Bioremediation: Working even better

INTRODUCTION

The most environmentally-friendly way to reduce or clean-up organic pollutants in soil, water and air is through bioremediation. Bioremediation uses microorganisms, both bacteria and fungi, to detoxify, transform and degrade hazardous pollutants to carbon dioxide and water. The Forest Products Laboratory (FPL) has been working with industry in Mississippi for over 15 years to clean-up soil and water contaminated with organic wood preservatives.

The FPL's bioremediation research group directed the first U.S. Environmental Protection Agency (EPA) SITE demonstration for bioremediation of organic wood treating wastes at a wood preservation facility in Mississippi.

During the past 5 years, these scientists have expanded into another type of bioremediation called biofiltration. Biofiltration is the use of microorganisms to degrade pollutants in an air stream.

Advantages of bioremediation include:

- **More economical -** Bioremediation can often reduce industry's environmental control costs by 20-50%.
- **Safer -** Bioremediation is often done on-site and does not require off-site transportation of hazardous materials through cities and towns.
- **Complete disposal** - Bioremediation breaks down the contaminants of concern to non-toxic by-products.
- **Continuous -** Here in the Southeast bioremediation operates 24 hours a day, 7 days a week.
- **High public approval -** Bioremediation is a 'natural' way to clean the environment.

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Soil and Water Bioremediation

Accidental discharges and past legal disposal practices have, unfortunately, led to soil and groundwater contaminated with the organic wood preservatives, creosote and pentachlorophenol (PCP), at current and former wood-treating sites. Laboratory-, field-, and full-scale studies conducted through the FPL continue to evaluate individual site characteristics and determine the amendments needed for successful clean-up.

Groundwater contamination has been the result of leaching of these wood preservatives from the soil at treating plant sites down into groundwater reserves. Pump-and-treat systems which pump the contaminated water to the surface and treat water in above-ground bioreactors are the most common form of groundwater bioremediation. One site in south Mississippi, has been pumping 100,000 gallons of contaminated groundwater per day into two above-ground bioreactors for the past ten years. A bacterium isolated from the FPL is added to these bioreactors weekly. After treatment, the water is clean enough to be discharged into the publicly owned treatment works. Cost savings to this site is estimated to be $35,000 - $50,000 annually.

In order to further stimulate the biological degradation of organic contaminants in groundwater and to reduce the time and cost of pump-and-treat systems, an in-situ study was initiated by FPL at a wood-treating site in southern Mississippi. Bacteria, nutrients, and an oxygen source have been periodically injected into a contaminated groundwater system on this site since 1993. Total polycyclic aromatic hydrocarbon concentrations (from creosote) have significantly decreased during this period from 31.8 to less than 5 mg/L. Pentachlorophenol levels have been reduced from 0.6 to 0.3 mg/L. This technolog should continue to enhance the biodegradation of creosot components and chlorinated phenols in contaminated subsoil and groundwater and ultimately reduce overall costs associated with current technology.

At another site in central Mississippi, soil contaminated with PCP and total petroleum hydrocarbons (TPH) was evaluated by FPL researchers in a year-long pilot-scale landfarm study to determine the best soil amendments to enhance biodegradation for this site. The addition of 3% chicken manure as a nutrient source provided excellent degradation of both PCP and TPH, reaching permitted evels within 90 days. The non-amended soil took approximately 250 more days to achieve the same level c degradation for PCP. This site is currently establishing a full scale landfarm in order to bioremediate the contaminated soil.

Air Biofiltration

The 1990 amendments to the Clean Air Act imposed stricter regulations on the forest products industry's volatile emissions from wood dry kilns and wood presses. The EPA has mandated use of multimillion dollar incineration units on kilns for all companies and those not in compliance with air quality standards. Since most lumber is dried in a kiln, the cost of drying has gone up tremendously because of these environmental regulations. Ultimately, that cost will be passed on to the consumer in the price of lumber.

Laboratory-scale biofilters have evaluated different matrices and fungal inocula at elevated temperatures. At these elevated temperatures (40-50 degrees C), fungi appear to dominate the degradation process. Laboratory columns containing certain fungi can reduce monoterpenes to non-detectable levels. Fluctuating the biofilter temperatures to represent the pilot-scale kiln system did not appear to impact degradation abilities. In the pilot-scale biofilter, the kiln emissions are first condensed, then the condensate is sprayed into the biofilter. This is necessary because temperatures exiting the kiln are lethal to microorganisms. A total carbon analyzer is mated to the biofilter to measure VOC's. During the first trial run, the maximum biofilter inlet temperature was approximately 38 degrees C (compared to 78 degrees C without the condenser). Over a 6 hour period the temperature decreased from 33 degrees C to 24 degrees C. This provides a temperature that can be tolerated by microorganisms. The total hydrocarbon concentrations entering the biofilter varied from 1,775 ppm down to 383 ppm over the six hour period, with the maximum at 2,668 ppm.

Total hydrocarbon concentrations leaving the biofilter ranged from 259 ppm to 79 ppm. This results in a 10-fold decrease in hydrocarbon concentration due to the biofilter. Further biofilter runs will evaluate the addition of microorganisms or other treatments as determined by the laboratory studies.

Another biofiltration study is focusing on control of solvent emissions from furniture manufacturers. The wood furniture industry in Mississippi is the leading manufacturing sector in the state with over 26,000 people employed. Eighty-six percent of wood furniture plants employ fewer than 50 people. These small plants cannot absorb the cost of expensive incineration technologies. Air sampling around a Mississippi wood furniture plant provided information into the type of chemicals emitted into the atmosphere. FPL scientists have begun to evaluate what conditions are optimal in laboratory biofilters for degradation of these types of chemicals.

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NEW RESEARCH

Two new bioremediation projects are phytoremediation and air sparging. Phytoremediation is the use of plants to either stimulate microbial degradation of contaminants in soil and water or to actively uptake the contaminants into the plant's system. The study at FPL will address the use of plants to stimulate the microbial degradation of PCP and creosote in contaminated soil and water.

Air sparging is the process of actively pumping air into or below a groundwater table in order to provide oxygen to the microorganisms for active biodegradation of contaminants in the groundwater. In this project, bacteria and nutrients are also being added to the groundwater. Monthly samples are monitoring the efficiency of this bioremediation technique.

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