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Assessment of Pesticide Toxicity in Selected Pakistani Fruits

Irum Jamil[1], Zaheer Ahmad[1], Muhammad Imran Khan[2], Fawad Ahmad[1*]

[1] Department of Chemistry, University of Wah, Quaid Avenue, Wah Cantt., (47010), Punjab, Pakistan
[2] Research Institute of Sciences and Engineering (RISE), University of Sharjah, Sharjah 27272, United Arab Emirates

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ABSTRACT

Persistent organic pollutants and heavy metals are damaging the environment. Crops and fields are destroyed by the seepage of heavy metals from untreated industrial waste. The burning and incineration of a variety of items also contributes to main and secondary emissions of pollutants. The excessive usage of Pesticides in Pakistan causes contamination, which effects the ecosystem. Although they increased life quality but also posed a significant health danger. The toxic properties of various pesticides and organic pollutants in Pakistani fruits was observed by exceeding the MRLs. The study aimed to stimulate discussion among Pakistan's stakeholders about the dangers and toxicity of pesticides, as well as prompt plans for environmental cleanup and more environmentally friendly farming. Due to ignorance, a sizable section of the populace is unaware of the issue of pesticide residues and their accumulation in the food chain. The major goal of the review is to record, evaluate, and examine the findings of earlier research on the levels of various pesticides in particular fruits from Pakistan. The results of the earlier investigations made it abundantly evident that more than 50% of the samples were contaminated with pesticides such as organophosphate, pyrethroid, and organochlorine.

*Corresponding Author's Email: fawad.ahmad@uow.edu.pk

1. Introduction

Science has undergone a revolution as a consequence of the commencement of technical innovations coupled with modernization of scientific understanding and enhanced accessibility (Rasheed et al., 2022). A wide range of synthetic chemicals are employed in modern industry to create things we use every day including insecticides, food, colours, pharmaceuticals etc (Baqar et al., 2017). Environmental pollution has increased significantly over the past few decades as a result of rapid industrialization and enormous population growth (Habiba et al., 2022). Environmental pollution is attributable to natural contaminants that are then changed, either directly or indirectly, by human activities (Conrad, White, Santos, & Sanders, 2021). Environmental components are polluted as a result of human activities that frequently employ chemicals that are not acceptable for environment. This degradation of the environment puts living things at risk (Mukiibi et al., 2021).

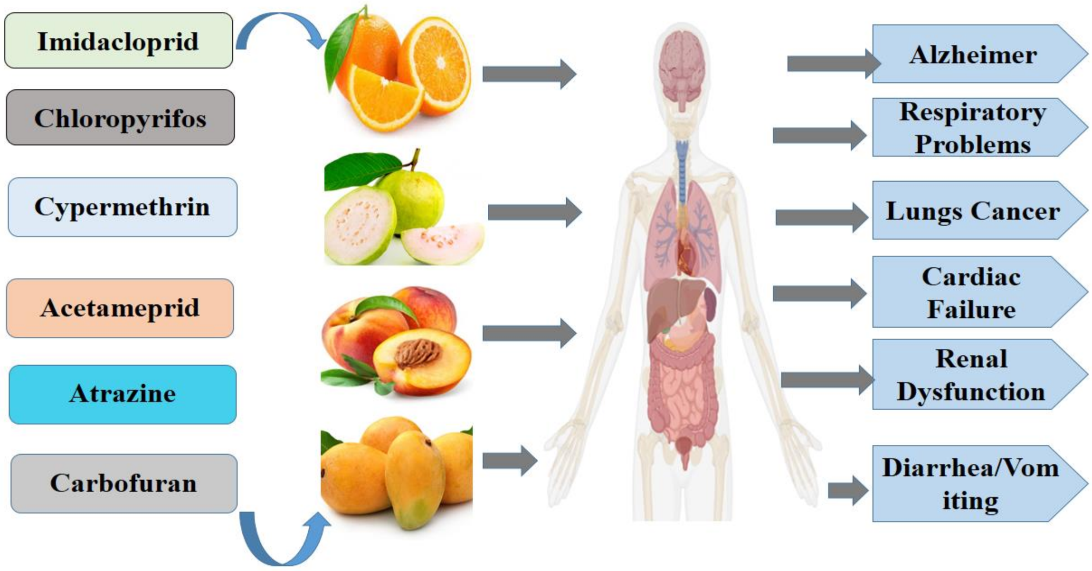

Figure 1: Pesticide Residues in some Pakistani Fruits and their Potential Health Risks

2. Problems Associate with Pollutants

In recent decades, various regions of the world have reported increased concentrations of a wide range of contaminants or pollutants, including toxic heavy metal ions, inorganic anions, micro pollutants, and organic compounds like dyes, phenols, pesticides, humic substances, detergents, and other persistent organic pollutants (Saxena, Purchase, Mulla, Saratale, & Bharagava, 2020). These hazardous chemicals' discharge into natural water bodies has wreaked havoc on the flora and wildlife and upset the ecological equilibrium (González-González et al., 2022). Numerous of these contaminants not only have significant levels of environmental mobility and a high potential for bio accumulation in the food chain, but they are also chemically and biologically resistant (Parra-Arroyo et al., 2022). Water is essential to life on earth, but it is heavily polluted by industrial pollution and pesticides. The textile industry is very important in the development of economy, but it also seriously pollutes the environment. The need for colours, stain-resistant clothing, and other hue items is growing in daily life, spurring the growth of the dyeing industry. These factories release toxic organic pollutants into the environment, including organic azo-dyes, surfactants, and phenolic compounds, which severely disturb the natural balance and have an adverse effect on all forms of life. These factories use enormous amounts of water and a variety of chemical substances for the dyeing process (Ahila, Vinodini, Ancy Jenifer, & Thamaraiselvi, 2022).

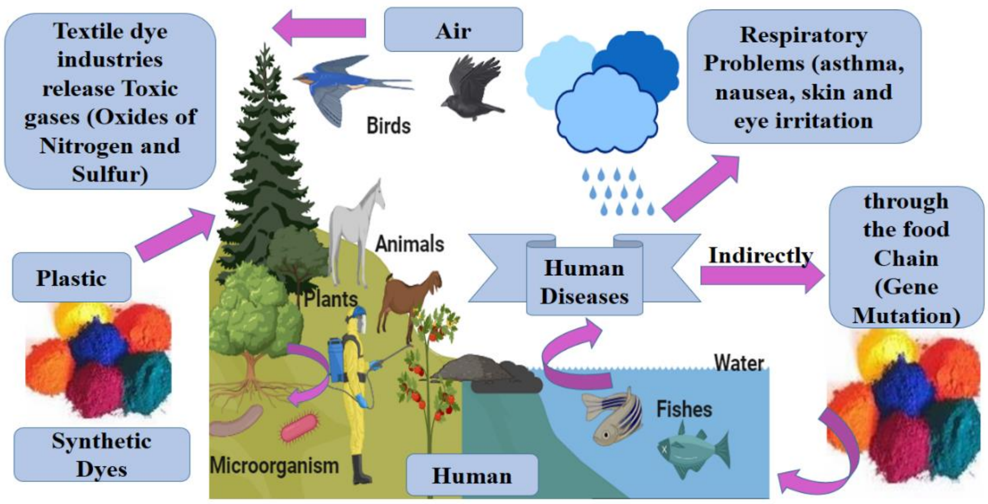

Figure 2: A schematic representation of the synthetic dyes and pesticide cycle in several Ecologies

Aquatic plants cannot photosynthesize when there is an increased concentration of colourful chemicals in the effluent combined with surface water. Additionally, it has an impact on both human and animal health as well as the fertility of agricultural soil (Cai et al., 2022). Water shortages are caused by physicochemical changes in surface and subterranean water quality brought on by textile waste (Teo et al., 2022). Traditional treatment techniques are costly and ineffective at effectively removing organic pollutants from wastewater (Pérez, Lebrero, & Muñoz, 2020). Thus, the treatment of textile industry wastewater requires methods that are both economically and environmentally sound in order to prevent pollution and conserve natural resources without hindering this industry's expansion (T. U. Rashid, Kabir, Biswas, & Bhuiyan, 2020). Toxic dyes impart harmful effect on fruits, vegetables and crops.

Humans are routinely exposed to potentially hazardous metals (PTMs) through eating of vegetables, fruits, and cereal crops cultivated in contaminated areas, which is a major problem for food safety around the world (Bicudo Da Silva, Batistella, Moran, Celidonio, & Millington, 2020). Intensive agricultural chemical usage, urbanization, industrialization, open waste dumping, landfills, solid wastes, mining, and sewage/wastewater irrigation are a few examples of anthropogenic sources (A. Rashid et al., 2020). The ability of plants to absorb metals is determined by either plant intake or soil-to-plant transfer factors of the metals, which are dependent on the species of plant (Nawab, Farooqi, Xiaoping, Khan, & Khan, 2018). Plants absorb hazardous metals from polluted soil solutions and/or deposits on their surfaces that are exposed to contaminated surroundings (Riyazuddin et al., 2022). PTM concentrations in various foods vary depending on the soil composition, nutritional balance, metal permissibility, absorption capacity, and species selectivity (Shahzad Akhtar et al., 2022). When fruits, vegetables, and cereal crops are harvested, produced, transported, and sold, PTMs from industry and vehicle emissions can also be released (Y. K. Khan, Toqeer, & Shah, 2022). Many of these contaminants have significant levels of environmental mobility, a high potential for bioaccumulation in the food chain, and are not just chemically or biologically resistant (Peña, Delgado-Moreno, & Rodríguez-Liébana, 2020).

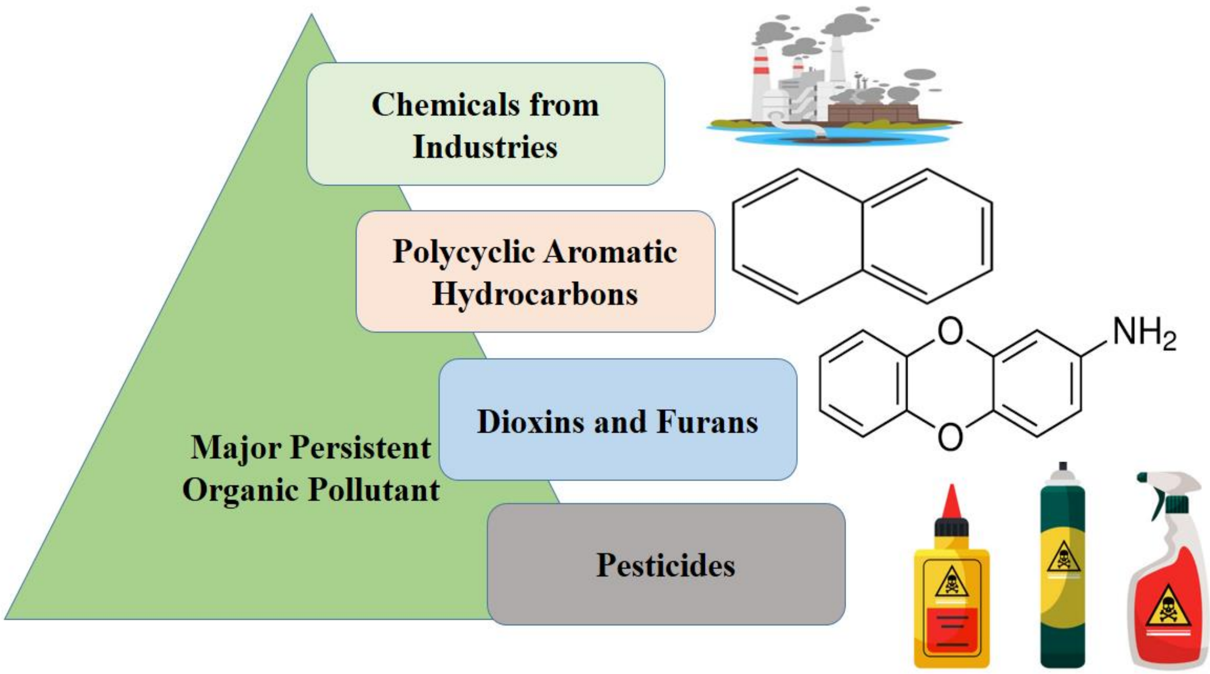

Figure 3: Different Sources of Major Persistent Organic Pollutants in the environment

3. Pesticides

Pesticides are chemical compounds that are used to control weeds, plant diseases and to enhance both the yield and quality of food products (S. Tang et al., 2022). Since most farmers are unaware of employing these chemicals, it is natural that these pesticides interact with the environment by changing the qualities of their hosts and causing negative effects. Pesticides are absorbed by soil particles, which then transported to the plant and animal food chain. This has a negative impact on the ecosystem by producing acute or chronic illnesses in individuals of all ages. Pesticides contain a variety of heavy metals, toxic chemicals, and pollutants which impart major risks to the aquatic ecology after they are released (Dad et al., 2022). Plants absorb hazardous metals from polluted soil solutions and/or deposits on their surfaces that are exposed to contaminated surroundings (Guo et al., 2022). These contaminents effect the aquatic water bodies as well as they harm human health also. Many water borne diseases like Cholera, Typhoid, Hepatitis, gastroenteritis are caused by contamination in water (Rao et al., 2022). The most essential component of ecosystem is soil (land) which can be contaminated by both organic and inorganic substances, including pesticides. The health of the soil is altered by surplus harmful compounds, which has adverse impact on the health of the crop, and animals (Zhang et al., 2022). Over use of fertilizers containing nitrogen boosts the prevalence of pests and diseases (Villaseñor-Ortiz, de Mello Prado, da Silva, & Lata-Tenesaca, 2022). Due to fertilizer and direct disposal of household trash to plants result in increased phosphorus levels in soil and ground water, which serve as significant barrier to nutrient uptake (Rajmohan, Chandrasekaran, & Varjani, 2020). The ability of plants to absorb metals is determined by either plant intake or soil-to-plant transfer factors of the metals, which are dependent on the species of plant. Plants absorb hazardous metals from polluted soil solutions and/or accumulates on their surfaces that are susceptible to hazardous surroundings (Ahmad, Nisar, & Mehmood, 2022). The use of pesticides has undoubtedly enhanced agricultural production overall, but their lingering residues have a detrimental effect on both the environment and human health (Jehan, Muhammad, Ali, & Hussain, 2022). The danger to human life posed by dietary food, drinking water, and the residential risk brought on by pesticide residues has received a lot of attention (T. Anwar, Ahmad, & Tahir, 2011). Maximum Residue Limits (MRLs), Average Daily Intake (ADIs), and Good Agricultural Practices are some of the concepts used to manage pesticides and their contamination of food items (GAPs) (H. Tang et al., 2021). When measuring the daily intake of a specific pesticide through food, information from nutritional surveys takes into account the specifics of regional eating patterns and the level of a need. To calculate the MRLs for pesticides in food commodities, it is essential to take into account certain criteria, including ADI, terminal residues, and dietary patterns (Feng et al., 2015).

4. Classification of Pesticides

The classification of pesticides is based on their origin, target organism, and chemical make-up. According to WHO, Pesticides are classified on the basis of their chemical properties (Garcia, Bussacos, & Fischer, 2008). Some major pesticides present in Pakistani peach, Mango, Guava and Orange are: Organochlorine, Organophosphate, Pyrethroid, Triazines. Pesticides can be produced artificially or naturally. Pesticides like endosulfan, dieldrin, aldrin, lindane, and DDT are widely used in agriculture, largely to increase crop yields and safeguard crops from pests in order to meet the demands of a growing world population (Okereafor, Garba, Okunola, & Adamu, 2022). Pesticides containing organochlorines (OC) are extremely poisonous and carcinogenic (Baqar et al., 2018). Pesticides have been linked to harm to the kidneys, liver, and brain system as well as cancer, immune insufficiency, disturbance of the reproductive process, and alteration or interference with the normal operation of the endocrine system (Awasthi & Awasthi, 2019). The use of natural pesticides as an alternative to synthetic pesticides is therefore strongly advised for food security and environmentally sustainable practices (Mohamed, Sharaf, Ataweia, & Bakry). Chlorinated hydrocarbons, or OCs, are used to control mosquitoes and in agriculture. They are hazardous to many species and persistently persist because they are soluble in lipids, store in animal fatty tissue, and are subsequently transferred down the food chain (Jayaraj, Megha, & Sreedev, 2016). OC pesticides have been banned in numerous nations across several continents, yet due to their great persistence, they are still found in the environment (Sultan, Hamid, Junaid, Duan, & Pei, 2023).

During World War II, German chemists created organophosphorous pesticides (OPPs) (Kunhikrishnan, Shon, Bolan, El Saliby, & Vigneswaran, 2015). Organophosphorus pesticides include chlorpyrifos, profenophos, quinalphos, dimethoate, and phorate (Fu et al., 2022). OPPs can be dissolved in water or organic solvents. They are less prone to contaminate and enter groundwater than chlorinated hydrocarbons, and some of them are harmful to the Nervous System (Freed, Schmedding, Kohnert, & Haque, 1979). They are absorbed by plants, transferred to leaves and stems, and then fed to insects that eat leaves by those plants. Around the world, OPPs are used as an alternative to OC insecticides to control insects in fruits, vegetables, and cereals. Due of their widespread applicability, low persistence, and relative inexpensive cost, OPPs and carbamates are still employed (Muhire, Li, Yin, Mi, & Zhai, 2021). OPPs are continue to be utilised because of their generally inexpensive cost, low tenacity and broad applicability. They work by blocking the enzyme acetylcholinesterase, and therefore disrupting the human and insect central nervous systems.

Exposure to OPPs is to blame for around 80% of hospitalizations resulting from pesticide poisoning in humans (Tariq, Afzal, Hussain, & Sultana, 2007). Synthetic pyrethroid pesticides include cypermethrin, fenvalerate, deltamethrin and carbofuran (Mehmood, Arshad, Mahmood, Kächele, & Kong, 2021). Allethrin and bioallethrin, the first synthetic pyrethroids, were created in 1949 (Ford, Mahadeva, Carbone, Lacy, & Talley, 2020). Resmethrin, the first generation synthetic pyrethroid, was created in 1962 by changing the structure of naturally occurring pyrethrins to boost their stability in sunlight and insecticidal activity (Narenderan, Meyyanathan, & Babu, 2020). The commercial utilisation of bioresmethrin, which was created in 1967 from resmethrin, began in the late 1960s. Additionally, two new, strong pyrethroids called cypermethrin and deltamethrin were created (Bhatt, Zhou, Huang, Zhang, & Chen, 2021).

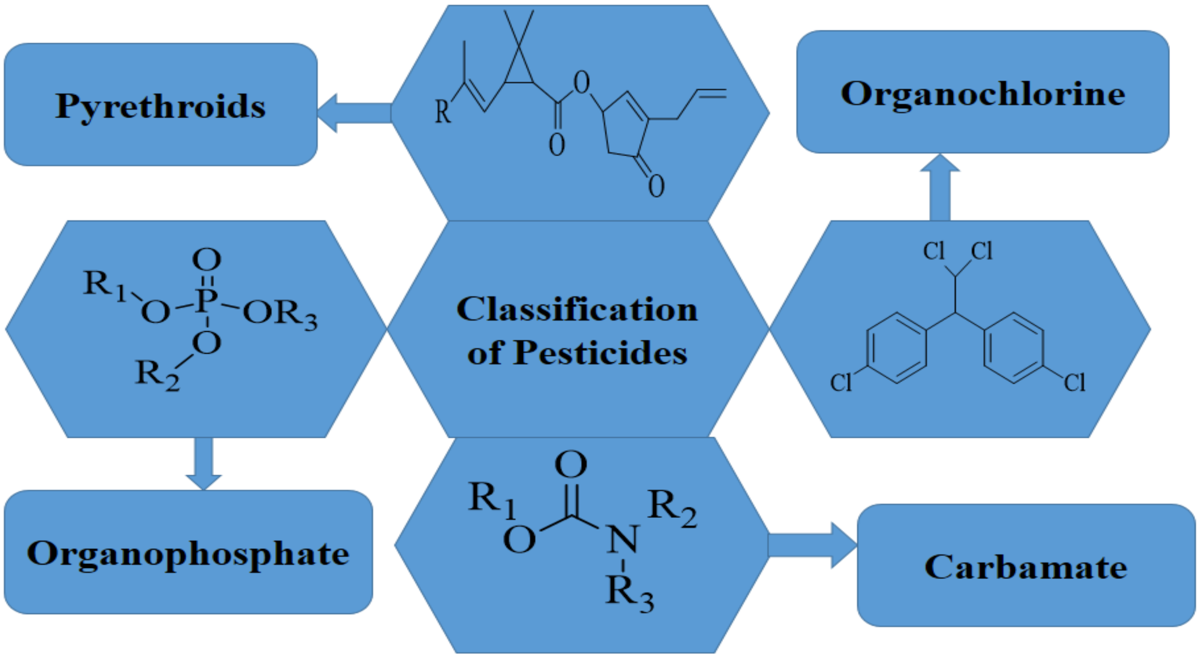

Figure 4: Classification of Pesticides

5. Pesticides in Pakistani Fruit

Pakistan, an agricultural nation, uses 22.2 million ha for crop production, of which 4.5 million ha are devoted to the production of fruits and vegetables (Syed et al., 2014). Due to increased domestic demand, manufacturing has significantly increased in recent years (Organization, 2003). Fruits and vegetables, like other crops, are vulnerable to pest assault. Different pesticides are utilised in Pakistan for defense, insect control, and weed eradication (M. Khan, Mahmood, & Damalas, 2015). In order to control insect pests and various crop diseases, Pakistan, a country with a large agricultural sector, uses a lot of organochlorine pesticides (OC), causing environmental contamination and human exposure as a result (Li et al., 2004).

Unfortunately, OC pesticides and other agrochemical poisons affect more than half a million people each year in Pakistan. Toxic active components have accumulated in the food chain as a result of the heavy usage of pesticides (Bhardwaj, Sharma, Abraham, & Sharma, 2020). Pakistan is the second-largest consumer of pesticides for agricultural use in South

Asia (Elazzouzi et al., 2022). However, only a small portion of Pakistani farmers (19%) are familiar of pesticide usage. There is a lot of evidence to suggest that farmers have abused and overused pesticides, particularly in cotton-growing regions (Kim, Kabir, & Jahan, 2017). The biological monitoring studies have shown that due to occupational exposure, farmers are more likely to experience acute and chronic pesticide-related health consequences (S. Rashid, Rashid, Tulcan, & Huang, 2022). Furthermore, there is an unique risk for field workers, fruit pickers, and an undesirable residue concentration in fruits when pesticides are used intensively (greater sprays than the allowed amount) in cotton areas (Raza et al., 2023). MRL (maximum residue limit) can be defined as tolerant level to store residues in the food commodities, as already set by the USEPA (AL-Zaidi, Baig, Muneer, Hussain, & Aldosari, 2019).

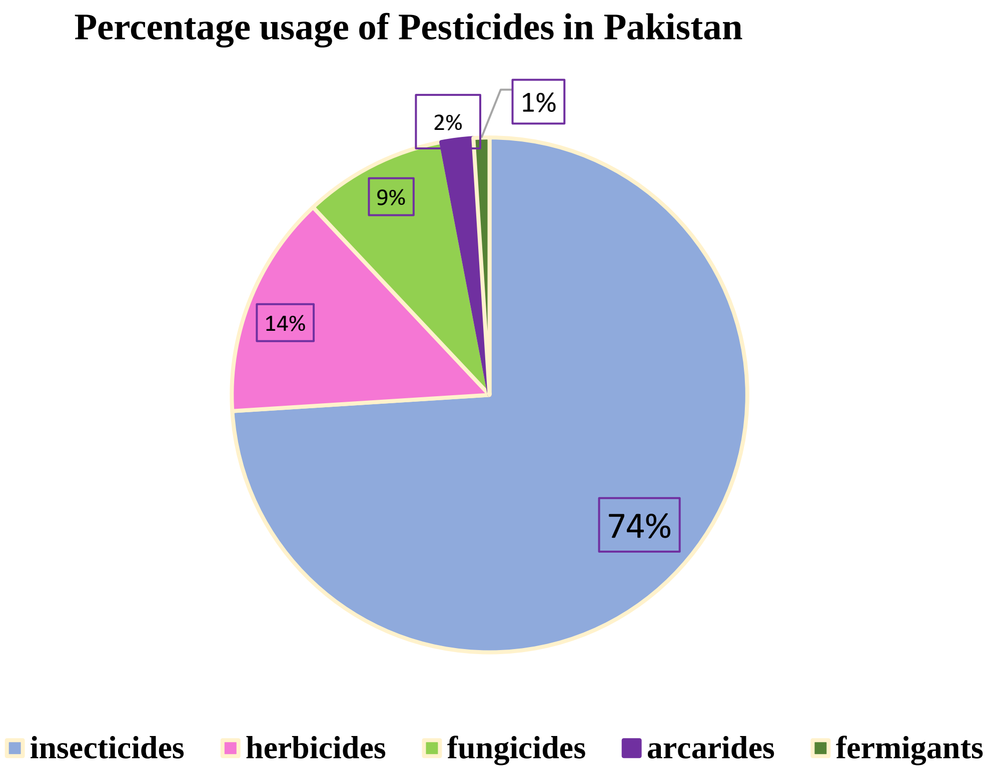

Figure 5: Percentage Distribution of Different Pesticides in Pakistan

Although fruits and vegetables have varying residual pesticide levels, this may be because of the zone's varying climatic conditions (hot, humid, and cold), or because plant species vary (Memon, Bhanger, & Akhtar, 2009). In Pakistan in particular, irrigation is thought to be a prevalent practice and a quick means to contaminate food through soil and water. Due to greater concentrations of dieldrin, DDT, methamidophos, and diazinon than the allowed threshold and MRL, more than 50% of the collected fruits and vegetables were determined to be contaminated (Jiang et al., 2009).

5.1. Peach

Peach *(Prunus persica)* is a member of the Amydyloidae, subfamily of Rosaceae. Rosaceae is the 19th largest plant family (Azam, Sarker, & Naz, 2016) Peaches are one of the most widely consumed fruits in the world and are both economically and nutritionally essential (Faheem et al., 2015). China is the world’s biggest producer of peaches with an annual production of 15.8 million tonnes (Bilal et al., 2022). Pakistan is the world’s 25th larger producer of peaches with an annual production of 73900 tonnes and 0.3% export share (Bilal et al., 2022). It is cultivated on 13819 hectares of land. Peach is a staple food in Pakistan’s Northern Region and the second most substantial stone fruit (Zhao et al., 2015). Peaches are mostly grown in Pakistan's NWFP and Baluchistan, as well as several low cold and early maturing cultivars in the Potowar region of Punjab.

The most widely used cultivars in Peshawar and Swat region early grand include Florida king 6-A and 7, 8, and 9 numbers. While Golden Early, Shah Pasand, and Shireen are grown in Baluchistan (Faostat, 2016). Even though pesticides are made for particular purposes, they were also infamous for having a negative impact on the environment (Shazia Akhtar et al., 2020). The statement that OCs are "poisonous to humans, animals, plants, and overall food webs" has been ratified. It is observed that detection of different pesticides in Pakistani Samples of Peach lies within the Residual Limit (Rana, Asghar, Haider, & Davies, 2021; Samad, Akhtar, Shahid, & Ahad, 2019).

Table 1
Comparison of Detection of different Pesticides in Pakistani Peach, their Class and Chemical Formula (Abbasi et al., 2022)

Compound Name	Chemical Formula	Chemical Class	General Class	EU MRL mg/Kg	FAO MRL mg/Kg	Log K at ≤ 25 ºC,(pH 5-7)	Detection Range mg/Kg
β-Endosulfan	$C_9H_6Cl_6O_3S$	Chlorinated cyclodiene	Insecticide	0.05	n.a	4.79	0.0083
Chloropyrifos	$C_9H_{11}Cl_3NO_3PS$	Organophosphorus	Insecticide	0.01	0.5	$5.0*10^4$	0.0113-0.1247
Captan	$C_9H_8Cl_3NO_2S$	N-trihalomethylthios	Fungicide	6	20	610	0.0144
Alpha-Cypermethrin	$C_{22}H_{19}Cl_2NO_3$	Parethroid	Insecticide	2	n.a	$0.87*10^7$	0.0115-0.3783
Dieldrin	$C_{12}H_8Cl_6O$	organochlorine	Insecticide	0.01	n.a	5.4	0.0063
Atrazine	$C_8H_{14}ClN_5$	Triazine	Herbicide	0.05	n.a	2.5	0.00839

LOD: limit of detection, LOQ: limit of quantification, MRL: maximum residue synthesis, n.a: non-agriculture

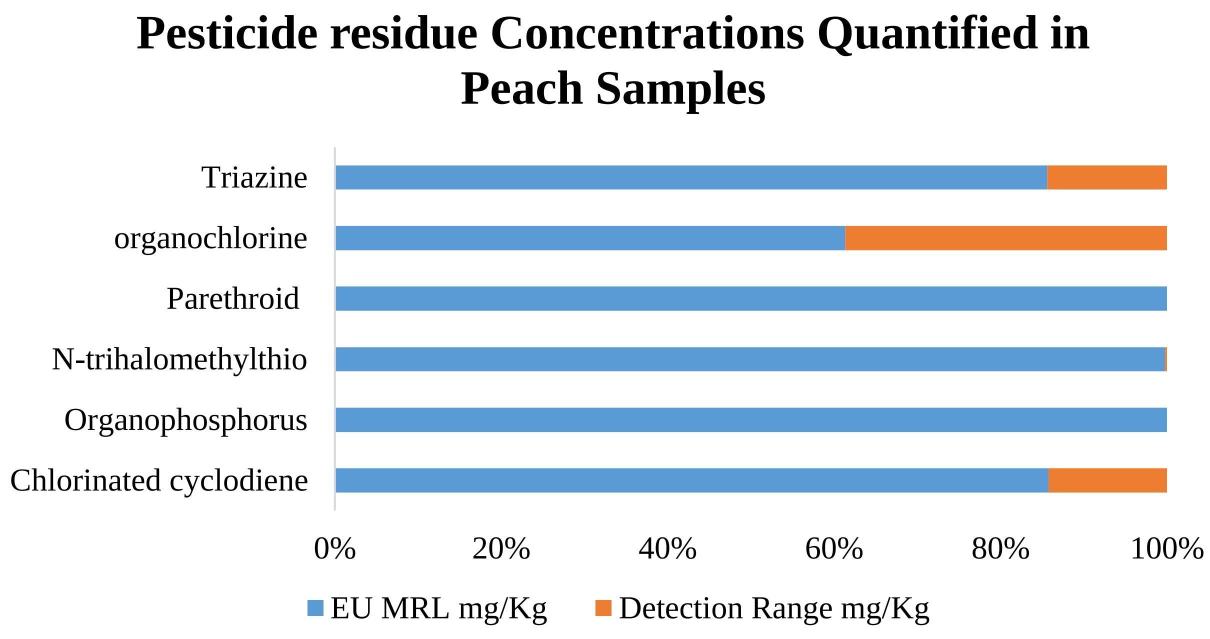

Figure 6: Analysis of Different Pesticide Residues in Pakistani Peach

5.2. Mango

Mango is regarded as the "King of Fruits" among all fruits due to its widespread consumption throughout the world and numerous health advantages it provides to people of all ages (Ahmed & Jahanzaib, 2022). The most widely cultivated tropical fruit in South Asia is the mango, which has now spread around the world (Saeed Akhtar, 2015). The national fruits of Pakistan and India is mango since these countries produce the majority of the world's mangoes. It is Pakistan's second-most popular area for consuming fresh fruit and a great source of vitamins, minerals, iron, sugar, fibre, and lipids. The third-largest exporter of mangoes worldwide is Pakistan. Hyderabad, R.Y. Khan, Muzaffargarh, Muzaffargarh, and Multan are the principal mango-producing districts (Fateh, Mukhtar, Mehmood, Ullah, & Kazmi, 2022). Sindh produces about 400,000 lac tons of mangoes a year, of which 40% are sent to Middle Eastern countries. They are typically greenish in colour, sweet, and have an irresistible aroma. Popular varieties of mango grown in Sindh include Sindhri, Langra, and many others. It is noticed that presence of Imidacloprid, Buprofezin and Chlorpyrifos in different pesticides exceeds the Permissible Limits in Mangos (Farooq, Arif, Gogi, Atta, & Nawaz, 2019).

Table 2
Screening of Different Pesticides, Their Maximum residue Concentrations and Detection Range quantified in Pakistani mangos (Kumar et al., 2021)

S.No.	Compound Name	Chemical Formula	MRLs mg/kg	Detection Range mg/kg
1	Lambda Cyhalothrin	$C_{23}H_{19}ClF_3NO_3$	0.20	0.05
2	Cypermethrin	$C_{22}H_{19}Cl_2NO_3$	0.70	0.08
3	Acetameprid	$C_{10}H_{11}ClN_4$	0.50	0.09
4	Imidacloprid	$C_9H_{10}ClN_5O_2$	0.20	0.79
5	Buprofezin	$C_{16}H_{23}N_3OS$	0.01	0.09
6	Chlorpyrifos	$C_9H_{11}Cl_3NO_3PS$	1	1.4

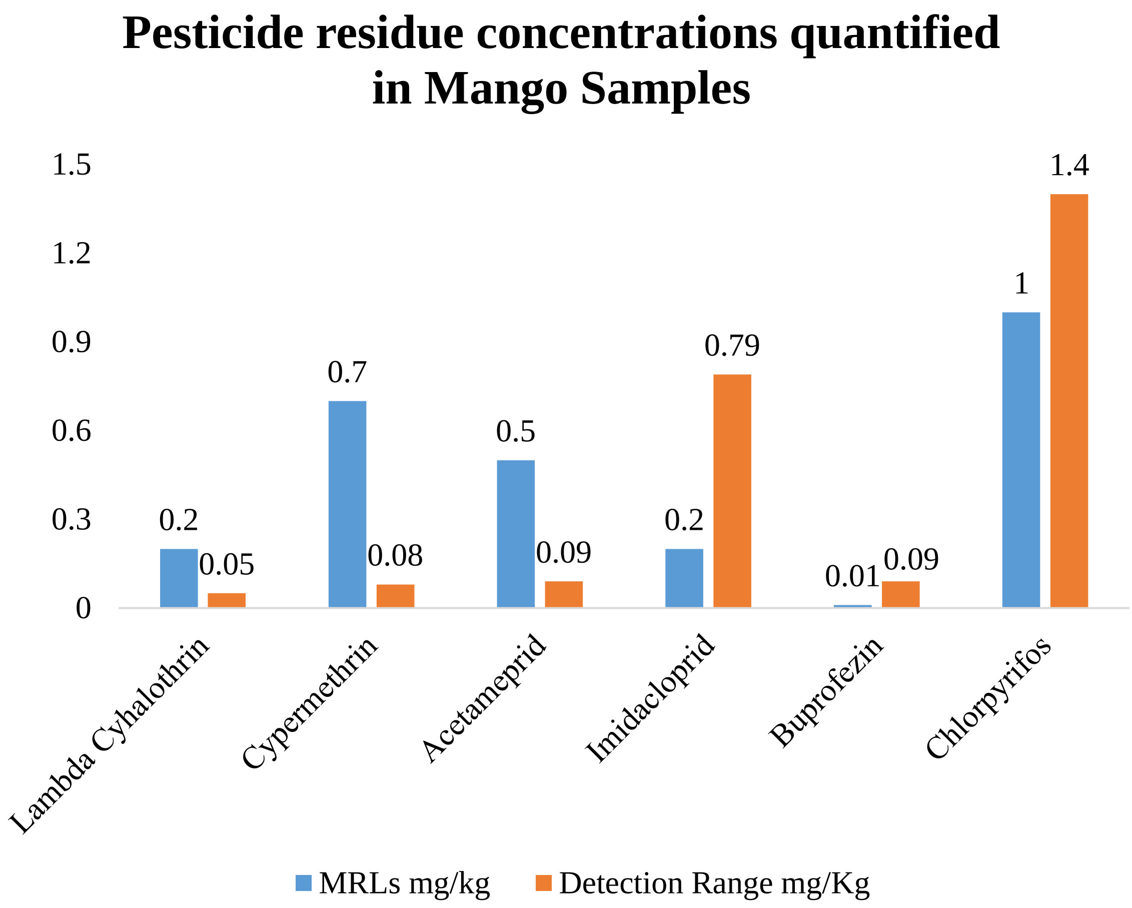

Figure 7: Graphical representation of presence of different pesticide components in Pakistani Mango samples

5.3. Guava

In Pakistan, the guava (Psidium guajava), often known as the tropical apple, is a common fruit (Shah, Usman, Fatima, & Nawaz-ul-Rehman, 2019). Fruit contains 82% of water, 0.7 % protein, 11% of carbohydrates, as well as healthy doses of vitamins A, B, and C, minerals, and pectin. It has three to six times as much vitamin C as oranges, ten to thirty times as much as bananas, and roughly ten times as much as papaya (Noonari, Memon, Wagan, Mushtaque, & Ismail, 2016). The guava plant is widely grown in Punjab and Sindh. It is a tropical tree that can adapt to the majority of climatic and soil conditions (D. Khan et al., 2020). Guava comes in third place among Pakistan's principal fruits in terms of area and output, after citrus and mango, which cover 183.8 thousand hectares, 151.5 thousand hectares, and 63.5 thousand hectares, respectively. According to data, between 1999–2002 and 2004–2005, guava output climbed from 494.5 to 570.6 thousand tonnes, while guava area increased from 60.3 to 63.5 thousand hectares. After analysis of different guava samples it is observed that maximum pesticides exceeds the Residual limits (Sana Akhtar, Yaqub, Hamid, Afzal, & Asghar, 2018).

Table 3
Detected Concentrations of Pesticides in different samples of Guava and their Maximum Residual Limit (F. Anwar & Rashid, 2007)

S.No.	Pesticides	Chemical Formula	MRLs (mg/kg)	Detected Concentrations (mg/kg)
1	Difenoconazole	$C_{19}H_{17}Cl_2N_3O_3$	75	81.5
2	Bifenthrin	$C_{23}H_{22}ClF_3O_2$	0.03	5.13
3	Paraquat	$C_{12}H_{14}C_{12}N_2$	0.01	6.6
4	Imidacloprid	$C_9H_{10}ClN_5O_2$	1	1.65
5	Diomethomorph	$C_{21}H_{22}ClNO_4$	0.25	0.48
6	Chlorpyrifos	$C_9H_{11}Cl_3NO_3PS$	0.05	0.06
7	Lambda Cyhalothrin	$C_{23}H_{19}ClF_3NO_3$	0.02	0.05
8	Cypermethrin	$C_{22}H_{19}Cl_2NO_3$	0.05	0.84
9	Acetameprid	$C_{10}H_{11}ClN_4$	0.01	0.05
10	Imidacloprid	$C_9H_{10}ClN_5O_2$	0.05	0.80
11	Buprofezin	$C_{16}H_{23}N_3OS$	0.30	0.16

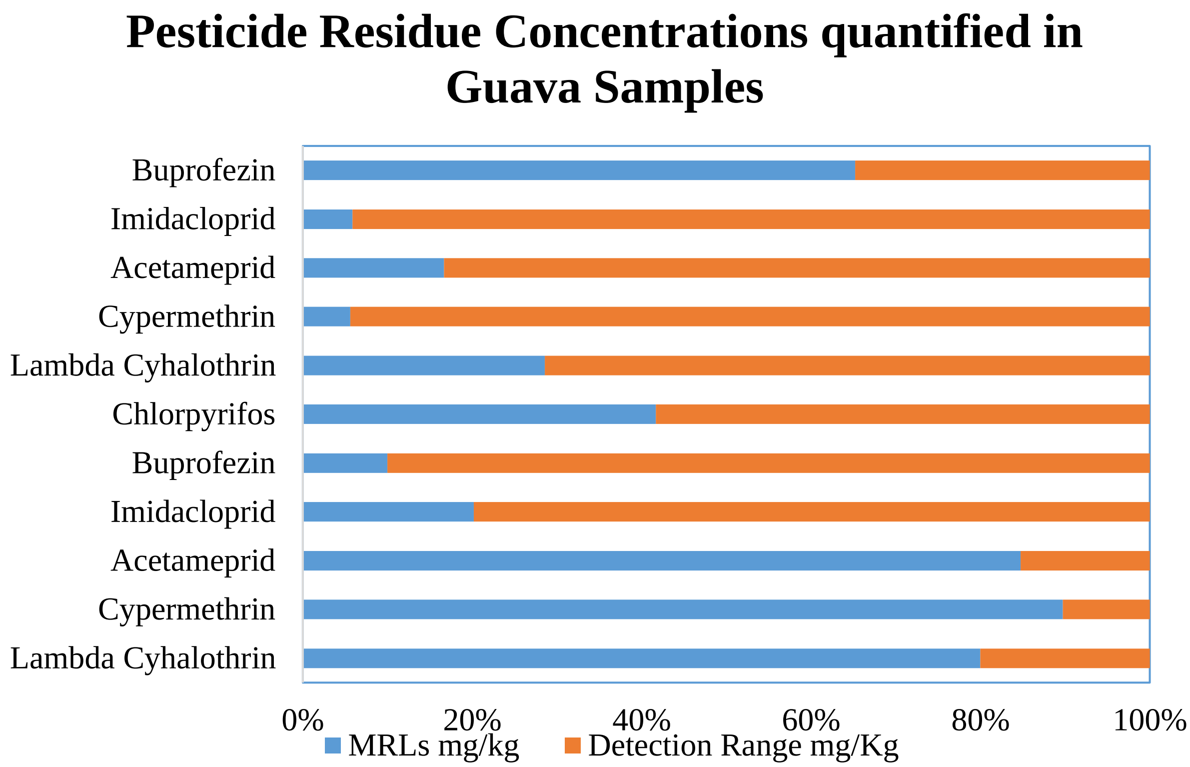

Figure 8: Assessment of different Pesticide Residues in Pakistani samples of Guava

5.4. Orange

Numerous tropical and subtropical nations worldwide grow citrus fruits. Along with top nations like Brazil, the United States, China, Japan, and Mexico, Pakistan is one of the biggest producers of citrus (Kinnow) fruit (Aziz et al., 2020). In addition, both in terms of productivity and area, citrus is the main fruit crop in Pakistan in terms of its complete fruit culture. These fruits are produced on 210.47 thousand hectares in the Punjab province, with a production level of 2.29 million tons (Kumar et al., 2022).

Table 4
Screening of different Pesticides in Orange samples and their comparison with Maximum Residue Limit (Rehman et al., 2022). Pesticide residue concentrations quantified in Orange samples

S.No.	Pesticides	Chemical Formula	MRLs (mg/kg)	Detected Concentrations (mg/kg)
1	Acetameprid	$C_{10}H_{11}ClN_4$	0.01	1.8
2	Carbofuran	$C_{12}H_{15}NO_3$	0.005	0.02
3	Imidacloprid	$C_9H_{10}ClN5O_2$	0.01	0.4
4	Atrazine	$C_8H_{14}ClN_5$	0.01	0.35
5	Chlorpyrifos	$C_9H_{11}Cl_3NO_3PS$	0.067	1.5
6	Heptachlor	$C_{10}H_5Cl_7$	0.005	0.25
7	β-Endosulfan	$C_9H_6Cl_6O_3S$	0.025	0.45
8	α-Cypermethrin	$C_{22}H_{19}Cl_2NO_3$	0.067	7.01

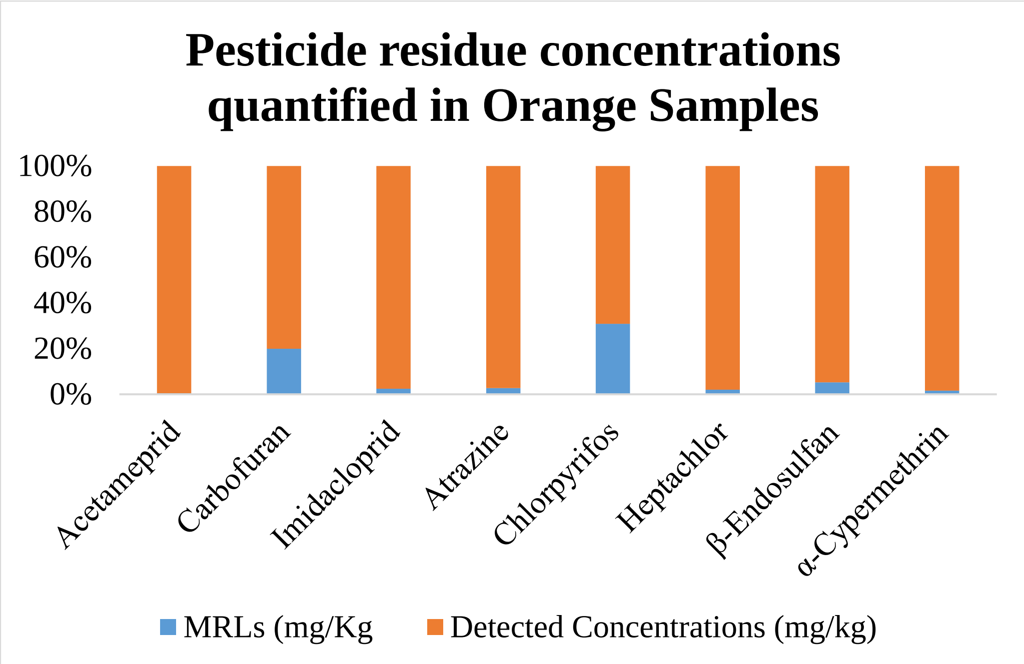

Figure 9: Detection of Pesticide Concentration in Pakistani Orange Samples

Conclusions and Future Perspectives

Pesticides are used to increase agricultural output, stop the spread of disease-carrying insects, and kill or inhibit harmful pests. Except for (cash crop) cotton, pesticides are not used in Pakistan in ways that are likely to maximize advantage due to a lack of understanding within the farming community and a lack of adequate regulatory agencies (Damalas, 2009). In the present study comparison of different results showed that peach samples have less Pesticide Residue while detection of pesticides in different samples of Guava and Orange exceeds the Residual Limit. Both Fruits are highly contaminated. Misuse of Pesticides cause harm. They are toxins, therefore exposing people to them could have fatal or negative effects. When pesticides are present in food products and accumulate in tissues have a direct harmful effect on human health.

In the industrialized world, strict government restrictions based on accurate and trustworthy analysis have been put in place regarding the presence of harmful pesticide residues in food Crop Plants or soil may not be treated with any type of pesticides in this system, with the exception of suggested fertilizers, as the active ingredients in pesticides are toxic to crop plants. However, many remediation techniques have been recorded to clean up the damaged ecosystem.

1. Vegetables are the staple meal in diet, and nutrition is unquestionably the main way humans are exposed to PAHs. How and how much PAHs are accumulated in the vegetables cultivated in agricultural areas is a major source of concern for scientists and local authorities.

2. The main factor behind the high concentration of PAHs in the environment appears to be the widespread use of natural gas as fuel. Common fuels used in businesses and homes include natural gas and furnace oil. Because gasoline is so expensive, compressed natural gas, or CNG, is a common fuel for cars in Pakistan. However, to date, Pakistan has not made any effective attempts to determine the amounts of PAHs in vegetables produced there.
3. The main causes of increased pesticide residues in agricultural commodities and thus higher risk of their exposure to end users are farmers' sole reliance on chemical pesticides is lack of training resources and knowledge and incorrect handling.
4. To increase farmers' understanding of pesticide use and proper handling, the government must impose strict controls on the production and distribution of pesticides as well as make training facilities and effective extension services easily accessible to the agricultural community. As a result, the danger of exposure will be lowered, and the harmful impacts of pesticides on the environment will be lessened. Alternative pest management methods must be investigated, including biopesticides (natural or microbial-based products) and allelopathic plant extracts (allelochemicals).

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