



# Research Brief #6

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## Understanding the Biotransformation and Fate of Halogenated Organic Compounds in Sediments

### Introduction

Once viewed as natural sinks for storing pollutants, bottom sediments are now considered an important source of the chemical pollution in American waters. Over the past decade, scientists have focused increasing attention on the processes and process interactions that bind polluting compounds in sedimentary layers and sometimes transform them into less harmful substances. Researchers need more basic knowledge before they can understand the factors responsible for releasing contaminants from sediments or assess biotransformation as a potential method of remediation.

### Project Focus

Halogenated organic compounds are significant causes of contamination in the Bayou d'Inde, a tributary of the

Calcasieu River in southwestern Louisiana. In this waterway, hexachlorobutadiene (HCBD) and hexachlorobenzene (HCB) released by petrochemical and organic chemical manufacturing plants have collected in sediments, then have been released into saltwater and freshwater where they contaminated numerous organisms. As a result, two major Louisiana industries, seafood and outdoor recreation, have sustained considerable damage.

These pollutants also are collecting in sediments throughout the United States, causing similar problems; thus, there is widespread interest in improving basic understanding of sedimentary contamination. Toward this end, researchers at Georgia Tech's School of Civil and Environmental Engineering are using sediment and water samples collected from the Bayou d'Inde to characterize the

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### Summary of the Problem

Scientists once believed that sediments beneath bodies of water served a beneficial purpose as natural sinks for contaminants. They now realize that pollutants do not always remain fixed in sedimentary layers but break free to contaminate water sources.

Research that focuses on contaminated sediments has increased over the last 10 years; however, the basic processes and process interactions responsible for partitioning and transforming toxic chemicals in sediments still are not well understood. The processes that must be studied include:

- *biotransformation*, in which active microorganisms change the contaminants to less hazardous form;
- *adsorption or desorption*, in which contaminants bind to or release from solid particles;
- *diffusion*, in which contaminants spread out or scatter over an area; and
- *volatilization*, in which contaminants are converted from liquid to gaseous form.

Research studies that clarify these processes will provide a scientific basis for deciding whether contaminated sediments must be remediated and what kind of intervention is necessary.

The knowledge gained in these investigations will influence future regulatory policies governing the release of toxic chemicals and on assessments of exposure and risk.



**Graduate student Mark Prytula conducts Soxhlet extraction in the lab to help quantify contamination levels in sediment samples from the Bayou d'Inde.**

mechanisms and transformations that determine the fate of these contaminants. The researchers have focused special attention on the rate and extent that these compounds are biotransformed under a variety of conditions. They have found that contaminants tend to stay bound in sediments without breaking down into less harmful compounds unless they receive a degradable, external carbon source. This discovery has revealed a key mechanism in the release of contaminants from sediments into water. It also suggests a way to make a remediation strategy effective in breaking down toxic chemicals in sediments. This research study began in 1992 and is still in progress. The following sections summarize work undertaken in different project phases to date.

### Contaminant Characterization

The Georgia Tech researchers characterized sediment and water samples from the Bayou D'Inde for pH, alkalinity, major anions, volatile and dissolved solids, volatile and extractable chlorinated organic compounds, total organic carbon, and dissolved organic and inorganic carbon. They determined that HCBD and HCB were the dominant organic contaminants in Bayou d'Inde sediments.

### Contaminant Release

Researchers assessed the sample data to characterize the process of desorption for the release of five chlorinated organic compounds from solid sedimentary particles. The compounds were HCBD, HCB, pentachlorobenzene (PeCB), 1,2,4,5-tetrachlorobenzene (1245-TeCB), and 1,2,4-trichlorobenzene (124-TrCB). The research team found that the desorption pattern of all of the compounds except 124-TrCB begins rapidly, then slows down considerably.

From these tests, the researchers concluded that the contaminants, especially HCBs, release extremely slowly from sediments because they

are bound strongly to the sediment's organic matter. Toxic chemicals are kept from breaking free of sediment bonds and re-entering the water body.

### Biotransformation Experiments

Another series of experiments showed that the tight bonds between sediment organic particles and contaminants also retard the activity of bacteria in breaking down pollutants into less toxic forms. Researchers found that sulfate-reducing and methane-forming bacteria replace the chlorine atoms in HCBD and HCB with hydrogen, a process known as microbial reductive dehalogenation. The resulting compounds are less prone to form bonds with sedimentary particles and show a greater tendency to dissolve in water. Unfortunately, this process slows as the degree of chlorination in HCBD and HCB drops. If researchers can determine causes of this slowdown, then it may be possible to enhance biotransformation.

### Future Activities

In the current phase of the project, the Georgia Tech group is focusing on the possible factors that control the biotransformation process in sediments. These factors include the bioavailability of sediment-bound contaminants, the lack of important nutrients (such as a degradable organic carbon, nitrogen, or phosphorus), and temperature limitations.

### Research Significance

This research will provide a basis for determining if *in-situ* or *ex-situ* remediation methods are most appropriate for cleaning up contaminated sediments. The results also are likely to influence regulatory policies governing release of toxic chemicals into American waters and improve the accuracy of exposure/risk assessments. The impact of the findings will be nationwide, because the contaminants and processes under investigation are found throughout the country.



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