species onto the surface of MSP results in a change in the resonance frequency of the MSP. Therefore, by measuring the change in resonance frequency of the MSP, the number of bacterium cells captured on the MSP surface can be calculated. The resonance frequency of the MSP is continuously monitored wirelessly using magnetic signals. When the target species are bonded on to the antibody, which was immobilized on the MSP surface, the mass load of the MSP will change, which results in a change in resonance frequency. Therefore, the capture of target species by the MSP can be determined in a real-time manner. The target species captured by the MSP present the concentration of the bacteria in the water sample. More importantly, many MSP sensors can be employed at the same time and the capture of target species by one of many MSP sensors can be determined, which significantly enhance the apparent sensitivity of the MSP technology. Additionally, the MSP sensors in the water sample can be stirred using a magnetic field, which brings the sensor to target and therefore increases the possibility for the MPSs to capture the target species in the water sample. The performance of the MSP sensors was tested in air and water. The high performance of the MSP sensors was demonstrated in these experiments.

The objectives of the project are: 1) Immobilizing the antibody onto the surface of the MSPs and fabricating the MSP biosensor for detecting the *E. coli* bacteria in water. MSPs in lengths from 1000 to 50 μm and in thickness from 1 to 10 μm will be fabricated. The antibody against *E. coli*, which is commercially available, will be immobilized onto the surface of MSP as the receptor. Different techniques, such as Langmuir-Blodgett (L-B) technique and the direction physical adsorption, will be employed to immobilize the antibody. The optimum process for immobilizing the antibody onto the surface of the MSPs will be determined; 2) Building a prototype device based on the MSP-technology. All the sensors will be characterized under controlled laboratory conditions; 3) Determine the performance of the MSP sensor; 4) Improve the integating system to evaluate the feasibility of developing a handheld device and the methodology for in-field testing of water quality based on the MSP technology; 5) training students, and 6) submitting proposals for additional funding.

Research findings and their significance

The magnetostrictive thin film (amorphous FeB alloy) in a thickness from 10 μm down to 1μm was prepared using sputtering and electrochemical deposition. It was experimentally found that the FeB thin film exhibits a great magnetostrictive effect required for developing high performance biosensor based MSP technology. The MSPs in lengths from more than 1000 μm down to 50 μm were fabricated from the FeB thin film. The antibody against *E. coli* has been successfully immobilized onto the surface of the magnetostrictive thin film using the direction physical adsorption. All these achievements form a solid foundation for developing MSP biosensors for detecting *E. coli* in water samples. The specifications and performance of MSP sensors in lengths from 500 μm to 2000 μm have been determined. The results indicate that the MSP sensors have a greater performance than other sensors. The integation system was modified. A new system was built. The results demonstrated the feasibility to fabricate an integation system for the MSP sensors in a price range of a couple hundred dollars. All these results are consistent with our previous estimation. All these indicate that using the MSP technology as a cost-effective device can be developed for monitoring water quality in a real-time manner.

Continuing support is needed to combine all these achievements together to develop a real device for monitoring water quality.

Information Transfer Program

Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	2	0	0	0	2
Masters	1	0	0	0	1
Ph.D.	4	0	0	0	4
Post-Doc.	0	0	0	0	0
Total	7	0	0	0	7

Notable Awards and Achievements

Development of a low-cost device capable of detecting E.coli in water in a real time manner. Additional funding will be required to develope a marketable device. Patents are pending for the device and methodology.

A scientific understanding of the hydrologic and geomorphic characteristics of watersheds will allow for the development of management prescriptions and determine a prescription that will let farmers maximize the amount of applied-litter and still provide the best water quality protection possible.

Stabilized FeS nanoparticles can be used in an in-situ remediation/immobilization process. The application of FeS nanoparticles can substantially reduce the biological availability of Hg in water and soil/sediment.

Publications from Prior Projects

None