# Research Brief #22

1999

## Measuring the Response and Bioavailability of Organic Pollutants

### Introduction

Agencies of the U.S. Defense must clean up contaminants in military bases now being closed. The substances of particular concern are the chlorinated organics, explosives such as trinitrotoluene (TNT), and petroleum hydrocarbons.

Previous research by Rice University researchers (HSRC *Research Brief* #16) suggests that a fixed portion of organic pollutants becomes *adsorbed*, or sequestered, in sediments and resists being *desorbed*, or released, back into the environment. The size of the desorption-resistant fraction depends upon the type of soil and type of contaminant. Residual contamination may be acceptable if it is not biologically available, or cannot be taken up by surrounding organisms. The definition of "clean" can be revised, greatly reducing removal costs.

The objective of this work is the determination of the bioavailability of this desorption-resistant fraction. Researchers hope to provide methods to predict the actual risk of release, given various amounts and types of contaminants, and to collect data for agencies to use in calculating the endpoint, or "no action" level, at which clean-up can cease.

### Physical and Chemical Processes

The first part of the study examines the physical and chemical mechanisms involved when sequestered contaminants are released back into the surrounding environment. A major objective is to produce and characterize sediments contaminated only with a desorption-resistant fraction whose bioavailability can be evaluated in further testing. The process occurs in two steps, with the major portion of contaminants able to be adsorbed or desorbed rapidly, and a smaller residual portion remaining adsorbed for extended periods of time. From previous research, researchers have proposed an adsorption-desorption model for this behavior.

Using well-characterized samples, researchers are measuring the desorption-resistant characteristics of historically contaminated and freshly contaminated sediments across a wide range of soil and water concentrations. Preliminary results support the model, suggesting the amount of water needed to flush out the desorption-resistant portion is nearly 150 times that of the non-resistant portion. Moreover, the time needed to clean the resistant portion totally is increased by up to two orders of magnitude.

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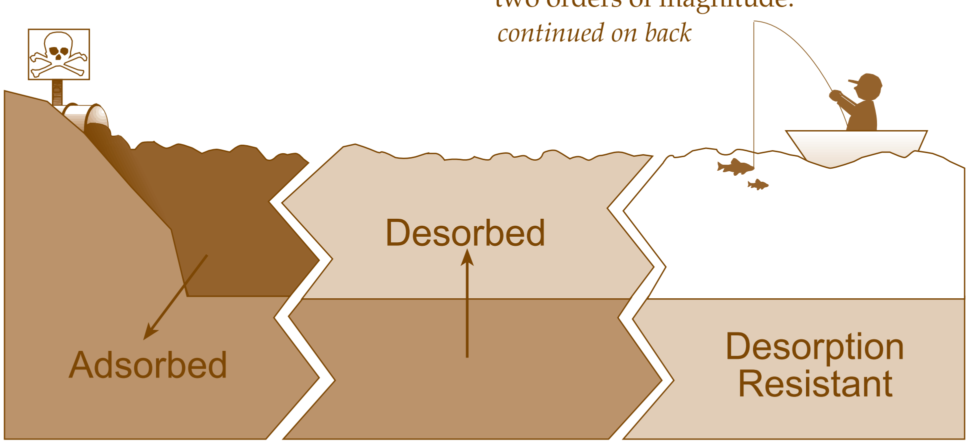



### Summary of the Problem

The question of "How clean is clean?" is crucial for soils and sediments contaminated with organic pollutants. The conservative approach of removing 100 percent of contaminant mass is time-consuming and expensive. Specific data are needed on the actual exposure these pollutants pose to living organisms and the amount of remediation actually needed.

Previous research suggests that a significant portion of organic pollutants becomes sequestered in sediments and resists being released back into the environment. If residual contamination is acceptable, the definition of "clean" can be revised, greatly reducing removal costs.

In this study, researchers from Louisiana State University, Rice University, and Southern University at Baton Rouge seek to understand the physical, chemical, and biological variables involved when organic pollutants are exposed to sediments. They are measuring the extent to which sequestered contaminants are released from sediments and made available to surrounding organisms, such as microbes, worms, and plants. Knowing this, they hope to revise assumptions about risk and better predict the endpoints at which clean-up can cease.

This study is funded by the Hazardous Substance Research Centers (HSRC) and the Defense Threat Reduction Agency (DTRA) of the Department of Defense.

## Biological Processes

In the second part of the study, researchers are testing the ability of various types of biological organisms to accumulate the contaminants or promote their release. These studies serve to directly evaluate the bioavailability of the desorption-resistant contaminants. The organisms being studied are those at the bottom of the food chain—bacterial microbes, bioturbating (soil-mixing) worms, and wetland plants. (A related project funded by the DTRA is studying the same processes with algae.)

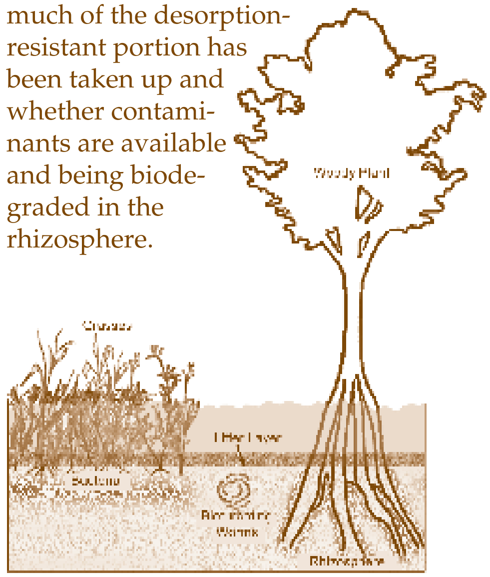
**Bacterial microbes:** Microorganisms such as bacteria commonly desorb and biodegrade polycyclic aromatic hydrocarbons (PAHs). Researchers are using two experimental conditions to measure the effect of bacteria on PAHs: high activity bacteria to challenge desorption-resistant and non-resistant PAHs over short periods of time (up to a month), and low activity bacteria to challenge desorption-resistent PAHs over longer periods of time (up to a year). Preliminary studies suggest that desorption-resistant napthalene may be biodegradable, and further study is continuing.

**Bioturbating worms:** Researchers are also studying the effect of freshwater worms such as *Limnodrilus hoffmeisteri* on sediments containing persistent PAHs. These worms are "conveyer-belt" feeders; they mix sediments by feeding at a depth and defecating on the surface. In this part of the study, bioturbating worms are introduced into laboratory beds containing known quantities of contaminants and constant water flow. Researchers then measure the degree to which the worms redistribute organic carbon matter, release PAHs into the overlying water, and by aerating the sediments, assist aerobic bacteria to biodegrade the PAHs.

During the feeding process, bioturbating worms also metabolize certain types of contaminants, such as pyrene. Preliminary studies showed the accumulation and degradation of readily available pyrene. Work is ongoing to test the availability of desorption-resistant contaminants.

**Wetland plants:** Since wetland plants are found in many military sites, phytoremediation (biodegradation by plants) has been proposed as a cost-effective way to reduce contamination. However, in plants there is a complex relationship among contaminant bioavailability, plant uptake, and the biodegradation process. Of particular interest are plant enzyme systems, the rhizosphere (area near plant roots where bacteria are active), and the "litter layer," rich in recently discarded carbon matter, which may also affect sorption.

Researchers will introduce two types of wetland plants—herbaceous grasses and woody plants—to well-characterized soil samples containing radiolabeled organic contaminants. Then they will measure contaminants in the soil, as well as in plant roots, shoots, and leaves, to measure how much of the desorption-resistant portion has been taken up and whether contaminants are available and being biodegraded in the rhizosphere.



For related *Research Briefs*, see:

*Understanding the Biotransformation and Fate of Halogenated Organic Compounds in Sediments* (#6, 1995)

*Predicting When Contaminants Will be Released from Sediments* (#8, 1995)

*How Clean is Clean Enough if Contaminants are Irreversibly Adsorbed* (#16, 1997).

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Project Title: *Biological Response and Availability of Desorption-Resistant Organic Pollutants*

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