B I O R E M E D I A T I O N

What is bioremediation?

To "bioremediate", means to use living things to solve an environmental problem such as contaminated soil or groundwater. Some microorganisms that live in soil and groundwater naturally eat certain chemicals that are harmful to people and the environment. The microorganisms are able to change these chemicals into water and harmless gases, such as carbon dioxide. Plants can also be used to clean up soil, water or air; this is called *phytoremediation*.

How does bioremediation work?

In order for the microorganisms to do their work, the right temperature, nutrients and amount of oxygen must be present in the soil and groundwater. The right combinations of helpful microbes can eat the pollutants until it disappears. Then the microbes themselves disappear, because there's no more pollution for them to eat. Certain plants are also able to take up pollutants from the environment through their roots and leaves.

Why use bioremediation?

Advantages

- Works on a variety of organic and inorganic compounds
- Can be done either on-site or off-site
- Easy to implement and maintain
- Low-cost compared to other treatment methods
- Environmentally-friendly and aesthetically pleasing
- Reduces the amount of wastes to be landfilled

Disadvantages

- May take several years to remediate
- May depend on climatic conditions
- Restricted to sites with contamination near the roots
- Harvested plants may be classified as hazardous waste
- Consumption of contaminated plants may be harmful
- Possible harmful effects on the food chain

Mighty Microbes

Examples of microbes used for bioremediation include:

Deinococcus radiodurans bacteria have been genetically modified to digest solvents and heavy metals, as well as toluene and ionic mercury from highly radioactive nuclear waste.

Geobacter sufurreducens bacteria can turn uranium dissolved in groundwater into a non-soluble, collectable form.

Dehalococcoides ethenogenes bacteria are being used in ten states to clean up chlorinated solvents that have been linked to cancer. The bacteria are naturally found in both soil and water and are able to digest the solvents much faster than using traditional clean up methods.

An enzyme from a bacterium, ***Thermus brockianus***, found in Yellowstone National Park, breaks down hydrogen peroxide 80,000 times faster than current chemicals in use.

The bacterium, ***Alcaligenes eutrophus***, naturally degrades 2,4-D, the third most widely used herbicide in the U.S.

Did you know...?

Microbes are used to degrade gasoline, the most common contaminant of groundwater in the United States.

Adding powdered seaweed to DDT-contaminated soil boosts the cleaning activity of DDT-eating microbes. In one test site, 80% of the DDT was removed after six weeks.

Microbes and fungi are used in air filters to control odors from sewage treatment plants and in the paint industry.

A gene for a protein found in rat livers that binds with toxic metals has been inserted in both tobacco plants and algae. With this gene, the tobacco plant and the algae are able to extract several hundred times more toxic metal compounds from soil or water compared to plants without the gene.

One particular microbe degrades polycyclic aromatic hydrocarbons (PAH's), which are cancer-causing petroleum byproducts. The microbes, called simply "sulfate-reducers", are able to attack PAH's in the sediment of Boston Harbor where scientists thought the contaminant could not be treated due to lack of oxygen.

Powerful Plants

Some plants used for phytoremediation are:

Alfalfa - symbiotic with hydrocarbon-degrading bacteria

Transgenic *Arabidopsis* - carries a bacterial gene that transforms mercury into a gaseous state

Bamboo family - accumulates silica in its stalk and nitrogen as crude protein in its leaves

Indian mustard (*Brassica juncea*) - accumulates selenium, sulfur, lead, chromium, cadmium, nickel, zinc, and copper

Chinese ladder fern (*Pteris vittata*) - accumulates arsenic

Cottonwood (with added *E.coli* gene) - accumulates mercury

Tomato and alpine pennycress - accumulates lead, zinc and cadmium

Poplar - used in the absorption of the pesticide, atrazine

Bioremediation in Your Home

Look for household, carpet, bathroom or drain cleaners with "enzyme action". Those enzymes are bacterial enzymes, made by friendly bacteria in those products. Once the pollutant in your carpet or bathroom surface is gone, the bacteria run out of food, and die off.

Some plants are known for their ability to improve air quality by absorbing indoor air pollutants such as formaldehyde, benzene and trichloroethylene.

Formaldehyde is found in tobacco smoke and burning wood, and emitted by curtains, carpets, furniture, glues and household cleaning products. **Benzene** is a common solvent found in glues, oils, furniture wax, detergents and paints. **Trichloroethylene** is found in paints, adhesives, inks and varnishes.

Some of the best houseplants for filtering indoor air (and the pollutants they filter) include:

Green spider plant - *Chlorophytum comosum* (formaldehyde)

Mother-in-law's tongue or snake plant - *Sansevieria trifasciata* (formaldehyde and benzene)

Chrysanthemums - *Chrysanthemum* sp. (benzene)

Gerbera daisies - *Gerbera* sp. (benzene and trichloroethylene)

Varieties of *Philodendron* sp.: *P. scandens*, *P. domesticum* and *P. selloum* (formaldehyde)

Varieties of *Dracaena* sp.: *D. fragrans*,*D. deremensis*, *D. warneckii* and *D. marginata* (formaldehyde)

English ivy, *Hedera helix* (benzene)

Golden pothos - *Epipiremnum aureum* (formaldehyde)

Peace lily - *Spathiphyllum* (formaldehyde, benzene and trichloroethylene)

Aloe vera - *Aloe vera* (formaldehyde)

For an average home of under 2,000 square feet, it is recommended to use at least fifteen samples of a good variety of these common houseplants to help improve air quality. The plants should also be grown in six-inch containers or larger.

For more information

A Citizen's Guide to Bioremediation
http://www.clu-in.org/download/citizens/bioremediation.pdf

A Citizen's Guide to Phytoremediation
http://www.clu-in.org/download/citizens/citphyto.pdf

Government of Canada: Bioremediation
http://biobasics.gc.ca/english/View.asp?x=741

Microbe Zoo: Dirtland
http://commtechlab.msu.edu/sites/dlc-me/zoo/zdtmain.html

Microbes Clean the Air
http://pubs.acs.org/subscribe/journals/esthag-w/2002/oct/tech/kb_airbiofilter.html

Microbes Clean Up Toxic Waste
http://www.ars.usda.gov/is/AR/archive/mar97/microbe0397.htm

Microbiology and Bacteriology: The World of Microbes
http://www.bact.wisc.edu/Microtextbook/index.php?module=Book&func=displayarticle&art_id=22

Phytoremediation: Using Plants to Clean Up Soils
http://www.ars.usda.gov/is/AR/archive/jun00/soil0600.htm

U.S. Geological Survey's Bioremediation: Nature's Way to a Cleaner Environment
http://water.usgs.gov/wid/html/bioremed.html