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Bioremediation : An Overview

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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.*

Background of bioremediation:

Natural Attenuation is not fast enough, not complete enough, not frequently occurring enough to be broadly used for some compounds, especially chlorinated solvents. The current trend is to stimulate/enhance a site's indigenous subsurface microorganisms by the addition of nutrients and electron donor. In some cases, bioaugmentation is necessary when metabolic capabilities are not naturally present.

Historical perspective:

In the year 1900, a biological process was used to treat organics derived from human or animal wastes. In the year 1950 approaches were used to treat the industrial wastes. In 1960 and 1970 approaches were used to synthesis chemicals in wastewaters and different methods were used to remove hydrocarbon contamination such as oil spills

While in the year 1990, natural attenuation of 70's and 90's and development of barrier approaches were made. Future work was done in the field of high-rate in situ bioremediation and bioaugmentation in the year 2000.

Principles of bioremediation:

Bioremediation is based on the idea that organisms are capable to take in things from the environment and use it to enhance their growth and metabolism. With this unique characteristic lay the fundamental principle of Bioremediation, to use microorganism to take in contaminated substances from the environment or convert it to a nontoxic form. Bacteria, Protista, and fungi are well known for degrading complex molecules and transform the product into part of their metabolism.

Process of bioremediation:

Bioremediation is a treatment process that uses microorganisms (yeast, fungi, or bacteria) to break down, or degrade, hazardous substances into less toxic or nontoxic substances. Microorganisms, just like humans, eat and digest organic substances for nutrients and energy. In chemical terms, "organic" compounds are those that contain carbon and hydrogen atoms. Certain microorganisms can digest organic substances such as fuels or solvents that are hazardous to humans. The microorganisms break down the organic contaminants into harmless products — mainly carbon dioxide and water.

Types of bioremediation:

The two main types of bioremediation are in situ bioremediation and ex situ bioremediation. In addition, another offshoot of bioremediation is phytoremediation

***In situ* bioremediation:**

In situ bioremediation is when the contaminated site is cleaned up exactly where it occurred.

It is the most commonly used type of bioremediation because it is the cheapest and most efficient, so it's generally better to use.

There are two main types of in situ bioremediation: intrinsic bioremediation and accelerated bioremediation.

Intrinsic bioremediation:

Intrinsic bioremediation uses microorganisms already present in the environment to biodegrade harmful contaminant.

There is no human intervention involved in this type of bioremediation, and since it is the cheapest means of bioremediation available, it is the most commonly used.

When intrinsic bioremediation isn't feasible, scientists turn next to accelerated bioremediation

Accelerated bioremediation:

In accelerated bioremediation, either substrate or nutrients are added to the environment to help break down the toxic spill by making the microorganisms grow more rapidly.

Usually the microorganisms are indigenous, but occasionally microorganisms that are very efficient at degrading a certain contaminant are additionally added.

Sources of contamination:

Biodegradative abilities of indigenous microorganisms
Presence of metals and other inorganic
Environmental parameters
Biodegradability of pollutants
Chemical solubility
Ex situ Bioremediation:

Ex situ bioremediation is when contaminated land are taken out of the area to be cleaned up by the organism.

This type of bioremediation is generally used only when the site is threatened for some reason, usually by the spill that needs to be cleaned up.

Ex situ bioremediation is only used when necessary because it's expensive and may damage the areas.

Sources of contamination:

Industrial spills and leaks

Surface impoundments

Storage tanks and pipes

Landfills

Burial areas and dumps

Injection wells

Scope of bioremediation in agriculture:

Bioremediation is also widely used in agriculture, for preparing soil and controlling livestock waste. It can effectively break down chlorinated pesticides, dioxin and ammoniated hydrocarbons. Bioremediation can purify ground water, clean the air, prevent the off-gassing of Volatile Organic Chemicals (VOCs), and even accelerate the half life of radioactive compounds.

The scope of environmental bioremediation extends to: Inorganics viz., Arsenic, Mercury, Chromium, Fluoride, Cyanide, abandoned mines, fly ash disposed sites, engineered phyto treatment technologies, biological permeable barriers; and Organics viz., petroleum hydrocarbons, pesticides and explosives. Quite a variety of plants, natural, transgenic, and/or associated with rhizosphere micro-organisms are extraordinarily active in these biological interventions and in cleaning up pollutants by removing or immobilizing them.

Plant physiology, agronomy, microbiology, hydrogeology, and engineering are combined to select the proper plant and conditions for a specific site. The specific mechanisms that are emphasized in an application depend on the mobility, solubility, degradability, and bioavailability of the contaminant(s) of concern.

Advantages of bioremediation:

Bioremediation is a natural process and is therefore perceived by the public as an acceptable waste treatment process for contaminated material such as soil. Microbes able to degrade the contaminant increase in numbers when the contaminant is present. The residues for the treatment are usually harmless products and include carbon dioxide, water, and cell biomass. Theoretically, bioremediation is useful for the complete destruction of a wide variety of contaminants. Many compounds that are legally considered to be hazardous can be transformed to harmless products.

Disadvantages of bioremediation:

Bioremediation is limited to those compounds that are biodegradable. Not all compounds are susceptible to rapid and complete degradation. There are some concerns that the products of biodegradation may be more persistent or toxic than the parent compound. Biological processes are often highly specific. Important site factors required for success include the presence of metabolically capable microbial populations, suitable environmental growth conditions, and appropriate levels of nutrients and contaminants

Practices for bioremediation:

Understand physical and chemical characteristics of the contaminants of interest

Understand the possible catabolic pathways of metabolism and the organisms that possess that capability

Understand the environmental conditions required to:

Promote growth of desirable organisms:

Provide for the expression of needed organisms

Engineer the environmental conditions needed to establish favorable conditions and contact organisms and contaminants

Strategies and challenges for bioremediation:

Microbial genetics or role of genetics

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.

Radioactive materials:

Inorganic pollutants which contaminate land and water bodies include heavy metals, metalloids fluoride and cyanide etc.

Arsenic:

Arsenic (As) is one of the most toxic elements present in soils and water. Arsenic contamination affects biological activities as a teratogen, carcinogen and mutagen as well as having detrimental effects on the immune system. The most common manifestations are skin melanosis and keratosis.

Mercury:

Contamination of mercury is reported to be widespread in India and that is toxic to the environment.

Chromium:

Chromium (Cr) is the chief heavy metal contaminant found in the tannery effluent. Cr is a toxic element to higher vascular plants and its detrimental to its growth, development and reproduction.

Biological permeable barriers:

Biosorption process removes heavy metals which can be quite toxic even at low concentrations. Biosorption is particularly suited as a polishing step whereby wastewater with a low to medium initial metal concentration from a few to about 100 ppm can be decontaminated. It offers high effluent quality and avoids the generation of toxic sludge.

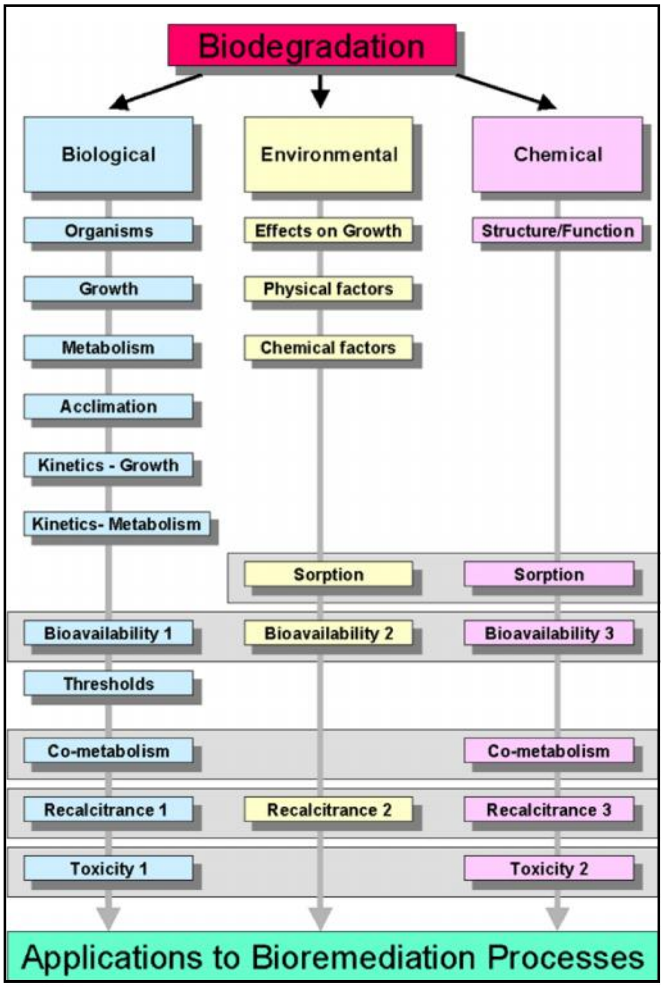
Future of bioremediation:

Companies and individuals are investing in biotechnology futures in spite of the high risks. As a result bioremediation companies have a viable future regardless of its long term effectiveness. Bioremediation is a new and promising technology in which the methods and effectiveness are continually being improved.

Yet…Bioremediation still remain a controversial issue. However, the regulatory obstacle to bioremediation is becoming fewer and fewer. As the field of biotechnology, is beginning to be more acceptable to the general public. The method of bioremediation is also expanding to new developments improvement takes its way to a brighter future.

Conclusion:

Bioremediation continuous to be the favoured approach for processing biological wastes and avoiding microbial pathogenesis. Its utilized microbes such as bacteria, yeast, algae and plants; microbes obtain energy when they degrade contaminant. Bioremediation is cost efficient and helps chemical and physical methods of managing wastes and environmental pollutants.



Bioremediation will play an increasingly important and a result of new and emerging techniques and processes.

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