



Research Brief #24

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Phytoremediation in Wetlands and Confined Disposal Facilities

Introduction and Objectives

Researchers at Louisiana State University and Southern University–Baton Rouge are developing a scientific basis for using a phytoremediation (plant-based) approach to clean up subaqueous and wetland sediments contaminated with chlorinated organic compounds.

Hydrophobic chlorinated organics are widespread in sediment contaminants and typically resist chemical breakdown. They often bioaccumulate through the food chain, creating significant health hazards. One possible mechanism for economical clean-up of these contaminants is rapid biodegradation by halo-respiring microorganisms. Previous research has shown that the cultivation of herbaceous wetland

vegetation in sediments stimulates reductive dechlorination in the plant root zone by anaerobic bacteria.

The study's primary hypothesis is that organic matter in vegetative roots stimulates production of hydrogen. This element serves as a fuel for microorganisms that break down chlorinated compounds in sediments. A secondary hypothesis of the study is that plant uptake and aerobic biodegradation of lower chlorinated daughter products may also be important mechanisms for breaking down certain chlorinated contaminants in sediments.

Researchers hope to identify the types of sediments conducive to a plant-based remedial approach. They believe that optimal results will occur in sediments where conditions are not

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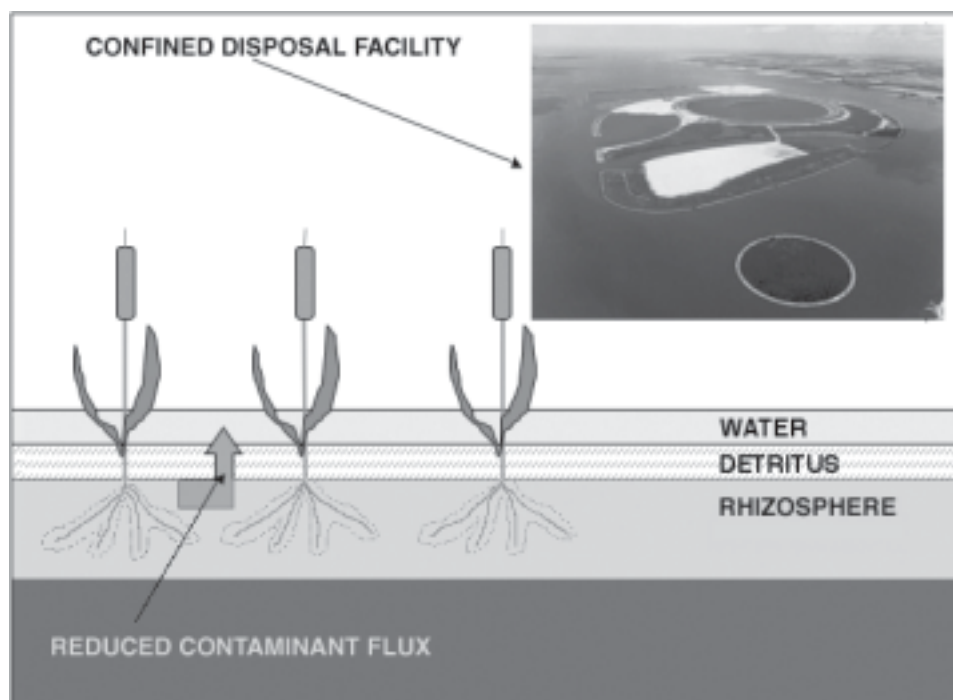
Summary of the Problem

Hydrophobic chlorinated organics are common sediment contaminants that pose threats to human and ecosystem health. These compounds often resist breakdown in sediments and spread to dangerous levels in the food chain. Because of the enormous potential expense of conventional remediation options, researchers are looking at alternative methods for treating sediments contaminated with chlorinated organics.

Phytoremediation is one clean-up method that has shown promise for cost-effective treatment of chlorinated organic contaminants in sediments. This technology makes use of trees and other vegetation to detoxify contaminants.

Scientists have observed rapid natural recovery in some types of chlorinated organics in vegetated sediments such as wetlands. This detoxification has occurred because of degradative activity of microorganisms living in plant root zones. Research has shown that the presence of wetland vegetation stimulates bacterial dechlorination.

Before effective remediation approaches can be designed, more research is needed to increase understanding of the fate of chlorinated organics on or near the roots of plants. Specifically, scientists need to determine if and how vegetation contributes to the biodegradation activities of the halo-respiring microorganisms that break down chlorinated organics. They must also consider the impact of other mechanisms on microbial dechlorination. The research described in *Research Brief 24* focuses on these concerns.



This illustration shows how phytoremediation might work in a confined disposal facility to provide a source of hydrogen for halo-respiring microorganisms to use in biodegrading persistent chlorinated contaminants in sediments.

present for rapid reduction of contaminants (e.g. insufficient organic carbon content or other barriers to achieving low redox potential).

Chlorinated Ethene and Ethane Dechlorination Studies

In year one, researchers completed an extensive set of experiments to determine the factors that control reductive dechlorination of chlorinated ethenes and ethanes in the rhizosphere (plant root zone). The experiments took place in upflow core mesocosms and serum bottle microcosms, utilizing natural wetland peats from a freshwater marsh and a constructed wetland compost mixture. These microcosm studies determined potential *in-situ* energy yields and predicted the potential energy that could be generated from hydrogen oxidation processes to fuel biodegradation in a plant rhizosphere.

The chlorinated ethene and ethane dechlorination experiments provided a guide for determining the type of conditions needed for successful biodegradation of chlorinated contaminants in subaqueous sediments in confined disposal facilities. Major findings of the completed wetland peat studies were as follows:

- High rates of complete reductive dechlorination of chlorinated ethenes and ethanes were achieved in rhizospheres of wetland cores and were maintained for two years without supplemental nutrients or carbon;
- The calculation of energetics for reductive dechlorination of chlorinated ethenes and ethanes proved useful in predicting which terminal electron-accepting processes would occur and under what conditions; and
- Detailed examinations of hydrogen thresholds and the effects of sulfate and sulfite improved understanding of the interaction of various terminal electron-accepting processes in the rhizosphere.

Studies of Effects of Vegetative Cultivation in Sediments

Another set of studies, which began in year one, focused on the effects of vegetative cultivation in sediments contaminated with more hydrophobic chlorinated organics. 1,2,3,4-tetrachlorobenzene was chosen as a test contaminant because of its chlorination pattern and also because it is the most hydrophobic chlorobenzene that can be directly dechlorinated by certain halorespiring organisms. Initial studies took place in a serum bottle and core mesocosms using two bayou sediments.

These experiments helped researchers to determine the sediment types in which a plant-based remediation approach could be successful. Laboratory studies established the kinetics of 1,2,3,4-tetrachlorobenzene dechlorination in sediments with a range of organic matter content. They identified the role of hydrogen as an electron donor, the expected daughter products of dechlorination, and the relative role of methanogens in dechlorination.

Additional microcosm studies with root material involved *Phragmites communis* (common reed) and *Typha latifolia* (cat tail) species cultivated in sediments. In sediments amended with fresh *Phragmites* roots, levels of ambient H₂ and methane increased while dechlorination rates rose in direct proportion to the amount of root matter added.

Future Work

First-year work showed that root material stimulated the dechlorination process, but researchers need to work with sediments that are not so easily reduced to better demonstrate the stimulatory effect of plant cultivation in wetlands. In addition, the project team will experiment with established techniques to determine known amounts of chlorobenzene in the labile and desorption-resistant fraction so that future results can be more representative of "aged" field sediments.



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