Emerging Contaminants of Concern in the Environment: Sources and Potential Effects

As our ability to detect substances of concern in the environment improves, it increases the number of contaminants that need to be regulated under various environmental statutes. For the last four decades, the progressive improvement of sensitive analytical techniques has revealed the presence of several chemicals in the environment. Subsequently, the so-called “emerging contaminants” (ECs) have become an increasing area of concern for environmental research.
A recent research study conducted by the Cooperative Extension Service Center for Nutrition, Diet and Health, funded by the Water Resources Research Institute reported that before a blind taste of various types of drinking water, most participants, who live and/or work in the District of Columbia least preferred municipal water for drinking versus various spring, mineral, and distilled bottled water. Their perception of poor municipal water quality was based on bad taste. However, the blind taste test indicated that other than spring bottled water (34%), most participants preferred the municipal water (30%). Though the participants had a specific perception of municipal water quality based on taste, the reality from research data indicated otherwise.

The influence of the media during the lead contamination in DC municipal water created again other perception of poor quality municipal water not fit for consumption. The Washington Aqueduct (water treatment), the DC Water and Sewer Authority (water distribution), and the U.S. Environmental Protection Agency (water regulator) have reported and demonstrated that the application of orthophosphate as a corrosion inhibitor has curtailed the problem and our municipal water is now safe for consumption. However, after two years, the perception of poor municipal water quality, still persists especially among those residents that can least afford to continuously purchase bottled water. So, how do we change the perception of poor municipal water quality that has had a real economic impact on our residents?

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The Water Resources Research Institute has collaborated with the Cooperative Extension Service Water Quality Education Program, the Agriculture Experiment Station, the School of Engineering and Applied Sciences, and the Biological and Environmental Science Department to provide access to credible drinking, surface and ground water quality data to our residents and policy makers. Scientific data and extension education will be used to change perceptual behavior to behavior based on the reality. We have made significant progress in achieving this goal. The Water Quality Testing Lab in our Biological and Environmental Science Department has equipment to test water quality parameters such as nitrate, nitrite, and ammonia; phosphate and orthophosphate; carbonates and bicarbonates; volatile fatty acids; pH; turbidity; dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD); other nutrients; and heavy metals such as lead and arsenic. The Environmental Simulation Lab in the Civil Engineering Department has the capacity for urban water system analysis and optimization and storm water quality and quantity modeling (SWMM Model); wastewater treatment modeling and process optimization (WEST Model); and geo-referencing water quality problems (GIS). For more information on our capacity, please visit our website at http://www.udc.edu/wrri.

Data collected from random sampling and testing will be placed in a geographically plotted water quality web-database being developed by our own Computer Science student intern, Travis Branham, supervised by Dr. Li Chen. More information on this database is detailed further in the newsletter; however, when completed and active, it will provide our residents with direct access to drinking, surface, and ground water quality data. The Cooperative Extension Service Water Quality Education Program will provide the necessary outreach and education to train residents to utilize the tool. Our goal is to provide quality assurance regarding DC water resources while helping to change the negative perception. Please continue to read and enjoy articles of the amazing research projects implemented through the Institute to solve DC water resources problems while training students to become future research scientists.
Emerging Contaminants of Concern in the Environment: Sources and Potential Effects

As our ability to detect substances of concern in the environment improves, it increases the number of contaminants that need to be regulated under various environmental statutes. For the last four decades, the progressive improvement of sensitive analytical techniques has revealed the presence of several chemicals in the environment. Subsequently, the so-called “emerging contaminants” (ECs) have become an increasing area of concern for environmental research. Emerging contaminants include chemicals or materials that are characterized by a perceived or real threat to human health or environment and have a lack of published health standards or have a standard that is evolving or being reevaluated, along with the discovery of new sources, a new pathway to humans, or a new detection method or technology.

They may also be called emerging contaminants of concern and broadly defined as any synthetic or naturally occurring chemical or any microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and (or) human health effects. In some cases the release of emerging chemical or microbial contaminants into the environment has likely occurred for a long time but may not have been recognized until new detection methods were developed. In other cases, synthesis of new chemicals or changes in the use and disposal of existing chemicals can create new sources of emerging contaminants.

Being called an emerging contaminant or chemical does not mean that such chemicals of concern are new. These chemicals have been released into the environment as long as they have been in use. It is mainly related to a knowledge gap or reflects limitations in the chemical’s regulatory system at the national and international level. Regulation of emerging contaminants requires sufficient data or knowledge of the contaminants related to human health effects, occurrence and fate and transport in the environment including mobility and persistence. As these compounds are not measured or concentrations are below detection limits of readily available analytical techniques, there is no sound scientific evidence for the regulators. However some laboratory studies have shown these chemicals can be either endocrine disruptors or carcinogenic to wild life and hence expected to cause cancer to humans.

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Emerging chemical classes

Pesticides/herbicides
Chemical pesticides can kill not only the disease-causing organisms for which they were designed but also other living organisms beneficial to our environment. The ingredients of some of these pesticides might be used in chemical formulations whose environmental and human health effect is not well studied or known and thus not regulated.

Gasoline additives
Tertiary butyl alcohol (TBA) and methyl tertiary butyl ether (MTBE) are added to gasoline to improve oxygenation (NTP, 1995). MTBE was added at 11% by volume to almost all the

See Emerging Contaminants page 4
Emerging Contaminants, from page 3

gasoline used in California until December 31, 2002, and thus produced in high volume. These gasoline additives are known to cause cancer in rats and are suspected to affect human health.

Pharmaceuticals and antimicrobials

Two well known potential chemicals of concern in pharmaceutical products are antibiotics and sex hormones which can result in emerging resistant strains of microorganisms and endocrine disruption respectively. Limited amounts of drugs that are administered are assimilated by humans and animals. Consequently, portions of these substances may be excreted in wastewater to contaminate our water resources. Synthetic estrogen hormones are used as a growth promoter in beef production. Others such as ethynylestradiol and mestranol are active in birth control. These synthetic estrogens are persistent; and their occurrence in the environment has been linked to feminization of male fish, increased prostate and breast cancer in humans, and human male reproductive disorders. Significant amounts of steroid hormones are produced by Concentrated Animal Feeding Operations (CAFOs). Such highly potent emerging contaminants can contaminate water resources through agricultural soil amendment manure application.

Antibiotics are used in both humans and veterinary medicines to treat infectious diseases. As antibiotics become more widely used, resistant strains of both harmful and harmless bacteria are replacing antibiotic susceptible bacteria. The resistant bacteria in one environment may not be confined to that specific environment but may be carried far away by wind, water, animals, food, or people.

Furthermore, many of the soaps on the market contain some type of antibacterial agent which is persistent in the environment. Pollution with a persistent antimicrobial agent such as triclosan is widespread, affecting drinking water resources, agricultural soils, and aquatic sediments. Triclocarban is a trichlorinated phenyl urea pesticide used extensively as an antimicrobial additive. The effect of triclosan on environmental and human health is not yet known, but its possible contamination with dioxin during the manufacturing process has raised concerns. Dioxins are highly carcinogenic chemicals that can cause severe health problems including weakening of the immune system, decreased fertility, altered sex hormones, birth defects, and cancer. Another public health concern is that since TCC acts like antibiotics to kill bacteria, bacteria resistant to TCC could be resistant to antibiotics.

Personal Care Products

Personal care products include varieties of household products such as fragrances (artificial scents), insect repellents, and cosmetics (perfumes, soaps, nail polishers and lotions). Today, most fragrances are synthesized, primarily from volatile organic petroleum products. About 3,000 chemicals are used in the fragrance industry, but very few of these have been tested for their cancer-causing potential or other health effects. Some perfume and body lotion contain phthalates, which are suspected carcinogens and endocrine disruptors.

As pre-market safety testing, review, or approval is not required, cosmetics are the least regulated products under the Federal Food, Drug, and Cosmetic Act (FFDCA). A wide range of personal care products including shampoos, hair conditioners, cleansers, lotions, and creams, contain surfactants or detergents such as phthalates, ethoxylated alcohols, polysorbates, and laureths. These ingredients are contaminated with the potent and volatile carcinogens ethylene oxide and 1,4-dioxane. These compounds are highly volatile and both readily inhaled and absorbed through the skin which could pose a risk to human health.

Sunscreen Products

In an analysis of 785 different sunscreen products, the Environmental Working Group found 84% of those with a sun-protection factor (SPF) of 15 or higher did not give users the protection they boasted. Sunscreen does not actually prevent cancer directly; rather it blocks the absorption of UV lights (UVA and UVB), which causes sunburn and leads to skin cancer. Approximately 65% of melanomas and 90% of basal and squamous cell skin cancers are attributed to UV exposure. One should also note that not all sunscreens block all UV light, and only 15% prevent sunburn. Furthermore, some chemical ingredients used in most sunscreen products are carcinogenic and safety test results are not available. As these chemicals are absorbed through the skin they may enter the bloodstream. The cocktail of chemicals involved in sunscreens could be converted into “free radical” molecules, which could cause cell damage and lead to cancer (http://news.bbc.co.uk/1/hi/health/411226.stm).

Phthalates

Phthalates are a group of chemical compounds that are added to plastics to increase their flexibility, including dibutyl phthalate (DBP), benzyl butyl phthalate (BBP), di-2-ethylhexyl phthalate (DEHP), di-isononyl phthalate (DINP) and di-isodecyl phthalate (DIDP). Plastic materials used for various purposes such as personal care products and medical equipment like tubes and blood bags, may contain high levels of phthalates. Phthalates are also found in cosmetics and fragrances such as perfumes and other artificial scents (Houlihan et al., 2002; Duty et al., 2003). Phthalates are added to cosmetics and fragrances for multiple reasons: their oily texture helps substances penetrate and soften skin, and they help scented products last. The multipurpose chemical characteristics of phthalates have resulted in widespread occurrence of these compounds in our environment including in milk and milk products, and infant formulas (Sørensen, 2006).

The exposure of pregnant women to high phthalates in the environment is linked to initiation of fetal developmental abnormalities or interference with the development of male reproductive organs in the fetus (Hokanson, 2006; Houlihan, 2002). Phthalates are widely used ingredients in cosmetics and fragrances, and the consequences of constant long-term exposure to low concentrations of a mixture of synthetic compounds are not yet known.

Persistent organic compounds

One of the emerging persistent organic compounds is polybrominated biphenyl ether (PBDE) which is used in brominated flame-retardants, and is added to many common items such as electronic circuit boards, furniture, building materials, textiles, and vehicles. Significant amounts of PBDE are traveling through the food chain.
and have been found in common food products such as fish, meat, dairy products, and produce. PBDE also travels great distance and has even been detected in polar bears. PBDE levels in humans are rising in the U.S., but its human health effects have not been tested. High levels of this compound were also recorded in human fetuses (Mazdai et al., 2003). Laboratory experiments show exposure to PBDE in the womb and through nursing has caused thyroid effects and neurobehavioral alterations in newborn animals (Branchi et al., 2004). Rats and mice that ate food with decabromodiphenyl ether (one type of PBDE) throughout their lives developed liver tumors. Subsequently, EPA has classified decabromodiphenyl ether as a possible human carcinogen.

Can the available conventional wastewater treatments remove ECs?

The conventional water and wastewater treatment plants were designed to remove Biological Oxygen Demand, suspended solids, nutrients (nitrogen and phosphorus), and pathogens. As they are not designed to remove emerging contaminants, the current level of ECs in conventional wastewater effluent may not be safe. Recycling of wastewater effluent as a drinking water may also increase the concentration of these compounds in humans. Most ECs have a high affinity to activated sludge and might be concentrated in the biosolids. For example, mass balance study results suggested that approximately three-quarters of the mass of topical antiseptic triclocarban disposed of by consumers is released into the environment by application of biosolids on land as a soil amendment (Heidler et al., 2006).

This does not mean that the current conventional biological wastewater treatments remove no ECs. The conventional secondary wastewater treatments can remove 50 to 90% of hormones (natural or synthetic). This suggests that optimization of the existing wastewater treatment process may increase the removal capacity of some emerging contaminants, especially biodegradable ones. The highest removal efficiency can be achieved by applying advanced drinking water treatment processes such as granulated activated carbon, reverse osmosis, oxidation with chlorine and ozone under typical plant conditions. Such advanced treatment is also suitable for wastewater reuse. Coagulation, flocculation or sedimentation with alum and iron salts, excess lime/soda ash softening, ultraviolet irradiation at disinfection dosages, and ion exchange are all relatively ineffective methods of EC removal (Adams et al., 2001).

Opportunities and challenges in regulating ECs

The scientific evidence of the effects of emerging contaminants on human health and on the environment is in its early stages, and there is no sufficient toxicity data on the constant exposure of humans to very low concentration of mixed ECs. The rapid growth of both environmental and public health concern about these compounds creates an opportunity for the regulators and scientific communities to take timely action. Community pharmaceutical take-back programs that allow the public to bring unused drugs to a central location for proper disposal are good examples of proactive public action. Recent attention on emerging contaminants effects on aquatic life in the media is also creating pressure on public officials to do something about these contaminants. For example, the office of national drug control policy issued federal guidelines for proper disposal of prescription drugs (http://www.whitehousedrugpolicy.gov/drug-fact/factsht/proper_disposal.html). The challenge is that chemicals associated with emerging contaminants and their attendant by-products are found in numerous consumer, industrial, and agricultural products. Formulation of effective public policy requires appropriate source identification of ECs as well as the corresponding observed levels in the environment. Although the analytical techniques used to detect ECs are advancing, they do not tell us where these chemicals originated and how they made it into the water. Determination of point and non-point sources of ECs, together with the relative contribution of each chemical, needs to be the focus of future research. As ECs are a growing environmental problem, getting rid of them in the environment requires active participation of all stakeholders including consumers, manufacturers, researchers, environmental concern groups, regulators, and the development of effective pollution prevention measures.

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NTP. 2005. 12,3-Trichloropropene, report on carcinogens, eleventh edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program.

Development of a Web-based Application to Geographically Plot Water Quality Data

Government agencies, such as the U.S. Geological Survey, provide vast quantities of water quality data to the public, but it is often difficult for a citizen to find the data relevant to their specific location. Using a web-based application framework, along with Google Maps technology, it is possible to build a site that provides a geographical reference to the water quality data, allowing citizens to easily access information. The goal of this application is to bridge the gap between the availability of the data and its accessibility. Citizens visiting the site will be given the ability to search for the water quality testing locations nearest to them, and will then be presented with the actual testing results that have been found for that location on any given testing date.

This development of this site came about partly as a result of assisting one of my professors, Dr. Li Chen, over the summer on a project for the Water Resources Research Institute at the University of the District of Columbia (UDC). The project, for my part, consisted of building a database to mirror the water quality information for the DC area, compiled by the U.S. Geological Survey (USGS). As I worked to build the database, I was curious about what information the USGS had for locations near my neighborhood. Unless I knew the name of a specific testing location, however, I would have to guess which of the 67 metropolitan DC sites was nearest to my home. Finding the closest site was not the only issue; once found I began the arduous process of interpreting the actual testing results.

When I was asked to take part in the Washington Baltimore Hampton Roads - Louis Stokes Alliance for Minority Participation (WBHR-LSAMP) Summer Research Institute at UDC, the students were given the opportunity to come up with their own research topics. I decided to use the five-week program to build a web-based application to address the difficulties I had encountered finding relevant information in the USGS online database. Using a web application framework called Ruby on Rails, along with a MySQL database of water quality information, and the Google Maps application programming interface, I started building the application.

The resulting site allows residents in the metropolitan DC area to enter their address and find the water testing locations within a given radius. From there, individuals are presented with a series of testing dates which, when clicked, reveal the actual test results. The site can currently be found online: http://www.travisbranham.com/waterquality/

BY TRAVIS BRANHAM
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WRRI Attends the Steering Committee of the Anacostia Watershed Restoration Partnership

On August 9, 2007, Dr. Phelps sat in on the Steering Committee of the Anacostia Watershed Restoration Partnership meeting at the Metropolitan Washington Council of Governments (MWCOG), 777 N. Capitol St, NE. It was attended by representatives from EPA, the US Army Corps of Engineers (USACE), the DC Water and Sewer Authority (DC-WASA), the DC Department of the Environment (DC-DOE), the Maryland Department of the Environment (MDE), leaders of MWCOG Anacostia committees and other interested parties such as stream groups. Items included the Anacostia Waterfront Developers Panel, the upcoming Leadership Council Summit, the DC-WASA plans for controlling combined sewer outlets and nutrients, the Maryland State Highway perspective, watershed restoration planning by the USACE, and the Stormwater Management Act of 2007. The USACE presented a general 24-month timeline for restoration of the Anacostia watershed with final plans to be developed. It was decided to postpone the October Leadership Council Summit to early 2008.
Debating Water Quality: Washington DC and New Delhi

As a part of “DC meets Delhi”, a cultural event hosted by University of the District of Columbia (UDC), an academic panel comprising of academics, UN representatives, DC WASA officials and experts from volunteer organizations discussed urban water issues at the UDC on September 10, 2007.

The DC Urban Debate League and a High School Debating Team from Delhi took on the topic of water quality in urban areas. After preparation in their home city, the Delhi team debated with the Washington DC public school team on environmental and urban issues via videoconferencing followed by a discussion of the topic by environmental experts. This final debate was contextualized for students, teachers and the general public via (i) a series of documentary films on issues surrounding water usage, resources and socio-cultural needs in Delhi and Washington DC and (ii) a wide range of bibliographic and educational resource materials. The debates turned on critical environmental issues in urban areas, in particular that of water resources and quality. This topic was chosen because: (a) it transcends cultural and national differences; (b) the problem plagues both Washington DC and New Delhi and (c) consequently, it directly impacts students in both cities.

DC Water Resources Research Institute: Request for Proposals for FY2008

The Water Resources Research Institute (WRRI) at the University of the District of Columbia (UDC) was created in 1973 by the Water Resources Research Act of 1964 (PL 88-379) which established a federal/state partnership in research, information transfer, and education of new experts in areas related to water resource management. DC WRRI is one of a network of Institutes at land-grant universities, partly funded by the US Geological Survey (USGS), under the National Water Resources Research Institutes program.

WRRI mission is to provide the District of Columbia with interdisciplinary research support to identify DC water resources problems and contribute to their solution. The Institute maintains a website that highlights its mission and program overview. A publication list of water resources related research projects sponsored by WRRI over the past years is also available along with important issues related to DC water resources.

WRRI Seed Grant Program is requesting research, training and information transfer proposals related to critical areas of DC surface water, groundwater, and drinking water quality and quantity. Funds requested must not exceed $15,000 federal dollars and proposal budget must provide a 1:2 (federal to non-federal cash or in-kind match). Student training, an integral part of the Seed Grant Program, must be demonstrated in the proposal.
The Anacostia Watershed Society

The Anacostia Watershed Society (AWS, www.anacostiaws.org) is the oldest and most recognized group promoting the health and citizen awareness of the Anacostia River. Although the Anacostia runs along the lower edge of our Nation’s Capitol it has been called “America’s Forgotten River”, partly because much of it is National Park land and out of sight for local citizens. AWS was headed by Robert Boone 18 years ago (1989) with the motto of ‘START: Stop Trashing the Anacostia River Today’. AWS is now located at the George Washington House (Old Indian Queen Tavern) in Bladensburg, MD, with a staff of 15. In an interview, the Executive Director Jim Connolly said the AWS emphasis is on restoring the river to a fishable and swimmable condition through advocacy, education, restoration and recreation programs involving the communities of the Anacostia. Jim said AWS feels strongly that the appearance of the river is important and its activities are intended to focus awareness on the river. AWS mottos include “The River speaks for itself” and, since by focusing on the River the community benefits as well, “If you lift the River you also lift the Community”.

See Anacostia Watershed Society, page 12

EPA Web Information Tutorial for Water Resources Research

Washington DC, Dr. Phelps attended an intensive all-day workshop on Key EPA Internet-Based Tools for Watershed Management. For example, learning to “Surf Your Watershed” at www.epa.gov/surf/showed how to find combined information on any watershed from the US Geological Survey, the US Environmental Protection Agency and the US Department of Agriculture. This included links to online stream gage data and connections with existing State and Federal Programs and electronic discussion lists. For individual watershed Water Quality Database inquiries and mapping information the site is www.epa.gov/wqsdatabase/. Integrated data on watersheds is available at the Watershed Assessment and Tracking Results URL www.epa.gov/waters. There is a Database of Funding Opportunities at www.epa.gov.owow/funding.html. This very interesting course with limited enrollment was presented for just a few days at all EPA regional offices but the complete Overview-level Tutorial and its Workbook is available online at www.epa.gov/owow/watershed/wadacemy/epatools/. The WRRI office has a copy of the Tutorial available for examination. Dr. Phelps suggests anyone interested in working on the Anacostia watershed take a few days with this EPA Tutorial to learn the uses of this valuable aid to internet resources.
The United States Department of Agriculture-Agricultural Research Service (USDA-ARS) and the Mid-Atlantic Regional Water Program sponsored a conference from April 4-5, 2007 at the Beltsville Agricultural Research Center addressing Biofuels and Water Quality. The forum featured guest speakers and panel members from Maryland, Penn State, Purdue, and Virginia Tech Universities as well as from the USDA-ARS, Chesapeake Green Fuels, and the Environmental Working Group. The Chesapeake Bay Commission, the Chesapeake Bay Foundation, and the Maryland Grain and Soy Bean Producers were also represented on the panel. The presentations were divided into two segments; Ethanol as a Biofuel and Biodiesel and Gasification. Presentation topics ranged from ethanol production and the variety of crops conducive to ethanol conversion, to the economics and water quality implications of using ethanol as a biofuel.

The history of how ethanol first became a supplement if not alternative to fossil fuel consumption during the oil crisis of the 1970’s was one of many topics of discussion. Though technology and practices in ethanol production have improved vastly over the last 30 or so years making ethanol a more viable solution than before, several counterpoints were broached. It was pointed out that the production process used a fair amount of fossil fuel just in transporting necessary materials from point A to point B. Additionally, the choice of crops that grow in our climate zones also limit the feasibility and efficiency of ethanol use, whereas our counterparts in Brazil have a climate well suited to growing sugarcane. Unlike corn (the crop of choice for biofuel in the US), sugarcane is already a sugar and can be converted into ethanol much easier. Com needs to be converted from a starch to a sugar before it can be converted into ethanol.

One of the main issues of concern regarding water quality and preventing its degradation is the increased use of fertilizers to meet demand and to attain maximum yield of a nitrogen hungry crop like corn. The increase in fertilizer application can result in nutrients in excess of what the crop can readily utilize, subsequently contributing to non-point surface water pollution as a result of runoff or leaching into waterways. Another concern is that farmers will extend cultivation into the riparian buffer zone, compounding the problem of the over application of fertilizers and making the water ways and their inhabitants more vulnerable to the effects of pesticide use as well.

WRRI Attends Biofuels and Water Quality Conference

FEATURED

UDC RESEARCHER

Dr. Li Chen is a dedicated computer scientist and an Associate Professor of computer science at the University of the District of Columbia. He has been a visiting Assistant Professor at University of North Dakota. He has taught as an Adjunct Professor at Virginia Tech, Strayer University, and Trinity University in Washington, DC. He has been invited to give talks at the NIH, Georgetown University, University of Utah, George Washington University, Shanghai Jiaotong University (China), and the Software Institute at China Academy of Science, etc. Currently, he is working on the problems in discrete data reconstruction methods, especially gradually varied fitting for groundwater aquifers, image segmentation algorithms, and complexity analysis of algebraic groups.

Chen recently received a seed grant from the DC Water Resources Research Institute for 3D ground water modeling using gradually varied surfaces. He and his student intern, Travis Branhame, have worked closely with other members in the Environmental Simulation Lab. They have already gotten some preliminary research results in applying discrete fitting methods to real ground water results. In the next step of study, they will collaborate with other researchers to combine the industry standard software system MODFLOW to their ground water research project.

Chen’s related articles to discrete data fitting:


BY MARY FARRAH

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From February 20th through March 2nd, I spent 10 days out at sea while I volunteered aboard NOAA’s Albatross IV for the second leg of the Winter Bottom Trawling Survey (WBTS). The Northeast Fisheries and NOAA conduct 8 types of fishery independent surveys: spring and autumn bottom trawling surveys, sea scallop dredge surveys, hydraulic clam dredge surveys, summer Gulf of Maine trawl surveys on Continental Shelf, marine mammal sighting surveys, surveys of fish eggs and larvae, and special experiments. When the surveying ships are out at sea the crews are sampling around the clock, seven days a week. The areas surveyed are the Gulf of Maine, Georges Banks, and the Continental Shelf from New England to Cape Hatteras, North Carolina. The purpose of the surveys is to monitor recruitment, abundance, geological distribution of species, ecosystem changes, biological rates of stock, and to collect environmental data in addition to supporting other research.

We left from Woods Hole, Massachusetts for ten days out at sea in Georges Banks, but due to foul weather on the first leg of the WBTS, we sampled at stations in the Gulf of Maine and off the coasts of New Jersey and New York that had to be bypassed on the previous survey. Sampling stations are randomly selected at various depths. Fish species present at the sampling station have an equal chance of being represented by the data generated. The trawl nets would be set and then towed for roughly half an hour. The wench would then pull the net back aboard, the deck crew would typically dump the catch into the checker, and the scientists would then get to work.

Because the mission is scientific in nature, the trawl net is lined and capable of catching anything greater than 1 cm. This enables a whole spectrum of sizes and species to be monitored. Scientists can then determine the survival rate of young fish, the sizes of future harvestable stocks, and provide data on fish and other marine life that aren’t typically commercial stock. First we’d work by species; recording the weight of all the fish of a particular species present in the catch into the Fisheries Scientific Computer System (FSCS). Then we’d work recording the length of the individual fish within the species. Different protocols were in place depending on the species; some fish would be worked up with length differences as little as 1 cm. With that, the weight, sex, sexual maturity, volume of stomach contents, species of the prey, and its stage of digestion would all be recorded. In addition, the otoliths, scales or fins would also be collected.

The array of the catch was everything from shrimp 1cm in length, to striated argentines and butter fish, to scallops and loligo squid, to lobsters and crabs, to sea horses and pipe fish, to eels, spiny dog fish and skates, to mackerel, herring, flounder and butter fish, to black sea bass and cod. Ichtyoplankton and zooplankton were also collected periodically to monitor the bottom chain of the food supply and well being of the ecosystem. Salinity, temperature and other oceanographic and meteorological data was also monitored while out at sea.

The data gathered by these surveys is recognized as vital to discovering the influence that fishing and environmental changes have on not just fish stocks that are marketable, but a wide array of species.

For more information please visit the following website: www.nefc.noaa.gov/femad/ecosurvey/mainpage.

BY MARY FARRAH
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Occurrence, Fate and Transport Of 17ß-Estradiol and Testosterone in the Environment

**ABSTRACT:** Being the most potent endocrine disrupters, 17β-estradiol and testosterone have a growing environmental and public health concern. Despite significant quantities of these hormones being released into the environment through animal manure and wastewater effluent, their elimination through sorption and rapid degradation was suggested. Nonetheless, these compounds may persist in soil or sediments for several months, and their mobility and behavior in the environment is not well understood. Thus, this study reviews the current knowledge related to the sources and behavior of these compounds in the environment including their metabolites estrone and androstenedione, respectively. An overview of the current knowledge related to the occurrence, fate and transport of 17β-estradiol and testosterone in the environment is imperative. A better understanding of the factors and processes that affect the fate and transport of these compounds is of paramount importance.

**Introduction**

The widespread occurrence of steroid hormones in the natural water resources has been reported in both ground water and surface water including streams, rivers, ponds, estuaries, seas and oceans. 17β-estradiol (E2) and testosterone are naturally produced steroid estrogen and androgen, respectively. These compounds and their metabolites are relatively the most potent endocrine disrupters that may interfere with the normal functioning of the endocrine system at a very low concentration. For example, E2 was reported to reduce sperm fertility very drastically and induce vitellogenin in male trout at concentrations as low as 1 ng L-1 (Lahnsteiner et al., 2006). In general, exposure to E2 and its metabolite estrone (E1) in the environment was linked to feminization of male fish, decreased sperm counts, increased testicular, prostate and breast cancer and male reproductive disorder (Dickson et al., 1986; Harrison et al., 1997), whereas the presence of testosterone and its metabolite androstenedione in the aquatic ecosystem was linked to the masculinization of female mosquito fish (Thomas et al., 2002).

Despite those environmental and public health concerns, the processes and factors that affect the fate and transport of these compounds is not well understood. In laboratory studies, E2 and testosterone were shown to have a strong tendency to be sorbed into the soil or sediment organic matter, and degrade rapidly in soil and water. Subsequently the possibility of leaching into the ground water was indicated to be limited (Lee et al., 2003). Moreover, the persistence of these compounds in soils, ground water and surface water for several months is not consistent with the high sorption and degradation rate constants reported by the laboratory studies. Thus, for better characterization of their potential risk to the environment as well as human health, a better understanding of the factors and processes that affect the fate and transport of these compounds in the environment is imperative.

In this study, the available primary and secondary publications were reviewed and the current knowledge about the fate and transport of steroid hormones including their metabolites was discussed. As a result, the possibility of leaching of these hormones from the paper mill effluent and wastewater effluent into the soil or groundwater was indicated to be limited.

**2006 RESEARCH PROJECTS**

**Assessment of Waterborne Contamination with Human Pathogens in Tributaries of the Anacostia River Using the Asiatic Clam (Corbicula fluminea)**

The highly polluted 10 km freshwater Anacostia River estuary is the largest water body of Washington, DC, and the focus of environmental concerns. It runs along the lower third of the District and essentially separates Federal buildings and upscale housing from the poorer and mostly minority communities in the south and west districts. The Anacostia has been termed one of three Areas of Concern in the Chesapeake Bay and one of the 10 worst American Rivers. The District of Columbia is making plans for extensive waterfront development (Washington Post 2003) although the poor water quality of the Anacostia River has been known for years (Freudberg et al. 1989). There is a fishing advisory issued based on PCB and chlordane levels (Velinsky and Cummins 1994). The River has high bacterial levels (Washington Post 2004a) and tumors in catfish residing in this river are among the highest in the US (Pinkney et al. 2000, Washington Post 2004b). Anacostia benthic life is very poor and sediments have high levels of toxic contaminants (Velinsky and Ashley 2001; Velinsky et al. 1992; Phelps 1993; AWTA 2002). Amazingly, even with high coliform levels detected at the upper end of the estuary (Maeda and Connolly 2002), there have been no studies on human intestinal waterborne parasites such as Cryptosporidium parvum, Giardia lamblia, and microsporidia.

See Waterborne Contamination, page 19
Asian Freshwater Clams (Corbicula fluminea) as Biological Indicators of Waterborne Contamination with Human Protozoan Enteropathogens

Corbicula fluminea is a nonindigenous invasive bivalve species in North American fresh waters (Fig. 1). The species is well adapted for unstable and unpredictable habitats and is highly successful in waters impacted by agricultural runoff, wastewater discharges, and industrial pollution. It has been recognized that some bivalve species can harbor environmentally derived human pathogenic organisms as a result of concentrating, i.e., accumulation, the recovered pathogens from the surrounding water. Human protozoan enteropathogens such as Cryptosporidium parvum, Giardia lamblia, and microsporidia (i.e., Enterocytozoon bieneusi, Encephalitozoon intestinalis, and E. hellem) may bioaccumulate on healthy people, and can cause mortality (e.g., Cryptosporidium and microsporidia) in immunosuppressed individuals. Cryptosporidium and Giardia are very frequently transmitted via water, which is also involved in the epidemiology of microsporidian spores. These enteropathogens originate in potable waters from urban and agricultural runoff, malfunctioning septic systems, and wastewater discharges.

In order to determine if Corbicula fluminea clams collected from the Anacostia River contained the aforementioned human waterborne enteropathogens, the clams were depurated for three weeks in the laboratory. Clams were seeded daily at concentrations reported from surface waters demonstrated efficient removal of these pathogens by bivalves. The number of parasites in bivalve tissue progressively increased in relation to the concentration of waterborne contamination, and decreased after cessation of the contamination. The exposure experiments demonstrated that C. fluminea collected from the Anacostia River were contaminated with the transmissive stages of human waterborne enteropathogens such as Cryptosporidium parvum, Giardia lamblia, E. intestinalis, E. hellem, and E. bieneusi. The results of depuration experiments indicate that these pathogens are present in the Anacostia River water. Also, six-week laboratory exposure of C. fluminea to C. parvum and G. lamblia seeded daily at concentrations demonstrated efficient removal of these pathogens by bivalves. The number of parasites in bivalve tissue progressively increased in relation to the concentration of waterborne contamination, and decreased after cessation of the contamination. The results of depuration experiments demonstrated that C. fluminea can bioaccumulate human waterborne parasites in proportion to ambient concentrations. Thus, this species can serve as effective biological indicators of contamination of freshwater habitats with human waterborne protozoan parasites. Corbicula fluminea are convenient for water monitoring purposes because they do not have economic value, are easily collected, have a relatively small size, and form dense populations that facilitate collection of a large sample. Corbicula clams provide excellent ecological services and have an important role in aquatic habitats. By filtering suspended particles, these clams clarify the water and improve water microbiological quality.

AWS community volunteer activities mentioned in their 2006 Annual Report include cleaning the watershed through annual trash pickups, removing invasive plants, tree and wetland planting, storm drain stenciling, stabilizing streambanks, conducting river regattas and taking schools and visitors on river tours. AWS educational activities include a Watershed Explorers Program (grades 6-12), a River Habitat Program (grades 3-5), a Shad and Herring Awareness and Restoration Program (SHARE), a River of Words (ROW) school arts program and 3-year Rice Rangers program to restore wild rice to Anacostia wetlands.

AWS advocacy has been involved in many River issues including supporting the strengthening of MS-4 stormwater permitting in Montgomery and Prince Georges Counties, legal action in the District of Columbia and Maryland to reduce combined sewer overflows and sanitary sewer leaks, and a successful campaign to jump start trash reduction efforts in the Anacostia River. The latter was accomplished by having the river officially listed as impaired by trash, which is now a recognized pollutant by watershed officials. There is recent legislation mandating the total maximum daily load (TMDL) for trash and trash reduction. AWS supports Low Impact Development practices and Green Building design. A recent AWS Anacostia River trip included Maryland Senator Ben Cardin, Prince George’s County Executive Jack Johnson, and other officials along with discussion of the Clean Water Act as it could apply to the Anacostia River. The Anacostia Watershed Society has received numerous awards and involved tens of thousands of students and volunteers over the years to deserve its title as “The Voice of the River.”

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Effect of Best Management Practices on Contaminant Levels in Storm Water Runoff to the Anacostia River

This project is designed to examine the effectiveness of best management practices (BMPs) to retain stormwater pollutants from runoff over impervious surfaces. The federal government and local government agencies have funded, and/or partnered with other organizations, the construction of many bioretention cells, sand filters, and other BMPs for the prevention of stormwater contaminated runoff in Washington D.C. in an effort to prevent the further degradation of the Anacostia and Potomac Rivers, as well as Rock Creek. There is a need to further understand how these BMPs are performing, which are the most effective, and if design improvements are possible for future BMP installations.

Combined sewer overflows (CSO) continue to occur throughout major cities in the Northeast, Great Lakes, and Northwest regions of the U.S., primarily as a result of rainwater that is diverted from roads, parking lots, and the roofs of buildings during storm events. The rapid transport of water away from the built environment to natural water bodies has dominated engineering for the past 130 years, since the recognition that pathogens in wastewater caused several human diseases. In older cities with combined sewers the continued replacement of natural surfaces with impervious ones leads to greater amounts of stormwater runoff. The contamination of natural water bodies leads to the destruction of habitat, potentially leading to negative human health impacts. Developing best management practices to prevent rain water contamination, rivers are longitudinally linked systems with processes occurring in the upper reaches impacting downstream reaches and processes occurring in downstream reaches impacting upstream reaches through biological migration. The Anacostia River is an important link between the terrestrial and aquatic regions of the Potomac watershed and the larger Chesapeake Bay system. Although the health of the Potomac Estuary has been improving in recent years (Walker et al. 2004; Carter and Rybioki 1986), the Anacostia River, which runs into the estuary, remains a seriously stressed system with high levels of PAHs, PCBs, pesticides, and heavy metals (Phelps 2004). Researchers have also observed elevated concentrations of Aeromonas spp. during the summer months in Anacostia waters relative to concentrations observed in most natural waters (Cavari 1983). The effects of the degraded condition have been far reaching on the biological communities with high mortality rates of filter feeding bivalves (Phelps 1993, 2004); high tumor incidence among resident bullhead catfish (Sakaris et al. 2005, Pinkney et al. 2004), and adverse impacts on the populations of invertebrate macrofauna (Phelps 1985). These effects may impact the microbial community as well. Microbial DNA isolated from sediment from several locations on the Anacostia River reflecting a pollution gradient of heavy metals and organics (see Velinsky et al. 1994 and Wade et al. 1994 for sites), was found to have unique signatures in different regions of the river (Bushaw-Newton, Adams, and Velinsky, unpublished data). Despite increased attention on the Anacostia’s environmental degradation, improvements have been marginal (Hall et al. 2002). Benthic organisms remain rare; Asiatic clams experience extremely low survival and have not established resident populations; fish remain unsafe to eat; and over 100 million gallons of raw waste entered the river in the past decade.

See Best Management Practices, page 18

Nutrient Flow and Biological Dynamics in the Anacostia River

Rivers are longitudinally linked systems with processes occurring in the upper reaches impacting downstream reaches and processes occurring in downstream reaches impacting upstream reaches through biological migration. The Anacostia River is important link between the terrestrial and aquatic regions of the Potomac watershed and the larger Chesapeake Bay system. Although the health of the Potomac Estuary has been improving in recent years, the Anacostia River, which runs into the estuary, remains a seriously stressed system with high levels of PAHs, PCBs, pesticides, and heavy metals. Researchers have also observed elevated concentrations of Aeromonas spp. during the summer months in Anacostia waters relative to concentrations observed in most natural waters. The effects of the degraded condition have been far reaching on the biological communities with high mortality rates of filter feeding bivalves; high tumor incidence among resident bullhead catfish; and adverse impacts on the populations of invertebrate macrofauna. These effects may impact the microbial community as well. Microbial DNA isolated from sediment from several locations on the Anacostia River reflecting a pollution gradient of heavy metals and organics, was found to have unique signatures in different regions of the river. Despite increased attention on the Anacostia’s environmental degradation, improvements have been marginal. Benthic organisms remain rare; Asiatic clams experience extremely low survival and have not established resident populations; fish remain unsafe to eat; and over 100 million gallons of raw waste entered the river in the past decade.

See Nutrient flow and biological dynamics, page 14
Nutrient flow and biological dynamics, from page 13

two years (Washington Post 2005). While studies have concentrated on the larger, macrofauna, little attention has been paid to the microbial and the macroinvertebrate communities. Yet, the structure and function of these two communities often plays a key role in dictating the structure and function of the larger biological community as well as the chemical components of the system.

Therefore in order to best improve and protect the ecological function of the rivers, it is imperative to understand the role of the microbial community within that system. Our objectives are to evaluate the 2 microbial and macroinvertebrate communities of several sites within the upper reaches of the Anacostia River, upstream and downstream of the combined sewage outflow are in Bladensburg Maryland. We will 1) establish seasonal changes in biological oxygen demand, developing profiles of demand versus depth, 2) evaluate nutrient sources to bacteria, algae, invertebrates and characterize the origins of particulate organic matter through the use of the stable isotopes of sulfur, carbon and nitrogen, 3) characterize the composition of microbial communities at the different sites by DNA analysis, fatty acid profile and standard microbiological techniques.

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Update of Progress for Nutrient Flow and Biological Dynamics in the Anacostia River

Although the health of the Potomac Estuary has been improving in recent years, the Anacostia River, which runs into the estuary, remains a seriously stressed system with high levels of PAHs, PCBs, pesticides, and heavy metals. The effects of the degraded condition have been far reaching on the biological communities with high mortality rates of filter feeding bivalves; high tumor incidence among resident bullhead catfish, and adverse impacts on the populations of invertebrate macrofauna. These effects may impact the microbial community as well.

During the summer and fall of 2006, our objectives were to evaluate the microbial communities of several sites within the upper reaches of the Anacostia River, upstream and downstream of the combined sewage outflow are in Bladensburg Maryland. Specifically we wished to 1) establish seasonal changes in biological oxygen demand, developing profiles of demand versus depth, 2) evaluate nutrient sources to bacteria, algae, invertebrates and characterize the origins of particulate organic matter through the use of the stable isotopes of sulfur, carbon and nitrogen, 3) characterize the composition of microbial communities at the different sites by DNA analysis, fatty acid profile and standard microbiological techniques.

We found that soils at Bladensburg in the summer show a number of both odd-number and branched fatty acids, indicating bacterial origins. These unusual fatty acids made up approximately 9% of all the fatty acids. 16:0, 16:1 and 18:1 were the dominant fatty acids in the Bladensburg sediments and these are probably derived from photo-synthesis. Filtered material from the water column for this date and site showed several short chain fatty acids and the sample was dominated by trans-4,4-dimethyl-2-pentenoic acid, which may indicate bacteria (the cis was also present, but a much lower amount). A number of products from fatty acid metabolism were observed in the sediment, indicating bacterial activity. Stable isotope analysis however, showed that in situ bacterial projection is probably not the principle source of organic material. Organic carbon and nitrogen is a mix of within stream and terrestrial photosynthetic production, plus some bacterial production. Organic content in the soil positively correlates with bacterial counts, biological (microbial) oxygen demand, concentration of soluble reactive phosphorus, dissolved organic nitrogen as well as inorganic nitrogen. Bacteria probably increase in the summer in response to the accumulation of inorganic nutrients in the Anacostia as it flows downstream, and their imprint on the stream function can clearly been measured. Additionally, polycyclic aromatic hydrocarbon (PAH) degrading bacterial have been detected in the river. This indicates that the environment contains high enough concentrations of PAHs so that those compounds become organic carbon sources for heterotrophic bacteria.

Further work investigating the diversity of hydrocarbon compounds and the potential anthropogenic sources of the hydrocarbon is being developed, as is work identifying more specifically the types of bacterial living in the Anacostia and the possibility of antibiotic resistance among those bacteria.
Silica and Siliceous Surfaces as Hosts for Hazardous Metals in Water

**Findings**

Sorption of polyvalent metal ions on siliceous surfaces is of great importance to water quality. On one hand, sorption of such ions on rocks or soils bordering a contaminated stream is beneficial, but sorption on small siliceous particles in the water supply system may facilitate the transport of such ions. The study described below explored the effects of various parameters on the sorption of Cu(II) and Pb(II) ions on highly pure (99.8%) silica gel, following pretreatment of the silica gel for 50 hours with various aqueous media. The results of a typical set of experiments involving rotating 0.5 g of silica gel with 50 mL solution of 10 mg/L Cu + 10 mg/L Pb (both ions introduced as acetates) at pH 5 are shown in Table 1.

Major conclusions of the study were as follows:

- Upon rotating the solution with the silica gel at room temperature, a contact time of 2 hours was sufficiently long to approach the sorption equilibrium.
- Sorption of Cu(II) and Pb(II) exhibited similar dependence on time, temperature, and pH, but the extent of Pb(II) removal was larger than that of Cu(II).
- The uptake of both Cu(II) and Pb(II) decreased with increasing temperature.
- Raising the pH from 5 to 8 enhanced the uptake of Cu in 6-hr and 24-hr experiments and the uptake of Pb in 6-hr but not in 24-hr experiments, probably due to the amphoteric nature of Pb.
- The use of silica gel with a larger surface area did not enhance the sorption of Cu and Pb, because the added surface area is due to deep, narrow pores.
- The effects of pretreatment of the silica gel on the uptake of Cu and Pb were as follows:
  - HNO₃ = HCl = H₂SO₄ << H₂O << NH₄OH/NaNO₃ < NH₄OH

These findings are consistent with sorption equilibria such as:

\[ SiO_2(s) + M^{2+} \leftrightarrow Si(OM^{(2-)}) + H^+ \]

where the subscript s denotes a solid phase.

- The slightly lower uptake observed upon pretreatment with NH₄OH/NaNO₃, compared with pretreatment with NH₄OH alone, can be attributed to a decrease in effective surface area as a result of enhanced silica dissolution in the presence of Na⁺ ions.
- In general, the concentration of dissolved silica increases with increasing time, temperature, amount of silica gel, pH, and Na⁺ concentration.

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**Table 1: Removal (%) of Cu and Pb from aqueous solution using silica gel**

<table>
<thead>
<tr>
<th>Surface area, m²/g (Pure size, nm)</th>
<th>Pretreatment</th>
<th>6-hr experiment</th>
<th>24-hr experiment</th>
<th>Silica gel</th>
<th>Removal from solution, %</th>
<th>Silica loss, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>750 (4) De-ionized water</td>
<td>Cu</td>
<td>54 + 1</td>
<td>81 + 1</td>
<td>100</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>300 (10) De-ionized water</td>
<td>Pb</td>
<td>62 + 1</td>
<td>90 + 1</td>
<td>100</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>300 (10) 2 M H₂SO₄</td>
<td>Cu</td>
<td>18 + 1</td>
<td>19 + 1</td>
<td>100</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>300 (10) 2 M HNO₃</td>
<td>Pb</td>
<td>19 + 1a</td>
<td>33 + 1a</td>
<td>100</td>
<td>0.8</td>
<td>0.8a</td>
</tr>
<tr>
<td>300 (10) 4 M HCl</td>
<td>Cu</td>
<td>14 + 1</td>
<td>14 + 1</td>
<td>100</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>300 (10) 4 M HNO₃</td>
<td>Pb</td>
<td>16 + 1</td>
<td>18 + 2</td>
<td>30 + 3</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>300 (10) 4 M NH₄OH</td>
<td>Cu</td>
<td>97 + 1</td>
<td>99 + 1</td>
<td>100</td>
<td>0.8</td>
<td>1</td>
</tr>
<tr>
<td>300 (10) 4 M NH₄OH + 1 M HNO₃</td>
<td>Pb</td>
<td>89 + 2</td>
<td>99 + 1</td>
<td>100</td>
<td>4.4</td>
<td>1.8</td>
</tr>
</tbody>
</table>

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**W A T E R HIGHLIGHTS**

WINTER/SPRING 2007 15

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See Silica and Siliceous Surfaces, page 17
Wet-Weather Flow Characterization for the Rock Creek through Monitoring and Modeling

In spite of massive public investments in sewage and drainage infrastructure, pollution loading from wet-weather flows continues to have significant impacts on receiving waters. Trends in urbanizations, increased quantities of urban wet-weather flows and corresponding increase in pollution loadings discharged to receiving waters demand that wet-weather flow control systems be planned and engineered to effect higher levels of water quality control. For future investments in drainage infrastructure to be cost-effective, decisions in wet-weather flow control systems planning must be made within a rigorous, comprehensive and systematic framework.

Similar to many older cities in the nation, the sewer system in the District of Columbia is comprised of both combined and separate sewer systems. It has been recognized that these systems contribute significant pollution to the Anacostia and Potomac Rivers and Rock Creek through Combined Sewer Overflows (CSOs) and Storm Sewer discharges during wet-weather (i.e., rainfall and snowmelt) events. These overflows and associated pollutant loads can adversely impact the quality of the receiving waters. As per the District of Columbia water quality standards, the designated use of the Anacostia River, Potomac River and Rock Creek is Class A or suitable for primary contact recreation. Because the water quality in the receiving waters currently does not meet these standards much of the time, the actual use of the water body is Class B or suitable for secondary contact recreation and aquatic enjoyment. As a result, the District law prohibits primary contact recreation such as swimming in each of the receiving waters (DC WASA, 2002). To address these problems, the District of Columbia Water and Sewer Authority (WASA) has developed a Long Term Control Plan (LTCP) that provides the alternative solutions and their implementation costs.

In order to support LTCP a continuous monitoring and modeling of the system is necessary not only to provide technical assessment but also to develop a cost-effective solution. In this regard, a long-term study has been proposed to characterize the Rock Creek wet-weather flows. Rock Creek is a free flowing urban stream located within a completely developed environment. The initial goal of the proposed study is to perform water resources engineering analysis and characterize the runoff quality in terms of pollution loads from CSOs and storm water discharges. The characterization will be very much helpful for the Total Maximum Daily Load (TMDL) development as well as in the development of LTCP. Furthermore the characterization will meet the objective of Mid-Atlantic Regional water quality program.

The objective of this research proposal is to develop a complete proposal for further multi-year funding from federal and other relevant agencies. This grant will act as a seed grant for the future proposal and study.

Monitoring Runoff Quality at the Rock Creek

Monitoring and modeling are two essential components of implementing CSO Control policy (EPA, 1999). A planned development and implementation of a monitoring and modeling effort will support the selection and implementation of cost-effective CSO controls and an assessment of their improvements on receiving water quality.

Rock Creek, a tributary of the Potomac River is primarily an urban stream. The watershed for the creek covers part of Montgomery County (approximately 60 mi²) and part of the District of Columbia (approximately 16 mi²). The total length of the Rock Creek (in Maryland and Washington DC) is approximately 33 mi of meandering stream. The Creek flows from its source near Laytonsville, Maryland to the Potomac River in Washington DC. Water quality in Rock Creek is important to biotic life in and near the creek, and in the Potomac River Basin and the Chesapeake Bay (USGS, 2000). The water quality of the Rock Creek has been affected by urbanization and agricultural growth in the watershed.

In the long-term monitoring program, it is envisioned that a number of water quality parameters that include suspended solids, nutrients, heavy metals and other toxins, will be monitored at various representative sites of Anacostia and Potomac Rivers and Rock Creek and the monitored data will be used for the development of integrated drainage system and receiving water system models. The scope of this present research is limited to field monitoring of Dissolved Oxygen (DO) at several locations within the Rock Creek nearer to University of the District of Columbia. The data...
Mean and Standard Deviation of DO at three locations

The measurement of Dissolved Oxygen at the Rock Creek reveals that there is no evidence of low dissolved oxygen problems around the measured locations. The stream is naturally aerated by turbulence as it flows over the irregular channel bottom. It is free-flowing stream which provides relatively short residence time to wet weather pollution at the measured locations.

Silica and Siliceous Surfaces

Silica is known to adsorb on both quartz and silica gel (Ames et al., 1983; Nirdosh et al., 1987). Further work is necessary in order to evaluate the importance of sorption of hazardous metals on silica or their co-precipitation with silica in various aqueous environments, in particular those relevant to drinking water and environmental streams in geographical areas where widespread contamination with respect to lead and copper exists, such as the Washington, DC, area.

In order to compare this treated, tap water with natural waters from the Potomac River watershed upstream of the District, several river samples from the Harpers Ferry National Historical Park were similarly passed through a series of membrane filters and analyzed.

Although the ratios of silica concentration to those of alumina and calcium oxide in the natural stream samples are lower than those in the tap water, some free silica (presumably as quartz) is probably present in the suspended sediment of the river. For instance, this is likely to be the case in the Maryland Heights Potomac Stream of Table 3, in particular with respect to the fine particulate fraction (1.2-5.0 microns). This free silica would therefore be available to sorb metal ions. Thus the metal ions that are found in the particulate matter suspended in the natural water, as well as in the tap water, may be present, at least in part, in adsorbed form on silica particles.

Reactions at silica surfaces are complex and the presence of foreign ions in solution can enhance sorption and ion exchange on siliceous surfaces. For example, polyvalent ions, such as Cu2+, react very slowly with siliceous surfaces in near-neutral solutions. The process is greatly accelerated when the siliceous surface is contacted with solutions of sodium and particularly ammonium ion, prior to or simultaneously with contact of the copper solution (Patrick and Barclay, 1925; Ponomareva et al., 1975; Simmons, 1981). Organic species attached or adsorbed on silica surfaces are also known to promote sorption of metal ions (Macedo and Barkatt, 1987a, 1987b; Chiron et al., 2003). The concentration of metal ions affects the adsorption kinetics of metal ions, even though the adsorption equilibrium is unaffected if the concentration of metal ions is sufficiently high to produce full occupancy of the surface sites (Vithayaveroj et al., 2003). Previous contact of siliceous surfaces with specific anions, such as sulfate, also affects adsorption properties with respect to heavy metal ions (Nirdosh et al., 1987).

The surface activity of the siliceous substrate, as modified by the chemical environments to which it has been exposed, is reflected in its zeta potential (Fuller, 1971; Parks, 1965; Parks, 1967). Thus, in order to evaluate the potential of such contaminant retention systems to real-world conditions in urban settings with multiple contaminants present, the effects of variations in gel composition and solution composition need to be investigated. The overall objective of the proposed research project is to examine the effects of these parameters on the sorption of hazardous metals on siliceous surfaces.
port of E1, E2, testosterone and androstenedione in the environment is summarized. Also, an overview of the potential sources and the recorded environmental concentrations in the environment is given.

Summary
This review study indicates that there is a widespread occurrence of E2 and testosterone in the environment, but little is known about the behavior of these endocrine disrupting hormones as well as their metabolites. Significant concentrations of these compounds were reported to reach ground water as well as surface water. Sorption, desorption and biodegradation processes are the governing processes of fate and transport of these compounds in the environment. Sorption and desorption are affected by the type and quantity of the compound, soil type, and content of organic carbon and swelling clay. In the absence of swelling clay, the review study reveals that at environmentally relevant concentrations, estrogens may have a rapid desorption rate constant.

On the other hand, factors that affect the biodegradation of E1, E2, testosterone and androstenedione include types of compounds present and their initial concentration, soil type, soil organic matter content, moisture content, clay minerals, aeration, inhibiting factors including antibiotics, viable microbial biomass and temperature. All four hormones may degrade rapidly within a week in both waters and soils or persist for several months in soil and/or sediment depending on those factors. Under aerobic conditions, all three steroid hormones will be degraded rapidly, provided that the carbon source, temperature and soil moisture are not the limiting factors. Low temperature (12°C), dry soil and moistened soil to the field capacity can negatively affect biodegradation of these compounds. Under anaerobic conditions, biodegradation of all four steroid hormones under consideration is limited. E2 and testosterone tend to degrade very slowly, and their metabolites E1 and androstenedione may accumulate. Thus, persistence of E1 and androstenedione in anoxic conditions, together with their possible rapid desorption, may govern the fate and transport of these compounds in soil and surface water. In addition, the increase of sorption, due to higher clay content or organic carbon content, may reduce the biodegradation rate constant of testosterone as it reduces bioavailability. Further research is required to investigate the effect of E1, E2 and androstenedione.

Best Management Practices, from page 13
remove pollutants before the runoff enters the combined sewer system, and retain or delay the movement of water in a decentralized fashion can potentially mitigate CSO events.

Urbanization creates impervious surfaces such as roads, sidewalks, highways, rooftops, and parking lots that result in an increase of stormwater runoff at the expense of infiltration. The stormwater runoff quickly flows over those impermeable surfaces and accumulates toxic pollutants such as heavy metals generated by automobile use, weathering of building materials and atmospheric deposition. A nationwide U.S. urban study showed that heavy metals were by far the most prevalent pollutant constituents of urban stormwater runoff. Due to its toxic content, the storm water runoff when discharged to a stream, severely impacts the quality of natural water systems by causing a threat to aquatic life and human health, and also flooding and erosion. As a result, urban stormwater runoff has been identified as one of the most significant water pollution problems in the United States. To address the problem of surface water pollution from urban stormwater runoff, a number of engineered and managed natural systems have evolved and are being offered as “best management practices” (BMPs) for low impact development. They are part of the United States Environmental Protection Agency’s (USEPA) effort to regulate the release of pollutants into natural aquatic environments through water quality standards set forth by the National Pollutant Discharge Elimination System (NPDES). A stormwater BMP is a device, practice, or method used to remove, reduce, retard, or prevent targeted stormwater runoff pollutants from reaching receiving waters in the most cost-effective manner.

In the early 1990’s, Prince George’s County, Maryland began developing and promoting a natural-based stormwater BMP system known as bioretention (or rain garden). Bioretention is a simple but effective way to improve the quality of stormwater runoff from developed areas such as parking lots, in order to minimize surface water impacts. Bioretention is a porous sand/soil media, supporting a vegetative layer, with a topping layer of hardwood mulch. Water quality enhancement occurs through the bioretention facility via biological, chemical and physical processes including phytoremediation, precipitation, adsorption, complexation, microbial activity, decomposition, sedimentation, filtration, and volatilization. In urban environments these systems are typically designed by filling a concrete box with gravel, sand, planting soil, a top layer of mulch, and various species of water loving plants. Currently little is known with regard to the field performance of bioretention cells.

Few researchers have evaluated the performance of best management practices with actual stormwater runoff.

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http://www.udc.edu/wrri/publication.htm


Waterborne Contamination, from page 11
(i.e., Encephalitozoon intestinalis, E. hellem, and Enterocytozoon bieneusi) in the Anacostia River or its tributaries. These biological contaminants originate from human and non-human, point and non-point sources as they infect humans, livestock and wildlife (Graczyk et al. 1997a; Graczyk et al. 2004). These category B biodefense pathogens are on the CDC, NIH, and USEPA priority lists, because they significantly contribute (particularly Cryptosporidium) to morbidity of healthy people and mortality of immunosuppressed individuals (Graczyk et al. 1997; Graczyk et al. 2004).

Protozoan parasites could also be contributed by the numerous Canadian geese residing in and visiting the Anacostia River watershed (Graczyk et al. 1998a). Eighty percent of the Anacostia's tributaries are in Maryland. There have been relatively few studies of the tributaries but all suggest they are a major source of the chemical and biological contamination of the tidal River (Gruessner et al. 1997; Coffin et al. 1999; Phelps 2000; Phelps 2002; Werner et al. 1997). The proposed project is to assess contamination of the MD and DC tributaries to the Anacostia River with human waterborne pathogens using the Asiatic clam, Corbicula fluminea. Molluscan shellfish are considered an ideal organism to study environmental aquatic health as they filter feed and bioaccumulate rather than detoxify pollutants. Because the Asiatic clam is common, widespread, and resistant to environmental toxicants, it is recommended for freshwater contaminant bioaccumulation studies by the National Water Quality Assessment Program (Crawford and Luoma 1993). Translocated Asiatic clams have been used to detect organochlorines and pesticides (Hartley and Johnston 1983; Colombo et al. 1995). Asiatic clams can concentrate important human enteric disease protozoa such as Cyclospora cayetanensis (Graczyk et al. 1998b), Cryptosporidium parvum (Graczyk et al. 1998c) and Giardia lambia (Graczyk et al. 1997b; Graczyk et al. 1999; Graczyk et al. 2003). The nearby Potomac River, a Chesapeake Bay restoration success, has a large Corbicula population (Phelps 1995; Phelps 2002) being used for this study.

The overarching objective of the proposed project is to assess contamination of the MD and DC tributaries to the Anacostia River with human waterborne pathogens using the Asiatic clam (Corbicula fluminea). Specifically we will: 1) Identify the source of human waterborne pathogens in the Anacostia River watershed by involving in the project graduate and undergraduate students; 2) Demonstrate the use of the locally available Corbicula clam to assess contamination of Anacostia watershed tributaries with microbiological contaminants; 3) Bring to the attention of Maryland and the District of Columbia administration and public health officials the necessity for cooperation to resolve the contamination problems of the Anacostia River; 4) Facilitate the development of the best management plan for remediation of the water quality and contamination of the Anacostia River; 5) Publicize the results in the scientific literature among scientific communities and among appropriate local agencies; and 6) Provide training for graduate and undergraduate.

BY THADDEUS K. GRACZYK, M.SC., PH.D.
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WRRI FY 2007
Seed Grant Awards

The following five proposals were submitted and approved for FY 2007 grants.

**TITLE OF AWARD:** Modeling of an Integrated Urban Wastewater System in the District of Columbia

**PRINCIPAL INVESTIGATOR:** Tolessa Dekissisa, Ph.D., Research Associate, Water Resources Research Institute, University of the District of Columbia, E-mail: tdeksissa@udc.edu

**CO-INVESTIGATOR:** Pradeep K. Behera, Ph.D., P.E., Associate Professor, Engineering, Architecture & Aerospace Technology, University of the District of Columbia, Email: pbehera@udc.edu

**GRANT AWARD:** $14,876

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**TITLE OF AWARD:** Gradual Variation Analysis for Groundwater Flow in the District of Columbia

**PRINCIPAL INVESTIGATOR:** Li Chen, Ph.D., Associate Professor, Department of Computer Science and Information Technology, University of the District of Columbia, Email: lchen@udc.edu

**GRANT AWARD:** $15,000

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**TITLE OF AWARD:** Decision support system to deal with water emergencies for Metropolitan DC

**PRINCIPAL INVESTIGATORS:** Shivraj Kanungo, Ph.D., Associate Professor, Department of Decision Sciences, George Washington University, Email: kanungo@gwu.edu

**GRANT AWARD:** $14,960

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**TITLE OF AWARD:** Modeling of an Integrated Urban Wastewater System in the District of Columbia

**PRINCIPAL INVESTIGATOR:** Harriette L. Phelps, Ph.D., Professor Emeritus, Department of Biological and Environmental Sciences, University of the District of Columbia, Email: hphelps@hers.com

**GRANT AWARD:** $15,000

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**TITLE OF AWARD:** Molecular Signaling by Environmental Arsenicals in Mammalian Cells

**PRINCIPAL INVESTIGATOR:** Deepak Kumar, Ph.D., Assistant Professor, Department of Biological and Environmental Sciences, University of the District of Columbia, Email: dkumar@udc.edu

**GRANT AWARD:** $14,960
STAKEHOLDERS:
■ Residents of the District of Columbia
■ DC Local Government
■ DC Bureau of Environmental Quality
■ DC Water and Sewer Authority
■ DC Local Schools and Universities
■ DC Non-profit Environmental Organizations
■ Water resources management private industries
■ US Environmental Protection Agency (EPA)
■ US Geological Survey
■ US Department of Interior
■ US Department of Agriculture
■ Interstate Commission on the Potomac River Basin
■ Anacostia Watershed Restoration Committee
■ Chesapeake Bay Foundation
■ Chesapeake Bay Program Scientific and Technical Advisory Committee
■ The National Institute for Water Resources

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■ Edward Graham, Metropolitan Washington Council of Governments, Department of Environmental Programs
■ Simeon Hahn, Anacostia Watershed Toxics Alliance, NOAA Office of Response and Restoration
■ Doug Siglin, Chesapeake Bay Foundation

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■ Holly Graphics Design and Print Management

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