



# Research Brief #12

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## Fundamental Studies of TNT Transport From Soil to Water

### Introduction

Environmental researchers want to use aquatic plants as a medium for absorbing and neutralizing trinitrotoluene (TNT) contaminants in soils. However, for such an approach to work, a physical process that dissolves TNT and a biochemical reaction that converts the contaminant into non-polluting products are needed.

Researchers at Louisiana State University (LSU) are searching for techniques to enhance TNT dissolution. The LSU research group is using packed-bed, leaching-bed, and static (batch) reactors to study how TNT is transported from soil to water. The data emerging from this investigation will be integrated with information gathered in related studies at Rice University and the Georgia Institute of Technology (see "Summary of the Problem" in column at right). These findings will serve as the basis for a model of TNT transport that can be used in designing a field-scale TNT-treatment system.

### Experimental Studies

In the packed-bed study, researchers simulated field conditions by flowing water through a stainless-steel column filled with contaminated soil. By monitoring TNT concentrations in the effluent and in the sediment beds, the LSU group was able to develop mathematical equations to measure the rate at which the contaminant dissolved.

In the leaching-bed experiment, researchers flowed TNT-contaminated water over a flat bed extractor. They measured contaminant levels in the effluent from this leaching bed at established time intervals. In this way, they determined TNT leaching rates, mass transfer coefficients, and the amount of TNT that can be extracted from soil. These data are necessary for scaling up a laboratory setup to a system that can be used in the field.

In static (batch) experiments, the LSU group sampled water above a small soil column with low concentrations (10-50 mg/L) of TNT. When

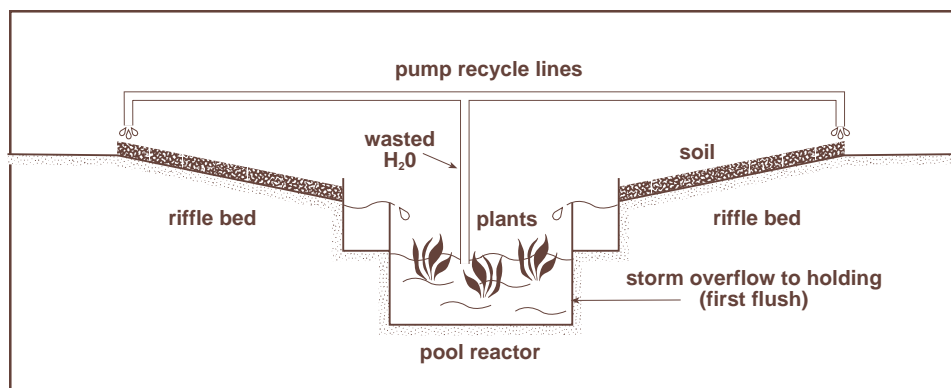
### Summary of the Problem

Researchers at Georgia Institute of Technology, Louisiana State University, and Rice University are investigating the effectiveness of aquatic plants as a means of cleaning soils contaminated with trinitrotoluene (TNT). An explosive compound used in munitions, TNT is found in soil at many ammunition plants and military bases in the United States. The ability of aquatic-plant enzymes to reduce and assimilate TNT and convert it into nonhazardous plant mass has been investigated in bench-scale and pilot-scale studies with aquatic plants and natural organic matter in soils and sediments. Researchers have developed and investigated a working hypothesis in which TNT is initially transformed to aminated intermediates which are then conjugated and assimilated into plant mass.

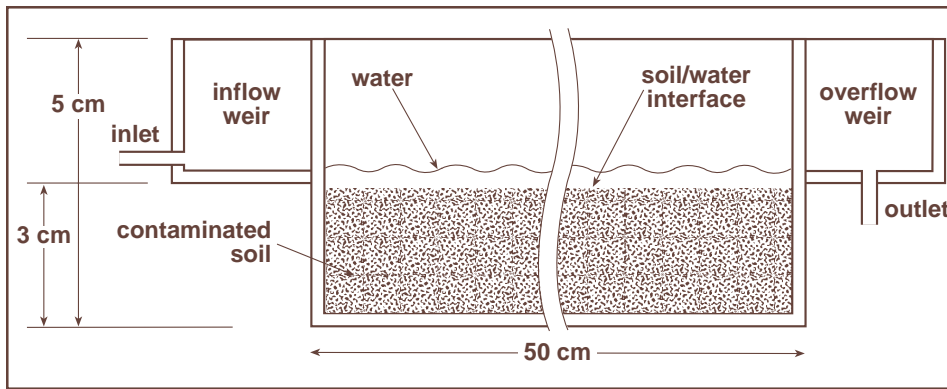
Rice University is conducting fundamental studies of plant transformations and pathways. Georgia Tech is studying whole-plant biochemical processes, as well as the physicochemical processes that affect the fate of biochemical intermediates produced by the remediative plant/soil system. Georgia Tech researchers also conducted pilot-scale studies aimed at placing (and testing) the plant remediation system in the field. Louisiana State University characterized the transport of TNT in contaminated soils from soil to water, and are developing models of TNT transport for use in investigating an enhanced-flow TNT-treatment system.

The three-university project on phytoremediation of TNT was managed by HSRC/S&SW Co-Director F.M. Saunders at Georgia Tech. This fact sheet focuses on LSU's phase of the project.

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*A proposed riffle-bed pool reactor where in-situ bioremediation of TNT can take place*



LSU researchers used a flat bed reactor to simulate the flow of TNT-contaminated water. They are determining TNT leaching rates, mass transfer coefficients, and the amount of TNT extractable from soil. This information is necessary for remediation systems to be scaled up for field use.

early analyses showed no diffusion of TNT into the liquid phase, researchers cored and layered the soil columns to determine TNT concentration profiles. They found that TNT diffuses very slowly through soils.

## TNT Models

The TNT concentration was relatively low in the soil used in most of the LSU experiments. This finding suggests that the pore-water concentration and pollutant flux decrease over time. The consistency between modeling and experimental results to date indicates that the LSU researchers have accurately simulated the fundamental transport mechanisms at work in TNT dissolution. The group examined both dynamic and static reactors to determine if water-side or soil-side resistance controlled the leaching process. Models developed to fit the reactor data indicate:

- TNT diffusion rates through soil are slowed down when concentrations

of the contaminant are low (10 to 50 mg/kg);

- water-side resistance controls the flux in highly contaminated soils (10,000 mg/kg of TNT).

## Future Work

As modeling of the bed experiments continues, researchers are focusing on enhancing the transport of TNT from sediments to the water column in a modified flat-bed extractor. The method will provide a pulsed flow to the bed to avoid the common low-level tailing of concentration often observed in these flux experiments. Also, researchers will obtain sorption isotherms for compounds of interest in the TNT-contaminated soils to improve understanding of the transport process. As the study progresses, LSU will continue to share its research data from the project with Rice and Georgia Tech groups. The researchers intend to build a model to aid in field testing of the TNT treatment system.



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