Bio. Res. Today 2024, 6(6):336-338

Biotica Research Today

e-ISSN: 2582-6654

June, 2024

Article ID: RT1673 Popular Article

Bioremediation: A Novel Approach towards Waste Management

Shivali Dhiman[1], Balbir Singh Dogra[1*], Shiv Pratap Singh[1] and Anuj Sohi[2]

[1]*Dept. of Vegetable Science, College of Horticulture and Forestry, Neri, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Hamirpur, Himachal Pradesh (177 001), India*

[2]*Dept. of Vegetable Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh (173 230), India*

Corresponding Author

Balbir Singh Dogra

✉: dogra1970bs@gmail.com

Conflict of interests: The author has declared that no conflict of interest exists.

How to cite this article?

Dhiman, S., Dogra, B.S., Singh, P.S., *et al*., 2024. Bioremediation: A Novel Approach towards Waste Management. *Biotica Research Today* 6(6), 336-338.

Abstract

The environment quality directly linked to life's quality on earth. In the present scenario due to the increasing growth and development in the human society, the stability in the climate is drastically changing. Due to the increase in manufacturing industries and intensification in agriculture, results in release of harmful chemical compounds which leads to soil and water contamination. Therefore, we need a biological mechanism with which we can enhance the quality of our life by transforming and eliminating the organic or inorganic pollutants. Bioremediation is considered to be the best alternative nowadays for removal of these contaminants from environment. Bioremediation uses natural occurring microorganisms (fungi and bacteria) used to remove environmental contamination. This biological mechanism is safer than the existing physical and chemical treatments.

Keywords: Bioremediation, Climate, Quality, Vegetable

Introduction

Throughout the food supply chain, from growing and harvesting to processing, storing and distributing, food losses and waste arise, culminating in consumption by individuals and restaurants. Around 1/3rd of food intended is either discarded or lost for consumption of human annually around the world amounts to 1.3 billion tons. In India, urban regions are responsible for approximately 50 million tons of municipal solid waste annually. As cities grow rapidly and the amount of waste produced by each person rises daily, the production of municipal solid waste is consistently on the rise (Saha *et al.*, 2010). Over 90% of this waste is disposed of in unscientific landfills or unregulated dumping sites near towns and cities. This practice significantly contributes to global warming through greenhouse gas emissions. Bioremediation is a method that employs living entities, primarily microbes, plants and their enzymes, to clean up environmental pollutants and hazardous substances from contaminated sites. The goal is to break down, neutralize, or transform these pollutants into harmless or less harmful substances and restore the sites to their natural state (Azubuike *et al.*, 2016).

Strategies for Bioremediation

Various methods are used based on how wet or aerated an area is. *In situ* methods refer to techniques that are applied directly to the soil and groundwater on-site with minimal disruption. *Ex situ* methods are used on soil and groundwater that have been excavated or pumped out from the site. Bioaugmentation involves introducing microorganisms capable of breaking down contaminants.

- ***In situ*** bioremediation is a process where soil and groundwater are treated right at the location with minimal interference.
- ***Ex situ*** bioremediation involves treating soil and groundwater that have been taken out from the location through digging or pumping.

1. *In situ* Bioremediation

It is favoured because it treats pollutants directly at the contaminated site without needing to dig or disrupt the area (Figure 1). Natural *in situ* bioremediation happens without any intervention, while enhanced bioremediation (*in situ*) employs bio-sparging, bioventing and phytoremediation to aid the process (Azubuike *et al.*, 2016). While *in situ* bioremediation is cost-effective, avoiding expenses related

Article History

RECEIVED on 11th June 2024 RECEIVED in revised form 16th June 2024 ACCEPTED in final form 17th June 2024

to digging and transport (with costs arising only from design and setup of equipment to boost microbial activity), it's less controllable and effective compared to *ex situ* methods. It's employed successfully for treating sites polluted with chlorinated solvents, dyes, hydrocarbon and heavy metals.

Bioventing

Bioventing is an emerging technique which boosts *in situ* bioremediation of degradable aerobic substances in soil by providing oxygen to existing microbes in soil. Unlike soil-vapor extraction (SVE), bioventing utilizes minimal air-flow rates for providing sufficient oxygen for supporting microbial degradation processes. The bioremediation process for absorbed fuel residues and volatile substances occurs as vapor slowly moves through soil teeming with biological activity. This method enhances oxygen levels while also extracting vapours. By creating a vacuum within the contaminated soil, air is drawn down from the surface through drilled holes, effectively removing organic volatile compounds. Aim of this method is to remove petroleum contaminants through venting from soil which includes 800 kg of hydrocarbons and about 572 kg through biodegradation.

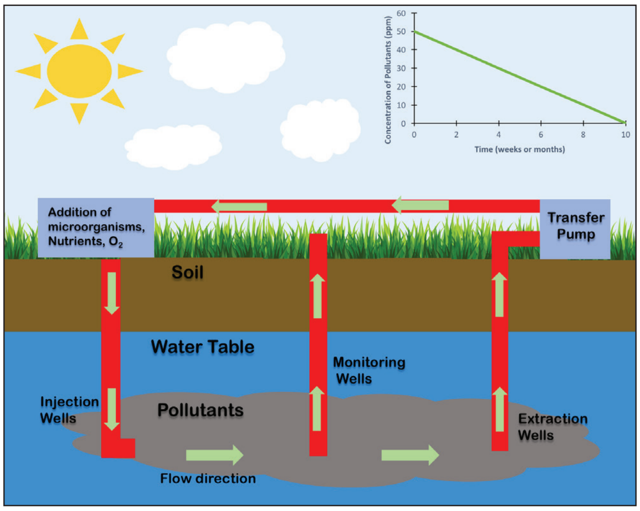

Figure 1: In situ bioremediation

Bio-Sparging

Differing from bioventing, bio-sparging introduces air into the subsurface soil (specifically, the saturated zone), prompting organic volatile pollutants gives rise to biodegradation surfaces. This method also boosts removal of pollutant from contaminated sites by invigorating microbial activity. Bio-sparging's effectiveness hinges on soil permeability and pollutant biodegradability. Bio-sparging is commonly employed for remediating hydrocarbon-contaminated aquifers, including those affected by benzene, xylene, toluene, and ethylbenzene.

Phytoremediation

Phytoremediation, an emerging bioremediation approach, utilizes their root systems and plants to remediate polluted water and soil. Research has commonly found that at polluted sites, plants remove pollutants primarily through passive uptake; then transport them from the roots to the shoots *via* xylem flow, culminating in accumulation within the shoots. Bioremediation techniques that utilize vegetation hold great promise for breaking down, accumulating, stabilizing and altering persistent pollutants by serving as a biological filter and metabolizing the contaminants (Bera *et al.*, 2020). Phytoremediation is viewed as a novel and economical alternative bioremediation approach for cleaning up dangerous contaminated areas. Phytoremediation employs diverse strategies customized for specific pollutants whether elemental (such as radionuclides and toxic heavy metals) or organic (including chlorinated compounds and hydrocarbons). These strategies address various outcomes, including degradation, accumulation, stabilization, transformation, volatilization, filtration or a combination of these processes.

2. *Ex situ* Bioremediation

These methods include digging up or taking away polluted soil from the ground.

Land Farming

The land farming method involves digging up contaminated soil, spreading it out and periodically tilling it over a stable layer of soil above ground to facilitate the aerobic breakdown of pollutants by indigenous microorganisms. Tilling helps by providing air, nutrients and water to boost microbial activity in land farming. This technique is typically limited to treating the top 10-35 cm layer of soil (Kumar and Tyagi, 2020). Agricultural lime is employed to maintain a neutral pH level. While land farming is typically an *ex-situ* bioremediation technique, it can occasionally be classified as *in-situ*. It's commonly applied to sites contaminated with aliphatic and polycyclic aromatic hydrocarbons, as well as PCBs. Due to its simplicity, low equipment needs and minimal maintenance costs; this method is increasingly favoured over traditional dumping methods.

Composting

Composting entails blending polluted soil with a bulking substance like straw, hay, or corncobs to facilitate optimal air and water delivery to microbes (Figure 2). Mechanically agitated composting places the soil in vessels for mixing and aeration. In windrow composting, soil is formed into elongated heaps called windrows and mixed periodically with tractors. Compost remediation is noted for its rapid cleanup times, often taking weeks rather than months.

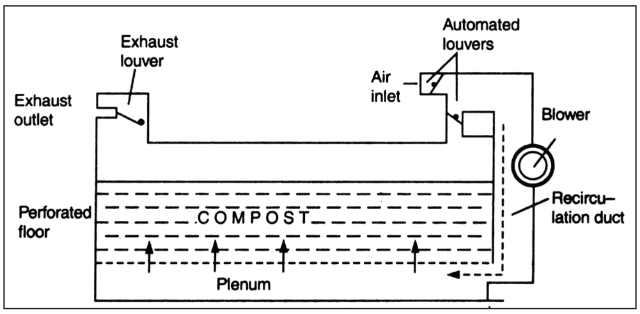

Figure 1: *In situ* bioremediation

Bio-Piles

Bio-piles are a method for treating soil dug up and contaminated with hydrocarbons that are amenable to aerobic treatment. Bio-piles, also referred to as bio-heaps, bio-cells, compost piles and bio-mounds which target petroleum contaminants reduction in soil via biodegradation. This is done by pumping air into or out of the pile through a system of pipes and pumps, which enhances microbial respiration and thus increases the breakdown of the petroleum pollutants.

Advantages of Bioremediation

- Bioremediation is seen as an eco-friendly waste treatment process for contaminated materials like soil because it's a natural process. Microorganisms that break down contaminants multiply when the contaminant is present and decrease once it's degraded.
- In theory, bioremediation can completely reduce a quantity of pollutants. Many hazardous substances can be converted into non-toxic forms, reducing the risk of future legal liabilities related to the treatment and disposal of contaminated materials.
- Bioremediation offers the advantage of destroying pollutants entirely rather than just moving them from one part of the environment to another, such as from soil to water or air.
- It can usually be performed on-site with minimal disruption to daily activities, negating the need for transporting hazardous waste and the associated risks to health and the environment.
- Bioremediation is often more cost-effective than other clean-up methods used for hazardous waste.

Disadvantages of Bioremediation

- Bioremediation can only be applied to biodegradable compounds; not all substances can be degraded quickly and completely.
- There's a concern that the by-products of biodegradation could be more toxic or persistent than the original contaminant.
- Bioremediation's effectiveness is highly dependent on specific conditions such as the presence of microbes capable of metabolizing the contaminants, suitable environmental conditions for microbial growth and the right levels of nutrients and pollutants.
- Scaling up from small-scale laboratory studies to full-scale field operations is challenging and often unpredictable.
- Further research is necessary to create bioremediation methods suitable for sites with complex contaminant mixtures that are unevenly distributed in the environment.
- Bioremediation usually takes longer than other remediation methods like soil excavation and removal or incineration.

Conclusion

As environmental contamination accelerates, we urgently need effective solutions to prevent disastrous outcomes. It's crucial to minimize such waste. Bioremediation has emerged as the most effective, economical and eco-friendly approach compared to traditional chemical and physical methods of waste management. The legal barriers to adopting new cleanup methods like bioremediation are diminishing due to growing governmental, commercial and public support. Despite challenges, there is a significant market and potential for bioremediation techniques and programs. With advancements in biotechnology, molecular biology and bioinformatics, the future looks promising for developing bioremediation processes. A major global challenge ahead is raising awareness about waste management. Therefore, it's essential to implement well-structured policies for efficient waste management starting at the community level.

References

Azubuike, C.C., Chikere, C.B., Okpokwasili, G.C., 2016. Bioremediation techniques-Classification based on site of application: Principles, advantages, limitations and prospects. *World Journal of Microbiology and Biotechnology* 32, 180. DOI: https://doi.org/10.1007/s11274-016-2137-x.

Bera, L., Pradhan, S., Saha, D., 2020. Green bioremediation technology. *Biotica Research Today* 2(8), 792-793.

Kumar, N., Tyagi, B., 2020. Bioremediation: Principles and application in environmental management. In: *Bioremediation for Environmental Sustainability: Toxicity, Mechanisms of Contaminants Degradation, Detoxification and Challenges*. (Eds.) Saxena, G., Kumar, V. and Shah, M.P. Elsevier Inc. pp. 3-28. DOI: https://doi.org/10.1016/C2019-0-01053-9.

Saha, J.K., Panwar, N., Singh, M.V., 2010. An assessment of municipal solid waste compost quality produced in different cities of India in the perspective of developing quality control indices. *Waste Management* 30(2), 192-201. DOI: https://doi.org/10.1016/j.wasman.2009.09.041.