Rivista Italiana di Filosofia Analitica Junior Vol 14, No. 2 (2023)
ISSN: 2037-4445

Evaluate the Safety and Environmental Impact of Common Pest Control Chemicals

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ABSTRACT

In order to minimise agricultural losses and maintain product quality, pesticides are used in agriculture to control pests, illnesses, plants, and other plant adversaries. However, occupational exposure to pesticides as well as leftovers in food and drinkable water pose significant health risks. Pesticides are developed in accordance with stringent regulations with the goal of functioning with reasonable assurance and having a minimum effect on human health and the environment. Workers in the agricultural industry who toil in open fields and gardens, those who make their living in the insecticide industry, and those whose job it is to rid homes of household pests are frequently subjected to chemical hazards on the job. Although pesticides are primarily ingested through food and drink, they can also be discovered inside the house. The toxicity of the pesticide, the application techniques, the amount, the absorption on soil colloids, the atmospheric conditions after application, and the length of time the pesticide spends in the environment are all factors that influence its effect on the environment. It is challenging and unreliable to conduct risk assessments of the impacts that pesticides have on human health and the environment because of the disparities in the lengths of exposure, kinds of pesticides, and circumstances in the environment. The number of parameters that are used and the technique that is used to implement them to evaluate the detrimental effects of pesticides on human health could have an impact on risk assessment as well as the characterization of pesticides that have already been authorised and the approval of novel chemicals in the near future. As a result, new methods or tools with a higher degree of certainty are required to accurately predict the dangers posed by herbicides and lessen the adverse effects these chemicals have on human health and the environment.

The World Health Organization (WHO) assigns different levels of danger to different types of pesticides, with a focus on the protection of human health. Both human health and the health of the environment can benefit from their meticulous application and comprehension of their categorization. This research examines the natural impacts of pesticides as well as their widespread use. The primary focuses of research were on the impacts that pesticides have on natural systems, water, plants, human health, and food preservation. Herbicide control techniques that are friendly to the environment include bacterial decomposition, mycoremediation, phytoremediation, and bioremediation based on microalgae. Catabolic enzymes are used by microbes to break down toxic substances and clean the environment. This research highlights the importance of evaluating the effects of pesticides on both human health and the environment.

Keywords: Environmental, Pest Control Management, and Agriculture.

1. INTRODUCTION

Pesticides are chemical compounds that are used to eliminate insects, rodents, fungi, and weeds. Products in this group include chemicals used to kill or prevent the growth of insects, weeds, nematodes, fungus, molluscs, rodents, and even plants [1]. Aquaculture, farmland, food preparation, and storing are just some of the commercial and food-based sectors that use it to safeguard crops, preserve food, and prevent the spread of disease via carriers. Insects, rodents, and other unwanted critters are referred to as "pests" in the United States. Pesticides eliminate pests or deter them.

The Controlled Substances Act defines insecticides broadly to include any substance used to control or kill plants. [2]. Pesticides are defined as "substances or compounds used for the control, prevention, or elimination of pests, animal or human disease vectors, and undesirable plant or animal species that impact food production, administration, marketing, storage, and transportation." Invasive species, undesirable flora and fauna, and disease carriers are all examples of pests. Pesticides have been used to control pests since the beginning of time. Sulfur-based chemicals are widely used as pesticides. More than 2,000 years have passed since the first documented use of Pyrethrum, or *Chrysanthemum cinerariaefolium*, as an insecticide. Before Paul Herman Muller developed Dichloro Diphenyl Trichloroethane (DDT) as a potent pesticide in 1939, pests were managed using saline water, organic chemicals, and synthetic chemicals. In the beginning, there was DDT. DDT increases both crop yield and food shelf life. The resultant worldwide rise in DDT consumption paved the way for the development of novel toxic chemicals. In the United States, DDT was replaced by organophosphates and carbamates after 1975.

According to Fernández 2021, China consumed 1.76 million metric tonnes of pesticides in 2019 [3]. The Brazil with 377 thousand, and finally Argentina with 204 thousand tons . Twenty percent of emerging nations use pesticides, including Cambodia, Laos, and Vietnam, according to the World Health Organization. Organochlorine pesticides like benzene hexachloride and DDT account for 90,000 metric tonnes of India's annual pesticide output. We can attribute 47.5% of the issue to herbicides, 29.5% to pesticides, 17.5% to fungicides, and 5.5% to other toxins. There are different types of pesticides. Based on their mode of action, chemical makeup, and target pests, pesticides can be broken down into three groups. Both the WHO and the GHS placed a premium on the need to categorise herbicides according to their toxicity or other harmful effects.

Pesticides have direct benefits, such as reducing pests that eat cabbage, that boost both output and quality [4]. The major results have twenty-six secondary effects, spanning from the upkeep of lush gardens to the safety of human lives. Unlike the more obvious main advantages, secondary benefits take longer to manifest. They could be subtle or time-consuming. There may be compelling reasons to use pesticides for their secondary benefits, but it is trickier to prove cause and effect. Cabbage output increases tax income, which in turn funds programmes that benefit children's health and education. Healthier people and territory that can be farmed forever while still maintaining wildlife are two side benefits. This was achievable with the help of herbicides, better irrigation practices, and high-yield crops. The yields of both wheat and corn in the United Kingdom and the United States have gone up. It has been hypothesised that developments in goods, equipment, and fertilisers are responsible for the uptick in output. Pesticides are essential in the food manufacturing and production industries because of the devastating effects that insects, diseases, and other pests can have on farming yields. Warren [5] noted that the 20th century saw a rise in food supply in the United States. Pesticides are used to increase agricultural harvests, protect food sources, and reduce the dangers involved. By using a wide variety of pesticides and applying them sparingly, we can reduce unnecessary application, contact, and harm. Due to the wide range of negative outcomes associated with herbicide use, careful refuse control is essential.

Pesticide biodegradation is a method of waste control that is both environmentally and eco friendly [6]. The capacity of microorganisms to break down harmful compounds has many applications for human health. Microorganisms discovered in garbage or soil have been shown to degrade herbicides in recent studies. Phytoplankton, Algae, Bacteria, Actinomycetes, and other Microorganisms. In this study, microbes and enzymes play a central part in the biodegradation of pesticides. There is a dearth of data on the types of pesticides, their toxins, and the methods for cleaning up their damage to the ecosystem. This document provides a summary of the most up-to-date methods for properly disposing of pesticides. This study examines the relationship between living systems, bioremediation, and the removal of contaminants.

2. CLASSIFICATION OF PESTICIDES

Pesticide toxicity in biological systems is determined by both the chemical composition and the quantity of the pesticide [7]. Pesticides include pesticides, fungicides, algicides, rodenticides, disinfectants, and antibacterials. When deciding which of two groups a herbicide belongs in, both its physical and chemical characteristics are considered. Organophosphates, organochlorines, carbamates, and pyrethroids made up the bulk of man-made toxins. Biopesticides can be made from a wide variety of sources, including plants, microbes, and fungi.

2.1. Classification of pesticides on the basis of toxicity

Dosage and duration are important factors in pesticide damage [8]. Herbicides can cause acute harm to animals, vegetation, and people even after brief exposure. If a herbicide has a high acute toxicity, even a small dose can be fatal. Both acute cutaneous toxicity (e.g., less than 50-mg/kg body weight of rat; highly; 50-200-mg/kg; moderately; 200-2,000-mg/kg, etc.) and acute oral toxicity (e.g., less than 5-mg/kg; highly; 5-50-mg/kg; moderately; 50-200-mg/kg, etc.) are used by the WHO to classify pesticides. Poisoning from pesticides has deadly long-term consequences. Both the broader population and people who work in the pesticide business are worried about the long-term effects of these toxins. Dangers from pesticides can be broken down into distinct categories, as defined by the WHO. In 2009, this categorization scheme joined the Globally Harmonized System based on the type of bug they are destroying, how they operate, and how they avoid illnesses, pesticides can be split into three categories. The following five types of input can be distinguished from it: There are several different types of pesticides, including: (1) Systemic pesticides, which are absorbed by animals or plants and transferred to other locations; in plants, this includes entering into untreated tissues of roots, stems, or leaves via multidirectional movement through the vascular system; (2) Non-systemic or Contact pesticides, which must come into contact with the pest directly; (3) Stomach toxicants, which enter the digestive tract and are absorbed inside the insect's body; and (4) Natural predators, which must come.

3. PESTICIDE AND SAFETY

When deciding whether or not to grant a herbicide product a license, authorities take into account the product's potential impact on human and environmental health [9]. Authorities can control the claims, labeling, packing, and promotion of herbicides once they are registered. This safeguards both consumers and the natural world. The process of getting a permit also needs proof that the intended use of herbicides presents no threat to human health or the natural ecosystem. Therefore, before any herbicide can be used commercially, it must first undergo a series of tests to determine if it poses a threat to humans, wildlife, endangered species, and other non-target creatures, and if it contaminates surface water and groundwater through absorption, discharge, and aerosol spread. The introduction of any non-target species into an ecosystem or food chain has the potential to have unintended consequences for human and animal welfare.The licencing process for pesticides is complex and takes substantial resources, knowledge, and effort from all stakeholders, including advocacy groups, pesticide producers, and regulatory agencies. There has been a rise in the amount of investigations into herbicide residues and toxicity in reaction to societal anxiety. Better hazard forecast methods, novel hazard reduction measures, and incorporating the growing body of relevant scientific knowledge into policy decisions can also lead to more effective herbicide licencing.

Basic procedures for herbicide licencing include the following [10], first, the manufacturer must decide whether or not to register the product; second, the manufacturer must submit a data report to the registration authority; third, the registration authority must review the data; and fourth, the registration authority must make a decision regarding product registration based on the data presented. The licencing authority weighs the benefits of herbicide use against the potential risks by compiling the necessary data. In light of this, it is essential that the registration process be open and honest, with criteria and instruction papers that can be easily found by anyone, and that the candidate be given full details of the results of each step along the way. The agency in charge of herbicide registration must also guarantee that all registered herbicides are free of harmful effects on people and ecosystems. These regulations are continuously being tightened as new information about chemicals becomes available. Scientific research into ancient toxins is being conducted alongside legal compliance checks. During the re-registration procedure, chemicals' impacts on human health and the ecosystem are assessed, and their risk levels are reduced if necessary. In reality, the list of herbicides that can be legally sold in the EU has been revised numerous times beginning in 1993 and continuing all the way up until December 2022. Pesticides made up 26%, herbicides 23%, and fungicides 17% of the 704 active substances that were prohibited. Many herbicide re-registration and tolerance review decisions have been finalised by the United States Environmental Protection Agency (EPA), which has enhanced product safety, human health, and environmental protection. Documents detailing the Re-registration Eligibility Decision outline the available options.

Manufacturers of pesticides [11] must perform, assess, and pay for a battery of scientific tests as part of the licencing process. The efficacy of the herbicide and the impacts on non-target species, as well as the makeup of the product, are studied in these trials. The information required to register an item should be comprehensive enough to span its complete lifetime. These should cover everything from the suggested label and uses to the safety data files, danger to humans and the environment, testing techniques, effectiveness for the intended use, herbicide leftovers, receptacle management, and waste product removal. It can require a lot of time and money to gather information about a particular drug. Toxicological research must adhere to strict standards, standard methods, and other requirements. Evaluations of herbicide safety and chemical analyses require accurate standards. Assessments of the ecological dangers of pesticides, with the end objective of learning what those dangers are and whether or not product usage must be altered to mitigate them for the sake of human health, animal health and the ecosystem. Experts at the licencing authority look at all the data they can get their hands on to decide how a herbicide will affect the ecosystem. If the risk evaluation shows that there is a high probability of damage to animals or phytotoxicity to non-target plants, the body responsible for granting permits may require more data and testing or require that only trained professionals apply the herbicide. The licencing body can decide not to allow operation.

4. IMPACT OF PESTICIDE ON HUMAN HEALTH

It is difficult and imprecise to assess the effects of pesticides on human health due to variations in exposure duration, dose, pesticide toxicity, field combinations, and climatic conditions among agricultural regions [12]. Those who live in close proximity to greenhouses, open fields, herbicide holding areas, or treatment areas are more apt to notice a change. So, it's likely that low exposure to a herbicide that's highly toxic is more dangerous to human health than high exposure to an insecticide that's only mildly toxic. However, the scientific community is still divided over whether or not herbicide traces in food and water pose a danger to public health.

Even though it can be challenging to perform a study of the hazards pesticides bring to human health, knowledge on possible health risks is necessary for the marketing of pesticides in Europe [13].

- These results are usually gleaned from a battery of experiments conducted on the metabolic rates of rodents, dogs, and bunnies.
- Experiments can be conducted to evaluate acute toxicity, sub-chronic or chronic toxicity, carcinogenicity, genotoxicity, teratogenicity, reproductive toxicity, irritancy, and generational effects.
- Acute toxicity tests, which evaluate the effects of short-term exposure to a single dose of pesticide and sub-chronic toxicity tests, which evaluate the effects of intermediate repeated exposure are both required by the EPA [14] for human health risk assessments
- Developmental and reproductive tests, which evaluate possible effects on exposed pregnant female's foetus and how pesticide exposure can affect a test animal's ability to reproduce successfully,
- Toxicological tests, which aim to determine the effects of a pesticide product

The ability of a herbicide to cause alterations in cellular DNA is evaluated in two ways: the mutagenicity test and the hormone disruption test. The endocrine system's susceptibility to pesticides is also evaluated with the help of the hormone disturbance test. The median lethal dose (LD_{50}) of a pesticide is the quantity of the chemical that, when ingested by animals, causes death in half of the tested specimens. The number reflects the mouth LD50 if the drug is ingested, and the dermal LD_{50} if it is taken through the skin. The acute respiratory lethal dose (LC_{50}) was also determined; this is the concentration of herbicide that must be inhaled for four hours for 50% of the animals to die. Inhalation and oral administration are both used at lethal doses. Tables 1-3 display the results used to create the WHO and EPA herbicide risk categories.

Table 1. WHO's categorization of pesticides & their acutetoxicity

Class	Classification	LD_{50} for the rat (mg/kg b.w.)			
		Oral		Dermal	
		Solids	Liquids	Solids	Liquids
Ia	Extremely hazardous	<5	<20	<10	<40
Ib	Highly hazardous	5–50	20–200	10–100	40–400
II	Moderately hazardous	50–500	200–2,000	100–1,000	400–4,000
III	Slightly hazardous	>501	>2,001	>1,001	>4,001
U	Unlike to present acute hazard	>2,000	>3,000	–	–

Table 2. EPA's categorization of pesticides & their acute toxicity

Class	Signal words	Acute toxicity to rat		
		Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)	Inhalation LC_{50} (mg/L)
I	DANGER	<50	<200	<0.2
II	WARNING	50–500	200–2,000	0.2–2.0
III	CAUTION	500–5000	2,000–20,000	2.0–20
IV	CAUTION (optional)	>5,000	>20,000	>20

Table 3. EPA's categorization of pesticides (eye and skin effects) & their acute toxicity

ISSN: 2037-4445

Class	Signal words	Acute toxicity to rat	
		Eye effects	Skin effects
I	DANGER	Corneal opacity not reversible within 7 days	Corrosive
II	WARNING	Irritation persisting for 7 days	Severe irritation at 72 hours
III	CAUTION	Irritation reversible within 7 days	Moderate irritation at 72 hours
IV	CAUTION (optional)	No irritation	Mild or slight irritation at 72 hours

It is easier for herbicides to reach the circulation through the gut than the skin, so their LD_{50}s in the food are smaller [15]. The LD_{50} values for pesticide active components derived from the World Health Organization's classification system need to be adjusted to account for the herbicide's actual ingredients. Because industrial pesticide toxicity is strongly influenced by their makeup. Emulsifiable pesticides, which increase the toxicity of the chemical, are more harmful than microencapsulated pesticides. Applying the emulsifiable concentrate instead of the microcapsule fluid increases the quantity of the toxic active ingredient that reaches the epidermis. Emulsifiable extracts are more hazardous than microcapsule solutions because they contain noxious chemical liquids. Because solids are harder to move through the skin, liquids are usually more toxic than solids. Long-term dosing studies with animals allow researchers to pinpoint the lowest herbicide concentrations at which no adverse effects are seen. The human average daily intake (ADI), or the safest quantity of a drug that can be taken repeatedly without ill effect over the course of a lifetime, is calculated using this dose. It's also referred to as the No Observed Effects Level (NOEL). An mistake number one hundred times higher than normal is used to calculate human food intake. The distinction between people and experimental creatures is thus removed. The Acute Reference Dose (ARD) is a computed number that accounts for circumstances in which people ingest food items contaminated with multiple kinds of pesticides at once and eat quantities of pesticides that are much higher than the ADI. Using the lowest NOEL as a starting point, ARD then makes adjustments for doubt. Short-term investigations of oral poisoning are used to establish the Acceptable Operator Exposure Level (AOEL) for herbicide workers.

5. PESTICIDE AND THE ENVIRONMENT

However, protecting only 30% of the world's farming goods with the widespread use of herbicides is bad for environments [16]. Herbicides cause harm and build in more areas than just farmland, and this may be due to insufficient governance, mishandling, or a lack of comprehension. Users don't take basic safety measures like covering their eyes and hands with plastic coverings as recommended by the manufacturer. Pesticides are bad for the ecosystem and the animals they don't target. Most particulate matter in the air comes from the earth and rain. Insecticides with a low volatility can be affixed to dust. The gas-phase interplay determines how long these particles survive. Persistent organic pollutants (POP) particles become much more toxic as a result of oxidation and photochemical processes. These POP's are insecticides, and their movement is influenced by a number of factors, including low water intake, climate, weather, temperature, and humidity. CUPs can be reprocessed and have a longer shelf life than organochlorine herbicides. How much of an effect pesticides have on the environment is determined by the ways in which their physicochemical properties, soil adsorption and persistence, soil factors [17], plant species, and climatic variation all interact with one another [18]. Pesticide toxicity, dose, weather conditions after application, and pesticide residue are additional potential environmental hazards. Pesticide outcome in the ecology, as well as the herbicide's activity, susceptibility, and environmental impacts, are known to be strongly influenced by soil and weather conditions [19]. This makes it impossible to perform field studies of herbicide impacts and behaviour in more than one place or over the course of more than one season. Therefore, in order to perform an environmental risk assessment, the behaviour and outcome of pesticides must first be investigated through the method of finding the PEC, which is known as the EEC in the United States [20]. To assess the effects of pesticides on key non-target species, these amounts are computed for soil, water, silt, and air, and then verified by comparing them to the three tiers of studies (Table 4). To assess personal risk, one can use the toxic exposure ratio (TER) [21]. To calculate the TER, we divide the LC_{50} or an equivalent measure of an organism's sensitivity (LD_{50}, NOEC = no observed effect dose) by the corresponding PEC. When the TER is below 100, a chronic risk assessment is required, while when the TER is below 10, a higher tier risk assessment [22] is required. If the TER is below 5, then the product will not be approved for use in the field unless it is absolutely certain, based on a thorough risk assessment, that it will not have any negative consequences under the conditions proposed for its implementation. The risk factor is the inverse of the threshold exposure ratio in the United States; it is determined by dividing the predicted exposure percentage by the recommended fatal dose.

Table 4. The 3 level of testing that determines the toxicity of pesticides to organisms other than their targets

Species	Tier 1 Acute toxicity	Tier 2 Reproduction test	Tier 3 Field test
Birds (bobwhite quail or mallard ducks)	LD_{50} (8–14 days)		Fish life cycle study
Freshwater fish (rainbow trout or minnows)	LC_{50} (96 h)	Effects on spawning	
Aquatic invertebrate (Daphnia, shrimp)	LC_{50} (48 h)	Full life cycle	
Non-target invertebrate (honey bee)	LD_{50} (48 h)	Effects of residues on foliage	Pollination field test
Non-target invertebrate (earthworms)	LC_{50} (14 days)	Effects of residues on foliage	
Aquatic plants (algae)	LC_{50} (96 h)	Plant vigour	
Other beneficial species	LD_{50} (48 h)		

6. CONTROLLING THE IMPACT OF PESTICIDES

An increasing number of people, it would appear, are worried about herbicides and the harm they may cause to both human health and the natural world [23]. These worries originated from scepticism regarding government environmental and health laws, as well as farming and commercial production methods. To decide whether or not a herbicide can be used safely, experts in the field need access to science data, policy guidelines, and their expert opinion due to the ambiguity regarding pesticide safety evaluations. Farmers worry that safer practises will force them to cut back on output or spend more on inputs like fertiliser and pesticides. Therefore, the farming community will be responsible for paying the expenses of herbicide risk reduction steps, which will have an effect on final product costs. Paul *et al.*, [24] used a cost-function-based production model to show that the elimination of pesticide-related environmental risk would increase output costs in the farming sector. These costs will instantly raise the bar for what is acceptable in terms of farming production, necessitating new approaches to insect control.

European Union (EU) officials recognised the dangers pesticides pose to people and the ecosystem, so they devised a Thematic Strategy on Sustainable Use of Pesticides [25]. To lessen the impact of conventional farming with pesticides on ecosystems and human health, agricultural experts have created alternative crop management practises. In order to ensure the safe output of farming goods while also protecting the ecosystem, peasant groups can follow the Integrated Crop Management (ICM) recommendations. Worker health and safety, product quality, assessment and tracking, and environmental concerns are also addressed in ICM [26]. We also talk about GAP, or good farming practises. Insect and fungal crop resilience, biological control, and other environmental and physical steps are all methods that are recommended by integrated pest management (IPM) for eradicating pests. The population of the animal nuisance or plant is reduced below the level of economic damage using these methods, and the effect of chemicals on other parts of the agro-ecosystem is minimised. Complementary pest management strategies include things like using crops that are resistant to insects and fungus, using biological control, and taking other cultural or physical measures. Only insecticides used in an IPM plan are allowed to be used under ICM. This software selects and applies herbicides to vegetation and checks for their presence in the final product. IPM pesticides are: (1) Biologically effective (high selectivity, rapid impact, optimal residual effect, good plant tolerance, low risk of resistance); (2) User-friendly (low acute toxicity and low chronic toxicity, optimal formulation, safe packaging, easy application method, long store stability); and (3) Environmentally friendly/compatible. (Low toxicity to non-target organisms, fast degradation in the environment, low mobility in the soil, no residues in food and fodder above the MRLs). Only an approximation should be used for the volume of the active component applied or the cost of the insecticides. This is because the dose of the active component does not correlate well with environmental action, and because chemicals that are safer for the ecosystem and more creative tend to be more costly. This shows that IPM would reduce the negative effects of pesticides on human health and the ecosystem without reducing farming output or increasing produce waste.

Chemical crop protection [27] has come a long way in recent years, with new active constituents discovered and a greater emphasis placed on assessing the environmental fate of these substances, the residues they leave on crops, and their potential toxicity to humans and wildlife. Chemical, biological, and molecular biology research has aided in both the discovery of new agrochemicals and the reevaluation of the safety of those already on the market. This has led to the development of new agrochemicals with improved safety profiles and novel modes of action. One of the oldest and most reliable agricultural practises is the use of chemical pesticides to safeguard crops. New agrochemicals and the right precautions for better and more effective pesticide application suggest that chemical crop protection will continue to play an important role in agriculture despite the fast rise of genetic solutions [28].

7. CONCLUSION

In recent years, there has been a rise in the use of pesticides, which has led to an increase in the contamination of land and water. Organophosphates, Organochlorine, Carbamates, and Pyrethroids are some of the most widely used pesticides, and each of these poses a danger to human health as well as the environment. It is important to have a solid understanding of the physical and molecular properties of pesticides in order to evaluate the impacts they have on the environment. These pesticides have to be changed into compounds that are non-toxic before they can be released. They have the highest level of resilience found in nature. Methods for reducing pesticide contamination have been tossed around in discussions among scientists. There are a number of different bioremediation techniques and systems that can either repair the problems caused by herbicides or develop healthier alternatives. In addition to being cost-effective and favourable to the environment, phytoremediation, algae bioremediation, mycoremediation, and microbial decomposition are all types of bioremediation. Today, microbial deterioration can be found everywhere. Chemicals and toxins produced by humans can be degraded by microorganisms and the enzymes they produce by the organisms. These pathways are not harmful to the environment in any way, but the metabolic pathways of microbes are extremely sensitive to environmental influences. Therefore, particular topics call for additional research before the applicability of this approach. It's possible that enzymatic degradation will occur. The study of enzymes that can break down man-made pesticides is becoming an increasingly vital area of research. Microbial decomposition is a slow and difficult process, whereas traditional bioremediation is quick and simple. In order to properly dispose of pesticide debris, it was necessary to use more robust microbes, updated DNA, and bioremediation techniques. There is also a contribution from biotechnology and microorganisms that have been genetically transformed. The presentation that was just watched demonstrates how pesticide-degrading microorganisms can be utilised to manage pesticide pollution in an environmentally responsible manner. Therefore, additional research on the species of microbes and enzymes is required to bring the dangers of herbicides to people and the environment down to acceptable levels.

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