Louisiana Water Resources Research Institute
Annual Technical Report
FY 2003

Introduction

This report presents a description of the activities of the Louisiana Water Resources Research Institute for the period of March 1, 2003 to February 28, 2004 under the direction of Dr. John Pardue. The Louisiana Water Resources Research Institute (LWRRI) is unique among academic research institutions in the state because it is federally mandated to perform a statewide function of promoting research, education and services in water resources. The federal mandate recognizes the ubiquitous involvement of water in environmental and societal issues, and the need for a focal point for coordination.

As a member of the National Institutes of Water Resources, LWRRI is one of a network of 54 institutes nationwide initially authorized by Congress in 1964 and has been re-authorized through the Water Resources Research Act of 1984, as amended in 1996 by P.L. 104-147. Under the Act, the institutes are to:

"1) plan, conduct, or otherwise arrange for competent research that fosters, (A) the entry of new research scientists into water resources fields, (B) the training and education of future water scientists, engineers, and technicians, (C) the preliminary exploration of new ideas that address water problems or expand understanding of water and water-related phenomena, and (D) the dissemination of research results to water managers and the public.

2) cooperate closely with other colleges and universities in the State that have demonstrated capabilities for research, information dissemination and graduate training in order to develop a statewide program designed to resolve State and regional water and related land problems. Each institute shall also cooperate closely with other institutes and organizations in the region to increase the effectiveness of the institutes and for the purpose of promoting regional coordination."

The National Water Resources Institutes program establishes a broad mandate to pursue a comprehensive approach to water resource issues that are related to state and regional needs. Louisiana is the water state; no other state has so much of its cultural and economic life involved with water resource issues. The oil and gas industry, the chemical industry, port activities, tourism and fisheries are all dependent upon the existence of a deltaic landscape containing major rivers, extensive wetlands, numerous large shallow water bays, and large thick sequences of river sediments all adjacent to the Gulf of Mexico. Finally, many of the problems facing the state are derived from changes taking place in or affecting this delta landscape, including coastal erosion, landloss, sea level rise and climate change, hurricane flooding, run-off and riverine flooding, degradation of water quality and hypoxia.

The Institute is administratively housed in the College of Engineering and maintains working relationships with several research and teaching units at Louisiana State University. Recent cooperative research projects have been conducted with Center for Advanced Microstructures and Devices, the Louisiana State University Agricultural Center and the EPAs Hazardous Substance Research Center- South & Southwest.

Research Program

The primary goal of the Institute is to help prepare water professionals and policy makers in the State of Louisiana to meet present and future needs for reliable information concerning national, regional, and state water resources issues. The specific objectives of the Institute are to fund the development of critical water resources technology, to foster the training of students to be water resources scientists and engineers capable of solving present and future water resources problems, to disseminate research results and findings to the general public, and to provide technical assistance to governmental and industrial personnel and the citizens of Louisiana.

The priority research areas for the Institute in FY 2003 focus on a selected research theme. Because of the small nature of the projects, it was apparent that a greater impact is possible if a thematic area is chosen to focus several complimentary research groups on a single issue. Several themes were considered. At the State level, greater emphasis was being placed on pollutant transport issues. In particular these issues focused on characterizing particulates for heavy metals in aquatic systems using non-invasive spectroscopy and tomography. Projects selected were from a range of faculty with different academic backgrounds including agricultural engineers, environmental engineers and water resources. Supporting research in this priority area has increased the visibility of the Institute within the State.

The research projects are designated as Projects LA-17B, LA-18B, and LA-19B, as listed below.

Project 2003LA17B Willson, Use of Synchrotron Microtomography an X-Ray Fluorescence to Better Understand Contaminant Diffusion in Reactive Barrier Systems

Project 2003LA18B Roy, Metal Speciation in Particulates in the Mississippi River in Louisiana

Project 2003LA19B Paudel, Economic Assessments of Best Management Practices and Environmental Policy Options for Attaining the Total Maximum Daily Load (TMDL) Goal in Louisianas Major Milkshed

These projects include 2 new projects in the areas of characterizing particulates for heavy metals in aquatic systems using non-invasive spectroscopy and tomography. One of the projects (2003LA19) has direct impact on non-point source pollution and mitigation problems associated with the TMDL regulatory issues.

Use of Synchrotron Microtomography and X-Ray Fluorescence to Better Understand Contaminant Diffusion in Reactive Barrier Systems

Basic Information

Title:	Use of Synchrotron Microtomography and X-Ray Fluorescence to Better Understand Contaminant Diffusion in Reactive Barrier Systems
Project Number:	2003LA17B
Start Date:	3/1/2003
End Date:	2/29/2004
Funding Source:	104B
Congressional District:	6
Research Category:	Ground-water Flow and Transport
Focus Category:	Sediments, Solute Transport, None
Descriptors:	Reactive Flow and Transport, Contaminated Sediments
Principal Investigators:	Clinton S. Willson

Publication

1. Rahman, A., S. Hartano, D. Carlson, and C. Willson, 2003, Incorporating Uncertainty into High-Resolution Groundwater Supply Models, in Proceedings of the Probabilistic Approaches & Groundwater Modeling Symposium held during the World Water and Environmental Resources Congress in Philadelphia, Pennsylvania, June 24-26, 2003, edited by Srikanta Mishra, ASCE Pub.
2. Brown, G.E., S. R. Sutton, J.R. Bargar, D.K. Shuh, W.A. Bassett, P. M. Bertsch, J. Bisognano, W.F. Bleam, D.L. Clark, P. De Stasio, S.E. Fendorf, P.A. Fenter, E. Fontes, J. Hormes, K.M. Kemner, S.C.B. Myneni, P.A. ODay., K.H. Pecher, R.J. Reeder, A. Roy, S.J. Traina, C.S. Willson, and J.M. Zachara, 2003, Molecular Environmental Science: An Assessment of Research Accomplishments and Needs, EnviroSync Molecular Environmental Science White Paper, SLAC-R-704, Stanford University, Stanford, CA 94309, 66pp.
3. Hanson, B. C., C.S. Willson, R. Milner, D. Carlson, A. Rahman, and S. Hartano, 2003. Annual Report, Evaluation of Aquifer Capacity to Sustain Short-, Long-Term Ground Water Withdrawal From Point Sources in the Chicot Aquifer for Southwest Louisiana. Water Resources Division, Louisiana Department of Transportation and Development, June 2003.

SYNOPSIS

Title Use of Synchrotron Microtomography and X-Ray Fluorescence to Better Understand Contaminant Diffusion in Reactive Barrier Systems

Problem and Research Objectives

Sediment contamination can occur as a result from the deposition of pollutants from the water column, deposition of contaminated particles, or through the seepage of contaminated groundwater. Unless removed or "controlled", contaminated sediments act as a continual source of pollutants to surface water bodies. This contamination may impact aquatic species and potentially render the water bodies unusable for recreation and/or drinking water supply.

This project will be among the first studies to non-destructively provide both spatial and temporal data on the migration of contaminants in porous media along with associated changes in the pore morphology. Contaminant concentration profiles will be quantified over time at the elemental level using X-ray fluorescence techniques. X-ray microtomography will be used to obtain high-resolution three-dimensional images of the pore structure. These images can be used to quantify the changes in pore morphology (e.g., tortuosity, porosity, etc…) over time due to physical and/or chemical processes. These data will allow for a better understanding of the pore-scale processes impacting the migration of contaminants in reactive barrier systems and for the validation or development of predictive models used to design capping systems.

Methodology

X-ray Fluorescence (XRF): Basic XRF has become a well-established multi-element technique, capable of yielding accurate quantitative information on the elemental composition of a variety of materials. The technique is well-suited for studying environmental science problems because it is non-destructive, relatively rapid, and solids can be analyzed with little or no sample preparation. Apart from light elements, all elements with atomic numbers greater than 11 can be detected. The method is sensitive down to microgram-per-gram level and the results are precise and accurate if matrix effects can be corrected.

White-light XRF experiments have been performed at the LSU Center for Advanced Microstructures and Devices (CAMD) synchrotron facility. To date, these scans have been on cores obtained from a pilot-scale experiment currently being conducted at the University of New Hampshire.

Synchrotron X-ray Microtomography (SXM): Synchrotron X-ray Microtomography has been developed over the past decade as a technique to non-destructively image the interiors of materials.Tomography deals with reconstruction of an object from its projections. Spatial resolutions on the order of ~ one to ten microns are possible because of the highly collimated and extremely bright X-rays produced by a synchrotron. These highly-parallel X-rays permit spatial resolution that is only limited by the optical

components used to image them. Furthermore, the ability to tune to a monochromatic X-ray energy allows elemental discrimination.

To date, all SXM experiments have been performed at the GeoSoilEnviroCARS (GSECARS) beamline at the Advanced Photon Source, Argonne National Laboratory. However, the tomography beamline at CAMD has recently been upgraded in order to improve our ability to image cores such as those proposed in this work.

Principal Findings and Significance

A series of XRF scans have been made over the past year. As mentioned above, all of the scans have been of cores obtained from the University of New Hampshire. However, the results from these experiments have demonstrated the effectiveness of CAMD's XRF facilities to obtain quantitative data from quasi-natural systems. The figure below shows one example of a diffusion profile obtained; in this case the diffusion profile is of Zn in a two sediment system where the negative values are in the contaminated Newton Creek sediment and the positive values are in a Great Bay sediment. Note the high resolution of the system (i.e., 0.5 mm) and the relatively small error bars, indicating good reproducibility.

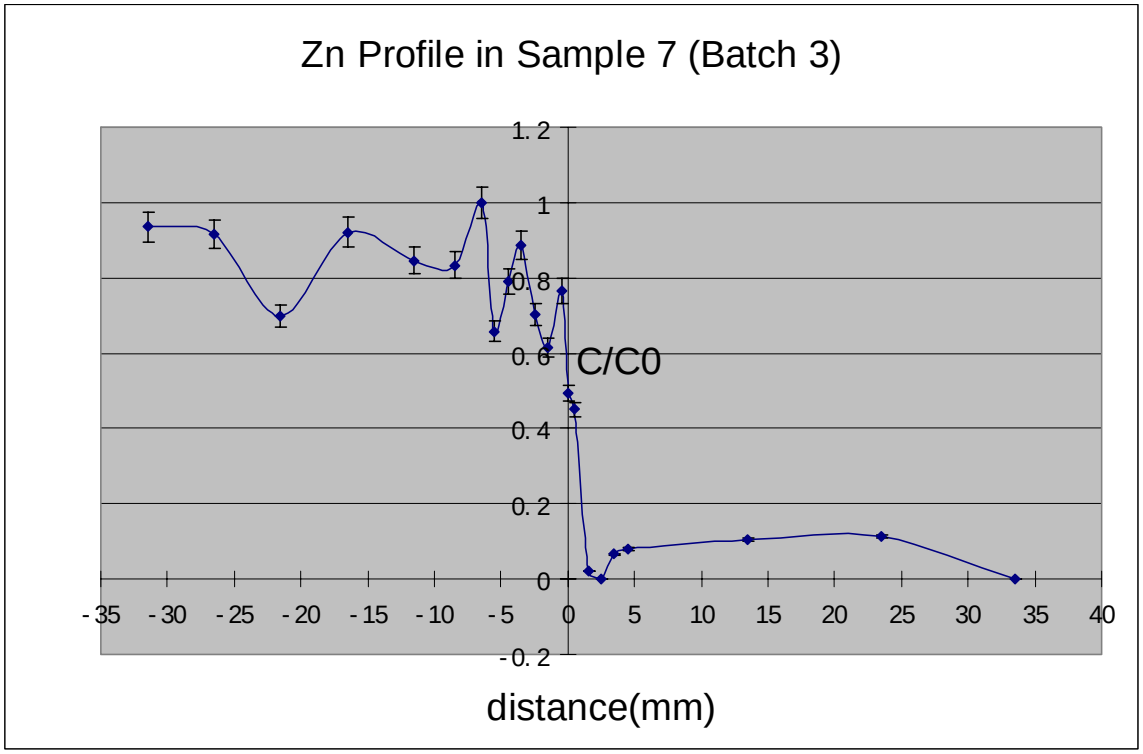

Figure 1: Zn Diffusion Profile

Based on the XRF data, we have been able to successfully fit a two-phase diffusion model and determine effective diffusivity values for a number of metals and sediment/barrier systems.

Synchrotron X-ray Tomography scans have been made on small tubes extracted from the larger cores from the UNH study and on tubes packed in our laboratory specifically for tomography experiments. The two figures below were made at the GSECARS tomography beamline at 12.54 micron-resolution and an energy of 33.0 keV. The first figure, a vertical cross-section through the column, shows the uneven interface between the sediment and the phosphate barrier system. Also note that even at this high resolution we are unable to distinguish individual sediment particles; this sediment primarily consists of fine sand, silt, and clay. The second tomography image is a three-dimensional image of a similar system. We are currently in the process of analyzing these systems for porosity, tortuosity, pore body/throat size distributions, etc…

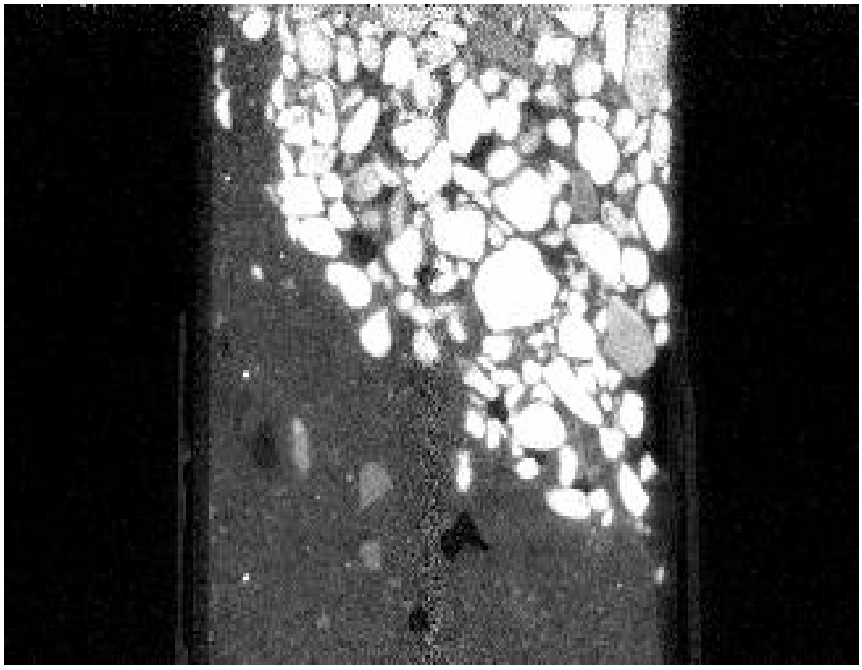

Figure 2: Vertical Cross-Section with sediment on bottom and phosphate barrier on top

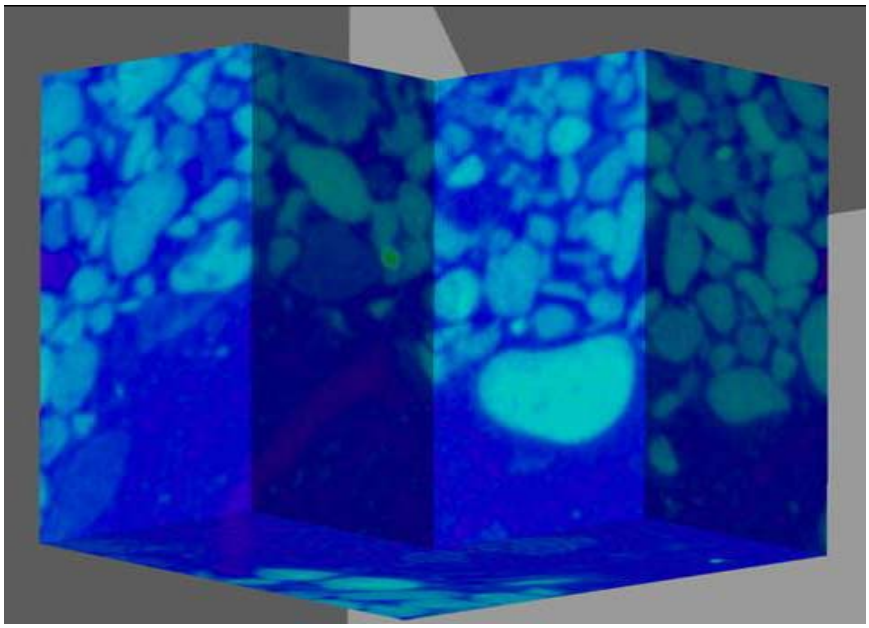

Figure 3: Three-dimensional image of sediment/phosphate barrier system

Based on the XRF data collected from the UNH project and the preliminary tomography images collected at APS, we have developed a detailed experimental plan to begin the small column XRF/SXM experiments this summer (i.e., 2004). We are now confident that we have the ability to obtain sufficiently high-quality data and quantify the important data. In brief, the procedure is as follows:

1. Packing of approximately 12 columns (5 mm i.d.). Two replicates of the following: Anacostia Sediment with no cap; Anacostia Sediment with "Florida" phosphate cap; Anacostia Sediment with "North Carolina" phosphate cap; Anacostia Sediment with sand cap; "spiked" sand system with no cap. The columns will be fully saturated and maintained at "ponded" conditions. The ponded water will be replaced at regular intervals.
2. SXM scan. From this scan, system (e.g., porosity, tortuosity, etc..) and pore-scale (e.g., pore body/throat sizes, connectivity, etc…) will be determined.
3. XRF scan. From this scan, diffusion profiles of the contaminants will be obtained.
4. Steps 2 and 3 will be repeated at 45 or 90 day intervals depending on the rate of diffusion and reactions.

Metal Speciation in Particulates in the Mississippi River in Louisiana

Basic Information

Title:	Metal Speciation in Particulates in the Mississippi River in Louisiana
Project Number:	2003LA18B
Start Date:	3/1/2003
End Date:	2/29/2004
Funding Source:	104B
Congressional District:	6
Research Category:	Water Quality
Focus Category:	Water Quality, Treatment, Toxic Substances
Descriptors:	speciation, remediation, toxic elements, water quality
Principal Investigators:	Amitava Roy

Publication

Title Metal Speciation in Particulates in the Mississippi River in Louisiana

Problem and Research Objectives

The levels of some toxic heavy metals in the Mississippi River have increased over the last several decades due to anthropogenic input, one of them being storm water. Storm water run off from the nation's highways often contains toxic heavy metals at high concentrations. They are derived from various sources such as automobiles, atmospheric deposition, and construction materials. The levels of heavy metals in stormwater can exceed EPA's safe drinking water criteria.

Sansalone and others (Liu *et al.* 2001; Liu *et al.* 2001a) have developed filter media which will remove heavy metals by adsorption on MnOx minerals in a very small space. Recent work, which included application of the MnOx (x depends on Mn charge) coating on concrete (MOCM) granules, showed that it is an effective medium in the removal of heavy metals from synthetic stormwater. Experiments in the laboratory showed that compared to ordinary concrete, the breakdown curve of the coated media was extended by several hours.

The basic building block of MnOx minerals is the MnO_6 octahedron. These can share edges to form sheets, and corners to form tunnel-like structures. Depending on the number of octahedra on each side of the tunnel, a MnOx structure can be 1x1, 2x3, etc., where each unit refers to one octahedron. The MnOx minerals are very fine grained and poorly crystalline, which result in a very high surface area (Post 1999). MnOx minerals are ubiquitous in soils and ocean floors. They possess very high adsorption capacity and selectively remove large amounts of heavy metals from these surroundings. They are highly charged, with the point of zero charge depending on the pH. Most of the adsorption of metal ions occurs at the surface of the MnOx minerals due to unsatisfied oxygen or hydroxyl bonds and only a minor amount enters the layers in between sheets (Taylor 1986).

The low crystallinity, small grain size and a high degree of mixing at the micrometer scale, makes characterization of MnOx minerals difficult. For example, single crystal X-ray structure analysis has not been performed for most MnOx minerals. Concrete itself is a multi-phase material, with the dominant phase the calcium silicate hydrate being a very poorly crystalline phase. X-ray absorption spectroscopy (XAS) was one of the several techniques used to investigate the properties of these media.

Chromium contamination is present in more than half of all EPA superfund sites (http://es.epa.gov/ncer_abstracts/sbir/91/phase1/topicf13.html). One of the problems associated with chromium contamination is that chromium has little or no interaction with the surrounding soil. The weak chromium soil interaction can result in wide spread groundwater contamination. It has been shown that strip mining, tanneries, and other industrial processes cause chromium contamination (Khan, 2001). Chromium in the hexavalent form is highly toxic and is a known cancer causing agent (Proctor et al. 2002). The current method of cleaning up a contaminated site is costly and time consuming. These technologies require continual monitoring to ensure public health. Phytoremediation can play an important role in cleaning up these sites. Instead of moving and processing the contaminated soil, it is possible to plant specific types of plants to clean the soil. Other plants have been shown the ability to uptake and sequester chromium. Mesquite (*Prosopis spp.*), sunflowers, soybeans, clover (*Trifolium*

bracycalynum), and creosote bush (*Larrea tridentate*) have the ability to remove chromium contamination from the soil. Watercress has been shown to have the ability to uptake Thallium without harming the plant and is an ideal candidate for more phytoremediation experiments. Watercress, as the name suggest, grows best near a stream or other bodies of water. It also grows well in cold climates. All these factors make watercress a perfect candidate for extracting metals out of a contaminated stream or river.

Methodology

Manganese oxide media

The manganese oxide media preparation techniques have been outlined in a series of publications by Sansalone and others (Liu et al. 2001a,b). In brief, two preparation methods were used to precipitate a birnessite-like MnOx and a cryptomelane-like MnOx. These coating were also applied to millimeter-size grains obtained from portland cement concrete.

Bioremediation

The watercress was grown in a water culture hydroponics system for two weeks. Each of the two ten-gallon glass aquariums was filled with 30 liters of distilled water. Both aquariums were given the proper amount of hydroponics fertilizer to maintain the watercress. To one aquarium 15 grams of Na_2CrO_4 was added, to obtain a final chromium concentration of 500 ppm. The watercress was obtained from a local grower and was grown in soil for seven days before selected cuttings were placed in a perlite medium. The watercress in the perlite medium was suspended in the aquarium so that 3 inches of the perlite was submerged into the water culture system. After two weeks, the watercress was extracted and left to dry for a week. The dried watercress was then separated into two sections, the stems and the leaves. Both stems and leaves were ground up to achieve homogeneity.

X-ray absorption spectroscopy

The XAS spectra were collected at the J. Bennett Johnston Sr., Center for Advanced Microstructures and Devices (CAMD), Baton Rouge, Louisiana, Double Crystal Monochromator beamline. The ring operated at 1.3 GeV. The current in the ring typically ranged between 130 to 60 mA. The experiments were conducted in air. The concentrated specimens were analyzed in transmission and those with low concentrations were analyzed in fluorescence by a thirteen-element high purity germanium detector. Specimens were prepared by smearing a very thin layer of the powder onto a Kapton tape. Ge 220 crystals were used in the monochromator. For chromium, the dried watercress samples were placed on Kapton tape for XAS analysis.

The XANES spectra for manganese were collected from 200 eV below the edge to up to 20 eV blow the edge in 3eV steps; from – 20 eV to 60 eV above the edge in 0.3 eV steps; and 60 eV above the edge to 300 eV above the edge in 3 eV steps. For manganese EXAFS, the range over which data could be collected was limited by the iron K edge at 7112 eV. Thus only several hundred eV of data could be collected. The steps

were 3 eV below the edge and 2 eV above the edge up to 7112 eV. The data was reduced by Athena written by Bruce Ravel.

The XANES spectra for chromium were collected from 200 eV below the edge with 3 Ev steps, from 20 eV from the edge to 40 eV above the edge with 0.3 eV steps, and up to 300 eV above the edge with 2 eV steps. The counting time at each step was determined in inverse proportion to the number of counts in that region.

Principal Findings and Significance

Manganese-coated cementitious media for wastewater treatment

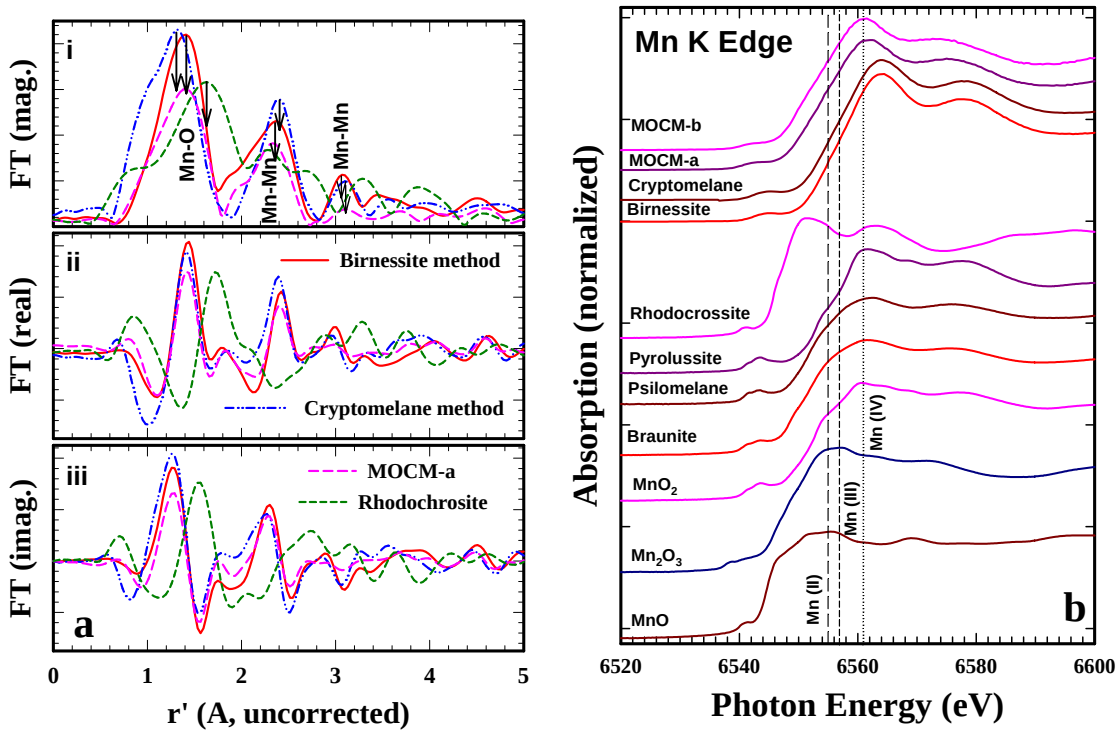

Figure 1: i: EXAFS spectra; ii: XANES spectra

Figure 1a shows the EXAFS spectra of the coating media. Broadly, there are three main peaks (Figure 7i), corresponding to Mn-O, Mn-Mn (edge-sharing), and Mn-Mn (double-corner sharing) distances (Manceau and Combes 1988). The double-corner sharing shell is absent in manganese phyllosilicates (birnessite in this study), where only edge-sharing between Mn-O octahedra occurs. The todorokite structure, in contrast, has both edge-sharing and corner sharing tetrahedra. Thus, while only two MnO distances occur in birnessite, 2.85 and 2.95 A, four Mn-O distances occur in todorokite. These are 2.84 Å, 2.93 Å, 3.46 Å, and 3.56 Å. The former two correspond to edge sharing distances, while the last two correspond to double-corner sharing distances. The EXAFS spectra of both the MnOx coatings show a strong Mn double corner peak.

Cryptomelane, a 1x1 MnOx structure (Post 1999), has both edge sharing and double cornering sharing octahedra like todorokite. Considering that TEM observations show only one MnOx phase in the birnessite-type coating, EXAFS suggest that the "birnessite" method coating has more of a tunnel-like structure. The ratio of the peak heights of Mn-Mn(edge) to Mn-Mn(corner) suggests that the "birnessite" method product is similar to nsutite, while the cryptomelane product is similar to ramsdellite. However, the cryptomelane precipitate is not a single phase but a mixture of MnOx phases.

The Mn K edge XANES spectra of the coating media are shown in Figure 1b. Several standard mineral spectra are also shown. A comparison of the birnessite method Mn XANES spectrum with the birnessite synthesized by Guest et al. 2002 (Guest *et al.* 2002) shows a substantial difference. A comparison among these spectra shows the following: the coating media have little Mn2+, most of the Mn being in the 4+ state. A least squares fitting of the birnessite method residue by pyrolusite and synthetic Mn_2O_3 showed it to be 80% Mn4+. However, the residual is somewhat high indicating that these are not the most appropriate standards to fit. Still, the fit provides an indication of the of proportions of different oxidation states.

The EXAFS data of MOCM-a are shown in Figure 7a. The figure (Figure 7ai) shows a distinct bulge around 1.9 Å in the pseudo-radial distance of the MOCM compared to those of the MnOx coatings. A comparison of the real and imaginary parts of the Fourier transforms suggests that the bulge is due to Mn-O shell in rhodochrosite which occurs at a much larger distance than the Mn-O shell in the MnOx coatings. Some manganese is thus entering the calcium carbonate structure. A comparison of the edge-sharing and corner sharing peak heights suggest that lesser corner sharing occurs in MOCM compared to the coatings themselves. Thus the MOCM MnOx has more birnessite-like structure.

The Mn K edge XANES spectra of MOCM-a and -b are shown in Figure 7b. Least squares fitting of the Mn spectra of MOCM-a showed that it contains more Mn3+ and possibly a minor amount of Mn2+. Qualitatively, these spectra occur at lower energy compared to the MnOx coatings, indicating they have less Mn4+. MOCM-b absorption edge occurs at slightly lower energy compared to MOCM-a, indicating it has lower overall oxidation state. The addition of rhodochrosite to the fit did not decrease the residual suggesting either its absence or its presence in a very small amount.

XANES spectroscopy of the coatings shows that very little of the Mn is present in the +2 oxidation state, if any. Assuming that only one type of MnOx is present in the birnessite-like coating, an assumption supported by TEM observations, the MnO_6 octahedra in the phase has both edge-sharing and corner-sharing octahedra. Thus the structure is unlike that of birnessite, which has only edge-sharing octahedra.

Hyperaccumulation, and Reduction of Cr (IV) to Cr (III) From a Hydroponics Solution by Watercress (Nasturtium officinal)

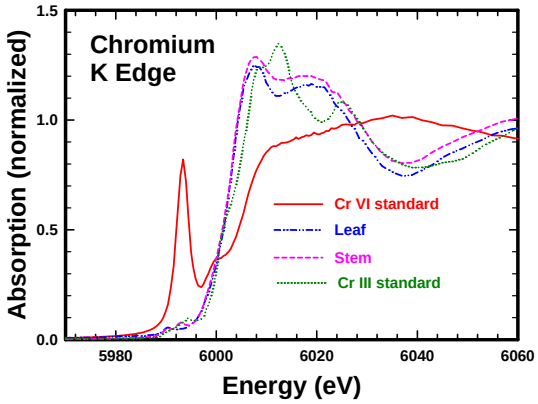

Figure 2

Figure 2 shows the XAS spectra of the leaf and stem samples of the watercress used in remediation treatment, along with that of sodium chromate, a standard.

First, the strong chromium peak in both the leaf and the stem indicates that watercress contains chromium and is capable of removing it from solution. Second, the hexavalent strong pre-edge peak of chromium at 5993.4 eV is completely reduced in the leaf, whereas some Cr VI remains in the stem. This pre-edge peak is absent in Cr III.

Flame atomic absorption spectroscopic analysis of the stem and leaf samples of the watercress was performed to obtain their chromium content. The concentrations of chromium in the stem and leaf samples were 400 ppm and 5,400 ppm, respectively. Watercress is thus a hyper accumulator of Cr.

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Economic Assessments of Best Management Practices and Environmental Policy Options for Attaining the Total Maximum Daily Load (TMDL) Goal in Louisianas Major Milkshed

Basic Information

Title:	Economic Assessments of Best Management Practices and Environmental Policy Options for Attaining the Total Maximum Daily Load (TMDL) Goal in Louisianas Major Milkshed
Project Number:	2003LA19B
Start Date:	3/1/2003
End Date:	2/29/2004
Funding Source:	104B
Congressional District:	6
Research Category:	Water Quality
Focus Category:	Water Quality, Economics, Methods
Descriptors:	Dairy Waste, BMP, TMDL, Optimization, Policy tools, Spatial Allocation
Principal Investigators:	Krishna P. Paudel, Wayne M. Gauthier

Publication

SYNOPSIS

Title: Economic Assessments of Best Management Practices and Environmental Policy Options for Attaining the Total Maximum Daily Load (TMDL) Goal in Louisianas Major Milkshed

Problem and Research Objectives: The primary goal of this study is to suggest the way of using dairy waste as crop nutrient source that is both economically profitable and environmentally consistent. The other goal of this project is to find the cost impact of implementing different BMPs and their efficacy in controlling point and nonpoint sources of pollution consistent with the TMDL goal set for the region by the EPA and DEQ. The major objectives of this study are:

1. To identify the economics of using dairy manure as a source of plant nutrient and identify an optimal spatial distribution of dairy farms with and without considering BMPs,

2. To identify the effects of extreme weather on dairy-related point and nonpoint sources of pollution with and without BMPs, and

3. To compare alternative environmental policies to control dairy production related pollution and relate them to pareto optimal solution.

Methodology

Objective 1: To identify the economics of using dairy manure as a source of plant nutrient, and identify an optimal spatial distribution of dairy farms with and without considering BMPs

Procedures:

Actual location of dairy operations, impaired waterbodies, crop and pasture lands, and numbers of dairy cows will be assessed using the GIS software and secondary data supplied by the EPA and USDA. The total amount of manure production in a year from dairy facilities in these three parishes will be estimated. Potential outlets of manure as sources of nutrients for crops and pasture will be calculated assuming that manure will be applied based on the plant nutrient uptake, slope of the land, distance from the nearby waterbodies, soil pH, and cropping history. First, the cost of hauling and spreading of liquid manure or slurry will be compared to the cost of chemical fertilizer. Nutrient application will be calculated based on the lowest nutrient element required by plants. If the phosphorus requirement of a crop is the lowest among three macronutrients (nitrogen, phosphorus, and potash), then the application will be based on that element. When applying dairy manures, the concentration of major nutrients in the nearby waterbodies would be considered.

Most of the producers in the region apply dairy manure on pasture land. Therefore, in addition to other considerations, manure application will be also based on what BMPs are adopted in the farm. Farm profits and costs will be calculated under each of the alternative scenarios where farmers do or do not adopt BMPs. Optimal spatial allocation of dairy facilities within the subsegment of the watershed will be calculated assuming BMPs are adopted and nutrient application reflects land character, nutrient needs of the crop, and economics of nutrient transportation and application.

Objective 2. To identify the effects of extreme weather on dairy-related point and nonpoint sources of pollution with and without BMPs

Procedures:

Current CAFO and AFO regulations state that the manure lagoons should not overflow under conditions of less than 12 inches of rainfall within 24 hours (EPA 2000). In Louisiana, there are few days when the rainfall exceeds this level. Using historical data, we would find the probability of rainfall exceeding the level set by the EPA. Estimates of different levels of rainfall and temperature on dairy waste hazards for the waterbodies would be made. The increase in cost of adopting precaution measure under such circumstances would be weighted against normal scenarios.

Objective 3. To compare alternative environmental policies to control dairy production related pollution to meet the TMDL goal and relate them to pareto optimal solution

Environmental policies such as tax, subsidies, marketable permit, and quota with standard would be compared considering that there is uncertainty involved due to weather factors in the undepletable externality situation. The uncertainty arises from both physical factors such as rainfall and absence of knowledge about the marginal benefit and marginal costs to dairy producers of various environmental policies. The standard Pigouvian result from the certainty situation will be compared to the marketable emission permit system. Situations when dairy manure gets dispensed to one or multiple water sources would be developed to find the pareto optimal solution in each case. Dynamic effect of pollutant and dynamic optimal solution of dairy manure disposal policies would be developed under the undepletable externality scenario outlined in the introduction. Dynamic and spatial dimensions would be considered relative to water level assimilation fluctuation from receiving sources. Since the Tangipahoa River drains into the Lake Ponchatrain, the potential for water pollution would be considered.

The implementation of any of the environmental policies, especially those improving water qualities, would have positive effects on the public's well being. These policies, if implemented, would provide clean water, which would promote recreation and minimize the processing cost of potable water. However, an individual dairy producer will incur costs either in the form of adopting BMPs or by reducing the number of dairy cows. Standard benefit cost analysis will be used to evaluate the net effect of increased water quality due to the implementation of new environmental policies. Regression techniques and secondary data will be used to estimate the number of visitors in the Tangipahoa River for a given time period. The regression model would consider the number of visitors as a function of water quality (different parameters such as nitrogen, phosphorus concentration). The marginal effects of decreasing these pollutants in the waterbodies will be assessed relative to the number of visitors. Numbers of visitors would be converted into total welfare by using how much money a median visitor spends during his/her visit looking at both the direct expense and the time value of the visitors visiting the recreational site.

Principal Findings and Significance

We have finished designing the dairy survey. The response obtained from the survey would help us to understand the BMP adoption pattern of farmers, and how dairy waste is allocated in Florida Parishes in Louisiana.

The survey was mailed to dairy farmers on May 27, 2004. We have used an incentive mechanism to get the maximum response back from the dairy producers in the region. Accordingly, every one of the first 50 respondents would be paid a $10 check. We have started receiving the survey responses back from the dairy farmers. We will compile the information obtained from the survey and analyze the data obtained. The analysis should help us to properly design the effective dairy manure management policy to meet the TMDL goal in the region.

Additionally, we are inputting the needed parameters in the TMDL model. We will start running the model as soon as we get all parameters needed for the model in place.

Information Transfer Program

One of the Institute's objectives is to make research results available to the general public and to interested researchers and institutions through publications and other information transfer activities. Although the information transfer component of the budget of Section 104 funds is relatively small (10%), LWRRI attempts to meet this goal in many ways which include actively participating in conferences and workshops, distributing summaries and other Institute information to the public and governmental agencies, maintaining internet access and web sites, and maintaining a library of water research materials. The Institute requests that its investigators participate in reporting and information transfer activities such as publications in professional journals, workshops, and seminars.

The Institute's information transfer program is a subset of its administration program. Assisting with LWRRI's information transfer activities are two undergraduate student workers, a program coordinator (part-time LWRRI support), one research associate (half-time LWRRI support), and the associate director, Dr. John J. Sansalone. Two research associates are also available to assist in information transfer activities of the Institute. The Director, Dr. John Pardue, attends the annual National Institutes of Water Resources meetings in Washington, D.C., to discuss Institute and Program activities.

Further assisting in information transfer, the Engineering Incubation Research Center (EIRC) has given LWRRI access to image processing, GIS, and computing systems. This access provides the Institute with the necessary tools to transfer information in visual graphic format, utilize Internet resources, and develop state-of-the-art presentations. Because of the Institute's expanding development, more emphasis is being placed on updating the public and other organizations about activities and objectives using electronic media and presentation tools.

The Institutes staff continues to maintain emphasis on acquainting Louisianas research community with the research-funding opportunities through the U.S. Geological Survey Section 104 research program. 104 G program announcements, Mississippi SE-TAC RFPs, and Section 104 RFPs were widely distributed (114+ email addresses and 319 regular mail addresses) to Louisiana colleges and universities and to research organizations throughout the state. In addition, public announcements were made at professional and faculty meetings to encourage wide participation in the program. We send out notifications of meeting and events for the American Water Resources Association, The Capital Area Ground Water Conservation Committee, and the Louisiana Rural Water Association.

In addition, our organization is contacted regularly with various questions for the public and/or private sector concerning water issues; we try to connect these people with the proper experts within our organization and the broader academic community. We are currently building a comprehensive web portal LAWATER.com in conjunction with the LWRRI web site to help facilitate this effort. Under the direction of our director, the Institute has developed a new branding symbol for all of the information transfer activities and publications and is reconstituting the newsletter. Our annual report is housed at the Louisiana State Archives, Hill Memorial Library at LSU, and is available online at the Institutes web site.

In response to the focused RFP for the 2003-2004 solicitations, we received 5 proposals and funded 3 of those after advisory board review. The theme, selected in consultation with faculty and advisory board members, is focused on characterizing particulates for heavy metals in aquatic systems using non-invasive spectroscopy and tomography. In addition, a continuing interest in total maximum daily load (TMDL) calculations in Louisiana water bodies is being maintained.

NIWR-USGS Student Internship Program

The Louisiana Water Resources Research Institute did not have any students in the formal NIWR-USGS Intern Program during this reporting period. The Institute maintains both formal and informal relationships with the Baton Rouge office through part time employment of students not in the intern program, and the USGS District Chief serves on the Institute Advisory Board. During this reporting period we have undergone a series of discussions with the state USGS office on rapidly expanding our participation in the student intern program. At the time of this report, those discussions have not been finalized.

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	5	0	0	2	7
Masters	4	0	0	2	6
Ph.D.	5	0	0	4	9
Post-Doc.	0	0	0	1	1
Total	14	0	0	9	23

Notable Awards and Achievements

The Director, Dr. John Pardue was awarded the LSU College of Engineerings Outstanding Faculty Research Award, 2004. In addition, Dr. Pardue was awarded the Faculty Achievement Award, Department of Civil & Environmental Engineering, Louisiana State University, 2003. Dr. Pardues funded grants are a result of his work in the water resources area:

1. Development of treatment wetland technology for VOC-contaminated groundwater, **John H. Pardue, William Moe and Fred Rainey**, Louisiana State University, CICEET-NOAA, $250K, 2002-2004.
2. Phytoremediation of wetlands and CDFs, **J. Pardue and W.M. Moe**. Hazardous Substance Research Center-South & Southwest, 2001-2004. $210,000.
3. Assessment & Remediation of public health impacts due to Hurricanes and major flooding events Louisiana Millennium Health Excellence Fund; 2001-2006. **I. Van Heerden**, PI; Pardue and Reible, water modeling group, $120,000 and
4. A water quality decision model for the identification of priority sites for the implementation of best management practices to maintain dissolved oxygen levels In the Ouachita River Basin LA DEQ, **Emy Roider, V Singh, D. Adrian, J. Pardue**, 2001-2004, $381,000.
5. Cumulative Effects of Flood-Induced Seepage on Piping Problems Associated with Levee Failures: Experimental and Field Investigation with Analytical Modeling for Risk Assessment Corps of Engineers, **D. Adrian, V Singh, J.Pardue**, 2000-2004, $206,000.
6. Enhancement of a Biotechnology thrust within the Hazardous Substance Research Center-South & Southwest. **D.D. Reible, W. Moe, F. Rainey and J.H. Pardue**, $225,000/year, 2002-2007.

The Associate Director, Dr. John J. Sansalone was awarded the Wesley Horner Environmental Engineering Award-American Society of Civil Engineers, 2004. Dr. Sansalones follow-on funding is a result of his past projects with LWRRI prior to his Associate Directorship. His funded grants related to follow-on funding are:

1. **Sansalone, J.J.**, (Principal Investigator), Settling Properties of Coastal Sediments, January 2004 December 2004, Soil Testing Engineers, $9800.
2. **Sansalone, J.J. (Principal Investigator), Griffin, D.M., Cartledge, F.K, and Tittlebaum, M.E.**, Transport, Treatment and Toxicity of Urban Rainfall-runoff, June 2004 June 2005, LTRC, $20,000. and
3. **Sansalone, J.J.** (Principal Investigator), Griffin, D.M., Cartledge, F.K, and Tittlebaum, M.E., Transport, Treatment and Toxicity of Urban Rainfall-runoff, June 2003 June 2005, LTRC, $349,905.

Publications from Prior Projects

1. 2001LA2521B ("Storm Water Transport of Particulate Matter From Elevated Urban Transportation Corridors into Waterways of Louisiana The Role of Partitioning and Implications For Treatment") - Articles in Refereed Scientific Journals - Sansalone, J.J., J.P. Hird, F.C. Cartledge, and M.E. Tittlebaum, Event-based Rainfall-Runoff Water Quality and Quantity Loadings from Elevated Urban Infrastructure Impacted by Transportation, J. of Water Environment Research, (in press), 2004.
2. 2001LA2521B ("Storm Water Transport of Particulate Matter From Elevated Urban Transportation Corridors into Waterways of Louisiana The Role of Partitioning and Implications For Treatment") - Articles in Refereed Scientific Journals - Dean, C.M., J.J. Sansalone, F.K. Cartledge, and J.H. Pardue, Influence of Hydrology on Storm Water Metal Element Speciation at the Upper End of the Urban Watershed, ASCE J. of Environmental Engineering, (in press) 2004.
3. 2001LA2521B ("Storm Water Transport of Particulate Matter From Elevated Urban Transportation Corridors into Waterways of Louisiana The Role of Partitioning and Implications For Treatment") - Articles in Refereed Scientific Journals - Sansalone, J.J and C.M. Cristina, First Flush Concepts for Suspended and Dissolved Solids in Small Impervious Watersheds, ASCE J. of Environmental Engineering, (in press) 2004.
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5. 2001LA2521B ("Storm Water Transport of Particulate Matter From Elevated Urban Transportation Corridors into Waterways of Louisiana The Role of Partitioning and Implications For Treatment") - Articles in Refereed Scientific Journals - Liu, D., J.J. Sansalone, and F.K. Cartledge, "Adsorption Characteristics of Oxide Coated Polymeric Media (âs < 1.0) for Storm Water Treatment - Part I: Batch Equilibria and Kinetics", ASCE J. of Environmental Engineering, (in press) 2004.
6. 2001LA2521B ("Storm Water Transport of Particulate Matter From Elevated Urban Transportation Corridors into Waterways of Louisiana The Role of Partitioning and Implications For Treatment") - Articles in Refereed Scientific Journals - Liu, D., J.J. Sansalone, and F.K. Cartledge, "Adsorption Characteristics of Oxide Coated Polymeric Media (âs < 1.0) for Storm Water Treatment - Part II: Equilibria and Kinetics Models", ASCE J. of Environmental Engineering, (in press) 2004.
7. 2001LA2521B ("Storm Water Transport of Particulate Matter From Elevated Urban Transportation Corridors into Waterways of Louisiana The Role of Partitioning and Implications For Treatment") - Articles in Refereed Scientific Journals - Sansalone, J.J. and Z. Teng, "In-situ storm water treatment and recharge through infiltration: Quality and Quantity Attenuation", ASCE J. of Environmental Engineering, (in press) 2004.

8. 2001LA2521B ("Storm Water Transport of Particulate Matter From Elevated Urban Transportation Corridors into Waterways of Louisiana The Role of Partitioning and Implications For Treatment") - Articles in Refereed Scientific Journals - Teng, Z. and J.J. Sansalone, "In-situ storm water treatment and recharge through infiltration: Particle transport and separation mechanisms", ASCE J. of Environmental Engineering, (in press) 2004.
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12. 2001LA2521B ("Storm Water Transport of Particulate Matter From Elevated Urban Transportation Corridors into Waterways of Louisiana The Role of Partitioning and Implications For Treatment") - Articles in Refereed Scientific Journals - Cristina, C. and J.J. Sansalone, "Kinematic Wave Model Of Urban Pavement Runoff Quantity Subject To Traffic Loadings", ASCE J. of Environmental Engineering, Vol. 129, No. 7, pp. 629 636, July 2003.
13. 2001LA2521B ("Storm Water Transport of Particulate Matter From Elevated Urban Transportation Corridors into Waterways of Louisiana The Role of Partitioning and Implications For Treatment") - Conference Proceedings - Sansalone, J.J, P. Zhou, R. Ferrell, H. Lin, H., F. Cartledge, "Physico-Chemical Characteristics of the Clay-size Fraction Entrained in Urban Rainfall-Runoff: Interactions with Anthropogenic Heavy Metals", 10th European Clay Conference, University of Modena, Italy, 2003.
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