Penn State Institutes of the Environment
Annual Technical Report
FY 2002

Introduction

The following report summarizes the FY 2002 program of research and educational outreach projects funded through the Pennsylvania Water Resources Research Center (PAWRRC) for the period March 1, 2002 to February 28, 2003. Much has changed administratively with PAWRRC over this year. The PAWRRC has a new director, Dr. David R. DeWalle, Professor of Forest Hydrology, School of Forest Resources at Penn State. The PAWRRC also became part of the Penn State Institutes of the Environment, a new organization, which replaces the former Environmental Resources Research Institute/Environmental Consortium at Penn State and serves as an umbrella organization for the numerous environmental institutes and centers in all colleges and departments across the Penn State campus. The Water Resources Research Act of 1964 (P.L. 88-379) initially created a water research and technology center in each state to: 1) initiate research addressing water problems and enhancing water science, 2) aid entry of new scientists into water resources fields, 3) help train future water scientists and engineers, and 4) extend water resources information to water managers and the general public. A summary of each research/outreach project sponsored by PAWRRC is given in the following report along with information about training of students and publications and presentations. In addition to formal research and outreach projects, a website (http://www.pawatercenter.psu.edu/index.htm) and a water quality analysis laboratory for inorganic constituents to support research is also maintained by PAWRRC.

Research Program

Research projects for FY 2002 that were funded through the Pennsylvania Water Resources Research Center (PAWRRC) fall into two categories: those awarded through a national competitive grants program (P.L. 88-379, Section 104g) and those competitively awarded through the PA base grant program (P.L. 88-379, Section 104b). National competitive grants are funded out of a program separate from the base grant funds given annually to each state water center. Five projects were administered by PAWRRC during FY 2002: one national competitive grant and three competitive base grant projects.

1. Enrichment, biochemical, and molecular techniques for assessing microbial arsenic reduction-Dr. John F. Stolz, Duquesne University, 104g grant.

2. Water reuse: Using crumb rubber for wastewater filtration-Dr. Yuefeng Xie, Penn State Univ-Harrisburg, 104b grant.

3. Re-suspension of bottom sediments by recreational watercraft-Dr. David F. Hill, Penn State Univ-UP, 104b grant.

4. Acid water mitigation methods-Dr. William E. Sharpe, Penn State Univ UP, 104b grant.

5. Development of 4-H water quality curriculum materials-Dr. William E. Sharpe, Penn State Univ-UP, 104b grant.

All of these projects dealt with water quality problems important to Pennsylvania and the northeast region of the United States. The first three involved basic research, while the last two projects are largely devoted to publication development and outreach as part of the PAWRRC Information Transfer Program.

Resuspension of Bottom Sediments by Recreational Watercraft

Basic Information

Title:	Resuspension of Bottom Sediments by Recreational Watercraft
Project Number:	2002PA2B
Start Date:	3/1/2002
End Date:	12/31/2002
Funding Source:	104B
Congressional District:	5th of PA
Research Category:	Engineering
Focus Category:	Management and Planning, Recreation, Sediments
Descriptors:	Ssediment Resuspension, Recreational Conflicts, Fluid Mechanics
Principal Investigators:	David F. Hill

Publication

1. Hill, D.F., M.M. Beachler, 2003, Wakes on Lakes, Research Penn State, p.11.
2. Hill, D.F., M.M. Beachler, Recreational boating impacts, a case study, in preparation.
3. Hill, D.F., M.M. Beachler, P.A. Johnson, 2002, Hydrodynamic impacts of commercial jet boating on the Chilkat River, Alaska, final report, 120 pp.

Problem and Research Objectives

Our nation's lakes, rivers, estuaries, and harbors serve important environmental, economic, and recreational roles. From a management point of view, balancing the numerous pressures on an individual water resource in such a way that the long-term health of that resource will be preserved is a serious challenge. The operation of watercraft has numerous potential impacts that deserve consideration, from noise pollution to fuel emissions, to erosion caused by wakes and turbulent prop wash. An understanding of (i) under what conditions these impacts occur and (ii) the consequences of these impacts are clearly of high management value.

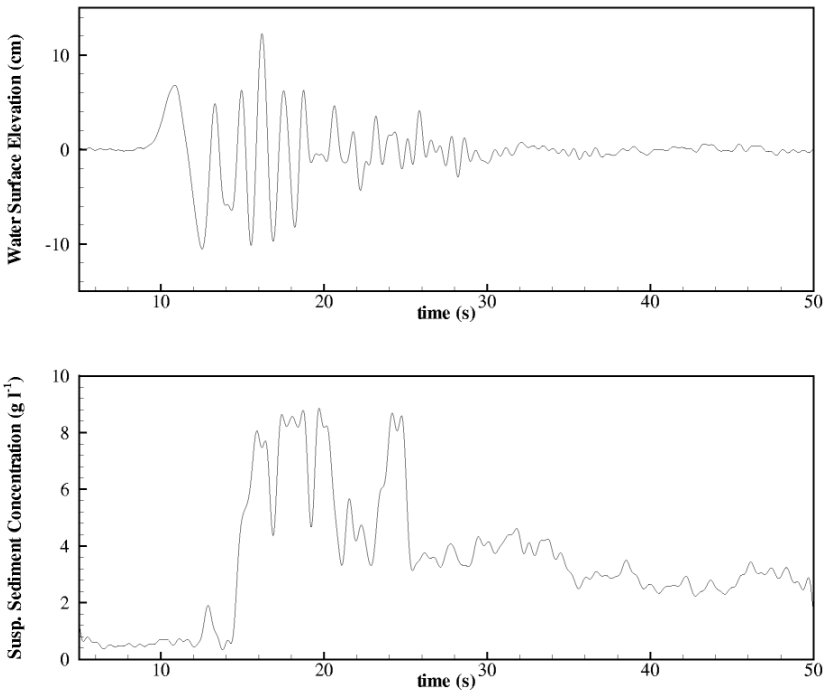
This research extended the work conducted by PI Hill during the period of 3/1/01 – 2/28/02. The specific objectives were to:

1. Refine our understanding of the conditions under which a recreational boat is capable of disturbing a sediment bed.
2. Conduct a study to determine how wake heights vary with operational parameters such as boat speed, size, and distance from shore.
3. Conduct a study to determine how much sediment is dislodged from a shoreline in response to boat passage.

Methodology

In order to answer these questions, a field study was conducted during the summer of 2002 in Haines, Alaska. A wide variety of measurements were made with an equally wide variety of instrumentation. In order to measure fluid velocity induced beneath passing boats, a Sontek Field Acoustic Doppler Velocimeter (ADV) was used. This instrument is capable of measuring all three components of fluid velocity at sampling rates up to 25 hertz. Next, a Downing & Associates Optical Backscatter Sensor (OBS) was used to measure the turbidity of the water in a variety of configurations. This device relies upon reflected infrared radiation and gives a measure of the 'cloudiness' of the water. By performing a laboratory calibration with local sediment samples, it is also possible to determine suspended sediment concentration values. Finally, wake heights were measured with capacitance wave staffs from Richard Brancker, Ltd., and Ocean Sensor Systems, Inc. In both cases, analog voltage output signals are directly proportional to the water surface elevation.

The experiments included both controlled and uncontrolled studies. The controlled studies were conducted by the investigators while the uncontrolled studies involved other boats passing by the study area. The advantage of the controlled studies is that the parameters, such as speed, etc. can be systematically varied. Nevertheless, the uncontrolled studies were of value in that they reflected the actual usage characteristics of the river. An individual experiment consisted of a single boat pass, with transient velocity, turbidity, and wake height data all being collected. Sample wave height and suspended sediment concentration (derived from turbidity) data are shown in the figure below.



Principal Findings and Significance

The present study yielded numerous interesting findings. First of all, it clearly demonstrated that boat wakes have the potential to dislodge significant amounts of sediment from the shoreline. In numerous trials, the turbidity meter 'pegged out' at its maximum value of 500 NTUs (nephelometric turbidity units). This is of concern from an erosion point of view as well as from a biological point of view as many plant and animal species are sensitive to turbidity levels. The measurements also demonstrated the conflict that exists in trying to simultaneously minimize impacts to the bottom and the shoreline of a water body. For example, erosive effects at the shoreline are minimized by reducing wake heights, which is achieved by requiring boats to travel at extremely slow speeds. However, this operation of a boat in so-called 'displacement' (i.e. non-planing) mode maximizes disruption to the bottom of the water body. Management decisions must therefore consider both of these effects carefully.

Next, the collected data were used to establish a predictive equation for expected maximum wave height (H_{max}) at shore. Based upon boat length (L) and distance from shore (x), it was found that

$$\frac{H_{\max}}{L} = 0.033\left(\frac{x}{L}\right)^{-0.43} .$$

Thus, if it is desired to keep wake heights below some threshold value, the minimum operating distance can readily be computed.

Finally, numerous calculations and estimates of hydrodynamic parameters, such as energy, power, and shear stress were made in an effort to compare the impacts of recreational watercraft use to the impacts associated with the ambient flow of a river. It was found that the conclusions varied widely depending upon the chosen parameter and upon the specific conditions of the site. Most interestingly, it was found that even seemingly low levels of boating activity can produce hydrodynamic impacts that exceed those of the background flow. It is still not clear which parameter is the most effective and accurate measure of shoreline impact. It is hoped that future research will resolve this lingering question.

Student Support

Michele Beachler, M.S., Civil & Environmental Engineering
Justin Lennon, M.S., Civil & Environmental Engineering

Water Reuse: Using Crumb Rubber for Wastewater Filtration

Basic Information

Title:	Water Reuse: Using Crumb Rubber for Wastewater Filtration
Project Number:	2002PA3B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	17th of PA
Research Category:	Water Quality
Focus Category:	Treatment, Waste Water, Water Quality
Descriptors:	wastewater filtration, crumb rubber medium, suspended solids, waste tires, and water reuse
Principal Investigators:	Yuefeng Xie

Publication

1. Xie, Y.F., Y. Zhou, B. Killian, S.Y. Hsiung, 2002, "An Innovative Filter Medium for Wastewater Filtration", AEESP/AAEE Conference 2002, Toronto, Canada,(Poster Presentation).
2. Hsiung, S.Y., and Y.F. Xie, 2003, Filtration Using a Crumb Rubber Media, the 2003 Penn State Environmental Chemistry Symposium, University Park, PA, (Poster Presentation).
3. Hsiung, S.Y., and Y.F. Xie, 2003, Waste Tires for Wastewater Water Treatment, Innovature 2003, Hershey, PA, (Poster Presentation).

Problems and Research Objectives

Pennsylvania has been in drought conditions in five of the last seven years. In February 2002, 62 of Pennsylvania's 67 counties were under a drought declaration. 24 counties were under drought emergency, 7 under drought warning, and 31 under drought watch. Using reclaimed wastewater for beneficial application is the key for solving the water shortage problems in Pennsylvania. Wastewater filtration is a critical treatment process for wastewater reclamation. An innovative filter medium consisting of crumb rubber from recycled tires was developed in the Environmental Engineering Laboratories at Penn State Harrisburg. In an earlier study we found that the filter performance of a crumb rubber filter was comparable with that of a conventional dual-media sand/anthracite filter using synthetic wastewater.

The objective of the proposed study is to optimize the crumb rubber media filter for wastewater filtration and conduct a side-by-side comparison between the crumb rubber filter and the conventional sand/anthracite filter. The feasibility of wastewater filtration for wastewater reuse will be evaluated as well.

Methodology

Phase I. Effects of the size and depth of crumb rubber
In this phase of the study, synthetic wastewater, prepared with mixed liquor samples from a local wastewater treatment plant, was used to evaluate the filter performance, including filtration rate, headloss, SS removal, and filter run time. Two 4-inch pilot filters, crumb rubber and dual-media sand anthracite, were used. The crumb rubber with various sizes was obtained from a local scrap tire recycle plant. Specific crumb rubber sizes were selected using sieves in laboratory. The objective of this phase of the study is to identify proper crumb rubber size and filter bed depth.

Phase II. Field Studies
The field study was used to verify the application of crumb rubber filters in wastewater filtration. A field study pilot unit was constructed under the project. Three 6-inch diameter clear PVC columns were used. Headloss indicators were constructed with glass tubes. The proper crumb rubber size and bed depth identified under Phase I were used in this study.

The Penn State University Park Wastewater Treatment Plant was used as the field test site. The plant uses primary sedimentation, trickling filter, activated sludge, final clarification, and chlorination. Currently, the wastewater effluent is discharged on two spray fields. The influent and effluent samples were collected for analysis of suspended solids, BOD, and phosphorus. Paired samples were also collected for a pilot scale dual-media sand/anthracite filter.

The field study provided side-by-side comparisons between the crumb rubber filter and dual-media sand/anthracite filter. The final comparison was made based on the filter effluent quality and filter water production.

Principal Findings and Significance

1. Both the sand/anthracite and crumb rubber filters were effective at reducing effluent suspended solids from 6-16 mg/L down to <5 mg/L, and reducing turbidity from 4-10 NTU to <4 NTU. For particles between 3 to 11 μm, a 90% removal was achieved in both filters.

2. The crumb rubber filter exhibited much less head losses than the sand/anthracite filter when operated at the same filtration rates. The crumb rubber filter can be operated at higher filtration rates than the sand/anthracite filter or anthracite filter.

3. The combination of higher filtration rates, lower head losses, and lower backwash water rates for the crumb rubber filter indicates that the crumb rubber filter can have significant higher water production rates than sand/anthracite filters.

4. The porosity of the crumb rubber medium was approximately 70% in comparison to sand medium at 45% and anthracite medium at 58%. In comparison to sand and anthracite, a greater depth filtration was observed in the crumb rubber filter, especially in the late filtration stage.

5. Various design, filtration, and backwash criteria were developed for the crumb rubber filter. For wastewater filtration, the authors suggest a filter medium depth of 36 inches and crumb rubber size at 1.2 to 2.0 mm. A filtration rate at 10 gpm/ft^2 and a backwash water flow rate at 12 gpm/ft^2 are also suggested.

6. Both crumb rubber filter and sand/anthracite filter gave a poor phosphorus removal. Further study should be conducted using various coagulant types (e.g., alum and ferric salts) and doses.

Student Supported

Three students were supported under the projects:
1. Shih-Yun Hsiung (MS), in Environmental Engineering at Penn State University Park
2. Mathieu Combescure (BS), French visiting student in Department of Civil and Environmental Engineering, Penn State University Park
3. You Zhou (ME), in Environmental Pollution Control at Penn State Harrisburg

Enrichment, biochemical, and molecular techniques for assessing microbial arsenic reduction

Basic Information

Title:	Enrichment, biochemical, and molecular techniques for assessing microbial arsenic reduction
Project Number:	2001PA9G
Start Date:	9/1/2001
End Date:	8/31/2003
Funding Source:	104G
Congressional District:	15
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Water Quality, Groundwater
Descriptors:	arsenic, bacteria, enrichment culture, biochemical probes, molecular probes, arsenate reductase
Principal Investigators:	John F. Stolz

Publication

1. Stolz, J.F., P. Basu, and R.S. Oremland, 2002, Microbial transformation of elements: the case for arsenic and selenium. Int. Microbiol. 5:201-207.
2. Oremland, R.S. and J.F. Stolz, 2003, The ecology of arsenic. Science 300:939-944.

Problem And Research Objectives

Arsenic is a naturally occurring element that can cause skin lesions, cancer (e.g., bladder, kidney, lung and skin), diabetes, and cardiovascular disease in elevated concentrations. It has also been shown to act as an endocrine disruptor, affecting the glucocorticoid receptor. Arsenicosis is a global problem that is primarily caused by the consumption of arsenic-contaminated groundwater. Bacteria that grow by using arsenate as a terminal electron acceptor may play a crucial role in the transformation and mobilization of arsenic in groundwater. It has become imperative, therefore, that effective methods be developed for the identification of these organisms in the environment. The purpose of this proposal is to improve enrichment culture methods and develop biochemical and molecular techniques for the identification of arsenate-respiring bacteria in order to assess microbial arsenic mobilization. Specific studies proposed include (1) formulation of enrichment media for culturing freshwater arsenate-respiring bacteria and (2) design and development of biochemical and molecular probes for the detection of Gram positive arsenate-respiring bacteria.

Methodology

The medium contains per liter K2HPO4 (0.225g), KH2PO4 (0.225g), NaCl (0.46g), (NH4)2SO4 (0.225g), MgSO4.7H2O (0.117g), yeast extract (1g), NaHCO3 (4.2g) Na2S.9H2O (0.1g), 10ml of SL10 trace element solution, 10ml of vitamin solution. Different concentrations of arsenate (1,5, and 10 mM) and different electron donors (e.g., acetate, lactate, pyruvate, formate) are then added. The pH is adjusted to 7.3 prior to autoclaving. The liquid medium is dispensed in crimped septum sealed tubes or bottles (125ml) and degassed with a 80:20% mixture of N2:CO2 for five minutes. The headspace is then degassed for one minute and the vessels sealed, crimped, and autoclaved. The vitamin solution, lactate, reducing agent, and bicarbonate are filter sterilized and added separately. The bottles are inoculated with a slurry made from soil sample (1 gm) in minimal medium lacking electron donor, acceptor, and yeast. After incubation, the bottles are examined for the visible production of arsenic trisulfide (a yellow precipitate). AsIII and AsV are determined with HPLC using a BioRad Aminex HPX-87H ion exclusion column, 16 mN H2SO4 as the eluent, a flow rate of 2ml/min, and UV detection at 195 nm. The morphology of the bacteria are determined using Gram staining and light and electron microscopy.

Enrichment cultures and isolates are screened for arsenate reductase activity using the methyl viologen assay. For the spectrophotometric assay, a reaction mixture containing 2.2 ml of HEPES buffer (50 mM, pH 7), 100 mg of sample (in 100 ml of buffer), 80 ml of methyl viologen (1mg/ml), and 100 ul of 5mM arsenate, is sparged for 5 minutes with oxygen-free dinitrogen in a Thunberg cuvette. A solution containing sodium dithionite (5mM) in bicarbonate buffer (0.01M, 100ml) is simultaneously sparged in the sidearm of the cuvette. The cuvette is then assembled and the contents of the sidearm mixed with the reaction mixture. The control cuvette contains all but the sample and is placed in the reference beam of the spectrophotometer. Activity is measured at 600 nm as the methyl viologen is oxidized by the reductase. For the zymogram, protein samples are solubilized

in SDS sample buffer and loaded onto a 4 - 12% gradient acrylamide gel (BioRad, Hercules, CA). After running the gel for an appropriate time (e.g., 2 hrs at 150 V) the gel is first stained in a solution of dithionite reduced methyl viologen and then developed with a solution of 5 mM sodium arsenate in Tris buffer (pH 8). A duplicate gel is blotted onto nitrocellulose and probed with the antibodies raised against 26 kDa polypeptide from S. barnesii or the 110 kDa subunit of the arsenate reductase from B. selenitireducens.

The procedure for purification of the RasR has been worked out in detail. Starting with 15 g of cells (pooling the harvest of three fermentor batches), the pellet is resuspended in 140 ml of 10 mM Tris -HCl buffer (pH 8.0) containing 1 mM EDTA and 10 µM phenyl methyl sulphonyl fluoride (buffer A). The suspension is then sonicated (150 W, 50/60 Hz) for 10 min on ice. The resulting suspension is centrifuged at 7500 x g for 15 min to remove the unbroken cells. The supernatant is then centrifuged at 200,000 x g for 2hrs. The supernatant is decanted and the reddish pellet resuspended in 50 ml of buffer A containing 0.3 M KCl and centrifuged at 100,000 x g for an additional 1 hr. The resulting pellet is resuspended in 50 ml of buffer A, and Triton X-100 is added to give a final concentration of 2% (wt/ vol). After the suspension is gently stirred for 2hrs at 4°C, the solubilized suspension is centrifuged at 100,000xg for 1 hr. The reddish supernatant is then loaded onto a DEAE-Toyopearl column (3x14 cm) equilibrated with buffer A containing 1 % Triton X-100 (wt / vol) and eluted with a NaCl gradient (0 - 0.5 M) in buffer A. Fractions with the enzymatic activity are pooled, dialyzed against 2 liters of buffer A containing 1% Triton X-100, and then subjected to a second DEAE-Toyopearl column (1.5 x11.5 cm) also eluted with a linear gradient of NaCl (0~0.5M) in buffer A containing 1% Triton X-100. The fractions with arsenate reductase activity are pooled and loaded onto a sephacryl S-300 size exclusion column equilibrated with 10 mM Tris-HCl buffer (pH.0.8) containing 1% Triton X-100 and 0.25 M NaCl. The yellowish-brown fractions containing pure RasR are pooled.

Principal Findings And Significance:

We tested an enrichment technique for assessing the potential for arsenate respiration in environmental samples. Using sediments from the Ohio River in Pittsburgh we have assessed the impact of arsenic concentration (1, 5, 10, and 20 mM) and electron donor (hydrogen, acetate, formate, pyruvate, lactate) of the enrichment of arsenate-respiring bacteria. Our results suggest that while electron donor may not matter significantly, the concentration of arsenic does. We found that 5 mM sodium arsenate produced the greatest amount of arsenic trisulfide (within 48 to 72 hours), an indication of arsenate and sulfate reduction. While the bottles containing 10 and 20 mM arsenate did not show copious production of arsenic trisulfide (Figure 8), HPLC analysis indicated that indeed the enrichments had transformed a significant quantity of AsV to AsIII. Those enrichments containing 1 mM arsenate did eventually show indication of arsenite production (in the form of arsenic trisulfide) but after much longer incubation periods (weeks to a month). We are currently in the process of tabulating this latest result and are preparing a publication on the methodology. This matrix, in conjunction with our

biochemical and molecular probes should be quite useful for assessing the potential for arsenate respiration in other environments.

We have also completed the characterization a new species of *Clostridium* that we isolated from sediments of the Ohio River. Designated strain OhILAs, it is able to couple the oxidation of acetate to the reduction of AsV to AsIII. While it can grow on medium containing up to 40 mM arsenate, it can only reduce 10 mM as the concomittant production of 10 mM arsenite is inhibitory. It can use either acetate or lactate as electron donors and in addition to arsenate, use selenate, nitrate, sulfate, and thiosulfate as electron acceptors. We are investigating further whether OhILAs can respire selenite, as the HPLC analysis was inconclusive. We have, however, established that it has a respiratory arsenate reductase similar to the arsenate reductase from *B. selenitireducens* (see below). Of greater significance is our finding that OhILAs is not only resistant to the poultry feed additive roxarsone (4 hydroxy,3 nitrophenol arsonic acid) but readily transforms it. It is resistant to high concentrations (at least 5 mM) and depending on growth substrates will transform it within 24 h (1g/L yeast) to a week (glycerol). We are currently analyzing the end products.

In the past year we have purified the dissimilatory arsenate reductase from the haloalkaliphile *Bacillus selenitireducens*. This enzyme is comprised of two subunits of 110 and 34 kDa. N-terminal sequence analysis has revealed a high degree of homology (50% identity, 85% similarity) with the ArrA and ArrB of the arsenate reductase of *Crysiogenes arsenatis*. It also exhibits a higher affinity for arsenate with an apparent Km of 38 mM. The enzyme is robust and maintains activity in SDS-PAGE gels as long as the sample is not heated. Using the methyl viologen assay with SDS-PAGE, we can readily detect arsenate reductase activity in bacteria with this type of enzyme. Thus it will be useful for rapidly screening new isolates. We have successfully cloned and sequenced the gene encoding the catalytic subunit (ArrA), and in collaboration with Dianne Newman's group at CalTech, are designing oligonucleotide probes and PCR primers. We are also in the process of raising antibodies against the catalytic subunit of the enzyme for use as an environmental probe.

Student Supported:(name, major, degree)

Anna Polshyna, chemistry and biochemistry, Masters degree (RA supported by NIWR) Edward Fisher, biology, Masters degree (research supported), Miru Thangavelu, biology, masters degree (research supported).

Presentations and Other Information Transfer Activities:

Departmental seminar, University of Oklahoma, Norman OK, Department of Botany and Microbiology, October 18, 2002.

Departmental seminar, St. Vincent College, Department of Biology, January 24, 2003

A manuscript describing the purification and characterization of the arsenate reductase from *B. selenitireducens* has been submitted to FEMS Microbiology Letters. A manuscript describing and the isolation and characterization of *Clostridium* sp. Strain OhILAs is in preparation.

Information Transfer Program

Development of 4-H Water Quality Curriculum Materials

Basic Information

Title:	Development of 4-H Water Quality Curriculum Materials
Project Number:	2002PA1B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	5th of PA
Research Category:	Not Applicable
Focus Category:	Surface Water, Water Quality, Non Point Pollution
Descriptors:	Youth, Education
Principal Investigators:	William E. Sharpe

Publication

1. Drohan, J.R., W.E. Sharpe, and S.S. Smith, 2003, Water Quality Matters - 4H book (in press).

Problem and research objectives

Watershed coordinators and volunteer groups need a quick, simple reference to low cost passive acid water remediation techniques.

Methodology

Prepare an educational circular on acid water remediation for watershed coordinators.

Principal Findings And Significance

Dissemination of "Passive treatment methods for acid water in Pennsylvania" has been carried out through Extension and by direct contact with staff members of the Pennsylvania Department of Environmental Protection. Ms. Schmidt completed her degree and has been employed by the New York State Extension as a water resources educator.

Information Transfer Program

Basic Information

Title:	Acid Water Mitigation Methods
Start Date:	3/1/2001
End Date:	6/30/2002
Descriptors:	Water Treatment, Water Quality, Mining, Acid Deposition
Principal Investigators:	William E. Sharpe

Publication

1. Schmidt, K.L. and W.E. Sharpe. 2002. Passive treatment methods for acid water in Pennsylvania. College Agricultural Sciences, Agric. Res. and Coop. Extension, Univ. Park, PA. 19p.

Acid Water Mitigation Methods

Basic Information

Title:	Acid Water Mitigation Methods
Project Number:	2001PA2661B
Start Date:	3/1/2001
End Date:	6/30/2002
Funding Source:	104B
Congressional District:	5th
Research Category:	Water Quality
Focus Category:	Treatment, Surface Water, Water Quality
Descriptors:	Water Treatment, Water Quality, Mining, Acid Deposition
Principal Investigators:	William E. Sharpe

Publication

1. Schmidt, K.L. and W.E. Sharpe. 2002. Passive treatment methods for acid water in Pennsylvania. College Agricultural Sciences, Agric. Res. and Coop. Extension, Univ. Park, PA. 19 p.

PROBLEM AND RESEARCH OBJECTIVES

Watershed coordinators and volunteer groups need a quick, simple reference to low cost passive acid water remediation techniques.

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PRINCIPAL FINDINGS AND SIGNIFICANCE

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USGS Summer Intern Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	1	0	0	0	1
Masters	5	3	0	0	8
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	6	3	0	0	9

Notable Awards and Achievements

A major advancement in understanding of the occurrence of arsenic in groundwater has resulted from research by Dr. John F. Stolz at Duquesne University on the project Enrichment, biochemical, and molecular techniques for assessing microbial arsenic reduction. Dr. Stolzs research has enhanced our understanding of bacteria that can avoid the toxic effects of arsenic and use immobile arsenate compounds as a nutrient or energy source under anaerobic conditions. This reduction of arsenate compounds in aquifers or sediments is coupled with the oxidation of organic matter and leads to the release of toxic mobile arsenite compounds into groundwater or river water. Although naturally occurring arsenic is widely found in groundwater throughout the world, especially in parts of India, organic arsenic compounds are still widely used in swine and poultry industries in eastern United States. Stolz’s research has been summarized in the recent review co-authored with his collaborator Dr. Ronald S. Oremland, The Ecology of Arsenic in the May 9, 2003 of "Science."

Publications from Prior Projects

1. 2000PA4G ("The Use of Seasonal Oxygen-18 Variations in Modeling Shallow Groundwater Recharge") - Articles in Refereed Scientific Journals - McGuire, K. J., D. R. DeWalle, W. J. Gburek. 2002. Evaluation of mean residence time in subsurface waters using oxygen-18 flucuations during drought conditions in the mid-Appalachians. J. Hydrol., 261,132-149.