An Overview on Bacterial Degradation of Pesticides

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ABSTRACT: Microbial activity has an impact on pesticide destiny in the environment. Some insecticides are easily destroyed by microbes, whereas others have proved difficult to break down. Pesticides are metabolized by a wide range of bacteria, including representatives of the genera Alcaligenes, Flavobacterium, Pseudomonas, and Rhodococcus. Microbial degradation is influenced by a variety of environmental factors, including the existence of microorganisms with the necessary degradative enzymes. Pesticide use has been beset by problems, with the pendulum swinging from organochlorine persistence to the low efficacy and rapid biodegradation of non-chlorinated alternatives. This study examines the biology or molecular characterization of certain pesticide-degrading bacteria to explain current advancements in pesticide biodegradation.

KEYWORDS: Bacterial Degradation, Pesticides, Molecular Biology, Biology.

1. INTRODUCTION

Both biotic and abiotic variables influence the destiny of pesticides in the environment. Pesticides are mostly destroyed in the environment by microbes, a process known as biodegradation, which is defined as the breakdown of a chemical into smaller compounds produced by microorganism and their enzyme (Atlas 1988). The rate of biodegradation of many insecticides varies greatly. DDT [l,l,l-trichloro-2,2-bis-(p-chlorophenyl)ethane] and dieldrin are two pesticides that have proved to be resistant. As a result, they last a long period in the environment and have been found to accumulate in food chains decades after being applied to soil. Pesticides that degrade more quickly, such as organophosphates, are increasingly preferred over pesticides that are more persistent, such as chlorinated pesticides [1], [2].

Others, including such atrazine as well as simazine, degrade slowly in the environment and may be leached into groundwater, posing a danger to drinking water sources. Pesticides like carbofuran and diazinon, on the other hand, are easily biodegradable and break down so quickly under certain soil conditions that they may not allow for efficient insect control[1]. To anticipate pesticide destiny in soils, researchers must first learn about the microorganisms that may breakdown pesticides, their activities, and the variables that restrict their activity in situ. The microbial metabolism of pesticides has been widely studied [3], [4]. In this study, we examine the variables that influence pesticide biodegradation as well as new studies on bacterial pesticide metabolism, with a focus on catabolic pathways as well as the genetic foundation for biodegradation[5].

Both biotic and abiotic variables influence the destiny of pesticides in the environment (Figure 1). Pesticides are mostly destroyed in the environment by microbes, a process known as biodegradation, which is defined as the breakdown of a chemical into smaller compounds produced by microorganisms or their enzymes [1], [2], [6], [7].

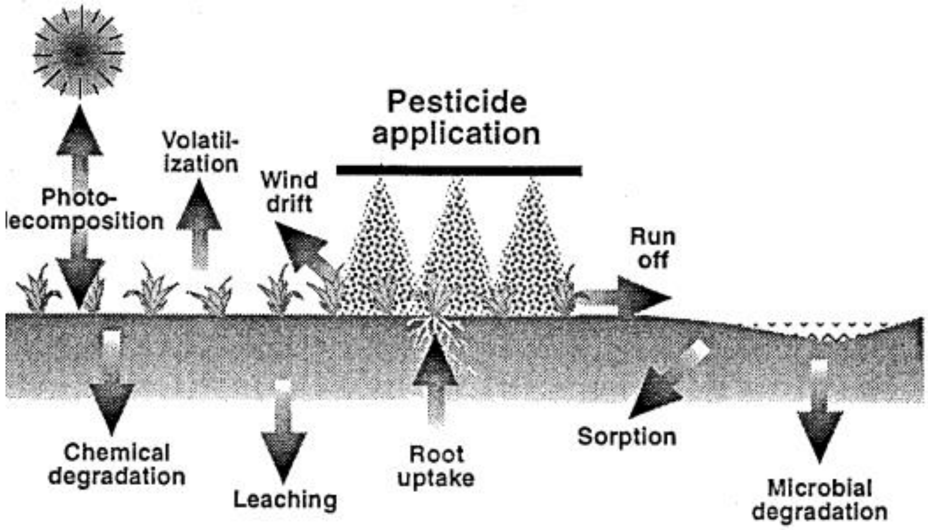

Figure 1: illustrate the fate of pesticides in the environment[5].

1.1 Factors that influence pesticide breakdown by microorganisms:

a. The natural world:

The presence and quantity of microorganisms that are suitable the microorganism makes contact with the substrate. pH, temperature, and salinity are all factors to consider. Water that is readily available Redox potential and oxygen tension Availability of nutrients Alternative carbon substrates are present The intensity and quality of the light adhesion to surfaces Electron acceptors with different properties[1].

b. The structure of the molecule:

-CI, -CH3, -COOH, -OH, etc. Chemical structure, molecular weight, and functional groups, e.g. -CI, -CH3, -COOH, -OH Toxicity and concentration Solubility in water is a term used to describe a substance's ability to

All of these factors have an impact on microbial activity. Bacteria or their enzymes must come into touch with the pesticide, as well as the pesticide and its metabolites must be delivered inside the cell for breakdown to occur. Some bacteria respond to substrates via chemotactic reactions, which may play an essential role in the environment; other develop in a filamentous shape toward possible substrates. Microbial activity is increased in the rhizosphere, which surrounds plant roots; for example, p-nitrophenol, a parathion hydrolysis product was mineralized more quickly in the rhizosphere of rice than in unplanted soil under non-flooded and flooded circumstances. Although it is becoming clear that large numbers of metabolically varied bacteria live in subterranean settings, little is known about their capacity to digest pesticides. Atrazine metabolism has been found in subsoils, although the microorganisms involved have not been identified studied carbofuran breakdown rates in maize fields. The degradation rates in the planted furrow were considerably greater than between the rows of maize. Differences in breakdown rates may be attributable to the pesticide administration technique or, alternatively, increased accessible carbon in the plant rhizosphere, which could boost microbial activity under the right circumstances[8].

The acclimation period refers to the time it takes for certain pesticides to biodegrade, i.e. the time it takes for no substantial breakdown to occur. Several explanations for acclimatization have been suggested. The acclimation period may represent the time it takes for the pesticide-degrading population to grow to a size that allows for faster degradation rates. Mineralization rates rise gradually when 2,4-D is applied to soils, with concurrent increases in the number of 2,4-D-degrading microbes . The similar impact was seen after the application of propham and glyphosate to soils. Acclimation periods may also be caused by unfavorable environmental circumstances that inhibit microbial activity. Alternatively, not all microbial populations are capable of degrading a pesticide before it is applied for the first time.

In certain cases, biodegradation may need the development of a new characteristic within the community, such as catabolic genes, which can occur via either a relaxation of substrate specificity or inducer specificity of preexisting enzymes, or the acquisition of particular enzymes through genetic exchange[9]. It is expected that there will eventually be enough beneficial modifications to existing genes, as well as genetic exchange across strains, either on plasmids or transposable elements, in such populations to enable a cell to use the new compound/pesticide. Such a modification will provide the strain a selection advantage, perhaps allowing it to dominate the community and so amplifying the new characteristic to the point where it becomes part of the community genome. This isn't the creation of a new gene, but rather the transformation of pre-existing genes into a compound unique to the community[2].

Chemical Composition Microorganisms may destroy almost any biogenic chemical if they are given the right growing circumstances. Synthetic compounds, such as insecticides, often include functional groups such as chlorine substituents and new configurations that enhance recalcitrance and, as a result, contribute to higher persistence. DDT, for example, was resistant to degradation, while its non-chlorinated counterpart diphenylmethane was Dieldrin and aldrin are two more compounds that have proved to be refractory owing to chlorine substitutions. Recalcitrance is affected by the amount and position of chlorine substituents on a pesticide molecule; for example, 2,4,5-T [2,4,5-trichlorophenoxy)acetic acid] is more recalcitrant than 2,4-D. In the 1970s, when it became clear that chlorinated pesticides were refractory, efforts were undertaken to switch to more easily decomposed organophosphate insecticides[7].

Biological Abundance Pesticide biodegradation in soils may be hampered by the chemical's restricted availability. A variety of variables affect availability, but poor solubility and/or significant adsorption to the soil matrix have the most impact. The water solubility of a pesticide is determined by its chemical structure, size, and functional groups. Some pesticides are very soluble, whereas others are administered as water-soluble salts or amides to improve their dispersion. Pesticides that are less soluble are administered as an emulsion or fine particles suspension in an aqueous carrier. The application methods are designed to provide an equal dispersion of the pesticide, which may help with biodegradation. Microorganisms may need physiological adaptations such as surfactant synthesis to proliferate at the cost of pesticides with poor solubilities in water. When cultivated in the presence of the organophosphate fenthion, two Bacillus spp. have been shown to generate emulsifying agents[7]. Pesticide compounds in soils may attach firmly to organic materials, limiting biological availability. Sorption of pesticides may increase or reduce microbial breakdown rates in soil. The pesticide dosage sprayed to the soil may be hazardous, but once bonded to the soil, the toxicity seems to be reduced, enabling biodegradation to occur.

Singh and Sethunathan investigated the breakdown of carbofuran sorbed to three distinct soils; degradation occurred significantly more rapidly in alluvial soils than in soils rich in organic matter. Because carbofuran was desorbed considerably more rapidly from alluvial soil, it seems that soil-sorbed carbofuran breakdown rates were linked to its desorption. It's conceivable that pretreating contaminated soils with surfactants is a way of increasing the pesticide's solubility and therefore its biodegradability. This method has been shown to improve the breakdown of the hydrocarbon phenanthrene in soil[10].

Pesticide Metabolism by Bacteria Pesticide degradation in situ is typically accomplished by a group of microorganisms rather than a single species. Pure culture investigations, on the other hand, allow for the discovery of the processes by which the pesticide is metabolized. The pesticide's transit into the cell, degradation routes, and the induction and control of degradative processes may all be investigated. The products of degradation are separated and identified. Pure culture studies also allow for the identification of genes involved in pesticide degradation, which can lead to the identification of genes involved in pesticide degradation and the development of specific gene probes for in situ detection of these organisms without the need for prior cultivation. Many of the microorganisms that can breakdown pesticides in pure culture have been isolated using traditional isolation methods such as enrichment culture and plating procedures. Bartha examines the techniques used shown in Table 1 [11].

Table 1: Examples of bacteria able to degrade pesticides in pure culture.

Pesticide group	Bacteria
Chlorinated hydrocarbons DDT	eutrophus Alcaligenes
Phenoxy compounds 2,4-D	eutrophus Alcaligenes Flavobacterium Arthrobacter Cepacian Pseudomonas
Triazine atrazine	Norcardia Pseudomonas Pseudomonas Rhodococcus Rhodococcus
Organophosphates parathion	Pseudomonas diminuta ATCC 27551 Flavobacterium ATCC 27551
EPTC	Rhodococcus Arthrobacter Rhodococcus
Carbamates carbofuran	Pseudomonas aeruginosa Flavobacterium is a kind of bacteria. Flavobacterium

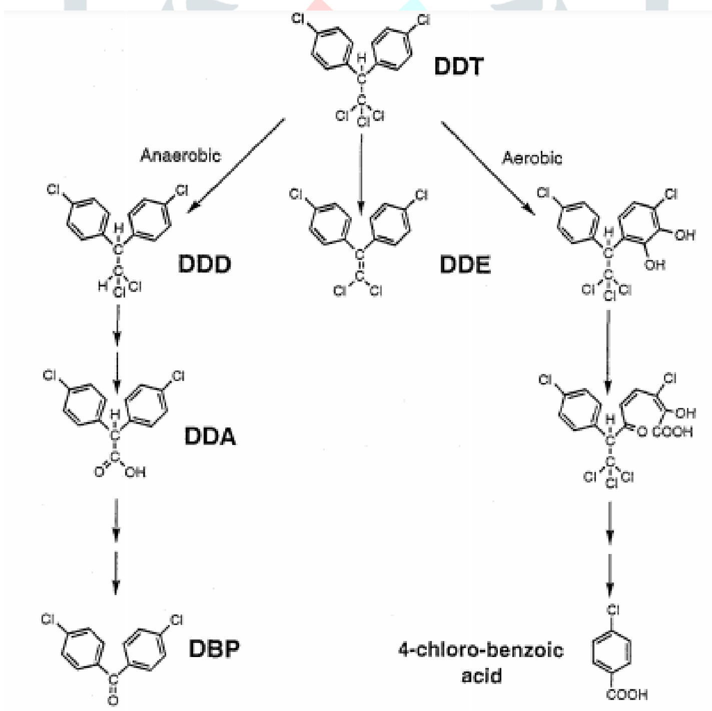

Figure 2: DDT breakdown mechanisms proposed by microorganisms. DDT stands for l,l,l-trichloro2,2-bis(p-chloropheny1)ethane.

DDT appears to be oxidized by a dioxygenase to yield a dihydroxy derivative that undergoes meta cleavage, ultimately yielding 4-chlorobenzoic acid, show in Figure 2, The dihydroxy-DDT intermediate and 4-chlorobenzoic acid were isolated as intermediates from resting cell incubations. This is the first report of aerobic metabolism of DDT by a bacterium, although the significance of resting, high cell-density incubations to environmental conditions is unclear, as is the significance, and prevalence, of strains such as this in DDT-contaminated soils. DDD stands for 1,l-dichloro-2,2-bis(p-chloropheny1)ethane. DDE stands for l,l-bis(p-chlorophenyl)-2-dichloroethylene. DDA stands for bis(p-chlorophenyl)-2-dichloroethylene. DBP stands Atrazine is a member of the s-triazine herbicide family.

It is used to control certain annual grasses and most broadleaf weeds in maize, sorghum, sweetcorn, and linseed crops in Australia and New Zealand. Atrazine's widespread usage and long-term persistence suggest that it may be a contaminant in both ground and surface waterways. This persistence may have consequences for water reuse, as shown by an Australian research that looked into residual atrazine in irrigation water on sensitive crops. There are just a few bacterial cultures that can metabolize atrazine in pure culture. Nocardia and Pseudomonas species enriched from atrazine-contaminated soil aerobically used one or more of atrazine's side chains.

2. DISCUSSION

Pesticide fate in the environment is affected by microbial activity. Some pesticides are readily degraded by microorganisms, others have proven to be recalcitrant. A diverse group of bacteria, including members of the genera Alcaligenes, Flavobacterium, Pseudomonas and Rhodococcus, metabolize pesticides**.** Pesticide usage has been plagued by issues, with the pendulum swinging from organochlorine persistence to non-chlorinated alternatives' poor effectiveness and fast biodegradation. This creates two issues that must be addressed the removal of persistent pollutants on the one hand, as well as the prediction and management of increased biodegradation on the other. To begin, how can soils with high amounts of persistent pesticides be decontaminated? The organochlorine pesticide DDT and its residual DDE accumulated in food systems owing to their sluggish breakdown rates. Leaching of pesticides into groundwater must also be addressed. Because atrazine and its metabolites may leak into ground water, it's crucial to figure out where degradation happens in real time. Given that atrazine biodegradation rates in subterranean settings are low , it is critical that the pesticide stay on the topsoil, where there is a much greater microbial population and the potential for pesticide breakdown is much increased.

3. CONCLUSION

Pesticide usage has been plagued by issues, with the pendulum swinging from organochlorine persistence to non-chlorinated alternatives' poor effectiveness and fast biodegradation. This creates two issues that must be addressed the removal of persistent pollutants on the one hand, as well as the prediction and management of increased biodegradation on the other. To begin, how can soils with high amounts of persistent pesticides be decontaminated? The organochlorine pesticide DDT and its residual DDE accumulated in food systems owing to their sluggish breakdown rates. This is owing to the compound's lack of breakdown or, conversely, it’s very sluggish metabolization rate. Novel solutions must be explored to address its persistence. Pretreatment with a surfactant may improve breakdown rates since DDT is insoluble in water and binds to organic materials. Leaching of pesticides into groundwater must also be addressed. Because atrazine and its metabolites may leak into ground water, it's crucial to figure out where degradation happens in real time. Given that atrazine biodegradation rates in subterranean settings are low, it is critical that the pesticide stay on the topsoil, where there is a much greater microbial population and the potential for pesticide breakdown is much increased.

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