Asian Journal of Research in Social Sciences and Humanities
ISSN: 2249-7315 Vol. 11, Issue 11, November 2021 SJIF 2021 = 8.037
A peer reviewed journal

AN ANALYSIS OF PESTICIDES BIOREMEDIATION

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DOI: 10.5958/2249-7315.2021.00204.5

ABSTRACT

The use of pesticides in the production of crops, fruits, and vegetables improves the economic condition of developing nations, establishing a significant success in this area. Despite the fact that pesticides are an essential part of agricultural operations, the widespread use of toxic pesticides poses a serious threat to the environment, water, soil, and public health. Because of the significant risks to human health, their use has been restricted, and several clean-up scenarios have been devised for various polluted locations. For degrading pesticides, biological methods such as bio augmentation, bio stimulation, bio surfactants, and bioremediation polluted areas are available, however the last one has been shown to be the most favoured way to neutralize harmful pesticides. In the presence of adequate nutrition and environmental conditions, bioremediation utilizes biological agents such as bacteria to breakdown pollutants. The type of the pollutants, as well as the properties of contaminated sites, temperature, pH, and the nature of the pollutants, are all significant variables in the bioremediation process. The goal of this chapter is to highlight the bioremediation methods available for removing pesticides from polluted areas, as well as their basics, benefits, limits, and pesticides handled.

KEYWORDS: *Agricultural, Bioremediation, Chemical, Pesticide, Soil.*

1. INTRODUCTION

Pollution in the environment is growing as a result of certain human activities, which is shown to be an inseparable cause. The expansion of industrial and agricultural businesses has resulted in increased pollution of soil and water in recent years. Many new technologies were created and improved, resulting in increased ability to produce new goods in order to meet human needs. Chemical goods such as insecticides, fertilizers, and medicines are increasingly being used to maintain some elements of life. Pesticides are among these organic chemicals that are extensively employed in agricultural production to control or prevent crop pests, and they are widely distributed in the environment, especially in the land, water, food items, aquatic system, and so on. The usage of pesticides in contemporary agricultural systems has increased at an ever-increasing pace in recent decades as food demand has risen dramatically. Pesticide usage increased as a historical trend in India's agricultural system about 5–6 decades ago[1].

1.1 Bioremediation History:

In many of the occurrences, science lagged behind mankind in the past. Biotechnology is a biological process that is utilized to create high-quality goods in order to improve the quality of human life. Previously, biotechnology was primarily used in the food industry, but it has lately been more widely used in a variety of sectors. Bioremediation is an environmental biotechnology technique that uses living organisms in the air, soil, and water to remove contaminants. The first humans to employ bioremediation to clear up pollutants was the Romans, who did it in 1972.

Natural remediation has been used by civilizations to clean wastewater and remove harmful chemicals from the water. George Robinson used microorganisms to decompose oil spills off the coast of Santa Barbara, California, in 1960[2].

1.2 Classes of Bioremediation:

1.2.1 In Situ Process:

In situ bioremediation involves the addition of nutrients to the soil surface, water reservoirs, and other bodies of water in order for organisms to breakdown the contaminants there.

In situ bioremediation was developed as a less costly technique for reduction of organic pollutants, inorganics, toxic metals, and other contaminants in various polluted sites. It highlights favorable conditions such as cheap operating costs, minimal risk to working laborers at polluted sites, and complete pollution removal. It is a preferred method because it prevents pollution from being transported from one region to another by limiting the spread of contaminants. This method elucidates the confusing connections between biomass and contaminants, as well as the measures that should be taken in response to them. Furthermore, it improves the microbial breakdown of organic components in the polluted zone. The biodegradation process is regulated by many variables such as biogeochemical and hydrogeological conditions, which determine the capacity of in situ bioremediation. The main benefit of the in situ method is that the contaminated site does not need to be removed or relocated. However, the in situ method's effectiveness is lower than that of ex situ remediation, and the depth of the soil cannot be handled adequately[3].

1.2.2 Ex Situ Process:

Ex situ bio remediation is a natural process that moves media from one place to another while also dealing with contaminants at that spot. This method is utilized for soil remediation because of its potential environmental impact, ease of implementation, and compliance with government laws. This approach may overcome flaws such as inadequate control of operating conditions and long remediation times. The disadvantage of the ex situ method is that it necessitates the excavation of polluted areas for the treatment process, which results in significant costs and health hazards for people. This method is extremely easy to see, and the time required to remove the pollutants is usually little[4].

1.3 Bioremediation of Pesticides:

Pesticides have a variety of negative effects on humans and the environment, necessitating the development of remediation methods. One of the biotechnological methods for reducing pesticide toxicity and concentration is bioremediation. It is recommended as a less costly and ecologically friendly approach for remediating pesticide-contaminated environmental areas, and it is the preferred option over alternative physical and chemical techniques for pesticide remediation. Microorganisms and plants are used in bioremediation methods to eliminate or convert pesticides into less harmful compounds via processes such as degradation, biotransformation, and confinement from the environment. The pace of pesticide remediation is determined by the accessibility of pesticides, the ability of microorganisms to absorb pesticides, the rate at which an enzyme destroys pesticides, and the rate at which organisms develop by using pesticides as an energy source.

The results of sorption, degradation, and volatilization are used to determine the effectiveness of bioremediation. When the pesticide and its metabolite remediation reaches an acceptable level in a short period of time, the bioremediation rate is adequate. The oxidative transformation, hydrolytic transformation, reductive transformation, conjugation reaction, and reductive dehalogenation are all part of the pesticide breakdown metabolic pathway. Some pollutants in the polluted area are resistant to microbial assault and decay slowly instead. Finally, the chemicals are resistant to the microbial process, making bioremediation an ineffective approach for treating such compounds. A variety of studies have been conducted to see whether the bioremediation method can breakdown a variety of pollutants. The organic pollutants produced by the chemical process must be effectively handled, and the Environmental Protection Act of 1986 describes the biological techniques for meeting the requirements[5].

1.4 Upside of Bioremediation:

It is regarded as a sufficient therapy for pesticide elimination in its entirety. Typically, bioremediation is an on-site process that minimizes waste movement from one location to another, such as from land to water or air. Toxic chemicals that are prohibited by law may be transformed into less hazardous ones. It makes use of the naturally occurring chemicals on the site to degrade contaminants. Carbon dioxide, cell mass, and water are all innocuous by-products of the bioremediation process. The main advantages of the bioremediation method are that it is less costly and less disruptive than alternative treatment options. Although bioremediation has many benefits, it is still in its early stages of development[6].

1.5 Downside of Bioremediation:

Due to the partial breakdown of pesticides, there is a possibility of generating less harmful and volatile chemicals. When compared to thermal treatment, the remediation procedure takes longer and takes longer to achieve an acceptable level of contaminants. It's difficult to extrapolate hypotheses from a laboratory to a field research. To track the breakdown of pesticides, field monitoring is needed. There is the potential for new contaminants to develop in both in situ and ex situ processes. The effectiveness of the bioremediation process is determined by factors such as microbial populations, suitable environmental conditions, and nutrient and pollutant concentrations. In certain instances, the end products of the degradation process are more hazardous than the original pollutant concentration. There are a few criteria that must be met: Bacterial and nutrient concentrations, non-toxic environments, and a restricted carbon supply are only a few of them. It's also difficult to extrapolate the findings from pilot-scale to full-scale operations. During the transfer of polluted areas, the development of microorganisms is restricted[7].

1.6 Strategies of Pesticides Bioremediation:

1.6.1 Involvement of Microbes in Bioremediation of Pesticides:

When pesticides are used as a source of nutrition by microorganisms such as fungus and bacteria, microbial remediation occurs. Under the right conditions, microbial remediation may be quick and thorough, resulting in total degradation in the environment. To breakdown pesticides, not only the presence of innate microorganisms at the polluted site is needed, but also the external addition of other microbes is recommended. Pesticide detoxification may be accomplished using a variety of microorganisms, which advances bioremediation methods. The microbial bioremediation of pesticides is regulated by the bioavailability of pesticides and their activities. Furthermore, frequent pesticide applications in the agricultural area accelerated the deterioration process. Microbial degradation, which is recognized as an essential process, has been used in many research linked to the removal of persistent organic pollutants from the environment[8].

1.6.2 Bacterial Bioremediation:

Microorganisms such as bacteria have been widely used for the cleanup of contaminants in the bioremediation process. Several studies have focused on microorganisms in the search for biotransformation enzymes. Bacterial remediators are a particularly useful technique since they are less costly, proliferate quickly, and are simple to manipulate. Bacterial bioremediation occurs in both aerobic and anaerobic conditions. Diuron is a herbicide or algaecide that is found in the water, soil, and other sediments as an active pollutant. Anthrobactersulfonivorans, Vario-vorax soli, and Advenella sp. form a three-member bacterial consortium that mineralizes this herbicide, resulting in mineralization rates ranging from 22.9 to 69.0 percent. Bacillus firmus has shown that it can bioremediate the pesticide fipronil, which poses a significant environmental threat. It is effective against a wide range of insects. Mixed microbial cultures are a novel biotechnological technique that may efficiently eliminate pesticides, prevent their agglomeration in the environment, and accelerate the breakdown of blended forms of pesticides.

The advantage of mixed consortia is that there will be a lot of competition and interaction between the microbial population and the target chemical. Microbial consortia were mostly selected for the degrading process at severely contaminated sites because microorganisms found there can withstand high concentrations of organic chemicals and the microbial population would be large. A research was conducted on the elimination of diazinon, an organophosphate pesticide, using single and mixed cultures of Streptomyces sp., and it was shown that the mixed culture removed diazinon more effectively than the single culture. Streptomyces sp. mixed cultures have the capacity to remove diazinon and other organophosphates from fluids and various natural frameworks[9].

Furthermore, pure culture is insufficient to breakdown blended forms of pesticides, and by using mixed consortia of bacterial strains, effective evacuation of pesticide mixtures may be achieved owing to the interaction among the mixed culture. The use of bacteria in the bioremediation process is a low-cost alternative to chemical and physical processes for the bioremediation of organophosphate pesticides. Because of its mycelial development and rapid growth rates, Streptomyces sp. is a key player in the breakdown of OPPs among bacterial species. As a result, bacterial remediation is a reliable method for the bioremediation of different contaminants-polluted frameworks.

When compared to chemical processes, bacterial bioremediation is less expensive and may be completed on-site. Furthermore, specialized bacteria are used in the bioremediation process, resulting in a minimal production of hazardous by-products. There are lower possibilities of forming deadly by-products in a few instances. Cloned genes lose their stability in contaminated environments as a result of the use of recombinant strains. This problem exists not just in marine species, but also in bacterial strains. Using recombinant live/dead E. coli, techniques for bioremediation of the extremely persistent hazardous chemical lindane from the environment were developed[10].

1.6.3 Phycoremediation:

The use of microalgae or macro algae to remove organic chemicals produced by anthropogenic activity is known as phycoremediation. Algae are photosynthetic microorganisms that transform organic molecules into a new, high-value molecule. The majority of phytoplankton is made up of blue-green algae that can adapt to a variety of contaminants. Due to acclimation, phytoplankton may grow in the presence of hazardous substances. Because linden is extremely harmful to both humans and the environment, microalgae species are highly recommended for the location polluted with the herbicide. The breakdown of OPPs in the presence of microbial enzymes has been the attention of several studies. Alkaline phosphatase, for example, is an enzyme produced by Spirulina platensis that has the ability to hydrolyse OPPs such as chlorpyrifos to their main metabolite 3, 5, 6-trichloro-2-pyridinol (TCP).

As a result of these discoveries, organism-secreted enzymes may be immobilized on solid matrix to detoxify contaminated areas. Microalgae treatment can manage a wide range of contaminants and amounts in polluted water. Atrazine is herbicide that may be eliminated using techniques like as Nano filtration, photocatalytic degradation, adsorption, and others, however these technologies are considered inefficient owing to their high energy requirements. The microalgae

Chlamydomonas Mexicana was used to investigate the breakdown of atrazine. The carbohydrate content of algae increases when atrazine is degraded, and it has also been shown that C. Mexicana can remove atrazine from contaminated streams.

1.7 Phytoremediation of Pesticides:

Phytoremediation is used to clean up the contaminants in the large-scale procedure. Growing plants or genetically modified plants to remediate pollutants in the environment is known as phytoremediation. Contaminants at the polluted site are permeated via the radical system and deposited in plant components such as stems, leaves, and roots. This invention is founded on the concept that in the presence of plant oxidative enzymes, toxicants in the environment are transformed to non-toxicants. Bioremediation based on plants is aided by microorganisms associated with the roots as well as physiological and biological features of the plants.

The word phytoremediation was first used in 1980, although its use in the treatment of organic contaminants dates back to the turn of the century. More than 2400 plant species can control the pest, however certain plants release the poisonous chemicals, while others control the insect via repellency and growth obstruction without causing harm to human health or the environment. Plant membranes carry a small number of low molecular weight pesticides, which are then discharged from the soil. The leaves are released via the evapotranspiration mechanism. Some processes, such as enzyme changes, phytoextraction, rhizofiltration, phytostabilization, and rhizodegradation, may generate non-toxic chemicals.

2. DISCUSSION

With the advent of the industrial revolution and the manufacturing of different pesticides, our agricultural yields have undoubtedly increased, and our majority of crops have been protected against pests. We can't afford to lose the bulk of our crops to bugs. Pesticides now serve an essential function in increasing production and providing a financial advantage to our farmers, but their usage in agricultural areas is currently a significant source of worry. Increased soil contamination has been a major source of worry. A large number of pollutants, one of which is a pesticide, have posed a significant danger to human health and the natural environment. The existing techniques (physical and chemical) are either insufficient or too expensive. Bioremediation is a new instrument or method in this regard. Pesticide detoxification may be done in an environmentally acceptable, cost-effective, and efficient manner via bioremediation.

3. CONCLUSION

Some of the problems, such as contamination with organic and inorganic pollutants, are addressed through bioremediation methods. Industries are exploring different remedial methods to avoid decontamination. In situ and ex situ bioremediation, as well as physical, chemical, biological, and sophisticated engineering technologies, are among the methods available. Bioremediation method is chosen based on the kinds of pesticides and organisms present, as well as the surrounding ecosystem. Pesticides are still used in developing nations, which necessitates the use of a different method to clean up the contaminated areas. Pesticide use is quickly rising, necessitating more awareness due to the negative consequences of pesticides on the environment and people. To detoxify contaminated areas, a variety of remediation methods are available, however bioremediation approaches provide much more advantages than the others. The remedial methods described in this chapter have certain benefits and drawbacks that must be determined in the appropriate setting. Unlike other traditional methods, this method does not need dredging and capping. It's an essential approach for removing pesticides from metabolic pathways. As a result, it is seen as an environmentally responsible approach for ensuring a secure future.

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