BIOREMEDIATION OF PESTICIDES: A REVIEW

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ABSTRACT

Pesticides are something of a persistent organic pollutant that is a source of worry because of its presence in a variety of ecosystems. Agrochemicals are exposed to physical, chemical, and biological breakdown processes in nature, yet they remain in the environment owing to their high stability and water solubility. 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.

KEYWORDS: *Bioremediation, Detoxification, Fertilizers, Pesticides, Pollution.*

1. INTRODUCTION

Pesticides are complex mixtures that are used to kill or control pests at a safe level. Pesticides are made up of a variety of compounds that serve various purposes. The fast growth of the human population has resulted in a build-up of a wide range of chemicals in the environment. As a result of the creation of these xenobiotics, new methods have been developed to decrease or remove them from the environment. Landfills, recycling, pyrolysis, and other earlier methods or technologies were employed to remove them from the environment, however they have negative environmental consequences and result in the creation of hazardous intermediates. These techniques have proven to be costly and difficult to implement, particularly in the case of pesticides. Bioremediation is a promising technique that makes use of microorganisms' capacity to remove pollutants from the environment while remaining environmentally benign, cost-effective, and flexible. The widespread use of pesticides has caused significant environmental and health issues, as well as affecting biodiversity(1–3). Pesticides not only impair soil quality but also reach the water table, where they infiltrate the aquatic ecosystem. As a result, the destiny of pesticides is often unknown, making decontamination of pesticide-polluted regions a difficult task. They have been categorized as persistent hazardous compounds due to their low biodegradability(4–7).

1.1 Soil contamination:

Soil, an essential resource on the globe, is deteriorating due to a number of factors. Heavy metals, pesticides, and trash from the city. Paper, plastic, and biological waste are found in municipal trash, as well as abandoned items from homes and businesses. Heavy metals in soil originate from a variety of sources, including air pollution, sewage, irrigation, industry, and pesticide and fertilizer usage. Contamination may lead to a loss of biodiversity and soil functionality, such as nitrogen cycling. Microbial activity is also inhibited by heavy metals(8).

1.2 Water contamination:

Water is probably the most valuable resource on the world, providing a unique home for a wide range of species. Pollution levels in aquatic ecosystems have resulted in a decrease in fresh water content on the globe. The number of Indians without access to toilet facilities has surpassed 700 million, and approximately 1000 Indians die of diarrhea every day. In China, fresh water is in short supply, and 500 million people do not have access to clean drinking water. Excessive use of fertilizers, herbicides, and pesticides has a negative impact on aquatic life. Eutrophication is caused by an excess of phosphorus(9–11). Pesticide use in Asia is likewise concerning. China is the country with the largest proportion of users, followed by Korea, Japan, and India. Pesticide usage in India is about 0.5 kg/hectare, with organ chlorine pesticides accounting for the majority of this. The use is due to the humid and warm climate. The idea of the green revolution has been instrumental in the use of a wide range of pesticides for high-yielding cultivars. India is now Asia's biggest producer of pesticides and ranks 12th globally. Pesticide residue in many crops has also hampered agricultural commodity exports in recent years. Pesticide safety, pesticide regulation, appropriate application methods, and integrated pest management are some of the major measures for reducing human exposure to pesticides and maintaining soil fertility for optimal production in this setting. In India, there is a scarcity of research on these topics. The biggest consumer is Uttar Pradesh, followed by Punjab, Haryana, and Maharashtra. Classification of pesticides Herbicides, insecticides, fungicides, and rodenticides are only a few of the compounds classified as pesticides. Pesticides are often categorized based on their structure. Organ chlorine, organ phosphorus, carbonates, and nitrogen-based insecticides are among the structural classifications(12–14).

1.3 History and use of bioremediation:

Bioremediation, in its simplest form, is the employment of microbes to clean up, eliminate, or immobilize pollutants in the environment. Natural bioremediation has long been utilized by civilizations to clean waste water, but it is only recently that it has been employed to reduce hazardous waste(15). George Robinson is responsible for modern bioremediation and the employment of microorganisms to eat contaminants. He ate an oil spill off the coast of Santa Barbara, California, with microorganisms.

1.4 Concerns about pesticides:

Pesticides are not only harmful to people, but they also endanger the land, water, and air quality. Pesticide pollution of surface and ground water poses a significant danger to the ecosystems in the surrounding area. Tumors, irritability, and convulsions are caused by organochlorine and organophosphates. Aside from that, owing to bio magnifications, organochlorine pesticides create significant environmental problems.

1.5 Bioremediation techniques for pesticides:

The high degree of toxicity produced by pesticides necessitates extensive bioremediation. Intrinsic bioremediation happens in certain instances due to microorganisms already existing in contaminated habitats, but it is also true that intrinsic bioremediation is insufficient in others. Remediation strategies for pesticides Pesticide contamination is a significant environmental issue that requires immediate attention. Treatment should, ideally, result in the annihilation of the compounds with no intermediates being produced. Pesticide breakdown by bacteria

Flavobacterium, Arthobacter, Aztobacter, Burkholderia, and pseudomona are among the bacteria that breakdown pesticides. Pesticide degradation has recently been discovered in Bacterium raoultella sp. The oxidation of the parent chemical, which produces carbon dioxide and water, is required for full biodegradation of the pesticide, which gives energy to microorganisms(16–19). Pesticide-degrading microflora should be added to soils when the inherent microbial community is incapable of managing pesticides(20). The enzyme system, as well as factors such as temperature, pH, and nutrition, have a role in pesticide degradation by microorganisms. Some pesticides are readily destroyed, while others are resistant to degradation due to the existence of anionic species in the molecule. Pseudomonas species decompose the Neonicotinoids in addition to organophosphorus compounds. Fungi have an important role to play. The small structural modifications that fungi make in order to breakdown pesticides and convert them to harmless compounds before releasing them into the soil, where they may be degraded further.

1.6 The function of enzymes:

Enzymes play a critical role in the biodegradation of all xenobiotics, are capable of regenerating contaminants at a rapid pace, and have the potential to repair a contaminated environment. Pesticide chemicals are degraded by enzymes in the target organism through internal detoxification processes and developed metabolic resistance, as well as in the broader environment via biodegradation by soil and water microbes. The P. putida theoretical oxygen demand (TOD) enzyme is part of a much broader family of enzymes that are used as biocatalysts in ecologically important processes(21). Fungal enzymes, particularly oxidoreductases, laccases, and peroxidases, have a wide range of applications in the removal of polyromantic hydrocarbons (PAHs) from fresh, marine, and terrestrial water. In the biodegradation of any xenobiotic molecule, enzymes play a critical role. The organophosphorus compounds have been extensively researched, and there is a large body of literature detailing the OP degrading enzymes. A great deal of effort has gone into discovering different plant items that may be utilized as bio insecticides, making it simpler to eliminate target pests using these products. Pesticides have been degraded by a variety of species, and the results have been positive. Toxicity classifications of pesticides established by the WHO, in which pesticides are divided into three categories based on their harmful potential, have also been shown to be degradable by microbes(22).

1.7 Pesticide use and application:

The need for chemical pesticides grew in tandem with the requirement for global food production to feed the world's rapidly expanding population. Effective pest control using chemical pesticides is one of the most effective methods to improve crop production. This is owing to an increase in insect pest assault, which is mostly driven by the current warm, humid climate. The usage of pesticides in industrialized and poor nations is vastly different. Endosulfan, Atrazine, Chlorpyrifos, Cypermethrin, Carbaryl, Acephate, Carbofuran, and other pesticides that have been approved for use in India are among the most widely utilized. In many nations, the use of some pesticides is limited or prohibited. Pesticides such as carbofuran, lindane, and others are highly regulated in the United States, while pesticides such as monocrotophos and chlordane are prohibited. Pesticide usage is also regulated differently in various nations. Many of the pesticides that the USEPA has prohibited or limited are still in use in many developing nations. Because several organochlorine pesticides have been banned, the use of organophosphorus insecticides has lately risen in comparison to organochlorine insecticides. Aphids and viral infections are the most common targets for organophosphorus pesticides. Pesticides such as organochlorine, carbamate, and pyrethroids are used to control insect pests such as Lepidoptera, Hemiptera, and Diptera. The majority of these insecticides are used to control insect pests in rice, wheat, cotton, plantation crops, vegetables, and fruits. All of these insecticides have larvicidal, adulticidal, and ovicidal action and are stomach and contact insecticides(23).

1.8 Environmental fate of pesticide:

Pesticide dosages were raised as demand for pesticides grew, and insect resistance developed as a consequence. As a result of the absence of early breakdown, pesticides and their metabolites remain in different settings. Contamination of water supplies, degradation of soil quality, bio magnification, and loss of biodiversity are all consequences of their persistence. Organochlorine pesticides such as DDT, endosulfan, and linden are examples of pesticides that are widespread, persistent, and bio accumulative in nature. Many organochlorine pesticide residues have been found in sediments and soil, as well as in sea water, ground water, and other water sources. Organochlorines, organophosphates, pyrethroids, and other chemicals have been found in environmental samples in addition to organochlorines.

1.9 Pesticide bioavailability:

Pesticide bioavailability is a significant stumbling block in the bioremediation of pesticide-contaminated soil. In the context of bioremediation, bioavailability refers to the quantity of pesticides that may be easily absorbed by microorganisms. According to the description above, pesticide bioavailability to microorganisms impacts the bioremediation process in a variety of ways, including:

a. Microbes struggle to generate energy at low pesticide concentrations, causing the catabolic gene systems involved in biodegradation to activate, slowing bioremediation.

b. Microbial cells may breakdown pollutant at low concentrations in a low-nutrient environment, but the low nutrients in the environment limit their development rate, resulting in a reduction in pesticide absorption by microorganisms.

c. c) Furthermore, the majority of biodegradation reactions are catalyzed by enzymes. According to Michaelis Menten kinetics, the rate of enzymatic response will be slower in a system with low pesticide dosage and microbial proliferation.

2. DISCUSSION:

Pesticide pollution has an impact on not just the ecosystem services provided by soil and water resources, but also the health of animals, plants, microbes, and humans. As a result, it is imperative that appropriate environmentally friendly methods for removing pesticides from polluted settings be devised. The significance of fungus in the biodegradation of several pesticides is highlighted by an overview of the evidence provided in this review paper. Several researchers have reported their results and studies on pesticide biodegradation in liquid and soil media by fungus isolated from various environmental components. According to a synthesis of these results in the current study, several fungal species are engaged in the biodegradation of various pesticides. As with bacterial biodegradation of certain pesticides, fungal biodegradation of pesticides does not seem to be conserved to any particular genus or species of fungus. Furthermore, it was shown that when bacteria and fungus were co-cultured with each other, their ability to fully breakdown pesticides were substantially increased. There are, however, limited research on cooperative degradation efforts. Such fungal/ microbial consortia should also be examined for their relationship and interaction with one other, pesticides, and environmental variables in order to obtain improved pesticide bioavailability and biodegradation.

3. CONCLUSION:

Pesticides have undoubtedly had a negative effect on soil fertility. Pesticide-contaminated soil has drawn a lot of attention since it has a negative effect on human health and the natural environment. Bioremediation offers a lot of promise for pesticide-affected soil remediation. Pesticides may be removed from the environment by microorganisms found in soil. The most significant method for pollutant removal is bio pesticide enzymatic degradation of contaminated environments, and breakdown of persistent chemical compounds by enzymatic reactions has been shown to have a high bioremediation capacity. As a result, bioremediation is a very promising method to dealing with pesticide pollution, and it has the potential to address the issue of pesticide contamination in soils. This technique has repeatedly shown its ability to destroy not just pesticides but also a wide range of organic substances. So now is the time to put this environmentally friendly technology to work for a better and safer future.

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