Pesticides and Their Chemical Influence

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❖ ABSTRACT

Pesticides have numerous beneficial effects. These include crop protection, preservation of food and materials and prevention of vector-borne diseases. For example, pesticides may be used in the prevention of malaria, which kills up to 1 million children per year, and for preventing other vector-borne diseases such as dengue, leishmaniasis and Japanese encephalitis. Pesticides are toxic by design – they are BIOCIDES, designed to kill, reduce or repel insects, weeds, rodents, fungi or other organisms that can threaten public health and the economy. Their mode of action is by targeting systems or enzymes in the pests which may be identical or very similar to systems or enzymes in human beings and therefore, they pose risks to human health and the environment. Pesticides are ubiquitous in the environment and most are synthetic. There is growing concern about children's exposure to pesticides and their special susceptibility. Children are not little adults, and may have higher exposures and greater vulnerability at both high and low levels of exposure.

Pesticides are used to kill the pests and insects which attack on crops and harm them. Different kinds of pesticides have been used for crop protection for centuries. Pesticides benefit to the crops; however, they also impose a serious negative impact on the environment. Excessive use of pesticides may lead to the destruction of biodiversity. Many birds, aquatic organisms and animals are under the threat of harmful pesticides for their survival. Pesticides are a concern for sustainability of environment and global stability. This chapter intends to discuss about pesticides, their types, usefulness and the environmental concerns related to them. Pollution as a result to overuse of pesticides and the long-term impact of pesticides on the environment are also discussed in the chapter. Moving towards the end, the chapter discusses the methods to eradicate the use of pesticides and finally it looks forward towards the future impacts of the pesticide use the future of the world after eradicating pesticides.

Keywords:- Pesticides, insecticides, residues, chemicals, pollutant etc.

❖ INTRODUCTION

A pesticide is a toxic chemical substance or a mixture of substances or biological agents that are intentionally released into the environment in order to avert, deter, control and/or kill and destroy populations of insects, weeds, rodents, fungi or other harmful pests. Pesticides work by attracting, seducing and then destroying or mitigating the pests. Pests can be broadly defined as “the plants or animals that jeopardize our food, health and / or comfort”. The use of pesticides has increased many folds over the past few decades. According to an estimate, about 5.2 billion pounds of pesticides are used worldwide per year. The use of pesticides for pest mitigation has become a common practice all around the world. Their use is not only restricted to agricultural fields, but they are also employed in homes in the form of sprays, poisons and powders for controlling cockroaches, mosquitoes, rats, fleas, ticks and other harmful bugs. Due to this reason, pesticides are frequently found in our food commodities in addition to their presence in the air (Pesticides n.d.). Pesticides can be natural compounds or they can be synthetically produced. They may belong to any one of the several pesticide classes. Major classes include organo-chlorines, carbamates, organophosphates, pyrethroids and noenicitinoids to which most of the current and widely used pesticides belong (Pesticides 101-A Primer n.d.). Pesticide formulations contain active ingredients along with inert substances, contaminants and occasionally impurities. Once released into the environment, pesticides break down into substances known as metabolites that are more toxic to active ingredients in some situations (What Is a Pesticide n.d.). Pesticides promise the effective mitigation of harmful bugs, but unfortunately, the risks associated with their use have surpassed their beneficial effects. Non-selective pesticides kill non-target plants and animals along with the targeted ones. Moreover, with the passage of time, some pests also develop genetic resistance to pesticides. This chapter focuses on the use of pesticides since the ancient times, I. Mahmood et al. merits of pesticide usage and most importantly, the harmful impact of pesticides on human health and the environment.

FORMULATE A QUESTION:

1. What are the chemicals used in Pesticides?

Chemically-related pesticides:

- Organophosphate: Most organophosphates are **insecticides**; they affect the nervous system by disrupting the enzyme that regulates a neurotransmitter.
- Carbamate: ...
- Organochlorine **insecticides**: ...
- Pyrethroid: ...
- Sulfonylurea **herbicides**: ...
- Biopesticides:

2. What are the major problems connected with pesticides?
   Many common pesticides are chemically related to nerve gas. The risk of using a pesticide depends on its level of toxicity and the level of exposure. Exposure to a small amount of a highly toxic pesticide can be fatal. But long-term exposure to large amounts of a less toxic pesticide can also have health impacts.

❖ **Background and Approach to the Study:**

Pesticides are used widely in agriculture in the United States. When effectively applied, pesticides can kill or control pests, including weeds, insects, fungi, bacteria, and rodents. Chemical pest control has contributed to dramatic increases in yields for most major fruit and vegetable crops. Its use has led to substantial improvements over the past 40 years in the quantity and variety of the U.S. diet and thus in the health of the public (see, for example, Block et al., 1992).

On the negative side, many pesticides are harmful to the environment and are known or suspected to be toxic to humans. They can produce a wide range of adverse effects on human health that include acute neurologic toxicity, chronic neuro-developmental impairment, cancer, reproductive dysfunction, and possibly dysfunction of the immune and endocrine systems.

The diet is an important source of exposure to pesticides. The trace quantities of pesticides and their breakdown products that are present on or in foodstuffs are termed residues. Residue levels reflect the amount of pesticide applied to a crop, the time that has elapsed since application, and the rate of pesticide dissipation and evaporation. Pesticide residues are widespread in the U.S. diet. They are consumed regularly by most Americans, including infants and children.

To protect the U.S. public against dietary pesticides and their potentially harmful effects, the U.S. Congress has enacted legislation to regulate residue exposures and to ensure that the food supply is safe as well abundant and nutritious. The two principal components of the legislative framework—the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA)—have provided the foundation for a comprehensive regulatory system.

Concern has arisen in recent years that the current pesticide regulatory system, which is intended to minimize health risk to the general population, may not adequately protect the health of infants and children. The traditional system assesses dietary pesticide risk on the basis of the average exposure of the entire U.S. population. However, it does not consider the range of exposures that exists within the population, nor does it specifically consider exposures of infants and children. The exposure of infants and children and their susceptibility to harm from ingesting pesticide residues may differ considerably from that of adults.

Concern about this uncertainty led the U.S. Congress in 1988 to request that the National Academy of Sciences (NAS) appoint a committee to study scientific and policy issues concerning pesticides in the diets of infants and children through its National Research Council (NRC). The committee was specifically charged with examining.

- what is known about exposures to pesticide residues in the diets of infants and children;
- the adequacy of current risk assessment methods and policies; and
- toxicological issues of greatest concern and in greatest need of further research.

❖ **PESTICIDE USE**

A pesticide is defined under FIFRA as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, nematodes, fungi, or weeds, or any other forms of life declared to be pests, and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant."

Pesticides have been used by humankind for centuries. Their use was recorded as early as the eighth century BC when the application of fungicides was documented in Homeric poems (Mason, 1928; McCallan,

1967). From the until the present, numerous mixtures have been developed to control fungi, insects, weeds, and other pests.

In the 19th century, sulphur compounds were developed as fungicides, and arsenicals were used to control insects attacking fruits and vegetables. Those compounds were highly toxic and consequently were replaced by chlorinated organic pesticides such as DDT and benzene hexachloride (BHC), which were developed during the 1930s and became widely used in the 1950s and 1960s. Chlorinated hydrocarbon insecticides such as DDT, BHC, dieldrin, aldrin, and toxaphene were enthusiastically adopted by farmers who hoped to control previously uncontrolled insects with what were believed to be relatively safe compounds with long environmental persistence. These chemicals were also used widely in the control Bottom of Form of malaria and other insect borne diseases. By 1955, more than 90% of all pest control chemicals used in U.S. agriculture were synthetic organic compounds, and in 1961 DDT was registered for use on 334 crops. Phenoxy herbicides such as 2,4-dichlorophenoxyacetic acid (2,4-D), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), and ethylene bisdithio carbamates (EBDCs) and dicarboximide fungicides also gained widespread use during that time.

Beginning in the late 1960s, the potential of the chlorinated hydrocarbons for bioaccumulation and long-term toxicity became widely recognized. Also, pest resistance to chlorinated pesticides became increasingly evident and problematic throughout the 1960s, leading many farmers to substitute organophosphates and carbamates for DDT and other chlorinated compounds. Public pressure to end the use of chlorinated pesticides contributed to the creation of the Environmental Protection Agency (EPA) in 1970 and the ultimate administrative revocation in 1972 of the use of DDT on all food sources in the United States. By the end of the 1980s, most food uses of chlorinated compounds were discontinued in this country, although heavy application continues in other nations.

Since the late 1960s, a decline has occurred in insecticide use on major commodities such as corn, soybeans, cotton, and wheat. This decrease was primarily the result of pest management programs, which led to an approximately 50% reduction in pesticide application to cotton crops nationwide. Another important factor was the development and widespread adoption of synthetic pyrethroid compounds, which are applied in gram quantities rather than pounds per acre. During this period, fungicide use on peanuts and wheat declined, but because of the continued application of fungicides to fruits and vegetables and the increasing acreage of those crops under cultivation, the overall volume of fungicides used has remained steady.

In contrast, the use of herbicides has increased dramatically. In 1955 approximately 3% of all acreage planted with corn and soyabean crops were treated with a herbicide; by 1985 that figure had increased to more than 95%, primarily because of the development of effective herbicides that were applied before the crop was planted. Herbicides now account for approximately 66% of all agricultural pesticides, but for a lower percentage of dietary exposure than is attributed to fungicides and insecticides, which are applied directly to the food closer to, or even after, its harvest. More than 90% of all herbicides are applied to just four crops: corn, soyabeans, cotton, and wheat.

Today, most pesticides are synthetically produced organic and inorganic chemicals or microbial agents. Some of these pesticides have been found naturally and have been synthetically reproduced for commercial use. The variety and amounts of pesticides now used are far greater than Bottom of Form at any previous time in human history. Approximately 600 pesticides are currently registered with the EPA (P. Fenner-Crisp, EPA, personal commune., 1993).

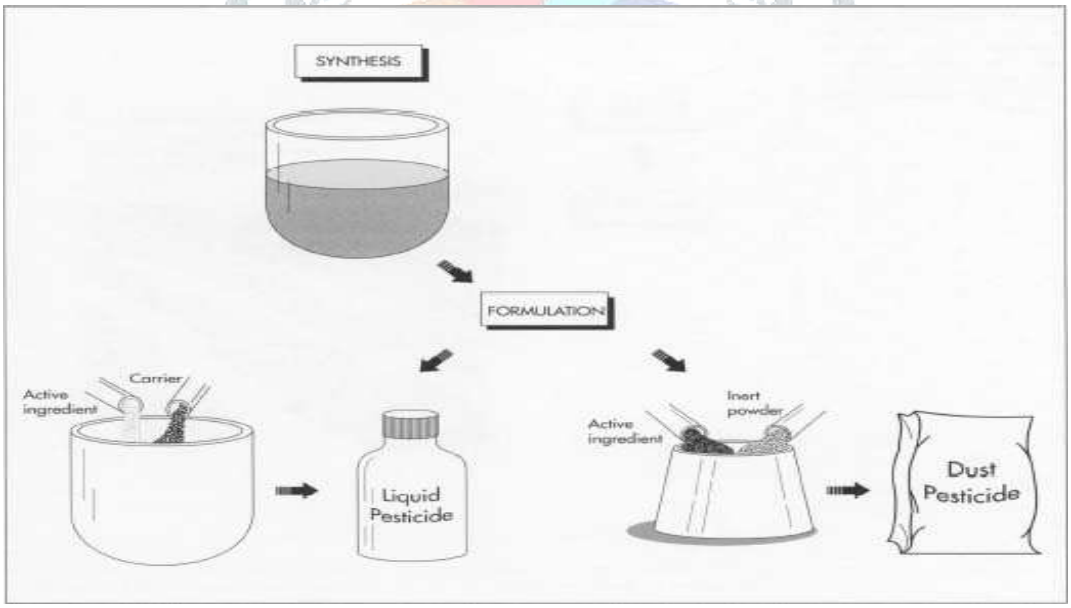
The most common food-use pesticides fall into three classes: insecticides, herbicides, and fungicides. In 1991, an estimated 817 million pounds of active pesticide ingredients were used for agricultural application in the United States. Of this total, herbicides accounted for 495 million pounds; insecticides, 175 million pounds, fungicides, 75 million pounds; and other pesticides, 72 million pounds; (EPA, 1992). "Other" pesticides were defined as rodenticides, fumigants, and molluscicides but do not include wood preservatives, disinfectants, and sulfur.

Insecticides. Insecticides control insects that damage crops through a variety of modes. Some work as nerve poisons, muscle poisons, desiccants, sterilants, or pheromones; others exert their effects by physical means such as by clogging air passages. The classes of insecticides most commonly used today are chlorinated hydrocarbons, organophosphates, and carbamates, and of these, the organophosphates are the most widely used. Typically they are very acutely toxic, but they do not persist in the environment. Well-known organophosphate pesticides include parathion, dichlorvos, malathion, chlorpyrifos, and azinphos-methyl. The toxicity to humans resulting from exposure to these compounds can differ markedly from chemical to chemical.

The carbamate insecticides are also very widely used in the United States today. They too are highly toxic, e.g., aldicarb. Other insecticides such as synthetic pyrethroids, e.g., permethrin, are valued because of their fast action and relatively low toxicity to mammals.

- **Herbicides:-** Herbicides are used to control weeds, which compete with crop plants for water, nutrients, space and sunlight. By reducing the weed population, the need for farm labor is decreased and crop quality is enhanced. Herbicides work through a variety of modes of action. Some damage leaf cells and desiccate the plant; others alter nutrient uptake or photosynthesis. Some herbicides inhibit seed germination or seedling growth. Others are applied to foliage and kill on contact, thereby destroying leaf and stem tissues. Some of the most widely used herbicides are 2,4-D [(2,4-dichlorophenoxy) acetic acid], atrazine, simazine, dacthal, alachlor, metolachlor, and glyphosate.
- **Fungicides:-** Fungicides control plant molds and other diseases. They include compounds of metals and sulfur as well as numerous synthetics. Some fungicides act by inhibiting the metabolic processes of fungal organisms and can be used on plants that have already been invaded andBottom of Form damaged by the organism. Other fungicides protect plants from fungal infections and retard fungal growth before damage to plants can occur. Fungicides frequently provide direct benefit to humans by retarding or eliminating fungal infections that can produce toxicants such as aflatoxins. Fungicides that have been used heavily over the years include benomyl, captan, and the EBDC family of fungicides such as mancozeb.
- In addition to their agricultural applications, pesticides are also used for many non-agricultural purposes, e.g., in homes and public buildings to kill termites and other pests; on lawns and ornamental plantings to kill weeds, insects, and fungi; and on ponds, lakes, and rivers to control insects and weeds. Therefore, humans are exposed to pesticides from a variety of sources other than the diet, for example, through the skin or by inhalation. Some of these exposures are especially important when considering total exposures of infants and children.

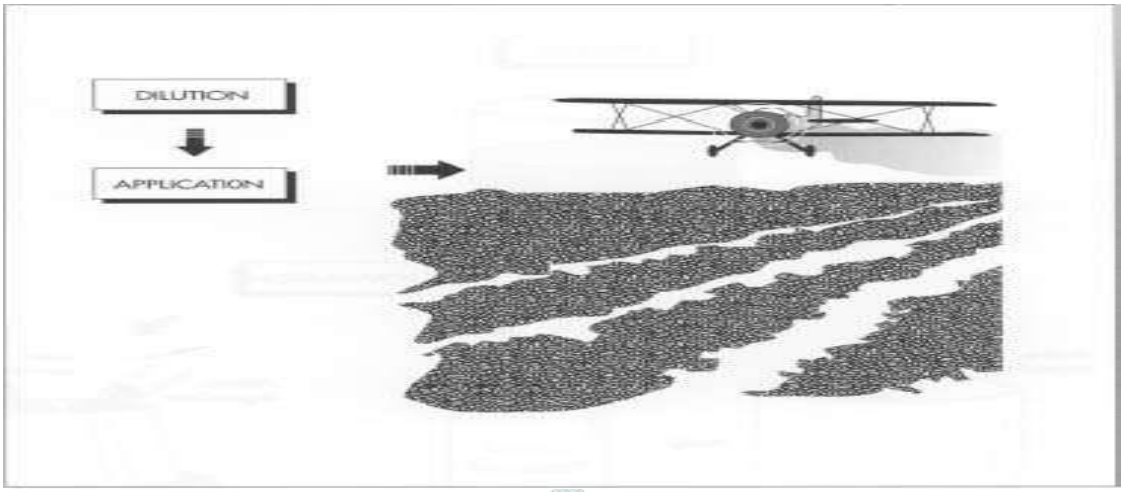
❖ **CONSTRUCT A EXPERIMENT & ANALYZE DATA**



Raw Materials

A pesticide consists of an active ingredient coupled with inert ingredients. The active ingredient kills the pests, while the inert ingredients facilitate spraying and coating the target plant; they can also contribute other advantages that are not conferred by the active ingredient alone. Active ingredients were once distilled from natural substances; now they are largely synthesized in a laboratory. Almost all are hydrocarbons derived from petroleum. Most pesticides contain other elements, the type and number of which depend on the pesticide desired. Chlorine, oxygen, sulfur, phosphorus, nitrogen, and bromine are most common. Inert ingredients can be many substances, dependent on the type of pesticide. Liquid pesticides have traditionally used kerosene or some other petroleum distillate as a carrier, though water has recently begun to replace kerosene. Emulsifiers (such as soap) are also added to distribute the active ingredient evenly throughout the solvent. A powder or dust pesticide will typically contain vegetable matter such as ground up nut shells or

corn cobs, clays such as diatomite or attapulgite, or powdered minerals such as talc or calcium carbonate as a base. To cause the pesticide to adhere better to the plant or soil, a material such as corn-starch or flour may be added.



After receiving the pesticide, farmers dilute it with water before applying it. Application can involve crop dusting with small air-planes or using sprinklers or tractors. Small farmers may even use hand-held sprayers.

The Manufacturing Process

Manufacturing a pesticide involves at least three separate activities. The active ingredient is first synthesized in a chemical factory, then formulated in the same place or sent to a formulator, who prepares the liquid or powder form. The pesticide is then sent to the farmer or other certified applicator, who dilutes it before applying it to the fields.

Synthesizing the pesticide

1. When a new pesticide is first developed, it is manufactured on a small scale in a laboratory. If the substance proves viable, production begins in the factory. Batch or continuous manufacturing insures a high volume, perhaps as much as 500 kilograms per cycle. Synthesizing a pesticide is a complex chemical procedure that requires trained chemists and a large, sophisticated laboratory. The basic procedure entails altering an organic molecule to form a pesticide. This may involve any of a number of specific reagents and catalysts and often must take place in a controlled climate (within a certain temperature range, for example). Once synthesized, the active ingredient is packaged and sent to a formulator. Liquid insecticides can be shipped in tank trucks or 200-liter drums. Transport of the active ingredient follows all regulations for hazardous materials transportation.

Formulating the pesticide

2. A formulator accepts the active ingredient, measures out the proper amount, mixes it with carrier if it is to be a liquid pesticide or with inert powders or dry fertilizers if it is to be a dust pesticide, then bottles or packages it. Liquid pesticides are packaged in 200-liter drums if a large-scale farmer is the anticipated customer or 20-liter jugs for small-scale operations. Dry formulations can be packaged in 5 to 10 kilogram plastic or plastic-lined bags. An emulsified formulation is usually concentrated to render transport easier (the active ingredient typically makes up 50 percent of the emulsified concentrate), but granulated and dry pesticides are ready to use.

Diluting the pesticide

3. The pesticide might be stored a short time before it is requested. When it is ready for transport, the estimated necessary amount is sent to the farmer, who dilutes the emulsified concentrate to create the amount of pesticide desired. In most instances, the final product consists of only .5 to 1 percent of the original active ingredient. The pesticide is now ready to be applied.

Applying the pesticide

4. There are several ways to apply a pesticide. The method with which Americans are most familiar is crop dusting, though its use is generally limited to large, flat areas. A plane loaded with 2000-liter (or larger) tanks flies over a field and sprays out the pesticide from booms. Booms are long, horizontal rods from which several sprinklers spray down. Another method is to attach the tanks and booms to a tractor and spray closer to the ground. For small farmers, the most economical method of spraying is to use one or more workers

with hand-held sprayers attached to small tanks. A hand pump can be carried on the shoulder; its tank capacity is only about 3 to 12 liters. Small tanks with a capacity of around 200 liters are also used. The pesticides are applied with a hand gun. A rough estimate of the amount applied is 150 to 300 liters per hectare.

Quality Control

Pesticides are by their very nature toxic substances; hence, a great deal of concern has centered on safety. The laws dealing with pesticide safety are very strict and will become even stricter in the future. Besides legal restrictions, pesticides are also subject to stringent quality control standards like any other manufactured product.

Most large pesticide manufacturers have highly developed quality control laboratories that test each pesticide for potency, emulsification, density, colour, pH, particle size (if a dust), and suspension (if a liquid). If the company makes more than one pesticide, the product's identity must also be verified. A pesticide must be stable, easy to apply, and easy to store. Shelf-life must extend past one year. In accelerated tests, the pesticide is subjected to high temperatures for a short period, then checked for effectiveness. A typical pesticide is 95 percent pure. Labels must be easy to read and meet all regulations. The manufacturer keeps files for each raw material, active ingredient, formulation, and packaged item, and samples are stored for three years.

Today's pesticides, when used properly, are very safe. Farmers who apply their own pesticides must be trained by the U.S. Agricultural Extension Service and certified by the state department of agriculture before they can purchase pesticides. Commercial applicators must also undergo training and pass a written test.

When preparing a formulation for application, which in most cases means diluting it, the applicator should wear protective clothing as directed by the label. Often, this protective garb includes an apron or coveralls, a broad-brimmed hat, long-sleeved shirt, long socks, unlined neoprene or rubber gloves, long pants, and unlined neoprene or rubber boots worn over shoes. For some pesticides, applicators must also wear goggles and/or a respirator.

As an additional precaution, application equipment is calibrated before each use. To calibrate a sprayer, the applicator measures off a distance in the field, then sprays it with a neutral substance such as water. The amount of water used is then checked to see if it is appropriate. All equipment is also checked to see if spraying is even, and worn equipment is replaced promptly.

By Products/Waste

When they were introduced, pesticides were seen as a wonderful technology that would increase crop yields and reduce insect-borne diseases. The first sign that this was a hopeful myth was the discovery in the 1950s that pesticide volume must be increased to have the same effect it once had. With the publication of *Silent Spring* by Rachel Carson in 1962, an awareness of the danger of unrestricted pesticide use grew.

Pesticides kill the pests they are aiming for most of the time, yet often they also kill the pests' natural predators, thereby exacerbating the problem. In some cases, exterminating a pest merely allows another pest to take its place. After a period of pesticide use, the insects become resistant to the pesticide, and stronger or more pesticides must be used to control the population. There is evidence that pesticides are misused, that their effect in some cases is negligible, and that applicators are not aware of the proper use of pesticides. Coupled with these concerns is the worry over blanket spraying of residential areas and contaminated food.

DDT is the most widely noted case of a pesticide that caused damage far from the farm. High levels of DDT have been found in birds of prey, causing them to become endangered because of the effect it has on their eggs. DDT becomes more concentrated the higher it climbs in the food chain, and many people have voiced their concern about its possible presence in humans. In 1972, the Environmental Protection Agency (EPA) announced a ban on almost all uses of DDT.

Several dozen other pesticides have also been banned, or their use restricted by the EPA. Ironically, these pesticides are still being exported to assist developing countries, where it is estimated that three million acute cases of pesticide poisoning occur per year, along with 20,000 deaths directly related to the misuse of pesticides. Because many of these countries export produce to the United States, the possibility of American contamination is high.

Integrated pest management (IPM) was begun in the 1960s in response to the pesticides dilemma. The idea behind IPM was to use a variety of insect controls instead of relying solely on chemical insecticides. The methods include introducing natural predators, parasites, and bacterial, viral, and fungal insecticides to the fields. Workers may simply vacuum up the insects, or introduce certain plants to ward off pests that attack a particular crop. Farmers may plow at the most effective time, plow their crop residue under, or strip harvest. They may plant pest-resistant plants. Sexual attractant traps may pull pests away from crops. Sterilized males can be released into the field. Insects can be engineered to remain juvenile and never reproduce, molt too rapidly and therefore die rapidly, or become too confused to locate crop foods. Other possibilities are being

tested at present. It is possible that in the future pesticide use will diminish as research leads to ways to combat pests with more knowledge and planning and less reliance on chemical intervention.

❖ **Conclusion and Future Prospects**

Pesticides have proved to be a boon for the farmers as well as people all around the world by increasing agricultural yield and by providing innumerable benefits to society indirectly. But the issue of hazards posed by pesticides to human health and the environment has raised concerns about the safety of pesticides. Although we Effects of Pesticides on Environment266 cannot completely eliminate the hazards associated with pesticide use, but we can circumvent them in one way or the other. Exposure to pesticides and hence the harmful consequences and undesirable effects of this exposure can be minimised by several means such as alternative cropping methods or by using well-maintained spraying equipment's. Production of better, safe and environment friendly pesticide formulations could reduce the harmful effects associated with the pesticide usage. If the pesticides are used in appropriate quantities and used only when required or necessary, then pesticide risks can be minimised. Similarly, if a less toxic formulation or low dose of a toxic formulation is used, the havoc can be curbed. As Paracelsus also once said "The right dose differentiates a poison from a remedy". There are organochlorines, which are used as pesticides. These pesticides are least biodegradable and their use is banned in many countries. Besides this fact, organochlorines are highly used in many places. This results in serious health hazards. Water pollution is on the rise due to these pesticides, even at low concentration, these pesticides have serious threat to the environment (Agrawal et al. 2010). The majority of farmers are unaware of the potential toxicities of pesticides. They have no information about types of pesticides, their level of poisoning, hazards and safety measures to be taken before use of those pesticides. Due to this reason, toxic and environmentally persistent chemicals are used to kill pests which can also lead to intentional, incidental or occupational exposure. These compounds have long term effects on human health. Awareness should be arranged for these farmers to reduce the uses of toxic pesticides (Sharma et al. 2012). In future chemical pesticides can be used in combination with natural treatments and remedies which result in more sustainable elimination of pests and insects. This combination not only promises environmental sustainability, but also has diverse applications in controlling of urban pests and invasive species (Gentz et al. 2010). Pesticides have also posed a serious threat on biological integrity of marine and aquatic ecosystems. It is the need of time to integrate the studies of different disciplines including toxicology, environmental chemistry, population biology, community ecology, conservation biology and landscape ecology to understand direct and indirect effects of pesticides on the environment (Macneale et al. 2010).

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