New Jersey Water Resources Research Institute
Annual Technical Report
FY 2002

Introduction

The New Jersey Water Resources Research Institute program for 2002 supported a wide range of research, student training, and information transfer activities. Research was conducted on soil hydraulic properties and pollutant transfer, engineering of systems for monitoring haloacetic acids and destroying VOCs, the biodegradation of MTBE, and several aspects of wetland ecology. This research supported 7 graduate students. In addition, an undergraduate internship program supported four students, working at teaching colleges throughout the state in addition to the state university. Informantion transfer activities included conferences, invited speakers, collaborations with other agencies in organizing water-related meetings, and the publication of a quarterly newsletter. Although the NJWRRI program had an impact on many aspects of water resources around the state.

Research Program

Effects of the Biopollutant, Phragmites australis, On the Nutritional Status (Biochemical Condition) of Juvenile Weakfish, New Directions Incorporating Otolith Chemical Signature Analysis

Basic Information

Title:	Effects of the Biopollutant, Phragmites australis, On the Nutritional Status (Biochemical Condition) of Juvenile Weakfish, New Directions Incorporating Otolith Chemical Signature Analysis
Project Number:	2002NJ1B
Start Date:	3/1/2002
End Date:	7/1/2003
Funding Source:	104B
Congressional District:	6th
Research Category:	Biological Sciences
Focus Category:	Wetlands, Ecology, Nutrients
Descriptors:	biochemical condition, salt marsh, juvenile weakfish, otoliths, stable isotopes
Principal Investigators:	Steven Y. Litvin, Michael P. P. Weinstein

Publication

1. Litvin, Steven, Vincent Guida and Michael Weinstein. 2003. Habitat utilization patterns of a juvenile marine transient: effects on biochemical condition and impicatioins on the value of habitat for fish production at the Estuarine Research Federation Bi-Annual Meeting, Seattle, WA. Sept. 14 18, 2003. (Abstract is accepted)

Priority Issues and Research Objectives

Phragmites australis ranks among the most aggressive biopollutants in wetland landscapes. By altering the marsh through its influence on hydroperiod, and geomorphology, *P. australis* reduces nekton access to the marsh plain, and by affecting the exchange of materials including organisms (trophic relays; Kneib 1997), presumably negatively influencing the production of commercially and recreationally important species. In the past 50 years, *P. australis* has become the dominant macrophyte in many brackish marshes of the mid-Atlantic seaboard. For example, more than 16,000 ha of salt marsh are presently covered with a near monoculture of *Phragmites* on the Delaware side of the Delaware Bay, and the magnitude of coverage is similar on the New Jersey side (Weinstein and Balletto 1999, Figure 1). While millions of dollars are invested in attempts to eradicate *Phragmites*, primarily through the use of potentially toxic herbicides, we have no real idea of its influence on nekton secondary production. Because marine transients contribute significantly to the $50 billion fishery of the coastal United States, it is critical that we quantify the effects of *P. australis* on habitat quality and function, especially for the nekton that depend upon coastal marshes during their first year of life. This is the key value of the proposed study that addresses the issue of restoring coastal ecosystem health and establishing indicators of their function.

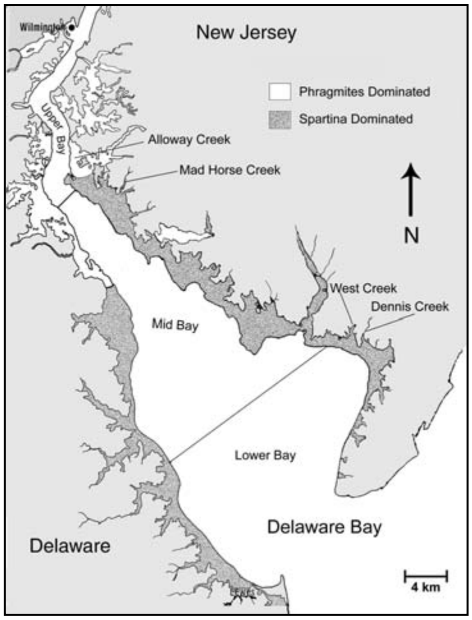

Figure 1.

Type III marine transients, including weakfish (*Cynoscion regalis*) and many taxa of commercial and recreational value, are species whose young use estuaries as “fine grained” environments, consisting of “boundary-less” habitat units, all of which may contribute to growth and survival during their first year of life (Levins 1968). Such species exhibit substantial flexibility in behavior and adaptive strategies to optimize growth and survival during the first growing season. However, abundant food at individual locations does not preclude young weakfish from establishing temporary residency in specific areas, at least long enough to take on the “signatures” of locally produced sources of organic matter. We previously identified seven sub-regions, including tidal marshes, of Delaware Bay where juvenile weakfish were seasonally abundant, and where different suites of primary producers contributed nutrients to secondary production in this species during the period June through October of each year (Figure 1).

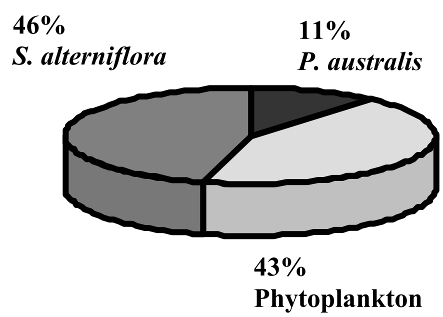

Figure 2. Relative Contribution of Primary Producers to the Nutrition of Juvenile Weakfish (> 60mm SL) Collected Just Prior to Emigration at the Mouth of Delaware Bay Derived from C and S Isotope Based Three Source Mixing Model.

Previous research, demonstrated that C, N and S derived from *Phragmites australis* dominated marshes of the Mid and Upper Delaware Bay support significant secondary production of juvenile weakfish, especially when fish are between about 20 mm and 60mm SL. Although the results of MANOVA and Discriminant Analysis suggest that young weakfish exhibit considerable site fidelity early in the growing season based on the reclassification of individual fish , their pattern of size-dependent movement down estuary as they grow, makes it clear that the *Phragmites* signal is “diluted” in the lower Bay, most likely by tissue turnover, in the late summer and early fall when larger juveniles are “staging” prior to emigration from the Bay. Residual *Phragmites* stable isotope signatures, however, are still clearly recognizable at the time when juveniles are preparing to exit the Bay (Figure 2).

To address the "dilution" issue (seasonal movement of larger individuals down Bay), and to identify the temporal-spatial history of habitat utilization, including the time spent in the upper Bay influenced by *P. australis* primary production, sagittal otolithes are being provided to Dr. Simon Thorrold of the Woods Hole Oceanographic Institution (WHOI). Dr. Thorrold has graciously agreed to use otolith microprofiles using carbon and oxygen stable isotopes ratios to track the previous temporal history of habitat utilization by bay mouth emigrants in the fall (Thorrold et al. 2001, 1998). In this way, we will have a complete record of the organic matter source history of all *survivors* exiting the Bay, as well as their nutritional status (using lipid analysis), and can estimate the contribution of *Phragmites*-dominated marshes to both secondary production and "quality" of individuals migrating hundreds of kilometers to over wintering areas (in terms of energy reserves).

As the tertiary link in many food chains, fishes are often reliable indicators of the condition of complex ecosystems. Thus, data on the intensity and direction of fat deposition, and the level of body fat reserves can not only be used to assess the "degree of well being", but also serve to integrate the overall value of habitats to their production. While the qualitative composition of food consumed influences the protein metabolism of fishes, it does not greatly alter the amino acid composition of proteins in the body. On the other hand, the lipid composition of the body is greatly influenced by dietary lipids. More specifically, it is the triacylglycerols (the main constituent of reserve energy) and free fatty acids that are influenced by diet (Shulman and Love 1999).

Fat storage depots may occur in numerous locations in finfishes (Shulman 1974): but in juvenile weakfish fatty deposits in muscle tissue appear to predominate. As in other species, energy is generally stored as neutral fats, triacylglycerols that account for up to 75% of all reserve lipids, but the storage may also be in the form of free fatty acids. In some species, more than three-quarters of the migration will be done *after* lipid reserves have been depleted and the fish must rely solely on muscle protein as a source of oxidative reserves (Shulman 1974), but the extent to which this may occur in weakfish is unknown.

Research Methods and Expected Results

Given the site fidelity (temporary residency) observed, could you infer that some of the seven sub-regions of Delaware Bay that have been defined (Figure 1) are more important than others in supporting weakfish production? If the biochemical condition and growth of juvenile weakfish from these sub-regions differs, as others suspect it does (Lankford and Targett 1994; Grecay and Targett 1996; Paperno *et al.* 2000), then recruitment to adult populations may be partially a function of habitat (sub-region) quality.

To address this hypothesis, aliquots of homogenate from two groups of juvenile weakfish are being analyzed for neutral lipid content, via thin layer chromatography-flame ionization detection (Parrish 1987), and subjected to carbon, nitrogen and sulfur stable isotope analysis. In addition, Dr. Thorrold will develop a carbon and oxygen microprofiles for a sagittal otolith of each individual. The first group of juvenile weakfish, up to 15 individuals < 60 mm SL from each sub-region, will be used to build a "baseline" of isotope values (otolith and homogenate) that will be used to elucidate the habitat utilization history of the second group of juvenile weakfish, up to 60 larger juveniles collected at the mouth of Delaware Bay just prior to emigration in 2001, via the same stable isotope parameters (Thorrold 1998, Litvin et. al. in prep). The neutral lipid content data will then be used to investigate the effect of differential habitat residency on the biochemical condition of the emigrating young-of the-year weakfish.

Progress to Date

Despite several months of delay due to the failure of an essential piece of equipment (a freeze drier which has been replaced) the weakfish collected for this study are in the midst of preparation for stable isotope, otolith and TLC/FID analysis.

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Measurement and Prediction of Hydraulic Properties Needed to Model Groundwater Quality in Southern New Jersey

Basic Information

Title:	Measurement and Prediction of Hydraulic Properties Needed to Model Groundwater Quality in Southern New Jersey
Project Number:	2002NJ3B
Start Date:	3/1/2002
End Date:	3/1/2003
Funding Source:	104B
Congressional District:	6th
Research Category:	Ground-water Flow and Transport
Focus Category:	Hydrology, Water Quality, Models
Descriptors:	hydrology, water quality, models, pedotransfer, contaminants, groundwater, southern New Jersey
Principal Investigators:	Daniel Gimenez

Publication

Progress Report: Measurement and Prediction of Hydraulic Properties Needed to Model Groundwater Quality in Southern New Jersey

Problem and Research Objective

Despite the importance of groundwater quality issues in New Jersey, information on hydraulic properties of soils and sediments is fragmentary and incomplete. Water retention and especially unsaturated hydraulic conductivity are properties difficult to measure and extremely variable through a landscape. Thus, a large number of samples are required to characterize a region. A viable compromise is to obtain reliable estimates from soil properties that are available or easy to obtain. For instance, soil properties typically used to predict hydraulic properties are sand, silt, and clay content, bulk density, and soil organic matter content. In general, statistical models used to predict properties that *we need* from properties that *we have* are known as *pedotransfer functions*.

The main hypothesis of this study is that measurement of hydraulic properties on representative soils and sediments of southern New Jersey will result in a core database from which the most accurate predictive models (pedotransfer functions) for these properties will be selected or developed. More importantly, our underlying hypothesis (supported by the bulk of scientific literature in the subject) is that accurate predictions of hydraulic properties are essential for improving the prediction of the fate and transport of contaminants through the vadose zone. The latter predictions are needed to quantitatively evaluate land management practices prior to their implementation. Consequently, the objectives of this project are:

1. Sample the main soil horizons in southern New Jersey and measure water retention and hydraulic conductivity functions.
2. Use sediment samples collected by the USGS in southern New Jersey to select and measure water retention and hydraulic conductivity functions on representative subsurface layers.
3. Test selected pedotransfer functions of both water retention and hydraulic conductivity functions on soil and sediment data collected from the first two objectives.
4. Modify or develop new pedotransfer functions specific for soils and sediments of southern New Jersey.

Methodology

Two types of samples are being presently analyzed:

1. In summer-fall 1996 unsaturated zone sediment was sampled by USGS (Trenton) personnel during the installation of shallow ground water observation wells at 48 sites. Site locations were selected at random within major land use categories to provide an assessment of ambient shallow ground water quality (Stackelberg et al., 1997). Core samples were collected throughout the unsaturated zone by driving a 61-cm long by 5.1-cm diameter split-spoon sampler with a drill rig hammer. Multiple sediment layers evidenced by visible color and texture changes were noted and the core samples were stored.
2. In spring 2003, three deep profiles were dug and sampled in coordination with NJGS personnel. The profiles were located in three Rutgers off-campus experiment stations located at Cream Ridge (Rutgers Fruit Research and Extension Center), Chatsworth (Philip E. Marucci Center for Blueberry and Cranberry Research and Extension), and Bridgeton (Food Innovation Research & Extension Center). The sites are part of the NJ Mesonet (Fig. 1).

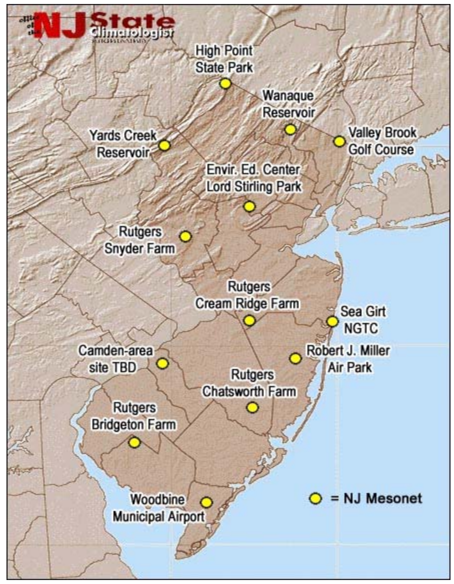

Fig. 1. NJ Mesonet sites.

Information available for each of the 48 wells sampled in 1996 includes site location coordinates, unsaturated zone thickness, moisture content data, bulk density, porosity, and particle size distribution. A more detailed particle size distribution was determined on 109 cores by optical diffraction using a Coulter LS-230 Particle Size Analyzer (Gee, 2002). This method allows for the partitioning of particle sizes ranging from 0.04 to 2000 microns into about 120 bins. Particles larger than 2000 microns (gravel) were sieved out and then integrated into the size-distribution results. Information for the sites sampled in 2003 includes location coordinates and a detailed profile description done according to NRCS procedures.

The constant head method (Klute and Dirksen, 1986) is being used to measure saturated hydraulic conductivity of disturbed samples by measuring steady state water flow through soils and sediments packed in cylinders (5-cm in diameter and 5-cm long). Water retention curves are being measured using pressure plate extractors at 8 pressure potentials covering from -3 kPa to -1500 kPa. For each material, ten replicates of saturated hydraulic conductivity and 4 replicates of each pressure potential are measured.

Seven particle size classes are being measured for each sample material. Hundred grams (100 g) of material are dispersed with 5% sodium hexametophosphate solution, shaken for 5 minutes and sieved through a No.270 sieve to retain particles larger than 0.05 mm (sand). Material that passed the No.270 sieve (silt and clay) is added to a cylinder containing deionized water and stirred at 30°C. A 25 ml sample is collected after 6 hours and 18 minutes from 10 cm below the water surface. The oven-dried weight of the sample is used to calculate clay content. The sand fraction is oven-dried and sieved through a set of sieves to separate gravel and sand types.

An undisturbed block of soil profile was sampled from the C-horizon at the Cream Ridge site (Fig. 2). The block was divided into 6 layers according to color pattern. For each layer, 3 clods were carved and used to determine bulk density according to the method of Brasher et al. (1966). After measuring bulk density, particle size was measured in each clod.

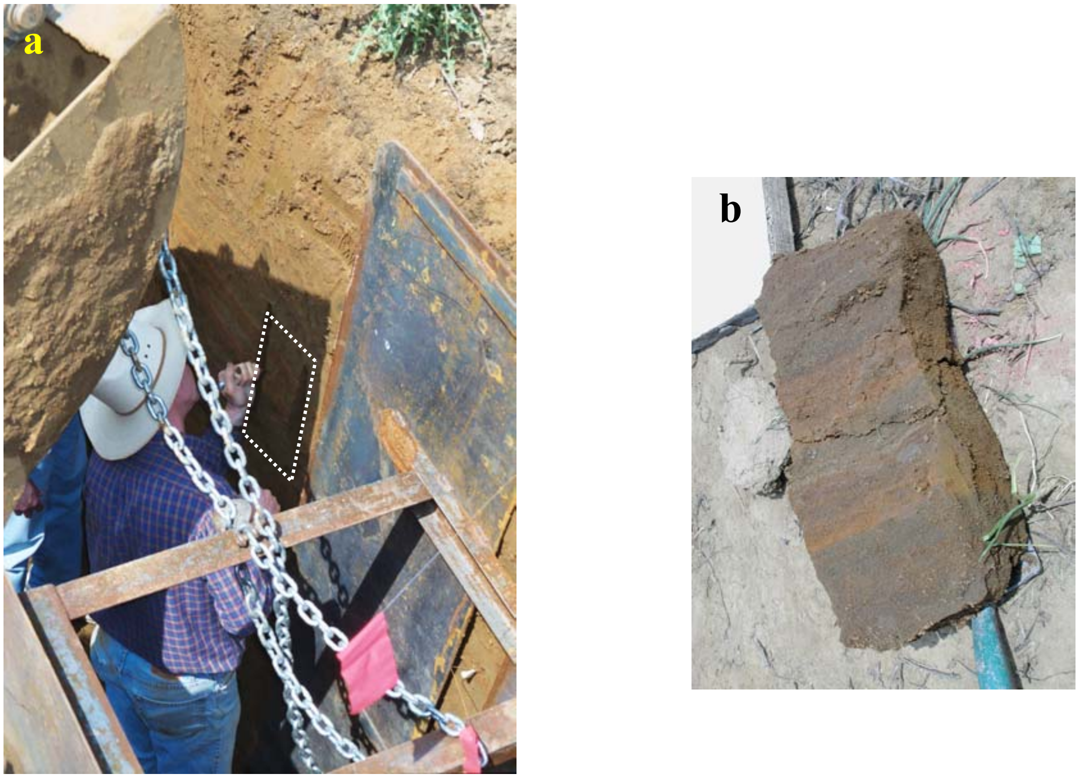

Fig. 2. a) Soil profile at the Cream Ridge site-dashed line shows the position of a sampled block (courtesy of Jeffrey Hoffman-NJGS), b) material sampled from profile showed in a. Differences in color correspond to changes in texture and bulk density (see Fig. 4).

Principal Findings and Significance

We are currently measuring water retention properties and particle size distribution in the material sampled from the NJ Mesonet sites. The vadose zone composition at the sites is distinctively different. At the Cream Ridge and Bridgeton sites we were able to sample 3 m below the surface, whereas groundwater was present at about 1.5 m below the surface at the Chatsworth site (Fig. 3). Layering in the Cream Ridge site (Fig. 2b) resulted in large variations in bulk density.

A detailed study on the relationship between particle size and bulk density revealed that bulk density in the vadose zone of the Cream Ridge site can be predicted from silt content and to a lesser extent by the content of 0.25-0.5-mm diameter sand (Fig. 4). This result is very important to predict changes in bulk density from particle size in these soils and to infer vertical profiles of hydraulic conductivity.

Preliminary results of water retention at the Cream Ridge site show greater retention (on a mass basis) in the A and B horizons (Fig. 5). Identifying the appropriate model is an important step to accurately model vadose zone hydraulic properties. Even though 3 more points of the water retention curves need to be measured, it is clear that the relationship log (water content)-log (pressure potential) is not linear. This fact limits the description of this property to the van Genuchten (1980) model. Analyses of relationships between particle size distribution (measurement in progress) and water retention will facilitate developing prediction tools needed to extrapolate these results to similar settings in the Costal Plain region.

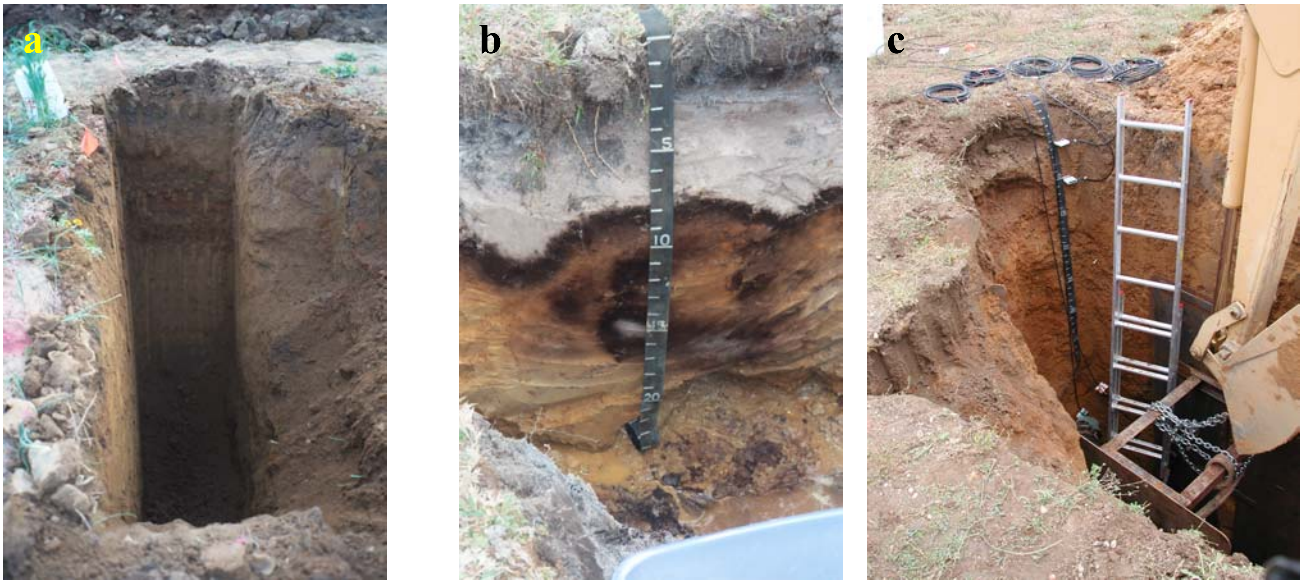

Fig. 3. Vertical profiles at the sampled sites a) Cream Ridge (courtesy of Jeffrey Hoffman-NJGS), b) Chatsworth (courtesy of Jeffrey Hoffman-NJGS), c) Bridgeton.

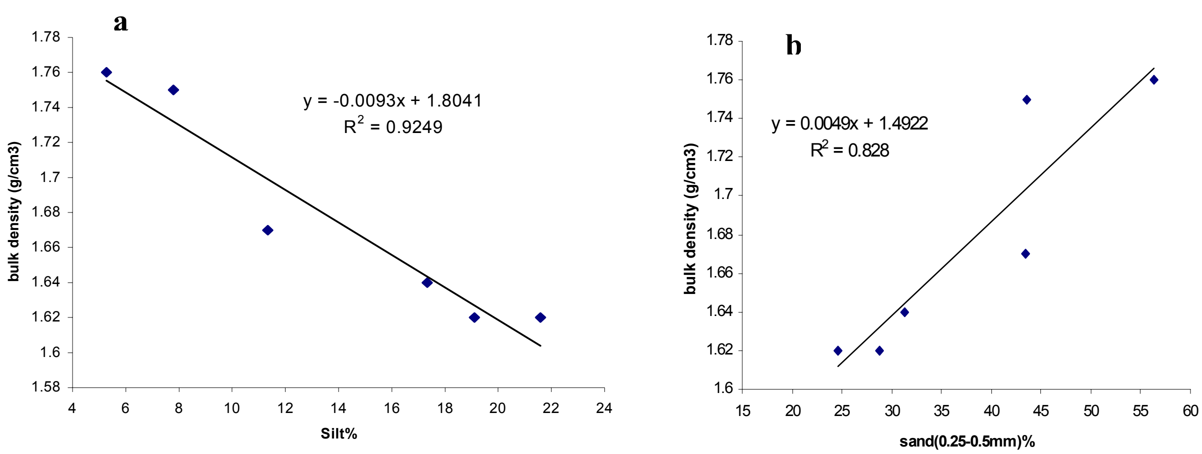

Fig. 4. Bulk density as a function two particle size classes a) silt content, b) sand content for 6 layers sampled from a block of material extracted from the Cream Ridge site (see Fig. 2).

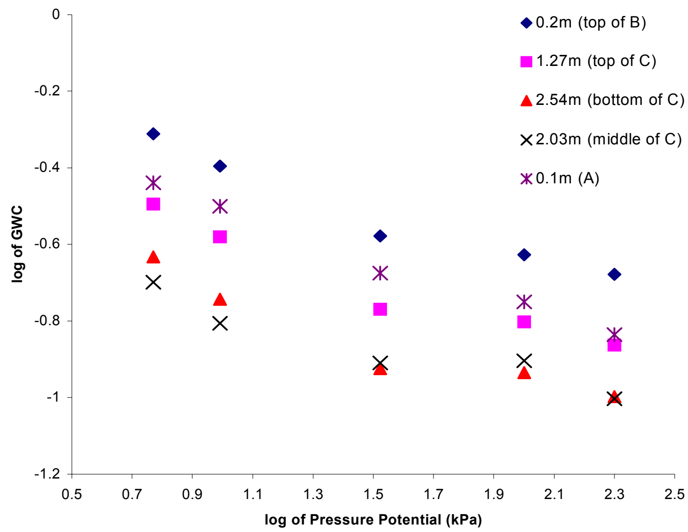

Fig. 5. Water retention curves for vadose zone material at the Cream Ridge site. Each point is an average of 4 replicates. Water content is expressed in gravimetric units.

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CONTINUOUS, ON-LINE MONITORING OF HALOACETIC ACIDS IN WATER USING ANALYTICAL MEMBRANE EXTRACTION

Basic Information

Title:	CONTINUOUS, ON-LINE MONITORING OF HALOACETIC ACIDS IN WATER USING ANALYTICAL MEMBRANE EXTRACTION
Project Number:	2002NJ4B
Start Date:	3/1/2002
End Date:	3/1/2003
Funding Source:	104B
Congressional District:	10th
Research Category:	Water Quality
Focus Category:	Water Quality, Methods, Non Point Pollution
Descriptors:	Disinfection By-Products, Haloacetic Acids, Membrane Extraction, On-line Monitoring
Principal Investigators:	Dawen Kou, Somenath Mitra

Publication

1. Kou, Dawen; Xiaoyan Wang, and Somenath Mitra, 2003, Supported Liquid Membrane Micro-Extraction (SLMME) with HPLC Detection for Monitoring Trace Haloacetic Acids in Water, Analytical Chemistry, In Review.
2. Kou, Dawen; Somenath Mitra, 2003, Extraction of Semi-volatile Organic Compounds from Solid Matrices, in S. Mitra (ed), Sample Preparation Techniques in Analytical Chemistry, New York: John Wiley & Sons, In print.
3. Slack, Gregory; Nicholas Snow, and Dawen Kou, 2003, Extraction of Volatile Organic Compounds from Solids and Liquids, in S. Mitra (ed) Sample Preparation Techniques in Analytical Chemistry, New York: John Wiley & Sons, In print.
4. Kou, Dawen; 2002, Development of Membrane Extraction Techniques for Water Quality Analysis, Ph.D. Dissertation, Department of Chemistry and Environmental Science, College of Science and Liberal Arts, New Jersey Institute of Technology, Newark, NJ, 91 pages.
5. Wang, Xiaoyan; Dawen Kou, Edmund J. Bishop, and Somenath Mitra, 2003, Supported Liquid Membrane Micro-Extraction (SLMME) for the Determination of Trace Organic Acids, presented at

the 27th International Symposium on Capillary Chromatography, Las Vegas, NV.

Year 2002 Project Report to U.S. Geological Survey and NJWRRI

Continuous, On-Line Monitoring of Haloacetic Acids in Water Using Analytical Membrane Extraction

Submitted by: Dawen Kou and Somenath Mitra
New Jersey Institute of Technology

Part II

Problem and Research Objectives:

Haloacetic acids (HAAs) are a group of compounds known as disinfection by-products (DBPs). They are generated during the disinfection (e.g. chlorination) of drinking water that contains natural organic matters (humic and fulvic compounds) and bromide (if present). The U.S. EPA lists nine HAAs (monochloroacetic acid, or MCAA, monobromoacetic acid, or MBAA, bromochloroacetic acid, or BCAA, dichloroacetic acid, or DCAA, dibromoacetic acid, or DBAA, bromodichloroacetic acid, or BDCAA, trichloroacetic acid, or TCAA, tribromoacetic acid, or TBAA, dibromochloroacetic acid, or DBCAA) as the major fraction of non-volatile DBPs. HAAs are toxic to humans, plants, and particularly to algae [1]. EPA has classified dichloroacetic acid and trichloroacetic acid as suspected carcinogens. According to EPA's regulations pertaining to disinfectants and disinfection by-products (D/DBP) [2], the current Maximum Contamination Level (MCL) for total HAAs in drinking water is 60 μg/L.

The importance of HAAs calls for sensitive methods for their determination. The standard EPA method 552 [3] for HAA analysis involves liquid-liquid extraction followed by derivatization and GC (gas chromatography) analysis. Low detection limits are attained at the cost of a lengthy, cumbersome extraction-derivatization procedure. In light of the limitations of the EPA methods, considerable efforts have gone into developing alternative techniques that do not require derivatization. These alternatives include methods using LC (liquid chromatography, and ion chromatography) [4-5], CE (capillary electrophoresis) [6], and ESI-MS (electrospray ionization mass spectrometry) [7]. ESI-MS provides excellent sensitivity and selectivity, but limited availability of the instrument precludes its wide use. With the current sample preconcentration techniques, the LC and CE methods are not sensitive enough for the analysis of drinking water samples.

The objective of this study is to develop a novel method/technique for HAA monitoring with high selectivity and sensitivity. The method will not involve derivatization, and will be simple, easy to use, and minimize the use of toxic solvents in sample preparation. It will be used to carry out continuous, on-line monitoring of haloacetic acids in drinking water.

Methodology:

A supported liquid membrane microextration (SLMME) technique was developed for the extraction and preconcentration of HAAs in water. Figure 1 illustrates the concept of SLMME. The HAAs first diffused from the bulk donor solution to the surface of the membrane, and then partitioned into the membrane liquid. After migrating across the membrane, they were extracted into the acceptor via deprotonation. The two processes occurred simultaneously, so the extraction was highly efficient. The concentrations of the neutral compounds remained unchanged on both sides, which implied no enrichment. Basic compounds were in the charged form in the donor and were not extracted. Therefore, SLMME provided both high enrichment and high selectivity for the acidic compounds.

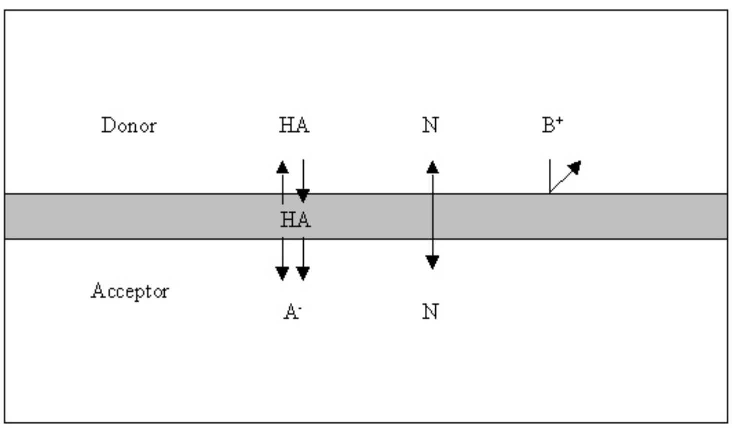

Figure 1. The concept of SLMME, HA, N and B^+ represent acids, neutral species, and bases respectively.

The SLM used in this study was made by impregnating a segment of microporous hollow fiber with a membrane liquid for a period of ten seconds. Two types of polypropylene microporous hollow fiber membranes were used to make the SLM. One was Celgard® X20. It had an i.d. of 400 µm and an o.d. of 460 µm, with an average pore size of 0.03µm and porosity of 40%. The other was Accurel® PP Q 3/2.

It had an i.d. of 600 μm and a wall thickness of 200μm, with an average pore size of 0.2 μm and porosity of 75%. The membrane liquids tested were di (2-ethylhexyl) phosphate (DEHPA) and di-hexyl ether (DHE). The effect of adding trioctylphosphine oxide (TOPO) into DHE was also investigated. The optimum combination was found to be 12cm PP Q3/2 membrane with DHE containing 5% TOPO as the supported membrane liquid.

A HPLC method that is capable of separating all nine HAAs has been developed. A Hewlett-Packard 1050 HPLC system was used for the analysis, with a Waters Resolve® C18 column. A Waters 486 Tunable Absorbance UV Detector was used at the wavelength of 210nm. The HPLC eluent was a 0.4M ammonium sulfate solution. The flow rate was programmed as follows. It was held constant at 0.5 mL/min during the first five minutes, and then increased gradually to 2.0 mL/min in the next three minutes. From 8 to 13 minute, the flow rate was kept constant at 2.0 mL/min. The injection volume was 20μl. Minichrom V. 1.62 software was used for data acquisition and analysis.

Principal Findings and Significance:

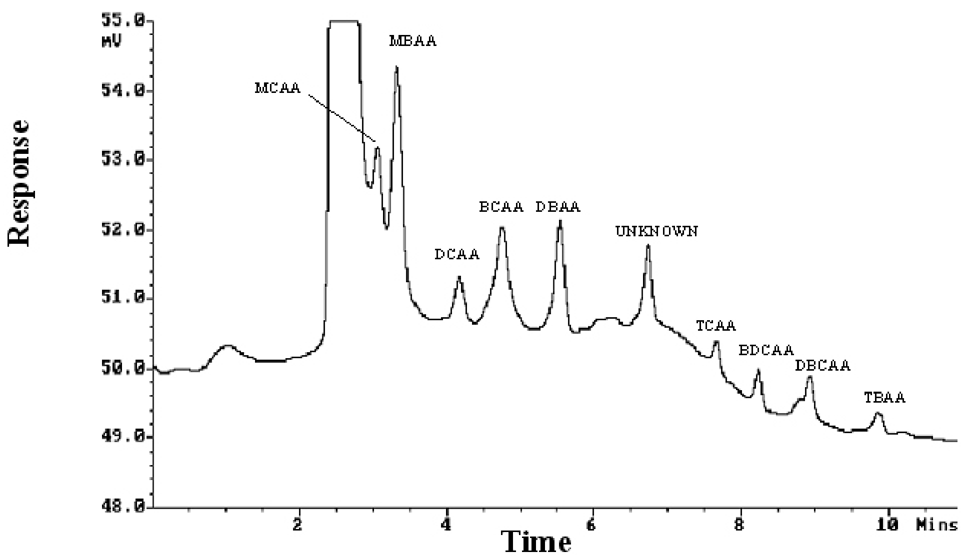

Figure 2. The chromatogram of nine HAAs in reagent water after SLMME. The concentrations were: MCAA at 40ppb, MBAA at 10ppb, DCAA at 0.8ppb, and the other six HAAs at 0.4ppb.

The developed supported liquid membrane microextraction technique is capable of achieving up to 3000 fold of enrichment of HAAs from water. The developed HPLC method using flow programming can separate the HAAs in 10 minutes. The extract from SLMME can be directed analyzed by this HPLC method, without derivatization. Figure 2 shows a chromatogram of HAAs at ppb level obtained using the developed SLMME-HPLC method. The analytical performance of this method is summarized in Table 1. This method showed excellent precision, and the detection limits were lower than or comparable to those by the standard EPA method. The SLMME device is inexpensive, easy to make, and uses only a few microliters of organic extractant. Work is in progress on coupling SLMME on-line with HPLC for real-time monitoring.

Table 1. Analytical Performance of SLMME-HPLC

	MDL (µg/L or ppb)*	MDL by EPA Method 552.2 (µg/L or ppb)*	Linear Dynamic Range (µg/L)	Linear Regression Coefficient	RSD (%)**
MCAA	7.7	0.273	20-160	0.999	6.0
MBAA	2.0	0.204	10-80	0.998	6.9
DCAA	0.21	0.242	0.8-20	0.999	11.9
BCAA	0.09	0.251	0.4-20	0.999	6.6
DBAA	0.10	0.066	0.4-20	0.999	5.1
TCAA	0.05	0.079	0.4-20	0.999	2.6
BDCAA	0.13	0.091	0.4-20	0.999	7.1
DBCAA	0.12	0.468	0.4-20	0.999	5.7
TBAA	0.08	0.82	0.4-20	0.999	3.7

* The Method Detection Limit (MDL) was obtained following a standard EPA procedure [8].
** The Relative Standard Deviations (RSD) based on seven replications was obtained at concentrations of 40, 10, and 0.8ppb for MCAA, MBAA, and DCAA respectively, and the concentration was 0.4ppb for the rest of the HAAs.

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Destruction of Volatile Organic Compounds Using the Photo-Chemical Remediation Reactor

Basic Information

Title:	Destruction of Volatile Organic Compounds Using the Photo-Chemical Remediation Reactor
Project Number:	2002NJ5B
Start Date:	3/1/2002
End Date:	3/1/2003
Funding Source:	104B
Congressional District:	6th
Research Category:	Water Quality
Focus Category:	Treatment, Groundwater, Toxic Substances
Descriptors:	: Photo-chemical remediation, reactor design and construction, ultraviolet light, volatile organic compounds
Principal Investigators:	Kenneth Y. Lee

Publication

1. Lee, K. Y., J. J-Y. Lee, and J. R. Stencel, 2002, Destruction of vapor-phase tetrachloroethylene (PCE) and trichloroethylene (TCE) using a novel photo-chemical remediation reactor, Partners in Environmental Technology Technical Symposium & Workshop, SERDP/ESTCP, 13, Washington DC.
2. Lee, J. J-Y., K. Y. Lee, and J. R. Stencel, 2002, Destruction of vapor-phase PCE using a novel photo-chemical remediation reactor, Thirty-Fourth Mid-Atlantic Industrial and Hazardous Waste Conference, edited by M. M. Häggblom, D. E. Fennell, and K. Y. Lee, 137, New Brunswick, NJ.
3. Lee, K. Y., 2003, Transport of contaminants resulting from dissolution of a coal tar pool in saturated porous media, submitted, Environmental Science & Technology.
4. Lee, K. Y., K. Kostarelos, and D. E. Fennell, 2003, Modeling the transport of dissolved contaminants originating from a NAPL source containing PAH compounds in groundwater, submitted, Water Research.
5. Lee, K. Y., J. J-Y. Lee, J. Khinast, J. R. Stencel, and M. Lavid, 2003, Photo-chemical remediation of PCE: Reactor design, construction, and preliminary results, in press, Journal of Environmental Engineering, ASCE.
6. Lee, J. J-Y., Photo-chemical remediation of volatile organic compounds, Ph.D. dissertation, Civil and

Environmental Engineering, Rutgers University, in progress.

Project Information:

A custom designed pilot-scale Photo-Chemical Remediation reactor is constructed for remediation of vapor-phase volatile organic halocarbons (VOHs), particularly chlorinated hydrocarbons such as PCE (tetrachloroethylene). Ultraviolet (UV) light, when emitted at an effective absorption frequency, cleaves a VOH's carbon-chloride bond, transforming harmful contaminants to harmless products. The stainless steel reactor is of tubular-shape with an inner diameter of 32 cm and a length of 105 cm. The net volume of the reactor is approximately 73.7 liters. Three stainless steel baffles are welded inside the reactor to create a well-mixed vapor phase and uniform UV contact time. Special low-pressure mercury amalgam UV lamps (Heraeus Inc.) are used as the photo energy source. Two independent vapor-phase PCE destruction experiments are conducted using different influent contaminant concentrations. Both experiments show a PCE destruction efficiency of over 99%.

Methodology

Figure 1 shows a schematic diagram of the reactor and the vapor phase flow path. Stainless steel (type 304) is selected for the construction of the tubular reactor vessel because of cost considerations, ability to resist corrosion, and ease in fabrication. The reactor is insulated to minimize heat loss. The reactor has an inner diameter of 32 cm and a length of 105 cm. The reactor volume is approximately 84.1 liters and this volume is reduced to approximately 73.7 liters with the insertion of sixteen Suprasil glass sleeves and three internal baffles. The Suprasil glass sleeves are geometrically positioned to provide uniform UV exposure inside the reactor (see Figure 1). Each Suprasil glass sleeve holds a low-pressure mercury amalgam UV lamp (Heraeus Inc.), which protects the UV lamp from contaminant vapor while allowing transmission of UV light into the reactor. Each UV lamp has an input power of 200 watts and an UV output of approximately 60 watts (30%). The internal baffles within the reactor help to provide a well-mixed flow of gas through the reactor and homogeneous UV contact time. Three thermocouples are mounted on the reactor to observe reactor temperature progression. The reactor and all associated hardware are mounted on a mobile frame for possible technology demonstration at a field site.

Table 1. Experimental Conditions

	Air compressor 2 flowrate [L/min]	PCE bubbler flowrate [L/min]	Reactor inlet PCE conc. [ppm_v]	Reactor residence time [min]
Experiment 1	4.36	0.19	94.0	16.2
Experiment 2	8.65	0.19	58.3	8.3

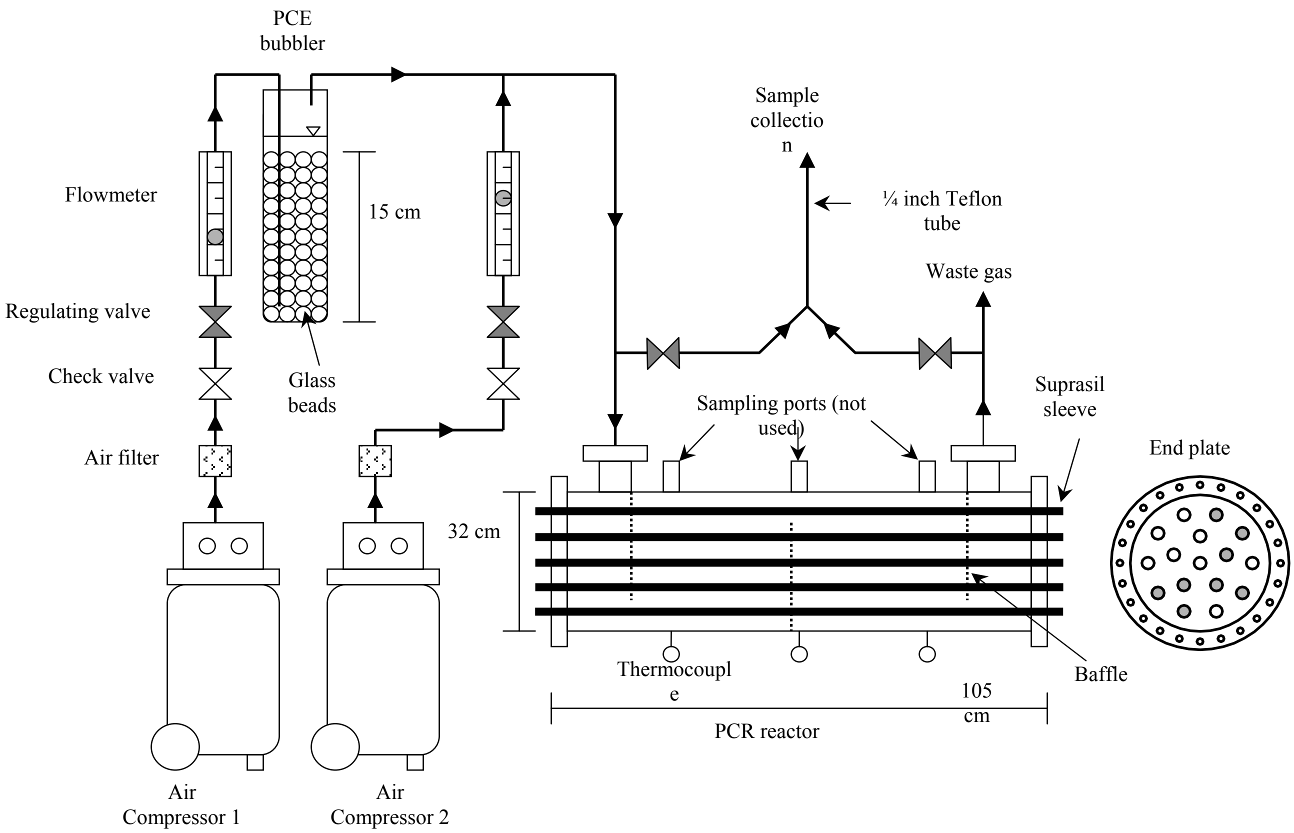


Figure 1: Reactor Flow Path.

Principal Findings and Significance

Two vapor-phase PCE destruction experiments are conducted in this study. The experimental conditions for each experiment are shown in Table 1. The main difference between the two experiments is the airflow rate from the second air compressor, which changes the vapor-phase PCE concentration into the reactor and also the reactor residence time. Prior to turning on the UV lamps, samples are collected and analyzed from the reactor inlet and outlet ports to verify consistent initial vapor-phase PCE concentrations throughout the reactor. Next, the UV lamps are turned on and effluent samples are collected and analyzed from the outlet port as a function of time. The effluent vapor-phase PCE concentrations as a function of time for both experiments are plotted in Figure 2. It should be noted that for each experiment the UV lamps are turned on at $t = 0$ min and are turned off at $t = 49$ min for the first experiment (solid circles) and $t = 56$ min for the second experiment (open circles). It should also be noted that only 8 UV lamps are operative during the experiments, and the operative lamps and their respective position within the reactor are shown on the end plate as shaded circles in Figure 1. It is apparent that the upper left corner of the reactor is without operative UV lamps. However, the UV/PCE contact time is assumed uniform due to the internal baffles. Results from both experiments showed PCE destruction efficiencies over 99%. It should be noted that in this preliminary study we are mainly interested only in the destruction of PCE. Hence, no end-products were analyzed.

Temperature could be a major factor affecting the photo-chemical reactions. Elevated temperature may increase the strength and rate of UV light absorption, and also broaden the range of light absorption, which leads to absorption shift to a longer wavelength. In this study, the reactor temperature reached in excess of 140°C due to heat generated from the UV lamps. To check for thermal destruction of PCE, an effluent sample is collected and analyzed for each experiment after the UV lamps are shut off. Note that for each experiment the effluent vapor-phase PCE concentration returned to the initial PCE concentration (see Figure 2) indicating no thermal destruction of PCE.

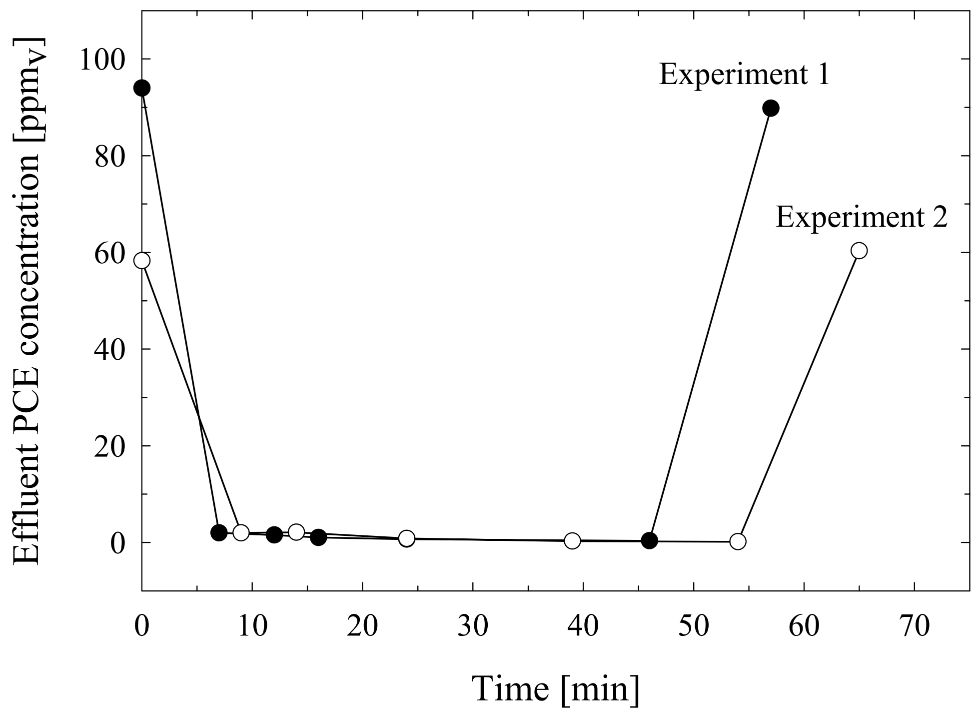


Figure 2: Effluent vapor-phase PCE concentrations as a function of time for experiment 1 (solid circles) and experiment 2 (open circles). The eight UV lamps are turned on at t=0 min for both experiments and are shut off at t=49 min for experiment 1 and at t=56 min for experiment 2.

Summary

A novel pilot-scale photo-chemical remediation reactor was designed, constructed, and utilized to perform two preliminary vapor-phase PCE destruction experiments. Influent vapor-phase PCE concentrations of 94.0 and 58.3 ppm_v with respective reactor residence times of 16.2 and 8.3 minutes were considered. The results show PCE removal efficiency of over 99% for both experiments. Furthermore, no thermal destruction of PCE was observed near 140 °C. The results from this study are very encouraging, and pave the way for future chlorinated hydrocarbon destruction experiments using other widespread contaminants such as TCE and TCA (trichloroethane).

Anaerobic biodegradation of MTBE under different anoxic conditions

Basic Information

Title:	Anaerobic biodegradation of MTBE under different anoxic conditions
Project Number:	2002NJ6B
Start Date:	3/1/2002
End Date:	3/1/2003
Funding Source:	104B
Congressional District:	6th
Research Category:	Not Applicable
Focus Category:	Treatment, Toxic Substances, Groundwater
Descriptors:	anaerobic MTBE degradation, biodegradation
Principal Investigators:	Piyapawn Somsamak, Max Haggblom

Publication

1. Somsamak, Piyapawn; Haggblom, Max, 2003, Anaerobic Biodegradation of Methyl tert-Butyl Ether under Methanogenic Conditions, in 103rd General Meeting American Society for Microbiology, May 18-22, 2003 , Washington, D.C.
2. Somsamak, Piyapawn; Cowan, Robert; Haggblom, Max, 2001, Anaerobic Botransformation of Fel Oygenates Under sulfate-reducing Conditions, FEMS Microbiology Ecology,37, 259-264

Anaerobic biodegradation of MTBE under different anoxic conditions

Problem and Research adjectives:

Methyl tertiary butyl ether (MTBE) contamination is threatening water resources all over the world. MTBE has been used as an octane enhancer for twenty years, and to reduce emission of carbonmonoxide and formation of ozone. Sources of MTBE contamination in water resources include leaked-underground storage tanks and pipelines, storm runoff, precipitation. Recently, there have been reports of MTBE contamination in lakes and coastal environments as a result of motorized watercrafts. As has been observed in others states, MTBE is a prevalent contaminant in New Jersey groundwater and surface water bodies. MTBE biodegradation has been studied extensively under aerobic conditions. However, most of MTBE contaminated sites are subsurface with insignificant amounts of oxygen. While the application of enhanced *in situ* aerobic bioremediation of MTBE is limited, the fate of MTBE in the environment is mainly dependent upon anaerobic processes. MTBE degradation has been reported under both aerobic and anaerobic conditions, but little is known about anaerobic MTBE-degrading microorganisms in general and their activity at contaminated sites.

Methodology:

The cultures were established with estuarine sediment from Arthur Kill, NJ. The cultures were initially fed 100 mg/L MTBE in medium amended with 2.5 g/L $NaHCO_3$, and $Na_2S.9H_2O$ as reducing agent. No other terminal electron acceptors were added. MTBE concentrations were monitored over time by headspace analysis using GC-FID. The depletion of parent substrate and formation of intermediates were confirmed by direct aqueous injection using GC-FID. Active microcosms were respiked with MTBE and then transferred (1:10). This transfer process was repeated periodically. Active microcosms were then tested for biodegradation activity of structurally related ethers, namely butyl methyl ether, *sec*-butyl methyl ether, and 1,2 dimethoxypropane, *tert*-amyl methyl ether (TAME) ethyl *tert*-butyl ether (ETBE). Various concentrations of methanol and toluene were added to the enrichments to observe the effects on MTBE degradation more closely. We also studied the effects of other organic compounds on MTBE degradation. Because MTBE biodegradation was observed concomitant with the formation of methane, the methanogenesis inhibitor, 20mM bromoethanesulfonic acid (BES) was added in order to examine the role of methanogens in MTBE degradation.

Principal Finding and Significance:

The methanogenic MTBE-degrading enrichments transformed MTBE to TBA. and TAME to TAA (Fig. 1). The results suggest that demethylation of methoxy group is the initial step of MTBE and TAME biodegradation. These demethylation products, TBA and TAA, are likely to be dead-end products of MTBE and TAME degradation by the enrichments. This observation is consistent with the characteristics of sulfidogenic MTBE-degrading cultures previously reported. With BES, methane production was reduced greatly, but there was no significant inhibition of MTBE degradation observed (Fig. 2), suggesting that microorganisms other than methanogens are responsible for MTBE degradation. The addition of acetate, lactate, propionate and yeast extracts exhibited different degree of inhibitory effects on MTBE degradation (Fig. 3A, 3B, 3C). The addition of 4-20 mg/L toluene and methanol did not adversely affect MTBE degradation, but slightly enhanced (Fig.4). The methane production profiles suggests primarily that with toluene amendments methane produced mainly from MTBE-degradation intermediate, while methanol was readily degraded to methane. Further study is needed in order to identify the MTBE-degrading population.

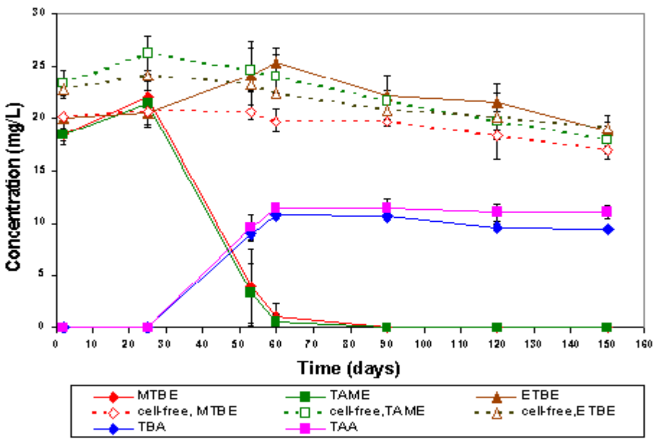


Fig. 1 Biodegradation of MTBE, TAME and ETBE by methanogenic MTBE-degrading enrichments

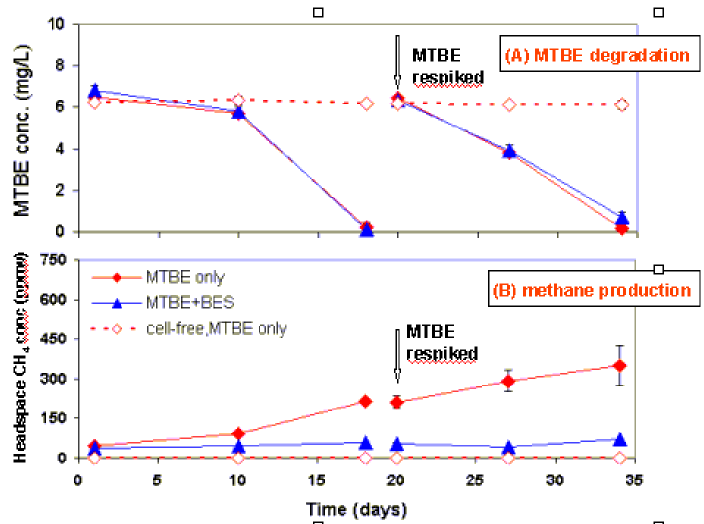
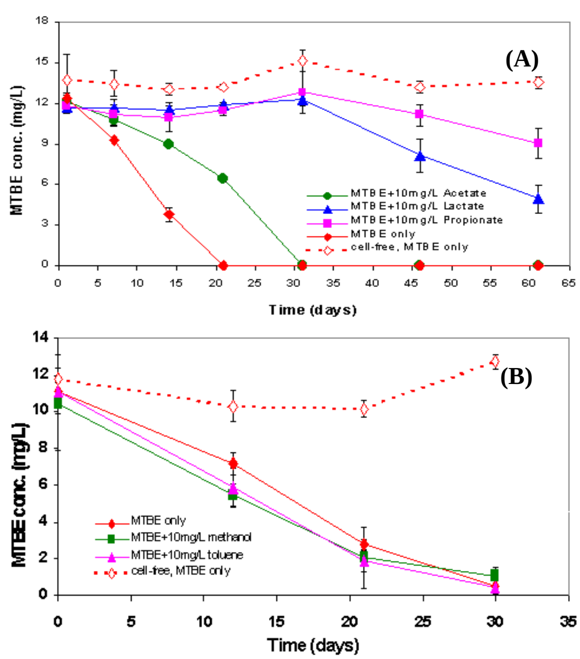


Fig. 2 Effect of methanogenic inhibitor, BES,on MTBE degradation (A) and methane formation (B)of methanogenic MTBE-degrading enrichments



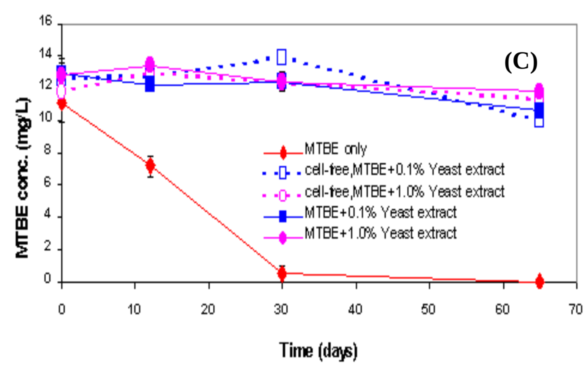


Fig. 3 Effects organic acids (A), methanol and toluene (B), and yeast extract (C) on MTBE utilization by methanogenic MTBE-degrading enrichments

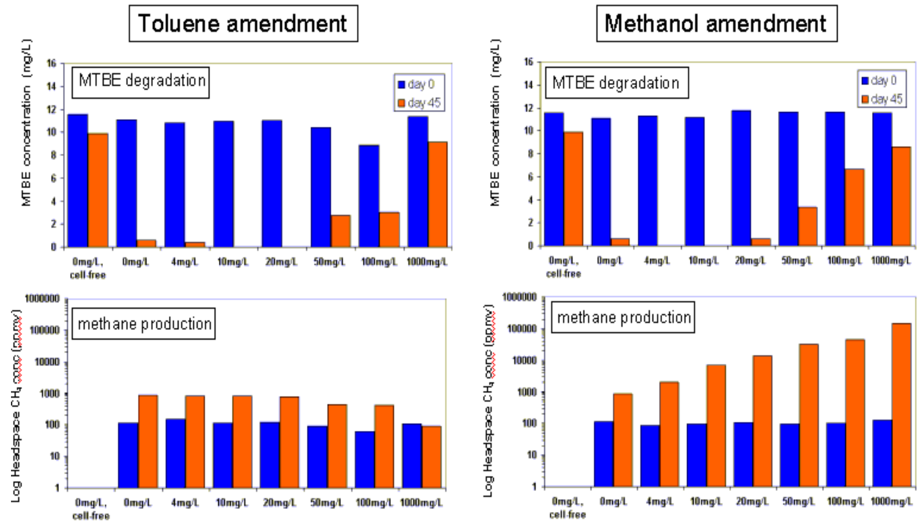


Fig. 4 Effects of various concentrations of toluene (A) and methanol (B) on MTBE utilization by methanogenic MTBE-degrading enrichments. There was no methane detected on day 0 and day 45 for cell-free of both treatments.

Salt Marsh Macrophyte Rhizosphere Effects on Sediment Microbial Community Catabolic Response Profiles

Basic Information

Title:	Salt Marsh Macrophyte Rhizosphere Effects on Sediment Microbial Community Catabolic Response Profiles
Project Number:	2002NJ8B
Start Date:	3/1/2002
End Date:	3/1/2003
Funding Source:	104B
Congressional District:	6th, 9th, 2nd
Research Category:	Water Quality
Focus Category:	Wetlands, Sediments, Methods
Descriptors:	carbon mineralization, Spartina alterniflora, Phragmites australis, sediment biogeochemical function, microbial function, Hackensack Meadowlands, wetlands
Principal Investigators:	B. W. Ravit, Joan G. Ehrenfeld

Publication

Problem and Research Objectives:

Due to their high assimilative capacities, salt marshes often act as a sink for introduced compounds. Retention of nutrient pollutants and metals in salt marsh sediments has been studied, but much less is known about the fate of organic pollutants or the value of estuarine marshes in promoting biotransformation of organic contaminants. This NJWRRI grant was requested to study the effect that different vegetation species have on salt marsh sediment microbial processes, specifically organic carbon mineralization rates. Measurement of microbial CO_2 production after the addition of various substrates results in a histogram profile for each vegetation type, and these catabolic response profiles (CRP) can then be compared. The purpose of this study is to adapt the CRP terrestrial techniques developed by Degens & Harris (1997) for use under anaerobic conditions, and to characterize the differences in *Spartina alterniflora* and *Phragmites australis* with respect to carbon mineralization.

Methodology

Sediment samples will be collected from brackish sites in the Hackensack Meadowlands (contaminated system) and the Glades wildlife preserve (non-contaminated system). Organic compounds from 8 main classes (amino acids, carbohydrates, carboxylic acids, alcohols, amides, amines, aromatics, polymers) typically found in root exudates will be added to the sediment samples. CO_2 evolution after a short (2-4 hour) bench top incubation period will produce a histogram that characterizes the ability of the *in situ* microbial community to mineralize the specific substrate. Brominated and chlorinated compounds will also be tested to determine if there are vegetation differences with respect to mineralization of halogenated organic compounds.

Principal Findings and Significance (Progress Report)

Initial tests indicate that this method can be used to differentiate wetland vegetation mineralization of organic carbon compounds.

Vegetation	CO2 Evolved/hr/g	Incubation Time	Substrate	Conc
Spartina	45.64	2 hours	a-ketoglutaric acid	200 mM
Phragmites	22.60	2 hours	a-ketoglutaric acid	200 mM
Mud	35.26	2 hours	a-ketoglutaric acid	200 mM

Concentrations: Due to the high levels of organic matter in wetland sediments, required concentrations of substrates may differ from those used by Degens & Harris (1997). Carboxylic acids tested in 100, 200, and 300 mM g^{-1} dry weight concentrations indicate that the 200 mM (used by Degens & Harris 1997) is also appropriate for wetland soils. Additional carboxylic acids are currently being tested using the 200 mM concentration. I am now in the process of testing the appropriate concentrations of other classes of substrates.

Incubation Timing: CO_2 evolution was tested after 1, 2, 3 and 4 hour bench top incubation times using carboxylic acid substrates. It was found that CO_2 production peaked after 2 hours in both vegetated and non-vegetated mud samples. However, after a 4 hour incubation period, CO_2 was found to decrease dramatically. I am in the process now of testing other substrate types for the correct incubation period.

It is possible that the decrease observed in CO_2 production is due to the CO_2 being used as a substrate for methanogenesis, resulting in CO_2 loss. I have decided to add the measurement of CH_4 to the experimental design. This means that the potential for methanogenesis, as well as carbon mineralization potential, will be measured for both vegetation types. I am currently in the process of developing a method to measure both CO_2 and CH_4 production using a single GC column and a single sample injection. The addition of methane measurement is an adaptation to the original Degens & Harris (1997) protocols that is important in the study of wetland soils.

Sediment Sampling Protocols: The first sampling protocol tried brought intact vegetation and sediment into the greenhouse, where samples were then extracted. It was found that this process resulted in sediment moisture loss as well as disruption of the rhizosphere zone. It was determined that natural sediment conditions will be less disturbed by taking cores in the field. These sediment cores will be taken from monospecific stands of each vegetation type and be immediately transported to the lab, where they will be maintained overnight at 15^0 C. Subsamples from the cores will be anaerobically transferred to 40 ml vials while in an anaerobic chamber, and anaerobically prepared sterile substrates will then be added.

Next Steps: It is anticipated that all initial adaptation tests will be completed during the summer 2003 field season. The experimental measurement of *Spartina* and *Phragmites* catabolic response profiles will be completed during Sept. 2003.

Human Components of Exotic Species Invasion in Urban Forested Wetlands

Basic Information

Title:	Human Components of Exotic Species Invasion in Urban Forested Wetlands
Project Number:	2002NJ9B
Start Date:	3/1/2002
End Date:	3/1/2003
Funding Source:	104B
Congressional District:	6th
Research Category:	Not Applicable
Focus Category:	Ecology, Wetlands, Recreation
Descriptors:	Forested wetland(s), Exotic, Invasive, Urban, Land Use, Trails, Ditches
Principal Investigators:	Heather Bowman Cutway, Joan G. Ehrenfeld

Publication

1. Bowman Cutway, Heather, 2003, Invasibility and Dispersal in Urban Wetlands, Northeast Ecology and Evolution Conference, New Brunswick, NJ

DOCUMENT 2:

Problem and Research Objectives:

While it has become dogma that urbanization promotes exotic invasion, my preliminary studies reveal that there is a significant difference in the number of exotics and the extent of invasion among wetland patches in the urban environment. These differences appear to be associated with the type of land use around the wetland and the activities that take place within the wetland. For a wetland to be invaded, particular conditions needs to be met. There must be an exotic seed source, that seed must be able to disperse into the wetland, successfully germinate and establish a seedling. That initial population must then have the ability to spread to other parts of the wetland. Further research is needed to explore the relationship between the presence of exotics in urban remnants and specific anthropogenic disturbances. By examining exceptions to the rule, a better framework for understanding invasibility can be advanced.

The objectives of my research are as follows:

1) Record the richness, density and distribution of exotic species in urban wetlands in different land use settings that are subject to varying levels of human use. (This part of the research was completed in the summer of 2001)
2) Determine the mechanism by which adjacent land use and interior human use affects the invasibility of urban wetlands at each step on invasion.
3) Verify whether land use and human use favor particular dispersal characteristics of both native and exotic species.
4) Determine if the mechanism by which land use and interior human use increase invasibility are the same.

Methodology:

The proposed research will test my hypotheses by examining the invasibility of forested wetlands (Cowardian Class PF01) in the Arthur Kill drainage basin in the central and northeastern New Jersey piedmont. The Arthur Kill watershed is appropriate for urban studies because it lies within one of nation's most densely populated and longest developed urban regions. At a population density of 5,326 people per square mile, it is 5 times more densely populated than New Jersey as a whole (the nation's most densely populated state) and 75 times denser than the nation's average (Greiliey 1993). The area, which has been settled since the 1660's, has a very long and diverse history of development (Wacker and Clemens 1995). However, amid the industry and residences relatively undisturbed habitat still exists, particularly wetlands, which were passed over by development (including a few of the largest intact tracts of open space in central and eastern New Jersey). Most importantly, the sheer number and diversity of shapes, sizes, and land use settings of forested wetlands in this highly urbanized region allows for a variety of ecological issues to be addressed.

Within the Arthur Kill watershed, I have a total of 17 study sites broken into several categories based on size and landscape position. Sites were selected by using NJDEP wetland inventory maps and aerial photographs, followed by a field visit for ground verification of site condition. I separated study sites into large (>50ha.) and small

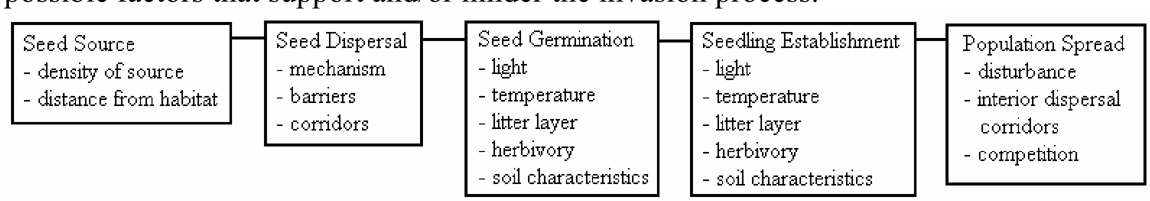
(<20 ha.) wetlands. Within the small category, wetlands have been separated by land use categories (residential vs. industrial) and shape/position categories (narrow riverine corridor vs. round, disconnected from a major waterway). All possible large study sites are within residential areas. Land use categories are determined by using aerial photographs and zoning designation. Through this approach, comparisons between categories can be made in addition to characterizing overall patterns.

I have conducted an extensive vegetation survey of each of these sites to characterize the species richness and density of native and exotic plant species. Sampling plots were located along two edges and within the interior along disturbances (trails and ditches) and in areas undisturbed by trails and ditches. Additional measurements were made to further describe the habitat including edge characterization, basal area, canopy density, and bareground and trash cover estimates. A checklist of hydrological indicators was used to estimate past and present hydrological conditions.

Through this vegetation survey, I determined that riverine corridor wetlands were the most highly invaded, an expected result due to the high amount of edge and natural disturbance in these wetlands. However, the most interesting pattern to be revealed by my study was the striking difference between wetlands surrounding by residential and industrial land use. Wetlands surrounded by residential land use had a significantly higher richness and density of exotic species than wetlands surrounded by industrial land use.

Having established a very interesting and unexpected pattern of invasibility in these wetlands, I now plan to perform several studies to determine what differences in these sites have resulted in differences in invasibility. Considering that many of these wetlands have the classic factors which should increase invasibility (high perimeter to area ratio, anthropogenic influence, pollution, and a long history of disturbance), why are some uninvaded? The answer to this question will not only aid in the formation of a more comprehensive theory of invasibility, but also give insight into how communities in urban ecosystems are structured.

For an invasion by an exotic plant species to occur, certain criteria need to be satisfied. At each stage of invasion, there are factors that could either increase or decrease the likelihood of that species continuing to the next stage of invasion. In order to determine why some wetlands are invaded while others are not, I need to carry out studies that address each of these factors. The flow chart below outlines each stage and possible factors that support and/or hinder the invasion process.



Seed Trap Study

Knowing the dispersal range, variations in seed rain, and the kind of propagules and their adaptations are essential for the understanding of the dynamics of both aboveground vegetation and the seed bank (Spence 1990). The collection of seeds is necessary to begin to determine if dispersal is the most important affect of land use (Ranney and Johnson 1997, Brothers and Spingarn 1992). Seed traps have been set at each initial sampling plot in the same configuration as vegetation sampling in 4 sites, 2 residential and 2 industrial. I will need to continue to monitor these traps on a weekly basis through the fall and then beginning again in the spring through the growing season for a full year of investigation. The results from this study will determine if seeds are entering the site at different sampling areas, how many seeds, which species, and propagule type (native and exotic). Further analysis will determine if seeds with particular life history characteristics are favored in some areas and what this means for invasibility and wetland regeneration.

Seed Bank Study

Although there are a total of 32 seed traps per site, they will only trap a fraction the of the seeds coming into the site and will most likely not capture any rare dispersal events which can be very important in population establishment. Therefore it is necessary to also conduct a seed bank study to track both past and present dispersal events. Seed banks often differ from the standing vegetation and are important factors in the regeneration of a community after disturbance (Leck et al. 1989). Soil from each of the 4 selected wetlands will be collected near each of the seed collection site to allow a direct comparison between standing vegetation, seed input, and viable seeds in the seed bank. The soil will spread onto flats and be exposed to a range of optimal conditions in terms of moisture and photoperiod in the greenhouse. Seedlings will be counted and identified.

Soil Survey and Hydrological Conditions

Soil characteristics determine what species can grow, where it can grow, and where it will be successful in producing the next generation. In wetlands, the hydrological conditions can be an important determinant in the soil characteristics of these sites. Many of these sites have been ditched and the hydrological regime disturbed. The soil may have been compacted or polluted. These factors may be important in determining whether a wetland is invasible. To further characterize these sites, I will collect soil from both the interior and edge of each site, measure litter and organic layer, and describe soil color and texture. I will measure bulk density, compaction, and organic content of the soil. Finally, I will have a battery of nutrient and metal analyses performed by the Rutgers Soil testing lab. Differences in soil conditions may indicate conditions that may encourage or discourage establishment by exotic species.

Seed Germination and Seedling Establishment Experiment

Studying the role of seed dispersal in invasibility is important because the pattern of seed-dispersion not only determines area of potential plant recruitment but also sets the stage for post-dispersal processes including germination, predation, competition, and reproduction (Cadenasso and Pickett 2001). Although it is necessary for exotic propagules to enter an area if it is to be invaded, the presence of appropriate microsites to germinate and grow is just as important. Exotic species are rarely considered selective when it comes to habitat preference, however in a highly urbanized wetland the appropriate conditions may not be present. To determine whether exotic seeds can germinate and grow, particularly in the industrial sites where they are not present, I will plant exotic seeds in the four wetlands in which the seed trap study was conducted in the same configuration. A subset of common exotics will be used including *Rosa multiflora*, *Alliaria petiolata,* and *Microstegium vimineum*. In each 2 x 2 meter plot, seeds of all 3 species will be set out in the spring of 2002. Half of the plot will be caged to eliminate predation. The plots will be tracked through out the summer to determine how many germinate and establish seedlings.

Principal Findings and Significance:

All of the studies that I proposed were planned for two years and will continue through the growing season of 2003. However, I am able to report on some preliminary findings. In my seed trap study, I have found that industrial wetlands have a higher number of seeds entering the wetland, but they are primarily from one species (*Betula populifolia*). If this one species is excluded, residential wetlands have a higher number and diversity of seeds entering the wetland. At the conclusion of this study, I will determine whether land use affects the type of seeds that are common and which type of wetland has a higher number of exotic seeds. In connection with my seed trap study, I will have two years worth of seed bank studies to further add to our knowledge of seed dispersal in urban wetlands. My preliminary findings show that residential wetlands have a higher number of seed germinating in the seed bank plots. Also, more grasses, sedges and rushes are found in the seed bank than typically found in the sites. In my seed germination and seedling establishment study, I was able to germinate one exotic species (*Rosa multiflora*) in all of the field sites and seed addition plots in the greenhouse. This supports my hypothesis that it is seed dispersal as determined by land use, not within site conditions, that are driving the differences in community invasibility.

Undergraduate Research Intern Program

Basic Information

Title:	Undergraduate Research Intern Program
Project Number:	2002NJ15O
Start Date:	6/1/2002
End Date:	12/31/2002
Funding Source:	Other
Congressional District:	6th
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	
Principal Investigators:	Joan G. Ehrenfeld

Publication

Using funding provided by Rutgers University, we offered an Undergraduate Research Intern program for the second year. In February, a call for proposals was sent out to all water-related principal investigators in our mailing list in New Jersey (approximately 200 names). The RFP solicited proposals to involve an undergraduate in water-related research over the summer, 2002, with the requirement that the student present the research at an appropriate forum, and to prepare a summary of the work to be posted on our website.

Of the eight proposals received, four were funded following review by the Advisory Council. They included the following projects:

Dr. Joseph Orlins, Dept. Civil and Environmental Engineering, Rowan University, "Hydrologic and Hydraulic Studies of South Jersey Dams."

In this project the student conducted analyses of three dams on the upper Mantua Creek watershed and helped Dr. Orlins prepare a report submitted to the NJ DEP regarding these structures. Dam failure has become an important issues in managing many streams in New Jersey, and this project trained the student to be do appropriate hydrologic and hydraulic analysis and to work with the public on important water management issues.

Dr. William Cromartie, Dept. Environmental Studies, Richard Stockton College of New Jersey, "Development of Improved Biomonitoring Protocol for the Great Egg Harbor River."

In this project, the student worked with the NJ Pinelands Commission and the Atlantic County Office of Regional Planning to adapt biomonitoring protocols to the acidic, blackwater streams of the New Jersey Pinelands. Standard protocols for assessing water quality do not work on this region, because the aquatic fauna is unlike the rest of the state, and is highly adapted to extreme water characteristics (high acidity, low alkalinity, low nutrients, high DOC). The work gave the students experience in freshwater sampling, water quality sampling, and GIS.

Dr. Colleen Hatfield, Dept. Ecology, Evolution, and Natural Resources, Rutgers University. "Effects of mixed land use on riparian plant community characteristics of New Jersey headwater streams."

In this project, the student used GIS to characterize landuse surrounding two streams that run through mixed-use watersheds in western New Jersey, and then assisted with sampling of vegetation in the riparian zone adjacent to the stream relative to each land-use type. The student gained experience with both riparian plant community analysis and the issues involving land-use effects on riparian wetlands.

Dr. Joseph Orlins, Dept. Civil and Environmental Engineering, Rowan University, "Streambank Stabilization of Chestnut Branch of Mantua Creek."

In this project, the student was involved in geomorphic analysis of the stream corridor running through the Rowan University campus, collection of data for hydrologic and hydraulic analyses, and monitoring of waterquality in the stream before and after streambank stabilization measures were taken, as based on the hydraulic and hydrologic data collected. The project contributed to an effort funded by the NJDEP. The student gained experience with all phases of conducting the sampling, interpreting the data and preparing a final report.

Wetlands in urban regions: connections among wetland structure, wetland function and regional water quality.

Project 2002NJ16G was not funded for FY2002.

Wetlands in Urban Regions: Connections Among Wetland Structure, Wetland Function and Regional Water Quality"

Significance and Regional Importance:

The New Jersey Department of Environmental Protection has made watershed management the primary process for the protection of water resources throughout the state. Of the 20 watershed management units that have been designated, nearly half are primarily urban in land-use (www.state.nj.us/dep/gis/), reflecting the largely urban/suburban nature of the east coast, as well as many regions throughout the country. Watershed management requires knowledge of the functional relationship between landscape elements and water quality and quantity. While extensive data is available to demonstrate the deleterious effects of urban land-use on water resources, there is much less information concerning the ameliorative effects of natural areas, particularly wetlands, within urban regions. In fact, there is remarkably little known about the biotic integrity or functional capacity of urban wetlands, as well as their role in protecting water quality .

Analysis of data collected as part of the Long Island-New Jersey Study Unit of the NAWQA Program demonstrate clearly that stream health, as indicated by both benthic invertebrate-based indices of biological integrity (Kennan 1998, 1999) and measurements of pollution by nutrients and pollutant chemicals (O'Brien 1997, O'Brien et al. 1997, Stackelberg 1997, Reiser and O'Brien 1999) is highly correlated with the amount of wetland in the basin. While the ability of wetlands to improve water quality is known in general, especially for agricultural landscapes, there is little information available to evaluate the effectiveness of different qualities and locations of wetlands within urban basins to improve or protect water quality. Indeed, there is little data permitting direct comparisons of wetland structure and function, especially for urban wetlands. Management of urban/suburban watersheds, as well as the restoration of these wetlands, requires better knowledge of the functional role of wetlands in protecting stream water. While the proposed study specifically addresses the urban watersheds of the LI-NJ NAWQA, the results will be widely applicable to urban/suburban watersheds throughout the country.

The research will result in quantitative and predictive relationships between the biological and chemical measures of surface water quality obtained through the NAWQA program and quantitative measures of the structure (invertebrate-based indices) and function (nitrogen removal capacity) of wetlands. Furthermore, the two measures of wetland quality will be analyzed for wetlands of different sizes and landscape positions relative to surface waters; the results will be integrated with spatial data on the extent and position of wetlands within the selected watersheds to yield predictive relationships between landscape structure within a watershed and downstream water quality.

These results will be of use to a variety of different groups. First, the results will be directly usable by land, water and watershed managers, in both the governmental and private sectors, seeking to protect and manage both wetlands and surface waters. For example, three current controversies in the Rahway River watershed (one of the proposed study areas) involve applications to destroy forested wetlands (one, to construct a sports complex, the other to construct a housing/commercial development) and a request for state funds to restore wetlands on a previously filled portion of the floodplain. Local and state officials are seeking scientific information on both the function of urban wetlands, and the connection of these wetlands to riverine water quality, in trying to resolve these situations, but the necessary data do not exist. Wetland protection and restoration in urban/suburban regions has taken on an extreme urgency, and is a high priority for government agencies from the federal to the municipal levels, as well as for land-management NGOs; our discussions with land managers in all these sectors indicate that the results will be immediately useful and highly valued by them. Second, the data will be useful to scientists trying to understand the linkage between terrestrial land-use and water quality, as models currently rely simply on total areal extent of wetlands, rather than specific placement, size and internal characteristics of wetlands within a basin. Third, there is an extraordinary lack of information about the functions and qualities of wetlands in urban landscapes; the data will thus provide wetland scientists with important data on a class of wetlands that are not well understood but which are critical for the management of water resources in urban environments. As over half the population of the US now lives in urban/suburban regions, the data will be widely useful. Fourth, the data will complement and extend the NAWQA data, thus improving the usefulness of this extensive research effort. Thus, the results will be directly useful to managers, but also useful to a wide variety of scientists studying the determinants of surface water quality.

Progress to date:

Delays were experienced in locating study areas for the project, because of the necessity of matching sites with suitable wetland soils and vegetation adjacent to low-order streams (capable of being sampled without a boat), in watersheds with data from the NAWQA system, with suitable access and permission to work. After lengthy examination of a large number of sites, fifteen sites were selected for the study, and permission received from the owner of the property for access and ability to sample. Although the original project design called for sites of different sizes and positions relative to the stream, it proved impossible to location sufficient sites of each type in each NAWQA watershed for which access and the combination of soils and stream conditions obtained. We therefore took the approach of using hydrogeomorphic classes to establish treatment groups. Five sites in each of three hydrogeomorphic classes were successfully located. Based on prior research by the PI, these hydrogeomorphic classes represent the dominant types of wetland found in this urban region. They are: (1) mineral flat wetlands – large wetlands located on glacial lake sediments, largely driven by precipitation; these sites were drained by small (2-3º order) streams; (2) mineral flat-riverine wetlands, also located on glacial lakebed sediments but also adjacent to higher-order rivers that provided overbank flooding that supplement precipitation as the dominant sources of hydrology; smaller streams within the wetland were selected for invertebrate sampling, and (3) riverine wetlands, adjacent to 4th-order and higher streams, for which overbank flow is the dominant source of water. In addition, four "control" sites were established to provide some comparison with the highly urbanized setting of the main sites. These sites were located either within the Great Swamp National Wildlife Refuge, a 5000-acre protected area within the heavily developed landscape of the rest of the project (mineral flat site) or in the floodplain of the Millstone River within the Delaware-Raritan Canal State Park. Neither site is truly free of urban impact,but both have natural habitat, rather than urban developed land, immediately adjacent to the sampled riparian wetland and stream corridor.

Within each site, we have installed (1) an RDS well for continuous monitoring of water table levels, and (2) three piezometers arrayed along a transect perpendicular to the stream and crossing the study area for soil function. The piezometers have been monitored on a bi-weekly basis while water is present, and the recording wells are being downloaded regularly. The project was significantly affected by the drought of 2002, as both the wetlands and the adjacent stream corridors were dry for much of the growing season (and indeed the clayey soils were sufficiently hardened that samples could not be obtained). We are now monitoring pH, conductivity, nitrate concentrations (using a nitrate probe), and temperature of the water in the piezometers on each measurement date.

The stream work accomplished to date includes the following:

1. Quantitative sampling of the macro-invertebrate community, by microhabitat type, was conducted through a 200-meter reach. Collected organisms were identified to genus or species, with the assistance of local specialists. A second sampling of the streams is planned for this autumn.

2. Stream habitats have been quantitatively described (sediment texture, stream cross-sectional profiles at 10 m intervals through the study reach, sinuosity, diversity of microhabitats).

3. A litter decomposition experiment was established to provide data on ecosystem function of these streams. Litter containers with a 3 mm mesh were prepared, containing two standard substrates in separate compartments (popsicle sticks, a standard wood substrate, and *Phragmites* stems, a standard herbaceous plant m,aterial substrate). Approximately 500 litterbags were constructed and deployed in the streams; they are being retrieved at monthly intervals over the next six months to monitor decomposition rates.

4. Artificial substrates have been prepared and are being deployed in the stream to provide a constant substrate for macroinvertebrate attachment. They will be retrieved at the end of the growing season and the invertebrates counted.

At each site, sequential incubations of core have been conduction to measure nitrogen cycling processes. These measurements have been made since the soils re-wetted when the drought ended last fall (sampling was physically impossible during the summer, due to the extremely hard condition of the dry, clayey soils). Every three weeks, two sets of samples are taken at five points across the sample wetland area of each site, using a soil probe with plastic inserts; one set is returned to the lab for extraction of mineral and dissolved organic N fractions, and the other sample capped and returned to the hole for field incubation until the next sampling episode. The samples returned to the lab are measured for denitrification activity (using acetylene inhibition) prior to extraction. Basic soil properties (moisture, pH, organic matter content) are also determined for each sample.

Work remaining to be done including sampling the vegetation to determine nitrogen uptake in plant tissue and sampling of litterfall to determine N return.

We hope to also conduct event-based sampling soil N dynamics (i.e., following re-wetting of the soil after rain) in order to capture transient dynamics during periods of changing soil moisture. However, challenges of having a rain event that affects the entire region (as opposed to localized thunderstorms), and the large travel time necessary to visit all sites (three days needed to sample all sites) has made this goal difficult to achieve thus far.

Finally, the GIS analysis of the study sites, to characterize land-use in the watersheds upstream of each study site, has yet to be completed.

Information Transfer Program

NJWRRI Information Transfer Activities

Basic Information

Title:	NJWRRI Information Transfer Activities
Project Number:	2002NJ14B
Start Date:	3/1/2002
End Date:	3/1/2002
Funding Source:	104B
Congressional District:	6
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	New Jersey Flows, Hackensack Meadowlands, TMDL, Watershed Management, water education
Principal Investigators:	Joan G. Ehrenfeld, Jeannine A. Der Bedrosian

Publication

Our information transfer efforts included the following activities:
1. Four issues of an 8-page newsletter, "New Jersey Flows", was published and distributed to a mailing list of approximately 2,000 people around the state (an increase of about 200 names since the previous year). The issues included (1) an issue highlighting presentations at the National AWRA meeting that concerned New Jersey water resources, (2) an issue profiling water education programs for K-12 and general public audiences, (3) an issue on TMDLs and research sponsored by the WRRI, and (4) an issue highlighting research in the Hackensack Meadowlands, a region of great political prominence in the state. The newsletter also carries announcements of water-related publications and conferences. The newsletter is also archived with the New Jersey Environmental Digital Library, a service of the Rutgers University Library system.

The newsletter carries regular columns in most issues that include 1) an update on water-related research activities at the NJ DEP Division of Science and Research, (2) an update on water-related research activities at the USGS – Trenton District Office, (3) an article by the State Climatologist on notable aspects of recent weather, as it affects water resources, (4) an article describing one of the 20 watershed management units of the state, written by a member of the planning staff for that unit (our goal is to acquaint readers with the diversity of watersheds present in the state).

2. Our website (http://njwrri.rutgers.edu/) pages describing recently completed research was updated to reflect the past year's work.

3. We were represented at and co-sponsored several conferences, including:
"The Watershed Symposium" primary sponsor, NJ DEP
"Stormwater Management and Stream Stabilization" primary sponsor, Meadowlands Environmental Research Institute
"Nutrients and Pesticides – Tools,, Research and Implementation" primary sponsor, NJ Agricultural Experiment Station
"Phosphorus and the Land – Second Annual Agricultural and the Environment Symposium", primary sponsor, NJ Agricultural Experiment Station
"The Science of Sprawl" Primary sponsor, NJ DEP

4. We initiated, organized and led a conference on "Watershed Management and the University" in which we explored the role that universities can take in helping develop watershed management programs with public and not-for-profit community groups. Speakers from five universities and colleges around the country came to share their experiences in setting up such programs, and speakers from five institutions in New Jersey described their efforts to develop such programs. Over 100 people, representing 27 academic institutions, many watershed management organizations, and government agencies attended.

5. We co-sponsored a visit by Dr. Robert Holmes, of the Ecosystem Center, Marine Biological Laboratory, to speak on "Increasing Arctic River Discharge: Responses and Feedbacks to Global Climate Change", with the Center for Environmental Prediction and the Ecology and Evolution Graduate Program of Rutgers University. In addition to his

public seminar, Dr. Holmes met with climate researchers and aquatic ecologists to discuss his research and provide advice to ongoing research in New Jersey.

5. We organized a meeting, working jointly with the New Jersey District Office, US Geological Survey, to inform members of the New Jersey State Legislature about important water issues that would be of concern to the state. The meeting was held at the State Legislature, in September, at the start of the legislative session. We intend to continue a program to provide timely information about water issues to the state legislature.

6. We circulated numerous announcements of meetings, water-related seminars, grant announcements and similar items to our list of about 200 water researchers around the state.

USGS Summer Intern Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	1	0	0	0	1
Masters	1	0	0	0	1
Ph.D.	5	1	0	0	6
Post-Doc.	3	0	0	0	3
Total	10	1	0	0	11

Notable Awards and Achievements

NJWRRI sponsored a conference, Watershed Management and the University which explored the role that universities can take in helping develop watershed management programs with public and not-for-profit community groups. Speakers from five universities and colleges around the country came to share their experiences in setting up such programs, and speakers from eight institutions in New Jersey described their efforts to develop such programs. Over 100 people, representing 27 academic institutions, many watershed management organizations, and government agencies attended.

First place poster award (Ph.D. level). Experimental results on the destruction of tetrachloroethylene (PCE) using a novel photo-chemical remediation reactor, New Jersey Water Environment Association Annual Conference, Atlantic City NJ, May 2002, J. J-Y. Lee and K. Y. Lee.

Publications from Prior Projects

1. 2001NJ1181B ("Vapor phase UV Destruction of organic contaminants") - Articles in Refereed Scientific Journals - Lee, K. Y., Transport of dissolved contaminants originating from a rectangular prism shaped multicomponent nonaqueous phase liquid source in saturated porous media, 2003, Environmental Geology, 43(1-2), 132-137.
2. 2001NJ1361B ("Pilot Study on the Use of Hydrogen Release Compounds for PCE Enhanced Biodegradation in Fractured Rock Aquifers") - Articles in Refereed Scientific Journals - Lee, K. Y. and C. A. Peters, 2003, UNIFAC modeling of cosolvent phase partitioning in NAPL-water systems, in press, Journal of Environmental Engineering ASCE.