Agricultural Pollution: Mitigating the Effects of Pesticides

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***Abstract*— Modern agricultural practices have started the process of agricultural pollution with the use of pesticides on crops. Pesticides are substances used to control or eradicate pests. The overuse of pesticides can generate agricultural pollution which is addressed by the Sustainable Development Goal N° 2 "Zero Hunger" in the aspects of food security and sustainable agriculture. Therefore, in this paper there will be an analysis of the problem of the use of pesticides in agriculture and several manners to mitigate them and in addition to this, will be an analysis of possible solution or strategies to address that issue. With this purpose in mind, this paper will follow the next order. First, there will be an account of the pollution by means of pesticides used in cultivated farm areas, as to identify the severity of the problem and its implication in the contamination of the environment. Secondly, there will be a section that will discuss possible solutions to the problem and finally there will be another that will discuss the advantages and disadvantages of the solutions. This paper is expected to contribute to the analysis of the implications of the use of pesticides in agriculture and to raise awareness of their effects on people and the environment.**

***Keywords:* Agricultural pollution; pesticide effects; mitigation of pesticides effects; degradation of pesticides.**

***Resumen*— Las prácticas modernas de agricultura han comenzado el proceso de contaminación por agricultura con el uso de pesticidas en los cultivos. Los pesticidas son sustancias usadas para controlar o erradicar pestes. El uso excesivo de pesticidas puede generar contaminación por agricultura la cual es una de las metas del Objetivo de Desarrollo Sostenible N°2 "Hambre Cero" en los aspectos de seguridad en los alimentos y agricultura sustentable. Por lo tanto, en este paper habrá un análisis del problema del uso de pesticidas en la agricultura y varias maneras de mitigarlos y además de esto, habrá un análisis de posibles soluciones o estrategias para abordar ese problema. Con este propósito en mente, este paper seguirá el siguiente orden. Primero, se realizará un recuento de la contaminación por medio de pesticidas usados en áreas agrícolas, así como una identificación de la severidad del problema y sus implicaciones en la contaminación ambiental. Segundo, encontraremos una sección que tratará posibles soluciones al problema y finalmente encontraremos una puesta en valor de las ventajas y desventajas de las soluciones. Este paper tiene como finalidad contribuir al análisis de las implicancias del uso de pesticidas en la agricultura y promover la conciencia de sus efectos en la gente y el medio ambiente.**

***Palabras clave*: Contaminación Agrícola; efectos de los pesticidas; mitigación de los efectos de los pesticidas; degradación de pesticidas.**

I. Introduction

For thousands of years, agriculture was a natural process that did not harm the land where the crops grew. In fact, farmers had the opportunity to inherit their land for many generations and the land would remain fertile. Nowadays, the development of different ways of farming and agriculture are the reasons why humans can live in the world. These ways are necessary means of survival and not having them can lead to famine all over the world.

However, modern agricultural practices have started the process of agricultural pollution with the use of pesticides on crops. Pesticides are substances used to control or eradicate pests [1]. The use of this kind of substances causes the degradation of the land and, more important, it negatively affects the environment around it.

Due this type of pollution, there is a need to ensure sustainable agricultural practices. This issue has been addressed by the United Nations in its report on the Sustainable Development Goals (SDG) since its publication in 2015. Sustainable Development Goal No. 2, which is called "Zero Hunger", or more specifically named as "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" [2, p.12] is related to this issue. This SDG has targets which address food security, nutrition and sustainable agriculture, ensuring that all people have access to adequate and nutritious food. Also, it addresses the promotion of sustainable use of natural resources to support human well-being and environmental balance.

In order to discuss the implementation of strategies related to SDG No. 2, in this paper there will be an analysis of the problem of the use of pesticides in agriculture and several manners to mitigate them. It will also analyse possible solutions or strategies to address this issue.

With this purpose in mind, this paper will follow the next order. First, there will be an account of the pollution by means of pesticides used in cultivated farm areas, as to identify the severity of the problem and its implication in the contamination of the environment. Secondly, there will be a section that will discuss possible solutions to the problem and finally there will be another that will discuss the advantages and disadvantages of the solutions. This paper is expected to contribute to the analysis of the implications of the use of pesticides in agriculture and to raise awareness of their effects on people and the environment.

II. Effects of the use of Pesticides

Pesticides are defined by the Food and Agriculture Organization (FAO) of the United Nations as a method for specific agricultural activities connected with the control of pests. This method consists in using a substance or a mix of substances to control, prevent, destroy any pest, animal or human disease vectors, undesirable plants. Also, it is used to

combat animal species that affect the production, management, sell, storage, and transportation of food. [3].

Pesticides are to be lethal only to the targeted pests, but this is not, in fact, exactly like that. These have different compounds including fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and other substances which can affect other living beings [4].

Although pesticides are fast and efficient solutions, they also bring about problems as the bad management and control of its use on the agricultural plantations. To guarantee the attainment of productive outcomes, manufacturers tend to make use of great amount of pesticides, which could lead to the danger of an overexposure to such pesticides. This exposure will both affect the product itself and the agricultural context where it is obtained [4].

The effects of using pesticides with no control or incorrect management in agricultural productions processes are present in every stage of its own production line. Starting with the contamination of agricultural crops, water, air, and local fauna within the agricultural region, the impact extends to the final product. Even minute quantities of chemicals, sufficient to pose health risks, can lead to the pollution of food. Also, the fauna affected by pesticides in agricultural areas can also be polluted and its consumption will affect the human health.

III. SOLUTIONS TO THE EFFECTS OF THE USE OF PESTICIDES

According to [5], approximately 9,000 species of insects and mites exist throughout the world. This means 8,000 species of weeds and 50,000 species of plant pathogens that damage crops. Different pests such as insects and plants cause losses estimated at 14% and 13% respectively. For this reason, pesticides are essential in agricultural production. Approximately one third of agricultural products are produced using pesticides. Without the application of these, the loss of fruits, vegetables, and cereals due to pests would reach 78%, 54% and 32% respectively. Crop loss due to pests is reduced by 35% to 42% when pesticides are used.

Although pesticides are beneficial for controlling the proliferation of pests, their unregulated and indiscriminate applications can cause adverse effects on human health, different forms of life and ecosystems. All these problems depend on the degree of sensitivity of the organisms and the toxicity of the pesticides.

For these reasons, various solutions will be presented. Some of these directly replace pesticides with ecological agricultural practices, others are based on the application of pesticides but at the same time on the decontamination of soil and food in the production chain.

A. Degradation of Pesticides by Ultraviolet Light

The ultraviolet light can be used to degrade pesticides. According to [6], the neutralization of agrochemicals using ultraviolet light (UV) is a method that consists of exposing chemical substances used in agriculture, such as pesticides and herbicides, to ultraviolet radiation in order to decompose or degrade these compounds into forms which are less toxic or not active. This process is based on photodegradation. The pesticide molecules are excited after absorbing energy from UV or visible light, resulting in their deactivation and breakdown into simpler and less harmful products.

Ultraviolet light can also be implemented as a replacement of agrochemicals in the field and in food production chains. This is because it is germicidal, which means it can be used effectively as a disinfectant to kill microorganisms, such as bacteria and viruses [7].

UV light works as follows. When the DNA of microorganisms absorbs ultraviolet light, it prevents them from reproducing and duplicating. Thus, this prevents their growth [7].

B. Degradation of Pesticides by Microorganism

Biodegradation is another form to degrade pesticides. It is a process that involves the complete rupture of an organic compound in its inorganic constituents. Among microbial communities, bacteria, fungi and actinomycetes are the main pesticide transformers and degraders. Fungi often bio transform pesticides and other xenobiotic substances by making small changes in the structure of the molecule, rendering it nontoxic. Biologically processed pesticides are released into the environment, where they are likely to be further degraded by bacteria [5].

Fungi and bacteria are considered excellent producers of extracellular enzymes. White rot fungi have been proposed as promising bioremediation agents, especially for compounds that are not easily degraded by bacteria. This ability arises from the production of extracellular enzymes that act on a wide range of organic compounds, as stated in [5].

The application of enzymes to transform or decompose pesticides is an advanced treatment technique aimed at removing these chemicals from contaminated environments, as [8] points out. Due to the diversity of chemicals used in pesticides, the biochemistry of pesticide bioremediation requires a variety of catalytic mechanisms and thus a variety of enzymes. Information for some pesticide degrading enzymes can be found in Table I.

TABLE I
Relevant enzymes in the bioremediation of pesticides [8]

Enzyme	Organism	Pesticide
Oxidoreductases (Gox)	*Pseudomonas* sp. LBr	Glyphosate
	Agrobacterium strain T10	
Monooxygenases:		
ESd	*Mycobacterium* sp.	Endosulphan and Endosulphato
Ese	*Arthrobacter* sp.	Endosulphan, Aldrin, Malation, DDDT and Endosulphato
Cyp1A1/1ª2	Rats	Atrazine, Norflurazon and Isoproturon
Cyp76B1	*Helianthus tuberosus*	Linuron, Chlortoluron and Isoproturon
P450	*Pseudomonas putida*	Hexachlorobenzene and Pentachlorobenzene
Dioxygenases (TOD)	*Pseudomonas putida*	Herbicides Trifluralin
E3	*Lucilia cuprina*	Synthetic pyrethroids and insecticides phosphotriester
Phosphotriesterases:	Agrobacterium radiobacter	Insecticides phosphotriester
OPH/OpdA	Pseudomonas diminuta	
	Flavobacterium sp.	
Haloalkane Dehalogenases:	*Sphingobium* sp.	Hexachlorocyclohexane (β and δ isomers)
LinB	*Shingomonas* sp.	
AtzA	*Pseudomonas* sp. ADP	Herbicides chloro-s-trazina
TrzN	*Nocardioides* sp.	Herbicides chloro-s-trazina
LinA	*Sphingobium* sp.	Hexachlorocyclohexane (γ isomers)
	Shingomonas sp.	
TfdA	*Ralstonia eutropha*	2,4 - dichlorophenoxyacetic acid and pyridyl-oxyacetic
DMO	*Pseudomonas maltophilia*	Dicamba

C. Replacement of Insecticides by Biological Control

Integrated pest management or biological control is defined by [8] as the reduction of pest populations by natural enemies (thus avoiding the use of agrochemicals). This is frequently referred to as natural control.

As the name of this method indicates, the replacement of insecticides by biological control emphasizes the biological control of insects. However, biological control of weeds and plant diseases is also included. Natural enemies of insect pests, also known as biological control agents, include predators, parasitoids, and pathogens [8].

The use of biological control agents such as microbial pesticides and parasitic insects can offer an environmentally friendly alternative. As well as this, it has a high potential to mitigate significant economic losses in agriculture and promote public health [9].

To develop this technique well, the first step is trying to discover a suitable natural enemy, which could be a bacterium, a fungus or an insect that can kill the target pest. Once in the laboratory, investigations are carried out to see if it could harm non-target organisms. This is a very important step because it is expected that this new organism does not cause further problems. Research is then carried out to produce large quantities of the suitable natural enemy.

In this line, research is being done to find a way to keep such good microbe alive for long periods of time. This last step allows the commercialization of the biological agent that consumers can use to combat specific pests [9].

IV. ENCOMPASSING THE ADVANTAGES AND DISADVANTAGES OF THE SOLUTIONS

A. Degradation of Pesticides by Ultraviolet Light

The degradation of pesticides by ultraviolet light has several advantages. As this light is radiated with UV-C LEDs, this brings about benefits like being more environmentally friendly, more compact, more durable, more capable of instantly work without previous warm up time, and most importantly, more configurable to reach the effectiveness. Also, by using UV-C LEDs, the use of mercury is not a problem because they are mercury-free, as stated by [7].

Whereas UV light degradation has benefits, it also has aspects like being restricted to only disinfect few unwelcomed microbial beings or microorganisms making it less convenient in the rest of cases. The UV-C is germicidal so it can only be used against bacteria and viruses. This limits the range of the application field [7].

B. Degradation of pesticides by microorganisms

The degradation of pesticides by microorganisms is considered one of the best solutions to combat the chemical compound in pesticides. It is an effective, economic, and environmentally friendly technique. Although it is a good alternative, it has not been fully developed or investigated [5].

C. Replacement of Insecticides by Biological Control

Some of the advantages of microbial control include reducing the use of chemical pesticides and environmental pollution and improving crop quality. Additionally, biological agents can be very specific when targeting only a specific pest, making them economical in the long run and, in some cases, they can be a self-sustaining system [9].

The disadvantage of classic biological control is that it does not always work. It is generally more effective against exotic pests and less effective against native insect pests. The reasons for failure are often unknown, but they may include the release of too few individuals, poor adaptation of the natural enemy to the environmental conditions at the release site, and lack of synchrony between the life cycle of the natural enemy and the pest [8]

V. CONCLUSION

In conclusion, it can be said that the use of agricultural pesticides is harmful to the health of everyone including humans, animals, and the environment. If the use of pesticides is not addressed responsibly, the effects of agricultural pollution will be more severe, bringing about different and undesirable problems.

To address these problems, various of the possible solutions or products have been presented in this paper. Some of these solutions were the UV radiation, the biological control, and the use of microorganisms in different cases and degrees of effectiveness. This paper has shown that these solutions have more positive than negative aspects in terms

of degrading or replacing agricultural pesticides and, therefore, mitigating their effects.

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