Tulane/Xavier Center for Bioenvironmental Research Project "Hazardous Materials in Aquatic Environments of the Mississippi River Basin"

C. Ide (cfide@mailhost.tcs.tulane.edu; 504-862-8370)
Tulane University
604 Lindy Boggs
New Orleans, LA 70118

G. Flowers (flowers@mailhost.tcs.tulane.edu; 504-865-5198)
Tulane University
202 Dinwiddie Hall
New Orleans, LA 70118

S. O'Connor (soconnor@xula.edu; 504-483-7506)
Xavier University
P.O. Box 45B
New Orleans, LA 70125

Introduction

Tulane and Xavier Universities have singled out the environment as a major strategic focus for research and training for now and beyond the year 2000. The Tulane/Xavier Center for Bioenvironmental Research (CBR) was established in 1989 as the umbrella organization to coordinate environmental research at both universities.

CBR projects funded by the DOE under the "Hazardous Materials in Aquatic Environments..." grant are defining the following: 1) complex interactions that occur during the transport of contaminants through wetlands environments, 2) actual and potential impact of contaminants on ecological systems and health, 3) mechanisms and new technologies through which these impacts might be remediated, and, 4) new programs aimed at educating and training environmental workers of the future. This project is particularly relevant to the U.S. Department of Energy's Environmental Restoration and Waste Management programs aimed at solving problems related to hazard monitoring and clean-up prioritization at sites with aquatic pollution problems in the DOE complex.

Objective

Bayou Trepagnier and its control site, Bayou Traverse, are situated in the wetlands found between the Mississippi River and Lake Pontchartrain in the New Orleans area (Figures 1 & 2). Bayou Trepagnier is contaminated with effluent from petroleum and petrochemical plants, including heavy metals and organic contaminants dissolved in pore waters and absorbed to sediments. Bottom sediments of the bayou are contaminated with lead, zinc, chromium, and polyaromatic hydrocarbons (PAH) as a result of the massive dumping of refinery wastes that

occurred in years prior to the passage of the Clean Water Act in 1972. Similar hydrocarbon and metals contaminants are present at DOE National Laboratory sites (e.g., Savannah River Site, A/M Area, SC), DOD sites (e.g., McClellan Air Force Base, Operable Unit B/C, CA), and EPA Superfund sites (e.g., French Ltd. Superfund Site, TX).

This project and its focus on Bayou Trepagnier is relevant to the Department of Energy because many of the national laboratory and weapons complex sites have similar environmental problems although on a much larger scale. Goals of this project include characterizing the contaminants that remain in sediments, soils, and the water of Bayou Trepagnier, understanding their fate and transport and bioavailability within the Bayou, and developing better, cheaper, and faster methods of cleaning up contaminants on site which can then be applied to DOE sites and polluted wetlands worldwide.

Approach

Bayou Trepagnier was chosen by the Tulane-Xavier DOE/EM Project as a natural laboratory for studying the fate and transport of heavy metal and organic contaminants in wetlands, including characterization of contaminant loadings, water quality, hydrology, and biota. Bayou Trepagnier is located in St. Charles Parish at Norco, Louisiana. The drainage system is bounded on the south by US Highway 61, on the north by Lake Pontchartrain, on the west by the Lower Guide Levee of the Bonnet Carre Floodway, and on the east by Bayou La Branche (DEQ, 1986). As stated in the DEQ impact assessment for Bayou Trepagnier, Bayou Trepagnier flows in a northeasterly direction through a bald cypress/tupelo gum swamp with mixed hardwoods on natural banks and spoil areas along the upper reaches of the stream. Approximately 4 miles from its headwaters, Bayou Trepagnier joins with Bayou La Branche. Bayou Trepagnier and Bayou La Branche are listed in the Louisiana Natural and Scenic Stream System.

Research clusters supported in the project carry out interdisciplinary studies related to the presence of contaminants, their fate and transport, and their bioavailability as a source of exposure and risk is Bayou Trepagnier. Other clusters are producing new technologies related to environmental assessment and remediation.

CBR research cores were established to streamline and coordinate sampling, contaminant characterization, and data analysis. The Field Work Core provides researchers with water, soil, or biotic samples, measures water quality parameters, and coordinates the overall plume characterization effort. The Analytical Core performs organic and inorganic analyses, insures uniformity of analysis protocols, and maintains Quality Assurance/Quality Control and instrument certification programs for each of the satellite labs involved in the project. The Data Management Core collects all data and enters it into the project database after review, develops tools for electronic access to the database, digitizes geographic features of the bayou, and uses Global Positioning System (GPS) to locate biotic and abiotic sampling locations. The Core also analyzes data and generates maps using a Geographic Information System (GIS).

Project Description

To date, identification, characterization, and monitoring of contaminants in Bayou Trepagnier has been conducted, as well as the characterization of histopathological, physiological, and molecular biomarkers of exposure. Already, specific research projects within the task areas of this project are being developed into usable technologies for DOE and other government and private entities in the areas of characterization, fate and transport, monitoring, modeling, and remediation.

Results

CHARACTERIZATION

- More than 40 organic and inorganic contaminants have been characterized. These include phenols (e.g., estrogenic alkyl phenols), hydrocarbons (e.g., PAH's), and metals such as lead, chromium, copper, and zinc.
- The contaminants in Bayou Trepagnier have been characterized in the water column; sediment; soil of the spoil banks; and biologic compartments including fish, shrimp, crawfish, microbiota, and vegetation (e.g., roots, leaves, and tree rings).

FATE & TRANSPORT

- High levels of organic and heavy metals contaminants remain in Bayou Trepagnier in sediments in the Bayou channel, in soils along the banks, and in plants.
- Lead contamination has been shown to migrate from the spoil banks into the surrounding marsh; the isotopic composition of the lead identifies its source as a mine in the Midwest.
- The effects of colloidal organic carbon (COC) on the fate and transport of heavy metals has been assessed.
- Impacts on the water quality in the bayou from the opening of a nearby flood protection spillway (the Bonnet Carre Spillway) have been assessed.

ECOTOXICITY

Ecology

- The plant and animal life in the bayou is being characterized in both the aquatic and terrestrial environments.
- The numbers, diversity, and distribution of the biologic components (including fish, amphibians,invertebrates and plants) is being studied taking into account variables such as seasonal and tidal changes, tree cover, and contaminant levels.

Risk Assessment

- Multivariate models for assessing ecotoxicity in fish and frogs have been developed. The models utilize biomarkers of exposure to contaminants and include immunological and enzymatic responses of fish (e.g., the Spotted Gar) and cytokine responses in frogs.
- The impacts of long-term heavy metal pollution on hardwood bottomland forest productivity, and metal accumulation in specific plants is being charted.

MONITORING

Sensitive Rapid On-site Immunoassays for Heavy Metal Contamination.

- A new, on site immunoassay has been developed that is quick, inexpensive, simple to perform, and reasonably portable (Figure 3).
- The immunoassay is both highly sensitive and selective (both critical aspects for analyzing environmental samples).

MODELING

Biomarker Risk Assessment Models

- Molecular biomarker analysis is being used to assess risk at specific environmental sites.
- Biomarkers in organisms on-site can also be used to chart the progress of remedial activities.

Models for Pore-Level Flow, Transport, Agglomeration and Reaction Kinetics of Microorganisms

- Mathematical models have been developed to investigate the behavior of bacteria from known contaminated sites.
- The results of these studies will provide important information for determining the best conditions for effective bioremediation.

Fate and Transport Model of Radionuclides in Surface Water in Belarus Following the Chernobyl Catastrophe

- Knowledge gained from this project is being applied to the transport of sediment and pollutants in aquatic environments in Louisiana and DOE sites that have similar characteristics and pollutants.

REMEDIATION/WASTE REDUCTION

Polyphosphazene-Based Ion-Exchange Membranes

- Phosphazene membranes, suitable for use in the clean-up of wastes that contain hazardous metal ions and radionuclides, are being developed.

Bioremediation Techniques Utilizing Fungi and Bacteria to Break Down PAH's.

- A novel method for encapsulating hydrocarbon-degrading fungal strains has been developed. This is a faster, more cost effective method for the use of fungi in bioremediation.

Application

Research conducted in the project is providing: 1) new, more efficient, methods for characterizing contaminant levels in the field, 2) models for predicting transport of contaminants through wetland environments, 3) molecular based methods for assessing exposure and associated eco and human health risk, and 4) new tools for carrying out remedial activities *in situ* in polluted wetlands.

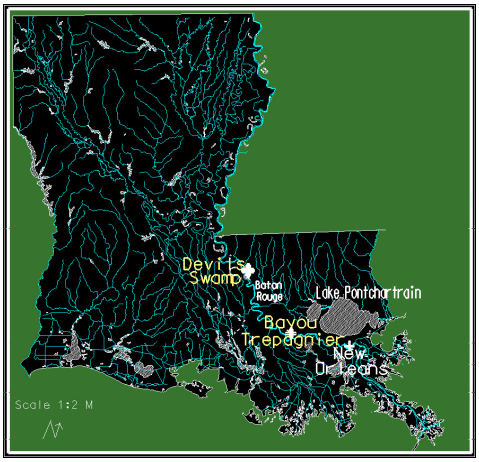
Future Activities

New work will refine and extend basic research findings into technology development and will move nearly developed technologies to the transfer phase. Emphasis will not only be placed on production of molecular based technologies for assessing environmental contamination, but also, on the design of molecular based machines that will automate and accelerate decision making and cleanup of contaminated wetlands.

Figure 1: Cypress Trees Along Bayou Trepagnier

Cypress Trees Along Bayou Trepagnier

Figure 2: Location of the Study Sites in Louisiana



Location of The Study Sites in Louisiana

Figure 3: Portable Immunoassay Kit for Heavy Metals

Portable Immunoassay Kit for Heavy Metals

Contract Information

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