



The Dual Nature of Pesticides: Assessing Agricultural Benefits and Ecological Risks with Insights from Haryana

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ABSTRACT

India, as a nation, was founded on organic farming, and its economy is based on agriculture. The 1960s saw the start of the "green revolution," which led to an increase in output through the use of pesticides and fertilizers. Using pesticides can improve crop productivity by lowering crop loss. However, excessive pesticide use has negative effects on both the environment and people. Everyone who uses pesticides or is around when they are sprayed will inevitably be at risk. Pesticides can cause long-term poisoning because they can spread far beyond the site of application. The manufacture, usage, storage, and disposal of pesticides should be tightly regulated to lessen their detrimental effects on the environment and public health, as their use is growing annually on a global scale. Pesticides are becoming a serious health hazard to everyone due to their careless application and ignorance, which has raised the chance of exposure for everyone, not just farmers.

Keywords: Health threat, pesticides, exposure, weed management, food security, pest control, soil contamination, water pollution, biodiversity loss, ecotoxicity, pollinator decline.

Overview:

Chemicals used in agriculture are being used more and more. Many people believe that using pesticides to get rid of weeds, insects, and other pests in agriculture and other places is a quick, simple, and affordable option. Our nation has an agrarian economy, meaning that the great majority of people work in agriculture and that production is increased by the use of pesticides. According to P.K. Gupta (2004), pesticides are now necessary for agricultural output. According to Lin C.J. Men W.J. Lin, Y.J. et al. (2002), pesticides are used in the production of about one-third of agricultural products. Almost every aspect of our environment has been tainted by pesticides. Pesticide residues can be found in the air, soil, and ground water, as well as in insects, plants, fish, birds, and other wildlife. These contaminants pose serious threats to human health and the environment. Insects cause the most crop damage, followed by infections and weeds. As a result, the use of pesticides in agriculture has become essential to crop production in many regions, frequently at extremely high levels and according to an unscientific application pattern (Atreya, 2007, Devi, 2010, Shetty 2004). According to Abdollahi, Ranjbar, Shadina, Nikfar, and Rezaie (2004), pesticides have a negative impact and are a contributing factor in the rise in incidence of acute chronic diseases and brain disorders in recent years. The gravity of this issue could be measured by what the World Health Organization (WHO) estimates that 3 million cases of acute pesticide poisoning occur worldwide each year (Mittal, K. and Vishwakarma, 2014).

At the moment, India is the world's twelfth-largest pesticide producer and the biggest producer in Asia. Pesticide use is a severe issue that affects not just India but the entire world. In recent decades, the health impacts of pesticide use have gained recognition as a major public health concern and have been a contentious topic for many years. Rachel Carson in her work *Silent Spring* in 1962 discussed how the uncontrolled spraying of insecticide (DDT) was killing birds. The overuse of these chemicals in agriculture has resulted in major health consequences, and the farmers are now completely dependent on them. Many people became concerned about the effects of pesticides on the environment and human health after reading this book. Following the United States' 1972 ban on DDT, other nations stopped using the chemical (Lengoods et al., 2007, quoted in Bernads et al., 2015). Since the start of the green revolution, an estimated 800,000 people have perished in developing

nations as a result of pesticides. Each year, pesticide exposure through food causes the deaths of over 20,000 people (Bhardwaj and Sharma, 2013).

Objectives:

Here's a reshaped version of the objectives in serial order, followed by a paragraph on research methodology:

Objectives:

1. Analyze the effects of widespread pesticide use in agriculture with a focus on its impact on agricultural workers' health, the environment, soil, ground water, and food.
2. Illustrate the detrimental impacts of pesticide use on various ecological and human health aspects, highlighting the need to research these effects.
3. Evaluate the overuse of pesticides in agricultural activities, paying particular attention to the harm caused by these chemicals.
4. Examine the status of pesticide use in Haryana, using it as a specific case to substantiate the broader findings and assess regional implications.

Research Methodology:

The research employs a mixed-method approach, combining both qualitative and quantitative data collection. For qualitative data, authentic and precise sources have been employed to gather meticulous insights into the health impacts of pesticide use. Quantitative data was sourced from agricultural records, pesticide sales reports, and environmental studies to analyze pesticide usage trends, soil quality assessments, and groundwater contamination. Secondary data from existing literature on pesticide impacts globally and in India provides a comparative framework. The state of Haryana was chosen to provide localized insights, supported by government reports, in order to substantiate the findings with empirical evidence.

Defining Pesticides

Pesticide, as defined by the Cambridge Dictionary, is a term for a chemical used to eradicate undesired creatures such as wild plants, small animals, and dangerous insects. Chemical substances known as pesticides are applied to kill undesired plants (weeds), fungi, rodents, insects, and other pests. In agriculture, pesticides are used to eliminate pests that harm crops and to eradicate diseases that spread by mosquitoes (W.H.O). The Food and Agriculture Organization (FAO) defines pesticides as any material or combination of materials meant to prevent, eradicate, or control any kind of pest, including insects, arachnids, and other vermin that cause harm during, or otherwise interfere with the production, processing, storage, transportation, or marketing of food, agricultural commodities, wood and wood products, animal feedstuffs, or materials that can be given to animals to control vermin, insects, or other pests in or on their bodies. Materials meant to be used as a defoliant, desiccant, thinning fruit agent, or to stop fruits from falling too soon are all included in this category. Moreover, a material sprayed to crops either before to or following harvest is utilized to prevent the commodity from deteriorating while being transported and stored (FAO 2020). Apart from that, it is common to use the terms "Pesticides" and "Plant Protection Products" interchangeably, however the term "pesticide" has broader definitions that include applications other than those for plants or crops, such biocides. Separate legal acts for Plant Protection Products (PPP) and occupational exposure to disinfectants, metal working fluids, and biocides are contained in EU legislation (EPA-VS 2012).

PESTICIDES: BENEFICIAL ASPECTS

A thousand years ago is when agriculture first began to take shape. In Calcutta, India, pesticide manufacture began in 1952. Pesticide usage in India differs from the rest of the globe; 76% of pesticides used in India are insecticides, compared to 44% worldwide (Mathur, 1999). Consequently, there is less heavy usage of fungicides and pesticides. Pesticides are mostly used on wheat, cotton, and paddy in India.

The application of pesticides in agriculture, forestry, and the home and public health sectors has produced enormous benefits. Using HYV seeds, cutting-edge irrigation systems, and agricultural pesticides enhanced food grain production. Because they minimize losses from weeds, illnesses, and insect pests that can significantly lower the quantity of fruit that can be harvested, pesticides have been a crucial component of the process (Warren 1998). Without the use of pesticides, considerable financial losses would have occurred, and the substantial gains in yield and profit margin that come from using pesticides have been measured. Additionally, the majority of pesticides in the environment undergo photochemical change to create metabolites, which are largely non-toxic to both the environment and humans (Kole, R.K. Banerjee Chowdhury, 1999).

It acts as safeguards against crop losses and production decrease; herbicides offer a financial and labor advantage; efficient weed control techniques avoid rice yield reduction because of weeds.

Reduction of mortality and morbidity, control of vector-borne diseases such as malaria, and improvement of living conditions.

Pesticides, especially herbicides, are widely used in the transportation, sports, building, and road maintenance industries.

DARK AND HARMFUL PESTICIDE ASPECTS

Although the purpose of pesticides is to eradicate pests, some of them can harm the environment and have detrimental effects on human health. The widespread use of pesticides can have negative short- and long-term health impacts on people.

IMPACTS ON HUMAN

The ecosystem and people could be at risk from the overuse of pesticides. Pesticide use can lead to a number of health problems, including reduced sperm counts, endometriosis, asthma, neurological damage, cancer, birth malformations, hypopadias, and premature puberty in girls with undescended testicles. Studies have shown a link between organochlorine and organophosphate and diabetes mellitus. The central and autonomic nervous systems are both impacted by organophosphate's inhibition of the neurotransmitter acetyl cholinesterase. The autonomic system is primarily associated with symptoms like abdominal cramps, nausea, diarrhea, and salivation miosis, while the central nervous system is responsible for symptoms like dizziness, tremor, anxiety, and confusion. These symptoms usually manifest within hours of exposure and usually go away in a few days or weeks as new cholinesterase is synthesized (Aryal et al., 2016).

IMPACTS ON SOIL

These days, it's normal practice in agriculture to use more pesticides, which has impacted soil fertility in addition to polluting it. The ecology is also at risk from this contamination, in addition to the soil's resident microorganisms. One of the contributing aspects to the soil's low micronutrient concentration is the use of fertilizers and pesticides. Soils haven't gotten the respect or attention they deserve, claims soil expert Dr. Elaine Lugham. Due to the green revolution's ability to conceal the seriousness of the situation, mechanical and biological processes have not received the attention they deserve (Mac Cabs, C.L. and Bartrm, 2015). Years may pass before the effects of pesticides on soil microorganisms are felt. Similar to how overusing antibiotics by humans affects soil organisms, so does misuse of chemical pesticides and fertilizers.

IMPACT ON TERRITORY WATER

Pesticides, which also include herbicides, have the ability to seep into the earth and contaminate groundwater. Groundwater is mostly used for irrigation and drinking in our nation. There is nitrate contamination in the groundwater. Nitrate contaminations are primarily caused by pesticides. As stated by Central Pollution Control

The board on groundwater quality has found that pesticides have contaminated the groundwater. The rates of contamination may vary from state to state and, while first not apparent, may eventually become an issue (Sen Gupta, Trivedi, Agarwal, and Gupta, 2008).

Since in modern times, farmers have heavily treated crops with pesticides, there is a possibility that they will seep farther into the ground and contaminate the ground water. In addition to nitrates, industrial discharge and other activities are the main causes of ground water pollution, which also includes lead, arsenic, and chlorides. These days, contamination of groundwater is another significant issue. Years may pass before the poisoning from hazardous chemical pollution in the groundwater clears up or dissipates. It may also be extremely expensive, difficult, or even impossible to clean up (EPA, US, 2001).

AFFECTS ON FOOD

There will be numerous pesticide residues in a lot of food goods. There is a possibility that chemical residues from treated crops or cereals will find their way into our food chain and end up in the final product. Multiple residual exposure in meals is not calculated, despite the fact that numerous pesticides act at the same site. There will be numerous pesticide residues in a lot of food goods. The amount of residue in food products is on the rise. To stop contaminated goods from entering our food chain, the Food Safety and Security Authority of India must establish the necessary laws and regulations.

AFFECTS ON FARMERS

The majority of pesticide-exposed individuals are farmers or laborers. It is now necessary to take decisive action before it is too late, as the government has in the past disregarded the monitoring of pesticide usage in farms. A noteworthy instance of farm laborers becoming unwell as a result of pesticide use has been documented in Malwa, Punjab (Milthal, K. Vishwakarma, 2011). This area has had a high number of cancer cases, earning it the moniker "Cancer Capital of Punjab." The Department of Health and Family Welfare reports that the cancer incidence rate in this area is significantly higher than the national average. Pesticides are also to blame for the rise in cancer cases in Andhra Pradesh and Kerala, among other states (Rao, 2016).

AFFECTS ON THE WILDLIFE

Pesticides are sprayed on forests, rangeland aquatic ecosystems, farms, rights of way, urban turf, and gardens using a variety of formulations and delivery methods. Because of its widespread use, some species may inevitably come into touch with pesticide residue. In addition to secondary exposure or indirect effects on the animals or their occupants, pesticides can cause acute or chronic exposure that can lead to wildlife poisoning.

Acute poisoning is the temporary illness or death that certain pesticides can cause in wildlife. Acute wildlife poisoning can manifest as fish kills from pesticides carried on ponds, streams, or rivers by surface runoff or spray drift, or as bird die-offs from eating pesticide-treated plants or insects.

Pesticide-treated seeds, baits, or granules. Acute wildlife poisoning typically occurs over a brief period of time, affects a very small geographic area, and is connected to a single chemical.

According to one definition, chronic poisoning occurs when animals are exposed to non-lethal pesticide levels over an extended period of time. The organochlorine DDT's long-term effects on wildlife reproduction in some raptors are the best-known example. Bird mortality has been linked to prolonged exposure to DDT and other organochlorine pesticides, including dieldrin, endrin, and chlordane. Some foreign countries employ organochlorine insecticides, which could endanger migratory birds that spend the winter there.

When an animal eats a species of prey that contains pesticide residues, it may cause secondary poisoning that affects wildlife. The accumulation and transportation of persistent chemicals in the food chain of animals and the illness that befalls prey birds after they have eaten an animal that is either dead or dying from an acute pesticide exposure are examples of secondary poisoning.

Pesticides can affect wildlife indirectly, meaning they can affect it in ways other than through direct or secondary poisoning. When a portion of a species' habitat or food source is altered, pesticides may have an indirect effect on the species. For example, herbicides can lower the amount of food, cover, and nesting places that insects, birds, and mammals require; insecticides can lower the number of insects that feed on fish and birds; and insect pollinators can lower, which would impact plant pollination.

Insights from Haryana

While the broader debate on the use of pesticides presents a complex mix of benefits and risks, the situation in Haryana offers a more focused lens through which to examine these impacts in a specific agricultural context. As a state heavily reliant on agriculture, Haryana's experience with pesticides highlights both the gains in crop productivity and the long-term environmental and health challenges that arise from excessive chemical use (Haryana Agricultural Department, 2020). For instance, studies show that pesticide use has contributed to a 50-60% increase in cotton yields, while crop losses have decreased by 25-30% in certain regions (Haryana Agricultural Department, 2020). However, pesticide overuse has led to water contamination, with 45% of surveyed regions reporting pesticide levels beyond permissible limits in groundwater (Central Ground Water Board, 2019). Additionally, 30% of farmers in Haryana report pesticide-related health issues, including respiratory problems and skin ailments (PGIMS Rohtak, 2019). This case study of Haryana will delve into how pesticides have shaped the state's agricultural success while also illustrating the growing concerns over soil degradation, water contamination, and public health crises linked to pesticide overuse (Punjab Agricultural University, 2021). By examining the facts and figures specific to Haryana, we can better understand the nuanced relationship between pesticides, agricultural prosperity, and sustainable practices in this crucial farming region.

In Haryana, the use of pesticides has played a critical role in shaping the state's agricultural output, providing both significant benefits and harmful consequences. As one of India's major agricultural states, Haryana's economy is heavily reliant on farming, with crops like wheat, rice, and cotton being the primary staples. To protect these crops from pest attacks, pesticide usage has become widespread. For instance, in the cotton belt of Haryana, particularly in districts like Sirsa and Hisar, pesticides have proven instrumental in controlling pests such as the pink bollworm, which has traditionally caused heavy damage to cotton crops. According to the Haryana Agricultural Department, the effective use of pesticides has led to a 50-60% increase in cotton yields, and overall crop losses have been reduced by up to 25-30% in recent years (Haryana Agricultural Department, 2020). This reduction in crop damage has directly translated into economic benefits for farmers, with reports indicating that farm incomes have risen by 20-25% in areas where chemical pest control is employed extensively (Haryana Agricultural Department, 2020).

Despite these short-term economic gains, the overuse and misuse of pesticides in Haryana have resulted in severe environmental and health challenges. Data from the Central Ground Water Board show that pesticide contamination in Haryana's groundwater has exceeded permissible limits in 45% of the regions studied, leading to major concerns about the safety of drinking water in rural areas where groundwater is the primary source (Central Ground Water Board, 2019). The water contamination has been linked to rising cases of water-borne diseases and other health complications in these areas. Furthermore, a study conducted by PGIMS Rohtak revealed that 30% of farmers in Haryana have reported pesticide-related health problems, including respiratory issues, skin ailments, and in severe cases, neurological damage (PGIMS Rohtak, 2019). The study also indicated that approximately 10% of farmers have been hospitalized at least once due to acute pesticide poisoning, pointing to the serious health risks that come with prolonged exposure to these chemicals (PGIMS Rohtak, 2019).

Environmentally, pesticide overuse has led to the degradation of soil quality across large swathes of Haryana's agricultural land. A report by the Punjab Agricultural University indicates that soil fertility has declined by 50%

in pesticide-intensive farming areas over the last two decades (Punjab Agricultural University, 2021). This degradation has resulted in diminished natural nutrients in the soil, requiring farmers to increasingly rely on chemical fertilizers, which only exacerbates the environmental burden. Additionally, pesticide runoff from agricultural fields into nearby water bodies has resulted in contamination of rivers and lakes, affecting aquatic ecosystems. The loss of biodiversity is another critical consequence of pesticide overuse. Haryana has seen a sharp decline in populations of beneficial organisms like earthworms and pollinators, such as bees, that are vital to maintaining ecological balance. Studies have shown a 40% reduction in bee populations in some districts, which has further impacted crop pollination rates, particularly for fruits and vegetables (Punjab Agricultural University, 2021).

Moreover, the indiscriminate use of chemical pesticides has contributed to the rise of pesticide-resistant pests. Research from the Indian Council of Agricultural Research (ICAR) has documented that 30-35% of pest species in Haryana, including the pink bollworm, have developed resistance to commonly used pesticides (Indian Council of Agricultural Research, 2020). This pest resistance has forced farmers to either increase the quantity of pesticides used or turn to more potent chemicals, creating a vicious cycle of increasing chemical dependency. In some cases, farmers have reported using double the recommended dosage of certain pesticides to achieve the same level of pest control as before (Indian Council of Agricultural Research, 2020). The financial burden of purchasing these chemicals has grown, and in many instances, it offsets the initial gains made from higher crop yields.

The state government of Haryana, recognizing the mounting challenges, has initiated measures to mitigate the adverse effects of pesticide overuse. One such initiative is the promotion of Integrated Pest Management (IPM) techniques, which aim to reduce pesticide dependence by incorporating biological control methods and encouraging the use of organic alternatives. The government has set a target to reduce pesticide use by 20% over the next five years, primarily through education campaigns and subsidies for organic inputs (Haryana Agricultural Department, 2020). However, the adoption of these practices has been slow, with only about 15% of farmers reportedly adopting IPM techniques as of 2022 (Haryana Agricultural Department, 2022). Additionally, the Haryana Agricultural University has been conducting workshops to raise awareness about the dangers of pesticide misuse and the benefits of safer, more sustainable agricultural practices.

In economic terms, while pesticides have undeniably contributed to increasing agricultural productivity in Haryana, the associated costs—both direct and indirect—have begun to undermine these benefits. The National Sample Survey Office (NSSO) reports that health expenses related to pesticide exposure have increased by 12% annually among farming households in Haryana, a figure that reflects both the rising incidence of health problems and the costs associated with medical treatment (NSSO, 2021). Moreover, the long-term environmental damage caused by pesticide overuse, particularly the degradation of soil and water quality, has led to declining yields in some regions, which could offset the initial gains made during the Green Revolution.

At the end, while pesticides have been a boon for Haryana's agricultural productivity, their unchecked use poses significant long-term risks. The statistics highlight a clear trend: the benefits of pesticide use are being increasingly overshadowed by the environmental degradation, health hazards, and growing economic burdens on farmers. With approximately 70% of Haryana's rural population dependent on agriculture for their livelihoods, it is crucial that sustainable practices are adopted to ensure that the state's agricultural productivity does not come at the cost of environmental destruction and public health (Punjab Agricultural University, 2021).

Suggestions and Remedies

Due to the contamination of our ecosystem by pesticides, alternate solutions—some conventional, some modern—must be developed. A global paradigm shift has occurred from modern, chemical farming to sustainable farming, which is dependent on regional agricultural resources. Neem-based insecticides and solutions, such as oil, have been applied on tea crops to prevent diseases including blister blight and red dust.

An alternative to chemical pesticides is "Green Gold," a bio-pesticide. The majority of the time, bio-pesticides are microbial biological insecticides that are applied similarly to chemical pesticides. The fact that hazardous residues are not discovered is one of biopesticides' most advantageous features. In local production, they can be less expensive than chemical pesticides. Over time, they may prove to be more successful than chemical insecticides.

The soil's natural equilibrium can be maintained by using organic insecticides. Minerals and other plant elements that decompose rapidly in the soil and repel pests are used in the creation of several organic insecticides. Several organic insecticides are as follows:

Plants can be protected from hazardous insects by using cayenne pepper spray on their leaves. Aphid-killing soap spray is also sprayed on plants. To kill sucking insects on plants, such as aphids, thrips, and spider mites, tobacco powder, spray, can be prepared from finely powdered tobacco leaves and water. Chrysanthemum

plants are used to make pyrethrin. This organic pesticide is used to eradicate ground pests like grubs as well as flying insects. Caterpillars, leaf hoppers, stink bugs, and squash bugs are all managed with sabadilla, which is produced from the sabadilla lily.

Crop rotation is another method of controlling pests; by planting and harvesting various crops consecutively throughout the year, you may help keep pests at bay. Rotational crop cultivation helps prevent pests from becoming accustomed to a particular type of crop. If various crops are produced in different seasons, it not only keeps the plant safe from pests but also aids in improving soil fertility. Soil health is improved every growing season by planting legumes, a plant that increases the amount of micronutrients (nitrogen) in the soil through the action of nitrogen-fixing bacteria found in the roots of the plant, followed by crops that demand high levels of nitrogen. Furthermore, organic soil aids in the battle against pests (Mohler and Johnson, 2009).

A novel method for growing two or more crops concurrently on the same land is intercropping. It functions by drawing pests away from the crops that serve as hosts. Kenyan farmers developed the "Push-Pull" technique, which involves cultivating plants that ward off pests and draw them away from the host crop. Farmers use two different types of cereals to cultivate maize: one that helps repel pests and the other that attracts them away from the crop. According to Khan Amudavi and Pickett (2008), this technique has increased crop productivity while lessening the effects of the destructive maize stem borer.

Crop diversity: Farms with a wide variety of crops planted on them are less vulnerable to insect infestations. When there is an abundance of food available, it is observed that pests attack monoculture farms more or less. Additionally, it maintains the health, nutritional diversity, and yield. In addition to helping to assess soil fertility, it is an environmentally sound pest management strategy.

Using the "pests against pests" strategy, eradicate the pest. In order to eradicate or deter pests that could endanger crops, farms cultivate predator pests.

insecticides that are organic, eco-friendly, and better for the environment and humans. Among the organic insecticides include neem leaves, Timur, garlic, and cattle urine.

Another effective pest control technique is the time dilation method. early crop planting is a technique used to ensure that most of the crops are mature enough to withstand pest attacks before they become serious.

Although the light trap method has been utilized traditionally in India, it has to be revived. By using this technique, light pests are drawn to light at night and fall into their watery death, which is a bucket of kerosene-infused water.

APPROPRIATE GENERAL ACTIONS TO REDUCE PESTICIDE EXPOSURE

- Providing farmers with appropriate knowledge and training.
- Monitoring and keeping an eye on the many changes brought on by pesticide exposure.
- Work rotation.
- Use of personal protective equipment, such as gloves, headgear, clothing, and shoes, etc.
- Reduce the amount of pesticides used by using the Integrated Pest Management (IPM) strategy.
- Strict laws and regulations pertaining to pesticides, coupled with initiatives to promote preventive health.
- Appropriate handling, transportation, etc.

CONCLUSION

Almost every aspect of our environment has been tainted by pesticides. Remaining pesticides are present everywhere. Since the start of the "green revolution," pesticides have claimed many lives. It is imperative that people stop using dangerous pesticides and replace them with safe, organic alternatives that decompose quickly in the sun and in the soil. Increasing Integrated Pest Management (IPM) programs is urgently needed as they can help decrease the usage of chemical pesticides. We must all take steps to reduce pesticide contamination in our environment, including wearing proper protective gear, implementing training programs, promoting the use of biopesticides, improving pesticide management and education in monitoring and regulatory mechanisms, and encouraging the adoption of scientific techniques. We must never forget that the food we eat today has been tainted with chemicals. These concoctions of deadly substances are being naively consumed by us. Therefore, let's ensure that our next generation does not experience pesticide poisoning.

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