Reading : Bioremediation and Phytoremediation

Course : Green Economy – Start-up Series

Generating Ideas

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Definitions

Bioremediation is the use of biological organisms to solve environmental problems such as contaminated groundwater or soil. Phytoremediation is the use of green plants to remove pollutants from the environment and render them harmless. Phytoremediation is, therefore, a form of bioremediation as green plants are biological organisms.

Because oil is an organic material, bioremediation can be used to help clean up oil spills

In a non-polluted environment, bacteria, fungi and other micro-organisms constantly work to break down organic matter. If an organic pollutant such as oil contaminated this environment, some of the micro-organisms would die, while others capable of eating the organic pollution would survive. Bioremediation depends on the natural processes and works by using or enhancing the ability of 'pollution-eating' organisms to grow rapidly and enable them to break down the organic pollutant at a correspondingly faster rate. In other cases, specialised bacteria may be added to help with degrading contaminants. Because oil is an organic material, bioremediation is often used to help clean up oil spills.

A benefit of bioremediation as a technique for cleaning up pollution is that it uses the same biodegradation processes that occur in nature and, because of this, depending on the site and

its contaminants, bioremediation may be a safer and less expensive solution than the alternatives that include incineration or landfilling of the contaminated materials. It also has the advantage of being able to treat large areas of contamination in place so that large quantities of soil, sediment or water do not have to be dug up or pumped out of the ground for treatment.

3 types of bioremediation:

There are three main types of bioremediation:

Biostimulation

Nutrients and oxygen - in a liquid or gas form - are added to contaminated water or soil to encourage the growth and activity of bacteria already existing in the soil or water. The level of contaminants is monitored to make sure that remediation occurs.

Bioaugmentation

Micro-organisms that can clean up a particular contaminant are added to the contaminated soil or water. Bioaugmentation is more commonly and successfully used on contaminants removed from the original site, such as in municipal wastewater treatment facilities. This method may not be very successful when done in-situ because it is difficult to control site conditions for the optimal growth of the added micro-organisms.

Intrinsic Bioremediation

This technique is also known as natural attenuation. This type of bioremediation occurs naturally in contaminated soil or water. This is often seen in petroleum contamination sites. Research is going on to find out if intrinsic bioremediation happens in areas with other types of chemical contamination. Application of this technique requires close monitoring of contaminant degradation to ensure that environmental and human health are protected.

All three types of bioremediation can be used at the site of contamination (in situ) or on contamination removed from the original site (ex situ). In the case of contaminated soil, sediments, and sludges, it can involve tilling the land to make the nutrients and oxygen more available to the micro-organisms.

Scientists do not yet completely understand all the mechanisms involved in bioremediation

Bioremediation will not, however work for all types of contamination. Scientists have yet to completely understand all the mechanisms involved in bioremediation, and organisms introduced into a foreign environment may have a hard time surviving. It may not be feasible at sites with high concentrations of chemicals that are toxic to most micro-organisms. These chemicals include metals such as cadmium or lead, and salts

such as sodium chloride.

More research needs to be carried out to completely understand the complex microbial processes which make bioremediation possible, especially the bioremediation of metals. Scientists are also trying to understand why some micro-organisms are better at degrading one kind of chemical than another. The development of better in-situ bioremediation strategies are also being studied since they are cheaper to carry out and are less disturbing to the environment. Currently, in situ treatments are problematic because naturally existing external conditions are too difficult to control (such as dense soil, cold conditions). Methods are being developed for more effective delivery of nutrients or micro-organisms in situ and ex situ.

Bioremediation usually means lower costs than chemical treatment processes

Because bioremediation uses the resources available in nature to clean up contamination, it usually means lower costs compared to chemical treatment processes and it is also less disturbing to the environment. However, because it is a natural process, it requires time.

Phytoremediation

Where bioremediation using fungi, bacteria or other micro-organisms is not feasible, for example in cleaning up areas contaminated by heavy metals, phytoremediation may provide a solution. As indicated above, phytoremediation is the use of green plants to remove pollutants from the environment and render them harmless. It can be used to clean up metals, pesticides, solvents, explosives, crude oil, and contaminants that may leak from landfill sites (called leachates).

Hyperaccumulators

Certain plant species — known as metal hyperaccumulators — have the ability to extract elements from the soil and concentrate them in the easily harvested plant stems, shoots, and leaves. These plant tissues can be collected, reduced in volume, and stored for later use.

Advantages of phytoremediation

Phytoremediation has a number of advantages:

- It is environmentally friendly, cost-effective, and aesthetically pleasing;
- It can be used to clean up a large variety of contaminants;
- Metals absorbed by the plants may be extracted from harvested plant biomass and then recycled;
- It may reduce the entry of contaminants into the

environment by preventing their leakage into the groundwater systems.

Disadvantages of phytoremediation

But inevitably, phytoremediation cannot be the solution to all problems. The disadvantages are:

- It relies on the natural cycle of plants and therefore takes time;
- The contamination needs to be within reach of the plant roots, typically three to six feet underground for herbaceous plants and 10 to 15 feet for trees;
- Some plants absorb a lot of poisonous metals, making them a potential risk to the food chain if animals feed upon them.

Research into phytoremediation is also finding ways to grow crops on marginal land and so enhance the productivity of these areas for agriculture and forestry. Being able to produce a wider range of crop species can make a major contribution to the efforts to cultivate marginal, stressed soil environments.

Biomining

One added opportunity from this research is also the potential for 'biomining'. This is the use of plants to mine valuable heavy-metal minerals from contaminated or mineralized soils, as opposed to decontaminating soils. It is envisaged that the crops would be grown as hay and they would be cut and baled after taking in enough minerals. They could then be burned and the ash sold as ore. Ash from alpine pennycress grown on a high-zinc soil in the United States for example, yielded 30 to 40 percent zinc — which is as high as high-grade ore. Electricity generated by the burning could partially offset the costs of biomining.

Bioremediation is very safe

Given that they are used to remediate heavily contaminated areas, we also need to ask if these techniques are safe. Bioremediation is very safe because it relies on micro-organisms that naturally occur in soil. These micro-organisms are helpful and pose no threat to people at the site or in the community. No dangerous chemicals are used in bioremediation. The nutrients added to make micro-organisms grow are commonly used fertilizers and because bioremediation changes the harmful chemicals into water and harmless gases, the harmful chemicals are completely destroyed. However, a site undergoing bioremediation should be constantly monitored, using soil and

groundwater samples, to ensure that the technique is working.

In the case of phytoremediation it is important to study whether the plants grown to clean up the pollution can be harmful to people. The plants and air should be tested to make sure that the plants do not release harmful gases. Some insects and small animals may eat the plants used for phytoremediation and scientists are studying these animals to see whether the plants can harm them. Further research is also being undertaken to determine if these animals pose harm to the larger animals that eat them. In general, as long as the plants used for phytoremediation are not eaten, they are not harmful to people.

References:

A number of sources were used to compile this introduction to bioremediation and phytoremediation, including:
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