New Jersey Water Resources Research Institute

Annual Technical Report

FY 1998

Introduction

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Hydrogeomorphic
Project Number	06
Start Date	01/01/1985
End Date	01/01/1985
Research Category	Biological Sciences
Focus Category #1	Acid Deposition
Focus Category #2	Acid Deposition
Focus Category #3	Acid Deposition
Lead Institution	Richard Stockton College of New Jersey

Principal Investigators

Problem and Research Objectives

Priority Issues: This project deals most closely with priority Ia. and If. The method of analysis (i.e., Rosgen Geomorphic Ar~alysis of Streams) was designed to assess the "norm" of various segments of streams in order to determine ecosystem health and remediative actions if necessary. The hydrologic behavior of streams is used to bring about the conditions for the maintenance of stream ecosystems. In addition, this projects also addresses priorities IIIa. This analysis is onsite. It attempts to establish a reproducible methodology and will be applied to the Atlantic White Cedar Bogs and Hardwood Swamps through which these streams flow. Specific Obiectives: 1. Apply the Rosgen Hydrogeomorphic Analysis to Penns Swamp Branch as a prototype for a larger study of the entire drainage basin of which it is part. 2. Analyze this stream up through the third level of Rosgen Analysis. 3. Assess the feasibility and attempt the fourth level of Rosgen Analysis 4. Assess the limitations of this method applied to sandy coastal plain streams. Brief Descr~ptions: Riparian environments form as a transaction between plant and animal communities with the geomorphic processes of streams. The volume of water and the nature of the material over which the streams flow control the depth, width, erosion, deposition and sinuosity

of the streams. Alteration of the materials by such things as the destruction of the bank vegetation starts a readjustment of the stream's depth, width, erosion, deposition and sinuosity. This, in turn, alters the plant and animal communities in the channel, along the banks and on the floodplain. Hydrogeomorphic analysis of wetlands and streams has received much attention in the last five years. Studies by M.M. Brinson (1993), RM. Lent & others (1997), C.M. Epstein (1997) and C.A. Cole & of hers (1997), applied geon~orphic techniques to wetland class)fication. But the extensive work of Dave Rosgen (1994, 1996) and the application of his technique by the U.S. rarest Service (C.C. Harrelson & others, 1994) utilizes hydrogeomorphic techniques to assess the "norms" and degradation of riparian environments of the prairie and rocky mountain states. Rosgen analysis assesses the "normative" state of streams from their source to their mouth and throughout their.drainage basin. It attempts to see what a "healthy" stream is as it varies from low to high stream discharges, high to low slopes, and with varying substrates. Once established '~nhealthy" reaches can be identified based on the established norm. This approach assesses "normal" stream erosion and deposition and the adaptation of ecosystems to those conditions. However, this technique has not been applied extensively to the east coast coastal plain and not at all for the New Jersey Pinelands. This study will be the first applied to the sandy streams of the New Jersey coastal plain. It will be applied to Penns Swamp Branch in the New Jersey Pinelands. This stream has been chosen because of its small size, accessibility by road at many points along its course, and because of prior work by the Stockton College students and faculty on Penns Swamp (C.M. Epstein, 1995, G.Zirnrnermann, undated).

Methodology

The following activities will be undertaken. 1.) Surveyed with transit to assess several geomorphic parameters (i.e., entrenchment ratio, width/depth ratio, sinuosity, slope, bankfull depth, width and discharge, etc.) used in Rosgen analysis. 2.) Assess through field observations the bankfi~ll channel level using such indicators as change in bank slope, changes in vegetation type, presence of erosional landforms, signs of siltation, and other signs observed onsite. 3.) Field measurements will be taken to determine stream depth, width, stream velocity and discharge, nature of the bank and channel substrate, and water temperature. 4.) Subdivide the stream into distinct segments based on common geomorphic parameters and establish geomorphic '`type reaches" that will provide the healthly "norm" for each segment.

Principal Findings and Significance

The methodology established by Rosgen (1996) is applicable to Penns Swamp Stream in spite of the dense vegetative cover. Though many parts of the stream where inaccessible, eight reaches, representative of the entire stream channel, were established along segments of the stream channel from source to mouth. Visual observations, field measurements and surveyed parameters where taken for each of these type reaches. Consequently, these reaches were assigned to three Rosgen stream types (E, DA, and C). The "calibration" of the Rosgen method to the New Jersey Pinelands involves two factors. First, the channel materials identified by Rosgen include rock, boulders, cobbles, gravel, sand, and mud, numbered 1 through 6. But the channel material present in many parts of Penns Swamp Stream is peat, which we designate by the number 7. There is another impact of the peat on the application of the Rosgen method. Peat, its vegetative cover, and the roots contained within the peat, resists erosion more effectively than most of the other channel materials covered by Rosgen. Consequently, the streams have lower sinuosities than those predicted by Rosgen. Second, the role of groundwater discharge due to shallow water tables is the major source of flooding in Penns Swamp Stream as well as for most of the other New Jersey Pinelands Streams. This has repercussions on the size of the flood prone area. Rosgen bases his prediction of flood prone area as a function increased channel discharge. This results generally

in a flood stage that is too high for Penns Swamp Stream. The pattern of stream types make a consistent pattern along Penns Swamp Stream. The headwaters of the stream are C type streams. These give way to DA type streams, which in turn give way to E streams near the stream's lower reaches. The change from C to DA marks increased peat production causing the single channel to break down into several channels as it flows over the peat and between wetland trees. Channels are cut deeper and deeper into the peat. Near its confluence, the Batsto River lowered Penns Swamp Stream's base level, thereby stimulating further channel deepened within the peat. The increased erosional down cutting has entrenched the lower reaches of Penns Swamp Stream into its floodplain resulting in a single, relatively deep and narrow channel. This is represented in the Rosgen method by the E type stream. The application and calibration of "Rosgen" analysis to Penns Swamp Stream suggests its applicability to the rest of the New Jersey Pineland Streams.

Descriptors

stream morphology, NJ Pinelands, Rosgen analysis, bankfull dimensions, floodplains, Coastal Plain

Articles in Refereed Scientific Journals

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Biodegradation of nonionic surfactants
Project Number	08
Start Date	01/01/1985
End Date	01/01/1985
Research Category	Biological Sciences
Focus Category #1	Acid Deposition
Focus Category #2	Acid Deposition
Focus Category #3	Acid Deposition
Lead Institution	NJ Institute of Technology

Principal Investigators

Problem and Research Objectives

Contamination of soils and groundwater by petroleum products is a very serious environmental problem. A large fraction of compounds (PAHs- polycyclic aromatic hydrocarbons) in petroleum are of utmost concem as many of these compounds are resistant to biodegradation and are highly toxic. In a typical petroleum contaminated site, the remedial operations require cleanup of the soils and groundwater by airstripping and carbon adsorption. However, both of these technologies are very expensive and contaminants are not destroyed but simply transferred to another medium requiring additional treatment and disposal. Thus, research, in recent years has focused on increasing the biodegradation rates of such compounds by surfactants. Addition of surfactants, detergents and emulsifiers have been successfully applied for cleanup of petroleum contaminated sites. However, recently a certain group of widely used surfactants (APEs) were banned in Europe because scientists discovered that APE breakdown products are highly toxic to aquatic organisms (Ahel et al., 1994; Renner, 1997). Recent evidence that some APE breakdown products are estrogenic has intensified concem over their environmental and human health effects. Throughout northem Europe a voluntary ban on APE use in household cleaning products began in 1995 and restrictions on industrial applications are set to follow by the year 2000. In the United States, industrial uses of APE encompass the largest category (55o/O). The primary industrial uses of APEs are for emulsion polymerization and polymer stabilization in plastics and elastomers; cleaning, spinning, weaving, and finishing of textiles; wetting agents and emulsifiers in agricultural chemicals; and pulping and deinking in the paper industry. Institutional use of APEs are confined to cleaning products, and most are found in commercial laundry detergents, janitorial products, and vehicle cleaners. In the household market, APEs are used mainly in laundry detergents and hard-surface cleaners. Most APEs enter the aquatic environment after disposal in wastewater. Problem Statement There are no U.S. regulatory act~ons to date for APks. U.S. and European regulators and researchers disagree strongly over the risks of APEs. Very few detailed studies have been conducted in the U.S. on the toxicity of APEs (Giger, 1987). An EPA study concluded that there might be concern in some U.S. rivers due to industrial discharges of APEs. More research on the fate and transport of APEs in the environment is therefore essential before APEs are banned or phased out in the U.S. Research Objectives This proposal aims at studying the fate and transport of common commercial nonionic surfactants in the environment. Studies will be conducted to assess the biodegradability of surfactants in surface waters, wastewaters and soils. Experiments to identify biodegradation intermediates will eventually be conducted by graduate students and toxicity tests will be performed on the intermediates. Mathematical modeling will also be incorporated to determine human health or ecological risks. Preliminary research on screening certain surfactants are already in progress. The findings from these experiments will be a significant contribution not only for researchers in the U.S. but all over the world by indicating whether APEs are indeed toxic or not. Furthermore, it will help address the federal mandate for integrating research and teaching at undergraduate institutions. Research experiences expose students to the creativity of the research process and enable them to apply their acquired knowledge from required coursework. Involving undergraduates in research will also encourage them to pursue an advanced degree. Lastly, this research will be instrumental in seeking funds from NSF and EPA and also in involving the state regulatory agencies, local industries and municipalities. Therefore the specific goals of this research are: To involve undergraduate students in research experiences that enhance their understanding of engineering fundamentals, To conduct preliminary biodegradation and sorption studies on nonionic surfactants, To conduct mathematical modeling of experimental data, and finally To stimulate undergraduate students in pursuing graduate studies by becoming involved in meaningful research in their early years.

Methodology

Surfactants will purchased from Sigma Chemicals, St. Louis, MO. and are listed in Table 1. Nonionic

surfactants are characterized by higher hydrocarbon solubilizing power, weaker adsorption to charged sites, less toxicity to bacteria, poor foaming properties and compatibility with other types of surfactants. Surfactants were without further purlfication as they would be in any large-scale application. Surfactant Triton X-114 Tergitol Np-9 Table 1: List of Surfactants | Type I Alkyl Phenol Ethoxylate Acclimated cultures capable of degrading these surfactants will be developed from wastewater obtained from the Winslow Wastewater Treatment Plant at Winslow, New Jersey. Enrichment cultures will be developed in batch reactors incubated at 20oC with surfactants as the sole carbon source. Batch experiments will be carried out in closed BOD bottles in the Hach BOD Trak System (Hach, Loveland, CO) with PC based data acquisition. Oxygen uptake measurements will be recorded with time and cell growth will be monitored by protein measurements utilizing the method of Lowry et al,. (1951). All experiments will be conducted in duplicates. Controls without surfactants will also be maintained. Surfactant concentrations will be monitored spectrophotometrically at a wavelength appropriate for each surfactant. Penn sand (Ricci Brothers Sand Co., Port Norris, NJ), which is almost pure quartz and characterized by a very low organic carbon content (foc=0.01o/O) will be used for sorption studies. The sand used in these studies will be the size fraction passing sieve #30 and retained on sieve #120, in order to remove any fine materials and large sand particles that may result in non-homogenous packing. Before each experiment, the sand will be washed with deionized distilled water and autoclaved. Autoclaving will be carried out at a temperature of 121oC and 15 psi Pressure. Sorption experiments will be conducted for all surfactants. Sorption of surfactants is an extremely important factor for surfactant enhanced soil remediation procedures. Surfactants are amphiphiles with spatial variations in polarity; they adsorb at the solid-liquid interface. Batch sorption experiments will be conducted to determine the sorptive properties of the selected surfactants. Experimental methods outlined by Jahan et al. (1997) will be followed. Mathematical modeling of biodegradation data will also be carried out by methods outline by Jahan et al. (1997) to characterize the rates of biodegradation and cell growth.

Principal Findings and Significance

For the APE surfactants, the alkly group is preferentially attacked until branching or a phenol group is encountered;; then the rate of polhyoxyethylene degradation becomes more favorable. The batch biodegradation experiments indicate that both surfactants are biodegradable by microorganisms present in wastewater. The oxygen uptake curves do not indicate any toxic or inhibitory effects of both surfactants at the concentrations studied. This of course does not eliminate the occurrence of toxic metabolitic intermediates.l THe occurrence and biodegradability of metabolites will be the focus of future studies. Sorption of surfactants were adequately described by linear isotherms. The sorption coefficient for Tergitol NP-10 was 0.0069 L/g and that of Triton X-114 wsas 0.0021 L/g. These values indicate that Tergitol has a greater affinity for Penn sand than Triton. Based on these findings and those from other studies, it is reasonable to expect that sorption of surfactants is adequately described by linear isotherms at low concentrations. Linear adsorption isotherms simplify the representation of the adsorption process in mathematical models and therefore enhance the predictive capabilities of such models. columm flow-through studies are in progress for studying sorption of these surfactants. Experimental results indicate that acclimated enrichment cultures can be cultivated from municipal wastewaters. Results for Tergitol are promising as the surfactant was readily biodegradable as evidenced by the oxygen uptake and Tergitol concentrations. No inhibitory or toxic effedcts were observed during biodegradation experiments. Sorptiondata indicate that surfactant sorption may have a significant role during commercial use of surfactants for agricultural purposes.

Descriptors

surfactants, biodegradation, water quality, microbial activity, soil sorption, alkyphenol ethoxylates

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	
Project Number	
Start Date	01/01/1985
End Date	01/01/1985
Research Category	Biological Sciences
Focus Category #1	Acid Deposition
Focus Category #2	Acid Deposition
Focus Category #3	Acid Deposition
Lead Institution	NJ Institute of Technology

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Georgene Mortimer	Associate Professor	NJ Institute of Technology	01

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Examination and characterization of nitrifying bacteria in water distribution system biofilms in New Jersey
Project Number	03
Start Date	03/01/1997
End Date	02/28/1998
Research Category	Biological Sciences
Focus Category #1	Water Supply
Focus Category #2	Nitrate Contamination
Focus Category #3	Water Quality
Lead Institution	New Jersey Water Resources Research Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Phanida Prommasith	Student	Rutgers University	01
Peter Strom	Associate Professor	Rutgers University	01

Problem and Research Objectives

Biofilms attached to the distribution pipe wall have been reported to be an important factor contributing to outbreaks of waterborne disease (Camper, et al., 1996). Increasing residual chlorine levels can help control biofilm formation. However, due to the increased potential for producing chlorination by-products (CBPs), there is a desire to decrease chlorine use instead. In some cases chloramination is

being practiced to maintain a chlorine residual while minimizing CBPs. Ammonia may be intentionally added for this purpose, or levels already may be high enough without further addition.

A main drawback of the continuous application of chloramines is increased heterotrophic bacterial densities in some slow-flow sections of the distribution systems. A similar problem has been reported to have occurred frequently in New Jersey. We suspect that decreased water quality in some chloraminated systems, along with the biofilm formation, may be largely a result of the activity of nitrifying bacteria.

Nitrifying bacteria are known to be resistant to chlorine. A main product of their activity, nitrite, reacts rapidly with residual chlorine to inactivite it. Further, nitrifiers are autotrophic, and thus donot require organic matter for growth. However, their release of metabolic by-productsmay enhance the growth of heterotrophic] bacteria.

The main objectives of this study are to investigate the presence of nitrifying bacteria in water distribution biofilms, the factors that support their presence, and their effect on the overall biofilm ecosystem. The specific objectives are:

1. to assess and analyze the density of nitrifying bacteria in water distribuiton biofilms

2. to identify and characterize ammonia-oxidizers and nitrite- oxidizers found

3. to statistically assess the number and types of nitrifying bacteria and their relation to the selected water quality parameters.

Methodology

This study includes two parts: (a) sampling and analyzing finished water distribution system biofilms, and (b) laboratory work on biofilms involving documenting conditions, data analyses, modeling, and evaluation.

The field study was conducted in collaboration with the United Water Company in Bergen Country, New Jersey. This facility practices chloramination and provides opportunities for inserting coupons in the distribution system pipes. Finished water samples was collected monthly from flushing hydrants. Standard Methods (American Public Health Association, 1995) was used for analyses including temperature, pH, free and total residue chlorine, ammonia, nitrite, nitrate, total organic carbon, and R2A spread plating. HPC enumeration was also done by CTC and DAPI microscopic counts (Rodriguez et al., 1992; Coallier et al., 1994). Nitrifying bacteria were enumerated by a five-tube most probable number (MPN) technique (Wolfe et al., 1990) in comparison with fluorescent hybridization technique (Amann et al., 1995; Wagner et al., 1995 &1996).

The laboratory study involved development of annular biofilm reactors that allowed evaluation of the growth of nitrifying bacteria and the formation of biofilm under more controlled conditions. Water samples from hydrant flushing was enriched for nitrifying bacteria under oligotrophic conditions and used as an enoculum for biofilm reactors. Nitrifiers and HPC counts were assessed under varying conditions of water quality parameters (e.g., pH, chlorine residual levels, chlorine to ammonia-N ratio, and total organic of carbon of the experimental water). Simple mathematical models have been proposed to compare observed results with theoretical calculated values.

Principal Findings and Significance

Substantial progress has been made towards the proposed research goals. Major findings and knowledge obtained from this project during the last year include the following.

1 There were abundant nitrifying bacteria present throughout distribution systems. Water samples randomly collected from running water taps and biofilm samples scraped from toilet tanks showed bacteria counts of ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) in the range of 0.2 to 24 MPN/ml and 0.2 to 11 MPN/ml respectively.

2 Biofilm samples contained the average (N=62) of 71.2% more nitrifying bacteria and of 78.6% more heterotrophic bacteria than tap water samples. Therefore monitoring drinking water microbial quality from tap waters appeared to underestimate the possibility of regrowth occurrence.

3 During hydrant flushing, AOB and NOB were detected from the time water flow started until roughly 4 minutes later (30 minutes in some cases). Heterotrophic plate counts (HPCs) were highest (4.8x105 cfu/mL) from time 0 to 30seconds, as were AOB (160 MPN/mL). NOB were highest (80 MPN/ml) from 5 to 20 seconds.

4 During the warmer seasons (March 1999- May 1999), the numbers of both AOB and NOB had increased 21%. In contrast, during colder seasons (January 1999-February 1999), the NOB number deceased only 12% while the number AOB reduced in average of 26%.

5 A review of treatment plant data in two year (May 1997-June1999) indicates seasonal effects which appear to be related to nitrification. At the time of HPC counts peaks in August, September, and October, the levels of nitrite-nitrogen and nitrate nitrogen increased while the concentrations of both dissolve oxygen and total chlorine residual dramatically decreased.

6 Nitrification seemed to occur relatively faster under the 3:1 chlorine to ammonia ratio than that of the 5:1 ratio, while maintaining pH at 7.5 and 0 chlorine residual.

7 Among four types of selected slide materials, polycarbonate was found to have the highest density of nitrifiers and HPC biofilms, as compared to high density polyethylene, stainless steel, and copper. Due to the slow growing of nitrifying bacteria, we have to extend the data collection phase in order to confirm some of our preliminary findings and fully complete the project.

Descriptors

Nitrification, Potable Water, Distribution System, Biofilm

Articles in Refereed Scientific Journals

Book Chapters

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Anaerobic pathways of PAH degradation in New Jersey Coastal Plain aquifers
Project Number	04
Start Date	03/01/1997
End Date	02/28/1998
Research Category	Biological Sciences
Focus Category #1	Toxic Substances
Focus Category #2	Water Quality
Focus Category #3	Treatment
Lead Institution	New Jersey Water Resources Research Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Gordon Lewandowski	Professor	NJ Institute of Technology	01
Georgene Mortimer	Student	NJ Institute of Technology	01
John Oberer	Student	NJ Institute of Technology	01

Problem and Research Objectives

The New Jersey Coastal Plain is a major source of groundwater for southern New Jersey. Consequently, the water quality in these aquifers are a significant issue. Many former Manufactured Gas Plant (MOP) sites contribute sign)ficantly to the degradation of groundwater quality throughout New Jersey. There are over 50 MGP sites in the state of New Jersey and approximately 20 in southern New Jersey. Mixtures of polynuclear aromatic hydrocarbons (PAM) compounds are a significant portion of the contamination typically associated with these sites. These contaminants are often present in the subsurface in the form of light non-aqueous phase liquids (LNAPL) and dense non-aqueous phase liquids (DNAPL). Long operational histories, site conditions, and large volumes of source material from these sites have created, in some instances, groundwater contamination plumes over 3,000 feet long.

The hydrogeologic conditions in the coastal plain aquifers (specifically for this study, the Kirkwood-Cohansey aquifer system) pose unique problems when remediating these large MGP plumes. The high permeability of the soils render pump and treat methods impractical because of the high pumping rates and consequent large volumes of water requiring treatment. In addition, stimulation of microbial degradation of the PAH contaminants through the addition of oxygen may not always be viable due to the high iron content of the aquifer matrix materials.

Although not as efficient as aerobic degradation, anaerobic degradation of the PAH compounds may prove to be a signif cant factor in the remediation of PAH contaminated plumes.

Indirect evidence collected from several former MGP sites throughout southern New Jersey indicate that the indigenous anaerobic organisms are degrading the contaminants at these sites. In addition, studies have been performed which suggest that PAH degradation will occur under certain iron reducing and sulfate reducing conditions (see references 6,8 and 9). Elucidation of the anaerobic pathways responsible for the degradation of the PAM's in the Kirkwood-Cohansey aquifers is the frst step in the development of innovative methods of remediation (i.e. enhancement of natural anaerobic degradative processes).

Objective: The objective of this project is to determine the potential for anaerobic activity in the KirkwoodCohansey aquifer system to degrade certain polynuclear aromatic hydrocarbons. This study will focus on nitrate-reducing, iron-reducing, methanogenic and sulfate-reducing microorganisms.

Methodology

The proposed research is related to the dissertation research of two Doctoral students (listed above) at the New Jersey Institute of Technology (NJIT). Isolation of PAH degrading cultures and microcosm studies will be performed at the Cook College of Rutgers University under the supervision of Dr. Lily Y. Young, who will also serve on the thesis committees. Chemical analyses will be performed at the Hazardous Substance Management Research Center at NJIT. The experimental results will be used to validate a mathematical model of plume migration developed by Dr. Lewandowski.

Soil samples will be collected from the Kirkwood-Cohansey aquifer system at various locations in southern New Jersey. Sample sites will be those of former manufactured gas plants. Saturated soil samples will be collected under anaerobic conditions. Samples will be collected from several locations within the groundwater contaminant plumes at several of these sites. The contaminated aquifer soil samples will be used as innocculum to isolate cultures of PAHdegrading microorganisms so that experiments can be performed with uniform PAH-adapted samples. Soil samples will be collected and slurried with groundwater from the site and incubated under strict anaerobic conditions. Solutions of selected individual PAH compounds will be prepared as substrate stock. In addition, solutions containing two or more PAHs may be prepared to study co-metabolic and/or inhibitory effects. The PAHs to be included in this study will be selected from the following:

o. naphthalene o 2-methylnaphthalene acenaphthene acenaphthylene fluorene fluoranthene o anthracene .o pyrene . o phenanthrene o dibenzofuran

The PAH substrate solutions will be added to serum bottles. The bottles will be flushed to remove oxygen. The incubated slurry and the appropriate electron acceptor medium will then be added under anaerobic conditions. Soils will be mixed and incubated in the dark. Gas chromatographic analysis of samples of the slurries and headspace gasses will be performed periodically during the experiments to determine substrate utilization and possible identif~cation of metabolic byproducts.

The results of this study are expected to identify one or more anaerobic pathway(s) occurring at these sites which may be manipulated to enhance the rate of PAH degradation.

Principal Findings and Significance

Descriptors

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	An analysis of PCBs in epitokous versus atokous forms of Nereis succinea and Glycera dibranchiata
Project Number	05
Start Date	03/01/1997
End Date	02/28/1998
Research Category	Biological Sciences
Focus Category #1	Toxic Substances
Focus Category #2	Wetlands
Focus Category #3	Water Quality
Lead Institution	Rutgers University

Principal Investigators

Problem and Research Objectives

The proposed research will analyze a previously unstudied pathway for PCB transport from the benthos to the water column, and develop a more sensitive and accurate method for monitoring bioavailable PCBs in the benthos.

Polychlorinated biphenyl (PCB) contamination of aquatic systems is common in industrialized areas of New Jersey. Like the chemically similar DDT, PCBs have well documented toxic and mutagenic effects, and are considered extremely hazardous at all trophic levels (Nelson et al. 1972) These hydrophobic

organic compounds bind preferentially with organic particulates and sediments (Weber Jr. et. al. 1983). Baker et. al. (1991) found PCBs to be 10-100 times more concentrated on settling particles than suspended particles. Thus there are often high levels of contamination at sites of sediment deposition, such as estuaries and tidal marshes. There is a general assumption that these sediments are the ultimate sink for chlorinated hydrocarbons (Reynoldson 1987). However, there are both biotic and abiotic processes that can allow PCBs in the sediment to reenter the water column and food web. Several authors have suggested that benthic invertebrates are an important link in the movement from water to sediment, and from sediment to fish (Woodwell et. al. 1967, Benvenue et. al. 1972, Moore et. al. 1980, Osborne et. al. 1982, Reynoldson 1987).

I propose measuring the bioaccumulation of PCBs as a function of the life history of two polychaete worms, Nereis .succinea and Glycera ~hranchinfa. Both these worms metamorphose into lipid rich epitokes in order to spawn (Clark 1961, Wilson et. al. 1988). As epitokes they leave the infauna and enter the water column, swimming to the surface to spawn. Epitokes thus provide a mode of transport for bioavailable PCBs into the water column. Fishes that do not ordinarily feed on infaunal organisms may therefore be exposed to PCBs that would have otherwise remained in the benthos. In addition, epitokes may carry higher PCB burdens than the infaunal form of these worms.

Clark (1961) found that lipid levels increase dramatically with the onset of the reproductive phase of a polychaete's life history. Prior to the onset of the reproductive phase, neutral storage lipids remain in low concentrations (Lawrence 1976). Transport of PCBs by dispersing epitokes is possible because of hydrophobic organic compounds' ability to bind to lipids. Rather than passing through organisms, PCBs become bound to lipid deposits within the organism. Organisms with higher lipid contents will tend to have higher concentrations of PCBs. Nfarkwell et al. (1989) found that the amount of PCBs adsorbed by polychaete tissues corresponds to the worm's total lipid levels. McLeese et. al. (1980) found differing PCB contents in Nereids in relation to their lipid content as a function of age. McLeese et. al. did not, however, measure changes in PCB content in relation to reproductive state. Lowe et. al. (1971) assumed that an observed sudden decrease in organic contaminants in oysters was due to spawning following the sequestering of contaminants in reproductive tissues. No one has measured the accumulation of organic contaminants in reproductive tissues in relation to the transport of those contaminants mediated by the spawning activities of the organism. ln general, transport of contaminants by migrating/dispersing organisms, is the least studied aspect of contaminant transport (Feynoldson 1987).

The study sites chosen are representative of the range of contamination found in estuaries and coastal marshes in New Jersey. The Rutgers Marine Field Station at Tuckerton is a relatively undisturbed estuary and tidal marsh system. Most of the watershed is protected in some form and there is little industrial development within the watershed. Conversely, Piles Creek is heavily industrialized with multiple sources of contamination. In addition to non-point sources there are several possible sources of contaminants either on or in the vicinity of Piles Creek. These include an abandoned photographic film manufacturing plant" the Linden Sewerage facility, several refineries, a Dupont chemical plant and the Linden Generating Station.

The proposed research is important for New Jersey's water resources in several ways. The two worms are abundant in the intertidal and near-shore benthos, where they provide food for both developing and adult fishes of recreational and commercial interest (Clark 1961, Wilson et. al. 1988, Aarnio et al. 1996). The proposed research would reveal a previously unstudied pathway for organic contaminants from the benthos to pelagic organisms. As a source of contaminants, polychaete epitokes may prove to have disproportionately high effects due to their high lipid content and tendency to synchronized

swarming. During periods of epitoke swarming, predatory fishes may receive large doses of contaminants in a short period of time.

In addition to measuring the potential for periodic spikes of PCBs into the pelagic ecosystem. this study will correlate levels of PCB contamination in the sediment with levels in swarming epitokes Previous work with bioaccumulation of PCBs in polychaetes has shown that contaminant accumulation is dependent on the life history stage of the worm (McLeese 1980, Markwell et al. 1988). This study will measure PCB accumulation at a single life history stage with relatively uniform lipid levels. By comparing levels of PCBs in the sediments to levels in the epitokes, it will be possible to correlate the two. Epitokes will provide a more accurate measure of bioavailable contaminants in sediments than analyzing benthic assemblages at random life history stages. Epitokes are easily caught and form swarms of a single species at a single life history stage.

Hvoothesis

I expect that epitokes of N. .mccinea and C. dibranchiata will show relatively uniform concentrations of PCBs and that they will show PCB levels several orders of magnitude higher than the surrounding sediment. I also expect the epitokes to have sign)ficantly higher levels of contamination than the infaunal atokous forms of the worms. I also expect atokous worms to show greater variation in PCB burdens between individuals due to their varying lipid contents.

I will test the hypothesis by measuring PCB loads of individual epitokous and atokous forms of the two polychaetes. Due to the cost of materials for PCB analysis (see Budget), I will lin~it the analysis to 20 samples. There will be one sediment sample from each site. A composite sample of epitokes and a composite sample of atokous worms will be taken from the Tuckerton site. The remaining samples will be divided between individual epitokous and atokous forms of the two species taken from the Piles Creek site. The majority of samples will come from Piles Creek because I expect to find much higher, more easily quantified PCB contamination at that site.

Methodology

From late June through early August I monitored two sites, one Piles creek off the Arthur Kill, and the other, Roanoke Yacht Club in Newark Bay by the I-78 bridge. I looked for N. succinea before dawn and after sun set, and G. dibranchiata in the morning and afternoon. Neither species appeared at either site despite the reported ability of these two abundant species to produce epitokes in cycles throughout the summer (Clark 1961, Wilson et al. 1988). Perhaps the high water temperatures due to El Niño inhibited spawning.

In late August I elected to switch study to the grass shrimp (Palaemonetes pugio). I collect samples of juveniles, adults, and gravid females. I expect that the high lipid levels in the gravid females will correlate with higher PCB burdens in those individuals than in the other life history stages. Thus the food chain effects and bio-magnification of PCBs may depend upon which life history stage of a benthic invertebrate is preyed upon. Since August, I have been experimenting with different techniques for extracting PCBs from tissue.

Working at the NOAA/NMFS organic chemistry laboratories at Sandy Hook, I have compared the results of hand grinding small amounts of tissue in CH2Cl2 and sodium sulfate to soxlet extraction. As well as experimenting with various extraction techniques, I have compared various manual chromatography column cleanup techniques and automated high performance liquid chromatography

(HPLC). I have also compared various methods of concentrating samples.

Principal Findings and Significance

Hand grinding in a solvent is the least laborious method for sample extraction when compared to the effort required to prepare the Organimation soxlet extractor. However, hand extraction, while successful in extracting PCBs and other organics from small tissue samples, contaminates the sample with tissue and sodium sulfate. The sample must then be hand filtered, eliminating any labor savings. The continuous reflux and filtration in the soxlet extractor provides a much cleaner and uniform sample. Once extracted, a sample must have lipids removed. I have found that manual column cleanup with either deactivated or reactivated sodium silica is adequate for lipid removal from samples with low total lipids. However, manual column cleanup allows co-elution of PCBs and pesticides, making analysis difficult. I have found that the best method for samples with low total lipids is a manual column cleanup followed by HPLC for separation of PCBs from pesticides. For samples with a higher lipid content, two HPLC steps would be needed, one for cleanup, and one for separation. Finally, I have found that sample concentration in a Turbovap is the best method for sample concentration. The Turbovap has drawbacks, notably problems with condensation and loss of sample due to lack of a reflux stage, but it has proved a superior technique, especially when humidity is low. Concentration and solvent exchange using mini-Snyder reflux columns is too risky due to the tendency for the column to become jammed with solvent and explode.

Once the analysis of PCBs in my samples is done, I will be able to start examining food chain effects. The NOAA labs are beginning a project that hopes to identify bluefish (Pomatomus saltatrix) stocks using PCBs to identify fish feeding in a particular area. By following the movement of PCBs from sediment to shrimp, and shrimp to bluefish, I will be able to link juvenile and young of the year fish with a particular habitat.

Descriptors

PCBs, polychaete worms, estuaries, benthic invertebrates, toxic substances, sediment contamination

Articles in Refereed Scientific Journals

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Water resources and climate change
Project Number	09
Start Date	03/01/1997
End Date	02/28/1998
Research Category	Climate and Hydrologic Processes
Focus Category #1	Climatological Processes
Focus Category #2	Water Quantity
Focus Category #3	Hydrology
Lead Institution	Rutgers University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
James Miller	Associate Professor	Rutgers University	01

Problem and Research Objectives

Priority issue: The future of water resources in New Jersey depends on a combination of factors which include changes in population/water demand and potential changes in climate. An important issue is how these two factors will affect the availablity of water from the Delaware River system. Objective: The objective of this research is to understand how potential climate change coupled with changes in population and water demand might affect future water resources. The focus will be on the Delaware River system.

Methodology

Project description: The future water resources of the Delaware River system depend on a combination of factors, including changes in population, precipitation, evaporation, temperature, and sea-level rise. To achieve the objective of this proposal, a hydrologic systems model (HSM) based on the STELLA (1992) systems modeling software will be developed and applied to the Delaware River. Input to the HSM will include temperature and precipitation from climatology for the present climate and from a global coupled atmosphere-ocean model for a potential future climate with increased atmospheric greenhouse gases. For the present climate, the HSM's monthly river flow will be compared with observed flow at selected stations. For the future climate, sea-level rise will also be incorporated, and its impacts on flow rates and upstream salinity will be assessed. The student (Hassell) and faculty advisor (Miller) will work together on all aspects of the project. Hassell is already familiar with the STELLA software and will take the lead in developing the HSM. He will also be responsible for reviewing the relevant literature on water resources and climate change, for developing and running the HSM, and for analyzing the results. The climate change experiments will use the rate of sea-level rise and changes in

temperature and precipitation predicted by the global climate model of Russell et al. (1995) as input to the HSM to predict potential changes in Delaware River flow as atmospheric greenhouse gases increase during the next seventy years.' These input data will be supplied by Miller who has extensive experience working with global climate models. Additional model simulations will be made based on projections of future water use from the New Jersey Statewide Water Supply Plan (1996). The river flow predicted by the model will be compared with observed flow data from the U. S. Geological Survey. A multi-year data set of Delaware River flow is available on disk, and has already been obtained and used. Wolock et al. (1993) have done a set of climate change scenarios in which they specify future changes in precipitation and temperature. Our model will be run for several of these same scenarios and compared with Wolock et al. (1993). Our model results will differ from Wolock et al. (1993) because our predictions of future river flow will be based on predicted changes in precipitation and temperature from the global climate model rather than on specified changes. The results from this study will provide insight into potential impacts on water resources in New Jersey during the next century. The work will improve understanding of how the physical system is linked with the political and social dimensions of water resource issues. Since the Delaware River system extends beyond the borders of New Jersey, some of the regional issues within the basin will also be examined. Although the focus of the study is on the Delaware River system, the results will also be have implications for other types of water resources in New Jersey, such as groundwater, surface water, and salt water intrusion.

Principal Findings and Significance

Figure 1 shows that the hydrologic model's mean monthly streamflows for the present climate simulate the mean flows observed at Montague and Trenton reasonably well. Spring peaks in runoff due to snowmelt in the upper portion of the basin are clearly seen along with the substantial drop in streamflow during the summer due to increased evaporation. The climate change scenarios from the GCM were then input to the hydrologic model. This was done in three steps. First only the temperature increase was input to the hydrologic model, then only the precipitation increase and finally both the temperature and precipitation increase were input together. When only the temperature was increased (figure 2), streamflow decreased in all months at both Montague and Trenton, except in the late winter and early spring because the snowmelt started earlier than usual. The reservoir storage in New York City reservoirs in the northern part of the basin also showed the same variation as the streamflow. When only precipitation was increased (figure 2), water availability in all areas increased. The streamflows at Montague and Trenton increased above the current climate during all months of the year. Reservoir storage increased during all months except in mid spring when the reservoirs filled to capacity and spilled over. The salt front position moved downstream, further away from the Philadelphia water supply intakes. When the increases in temperature and precipitation were applied together (figure 2), the precipitation increase specified by the GISS GCM for this region was enough to offset the increase in temperature and evaporation. Streamflow and reservoir storage increased during the first four months of the year and then leveled off back to the current climate. The mean monthly salt front position moved downstream further than the current climate during the first four months and then was approximately the same as for the current climate during most of the year. One way to do regional hydrologic studies of climate change is the approach used in this paper where changes in temperature and precipitation from GCM climate change simulations are added to the mean observed values for the present climate. Such studies will become more realistic when GCM mean monthly variability more closely matches observed climate variability at the regional scale. The agreement between the GISS data used in this study of the Delaware River basin and the observed climate is reasonable, but far from perfect. As GCMs begin to use finer resolution, the accuracy of their applications to regional studies will improve. The information may be better than just for scenario creation and could have real world uses in planning. For now, regional scenarios are the best we can do. The principal results based on these

climate change scenarios can be summarized as follows: o Temperature Change: When only the temperature increase is input to the hydrologic model, the mean annual streamflow decreased, the winter flows increased due to increased snowmelt, and the mean position of the salt front moved upstream. o Precipitation Change: When only the precipitation increase was input to the hydrologic model, the mean annual streamflow increased, and the mean position of the salt front moved further downstream. o Temperature and Precipitation Change: When both the temperature and precipitation increase were input to the hydrologic model the mean annual streamflow changed very little, with a small increase during the first four months of the year.

Descriptors

climate change, water supply, global warming, Delaware River, hydrological models, sea-level rise

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Fish parasites of the upper, middle and lower regions of the Raritan River in New Jersey
Project Number	06
Start Date	03/01/1997
End Date	02/28/1988
Research Category	Biological Sciences
Focus Category #1	Non Point Pollution
Focus Category #2	Ecology
Focus Category #3	Water Quality
Lead Institution	Rutgers University

Principal Investigators

Problem and Research Objectives

Anthropogenic (human-derived) contaminants include heavy metals, toxic nonmetals, petroleum hydrocarbons and pathogens, and the release of these contaminants into aquatic systems has been coupled to numerous ecological and human-health effects (Abel, 1989). River runoffis one ofthe principal pathways by which contaminants enter estuarine and oceanic waters (Kennish, 1994), and programs that monitor biotic communities in rivers may be critically important in guiding solutions to acute aquatic pollution (Gunkel, 1994; MacKenzie et al., 1995; Marcogliese and Price, 1997).

A variety of organisms can serve as bioindicators to monitor the effects of pollutants in the aquatic environment (Gunkel, 1994). Helminth (worm) parasites of fishes may rank among the most sensitive of bioindicators for several reasons (MacKenzie et al., 1995). Parasite infections of fish reflect the health ofthe entire aquatic community because of their complex life cycles, e.g., a typical parasite life cycle may include the fish definitive host and one or more intermediate invertebrate hosts. For the parasite to survive, all hosts must occur in a stable community structure (Marcogliese and Cone, 1997), thus changes in environmental conditions (e.g., pollution), that affect any of the hosts (directly or indirectly) will have a sign)ficant effect on the prevalence and intensity of parasites in the fish (MacKenzie et al., 1995; Marcogliese and Price, 1997).

Pollutants may also have direct toxic effects on the parasitic worms, reducing their infections in the fish, or conversely, the toxins can affect the fishes' resistance, which may increase infection levels (MacKenzie et al., 1995). In addition, parasitic worms can provide very sensitive measures of the levels of contaminants in the water. Differences in their physiology allows worms to accumulate some toxins (particularly heavy metals) much faster than the tissues of their fish hosts (Sures et al., 1997).

Good indicators must be sensitive to environmental changes so that reductions in their numbers can be used as a warning of deteriorating conditions before the majority of less sensitive organisms are seriously affected. Parasites furfill this role admirably (MacKenzie et al., 1995), and parasite-based indices should be an integral part of programs that monitor pollution in aquatic systems (Marcogliese and Price, 1997)

6. Objective:

The specific objective of this study is to provide baseline data on the occurrence of fish parasites along the Raritan, from a minimally polluted first order stream to the heaviest polluted downstream waters. [The long term objective is to monitor the health of New Jersey's Raritan river using parasitic worms as bioindicators. The Raritan is of great historic and sentimental importance to Rutgers University. Our school song is "On the banks of the Raritan." Student interest and involvement in any project involving the health of this river is very high, and the students will provide a steady source of manpower for this project.]

Methodology

Fish samples were collected from three sites on the Raritan River: Stanton Station, Dartsmille and High Bridge. These sites were chosen as representatives of different levels of moderate disturbance (Dartsmille and Stanton Station) and undisturbed (High Bridge) streams on the basis of the data collected by the New Jersey Department of Environmental Protection in 1995. Backpack generators were used to shock the fish and the specimens of species of interest were brought into the lab, counted

and identified. The fish were then killed and freezer-stored. For necropsy, the specimens were defrosted, weighed, measured, and sexed. The skin and the fins were examined for ecto-parasites, then the eyes, opercula, gills, liver, stomach, intestines and gonads of every specimen were surveyed for presence of endo-parasites. All results were logged on a necropsy sheet. All parasites recovered were stored in 75% alcohol for later identification. In the spring of 2000, samples will be collected from the fourth site, Donaldson Park, which is a highly disturbed site. After necropsy of the fish from that site, we will complete the analysis of the differences between the prevalence and intensity of parasite infections among the four sites.

Principal Findings and Significance

The study has not been completed to date, but several trends are beginning to show. Based on the pollution data obtained from NJDEP and parasite infections in the Stanton Station and Dartsmille sites, the lightly disturbed site (Dartsmille) seems to show high prevalence and intensity of trematodes and acanthocephalans, when compared to the moderately disturbed site. Nematode prevalence is not different between sites, although there is a large number of species present in both locations.

A relatively high snail population signifies an enriched but healthy environment. From the collected data, we see a higher prevalence of trematodes in Dartsmille than in the Stanton Station site. Most fish trematodes use snails as their intermediate host and this suggests that snail populations are bigger at Dartsmille than at Stanton Station. This can be a valuable tool in determining the level of organic enrichment, however snail populations cannot be used as an indicator of chemical pollution. The relatively high prevalence of acanthocephalans in the specimens from Dartsmille, when compared to Stanton Station could be linked to the crustacean population, since they are a common intermediate host for acanthocephalans. Since the correlation between acanthocephalans and crustaceans is a direct one, it is reasonable to assume that Dartsmille has lower levels of light chemical pollution then Stanton Station, since most crustaceans are not very tolerant towards raising pollution levels. It’s harder to explain the relatively low numbers of nematodes within the collected specimens from both sites, because without positive identification of the species the details of their life cycles are unknown. At this point it is hard to draw conclusions about the High Bridge site due to the lack of sufficient data, the site will be resampled in the spring of 2000. Summing up at this intermediate stage of the project, trematodes, and indirectly snail populations within aquatic systems may be viable indicators of organic enrichment of freshwater streams, whereas acanthocephalan populations in fish may be viable indicators of chemical pollution stress on the stream.

Descriptors

fish, rivers, nonpoint source pollutants, water quality, indicators, parasites

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Isolation and functional characterization of microorganisms from a mixed culture capable of degrading the gasoline oxygenate, Methyl-tert-butyl ether (MTBE)
Project Number	01
Start Date	03/01/1998
End Date	02/28/1999
Research Category	Biological Sciences
Focus Category #1	Toxic Substances
Focus Category #2	Treatment
Focus Category #3	Water Quality
Lead Institution	Rutgers University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Jaruwan Talawat	Student	Rutgers University	01
Jerome Kukor	Assistant Professor	Rutgers University	02

Problem and Research Objectives

Methyl tert-butyl ether (MTBE) is a major gasoline oxygenate that is being used to enhance combustion in vehicle which in turn reduces carbon monoxide emissions. Its consumption is very high — accounting for as much as 15 % of the total volume of gasoline. Because MTBE is highly water soluble and has a high density, it is the major threat to ground water wherever a gasoline spill or storage tank leakage occurs. According to a random sampling done by USGS's National Water Quality Assessment program, contamination of MTBE in ground water was detected in 27% of urban wells. This survey was conducted only 3 years after the enforcement of the 1990 Clean Air Act that called for the addition of gasoline oxygenates to reduce carbon monoxide production. This demonstrates how rapidly MTBE has become a major environmental concern. New Jersey in particular has a high rate of consumption. Moreover, since New Jersey has a very high vehicle to area density, the possibility of

water supply contamination from MTBE is widespread throughout the State. This demonstrates that solutions are urgently needed. Bioremediation is an attractive approach since it occurs through natural microbial degradative processes with the need for only a minimal amount of human engineering intervention. However, there is little information on the intrinsic biodegradability of MTBE since it is truly a xenobiotic compound, having only recently been introduced into the biosphere. Therefore, finding new information concerning the biodegradability of MTBE is part of the solutions. Research from earlier in the decade indicated that MTBE was largely resistant to biodegradation. However, research in several laboratories has recently shown that MTBE can be degraded under specified condition. The research project to be described here focuses on a mixed microbial consortium (obtained from Cowan and Park at Rutgers) capable of degrading MTBE as the sole source of carbon and energy. Our goal is to isolate and functionally characterize microorganisms from the mixed culture in order to better understand key features of the mechanisms by which MTBE is biodegraded. This understanding will help us to be able to predict how biodegradability might change in response to shifts in microbial community structure, composition ,and dynamics which in turn will help us to be able to control the process more efficiently.

Methodology

The bacteria was isolated from the mixed culture by direct plating onto a minimal salts medium (MSM) with MTBE as the sole source of carbon and energy. After microcolonies developed, individual isolates were selected and purified on a complex nutrient medium. The isolates were tested individually and in combination for MTBE removal by inoculating them into MSM liquid medium with MTBE as sole carbon and energy source. Initial inoculum density was standardized and aliquots were taken periodically to analyze MTBE removal by gas chromatography(GC) using a FID detector. Effective isolates, i.e. those capable of sustained MTBE degradation with MTBE as the sole carbon and energy source, were to be further characterized in order to identify the isolates taxonomically and to carry out functional characterization. Initial analyses were to be conventional microbiological characterization, followed by BIOLOG catabolic profile analysis, fatty acid methyl ester analysis of signature membrane lipids, and phylogenetic analysis based on 16 S rRNA gene sequence analysis. Once isolates have been characterized by these protocols , we will determine whether tranposon mutagenesis in combination with GC- mass spectrometry analysis of metabolically blocked transposon mutants will allow us to determine the catabolic pathway for MTBE utilization.

Principal Findings and Significance

This mixed culture is more complex than we expected. We obtained over 40 isolates from the direct plating method, however neither individual isolates nor reconstituted mixed culture from all isolates were able to remove MTBE from liquid minimal salts medium with MTBE as sole source of carbon and energy. Even though we have not uncoverd effective isolate(s) or a defined consortium yet, we were able to identify many members of the consortium through the BIOLOG system. Some of the isolates were identified as Arthrobacter histidinolovorans, Alcaligenes xylooxidans, Pseudomonas putida, Ochrobactrum anthropi, and Rhodococcus erythropolis, However, some of them could not be identified by BIOLOG catabolic profile analysis.

We found that even though we scraped all colonies that developed on the plates after giving MTBE as the sole source of carbon and energy and put them in MSM liquid medium with MTBE, we still had no MTBE removal. Plates that were used for isolation came from 10-2 — 10—5 dilution since we noticed they had more distinguishable and developed colonies than 10-0 — 10-1 dilution. To validate the isolation technique, we set up a serial dilution experiment by direct plating the mixed culture from 10-0

— 10-5 dilution and scraped all developed colonies to perform MTBE removal analysis. We found that only the 10-0 dilution retained the capability of degrading MTBE. This means that we missed something in the process of dilutiing from the active consortium that might play an important role in MTBE biodegradation. Therefore, we extracted DNA from both dilution that retained and dilution that lost the capability to degrade MTBE in order to distinguish between the two. The technique used was terminal restriction fragment length polymorphism (TRFLP) technique which uses fluorescent primers to do polymerase chain reaction (PCR). After using restriction enzymes to digest the PCR product, fingerprints of the samples can be compared and analyzed for the difference between the samples. The results did not show obvious differences between the community on the plate that degrades MTBE and the plate that contained the closest dilution that could not degrade MTBE. Nevertheless, the two microbial communities show slight differences in the number of particular members present.

These findings need to be further investigated in order to determine whether MTBE biodegradation depends on the proportion of the members in the community, or the restriction enzyme used in the TRFLP experiment was not capable of distinguishing between the two samples. If the community need to be present in a particular proportion in order for MTBE degradation to occur, it is possible to find fingerprints of the key members. Then we can design DNA probes in order to do hybridization with the original mixed culture capable of degrading MTBE. This would allow us to find the microorganism(s) from which the key fingerprint(s) come. After that we can continue our original plan of investigating the mechanism of MTBE biodegradation.

Descriptors

MBTE, biodegradation, groundwater quality, bioremediation, microbial consortia,

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	The effects of mosquito control ditches on the intertidal plant community and ribbed mussel
Project Number	02
Start Date	03/01/1998
End Date	02/28/1999
Research	

Category	Biological Sciences
Focus Category #1	Wetlands
Focus Category #2	Ecology
Focus Category #3	Geomorpological and Geochemical Processes
Lead Institution	New Jersey Water Resources Research Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Marlene Cole	Student	Rutgers University	01
Richard Lathrop	Associate Professor	Rutgers University	01

Problem and Research Objectives

The hydrology of New Jersey's coastal salt marshes has been greatly altered by mosquito management. This study addresses ecological consequences of structural alterations of salt marsh hydrology on ecosystem structure and function. In my previous research I found that marshes with mosquito control ditches differ from naturalt marshes in several measures of the amounts and arrangements of water bodies and marsh surface patches (Cole 1997). I now propose to expand this analysis and link the differences in landscape patterns to population and ecosystem level properties with a focus on differences in the interface between land and water, specifically in the intertidal plant community and ribbed mussel conditions. By linking landscape pattern with hydrology and the flora and fauna at the land-water interface, this study will provide indicator measures of salt marsh ecosystem health. The research proposed herein is part of a larger proposed research program that will also include analyzing the impacts of ditching on community-level interactions and measures of marsh productivity. Research methods will include cartographic analysis of remotely sensed images with geospatial technology as well as field surveys in ditched and natural marshes. This study will provide essential information for managers and engineers working in the restoration and creation of coastal wetlands in New Jersey and elsewhere.

In this study, I seek to develop and test indicators of salt marsh ecosystem health. I will gather data from natural marshes and marshes that have undergone grid ditching for mosquito control. The study will address the effects of this common management technique on the amount and spatial arrangement of low marsh plant communities and the abundance, location and size of ribbed mussels in the intertidal zone. There has been great interest in salt marshes as nursery habitat for economically important fishery species (Boesch and Turner 1984), as habitat for resident and migratory water birds, and as zones of high primary productivity (Nixon 1980). New Jersey's salt marshes have undergone extensive alterations by modern society but science still lacks an understanding of the intricacies of salt marsh ecological structure and function to evaluate interface of land and water, where the highly productive tall form of Spartina alterniflora and ribbed mussel, Geukensia demissa, occur.

Tidal inundation and salinity are generally considered to be the primary factors determining marsh plant

distribution. Local flooding characteristics can be affected by distance from the inlet along a creek and small-scale topography such as creek banks. As flooding can influence salinity, techniques modifying topography potentially alter the distribution of flora and fauna and, potentially, their interaction and function. The construction of parallel, tidally-connected ditches ("grid ditches") to drain the waters used by breeding mosquitoes and to promote access by larvivorous fish is controversial yet widespread. By 1938, approximately 90 percent (562,500 acres) of the total area of tidewater marsh along the Atlantic coast from Maine to Virginia had been grid-ditched for mosquito control (Bourn and Cottam 1950). However, very little research has addressed the effects of grid-ditching on ecological structure or function. Some research has linked grid ditching to a reduction in both populations of invertebrates and invertebrate species diversity (Bourn and Cottam 1950), and found it detrimental to marsh birds (Meredith and Saveikis 1987).

The ribbed mussel, Geukensia demissa, occurs abundantly, buried in dense clumps in a narrow vertical band in the upper intertidal zone along much of the Atlantic coast of North America (Seed 1980), especially among the roots of Spartina alterniflora (Kuenzler 1961), which generally occurs in its tall form at the more tidally inundated part of its range. In habitat of tall form S. alterniflora, net primary productivity is positively correlated with ribbed mussel density and (Bertness 1984). Mussels also help prevent soil erosion and provide habitat and refuge for fish (K. Able, personal communication). Thus mussels provide important services to the salt marsh ecosystem and drastic reductions in their abundance could indicate or result in degradation of salt marsh ecosystem health. Despite the seeming importance of the land-water interface, we do not have adequate information about the ram)fications of major alterations such as ditches on population level effects, community composition of the marsh or ecosystem level processes. Thus, mussels and tall form S. alterniflora can serve as an indicator of the quality of land-water interface.

Methodology

After delineating four study watersheds of marsh creeks (two ditched and two unaltered), I developed a stratified random sampling regime to characterize both local and landscape-level responses of tall form Spartina alterniflora distribution and G. demissa abundance across the study watersheds. I established 85 sampling transects running from channels or ponds across the marsh surface to the point of intersection with another water body. We recorded the height profile of S. alterniflora across each transect as well as presence/absence data for G. demissa at 3 cm intervals in a narrow swath. Due to tidal constraints and access, the sampling proved a formidable challenge, but has now been completed.

Principal Findings and Significance

Initial results indicate that plants are generally higher and mussels are generally more abundant closer to water channels. Plant height is positively correlated with mussel presence. Due to the fact that small ditches account for much of the land-water interface in the ditched marsh sites, possibly assuming the role of small creeks in unaltered marshes, I compared the two with respect to mussel distribution. Small ditches in the ditched marsh have a more gradual decline in mussel concentration with distance from the channel edge than do small creeks in the natural marsh. This may indicate that it is less advantageous for mussels to congregate nearer to small ditches than small creeks, suggesting a lack of functional equivalency of these habitat types for mussels.

Descriptors

salt marsh, landscapes, land-water interface, mosquito control, ribbed mussel, drainage ditch networks

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Information Transfer Program

USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	4	N/A	N/A	N/A	4
Masters	N/A	N/A	N/A	N/A	N/A
Ph.D.	5	N/A	N/A	N/A	5
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	9	N/A	N/A	N/A	9

Awards & Achievements

K. Jahan (project 09): Lindback Foundation Junior Faculty Award for conducting research on biodegradation of nonionic surfactants K. Jahan (project 09): Student award, Best Technical Paper, Delaware Valley Engineer's Council

Publications from Prior Projects

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