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Phytoremediation: Using Plants to Clean Up Pollution

Using Plants to Clean Up Pollution

If you were chosen to clean up the radioactive pollution left by a nuclear accident, you probably wouldn't suggest growing sunflowers on the site. Yet that is exactly what scientists in Chernobyl are doing, using a new technique called phytoremediation.

Phytoremediation — from *phyto* (plant) and *remediate* (to fix or cure) — is a form of biotechnology that uses green plants to clean up contaminants in the environment. It can be used on organic wastes such as pesticides and petroleum, or on heavy metals like uranium and nickel.

Traditional methods of cleaning up industrial and agricultural pollution are often not completely effective. Dumping wastes in a landfill, for instance, only moves the problem from one site to another. And because of the great cost involved, only a few sites can be tackled at once.

Fortunately, scientists have discovered that plants can be used to clean up pollution. Plants have long and thirsty roots, they naturally absorb minerals from the surrounding soil and water, and some can even digest the harmful materials they consume.

Phytoremediation is a promising new technique that can deal with pollution cheaply, thoroughly and on-site by using trees, crops, and flowering plants.

Putting the Petal to the Metal

Phytoextraction, a technique that is often used to clean up metals, is one example of how plant roots take in toxic material. Because plants, like animals, need metal for growth, they are natural collectors of industrial by-products such as nickel, copper, zinc, chromium, iron and manganese.

While all plants take in minerals, some have a more voracious appetite than others. *Hyperaccumulators* are plants that can absorb about 1 per cent of their own dry weight in heavy minerals. Some common hyperaccumulating plants include *Brassica juncea* (Indian mustard), *Pelargonium* (geranium) and *Helianthus annuus* (sunflower). There is, for example, a rubber tree found in the South Pacific that is blue in colour because it absorbs up to twenty per cent of its own weight in nickel.

Hyperaccumulating plants are valuable because they can clean up large amounts of pollution from soil or water. They also have direct economic potential as highly concentrated sources of metal that can be recovered for re-use.

Digesting Pollution

Like humans, plants digest their food. With the help of enzymes (proteins that spark biochemical reactions), they can break down organic materials from the soil and water and put them to use as fuel. This process is known as *phytotransformation.*

In *phytotransformation*, plants can change harmful toxins into simple substances like carbon dioxide, water and methane. Sometimes, the chemicals are converted within the plant. In other cases, the breakdown takes place in the soil through the action of released plant enzymes.

Once this task is accomplished, plants can release the new products into the air through their leaves, in a process called *volatilization*. In this way, pollution can be changed into gas in the air, or even into the water we drink.

Hungry Microorganisms

Plants do not work alone to clean up wastes in the environment. They have help from the millions of microorganisms living in the surrounding soil. Plant roots allow oxygen to enter the soil. In a process called *phytostimulation*, the oxygen encourages the growth of fungi and bacteria. In return, these tiny organisms digest large amounts of toxins before they enter the plant root.

Microorganisms do their work in the rhizosphere, or plant root zone. They will eat whatever they can for energy and nutrition— including pollution. With their healthy appetites, they are responsible for breaking down large amounts of contamination. Phytostimulation depends on these tiny organisms as much as it depends on the plant roots where they make their home.

Pole-planted poplars near Kelvington

A Local Example: Using Poplar and Willow to Clean Up Petroleum

Many of the older gas service stations in our province have left behind petroleum pollution as a result of leaking tanks. In 1997, workers at Saskatchewan Federated Co-operatives Limited began experiments to see if plants could be used to clean these areas.

Employees at the Federated Co-operatives Limited planted 203 poplars on a test site near Kelvington. Cuttings from mature trees were placed as far as twelve feet into the soil in a technique known as pole-planting. Balsam poplars were chosen for the experiment because they are hardy, fast-growing and readily available in Saskatchewan. An adult poplar can take in up to 120 litres of water per day.

Some of the trees were planted directly in high-petroleum areas, and others were planted on the outskirts of the pollution. One year later, 65 per cent of the trees were still alive and did not seem affected by the contamination. The 35 per cent of trees that did not survive died as a result of a fungal blight, not diesel and gasoline poisoning.

The Kelvington experiment showed that trees have great potential for cleaning up petroleum. The next year, the experiment was repeated on a larger scale. This time, young trees were used instead of poles. To prevent disease, workers planted several varieties of poplar and willow. So far, the survival rate is 95 per cent.

Workers at the Federated Co-op now know that poplar and willow trees can send roots into contaminated soil and drink from contaminated ground water. Their next step is to measure how the levels of petroleum in the soil and groundwater change over time. They expect that it will take ten years to see full results.

The Promise of Phytoremediation

Phytoremediation can turn abandoned lots into green and leafy land at very low cost. Burning polluted soils can cost thousands of dollars per tonne. The same amount of soil can be planted with trees or flowers for as little as twenty-five dollars.

But the process requires patience. Because phytoremediation relies on the natural life cycle of plants, clean-up may take anywhere from three to ten growing seasons. Many hyperaccumulating plants grow very slowly. Researchers are working to develop new varieties to quicken the process. *Brassica juncea*, or Indian mustard, is one example of a fast-growing plant that has been used to clean up lead.

Scientists are just beginning to understand how plants, soil, roots, microorganisms, sunlight and gases work together to bring barren land back to life. But the promise of phytoremediation is clear. Green, clean and inexpensive, plants are the clean-up technology of the future.

Special thanks to Dr. Jim Germida, Head, Department of Soil Science, University of Saskatchewan and Trevor Carlson, Federated Co-operatives Ltd. for their assistance with this paper. Photo courtesy of Federated Co-operatives Ltd.

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