A study of Bioremediation and its advantages or disadvantages

Namrata Arya

SOBAS, Sanskriti University, Mathura, Uttar Pradesh, India

Email Id- namrata.sobas@sanskriti.edu.in

ABSTRACT: Bioremediation is a cutting-edge method that uses natural biological processes to entirely remove harmful pollutants from the environment. Any method that involves the utilization of microbes, fungus, green plants, or their enzymes to restore the natural environment after it has been contaminated. In situ and ex situ bioremediation methods are the two types of bioremediation technologies. Ex situ bioremediation includes removing contaminated material from the site to be treated elsewhere, whereas in situ bioremediation involves treating the polluted material on-site. Bioventing, bioreactor, landfarming, composting, and bio-stimulation are some examples of bioremediation technology. Bio remediators are microorganisms that fulfil the function of bioremediation. However, not all pollutants are easily removed by microorganisms in bioremediation. Heavy metals like cadmium and lead, for example, are not easily ingested or caught by organisms. Metals like mercury may be assimilated into the food chain, exacerbating the problem. This article explains what bioremediation is, the principles of bioremediation, the factors of bioremediation, methods, kinds, genetic engineering techniques, bioremediation monitoring, & bioremediation advantages as well as drawbacks.

KEYWORDS: Bioremediation, Environment, Ex Situ, In Situ, Microorganisms.

1. INTRODUCTION

The total condition of the environment is closely related to the quality of life on Earth. We used to assume that we had an endless supply of land and resources; today, however, the world's resources reflect our carelessness and ignorance in exploiting them to varying degrees. In many nations, the concerns connected with polluted sites are becoming more prominent. Contaminated areas are typically the result of historical industrial operations when the health and environmental consequences of hazardous material manufacturing, usage, and disposal were less well understood than they are now. Contaminated land is now widely recognized as a potential threat to human health, as well as the continued discovery of contaminated land in recent years has prompted international efforts to remediate many of these sites, either in response to the risk of adverse health or environmental effects caused by contamination, or to enable the site to be redeveloped for use. Traditional remediation methods included digging up contaminated soil and transporting it to a landfill, or capping and containing polluted parts of a site[1]. There are several disadvantages to the approaches. The first technique merely relocates the pollution and may pose substantial dangers in hazardous material extraction, handling, and transportation. Furthermore, finding new landfill sites for eventual disposal of the waste is becoming increasingly difficult as well as expensive. Bioremediation is an option that offers the possibility to destroy or render harmless various contaminants using natural biological activity. Because bioremediation appears to be a viable alternative to traditional clean-up technologies, research in this subject is quickly expanding, particularly in the United States. Bioremediation has been utilised with different degrees of effectiveness in a variety of locations across the world, including Europe. As more information and experience is gathered, techniques are improving, and there is little question that bioremediation offers a lot of potential for dealing with specific forms of site pollution. Unfortunately, bioremediation's concepts, procedures, benefits, and drawbacks are not well recognized or understood, particularly among those who will have to actually deal with bioremediation proposals. We hoped to help by offering a clear, practical picture of the processes involved in bioremediation, the benefits and drawbacks of the technology, and the problems to consider when dealing with a bioremediation proposal[2]. In Figure 1, types of bioremediation are illustrated.

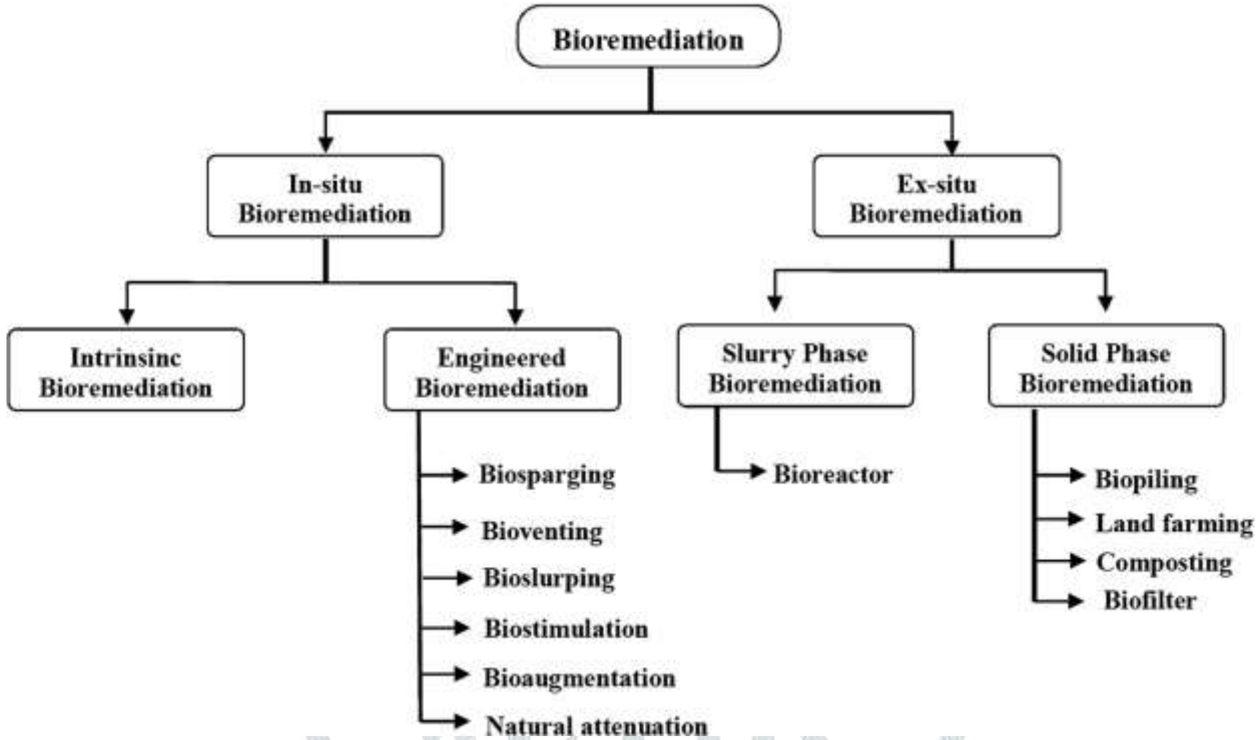

Figure 1: Illustrating the Types of Bioremediation (In-Situ and Ex Situ)

1.1.Bioremediation Principles:

Composting or wastewater treatment are two well-known examples of ancient environmental biotechnologies. Recent research in molecular biology and ecology, on the other hand, suggests that biological processes may be made more efficient. The cleanup of contaminated water and land regions is one of these studies' notable successes. Bioremediation is the process of biologically degrading organic wastes under controlled circumstances to a benign state or levels below regulatory concentration limits.

Bioremediation is the process of degrading environmental pollutants into less harmful forms using living creatures, mainly bacteria. It degrades or detoxifies chemicals that are harmful to human health or the environment using naturally occurring bacteria, fungus, or plants. The microorganisms might be native to the polluted region, or they could have been isolated elsewhere and transported to the contaminated site. Living organisms change contaminant chemicals through reactions that occur as part of their metabolic activities. The activities of numerous organisms often result in the biodegradation of a chemical[3].

Microorganisms must enzymatically attack contaminants and transform them to harmless compounds for bioremediation to be successful. Because bioremediation is only successful when environmental circumstances allow for microbial growth and activity, it is frequently used to manipulate environmental factors to speed up microbial growth and degradation.

1.2.Bioremediation Factors:

Controlling and optimizing bioremediation processes is a complicated system involving many variables. The presence of a microbial population capable of degrading pollutants; the availability of contaminants to the microbial population; and environmental variables are among these considerations (type of soil, temperature, pH, the presence of oxygen and other electron acceptors, and nutrients).

1.2.1. For Bioremediation Processes, Microbial Populations: Microorganisms may be isolated from nearly any type of environment. Microbes adapt and flourish at subzero temperatures, high heat, desert conditions, water, with an abundance of oxygen, including anaerobic circumstances, with the presence of dangerous chemicals, or on any waste stream. An energy source and a carbon supply are the two most important necessities[4].

1.2.2. Aerobic: When there is oxygen present. Pseudomonas, Alcaligenes, Sphingomonas, Rhodococcus, as well as Mycobacterium are examples of aerobic bacteria known for their degradative ability. Pesticides and hydrocarbons, including alkanes and polyaromatic chemicals, have been found to be degraded by these microorganisms on several occasions. Many of these bacteria rely only on the pollutant for carbon or energy.

1.2.3. Anaerobic: When there isn't any oxygen available. Anaerobic bacteria are less common than aerobic bacteria. The use of anaerobic bacteria for bioremediation of polychlorinated biphenyls (PCBs) in river sediments, as well as dichlorination of the solvent trichloroethylene (TCE) as well as chloroform, is gaining popularity[5].

1.3.Bioremediation Techniques:

Depending on the degree of saturation and aeration of a region, several approaches are used. The term "in situ" refers to procedures that are applied to soil and groundwater on-site with minimum disturbance. Ex situ procedures are those that are used on soil as well as groundwater that has been evacuated from a location by excavation (soil) and pumping (groundwater) (water). Microorganisms with the capacity to breakdown contaminants are added to bioaugmentation procedures.

1.3.1. Bioremediation in situ:

These procedures are the most popular since they are less expensive and cause less disruption because they treat pollutants in site rather than excavating and transporting them. The depth of soil that can be efficiently treated limits in situ treatment. Effective oxygen diffusion for optimal bioremediation rates in many soils extends just a few centimeters to approximately 30 cm into the soil, while depths of 60 cm and higher have been successfully treated in other situations. The following are the most essential land treatments.

The most popular in situ therapy is bioventing, which includes delivering air and nutrients to polluted soil via wells in order to encourage the indigenous microorganisms. Bioventing uses low air flow rates and only delivers the quantity of oxygen required for biodegradation, reducing volatilization and pollutant release into the atmosphere. It is effective for simple hydrocarbons and can be utilized if pollution is found far under the surface.

In situ biodegradation includes cycling aqueous solutions through polluted soils to provide oxygen and nutrients to naturally occurring microorganisms that breakdown organic pollutants. It's suitable for both soil and groundwater. In general, circumstances such as the penetration of water-containing nutrients, oxygen, or other electron acceptors for groundwater treatment are included in this approach. Biosparging is the process of injecting pressurized air beneath the water table to raise groundwater oxygen levels and speed up the biological breakdown of pollutants by naturally existing microorganisms. Biosparging enhances the interaction between soil and groundwater by increasing mixing in the saturated zone. The simplicity and low cost of adding small-diameter air injection sites provides for a great deal of flexibility in the system's design and construction. Bioaugmentation. The addition of microorganisms, either native or foreign, to polluted areas is a common part of bioremediation[6].

Bioaugmentation: The addition of microorganisms, either indigenous or foreign, to polluted areas is commonly used in bioaugmentation and bioremediation. The utilization of additional microbial cultures in a land treatment unit is limited by two factors, 1- Nonindigenous cultures seldom compete effectively enough with indigenous cultures to grow and sustain meaningful population levels, and 2- most soils with long-term exposure to biodegradable waste include indigenous microbes that are excellent degraders provided the land treatment unit is adequately managed.

1.3.2. Ex situ bioremediation

These methods entail excavating or removing contaminated dirt from the ground.

- *Landfarming:*

It is a basic process in which polluted soil is dug and placed over a prepared bed, then tilled on a regular basis until contaminants are degraded. The objective is to encourage indigenous biodegradative bacteria and make it easier for them to degrade pollutants aerobically. The technique is often confined to the treatment of the top 10–35 cm of soil. Landfarming has gotten a lot of interest as a disposal option since it has the potential to minimize monitoring and maintenance expenses as well as clean-up responsibilities.

- *Composting*:

It's a method that includes mixing polluted soil with non-hazardous organic amendments like manure or agricultural waste. The inclusion of these organic materials encourages the growth of a diverse microbial population as well as the high temperatures associated with composting. Landfarming and composting are combined in bio piles. Engineered cells are built similarly to aerated composting heaps. They are a refined version of landfarming that tend to reduce physical losses of pollutants through leaching and volatilization. They are often employed for the treatment of surface pollution with petroleum hydrocarbons[7].

1.4.Advantages of bioremediation:

- Because bioremediation is a natural process, the public views it as an acceptable waste treatment method for polluted materials like soil. As the contamination is present, the number of microbes capable of degrading it increases; when the contaminant is destroyed, the biodegradative population decreases.
- Carbon dioxide, water, and cell biomass are examples of treatment leftovers that are typically innocuous. 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 harm- less products. This eliminates the chance of future liability associated with treatment and disposal of contaminated material.
- Rather than transmitting toxins from one environmental medium to another, such as from land to water or air, target pollutants can be completely destroyed.
- Bioremediation may frequently be done on-site without causing significant disturbance to normal operations. This also removes the need to transfer large amounts of garbage off-site, as well as the possible health and environmental risks that might occur during transit. Bioremediation has the potential to be less costly than other methods for hazardous waste cleanup.
- Bioremediation can prove less expensive than other technologies that are used for clean-up of hazardous waste.

1.5.Disadvantages of bioremediation

- Bioremediation is only possible with biodegradable chemicals. Not all chemicals can be completely degraded in a short period of time.
- Some people are concerned that biodegradation products would be more persistent or hazardous than the parent chemical.
- Biological processes are frequently quite specialized. The existence of metabolically competent microbial populations, acceptable environmental growth conditions, and optimum amounts of nutrients and pollutants are all important site variables.
- Extrapolating from bench and pilot-scale research to full-scale field operations is tough. each 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.

2. LITERATURE REVIEW

R. Boopathy et al. studied about the use of microorganisms to destroy, or reduce the concentration of, hazardous wastes on a contaminated site are called bioremediation. Such a biological treatment system has various applications, including, cleanup of contaminated sites such as water, soils, sludges, and waste streams. The treatment of the Alaskan shoreline of Prince Williams Sound after the oil spill of Exxon Valdez in 1989 is one common example in which bioremediation methods got public attention. There are numerous other success stories of bioremediation in cleaning up chemical spills, leaking underground storage tanks of gasoline, and many toxic industrializes[8].

Tomotada Iwamoto et al. discussed about the use of microbes to clean up polluted environments, bioremediation, is a rapidly changing and expanding area of environmental biotechnology. Although bioremediation is a promising approach to improve environmental conditions, our limited understanding of biological contribution to the effect of bioremediation and its impact on the ecosystem has been an obstacle to make the technology more reliable and safer. Providing fundamental data to resolve these issues, ie., the behavior of the target bacteria directly related to the degradation of contaminants and the changes in microbial communities during bioremediation, has been a challenge for microbiologists since many environmental bacteria cannot yet be cultivated by conventional laboratory techniques Such advanced molecular microbiological techniques will provide new insights into bioremediation in terms of process optimization, validation, and the impact on the ecosystem, which are indispensable data to make the technology reliable and safe[9].

Asha A. Juwarkar et al studied Sustainable development requires the development and promotion of environmental management and a constant search for green technologies to treat a wide range of aquatic and terrestrial habitats contaminated by increasing anthropogenic activities. Bioremediation is an increasingly popular alternative to conventional methods for treating waste compounds and media with the possibility to degrade contaminants using natural microbial activity mediated by different consortia of microbial strains. In this review, we discuss the various in situ and ex situ bioremediation techniques and elaborate on the anaerobic digestion technology, phytoremediation, hyperaccumulation, composting and biosorption for their effectiveness in the biotreatment, stabilization and eventually overall remediation of contaminated strata and environments[10].

3. DISCUSSION

Bioremediation is a cutting-edge method that uses natural biological processes to entirely remove harmful pollutants from the environment. Any method that involves the utilization of microbes, fungus, green plants, or their enzymes to restore the natural environment after it has been contaminated. In situ and ex situ bioremediation methods are the two types of biological methods. Bioremediation is significantly less costly than other hazardous waste cleanup solutions. Bioremediation has a variety of economic and efficiency benefits that may be used in regions that are inaccessible without excavation. Bio remediators are microorganisms that fulfil the function of bioremediation. However, not all pollutants are easily removed by microorganisms in bioremediation. Heavy metals like cadmium and lead, for example, are not easily ingested or caught by organisms. Metals like mercury may be assimilated into the food chain, exacerbating the problem. This article explains what bioremediation is, the principles of bioremediation, the factors of bioremediation, methods, kinds, genetic engineering techniques, bioremediation monitoring, & bioremediation advantages and disadvantages.

4. CONCLUSION

Bioremediation is a cutting-edge method that uses natural biological processes to entirely remove harmful pollutants from the environment. Any method that involves the utilization of microbes, fungus, green plants, or their enzymes to restore the natural environment after it has been contaminated. When alternative remediation methods aren't cost-effective or practicable, phytoremediation is a good option. It may also be utilized in conjunction with other technologies when vegetation is employed as a final cap as well as closure of the site. Its disadvantages include long remediation timeframes, the potential for contamination of the vegetation and food chain, and problems in establishing and maintaining plants at particular sites with high toxic levels. Bioremediation is a state-of-the-art method that utilizes natural biological processes to remove harmful pollutants in an environmentally friendly manner Any technique that involves the utilization of microbes, fungus, green plants, or their enzymes to restore the natural environment after it has been contaminated. In situ and ex situ bioremediation methods are the two types of bioremediation technologies.

This article explains what bioremediation is, its concepts, factors, methods, kinds, genetic engineering approaches, bioremediation monitoring, and its benefits and drawbacks.

REFERENCES:

[1] K. Laboratories, "Microorganisms relevant to bioremediation Kazuya Watanabe," pp. 237–241, 2001.

[2] M. Borg, "Bioremediation of Petroleum Pollutants," pp. 311–321, 1995.

[3] R. Singh, D. Paul, and R. K. Jain, "Biofilms : implications in bioremediation," vol. 14, no. 9, 2006, doi: 10.1016/j.tim.2006.07.001.

[4] V. M. Kensa, "BIOREMEDIATION - AN OVERVIEW," vol. 27, no. 2, pp. 161–168, 2011.

[5] A. Malik, "Metal bioremediation through growing cells," vol. 30, pp. 261–278, 2004, doi: 10.1016/j.envint.2003.08.001.

[6] S. Sharma, "Bioremediation : Features , Strategies and applications," vol. 2, no. 2, pp. 202–213, 2012.

[7] K. P. Shukla, N. K. Singh, and S. Sharma, "Bioremediation : Developments , Current Practices and Perspectives," vol. 2010, pp. 1–20, 2010.

[8] R. Boopathy, "Factors limiting bioremediation technologies," vol. 74, 2000.

[9] T. Iwamoto and M. Nasu, "Current Bioremediation Practice and Perspective," vol. 92, no. 1, pp. 1–8, 2001.

[10] A. A. Juwarkar and S. K. Singh, "A comprehensive overview of elements in bioremediation," pp. 215–288, 2010, doi: 10.1007/s11157-010-9215-6.