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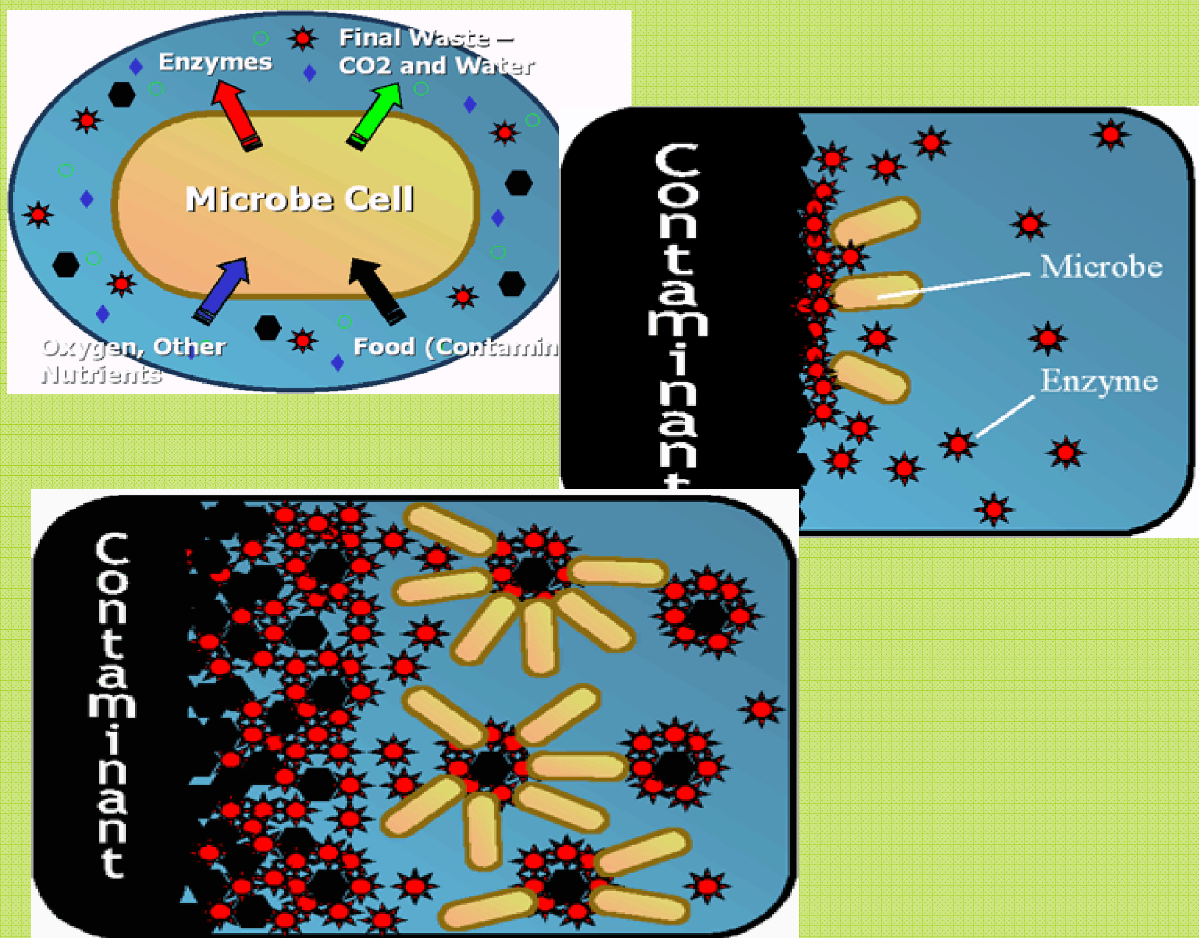
NEWS LETTER



BIOREMEDIATION:

A PRUDENT APPROACH IN ENVIRONMENTAL POLLUTION MANAGEMENT

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INSTRUCTIONS TO CONTRIBUTORS

ENVIS Newsletter on Environmental Biotechnology is a half-yearly publication publishes articles related to the thematic area of the ENVIS Centre. Popular or easily intelligible expositions of new or recent developments are welcome

Manuscripts should be typewritten (font should be Times New Roman and font size ought to be 12) on one side of the paper in double spacing with maximum of 6-8 typed pages

Figures and typed table should be in separate pages and provided with title and serial numbers. The exact position for the placement of the figures and tables should be marked in the manuscript.

Articles should be sent to

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EDITORIAL

The population explosion and industrial development in the world has resulted in an increase in the area of polluted soil and water. With advances in biotechnology, bioremediation has become one of the most rapidly developing fields of environmental restoration, utilizing microorganisms to reduce the concentration and toxicity of various chemical pollutants, such as petroleum hydrocarbons, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, phthalate esters, nitroaromatic compounds, industrial solvents, pesticides and metals. A number of bioremediation strategies have been developed to treat contaminated wastes and sites. Environmental biotechnology employs the application of genetic engineering to improve efficiency and cost, which are central to the future of widespread exploitation of microorganisms to reduce the environmental burden of toxic substances.

Thus in Volume-17, we have discussed on the different approaches of bioremediation in the field of environmental pollution management. Further we appreciate the views of the reader /user groups about this newsletter. We also invite relevant articles, news, events on this topic for publication in newsletter in future

(S. C. Santra)

IN THIS ISSUE:

Bioremediation: A Prudent Approach in Environmental Pollution Management

WHAT IS BIOREMEDIATION?

Bioremediation is the intentional use of biological degradation procedures to remove or reduce the concentration of environmental pollutants from sites where they have been released. The concentrations of pollutants are reduced to levels considered acceptable to site owners and/or regulatory agencies. A bioremediation project or program should consider many aspects of the site, the contamination, the microorganisms, the environment, the goals and regulatory limits on contaminants set by the appropriate agencies (MoEE, EPA, etc.) and features that would impact on the successful outcome of the project.

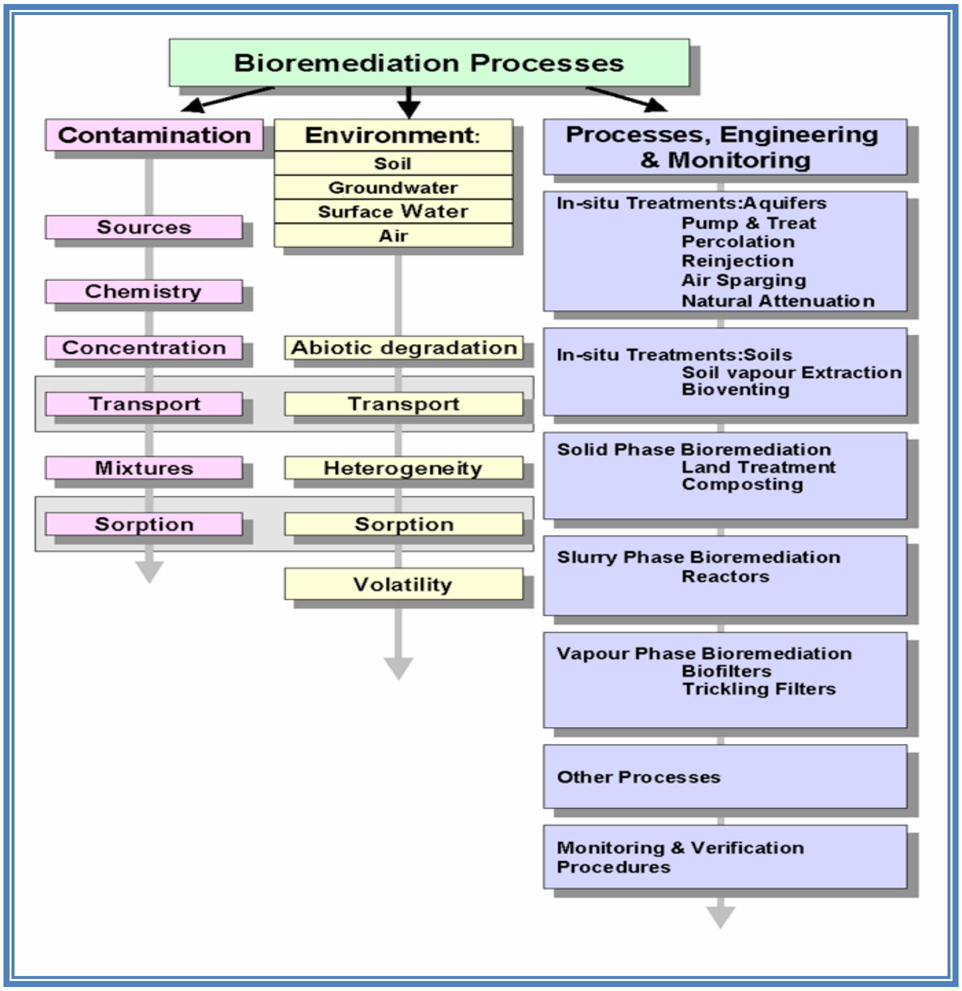

Fig.1. Overview of Bioremediation Process

PRINCIPLES OF BIOREMEDIATION

1. Environmental biotechnology is not a new field; composting and wastewater treatments are familiar examples of old environmental biotechnologies. However, recent studies in molecular biology and ecology offer opportunities for more efficient biological processes. Notable accomplishments of these studies include the clean-up of polluted water and land areas.

2. By definition, bioremediation is the use of living organisms, primarily microorganisms, to degrade the environmental contaminants into less toxic forms. It uses naturally occurring bacteria and fungi or plants to degrade or detoxify substances hazardous to human health and/or the environment. The microorganisms may be indigenous to a contaminated area or they may be isolated from elsewhere and brought to the contaminated site. Contaminant compounds are transformed by living organisms through reactions that take place as a part of their metabolic processes. Biodegradation of a compound is often a result of the actions of multiple organisms. When microorganisms are imported to a contaminated site to enhance degradation we have a process known as bioaugmentation.

3. For bioremediation to be effective, microorganisms must enzymatically attack the pollutants and convert them to harmless products. As bioremediation can be effective only where environmental conditions permit microbial growth and activity, its application often involves the manipulation of environmental parameters to allow microbial growth and degradation to proceed at a faster rate.

4. Like other technologies, bioremediation has its limitations. Some contaminants, such as chlorinated organic or high aromatic hydrocarbons, are resistant to microbial attack. They are degraded either slowly or not at all, hence it is not easy to predict the rates of clean-up for a bioremediation exercise; there are no rules to predict if a contaminant can be degraded. Bioremediation techniques are typically more economical than traditional methods such as incineration, and some pollutants can be treated on site, thus reducing exposure risks for clean-up personnel, or potentially wider exposure as a result of transportation accidents. Since bioremediation is based on natural attenuation the public considers it more acceptable than other technologies.

Factors of Bioremediation

Microbial Populations for Bioremediation Processes

Microorganisms can be isolated from almost any environmental conditions. Microbes will adapt and grow at subzero temperatures, as well as extreme heat, desert conditions, in water, with an excess of oxygen, and in anaerobic conditions, with the presence of hazardous compounds or on any waste stream. We can subdivide these microorganisms into the following groups:

- ***Aerobic*.** In the presence of oxygen. Examples of aerobic bacteria recognized for their degradative abilities are *Pseudomonas*, *Alcaligenes*, *Sphingomonas*, *Rhodococcus*, and *Mycobacterium*. These microbes have often been reported to degrade pesticides and hydrocarbons, both alkanes and polyaromatic compounds. Many of these bacteria use the contaminant as the sole source of carbon and energy.

- ***Anaerobic.*** In the absence of oxygen. Anaerobic bacteria are not as frequently used as aerobic bacteria. There is an increasing interest in anaerobic bacteria used for bioremediation of polychlorinated biphenyls (PCBs) in river sediments, dechlorination of the solvent trichloroethylene (TCE), and chloroform.
- ***Ligninolytic fungi.*** Fungi such as the white rot fungus *Phanaerochaete chrysosporium* have the ability to degrade an extremely diverse range of persistent or toxic environmental pollutants. Common substrates used include straw, saw dust, or corn cobs.
- ***Methylotrophs.*** Aerobic bacteria that grow utilizing methane for carbon and energy. The initial enzyme in the pathway for aerobic degradation, methane monooxygenase, has a broad substrate range and is active against a wide range of compounds, including the chlorinated aliphatics trichloroethylene and 1,2-dichloroethane.

Environmental Factors

Nutrients

Although the microorganisms are present in contaminated soil, they cannot necessarily be there in the numbers required for bioremediation of the site. Their growth and activity must be stimulated. Biostimulation usually involves the addition of nutrients and oxygen to help indigenous microorganisms. These nutrients are the basic building blocks of life and allow microbes to create the necessary enzymes to break down the contaminants.

Carbon is the most basic element of living forms and is needed in greater quantities than other elements. In addition to hydrogen, oxygen, and nitrogen it constitutes about 95% of the weight of cells. Phosphorous and sulfur contribute with 70% of the remainders. The nutritional requirement of carbon to nitrogen ratio is 10:1, and carbon to phosphorous is 30:1.

Table 1. Composition of microbial cell

Element	Percentage	Element	Percentage
Carbon	50	Sodium	1
Nitrogen	14	Calcium	0,5
Oxygen	20	Magnesium	0,5
Hydrogen	8	Chloride	0,5
Phosphorous	3	Iron	0,2
Sulfur	1	All others	0,3
Potassium	1		

From R. Y. Stainer *et al*. The Microbial World, 5th ed., Prentice-Hall, NJ (1986).

Environmental Requirements

The control and optimization of bioremediation processes is a complex system of many factors. These factors include: the existence of a microbial population capable of degrading the pollutants; the availability of contaminants to the microbial population; the environment factors (type of soil, temperature, pH, the presence of oxygen or other electron acceptors, and nutrients)

Table 2. Environmental condition affecting degradation

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Parameters	Condition required for microbial activity	Optimum value for an oil degradation
Soil moisture	25–28% of water holding capacity	30–90%
Soil pH	5.5–8.8	6.5–8.0
Oxygen content	Aerobic, minimum air-filled pore space of 10%	10–40%
Nutrient content	N and p for microbial growth	C:N:P = 100:10:1
Temperature (°C)	15–45	20–30
Contaminants	Not too toxic	Hydrocarbon 5–10% of dry weight of soil
Heavy metals	Total content 2000 ppm	700 ppm
Type of soil	Low clay or silt content	

- **pH-** Microbial growth and activity are readily affected by pH, temperature, and moisture. Although microorganisms have been also isolated in extreme conditions, most of them grow optimally over a narrow range, so that it is important to achieve optimal conditions.If the soil has too much acid it is possible to rinse the pH by adding lime.
- **Temperature-** Temperature affects biochemical reactions rates, and the rates of many of them double for each 10 °C rise in temperature. Above a certain temperature, however, the cells die. Plastic covering can be used to enhance solar warming in late spring, summer, and autumn.
- **Available water-** Available water is essential for all the living organisms,and irrigation is needed to achieve the optimal moisture level.
- **Oxygen content-** The amount of available oxygen will determine whether the system is aerobic or anaerobic. Hydrocarbons are readily degraded under aerobic conditions, whereas chlorurate compounds are degraded only in anaerobic ones. To increase the oxygen amount in the soil it is possible to till or sparge air. In some cases, hydrogen peroxide or magnesium peroxide can be introduced in the environment.
- **Soil type-** Soil structure controls the effective delivery of air, water, and nutrients. To improve soil structure, materials such as gypsum or organic matter can be applied. Low soil permeability can impede movement of water, nutrients, and oxygen; hence, soils with low permeability may not be appropriate for *in situ* clean-up techniques.

Bioremediation Strategies

The possible types of bioremediation activities fall into two main categories: **ex-situ and in-situ.** In-situ bioremediation occurs in the soil, groundwater or other environment without removal of the contaminated material. In contrast, ex-situ bioremediation entails the removal of all or part of the contaminated material for treatment.

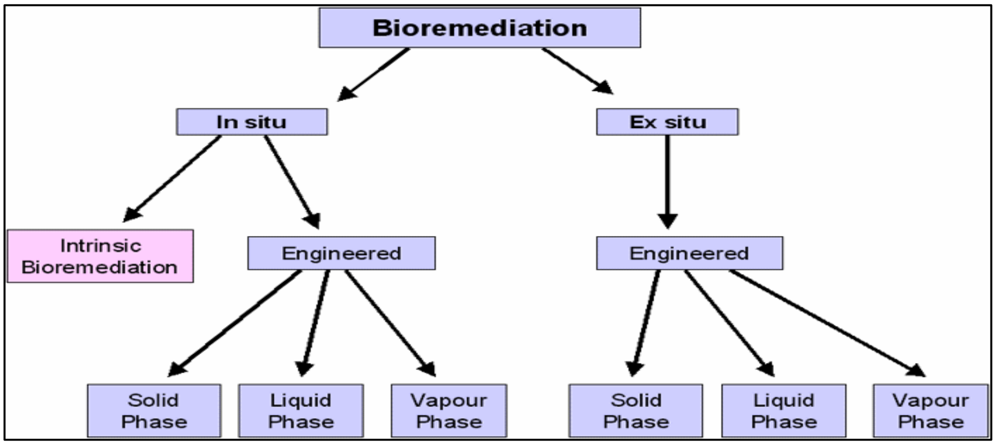


Fig 2. Different types of bioremediation activities

A. In-situ Bioremediation

In situ bioremediation means there is no need to excavate or remove soils or water in order to accomplish remediation. Most often, in situ bioremediation is applied to the degradation of contaminants in saturated soils and groundwater. It is a superior method to cleaning contaminated environments since it is cheaper and uses harmless microbial organisms to degrade the chemicals. Chemotaxis is important to the study of in-situ bioremediation because microbial organisms with chemotactic abilities can move into an area containing contaminants. So by enhancing the cells' chemotactic abilities, in-situ bioremediation will become a safer method in degrading harmful compounds.

Intrinsic bioremediation: This approach deals with stimulation of indigenous or naturally occurring microbial populations by feeding them nutrients and oxygen to increase their metabolic activity.

Engineered in situ bioremediation: The second approach involves the introduction of certain microorgansims to the site of contamination. When site conditions are not suitable, engineered systems have to be introduced to that particular site. *Engineered in situ* bioremediation accelerates the degradation process by enhancing the physico-chemical conditions to encourage the growth of microorganisms. Oxygen, electron acceptors and nutrients (eg: nitrogen and phosphorus) promote microbial growth.

The most important In-situ bioremediation treatments are:

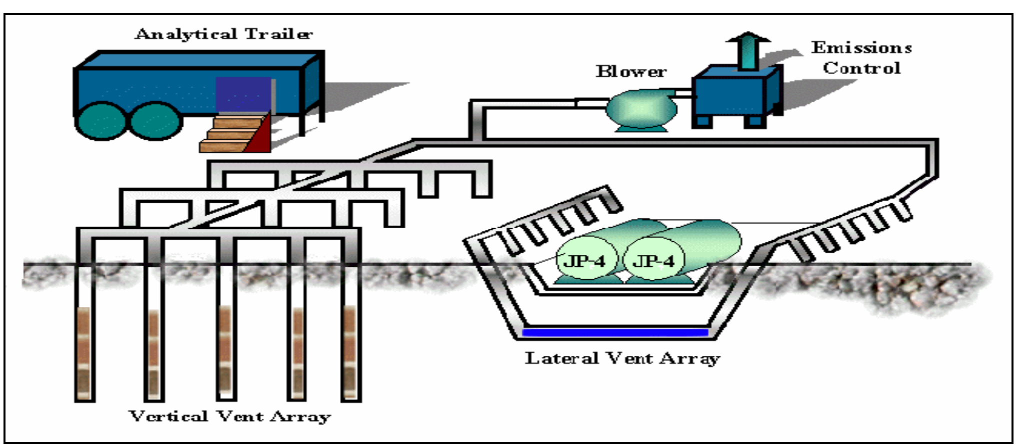


Fig.3. Typical Bioventig system

Bioventing-

It is the most common *in situ* treatment and involves supplying air and nutrients through wells to contaminated soil to stimulate the indigenous bacteria. Bioventing employs low air flow rates and provides only the amount of oxygen necessary for the biodegradation while minimizing volatilization and release of contaminants to the atmosphere. It works for simple hydrocarbons and can be used where the contamination is deep under the surface.

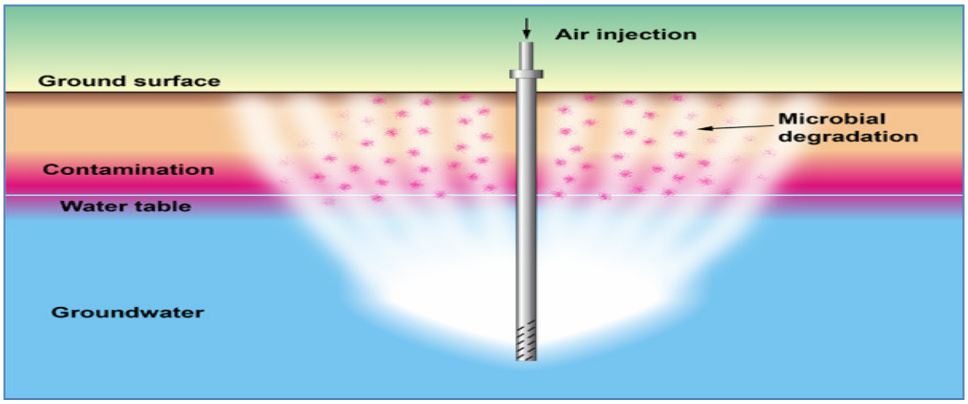


Fig 4 Biosparging enhances the microbial

Biosparging-

It involves the injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria. Biosparging increases the mixing in the saturated zone and thereby increases the contact between soil and groundwater. The ease and low cost of installing small-diameter air injection points allows considerable flexibility in the design and construction of the system.

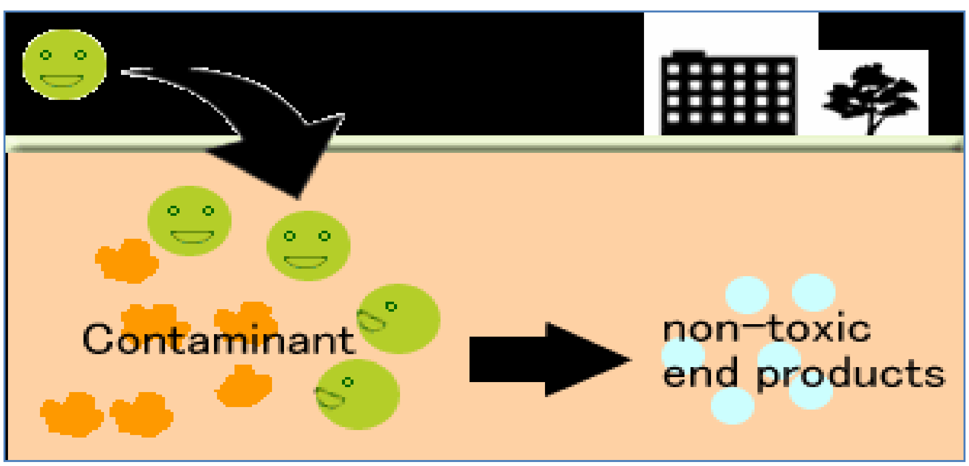


Fig 5. Bioaugmentation

Bioaugmentation-

Bioaugmentation is a technique that is mainly used in the saturated zone of the soil. For the introduction of the bacteria, it is imperative that permeable soil layers are present. The bacteria are added to the soil when it is demonstrated that the needed bacteria are not present at the contaminated site. The range of influence of the added bacteria depends on the infiltration technology, and on the bacteria. They might stick to the infiltration well, or do they have the tendency to migrate away from the infiltration well. Providing pre-grown micro organisms to a contaminated site that can degrade the contaminants to augment naturally occurring micro organisms is called **bioaugmentation**. This can be performed under both aerobic and anaerobic conditions. The addition of nutrients, electron acceptors, or electron donors might also be necessary.

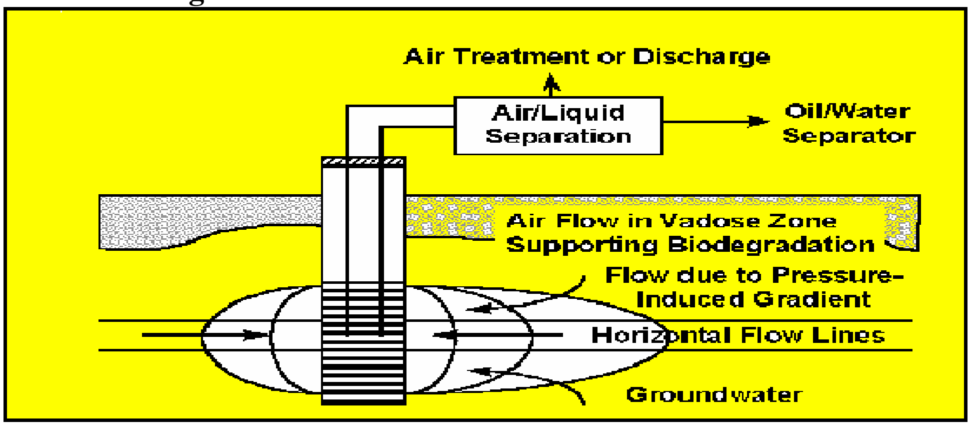


Fig 6 Typical In Situ Bioslurping System

- **Bioslurping-** It is a unique *in situ* treatment technique in that it also treats free product phases floating on top of the groundwater. This technique applies a vacuum to extract soil vapor, water, and free product from the subsurface. Each of those substances is then separated and properly disposed of.
- **Passive Treatments-** Passive techniques include **Activated zones, Bioscreens, Reactive walls and Reactive trenchs.** These techniques can be used when removing contaminants from non-homogenous soils. These techniques are attractive because they have high longevity, no significant maintenance, and no nutrient replenishment.

B.Ex-situ Bioremediation

Ex Situ Bioremediation processes require excavation of contaminated soil or pumping of groundwater to facilitate microbial degradation. Depending on the state of the contaminant to be removed, **ex situ** bioremediation is classified as;

- **Solid phase system (including Land farming, Composting, Biopiling)**
- **Slurry phase systems (including solid-liquid suspensions in Bioreactors)**

Solid phase system

The most important ex-situ bioremediation treatments under solid phase system are: Land farming, Composting, Biopiling

Fig 7.Typical land farming treatment unit

Land farming- It is a simple technique in which contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are degraded. The goal is to stimulate indigenous biodegradative microorganisms and facilitate their aerobic degradation of contaminants. In general, the practice is limited to the treatment of superficial 10–35 cm of soil. Since landfarming has the potential to reduce monitoring and maintenance costs, as well as clean-up liabilities, it has received much attention as a disposal alternative.

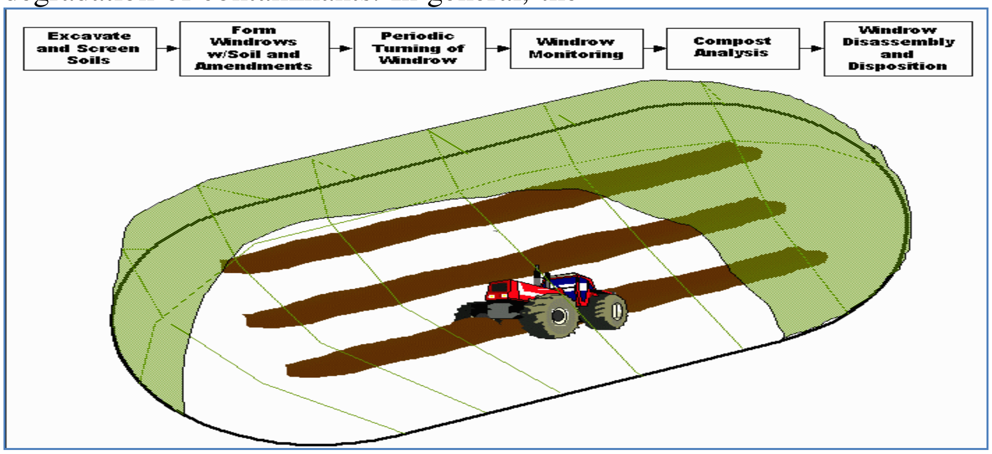


Fig 8.Typical Windrow Composting Process

Composting- is a technique that involves combining contaminated soil with nonhazardous organic amendants such as manure or agricultural wastes. The presence of these organic materials supports the development of a rich microbial population and elevated temperature characteristic of composting.

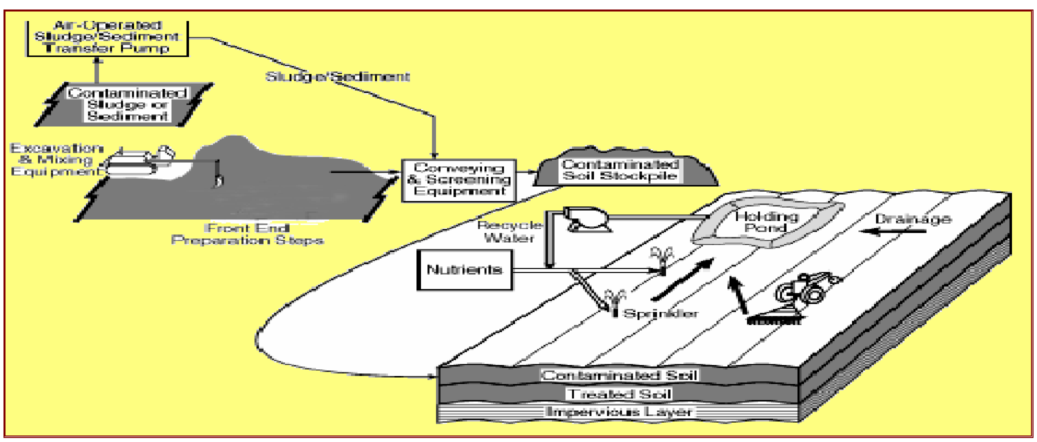
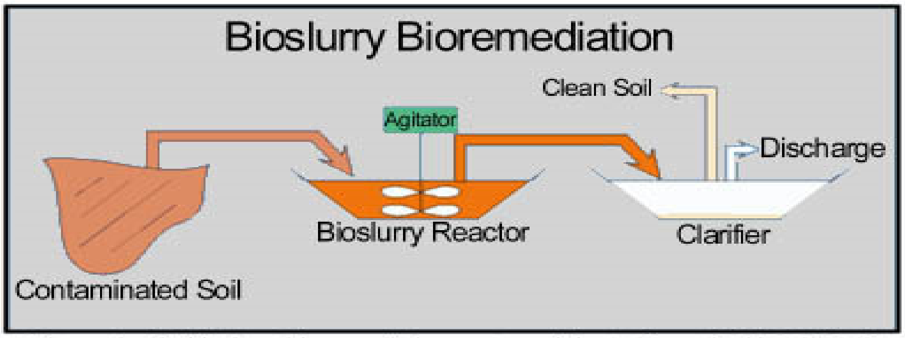


Fig 9.Typical biopile for solid phase bioremediation

Biopiling- It is a hybrid of landfarming and composting. Essentially, engineered cells are constructed as aerated composted piles. Typically used for treatment of surface contamination with petroleum hydrocarbons they are a refined version of landfarming that tend to control physical losses of the contaminants by leaching and volatilization. Biopiles provide a favorable environment for indigenous aerobic and anaerobic microorganisms.

Slurry phase systems

Slurry phase bioremediation is a relatively more rapid process compared to the other treatment processes. It consists of solid-liquid suspensions in Bioreactors.

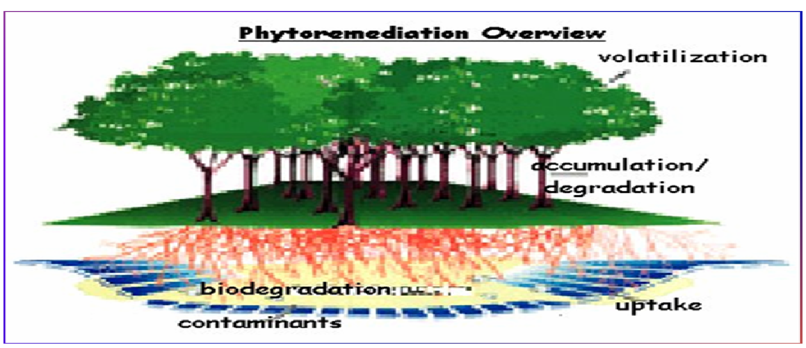


Schematic of a bioslurry bioremediation system. Adapted from the U.S. EPA (8).

Fig 10.Typical Bioreactor process

Bioreactors- Bioremediation in reactors involves the processing of contaminated solid material (soil, sediment, sludge) or water through an engineered containment system. A slurry bioreactor may be defined as a containment vessel and apparatus used to create a three-phase (solid, liquid, and gas) mixing condition to increase the bioremediation rate of soil bound and water-soluble pollutants as a water slurry of the contaminated soil and biomass (usually indigenous microorganisms) capable of degrading target contaminants. In general, the rate and extent of biodegradation are greater in a bioreactor system than *in situ* or in solid-phase systems because the contained environment is more manageable and hence more controllable and predictable. Despite the advantages of reactor systems, there are some disadvantages. The contaminated soil requires pre treatment (e.g., excavation) or alternatively the contaminant can be stripped from the soil via soil washing or physical extraction (e.g., vacuum extraction) before being placed in a bioreactor.

PHYTOREMEDIATION



Phytoremediation-Vegetation- based remediation shows potential for accumulating, immobilizing, and transforming a low level of persistent contaminants. In natural ecosystems, plants act as filters and metabolize substances generated by nature. Phytoremediation is an emerging technology that uses plants to remove contaminants from soil and water. We can find five types of phytoremediation techniques, classified based on the contaminant fate: **phytoextraction, phytotransformation, phytostabilization, phytodegradation, rhizofiltration,** even if a combination of these can be found in nature

1. Phytoextraction- *Phytoextraction* or *phytoaccumulation* is the process used by the plants to accumulate contaminants into the roots and aboveground shoots or leaves. This technique saves tremendous remediation cost by accumulating low levels of contaminants from a widespread area. Unlike the degradation mechanisms, this process produces a mass of plants and contaminants (usually metals) that can be transported for disposal or recycling.

2.Phytotransformation- *Phytotransformation* or *phytodegradation* refers to the uptake of organic contaminants from soil, sediments, or water and, subsequently, their transformation to more stable, less toxic, or less mobile form. Metal chromium can be reduced from hexavalent to trivalent chromium, which is a less mobile and non carcinogenic form.

3. Phytostabilization- *Phytostabilization* is a technique in which plants reduce the mobility and migration of contaminated soil. Leachable constituents are adsorbed and bound into the plant structure so that they form a stable mass of plant from which the contaminants will not reenter the environment.

4.Phytodegradation- *Phytodegradation* or *rhizodegradation* is the breakdown of contaminants through the activity existing in the rhizosphere. This activity is due to the presence of proteins and enzymes produced by the plants or by soil organisms such as bacteria, yeast, and fungi. Rhizodegradation is a symbiotic relationship that has evolved between plants and microbes. Plants provide nutrients necessary for the microbes to thrive, while microbes provide a healthier soil environment.

5.Rhizofiltration- *Rhizofiltration* is a water remediation technique that involves the uptake of contaminants by plant roots. Rhizofiltration is used to reduce contamination in natural wetlands and estuary areas.

Limitations of phytoremediation technology-

Phytoremediation is well suited for use at very large field sites where other methods of remediation are not cost effective or practicable; at sites with a low concentration of contaminants where only polish treatment is required over long periods of time; and in conjunction with other technologies where vegetation is used as a final cap and closure of the site. There are some limitations to the technology that it is necessary to consider carefully before it is selected for site remediation: long duration of time for remediation, potential contamination of the vegetation and food chain, and difficulty establishing and maintaining vegetation at some sites with high toxic levels.

GENETICALLY MODIFIED MICROORGANISMS (GEMS) AND BIOREMEDIATION

Bioremediation of environmental contaminants using genetically engineered organisms (GEMs) holds tremendous potential.

GEM for detecting PAHs in the soil- One of the areas, where genetically engineered organisms have been used and are likely to be used include biodegradation of polyaromatic hydrocarbons (PAHs) in soil. These PAHs include naphthalene, Phenanthrene, and anthracene, whose occurrence in the soil is due to spills or leakage of fossil fuels or petroleum products, in USA, Pseudomonas fluorescens isolated from PAH contaminated soils, was genetically engineered with lux genes from *Vibrio fischeri*, a bacterium that lives in the light generating organisms of certain deep sea fish. The lux gene was fused with a promoter normally associated with the naphthalene degradation pathway. These lux genes do not need any independent substrate for light production. The modified strain, *P. fluorescens* HK44 responds to napththalene by luminescence, which can be detected with the help of light sensing probes. This will allow the detection of PAHs in the contaminated soils, so that the biodegradations can now be optimized by altering moisture content and level of different gases in the soil

GEM for treating oil spill-The first genetically engineered organism for bioremediation was a pseudomonas, which was capable of degrading 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). The strain contained two plasmids, each providing a separate hydrogen degradative pathway, and therefore was claimed to be effective in treating oil spills. Several other microbes have been developed through genetic engineering for treatment of oil spills.

GEM for sequestering heavy metals- A new approach for bioremediation that was suggested recently, involved engineering of microorganisms to enhance their ability of sequester heavy metals in the soil. In this approach, the toxic metal within the soil remains bound to the GEM, so that it is less likely to be taken up either by the underground part (roots) of the terrestrial plants, or by other plants or animals living in the soil. The enhanced ability to sequester heavy metals (e.g. cadmium) was achieved by transfer of a mouse gene, encoding metallothionein a Ralstonia eutropha (a natural inhabitant of soil).

ADVANTAGES OF BIOREMEDIATION

1.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; when the contaminant is degraded, the biodegradative population declines. The residues for the treatment are usually harmless products and include carbon dioxide, water, and cell biomass.

2.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. This eliminates the chance of future liability associated with treatment and disposal of contaminated material.

3.Instead of transferring contaminants from one environmental medium to another, for example,from land to water or air, the complete destruction of target pollutants is possible.

4.Bioremediation can often be carried out on site, often without causing a major disruption of normal activities. This also eliminates the need to transport quantities of waste off site and the potential threats to human health and the environment that can arise during transportation.

5.Bioremediation can prove less expensive than other technologies that are used for clean-up of hazardous waste.

DISADVANTAGES OF BIOREMEDIATION

1 Bioremediation is limited to those compounds that are biodegradable. Not all compounds are susceptible to rapid and complete degradation.

2. There are some concerns that the products of biodegradation may be more persistent or toxic than the parent compound.

3. 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.
4. It is difficult to extrapolate from bench and pilot-scale studies to full-scale field operations.
5. Research is needed to develop and engineer bioremediation technologies that are appropriate for sites with complex mixtures of contaminants that are not evenly dispersed in the environment. Contaminants may be present as solids, liquids, and gases.
6. Bioremediation often takes longer than other treatment options, such as excavation and removal of soil or incineration.
7. Regulatory uncertainty remains regarding acceptable performance criteria for bioremediation. There is no accepted definition of "clean", evaluating performance of bioremediation is difficult, and there are no acceptable endpoints for bioremediation treatment.

Conclusion

Despite its short-comings, its pertinence in this world is unquestionable in the light of present day environmental hazards. Bioremediation provides a technique for cleaning up pollution by enhancing the same biodegradation processes that occur in nature. So by developing an understanding of microbial communities and their response to the natural environment and pollutants, expanding the knowledge of the genetics of the microbes to increase capabilities to degrade pollutants, conducting field studies of new bioremediation techniques which are cost effective, and dedicating sites which are set aside for long term research purpose, these opportunities offer potential for significant advances. There is no doubt that bioremediation is in the process of paving a way to greener pastures!

CURRENT EVENTS

Bacteria Chew Up Atrazine : Engineered *E. coli* seek and destroy herbicide-

Chemists at Emory University have reprogrammed bacteria to seek and degrade the herbicide atrazine. Such bacteria could prove useful for bioremediation of atrazine, which is toxic to animals and possibly humans as well. They engineer *Escherichia coli* to produce RNA molecules called riboswitches that change conformation when they bind atrazine. The switching activates the translation of a protein called CheZ that allows the bacteria to move and chase atrazine in their surroundings. The usual way to find riboswitches is to start with an RNA that tightly binds the target. Researchers screened a library of RNAs with moderate affinity for atrazine to find the best riboswitch. The team also rewired the bacteria to produce an enzyme that converts atrazine to hydroxyatrazine, which does not act as an herbicide and is not as toxic. [*Source: Nat Chem Biol. 2010 Jun, 6(6), 464-70]*

Production of Chemicals from Wood Waste Made More Environmentally-Friendly and Cheaper

Researchers from Delft University of Technology in the Netherlands have succeeded in making a significant leap forward in the production of biochemicals and biofuels from waste wood. They discovered that the bacterium *Cupriavidus basilensis* breaks down harmful by-products which are produced when sugars are released from wood. They also managed to incorporate the degradation process in bacteria which are in common industrial use. Bacterium *Cupriavidus basilensis* is capable of breaking furans down into harmless waste products, while leaving the wood sugars untouched. They unlocked the secrets of the entire degradation process in the bacterium, identifying the genes and enzymes involved. [Source: 2nd March, 2010, Proceedings *of the National Academy of Sciences*, USA (*PNAS*)]

Pickle Spoilage Bacteria May Help Environment

Spoilage bacteria that can cause red coloration of pickles' skin during fermentation may actually help clean up dyes in textile industry wastewater, according to a U.S. Department of Agriculture (USDA) study. Some species of Lactobacilli-food-related microorganisms-can cause red coloring when combined with tartrazine, a yellow food-coloring agent used in the manufacture of dill pickles. Agricultural Research Service (ARS) microbiologist Ilenys Pérez-Díaz and her colleagues have found that these spoilage Lactobacilli also may have environmental benefits. They noted that several Lactobacilli modify azo dyes, which are used in the textile industry and may wind up in wastewater if untreated. Though many azo dyes are nontoxic, some have been found to be mutagenic. This is the first report that food-related microorganisms can transform azo dyes into non-mutagenic substances. *[Source: ScienceDaily, September, 17, 2010]*

Metal-Mining Bacteria Are Green Chemists

Microbes could soon be used to convert metallic wastes into high-value catalysts for generating clean energy, Researchers from the School of Biosciences at the University of Birmingham have discovered the mechanisms that allow the common soil bacterium *Desulfovibrio desulfuricans* to recover the precious metal palladium from industrial waste sources. Hydrogenase enzymes located on the surface membrane of the bacterium carry out the reduction of palladium, which results in the accumulation of catalytic nanoparticles. The bacterial cells coated with palladium nanoparticles are known as 'BioPd." The group believes that BioPd has great potential to be used for generating clean energy. [Source: *Microbiology*, September, 2010; 156: 2630-2640

Researchers Train Bacteria to Convert Bio-Wastes Into Plastic

Researcher Jean-Paul Meijnen has 'trained' bacteria to convert all the main sugars in vegetable, fruit and garden waste efficiently into high-quality environmentally friendly products such as bioplastics. By adapting the eating pattern of bacteria and subsequently training them, Meijnen has succeeded in converting sugars in processable materials, so that no bio-waste is wasted. Hydrolysis of lignocellulose breaks down the long sugar chains that form the backbone of this material, releasing the individual sugar molecules. These sugar molecules can be further processed by bacteria and other micro-organisms to form chemicals that can be used as the basis for bioplastics. .(Source : Science Daily, 21 November, 2010)

FORTHCOMING EVENTS		
Microbes in Wastewater & Waste Treatment, Bioremediation and Energy Production	January 24 – 27, 2011	BITS – Pilani, Goa campus, Goa, India. E mail: mwt2011@bits-goa.ac.in
International Conference on "Biotechnology for Better Tomorrow " (BTBT-20)	February 6-9, 2011	Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra, India Websites: www.btbt2011.in and www.bamu.net
OMICS Publishing Group's Worlds Congress on Biotechnology: Hyderabad, India	March 21-23, 2011	Hyderabad International Convention Centre Website:http://www.omicsonline.org/biotechnology2011/ E-mail:biotechnology2011@omicsonline.org, www.omicsonline.org
Bioremediation And Sustainable Environmental Technologies	June 27-30, 2011	Reno, Nevada e-mail: biosymp@battelle.org Website: http://www.battelle.org/conferences/bioremediation/index.aspx

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