D.C. Water Resources Research Center
Annual Technical Report
FY 2005

Introduction

This report summarizes the activities of the District of Columbia (DC) Water Resources Research Institute (the Institute) for the period of June 1, 2005 through February 28, 2006. The fiscal year was again a very critical one for the Institute as a result of the probationary status levied by the review panel which assessed our five year evaluation report from 1998-2002. Initially, the Institute was placed on probationary status without eligibility for additional funding until remedial actions were completed to ensure that it met the requirements of the provision of section 104 of the Water Resources Research Act of 1984, as amended. However, an appeal of this decision was submitted to USGS by the Director of the Institute who highlighted changes and progress made within the two years of the new leadership. The appeal was denied, but the provision of probation was relaxed such that the Institute was eligible to apply for FY 2005 grant by June 1, 2005. The application was approved and below is a highlight of the implementation process to accomplish the following requirements:

1. Establish an Advisory Committee, a Technical Peer Review Committee; and an information transfer program including a regularly updated website.

A strategic Plan of Action Flow Chart was established and used as a monthly progress report to USGS. Guidelines for forming the Advisory Board and a Technical Peer Review Committee were established and implemented. Invitations to participate on the reestablished Advisory Board of the Institute were sent to Directors and Administrators of the following DC and Federal Agencies as well as Non Governmental Organizations in the District of Columbia:

1- DC Department of Health/Watershed Protection Division

2- DC Department of Health/Water Quality Division

3- DC Department of Parks and Recreation

4- Metropolitan Washington Council of Governments

5- USDA Cooperative State Research, Education, and Extension Service, National Water Program

6- Office of Water EPA

7- Chesapeake Bay Foundation

8- Anacostia Watershed Toxics Alliance, Office of Response and Restoration

9- Interstate Commission on the Potomac River Basin

10- Anacostia Watershed Society

11- U.S. Army Corps of Engineers

12- DC Water and Sewer Authority (WASA)

The Institutes received favorable responses from and met with the following new Advisory Board members:

1- Mr. Richard Gianni, Water Quality Manager, DC Water and Sewer Authority

2- Mr. James Connolly, Anacostia Watershed Society

3- Dr. Hamid Karimi, Manager, DC Department of Health/Watershed Protection Division

4- Dr. Edward U. Graham, Director of Water Programs, Metropolitan Washington Council of Governments

5- Mr. Simeon Hahn, Anacostia Watershed Toxics Alliance, Office of Response and Restoration

6- Mr. Doug Siglin, Chesapeake Bay Foundation

7- Ms. Kimberley A. Flowers, Director DC Department of Parks and Recreation

Invitations requesting participation on WRRI Technical Peer Review Committee were sent to our mailing list of faculty members and researchers in the consortium of DC Universities. The following members responded positively; however, only two reviewed the 7 proposals received for FY 2006:

1- Dr. Freddie Dixon (University of the District of Columbia)

2- Dr. Nancy Simon (US Geological Survey)

3- Dr. Harvey Lieber (American University)

4- Dr. James W. Mitchell (Howard University)

5- Dr. Ramesh Chawla (Howard University)

6- Dr. Leopold May (Catholic University of America)

7- Dr. Harriette Phelps (University of the District of Columbia)

The University of the District of Columbia hired a new webmaster to completely redesign the website and develop new mechanisms, procedures, and training to update program web pages. The Institute's site was redesigned and new information provided. Updates have not been as frequent because of the overload on limited staff; however, we have made several additions during the fiscal year.

2. Utilize the expertise at other universities in the District of Columbia in establishing research and information transfer programs.

An electronic mailing list of over 150 water resources faculty members and experts in the consortium of universities in Washington DC was established and has been sent regular information via email on local, regional, and national water issues when received by the Institute. This line of information transfer has enhanced the visibility and credibility of the Institute amongst these stakeholders and was truly reflected in the diversity of university faculty receiving seed grant awards for FY 2006. Only seven proposals were submitted for FY 2006; however, they were from five different universities. Listed below are the five grants awarded to researchers at five different universities.

The following five proposals were submitted and approved for FY 2006 grant.

1- Title of Award: Nutrient Flow and Biological Dynamics in the Anacostia River

Principal Investigator: Dr. Stephen E. MacAvoy, Assistant Professor

Department of Biology, American University

Grant award:$15,000.00

2- Title of Award: Assessment of Waterborne Contamination with Human Pathogens in Tributaries of the Anacostia River Using Asiatic Clams (Corbicula fluminea

Principal Investigators: Dr. Thaddeus K. Graczyk, Associate Professor

Department of Environmental Health Sciences, Division of Environmental Health Engineering, and Department of Molecular Microbiology and Immunology Johns Hopkins Bloomberg School of Public Health

Grant award: $15,000.00

3- Title of Award: Effect of Best Management Practices on Contaminant Levels in Storm Water Runoff to the Anacostia River

Principal Investigator: Dr. Charles C. Glass, Assistant Professor,

Department of Civil Engineering, Howard University

Grant award: $15,000.00

4- Title of Award: Silica and Siliceous Surfaces as Hosts for Hazardous Metals in Water

Principal Investigator: Dr. Aaron Barkatt, Professor

Department of Chemistry, The Catholic University of America

Grant award: $15,000.00

5- Title of Award: Wet-Weather Flow Characterization for the Rock Creek through Monitoring and Modeling Principal Investigator: Dr. Pradeep K Behera, Associate Professor

School of Engineering, Architecture & Aerospace Technology, University of the District of Columbia

Grant award: $15,000.00

This is a clear indication that the Institute is utilizing the expertise of other universities in the District of Columbia and will continue to strengthen the relationship by planning an annual conference to discuss new research problems and findings in the District.

Our matching requirements were met with non federal in-kind contributions from the indirect cost waved by each university and other collaborative match from the Department of Transportation. These research projects are related to DC drinking water quality, water chemistry and bio-monitoring of pollutants in Anacostia River and Rock Creek. These projects will provide water quality training for graduate and undergraduate students in the District of Columbia.

Research Program

The environmental quality of our Anacostia River continues to be the most urgent long term water resources problem in the District, hence the importance of storm water management and reducing runoff through Low Impact Development projects have become more critical. The Institute in conjunction with the School of Engineering and Applied Science has hired Dr. Pradeep K. Behera through a tenure-tracked teaching/research (67/33) faculty joint appointment. Dr. Behera is currently teaching Civil and Environmental Engineering courses. Dr. Behera possesses a vast research experience in the area of urban storm water management and his scientific findings have been published in peer reviewed journals and books. His recent journal article published include Runoff Quality Analysis of Urban Catchments with Analytical Probabilities Models in the ASCE Journal of Water Resources Planning and Management, Vol. 132, No. 1 January- February 2006 issue. His research areas of interest include Water Resources Engineering, Urban Storm Water Management, Non-point Source Pollution, Probabilistic and Statistical Modeling and Sustainable Urban Water Systems. He has been practicing engineering for last 15 years. He is an Associate Member of American Society of Civil Engineers and a Professional Engineer of Ontario, Canada. He will be working closely with the DC Water Resources Research Institute as a Research Associate Professor.

Dr. Tolessa Deksissa has also joined the Institute team as a part-time Research Associate. He will be working with innovative modelling software for predicting the movement of pollutants into DC water resources. Dr. Deksissa acquired his doctorate degree in Applied Biological Science: Environmental Technology at Ghent University, Belgium. His research interests include water quality analysis and modeling, environmental risk assessment, organic contaminant transfer in environment and the dynamic integrated modelling of fate and effect of conventional pollutants and organic contaminants in surface waters. His scientific findings have been published in peer-reviewed journals and books. He is an associate member of Society of Environmental Toxicology and Chemistry (SETAC), International Water Association (IWA) and River Network.

In an effort to assist in ascertaining and maintaining high drinking water quality in the District, the Institute is working with the DC Cooperative Extension Service, the School of Arts and Sciences and the School of Engineering and Applied Sciences to establish an EPA certified Water Quality Testing Laboratory. We anticipate that the lab will be fully functional after the 2006 summer and will proceed to achieve EPA certification in two years. This lab will allow the Institute and the Extension Service Water

Quality Education Program to serve as an unbiased monitor of DC drinking water quality through random sampling and testing of residential homes and public and private facilities.

A letter of intent to support and collaborate with the Chemistry Department at the George Washington University (GWU) was submitted by the Institute for an instrumentation proposal to the National Science Foundation. The proposal is for the purchase of a laser ablation-inductively coupled plasma-mass spectrometer (LA-ICP-MS) as a key testing instrument. This collaboration will enhance our ability to train 15 to 20 undergraduate Environmental Science students in the practical use of the LA-ICP-MS annually and also expand the Institute's research capabilities

The Institute collaborated with the School of Engineering and Applied Sciences at the University of the District of Columbia to sponsor the International Conference on Renewable Energy for Developing Countries (ICREDC-06) held April 6-8, 2006 at the OMNI Shoreham Hotel. This was one of the first conferences of this kind, addressing not only the needs and importance for renewable energy sources in the developing world but also what designs are available. Various applications were presented that could literally transform the lives people, especially in the area of water availability. Mr. David Garman, the Under Secretary of Energy from the U.S. Department of Energy and Congressman Mike Honda (D) of California were guest speakers. The School of Engineering and Applied Sciences Center of Excellence for Renewable Energy (CERE) was inaugurated. A demonstration site, with a combination of a solar photovoltaic panel that can reposition itself to face the direction of maximum sun exposure and a wind powered turbine that can generate energy to pump water from a depth of more than 100 feet, was also highlighted. The Institute and the Cooperative Extension Service will add a solar powered weather station to the site this summer.

The DC Water Resources Research Institute will continue to provide the District with inter-disciplinary research support to both identify and contribute to the solution of DC water resources problems. These research and educational projects provide students with essential practical skills required for future job opportunities and also allow faculty members access to new technologies and equipment that develop their expertise in water resource management. The Institute and researchers continue to accumulate valuable experiences in water resource management as related to the social, economic, and environmental aspect of water quality and quantity in the District of Columbia.

The Development of a MEMS-based Integrated Wireless Remote Biosensors

Basic Information

Title:	The Development of a MEMS-based Integrated Wireless Remote Biosensors
Project Number:	2004DC56B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	Washington DC
Research Category:	Not Applicable
Focus Category:	Water Quality, Non Point Pollution, Toxic Substances
Descriptors:	
Principal Investigators:	Esther T. Ososanya, Wagdy Mahmoud

Publication

The Development of a MEMS-based Integrated Wireless Remote Biosensors

Annual Progress Report for FY 2005

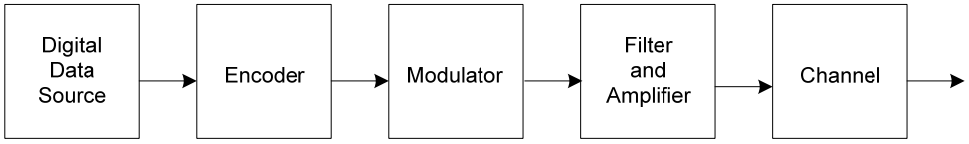
Prepared by: Dr. Wagdy Mahmoud and Dr. Esther T. Ososanya
Department of Electrical Engineering and Computer Science
School of Engineering and Applied Science
University of the District of Columbia

Date: June 2006

Prepared for the DC Water Resources Research Institute
Funds provided by USGS through the US Department of Interior

Introduction

The aim of this research is to study the feasibility of the design and implementation of an integrated wireless, low-power embedded biosensor monitoring system for the acquisition and transmission of biological functions from aquatic animals. The final goal of the research is to design a MEMS-based biosensor that can be integrated with a mixed-mode ASIC chip comprising of preamplifier, band-pass filter, analog amplifier, D/A module, modulator, transmitter, and a digital controller. The design will integrate MEMS, wireless communication, VLSI, and system-on-chip (BioSilico) technologies in the design of a low power environmental monitoring device. A schematic diagram of the digital communication system is shown in Figure 1.



Fgure 1: Schematic Diagram of the Transmitter for a digital Communication System

A large portion of the system has already been designed in a prototype level. The designed components include the preamplifier (shown in Figure 2), a two-stage band pass filter consisting of a low-pass filter (Sown in Figure 3) and a high pass filter (shown in Figure 4), and a variable gain amplifier shown in Figure 5.

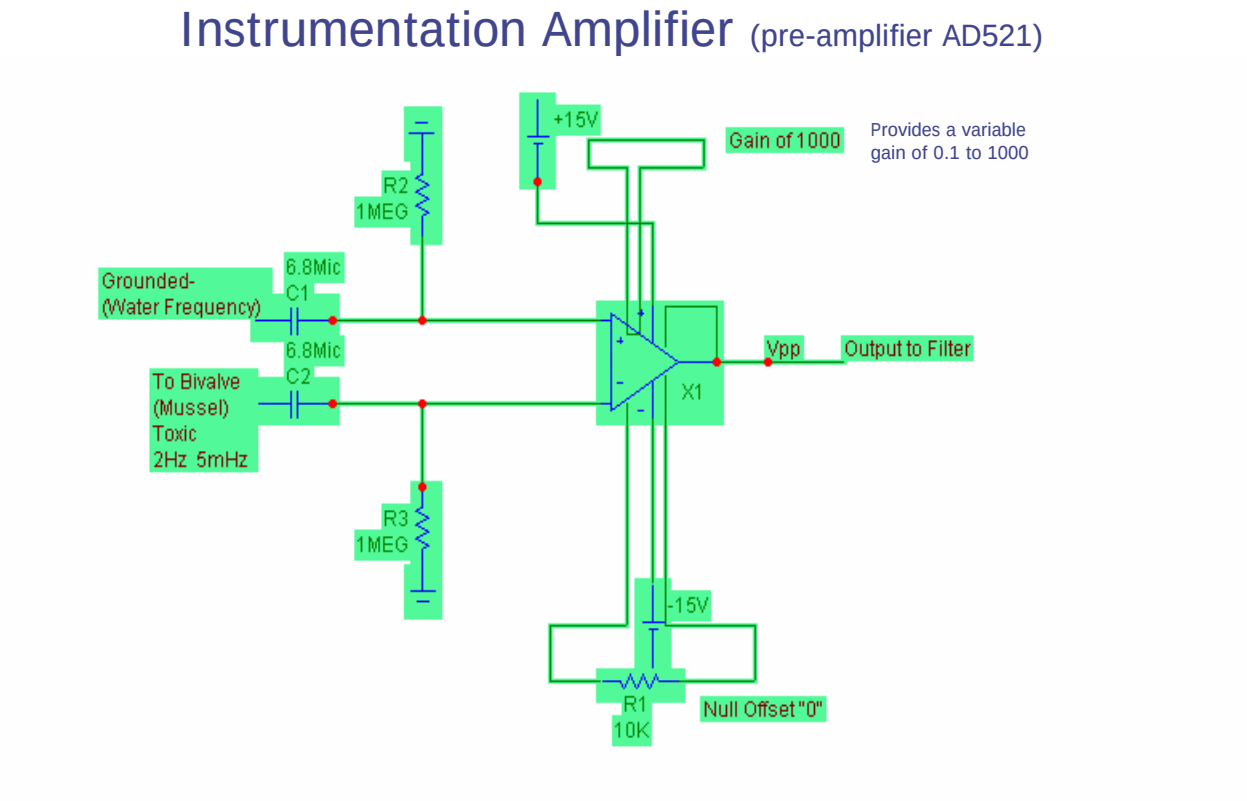


Figure 2: The preamplifier

First Stage Second-Order Low-Pass Butterworth Filter (LM324)

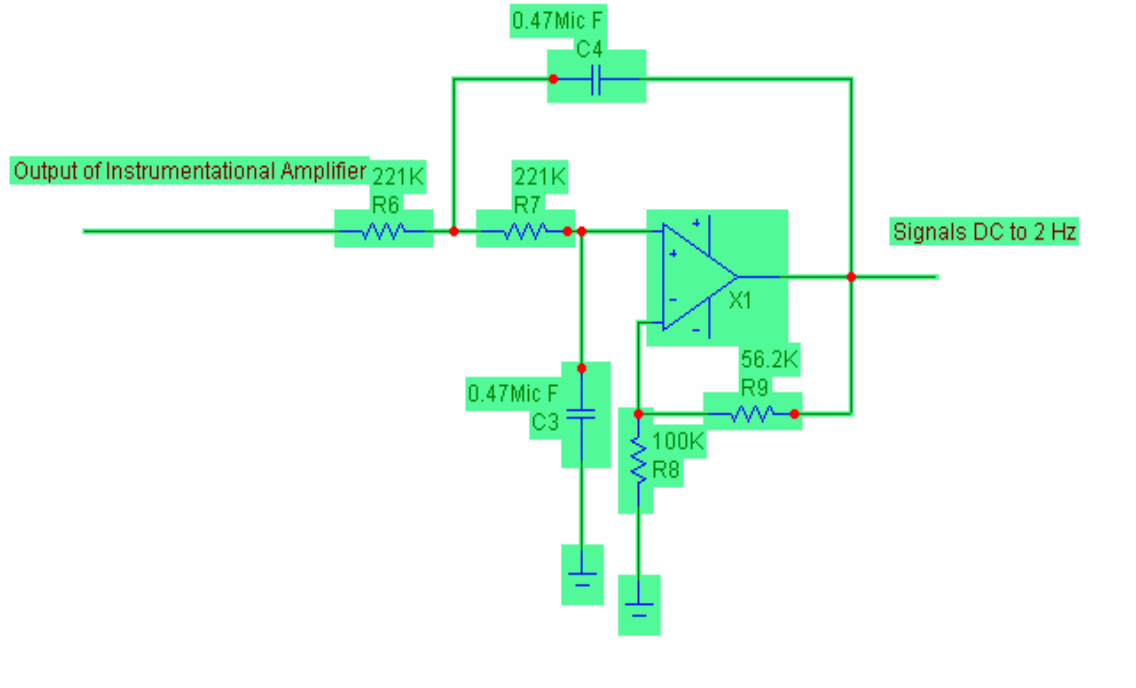


Figure 3: A low-pass filter design

Butterworth High-Pass Filter (LM324)

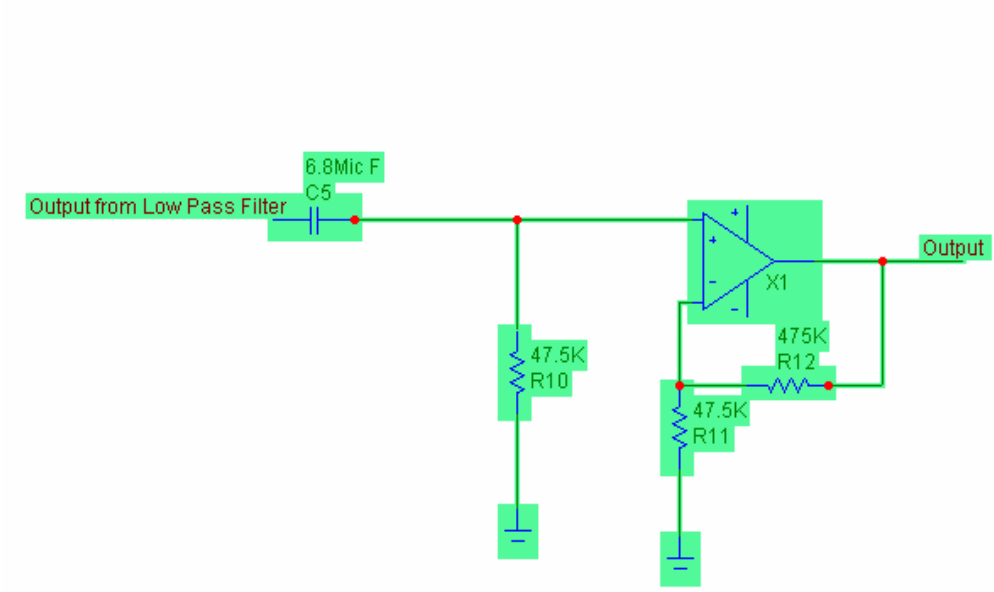


Figure 4: A high-pass filter design

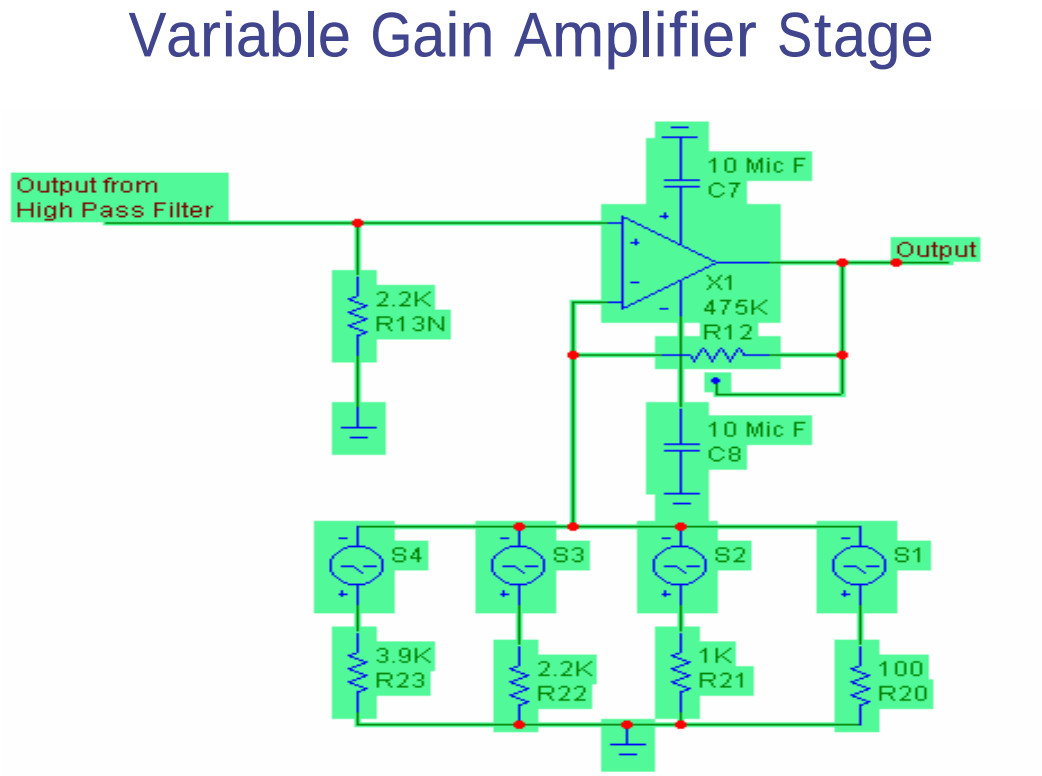


Figure 5: Variable gain Amplifier

The system also requires the design of a wireless communication RF system to transmit the acquired signals to a nearby receiving station. The basic building blocks of the wireless system include data modulator, phase-locked loop frequency synthesizer, spread-spectrum sequence generator, and RF power amplifier. Spread-spectrum transmission is superior to traditional narrow-band RF communication and can be designed to have high resistance to interference with RF spectrum users. Tight coupling such a communication system with the rest of bio-monitoring system will mandate placing it under water. The following section gives a brief overview of underwater acoustics and the major challenges facing designers of such system.

Underwater Acoustics

Until recently, underwater acoustics (UWA) communications systems were used in almost exclusively military applications. In past few years, there has been a huge increase in research and development of UWA communication systems for commercial applications. The need for such systems exists in applications such as remote control in offshore oil industry, speech transmission between divers, unmanned or autonomous undersea vehicle, and pollution monitoring of environmental systems.

In existing systems, transmitted signals can be grouped in four categories: control, telemetry, speech, and video. Control signals are used to send commands to submerged instrumentations and underwater robots. Data rates of control signals are usually small; however, highly reliable

systems are required. Telemetry signals are collected by devices such as hydrophones, and sonar systems. Data rates of telemetry signals are usually high, but very high reliability is not always required. Speech signals are transmitted between divers or between divers and surface stations. Speech transmission systems usually have data rates of few kilobytes per second. Video image transmission systems utilizing image compression techniques can send huge volume of data per second.

Underwater acoustics are usually band limited and suffers from the following features:

1. It produces irregular sound field at short distance. Unlike a point sound of sound in air, the intensity of sound near a point source in water is highly variable due to reflection from the oscillating surface boundary. Large and rapid fluctuation in amplitude or intensity is produced by reflection at the water surface.

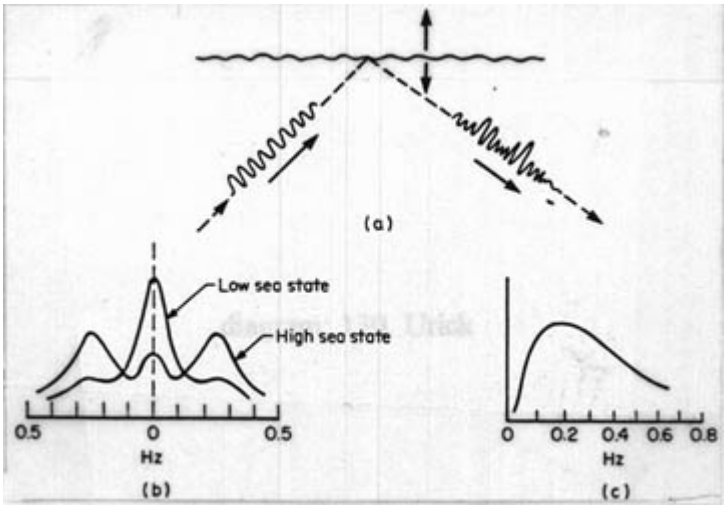


Figure a: a sinusoidal pulse is incident on the sea surface and is reflected and scattered as a pulse of variable amplitude and frequency; Figure b: Spectrum of the signal given in a; Figure c: the spectrum of the surface motion appears in, and widens, the spectrum of the incident sound

2. In addition to affecting the amplitude, the vertical motion of the surface wave superimposes itself upon the frequency of the sound incident upon it in the manner of frequency modulation. Therefore, it produces upper and lower sidebands in the spectrum of the reflected sound producing what is also known as the frequency smearing effect on a constant-frequency signal. *Frequencies different from the input frequencies appear at the output.* In addition, the generation of harmonics of the fundamental frequency occurs at the expense of the fundamental and portion of the power of the fundamental is converted into harmonics.
3. Underwater reverberation creates a shift in the center frequency of sinusoidal pulses causing what is also known as the Doppler shift. In addition, it causes a spreading out of the frequency band. In other words, it causes a change in the mean frequency and the spread of frequency spectrum.
4. Sound waves traveling in water encounter changes in temperature and pressure in different layer. In shallow waters, water temperature changes with depth and changes with seasons. This changes sound speed and signal refraction.
5. Water is more resistant substance than air; therefore, a greater force is required to drive pressure displacement in water. That is why underwater transducers use 'hard' piezoelectric

ceramics that have a reasonable displacement that force their energy into the water. This implies that designs that works in air may not work under water and some designs may work better than others may depending on the construction materials and the design technique. In addition, the quality of the water also affects underwater transmission systems; e.g., systems that can work in fresh water may not work in seawater or heavily contaminated water and systems that can work in aquarium may not work at all in realistic operating conditions.

Published literature provides solutions to many of the above stated problems. However, these solutions either implement computationally expensive algorithms requiring the use of a powerful computational engine and/or increase the power of the transmitted signal to compensate for the scattering and reflection effects.

Conclusions:

1. The communication system described above **cannot physically** work in real-life environment using a low power source. Designing the communication system as an underwater system will mandate the use of additional hardware and more power to operate the system. Commercial developed systems require substantial amounts of power in their transmitting modes. The question is How to power-up such a system?
2. Assuming that a solution for the power supply problem can be found, a large set of measurements of the system's operating condition including the ranges of the water quality, temperatures and velocity, noise, and reflective and refractive indices of the water. These measurements should be taken over a sufficient period in order to provide accurate design parameters for the system designer. This will require a much higher budget than the budget of this work

The main question:

Do we need to design an underwater communication system for this project?

In my opinion, the answer is NO. Environmental monitoring stations being developed and deployed in California, with funds from the NSF, use buoys to mark the locations of the stations and to carry a major portion of the system including data processing and communication. Similar scheme can easily be implemented in this project. The fish chamber can be attached to a buoy using a steel cable. The MEMS-based sensor can be integrated with an amplifier to amplify the sensed signals from the fish. The output of the amplifier should be connected via a coaxial cable that is parallel to the steel cable to the rest of the system housed in the buoy in a waterproof container along with a long-lasting set of batteries that supplies power to the system. The communication system for the modified design can efficiently be implemented using off-the-shelf standard components. The modified project will continue to have a research component consisting of the integration of a MEMS-based sensor with a VLSI-based amplifier. The design of such integrated device will be a major achievement. Such devices can be used in a wide variety of sensing applications.

BioSensor Project Progress Report
Dr. Esther T. Ososanya

Micromechanical systems (MEMS) technology integrates sensors, actuators, and electronics on the same silicon chip.
Work is in progress on the Mask layout of the following circuit modules and device structure:

1. Metal wire strips used as electrodes for detecting myoneural signals.

    (i) 3D Solid Model of the metal wires structure was built using the MEMS IntelliFab CAD tools to select and define the multiple microfabrication process steps layers for the microstrip device.

    (ii) The thin-film material properties of the microstrip structure were studied and analyzed using the IntelliSuite MeMaterial Analysis CAD tool. This allows us to characterize the thin-film material properties based on actual machine settings during fabrication. This step is important to ensure impedance matching of the probes and the instrumentation circuit to avoid signal loss. Accurate material properties are also necessary for accurate simulation results. Stress, Thermal variation, and Electrostatic analysis were also conducted on the microstrip device.

2. Instrumentation amplifier plus filter

    Using a circuit mask layout editor, the process technology for the mixed mode instrumentation circuit was defined. We are in the process of running SPICE simulation for transient analysis on this module.

3. Wireless Transmitter module

    (To be supplied by Dr. Mahmoud)

4. Final phase of this project will integrate all the above modules on the MEMS package, and repeat all the above simulations and analysis.

An Analytical Study of the Anacostia and Potomac Rivers

Basic Information

Title:	An Analytical Study of the Anacostia and Potomac Rivers
Project Number:	2005DC71B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	District of Columbia
Research Category:	Social Sciences
Focus Category:	Law, Institutions, and Policy, Water Quality, None
Descriptors:	None
Principal Investigators:	Julius A. Ndumbe

Publication

An Analytical Study on the Anacostia and Potomac Rivers

Annual Progress Report for FY 2005

Prepared by: J. Anyu Ndumbe, Ph.D
School of Business and Public Administration
University of the District of Columbia

Date: June 2006

Prepared for the DC Water Resources Research Institute
Funds provided by USGS through the US Department of Interior

Introduction

The Anacostia and Potomac Rivers run through Washington, DC. Both rivers suffer from poor water quality. Less than 2/3 of the rivers' water qualifies as healthy habitat for aquatic life, which is key to maintaining the health of the river. Over the years the activities and behavior of residents within the metropolitan areas have had adverse effects on streams and rivers. Water that run from lawns and streets storms into drains and streams picks up chemicals and excess fertilizers, pesticides and other chemicals that can make water unhealthy for human and wildlife. Pollution levels vary from river to river and the efforts towards cleanup has also taken a similar pattern. This is true the Anacostia and Potomac Rivers in Washington, DC.

Purpose of Study

The purpose of this study is to analyze the problem(s) afflicting the Anacostia and Potomac Rivers in Washington, DC. Particular emphasis will be paid to the sources of pollution and the role of the public and private sectors in cleaning these rivers.

Methodology

The method employed in this study is content analysis, which is a "detailed and systematic examination of the content of a particular body of materials for the purpose of identifying patterns, themes or biases" (Paul D. Leedy & Jeanne Ellis Ormrod, 2001, p.155). Content analysis help bring into context the problem being studied. Data on the Anacostia and Potomac Rivers was collected from many sources including: District of Columbia government publication, and literature published by the private organizations

involved with the river and major newspaper articles. A review of all this data helps distill vital information that is pertinent to a contextual understanding of the relevant issues in this study. Despite the helpful nature of this data in understanding the dynamics of the problems associated with both rivers, it fails to present a coherent and detail picture to the public perceptions on the state of the rivers and the various efforts geared at addressing the problems afflicting the rivers. The inhabitants of this region are important stakeholders in the cleaning-up effort of the river and revitalization plans. This is because both rivers are contributing tributaries to the Blue Plain – which is the source of portable water for the Washington, Metropolitan area.

(A) Anacostia River

The Anacostia River Watershed is located in the Washington, DC Metropolitan area. The river flows from Montgomery and Prince George's Counties to Washington, DC, where it flows into the Potomac River and eventually to the Chesapeake Bay. The watershed is comprised of three major drainage areas: the Northwest and Northeast branches and the tidal drainage. The Northeast and Northwest Branches are free-flowing streams and their confluence forms the Anacostia River in Bladensburg, Maryland. The drainage area is made up the river and its floodplain, and streams enclosed in the storm sewer systems. Excessive development on the land areas surrounding the Anacostia River has resulted in excessive surface runoff that contains metals, gases and debris that contributes to the degradation of the river and sedimentation along the segment of the river in Southeast Washington, DC. Rapid urbanization and uncontrolled development have contributed to the growing regional concern over the state and health of the river. This concern has forced varying interests

to explore way to clear the river. The Anacostia watershed currently includes several stakeholders of all socioeconomic and political backgrounds within Washington, DC and the suburban areas.

According to American Rivers the Anacostia River is polluted with a variety of substances from a variety of sources. Storm runoff, agricultural runoff, combined sewer overflow (CSO), sediment, heavy metals and other toxics constantly inundate the river to create a level of pollution which has caused American Rivers to categorize the Anacostia River as one of the 10 most polluted rivers in the United States in 1994, 1995 and on their endangered rivers list in 2000. (American Rivers web site 2001) Numerous entities have undertaken different studies on the Anacostia and Potomac Rivers over the years. In the 1990s the number of studies conducted by public and private institutions dramatically increased.

The Southeast Washington, DC segment of the Anacostia River covers 4,786 acres and approximately 32 percent of impervious area. The area is approximately 300 feet above sea level. Urbanization and development has contributed to the enormous hydrological transformation that the region has undergone. (Metropolitan Council of Government, 1999.) Prior to the arrival of the Europeans, "the Anacostia watershed was a thriving center of the Indian culture set amidst the Piedmont and Coastal Plain provinces in the early 17th century." The "Nanchotank Indian tribe" - -semi agricultural tribes inhabited the land area (Washington, DC) between the Potomac and Anacostia Rivers. The river at its virgin stage was habitat to a variety of fisheries. For example, red-breasted sunfish, white and yellow perch, catfish and herring were found in the river. The surrounding area was mostly covered with lust forest. This environment did

not only provide for a beautiful vegetal cover but was also host to numerous wild life that complimented the clear crystal Anacostia that flow into the Potomac River.

The arrival of the first European settler some 400 years ago paved the way for new human settlement to develop along the riverbanks of the Anacostia. These new settlements led to the proliferation of new land uses and urban centers. The urbanization process of Washington, DC that began with the arrival of the Europeans and continues today has drastically altered the natural ecosystem of the Anacostia River. Today the river is heavily polluted to the extent that it's difficult to find any semblance of its initial ecosystem.

Urbanization and suburbanization have greatly contributed to the transformation of the landscape of the Anacostia watershed. The building of road surfaces, commercial and residential buildings, parking lots, and sidewalks have greatly contributed to an increase in run-off into resulting from precipitation. The run-off from these impervious surfaces picks up debris and gases that are channeled into the river. It is important to add that the run-off in urban areas contain traces of metals such as mercury, copper, lead, Zinc, and petroleum hydrocarbons results from the exhausts of automobile dissolve in the run-off and are then transported to the river.

The sedimentation of the river from the cultivation agricultural field up-steam, erosion of the river banks and bed, high-suspended solid load has been complemented by runoff from paved and impervious areas to impair the biological and hydrological character of the Anacostia River. (Anacostia Watershed Network, 1999) Urbanization and suburbanisation have increased flooding, increased the deforestation and an influx of toxins and pollutants into the river. The Sewage inputs to the tidal river add organic

wastes, bacteria and debris into the river. It is important to note that the largest total suspended solids loads (TSS) generated in the Anacostia watershed comes from the Northeast and Northwest branches of the river. In fact, the annual TSS loading in the Anacostia watershed is estimated to be 48,200 tons, for an average of 0.43 tons/acre/year. (Warner, Shepp, Corish and Galli, 1997.)

Another problem afflicting the Anacostia River is the Combined Sewer Overflows (CSOs). Combined Sewer Overflows occur when the amount of runoff resulting from precipitation exceeds the capacity of this combined system resulting in the discharge of untreated sanitary waste and storm water directly into the river. It is estimated that about 6% of the annual pollutant load of the Anacostia are as result of CSOs. Additionally it is estimated that about 60 percent of the watershed in Washington, DC drains directly to the tidal Anacostia River through sanitary and sewer systems that date as far back as the 1800s. Consequently, constant broken sewage pipes created the problems of sew outflow to area. For Example, there are eleven main combined sewer outfalls to the Anacostia River and all discharge in the vicinity of the East Capitol Street and South Capitol Street bridges. (Anacostia Watershed Network, 1997)

(C) Cleanup Efforts in the Anacostia River

In 1996 the District of Columbia Environmental Regulation Administration produced an environmental report, The Anacostia River Toxics Management Action Plan, which included 113 references. The bulk of these citations were government, both Federal and local, reports, findings, regulations and studies. Ninety percent of the citations were dated in the 1990s. (pp.R1-R8)

In 1997 the United States Environmental Protection Agency (EPA) published a report An Environmental Characterization of the District of Columbia, which includes 90 citations over 90 percent of which were produced in the 1990s.

Both of these reports analyzed the levels of pollution in the waterways in Washington, DC. The recommendations outlined in each of the reports called for improvement of the condition waterways in the District of Columbia. The EPA report highlighted a need "to better communicate the idea of environmental risk to those persons whose activity patterns and lifestyles may result in potentially higher risks." (p.6-7) It called for the implementation of many of the recommendations in the 1991 Action Plan by Metropolitan Washington Council of Governments. The report also called on concerned parties to continue and expand cooperation among federal/state/local government agencies and other groups that are working to improve water quality and biological resources in the Anacostia watershed. Controlling non point source pollution and CSO is an important element of this endeavor. (p. 6-8)

The Washington Metropolitan Council of Government using the Simple Method (Schueler, 1987) estimated the annual Biochemical Oxygen Demand Load for the entire Anacostia watershed stood at 2,915680 Ibs/year. The Northeast and Northwest branches generated about 72 percent of the Biochemical Oxygen Demand

pollutant Load of the watershed. This level is about 5 times higher than the rate that exists prior to arrival of the Europeans in the Anacostia region. The Biochemical Oxygen Demand pollutant Load per sub drainage areas increases with increased size of the sub drainage area. It is important to note that high Biochemical Oxygen pollutant loads in the Anacostia River, especially during the summer months can reduce tidal river dissolved oxygen (DO) concentration to levels that are lethal to fishes and other river inhabitants. (Anacostia Watershed Network, 1997)

Various public and private initiatives have and are being undertaken to address the problems associated with the associated with the Anacostia Watershed. The clean up effort of private entities will include the work of organizations such as the Anacostia Watershed Network, the Anacostia Watershed Society and the Anacostia River Business Coalition. Each of these groups approaches the problems of the Anacostia watershed from their own unique perspectives. Additionally, the Government of the District of Columbia, Metropolitan Council of Governments, the Environmental Protection Agency (EPA), U.S. Geological Survey and National Parks and Planning Commission have over the years advance various approaches and plans designed to assist in the cleaning of the river. These governmental efforts have yielded little dividend. The combined efforts of the private and public sectors have to a limited extent contributed to advancing solutions, which are designed to address the problems of the watershed. Interestingly, none of these attempts have yielded maximum dividend. The failure to come up with a meaningful comprehensive plan for the Anacostia River in South East, Washington, DC confuses many because some will argue that part of the

Anacostia River inevitably flows into the Potomac River, which contributes to the Blue Plains. The Blue Plains provide drinking water for the Washington Metropolitan area.

Private bodies are embarking on several initiatives design to clean the river. Their activities range from educating the local population of the need for a clean river to developing comprehensive revitalization plans for the entire area. Private groups involved in different efforts aimed at revitalizing the river include: the Anacostia River Business Coalition, the Anacostia Watershed Society, the Anacostia Watershed Network, among others.

The Anacostia River Business Coalition (ARBC) was formed in 1997 by a group of businesses in and around the Washington, DC concerned about the health of the Anacostia River. The organization's main objective is to educate the citizen and businesses on the needs to control and prevent chemical pollution. ARBC undertakes a variety of projects that are design to clean and protect the river's shoreline and tributaries as well as serve as a conduct to link environmental projects with volunteered business.

The Anacostia Watershed Society (AWS) is a non-profit environmental organization that is working to restore and protect the Anacostia River and its watershed. The AWS was found in 1989 and through its volunteer restoration activities, the residents of the Anacostia watershed have the chance to be involved in determining their destiny and that of the river. The AWS since its inception has brought together 17,000 volunteers who have planted about 9,200 and have stenciled over 700 storm-drain within the watershed as well as removed 250 tons of debris and over 5,200 from the watershed. The organization has educated over 9,800 people using slides, explaining

the history of the river, the threats it presently faces and the various life style changes that people can undertake that will have a positive impact on the life of the river. (Anacostia Watershed Society, 1989.)

Equally important, the Anacostia Watershed Network, a non-profit group has undertaken studies and put out a comprehensive report, which identifies the various problems of the Anacostia river and proposed various approaches of dealing with these problems.

The Summit Fund, a private funding agency, has since 1993 “supported organizations working to bring about tangible and measurable improvement in the quality of life within the Washington, DC community.” In 1997 this organization responded to two important problems that had a direct bearing on the health and revitalization of the community. The present focus of the organization is on restoring and protecting the Anacostia River as well as one other initiative. Several recent grants have been directed towards outreach and education. The results of these programs are yet to be assessed. However, the focus of the grant recipients has not in the past been on that portion of the Anacostia River within the District of Columbia. Therefore it is doubtful whether the at-risk population will benefit from these programs.

The Private initiatives put together by private citizen to clean the river operate independent of the District government. These organizations are making serious contribution to the restoration of the river.

On the other hand, the District of Columbia government and other public entities have over the years made several attempts to clean the Anacostia River. Unfortunately, most of such efforts never took-off the ground or were simply abandoned for lack of

capital or the complete lack of political will. For example, in 1987 an intergovernmental partnership between the governments of the District of Columbia, Montgomery County, Prince George's county and the State of Maryland signed the Anacostia Watershed Restoration Agreement. The agreement was designed to formalize a cooperative partnership to clean up and restore the Anacostia River and its tributaries. Signatures of the agreement unanimously agreed to form the Anacostia Restoration Committee that was going to oversee development and restoration plans of the watershed. The Metropolitan Council of Government was also charged with providing the administrative and technical support to facilitate the Committee's efforts to restoring the watershed. Additionally, the Interstate Commission on the Potomac River was charged with conducting and implementing public education and participation program in the restoration effort and to develop a living resource program for the watershed.

It this vein that on March 22, 2000, the Mayor of Washington, DC, Anthony Williams on behalf of the District of Columbia and a dozen of federal agencies signed the Anacostia Waterfront Initiative Memorandum of Understanding (MOU) that created a partnership that will govern the creation of a new vision for the Anacostia River and its surrounding areas. This agreement represents the most important partnership ever crafted between the federal government and the government of the District. The agreement calls for the creation of a "new, energized waterfront for the next millennium, one that will unify the diverse waterfront area into a cohesive and attractive mixture of commercial, residential, recreational and open spaces."

Consequently, the District of Columbia's Office of Planning in collaboration with the General Services Administration, the National Parks Service, Office of

Management and Budget, Naval Washington District, Department of Labor, Transportation and others to develop a comprehensive and inclusive plan for the Anacostia Watershed. The new initiative for the Anacostia watershed come at the need time. (Office of Planning, Washington, DC, 2000.)

Despite numerous efforts by the District government to clean up the South east Washington, DC segment of the Anacostia River, it is still as polluted It is evident that the various cleaning-up initiatives of the Anacostia River have not been so successful over the years because the cleanup plan were never implemented properly and even in situation where implementations was done, it is usually in a disjoint and hap-hazard.

(B) Potomac River

The Potomac basin stretches across parts of four states – West Virginia, Virginia, Pennsylvania and Maryland as well as the District of Columbia. Its tributaries include the Shenandoah, Monocracy, Anacostia and the Occoquan Rivers This area cover what is often called the Potomac Water shed. About fifty-five percent of the basin is wood land with patches of agricultural land, urban and suburban developments. Almost all of the population of the Metropolitan area (approx. 6 million people) live in this basin.

Since 1965 when President Lyndon Johnson declared that the Potomac River was a “national disgrace” the Potomac has came a long way to meeting the goal of the Clean Water Act of 1970, which called for a promise of cleanable, swimmable and fishable water. Although much has been done to reduce and clean the pollution levels in the Potomac, evidence suggest that more still has to be done to restore the river to its original state. In waterways including the Potomac across the United States, researchers

found fish laden with estrogen and antidepressants. They also discovered that the fishes in these rivers showed evidence of major neurological or physiological transformation. (Juliet Eilperin, "Pharmaceuticals in Waterways raises Concerns" Washington Post, June 23, 2005; A03)

Another study that began in 2003 detected intersex among a significant percentage of smallmouth bass samples (55) collected from seven sites along the South Branch of the Potomac River including Indian Rock and Blue Beach Bridge above Romney, Old Fried Bridge above Moorefield, Fisher Bridge below Moorefield, Petersburg Gap above Petersburg and Petersburg below Petersburg . The study found that fish collected in "all but one in the sites South Branch had some incidence of skin lesions and some incidence of intersex." The source of the chemicals that contribute to the intersex condition among fish in portion of the Potomac river include poultry and animal manure, municipal sewage treatment plants, pesticides and herbicides. Run-off of these chemicals from fields applied with poultry litter to agricultural fields along the South Branch have also contributed to the pollution levels in the river. (www.wvrivers.org/poultrywaste.htm) Another major source of river pollution in the Potomac River is the massive amounts of discarded pharmaceuticals, which are often flushed down the drain, pose a threat to the aquatic life of the river and the health of people.

Additionally, rapid rate urbanization and suburbanization within the Washington, DC Metropolitan area has contributed to the increasing levels of pollution in the Potomac River. Run-off and Above surface runs washes and drains chemical into the river.

Cleaning the Rivers in the Potomac River

The Potomac River is one of 14 rivers designed out of 126 nominations from 46 states that competed for the presidential designation in 1998. The American Heritage Rivers Initiative focuses on three major objectives: economic revitalization, natural resources and environmental protection and, historical and cultural preservation. The Initiative helps communities of designated rivers to revitalize and river banks, natural habitats and helps celebrate their history and heritage. The Office of Surface Mining Reclamation and Enforcement at the U.S. Department of the Interior seized on the celebration ceremony to announce that for the FY 1999, a $150,000.00 grant to the Maryland Bureau of Mines to help control pollution from abandoned coal mines along the North Branch of the Potomac River. (Office of the Secretary, U.S. Department of the Interior, "The Potomac River is one of the 14 rivers designated" November 6, 1998)

In March 2005, the Alice Ferguson Foundation forged a clean up treaty – Potomac Trash Treaty -- between the representatives of the governments of the District of Columbia, Prince Georges, Montgomery and Charles Counties in Maryland as well as representatives of Fairfax county in Virginia committed to achieving a trash-free Potomac by 2013. The signatories to the treaty agreed to:

1. support and implement regional strategies aimed at reducing trash and increasing recycling;
2. increase education and awareness of the trash issue throughout the Potomac watershed; and

3. reconvene annually to discuss and evaluate measures and actions addressing trash reduction. (The Alice Ferguson Foundation, "DC-Regional Elected Officials Sign Potomac Trash Treaty, March 29, 2005)

The Potomac Trash Treaty forged the first ever historic coalition of political leaders to comprehensively deal with the issue water pollution in the region. The recognized that fact that trash and pollution flowing through Potomac watershed does not respect political boundaries. Collaboration of this nature if sustained will go a long way to developing recommendations that will adequately address the pollution problems afflicting the water shed.

In 1994, one of the goals of the Interstate Commission on the Potomac River Basin (ICPRB) and the Metropolitan Washington Council of Governments (MWCOG) was to educate the public on their role in cleaning the Anacostia River, and increasing their participation in other restoration activities. (Alliance for the Chesapeake Bay fact-sheet, updated by the ICPRB and MWGOG, May 1994) Although a public outreach program was initiated in 1988, very little was done to serve the most strongly at-risk population.

Additionally, the Potomac River Basin Initiative was the other public sector that contributed towards improving the part of the Anacostia River in South West Washington, which is a tributary of the Potomac. Although the initiative talked of the Anacostia River in its initial draft, evidence suggest that the problems of the river only exacerbated.

Conclusion

The Anacostia and Potomac Rivers are among American's most polluted urban rivers. The of pollution for these rivers is blamed on the private agricultural industry in Maryland as well as the residents of Maryland, Virginia and the District of Columbia for the pollution of the river as well as surface, and above surface run-off within the watershed area and urbanization and suburbanization. For many years the government did not pay close attention to the plight of urban rivers. In fact, for years the government failed to put in place meaningful and concerted efforts to clean and restore these rivers in general and the Anacostia in particular. Such benign neglect was a de facto contribution to the pollution problems that have afflicted the Anacostia and Potomac rivers for many years. It is important to add that these rivers are contributing tributaries of the Blue Plain – a major source of portable water for the Washington Metropolitan region. Perhaps this compounded with the public cry and call for cleaning both rivers, have resulted in cooperative agreements between private sector, the federal government and the government of the District of Columbia as well as intergovernmental partnerships between Montgomery County and Prince George's County in Maryland and the District of Columbia in recent years. There have been other public/private agreements that have been reached in order to enable a comprehensive clean up effort of the Anacostia and Potomac rivers.

The Anacostia River is one of the tributaries of the Potomac River. The Potomac River is a contributing source to the Blue Plains sewage treatment plant. Consequently, problems of the Anacostia River have direct or indirect consequences on the entire

Washington, DC metropolitan region. It is important that serious attention should be paid to the clean up efforts in the Anacostia and Potomac rivers.

Residents of the Washington, DC area are stakeholders in the watershed health. Private sector initiatives to educate residents on the health of the Anacostia and Potomac rivers, and development plans that are design to restore the watershed have resulted in improvements in the health of these rivers. Many private groups are active in cleanup efforts. These groups also organize workshops and training on essence of clean rivers and their impact on the health of residents. Pubic/private cooperative agreements have also encouraged and strengthen the relationship between the resident and their rivers. Consequently, the hitherto sense of abandonment and neglect, is gradually been substitute by one of encouragement and hope. Additionally, the recent government initiative such as the building of the Anacostia water front has added to this sense of hope and faith in government efforts and pronouncements. Continued cooperation between the public and private sector is one of the most viable approaches that would in the long-run sustain the revitalization the Anacostia and Potomac rivers.

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An Economic Impact Analysis of DC Drinking Water Quality

Basic Information

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Descriptors:	None
Principal Investigators:	Sharron Terrell

Publication

An Economic Impact Analysis of DC Drinking Water Quality

Annual Progress Report for FY 2005

Prepared by: Dr. Sharron Terrell
Department of Accounting, Finance and Economics
School of Business and Public Administration
University of the District of Columbia

Date: June 2006

Prepared for the DC Water Resources Research Institute
Funds provided by USGS through the US Department of Interior

Introduction

In January 2004, District of Columbia residents learned the drinking water supplied by the D.C. Water and Sewer Authority (WASA) was contaminated with lead (Swartz 2004 and Cohn 2005). The DC government immediately responded by forming the Interagency Task Force on Lead in Drinking Water (The Task Force) to investigate the problem and propose corrective action (Press Release, April 22, 2004). As a short-term solution to the lead leaching problem, The Task Force distributed water filters and test kits to some DC residents (Press Release, April 22, 2004) and informed households by mail and other media how to purify drinking water and water used for sanitation purposes (Williams and Swartz, C., April 22, 2004). Congress responded to the DC lead leaching problem by establishing the Lead-Free Drinking Water Act of 2004 (The ACT). The Act revised regulations regarding the acceptable level of lead in drinking water as well as legally established DC residents' rights to "a safe, lead free supply of drinking water," (Lead-Free Drinking Water Act of 2004). In testimony presented to the U.S. House of Representatives' Committee on Government Reform, Paul Swartz testified about negative health consequences to DC residents exposed to lead contaminated drinking water (Swartz, P., 2004). This study will assess household and commercial economic impacts implicit in the discussion of DC's drinking water problem.

The following tasks have been initiated towards the completion of the goal to assess the drinking water habits of DC residents.

1. A survey instrument has been designed to collect data on drinking water habits of DC

residents.

2. Four students were hired to administer the survey to DC residents randomly entering recreation and community centers. Students were given an orientation about the purpose of the project and assigned various tasks of a) contacting community centers to obtain authorization and access b) compiling names and addresses of DC churches and area supermarkets. Student employees are working approximately 15-20 hours weekly to complete the data collection process.
3. Student employees are also scheduled to compile survey information into a usable data set and will also conduct preliminary analysis of the data using Statistical Analysis Software (SAS).
4. One student has completed two training sessions to learn how to use SAS.
5. An additional 30 days is needed to conduct the survey, compile the data and generate preliminary results. This task will be conducted in the month of July.
6. An additional 30 days will be devoted to the analysis of results and preparation of a final report.
7. Supplies were ordered to facilitate the data collection process such as the SAS software, a laptop computer, pens, pencils and notebooks.

It's expected that the project will be completed according to the above plan and timetable.

Air-Deposited Pollutants in the Anacostia River Watershed

Basic Information

Title:	Air-Deposited Pollutants in the Anacostia River Watershed
Project Number:	2005DC73B
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Congressional District:	District of Columbia
Research Category:	Engineering
Focus Category:	Non Point Pollution, Climatological Processes, Models
Descriptors:	
Principal Investigators:	Abiose Adebayo, Lily Liang, Katya Verner

Publication

AIR-DEPOSITED POLLUTION IN THE ANACOSTIA RIVER WATERSHED

Annual Progress Report for FY 2005

Prepared by: Dr. Abiose Adebayo, Dr. Lily Liang and Dr. Katya Verner
Department of Engineering, Architecture and Aerospace Technology
School of Engineering and Applied Science
University of the District of Columbia

Date: June 2006

Prepared for the DC Water Resources Research Institute
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PROGRESS REPORT: AIR-DEPOSITED POLLUTION IN THE ANACOSTIA RIVER WATERSHED

The project Air-Deposited Pollution in the Anacostia Watershed aims to focus on the characterization of the contribution of aviation efflux to the adverse environmental poisoning of the Anacostia watershed. The combustion of aviation fuel leads to the build-up of nitrogen oxide (NOx) or airborne nitrogen. The investigation is complicated by, among other things, the breakdown or combination of aviation chemical aerosols with other chemicals in the air during the transport process. The diffusion and transport of these airborne pollutants and their eventual deposition in the watershed can be accomplished via wet and dry deposition mechanisms.

Airborne pollutants that fall to the earth's surface may be transported into streams, rivers, and the Anacostia River by runoff or through groundwater flow. A Technical Report titled: Fine Particles and Oxidant Pollution: Developing an Agenda for Cooperative Research by George M. Hidy, et al describes a background for the North American Research Strategy for Tropospheric Ozone (NARSTO). It suggests that airborne particles are suspended in complex mixtures of gases, including oxidants produced from photochemical reactions of VOCs and NOx.

These aerosols occur as complex internal and external chemical mixtures, whose physical and chemical natures are difficult to characterize. The aerosol and trace gases interact physically and chemically in a variety of ways. A particular important interaction involving atmospheric oxidants is associated with emissions of precoursor gases and particles in combination with oxidation processes in the gas phase. The challenge before researchers is to formulate a creative and rational method of defining the contribution of aviation-sourced pollutants that impact the watershed. These would be achieved by obtaining specific data on the volume and coordinates of the aviation aerosolized pollutants within the Anacostia River airshed and watershed.

The objectives of the present project include: 1) a comprehensive study of recent works related to the health of the Anacostia River as well as government policies that may impact the revitalization of the Anacostia River. In particular, the construction of the stadium along the River may have unfavorable ecological impact on the health of the River notwithstanding the stated economic benefits. The final report will address the dynamics of this new construction project in relation to the future health and clean-up of the Anacostia River. The National Environmental Trust (NET) provides a summary of major scientific reports on air pollution and public health. The reports include: The Importance of Population Susceptibility for Air Pollution Risk Assessment, Association of Particulate Matter Components with Daily Mortality and Morbidity in Urban Populations, Asthma in Children exposed to Ozone, Effect of Air Pollutants on Acute Stroke Mortality, etc. These and other reports can be found on the NET website at www.net.org ; 2) an objective definition of the airshed that impacts the Anacostia River and its estuaries. Literature survey revealed that considerable work has been done on the definition of the Chesapeake Bay airshed.

The region encompasses a vast area covering hundreds of thousands of square miles. The implication is that airborne pollutants released hundreds of miles from the watershed impact and get deposited in the watershed. However, our survey has not revealed similar body of work that seeks to define the Anacostia River airshed. It is important that the boundary of the airshed be accurately defined in order to model the airports that may impact the Anacostia watershed; 3) an assessment and review of literature pertaining to the source and nature of pollutants in the Anacostia River; 4) an analysis of existing models of airborne pollutants and their deposition mechanisms in the applicable watershed; 5) a presentation or development of alternative and more effective models for defining the load due to both wet and dry deposition caused by air pollution.

Such model will include; the neural modeling of pollution forecasting, application of numerical model to track the diffusion and transport of airborne pollutants, the use of fuzzy logic method to predict the relationship between air pollutants and watershed contamination, and the design of experimental algorithm to validate these various prediction models.

Within the past year, a comprehensive study of recent works related to the health of the Anacostia River and the impact on the surrounding population, as well as, the economic potential of the region has been undertaken. Unlike the substantial progress made in the remediation of the Chesapeake Bay over the past years, the condition of the Anacostia River has not improved. In fact, some studies suggest that the level of its pollution might be getting worse. This situation continues to impact adversely on the health of the surrounding population, especially through contact with the water and consumption of fish from the River. Various government policies and studies conducted over the past decade are summarized and enumerated in a report titled: Anacostia River and Tributaries Maryland and District of Columbia Comprehensive Watershed Plan – Section 905(b) (WRDA 86) Analysis.

These studies have carefully detailed the contaminant load in the River and proposed recommendations to alleviate and remediate the adverse impact on the environment. Several US Environmental Protection Agency (USEPA) studies and reports have detailed the chemical pollutants in the River and their health impact on the population. A USEPA Report titled: How to Measure the effect of Acid Deposition: A Framework for Ecological Assessments provide an assessment of airborne pollution of the Anacostia River. A detailed bibliography and synopsis of these reports will be provided in the final project report. Furthermore, an effort will be made to define the economic and ecological/environmental impact of the new stadium on the River. In particular, an attempt will be made to predict how the project might spur government action to mobilize necessary resources to effect the cleanup of the River.

Any attempt to develop theoretical/computational or experimental models to determine the contribution of airborne pollution to the contamination of the River must rely on an accurate definition of the boundaries of the pollutant “catchments” area, i.e. the airshed. So far our literature search has not revealed any meaningful publications or reports

detailing the Anacostia airshed. However, there are reports that define the Chesapeake Bay airshed. It is the aim of this project, therefore, to replicate the Chesapeake Bay airshed definition analysis to obtain an Anacostia River airshed. Such study would help to delineate the boundary of the region of pollutant emission that would impact the Anacostia watershed.

In addition, we are examining reports pertaining to other bodies of water, such as Lake Michigan. Water pollution in Lake Michigan by trace elements from pollution aerosol fallout authored by J.W. Winchester and G.D. Nifong was published in Water, Air, & Soil Pollution. The paper made a partial inventory of air pollution emissions for 30 trace elements in the Chicago, Milwaukee, and northwest Indiana metropolitan area and compared this with actual stream inputs measured for Zn, Cu, and Ni. The study concluded that the atmosphere may be a major source of Zn and other trace minerals in Lake Michigan. The report calls for more comprehensive chemical data to quantify unpolluted stream inputs for other elements in the Lake. More information is also available in **Deposition of Air Pollutants to the Great Waters, Third Report to Congress, June 2000.**

Efforts are underway to obtain the numerical model used in defining the Chesapeake Bay watershed from the Chesapeake Foundation. The Airshed Model (Regional Acid Deposition Model – RADM) tracks nitrogen emissions from all sources in the airshed. The model is three-dimensional; it stimulates movement both vertically and horizontally across a region. The airborne nutrients loads are transported by the Airshed Model and linked to the Watershed Model through deposition to land surfaces and to the Estuary Model through deposition to the water surfaces of the tidal Bay. In particular, efforts would be focused on the transport of airborne nitrogen and other byproducts of aviation fuel combustion. Computer models revealed that approximately 25% of nitrogen entering the Bay comes from the air.

The Bay airshed was defined as the area where NOx emission sources contribute 76% of the atmospheric deposition to the Bay and its surrounding watershed. Similar assumptions will be made in defining the Anacostia airshed. The Bay airshed is almost 350,000 square miles reaching from Toronto, Canada south to North Carolina and west to Indiana. The airshed configuration changes with continuous refinement and improvement in the computational model. Another challenge facing this present study is how to separate aircraft-induced air pollutants from those from automobiles and industries.

A comprehensive review of literature pertaining to the sources and nature of the chemical pollutants in the Anacostia River is currently underway. This task was assigned to the student member of the project team. The National Atmospheric Deposition Program (NADP) Library provides a wealth of data summaries, data reports, and technical reports focusing on the nature and sources of pollutants in the Anacostia River Watershed. The online database at http://nadp.sws.uiuc.edu/lib/bibsearch.asp contains numerous publications relevant to our problem. Upstream sources include both point and non-point

sources to waters above the fall line. Point sources of organic contaminants (PAHs and PCBs) are highly uncertain.

Urban runoff is a substantial source of select organic contaminants and metals to the Anacostia River. Below the fall line, atmospheric deposition loads increase in areas of the River adjacent to urban areas. It is believed that the regional airports in the Baltimore-Washington metropolitan area, as well as within the airshed contribute to the atmospheric deposition loads. Shipping and boating-related spills result in pollutant loads from jet fuel, gasoline, diesel fuels, asphalt, and PCBs. Pesticide loads to the River are largely unknown. Sources of chemical contaminants loads are dependent on land use characteristics. National Air Quality and Emissions Trends Report, 2000 features comprehensive information for the criteria pollutants and hazardous air pollutants, as well as relevant ambient air pollution information for visibility impairment and acid rain.

The Water Resources Research Journals contain several publications dealing with atmospheric contributions to water quality streams. A report by D.W. Fisher et al, details atmospheric contributions to the Hubbard Brook in New Hampshire. Other journal reports focused on the modeling of the effects of acid deposition, and the estimation of long-term water quality responses in a small forested catchments. The Water, Air, & Soil Pollution Journal carries publications addressing pollutant wet deposition mechanisms in precipitation and fog water; modeling the effects of acid deposition and control of long-term sulfate dynamics; and measuring dry deposition.

Nitrogen has been identified as a major component of airborne water pollutant. Nitrogen: Multiple and Regional Impacts is a 2002 USEPA report that summarizes atmospheric emissions, deposition, and impacts of oxidized nitrogen.

Evaluation of previous work and models on the evolution of air pollutions and the means of introduction to the waterways is underway and should be concluded by the end of July. In particular the Airshed Model developed for the Chesapeake Bay and several air pollution models for major waterways have been examined. The RADM involves 22,000 cells with each cell measuring eighty kilometers square. Stacked up, the cells make fifteen vertical layers reaching about fifteen kilometers high.

Two new models are being presented to compute and simulate the mechanism for the deposition of airborne pollutant in the Anacostia River. The initial effort is focused on delineating the Anacostia airshed. A simplified Navier-Stokes analysis in Cartesian coordinate system will be implemented to simulate the transport/diffusion of a prescribed aerosol distribution under a given ambient atmospheric air flow. The real problem will be solved with accurate aircraft-induced pollutant subject to prevailing atmospheric conditions at different times of the year. Accurate weather data, in particular air movement patterns would have to be obtained from the NOAA. The given airflow data will be used as input to a numerical algorithm to predict the deposition of airborne pollution within the watershed of Anacostia. There are various numerical/computational codes available in the market; these codes will be evaluated for the most appropriate and cost-effective for our problem of interest.

Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, will be used to extract patterns and detect trends. Once the pollution loads have been defined, a neural network algorithm will be defined to reveal hidden patterns. A Fuzzy-Belief-State-Based Reasoning model has been developed based on similar work by Dr. Liang, one of the project associates. In a real world it is often true that not all of the variables in a state can be observed at a given time. In such cases, the observation data is determined incomplete. Also, the present data contain noise. From an uncertain and incomplete observed input state vector we propose to use fuzzy-belief-sate-base to complete the observation, account for the uncertainty with beliefs, and perform a type of reasoning to select a decision as a response to that input. This process involves fuzzification, data association, belief inferencing, decision retrieval, and decision adjustment. This method can be used to capture evolutionary process whose interrelationships change over time. This will enable the prediction of the relationship between air pollutants and watershed contamination.

Preliminary assessment of experimental investigation using spectrography to monitor air chemistry suggests that one has of find a way to resolve the anomaly created by optical pollution in urban areas that will affect the result of the spectrographic analysis. Air contains molecules and radicals characterized by elements, such as, nitrogen and phosphorus.

At the conclusion of this phase of the project, the team plans to embark on a multi-year effort to perfect the various schemes described above.

Effect of Pelletized Poultry Manure on Vegetable Production and Vadose Zone Water Quality

Basic Information

Title:	Effect of Pelletized Poultry Manure on Vegetable Production and Vadose Zone Water Quality
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Descriptors:	None
Principal Investigators:	James R. Allen

Publication

Effect of Pelletized Poultry manure on Vegetable Production and Vadose Zone Water Quality

Annual Progress Report for FY 2005

Prepared by: Dr. James R. Allen, Researcher
Agricultural Experiment Station
University of the District of Columbia

Mary Farrah, Student, Research Assistant
Department of Environmental Sciences
University of the District of Columbia

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Introduction

Poultry produced from the Delaware, Maryland, and Virginia (DELMARVA) poultry industries in applied on farmland along with chemical fertilizer for crop production. However, a significant amount of unused manure is stored for future usage or remains to be disposed of. Perdue AgriRecycle Inc. has cleaned, sterilized, and pelletized poultry manure for easy handling and movement in crop and vegetable production. This material has been analyzed for nutrient content; however, not much data is available to demonstrate its effectiveness in crop and vegetable production as well as its effect on ground water quality or pfeisteria proliferation. Residents of Washington DC grow vegetables in their backyard and could potentially use this material as a soil amendment. Therefore, this experiment is designed to determine the effectiveness of pelletized poultry manure as a soil amendment in vegetable production and its potential effect on DC water resources. Information generated will be used for extension and outreach to benefit the residents of Washington DC. This project will impact both our sustainable agriculture project of recycling waste as a soil amendment and our efforts in enhancing environmental quality.

The Chesapeake Bay Agreement signed by leaders of Delaware, Maryland, Washington DC, and Virginia promises a 40% reduction in the Bay's nitrogen and phosphorus level by the year 2010. This reduction campaign was initiated particularly because of a chemical fertilizer and poultry manure in crop production areas. Eutrophication, caused by excess nitrogen and phosphorus, has also reduced the Bay's sub-aquatic vegetation significantly. The most recent Chesapeake Bay report, July 2002, indicates no improvement in the Bay's water quality. On a scale of 100, the Bay's environmental quality was graded as 27, which is extremely low. In fact, this grade did not change from the previous year regardless of clean up efforts.

Objectives:

1. To determine the extent to which pelletized poultry manure affects water quality when used as a soil amendment in growing vegetables.
2. To determine the feasibility of using pelletized poultry manure as a substitute for commercial fertilizer in the growing of vegetables in urban areas.

Progress Toward Achieving Objective 1

To achieve experimental objectives, an experimental plot has been established with soil of silt loam. The experimental design is a randomized block with three replications per treatment. This design has six blocks with each block representing one of six treatments. This six treatments being used are:

1. 2,000 kg ha^{-1} of chicken manure pellets + 500 kg ha^{-1} of commercial fertilizer (10-10-10).
2. 500 kg ha^{-1} of commercial fertilizer (10-10-10) only.
3. 1,000 kg ha^{-1} of chicken manure pellets + 500 kg ha^{-1} of commercial fertilizer (10-10-10).
4. 2,000 kg ha^{-1} of chicken manure pellets.
5. 1,000 kg ha^{-1} of chicken manure pellets.
6. No chicken manure pellets or commercial fertilizer. (Control or check plots).

In the experimental design, main plots are the six above named treatments and the crop varieties are butterbeans and collards as subplots. After clearing seed beds of surface debris, chicken manure pellets were added by broadcasting over the field surface with a manually operated garden seed spreader. Each main plot is 60ft. x 15ft. and subplot 15ft. x 10ft.

After treatments were added (Nov 20, 2004), two lysimeters were added to sample the water of vadose layer in each main plot at the distance of 20ft. apart. These lysimeters were each placed at two different depths, one 18 inches and the other 36 inches (Figs. I, II, III). The lysimeters installed were model 1920 FI pressure/vacuum soil water sampler. Each lysimeter at the 36 inch depth had a 1.5ft. long PVC pipe 1.5 inches

in diameter. They both had a 2 bar porous ceramic cup at the bottom end and two ¼ inch tubes protruding from the top (area about one foot above the soil surface) which was otherwise sealed. One of the tubes is connected to a 2006 G2 pressure/vacuum hand

Figure I. **Lysimeters being installed in the poultry pellet amended plot by William Hare and James Allen.**

Figure II. **Lysimeter in place at a depth of 18 inches.**

pump which will be used to collect water samples. The lysimeters were put in place on November 20, 2004.

Figure III. Lysimeter placement at the experimental site being reviewed by James Allen.

To protect the field from erosion, and ordinary cover crop variety of rye was broadcasted on the field plot at about a rate of four bushels per acre. They were planted on December 10, 2004 and the field plot is now well covered with the rye vegetation. Water sampling of the Vadose layer of each plot will begin in mid-January, 2005 and continue on a regular basis from that time onward. Collards were planted from seedlings on April 15, 2005 and butterbeans from seeds on the same date. The two crop varieties will be planted in each main plot. These main plots will each have six subplots 15ft. x 10ft. with 36 inches wide rows. Collards were planted 18 inches apart within rows from seedlings approximately 4.0 inches high while butterbeans will be planted from seeds within rows about 12 inches apart. During the growing season plots were kept well cultivated with the use of a garden cultivator or by hoeing.

Data collected during the growing season were Vadose water samples at 18 in. and 36 in., soil bulk density, soil porosity, seed yield of butterbeans and biomass data of both butterbeans and collards. Vadose water samples were be analyzed for nutrients such

as phosphorus, nitrogen and heavy metals where feasible. Data collected will be statistically analyzed, using the analysis of variance (ANOVA) to correlate the amount of chicken pellet manure added to crop yield and water quality (amount of the above named chemicals in the soil water samples).

Research findings will be communicated by paper presentations in professional meetings and the publications of journal articles.

Progress Towards Achieving Objective 2

Experimental plots seeded to rye as a cover crop in November, 2004 are now well covered with lush vegetable growth (Fig. I). Soil samples were taken from experimental plots on April 26, 2005. Sampling techniques included the following:

a) Sampling at depths 0-6 ″, 6-12 ″and 12-18 ″.
b) The field was divided into sections and duplicate soil samples were taken from each treated section in order to increase accuracy of analysis. (Figs. IV, V, VI, VII, VIII, IX).

Figure IV. Experimental plots covered with rye showing early lush spring growth.

Soil samples are now being air dried and will be sent to analytical labs for analysis to determine concentration of N, P and organic matter (OM) content of the soil given the palletized poultry manure compared to that amended with commercial fertilizer.

Figure V. **Student Assistant Raphil Billy take soil samples at the 0-6" depth.**

Figure VI. **William Hare taking soil sample at the 6-12” depth.**

Figure VII. **Soil samples being collected by researchers James Allen and William Hare.**

Figure VIII. Soil Sample being examined before sent off to a laboratory for chemical analysis.

Water samples from Lysimeters located in each treatment block at depths of 18 and 36″. In addition to the N and P concentrations mentioned for the soil samples, the water samples will also be tested for coliforms.

Figure IX. Student intern, Mary Farrah, taking water samples.

Preliminary Results

Highest organic matter concentration was in plots given the highest rate of poultry pellets (Table I). The lowest concentration was in plots given 0.45 g/Kg of soil and no fertilizer. This may be explained by the fact that a cover crop of rye might not produce as

Table I. Nutrient accumulation in soil based on sample depth and application of poultry pellets.

Treatments & Application Rates	**Sample Depth** (in.)	**P** (kg/ha)	**K** (kg/ha)	**Mg** (kg/ha)	**Ca** (kg/ha)	**pHw**	**pHg**	**CEC**	**% OM**
1	0-6	37.0	117	90.7	880	5.40	7.55	6.05	1.65
Pellet: 2,000 kg/ha	6-12	4.48	58.2	76.2	670	4.95	7.55	5.45	—
10-10-10: 500 kg/ha	12-18	11.8	77.8	113	963	4.90	7.38	7.65	—
2	0-6	23.0	95.8	86.8	861	5.30	7.58	5.65	1.50
Pellet: 0 kg/ha	6-12	5.60	65.5	85.1	642	5.00	7.55	5.40	—
10-10-10: 500 kg/ha	12-18	3.36	71.1	104	766	4.85	7.43	6.75	—
3	0-6	33.6	105	102	1,210	5.75	7.65	6.00	1.65
Pellet: 1,000 kg/ha	6-12	5.04	97.3	101	882	5.35	7.60	5.60	—
10-10-10: 500 kg/ha	12-18	3.36	70.6	104	952	5.05	7.48	6.8	—
4	0-6	65.5	110	113	2,103	6.45	7.70	7.60	1.60
Pellet: 2,000 kg/ha	6-12	7.84	65.5	84.0	1,151	5.70	7.68	5.60	—
10-10-10: 0 kg/ha	12-18	3.36	77.8	102	1,075	5.20	7.50	6.85	—
5	0-6	40.3	95.8	114	1,505	5.90	7.68	6.50	1.35
Pellet: 1,000 kg/ha	6-12	5.60	77.8	128	1,084	5.35	7.58	6.65	—
10-10-10: 0 kg/ha	12-18	3.92	81.8	127	1,012	4.90	7.48	7.00	—
6	0-6	37.5	104	123	1,558	5.95	7.70	6.45	1.50
Pellet: 0 kg/ha	6-12	6.16	71.7	119	1,122	5.30	7.53	6.85	—
10-10-10: 0 kg/ha	12-18	3.92	89.0	116	1,041	4.85	7.43	7.45	—

Table II. Average nutrient accumulation in soil based on rates of application of poultry pellets.

Treatments & Application Rates	P (kg/ha)	K (kg/ha)	Mg (kg/ha)	Ca (kg/ha)	pHw	pHg	CEC	% OM
1 Pellet: 2,016 kg/ha 10-10-10: 448 kg/ha	17.7	84.2	93.3	838	5.08	7.49	6.38	1.65
2 Pellet: 0 kg/ha 10-10-10: 448 kg/ha	10.6	77.5	92.1	739	5.05	7.52	5.93	1.50
3 Pellet: 1,008 kg/ha 10-10-10: 448 kg/ha	14.2	79.2	103	1,015	5.38	7.58	6.13	1.65
4 Pellet: 2,016 kg/ha 10-10-10: 0 kg/ha	25.8	84.8	99.7	1,444	5.78	7.63	6.68	1.60
5 Pellet: 1,008 kg/ha 10-10-10: 0 kg/ha	16.8	85.5	123	1,244	5.38	7.60	6.72	1.35
6 Pellet: 0 kg/ha 10-10-10: 0 kg/ha	16.5	88.5	120	1,241	5.37	7.54	6.92	1.50

much organic as plants in the other plots. However, at this point we cannot say why concentration of 1.50% OM in the control (treatment 6 in Table I) was more than 1.35% OM found in treatment 5 (0.45 g/Kg and 0.0g/Kg).

As expected, the highest concentration of total phosphorous was found in plots given the highest rate of poultry pellets (0.9 g/Kg of soil). However, when treatments 1 and 4 were compared, it appears that the absence of 10-10-10 did contribute significantly to phosphorous accumulation. Nutrients K, Mg, and Ca were relatively lower in plots given treatment 1 and 2 and that may be due to the pH levels of 5.08 and 5.05 in these plots (Table I).

Water sampling was somewhat difficult due to low accumulation of water in the lysimeters. The poor accumulation may be due to low rainfall resulting in little soil moisture. Another factor that may have had an impact on soil moisture accumulation was the soil compaction or high bulk density of the soil. This may have caused a significant amount of the rain to runoff rather than percolate through the soil, resulting in soil water accumulation only after significant rain events.

Both nitrogen and total phosphorous concentration in the soil was highest in plots given the highest rate of poultry pellets and 10-10-10 fertilizer (Table II). However, treatment 5 had the highest rate of nitrate/nitrite. This result cannot be explained at this point since treatment 5 had only half as much of the pellet as treatments 1 and 4 (Table II), but both still accumulated more nitrate/nitrite.

Table III. Nitrogen accumulation in soil water.

Treatments	Sampling Date	Lysimeter Depth (in.)	NO_3^-/NO_2^- (mg N/L)	Total P (mg P/L)	Total Kjeldahl Nitrogen (mg N/L)	Total Nitrogen (mg N/L)
1: Pellet: 2,016 kg/ha 10-10-10: 448 kg/ha	5/25/05	18	0.80	1.20	—	—
		36	0.65	0.85	7.6	8.25
2: Pellet: 0 kg/ha 10-10-10: 448 kg/ha	5/25/05	18	—	—	—	—
		36	0.20	<0.10	1.65	1.85
3: Pellet: 1,008 kg/ha 10-10-10: 448 g/ha	5/25/05	18	<0.10	—	—	—
		36	0.35	0.20	0.80	1.15
4: Pellet: 2,016 kg/ha 10-10-10: 0 kg/ha	5/25/05	18	0.60	—	—	—
		36	0.10	0.35	5.25	5.35
5: Pellet: 1,008 kg/ha 10-10-10: 0 kg/ha	5/25/05	18	0.15	0.10	1.90	2.05
		36	1.90	0.30	3.50	5.40
6: Pellet: 0 kg/ha 10-10-10: 0 kg/ha	5/25/05	18	0.20	<0.10	—	—
		36	0.10	0.15	—	—

In water samples collected so far, the presence of fecal Coliform has been found only in plots receiving the highest rate of pellet application (Treatment 1), given 0.9 g/Kg of poultry pellets l and 0.2 g/Kg of 10-10-10. Lack of soil moisture and clay content of soil, resulting in low water accumulation in the lysimeters, may cause difficulty in sampling. In many cases, lysimeter water samples were so low that they could not be analyzed.

There was no yield data for limas and collard greens due to poor stands.

Table IV. Presence of fecal Coliform in soil water as related to application of composted poultry pellets.

Treatments	Rate of Amendment Application	Sampling Date	Sample ID	Total Coliform (P/A Colilert)	E. Coli (P/A Colilert)
1	Pellet: 0.9 g/Kg 10-10-10: 0.2 g/Kg	10/13/05	T1A18"	Present	Present
			T1A36"	Present	Present
			T1B18"	Present	Absent
			T1B36"	Present	Absent
2	Pellet: 0 g/Kg 10-10-10: 0.2 g/Kg	10/13/05	No Water in Lysimeter	–	–
3	Pellet: 0.45 g/Kg 10-10-10: 0.2 g/Kg	10/13/05	No Water in Lysimeter	–	–
4	Pellet: 0.9 g/Kg 10-10-10: 0 g/Kg	10/13/05	T4A18"	Absent	Absent
			T4A36"	Present	Absent
			T4B18"	Absent	Absent
			T4B36"	Present	Absent
5	Pellet: 0.45 g/Kg 10-10-10: 0 g/Kg	10/13/05	No Water in Lysimeter	–	–
6	Pellet: 0 g/Kg 10-10-10: 0 g/Kg	10/13/05	T6A18"	Absent	Absent
			T6A36"	Absent	Absent
			T6B18"	Present	Absent
			T6B36"	Present	Absent

PLANS FOR FY 2006-2007

1. Yield data will be collected from the two test crops, sweet corn and lima beans. Harvesting of sweet corn and of lima beans is expected to occur by the end of July. Data to be collected and analyzed will be exclusively fresh market sweet corn and lima beans.
2. Water samples will be taken when significant rain events permit during the year. Soil sampling may be done before planting. Both water and soil sampling will be done again at the end of August when harvesting is expected to be ended.
3. In the fall of 2006, plots will be lightly disked and poultry pellets will be added prior to crop planting. The amount to be added will double based on preliminary soil and water test results.
4. Soil and water sampling data will be analyzed statistically and correlated to fresh weight of marketable yield of sweet corn and lima beans to determine how well

the pelletized poultry manure does as a soil amendment in the growing of fresh vegetables.

5. As mentioned before, in the fall, plots will again be seeded to cover crop rye.
6. All fresh market yield and soil and water analytical data will be analyzed using ANOVA along with appropriate test of significance techniques.
7. Test crops for FY 2006-2007 will be changed to sweet corn and lima beans. To further institute a rational rotation system, the crops will be changed to sweet corn and black-eyed peas in FY 2007-2008.

Information Transfer Program

The University of the District of Columbia hired a new webmaster to completely redesign the website and develop new mechanisms, procedures, and training to update program web pages. The Institute's site was redesigned and new information provided. Updates have not been as frequent because of the overload on limited staff; however, we have made several additions during the fiscal year. The Institute has also completed and electronically disseminated its first issue of the revamped Water Highlights Newsletter, Winter/Spring 2005. This twenty page document designed and published by student interns is very informative and highlights current research and educational projects sponsored by the Institute along with interactions among faculty members and their student interns on projects and conferences. The 2006 issue is completed and will be distributed this summer.

The Cooperative Extension Service/Water Quality Education Program Extension Agent, Ms. Wellela Hirpassa, has had a significant impact on the Institute's information transfer and outreach capacity. Listed are some of her accomplishments in conjunction with the Institute: prepared and distributed water quality education brochures and fact sheets to DC residents; conducted workshops on water quality education at various DC Recreation Centers and Public Schools; visited DC Water and Sewer Authority (DCWASA) Water Quality Division for potential collaboration; periodically visited USDA\CSREES National Water Program to enhance Water Quality Education Program for future collaboration; and participated on the Mid-Atlantic Regional Water Quality Program Steering Committee

In order to ensure consistency and continuity in the information transfer programs, the Institute has hired a Project Assistant that will coordinate its day to day activities. Ms. Mary Farrah, a former two year student intern with the Institute, is a 2006 summa cum laude graduate from the University of the District of Columbia with a BS in Environmental Science and an Associate degree in Water Quality. Mary will provide regular information for the website update and a quarterly newsletter.

Student Support

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

Notable Awards and Achievements

Publications from Prior Projects

None