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Biodegradation of Pesticides by Fungi and Microalgae

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INTRODUCTION

Pesticides have been used extensively throughout the intensive agriculture age to provide the ever-increasing demand for agricultural products. Pesticides are also extremely important economically, with a business worth billions (Shattuck 2021). As per the report of Business Research Company, in 2019, 84.5 billion US dollars in income was created, and by 2023, it is predicted to reach 130.7 billion US dollars (Adeola 2020). Pesticides are described by the World Health Organization (WHO) as a chemical substance which is used to control the population of insects, pests, and rodents, as well as to prevent the plant from plan pathogens (Leong et al. 2020). Long term usage of these pesticides leads to the development of resistance to them, and eventually leading to the use of higher dosage. Pesticide use improves agricultural yields, but uncontrolled use can result in pollution and harm. Excess pesticides can leak into soil, contaminating upper aquatic habitats, rivers, and streams (Weldeslassie et al. 2018). Run-off from farm areas or pesticide dispersion is the major sources of pollution. Pesticide pollution not only degrades the quality of water but also has an impact on aquatic biota (reduced algae and larvae populations), resulting in a biological disequilibrium. The retention or biological degradation of a pesticide is determined by its chemical nature. Pesticides can be divided into two types based on their chemical structure: chlorinated and non-chlorinated pesticides (Bose et al. 2021). Organochlorine based pesticides are the most stable in nature among chlorinated pesticides and cause biomagnification in biotic components, resulting in contaminated food (Zhou et al. 2018). They are physiologically highly stable and lipophilic, which means they degrade more slowly in nature. There are numerous kinds of organochlorine pesticides, each with a varying amount of toxic, such as endosulfan, eldrin and dieldrin.

Physicochemical methods have been used to reduce the toxicity levels of pesticides, but the results were not satisfactory on long term (Pang et al. 2020). The treatment options available for degradation of pesticides are quite costly, and they include complicated or dangerous chemical ingredients. Pesticides causes pollution and also cause damage to the living aquatic biota. Many water borne diseases are emerging due to the pesticide contaminated water bodies leading to 3.1% death rate as reported by World Health Organization (WHO) (Qadri et al. 2020). The toxic drinking water negatively impacts the human health and causes various disorders like neurological diseases, reproductive disorders, immune system suppression and cancer also. Lack of proper rules and regulations leads to overuse of pesticides in agricultural sector and ultimately leading to its accumulation in soil and water. Banned pesticides like dichlorodiphenyltrichloroethane (DDT) are still persistent in some regions even after 20 years of being applied. The level of persistence depends upon the chemical structure of the pesticide (Ma et al. 2020).

Mechanism of pesticide degradation

The pesticide residues can be degraded by fungal population and they are converted into non-toxic form and released back into the soil. Further, the bacteria present in the soil helps in complete degradation of the pesticides through co-metabolism and mineralization. The process of degradation takes place in 3 steps: (1.) Oxidation (2.) Hydrolysis (3.) Reduction (Bose et al. 2021). The enzymes responsible for the degradation of pesticides can be classified in 4 classes *viz.* hydrolases, translocases, oxidoreductases and transferases. Hydrolases are esterases like monophosphatase, phosphodiesterase and phosphotriesterase. They can degrade carbamate and organophosphate compounds (Bhatt et al. 2021). Oxidoreductases includes peroxidases, monooxygenases (e.g. cytochromeP450), dioxygenase and oxidases that facilitate redox reactions to breakdown the pesticides (Horn et al. 2021). Transferases conjugate the pesticide molecule with different groups eg.- glutathione S transferase, acetyl transferase and methyl transferase to aid biodegradation (Bapat et al. 2022).

Oxidation is the first step of pesticide degradation. It makes the compound water soluble. H_2O_2, superoxide radicals, hydroxyl and peroxide radical helps in oxidation. The degradative mechanism of dieldrin through *Phlebia aurea* to form 9-hydroxyaldrin is exhibited by oxidation and hydroxylation reaction (Pang et al. 2022).

Hydrolysis of esters form non-toxic compounds and the hydraulic activity can be enhanced by using alkaline medium for alkali-induced hydrolysis and acid medium for acid-induced hydrolysis. The degradation of endosulphan to produce endosulfan diol takes place by hydrolysis and oxidation (Mudhoo et al. 2019).

Reduction involves addition of hydrogen atom to the pesticide residue rendering it non-toxic in nature. It takes place under specific pH, temperature and anaerobic conditions in waterlogged areas, bogs or eutrophic lakes. Degradation of hexachlorocyclohexane takes place by replacement of chlorine with hydrogen (Zhao et al. 2020). The removal of chlorine makes hexachlorocyclohexane non-toxic. Thus, this degradative pathway involves reduction, non-reductive elimination and substitution reaction.

Other reaction are also significant in the biodegradation of pesticides involves rearrangements, cyclisation, dimerisation, biosoption and bioaccumulation (Bose et al. 2021).

Table 1- Studies on pesticide degrading fungi and algae

Pesticide	Fungi	Reference
Lindane	*Phanerochaete chrysosporium*	Xiao and Kondo (2020 a)
Heptachlor	*Phlebia tremellosa*	Xiao and Kondo (2020 b)
Heptachlor epoxide	*Phlebia acanthocystis*	Xiao and Kondo (2020 b)
Hexachlorocyclohexane	*Phanerochaete chrysosporium*	Sineli et al. (2018)
Dichlorodiphenyltrichloroethane	*Cladosporium sp*	Shirani-Bidabadi et al. (2020)
Dichlorodiphenyldichloroethylene	*Phanerochaete chrysosporium*	Zainith et al. (2020)
Dichlorodiphenyldichloroethane	*Trichoderma sp*	Nykiel-Szymańska et al. (2020)
Lindane	*Pleurotus ostreatus*	Xiao and Kondo (2020 a)
Aldrin	*Phlebia acanthocystis*	Xiao and Kondo (2019)
Dieldrin	*Phlebia acanthocystis*	Xiao and Kondo (2019)
Alpha endosulfan	*Fusarium ventricosum*	Mukherjee et al. (2019)
Beta endosulfan	*Fusarium ventricosum*	Mukherjee et al. (2019)
Endosulfan	*Aspergillus niger*	Ahmad (2020)
Pesticide	Algae	Reference
Dimethomorph	*Scenedesmus quadricauda*	Yadav and Sharma (2019)
Prometryne	*Chlamydomonas reinhardtii*	Jin (2012)
Fluroxypyr	*Chlamydomonas reinhardtii*	Wang et al. (2020)
Bisphenol	*Monoraphidium braunii*	Phouthavong-Murphy et al. (2020)
Mesotrione	*Pediastrum tetras*	Zhang et al. (2020)

Strategies for enhancement in biodegradation

Various methods can be used to elevate the capacity of micro-organisms to degrade the pesticides.

3.1. Bioattenuation involves conversion of complex pesticides into simpler compounds through biosorption and volatilization techniques, ultimately increase the rate of biodegradation by fungi (Olu-Arotiowa et al. 2019).

3.2. Bioaugmentation involves introduction of microbes on the pesticide contaminated site. It increases the catabolic activity and leads to degradation (Castro-Gutiérrez et al. 2020).

3.3. Biostimulation involves increase in the supply of nutrients, promote the enzymatic activity in microbes to facilitate pesticide degradation (Baćmaga et al. 2019).

Challenges

The pesticide population load can be degraded using microbial metabolism. The process of degradation is catalyzed by the enzymes released by the fungi and algae. Therefore, scientists are focusing on purification of enzymes capable of degrading the pesticides. But, the enzymes are immobile and they can't tolerate the adverse environmental conditions.

Understanding the microbial degradation pathway is also significant since it aids in the prediction of degradation by-products. By-products formed after the decomposition of the parent chemical can sometimes be harmful, accumulating in the surroundings and slowing down the disintegration rate of the parent component.

CONCLUSION

Pesticide use has expanded indiscriminately in recent years, resulting in environmental damage, particularly soil and water contamination. Pesticides come in all sorts of forms, but organochlorine pesticides, which are difficult to degrade, are the most durable. The research community has been working to come up with creative approaches to reducing pollution, such as biological degradation. The process is carried out by microorganisms such as bacteria and fungi, with enzymes playing a significant role in the decontamination of xenobiotics. Although this method is environmentally benign, feasible, and encouraging, it does have certain drawbacks. The metabolic routes followed by microbes are highly influenced by external environmental factors. As a result, there are still a few areas where more research is needed before this strategy can be declared successful.

REFERENCES

Adeola, F. O. (2020). Global Impact of Chemicals and Toxic Substances on Human Health and the Environment. *Handbook of Global Health*, 1-30. https://doi.org/10.1007/978-3-030-05325-3_96-1

Ahmad, K. S. (2020). Remedial potential of bacterial and fungal strains (*Bacillus subtilis, Aspergillus niger, Aspergillus flavus* and *Penicillium chrysogenum*) against organochlorine insecticide Endosulfan. *Folia microbiologica*, *65*(5), 801-810. https://doi.org/10.1007/s12223-020-00792-7

Baćmaga, M., Wyszkowska, J., & Kucharski, J. (2019). Biostimulation as a process aiding tebuconazole degradation in soil. *Journal of Soils and Sediments*, *19*(11), 3728-3741. https://doi.org/10.1007/s11368-019-02325-3

Bapat, G., Mulla, J., Labade, C., Ghuge, O., Tamhane, V., & Zinjarde, S. (2022). Assessment of recombinant glutathione-S-transferase (HaGST-8) silica nano-conjugates for effective removal of pesticides. *Environmental Research*, *204*, 112052. https://doi.org/10.1016/j.envres.2021.112052

Bhatt, P., Zhou, X., Huang, Y., Zhang, W., & Chen, S. (2021). Characterization of the role of esterases in the biodegradation of organophosphate, carbamate, and pyrethroid pesticides. *Journal of Hazardous Materials*, *411*, 125026. https://doi.org/10.1016/j.jhazmat.2020.125026