U.S. Environmental Protection Agency

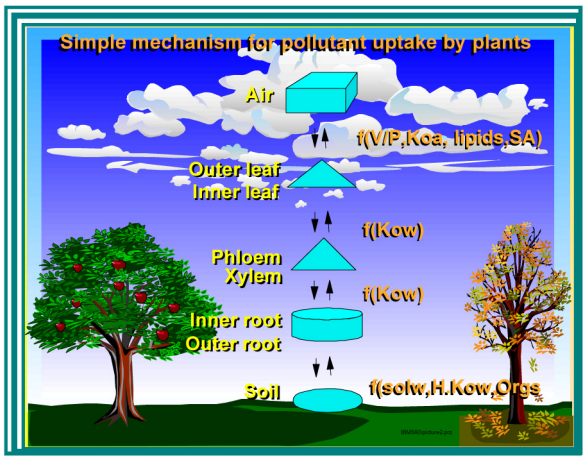
U.S. EPA Office of Research and Development
National Exposure Research Laboratory
Ecosystems Research Division

National Exposure Research Laboratory

Phytotransformation: The Ultimate Cleaner-upper

What is phytotransformation?

Research at the NERL Ecosystems Research Division indicates that plants can transform many organic contaminants in sediments, soils, and natural waters to more environmentally acceptable products. A variety of organic contaminants have been shown to be degraded by plants and trees. Furthermore, plant enzyme systems have been shown to be stable in sediments and soils for long periods of time and still maintain their activity. The diagram illustrates the mechanisms for pollutant uptake by plants.



Benefits

Using the knowledge that some aquatic plants have a high enzymatic activity for breaking down chemical toxins in soils and surface waters is leading to technology that is both economical and environmentally friendly to clean up hazardous waste sites, thus eliminating the dangers of further contaminating the environment with these chemicals.

Research Objective

The objective of our research is to determine which plants contain the most effective enzyme systems for transforming chemicals to safer products and to develop and incorporate plant/enzyme mediated transformation algorithms into multimedia models. We seek to quantitatively describe these processes in air, water, and land systems using molecular descriptors of the organic compounds and physical/chemical descriptors of the system to model pollutant fate.

Research Approach

- **Identification:** develop and separate plant enzymes that may be active in degrading chemicals.
- **Occurrence:** determine the occurrence of plant enzymes that have the potential capability of degrading a variety of toxic chemicals.
- **Transformation:** conduct degradation experiments in selected environmental matrices to determine the mechanism and degree of degradation of chemicals to safer products.
- **Effects:** determine the efficacy of these plant/enzyme systems for transforming these chemicals.

Results

- Several plants (aquatic and terrestrial) have been identified as containing the enzyme that reacts to make harmless the trinitrotoluene (TNT) found in abundance at abandoned military sites.
- Further research has shown that many aquatic and land plants can degrade chlorine compounds and restore the contaminated media.
- Plants have been shown to uptake and degrade organophosphate compounds such as pesticides to harmless products.

Phytotransformation

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Purpose

- Supports EPA's goal for restoration of contaminated waste sites by providing less expensive and environmentally safe methods of cleaning up hazardous waste sites.
- Supports EPA's sound science goal by developing algorithms for phytotransformation processes that can be incorporated into multimedia models.

Useful publications

1. Method for Remediating Environmental Contaminants, N. Lee Wolfe, Laura H. Carreira and Mark C. Delgado. Patent Number 5,711,020, Jan. 20, 1998.
2. Method and Composition for Remediating Environmental Contaminants., N. Lee Wolfe, Laura H. Carreira and Mark C. Delgado, Patent Number 6,100,382, Aug. 8, 2000.
3. Gao, J., A. W. Garrison, C. Hoehamer, C. S. Mazur and N. L. Wolfe. Uptake and Phytotransformation of o,p'-DDT and p,p'-DDT by Axenically Cultivated Aquatic Plants. J. Ag. and Food Chem. 48, 6114-6120, 2000.
4. Gao, J. Al W. A. Garrison, C. Mazur, C. Hoehamer, N. L. Wolfe. Uptake and Phytotransformation of Organophosphorus Pesticides by Axenically Cultivated Aquatic Plants. J. Ag. and Food Chem. 48, 6121-6127, 2000.
5. Garrison, W. A., V. A. Nzengung, J. K. Avants, J. J. Ellington, W. J. Jones, D. Rennels and N. L. Wolfe. Phytodegradation of p,p'-DTT and the Enantiomers of o,p'-DDT. Environ. Sci. Technol., 34,1663-1670, 2000.
6. Susarla, S., S. T. Bacchus, N. L. Wolfe and S. C. McCutcheon. Phytotransformation of Perchlorate and Identification of Metabolic Products in *Myriophyllum aquaticum*. Int. J. Phytoremediation 1(1):97-107, 1999.

Time Line

- **2004 —** Prototype model to quantitatively describe the atmospheric uptake and ensuing enzyme mediated transformations of volatile organics by plants.
- **2006 —** Prototype model to quantitatively describe enzyme mediated transformations of organics in aquatic systems.
- **2008 —** Prototype model to quantitatively describe enzyme mediated transformation of organics in soil/sediment.

Participants

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