Silent Poison: The Hidden Dangers of Pesticide Pollution in Pakistan's Farmlands

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Abstract

Pakistan is an agricultural country, with the sector contributing approximately 18.9% to the country's GDP and offering employment for nearly 42.3% of the workers. Pakistan, where the growth, economy, progress, development, economy and food security heavily depend on agriculture, pesticide contamination of farmland is becoming a growing environmental concern. While pesticides boost crop yields and help control pests, the hidden perils of it on agricultural soils is significant and repeatedly overlooked. In Pakistan, farmers commonly rely on chemical pesticides as their primary approach to pest control. The excessive use of these pesticides is partly due to limited awareness of sustainable alternatives and integrated pest management (IPM) practices, leading to soil quality deterioration and barren lands. Unregulated pesticide use is not only contributing to land pollution but is also leading to water and air pollution. In Pakistan, most pesticides are applied to cotton crops, approximately 70–85% of total pesticide then comes wheat, sugarcane, maize, potatoes, rice, and tobacco. This study focuses on the in-depth investigation of pesticide application across a piece of one-acre land for the purpose of research. The targeted area is in the tehsil of Jalalpur Nangyana, District Sargodha. This study also analyzed the production of sugarcane, wheat and potatoes under the influence of several pesticides. The yield helped in analyzing the soil quality briefly discussed in the methodology along with the results that summarize the long-lasting impacts on soil health. Spotlight will also be provided to a few recommendations which can help improve the agricultural practices in future.

Keywords: Pollution, Pesticide, Soil characteristic, agriculture, Crop production

1. Introduction

1.1 Background:

Pesticides include all chemical compounds or biological agents used on yields, crops, harvest livestock, or humans to control, repel, or eliminate pests that put them at risk. To control pests like insects, weeds, fungi, and rodents, these agents are used in forestry, public health, and agriculture, among other sectors. Although the use of pesticides is necessary to safeguard crops from harm and maintain food security, there are worries regarding the effects they may have on the environment and human health. Pesticides are chemicals developed to manage pests and include various types such as rodenticides, bactericides, microorganisms, nematicides, herbicides, molluscicides, piscicides, avicides, insecticides, fungicides, and lampricides (Yusuf Abubakar, 2020).While pesticides can be useful in managing pests, it's critical to remember that

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their practice must be carefully considered in order to reduce any adverse impact on the environment, non-target organisms, and human health. If the problem of pesticide pollution is not addressed as soon as possible, the catastrophic effects will make their way and cause demolition to an extent that has no end.

Jalalpur Nangyana, a well-known agricultural area and the study area lies in in Punjab province. Punjab plays a pivotal role in Pakistan's agriculture, contributing nearly 60% of the country's total agricultural output, making it essential to the national economy. Identifying the factors that influence agricultural productivity in this province will further enhance its contribution. The cropped area, agricultural labor, seed distribution, monetary spending on agricultural exploration and extension, land reclamation, and wheat price support were found to progressively contributing to agricultural production in Punjab. On the other hand, it was discovered that pesticides and food trading service costs had a negative impact. To boost agricultural output in the province, the provincial government should prioritize these factors. Jalalpur Nangyana, a well-known agricultural area in Punjab, emphasizes pesticide use to enhance crop yields and improve productivity across various crops. Pesticides not only help control the pests that might attack the crops, but it also aids increase the production. Hence, the results hold positive reviews of a lay man. The silent peril that remains hidden from the human eye must be exposed in order to save our agricultural lands. This directly refers to the impact of various pesticides on soil quality that attack slow but percolate deep within the roots.

2. Literature Review

The country's land area is diminishing, yet demand continues to rise (Arshad, Arfan, et al., 2019). Given the country's agricultural needs, all available irrigable land is being used to its fullest extent (Arshad, 2019). To ensure a consistent yield, farmers are increasingly turning to pesticides. Pesticides are used by the majority of the 1.8 billion people who work in agriculture globally to safeguard their crops. Moreover, pesticides are utilized for public health purposes, and several individuals apply insecticides to their gardens at home (AL-Zaidi, Abdullah A., et al., 2019). The rampant and unregulated use of pesticides has brought forth an alarming escalation of environmental and health risks. The rampant and unregulated use of pesticides has brought forth an alarming escalation of environmental and health risks. The extensive consumption of these toxic agents has resulted in a contaminated groundwater supply (Water Contamination and Human Health Risks in Pakistan: A Review, 2022). Major credit goes to the organochlorine pesticides (OCPs), rendering the water utterly unsuitable for consumption. Disturbingly, even Dichlorodiphenyltrichloroethane (DDT) has been detected in drinking water, its concentration varying with the seasons, peaking during the winter months. Moreover, these same perilous pesticides, combined with pyrethroids, have inflicted soil contamination, predominantly affecting areas associated with food safety, making their impact most poignant in brownfield regions (Abubakar, Yusuf, et al., 2020). The volatility of these OCPs has further caused air pollution in numerous cities across Punjab, where their usage is significantly high. Of utmost concern is the constant increase of pesticide concentrations on the degradation of food quality, exceeding the permissible limits. The consumption of fruits and vegetables containing elevated amounts of these toxins has resulted in severe health complications, altering both the taste and nutritional value of these natural delights. Even in the absence of direct pesticide application, the residual presence of these hazardous chemicals in water and air has proven to be exceedingly detrimental to both plant life and human health. Farmers frequently clean pesticide containers in water canals

or streams or toss them into bushes in developing and low-income agrarian economies, endangering both human health and the environment (Mehmood, Yasir, et al., 2021). Pakistan is one of the largest buyers of pesticides in the global market. Considering the geography of the country, significant growth in urban development is noticed in the province of Punjab making it the biggest consumer of pesticides in the agricultural sector The Punjab province leads in pesticide usage, accounting for 88.5%, followed by Sindh at 8.2%, Khyber Pakhtunkhwa (KPK) at 2.8%, and Baluchistan at 0.76% (Sajid, Rashid, and colleagues, 2022). Organophosphorus pesticides (OPPs) are the main chemicals used in agriculture to control insects and pests. Regretfully, extended exposure to OPPs in humans can lead to metabolic diseases as obesity, hypertension, dyslipidemia, and hyperglycemia (Leonel Javeres, Mbah Ntepe, et al., 2021).
Chemically manufactured pesticides are also utilized to combat damage and boost crop yields; however, they unfortunately come with undesirable side effects. Alternative 'botanical insecticides' may unintentionally impact pollinators and disrupt biocontrol services (Shah, 2019). Countries like China, the US, and Australia, among others, have successfully adopted microbial biopesticides on a large scale, reducing the reliance on synthetic pesticides in agriculture. However, no significant efforts have been made to promote their use in Pakistan's agricultural sector (Inam-ul-Haq, M., et al., 2019).Commercial production of these biopesticides could be a beneficial step toward organic farming, assisting in the development of pesticide-free agriproducts and biopesticides generated from them. They can be used efficiently in integrated nutrient and pest management strategies (Parewa, Hanuman Prasad et al., 2021).

Pesticides are inflicting significant damage to agricultural soils as a result of agrarian neglect and farmer ignorance. Farmers have constantly stated that actual farming expertise in managing agricultural land is more beneficial than formal education in agricultural sciences (Elahi, Ehsan, et al., 2020). Biopesticide use is rising globally to address the devastation caused by agricultural land loss (Inam-ul-Haq, M. et al., 2019). Essential oils have grown in popularity in the scientific community over the last decade since they have a lower environmental impact than local pesticides. The overuse of chemical fertilizers and pesticides is a major contributor to the contamination of agricultural water. The excessive use of chemical fertilizers and pesticides is a major source of agricultural water contamination (Zahoor, Iqra, and Ayesha Mushtaq, 2023). With so many other factors already leading to the loss of agricultural land in Pakistan.

3. Methodology

This study was conducted in the secluded village of Jalalpur Nangyana, located in Sargodha, central Punjab. The study revealed an increase in crop output on one acre of land. Three crops were targeted: wheat, sugarcane, and potatoes. Different insecticides were applied for all three crops, and yield production was calculated based on data provided by local farmers on-site. For one acre of land, pesticides are applied at a rate of 2.7 quarts per acre, using a minimum of 10 gallons of water per acre for ground application. This holds for one tenure of cultivation over one year. Wheat:

1. Wheat Pesticides:

Listed below pesticides were applied to the wheat crop:

- **Aldrin:** Organochlorine pesticides, like dieldrin and Aldrin, are commonly used in agriculture to control pests, particularly soil-dwelling insects. Dieldrin is formed when Aldrin, which is its precursor, is broken down and applied. Both substances are pesticides in the cyclodiene class.

● **Endrin:** Endrin, an organochlorine insecticide, is used in agriculture to control various insect pests.

● **Thiodane:** The insecticide "Thiodan" is the trade name for endosulfan, an organochlorine compound. Endosulfan is utilized as a broad-spectrum insecticide on crops such as fruits, vegetables , cotton and tea to control a variety of pests. Endosulfan, like other organochlorine pesticides, has been

Wheat Cultivation:

Wheat is primarily cultivated once a year in Pakistan. It is a winter (Rabi) crop, and the main wheat cultivation season typically occurs from November to April. The planting season starts in November, and the crop is harvested in April or early May, depending on the specific region and weather conditions. The Rabi season follows the Kharif season, during which crops like rice, cotton, and sugarcane are cultivated. The cycle of Rabi and Kharif seasons allows for diverse cropping patterns and optimal utilization of available resources throughout the year in different regions of Pakistan. The region of Jalalpur Nangyana is a part of central Punjab. For this research, the data was collected for the year 2020, 2021 and 2023 by the local farmers. The production of wheat in the year 2020 using Aldrin was 2.2 tons. In the year 2021, using a different pesticide, Endrin, the production yield showed a small variation of 2.1 tons. In the year 2023, again a different pesticide Thiodan was used, and it produced a significant change in the overall yield decreasing it to 1.9 tons.

Figure 1: Wheat field

3.1 Sugarcane:

3.1.1. Sugarcane Pesticides:

Listed below pesticides were applied to the sugarcane:

● **Sugarcane Special:** (Technical name: Propiconazol) These pesticides are specifically formulated for the targeted crop, which in this case is sugarcane.

● **Horticulture:** Chemicals created especially for use in horticultural practices are known as horticulture pesticides. Horticulture involves the cultivation of fruits, vegetables, flowers, and ornamental plants, and the term "horticulture pesticide" refers to a broad range of pesticides used to protect these crops from weeds, diseases, and pests. The insecticide Imidacloprid and fungicide Carbendazim are horticulture pesticides.

● **Sempra:** (Technical name: Halosulfuron Methyl 75% Water dispersible granules) Sempra is a suspension concentrate formulation designed to control annual dicotyledons and grasses in winter and spring cereals using selective contact and residual herbicide action. When growing

conditions are favorable, residual activity can continue for up to eight weeks following application.

3.1.1 Sugarcane Farming:

Sugarcane is typically cultivated once a year in Pakistan. Sugarcane is a tropical and subtropical crop, and its main cultivation season in Pakistan aligns with the Kharif season, which spans from April/May to October/November. During the Kharif season, farmers plant sugarcane, and the crop is harvested around 10 to 12 months later, depending on the specific variety and growing conditions. The local farmers of Jalalpur tehsil gave the data for sugarcane production using different pesticides over a span of four years. Production of sugarcane in the year 2021 using sugarcane special pesticide namely Propiconazol resulted in a yield of 800 mounds. In year 2022 using the pesticide Horticulture the yield increased to 1000 mounds. As stated earlier, the data could only be arranged by local farmers so the researchers were unable to interpret the kind of horticulture pesticide used for sugarcane. Therefore, the results were submitted keeping in view the general properties of horticulture pesticides and their impacts on sugarcane. In year 2023 Sempra was used and the yield decreased to 900 mounds.

Figure 2: Sugarcane field

3.2 Potato:

3.2.1 Pesticides for Potato:

Listed below pesticides were applied to the potatoes:

- **Emesto 24 fs:** Emesto Prime is an innovative fungicide that aids potato planters in treating their seeds. It is highly efficient against various soil- and seed-borne pathogens.
- **King Pokair:** King Poker is formulated to enhance nutrient absorption in crops, providing the essential elements needed for robust and healthy growth.
- **Antracol:** Antracol is a contact fungicide containing propineb, used to protect crops like rice, tomatoes, grapes, potatoes, pomegranates, and to control diseases such as leaf spots and early and late blight..

3.2.2 Potato Production:

Potatoes in Pakistan are typically grown in two main seasons: Rabi and Kharif.

- Rabi Season: The Rabi season occurs during the winter months, from November to April. Potatoes are planted in the Rabi season, usually starting in October or November, and the crop is harvested in March or April.
- Kharif Season: While not as common as Rabi cultivation, some regions in Pakistan also cultivate potatoes during the Kharif season, which spans from April/May to October/November. Kharif cultivation may involve varieties suitable for warmer temperatures and different planting and harvesting schedules.

Therefore, potatoes are cultivated at least once a year in Pakistan, primarily during the Rabi season. The exact timing and frequency may vary based on the region, climate, and specific local agricultural practices. In the region of Jalalpur, cultivation of potatoes occurs during the two seasons. The information about the total yield for three years using different pesticides was provided by the local farmers. The production of potatoes in 2021 using Emesto 24fs was 200 mounds. In year 2022, King Pokair was used and the yield obtained was 180 mounds. In 2023, pesticide Antracol contributed to a yield of 200 mounds.

Figure 3: Potato field

4. Results and Discussions:

4.1 Unveiling the impact of pesticides on wheat production:

After all the results were collected and analyzed, it was noticed that Aldrin produced the greatest yield for the year 2020. However, it was replaced the very next year with Endrin. Decision to replace or change pesticides each year is influenced by a combination of factors, including pest dynamics, regulatory changes and advancements in technology, economic considerations and a commitment to sustainable agricultural practices. Aldrin is known worldwide for a number of harmful effects which include environmental persistence, bioaccumulation in living organisms, toxicity to non-target species, human health risks through consumption of contaminated food and water, groundwater contamination, and adverse effects on soil microorganisms. This collectively impacts the soil quality overtime. Therefore, it is not recommended for a long term use over the same area. In the year 2021, endrin was considered for pest control over the one acre land. It decreased the production by one ton. The deviation was not a lot but it must be noted that endrin itself is a highly toxic organochlorine pesticide that has been banned or restricted in many countries due to its persistence, bioaccumulation, and harmful impacts on the environment and human health. Keeping in view the results obtained by endrin, farmers decided to change the pesticide to an insecticide named Thiodane in the year 2023. Thiodane, containing the pesticide endosulfan, has been widely used for wheat cultivation in the past. However, it can persist in the environment for long durations imposing serious threats to soil and hinder wheat production practices. The production in the year 2023 was the lowest. This suggests that the soil quality deteriorated over a span of years. It suffered from all the damage caused by Aldrin which was later followed by the consequences of Endrin and Thiodane thus reducing the capability of soil to bare the oppression against environmental hazards. The results of exact production quantity for the mentioned years is given by the table below.

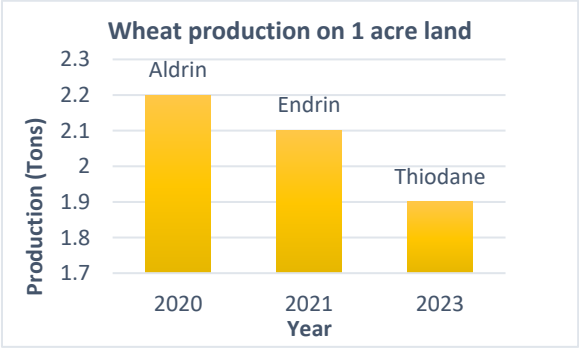

Figure 4: Wheat production over three years

4.2 Unveiling the impact of pesticides on sugarcane production:

For sugarcane, the results were analyzed on the basis of the production and the efficiency of the target pesticides. Sugarcane special (particularly the insecticide called Propiconazol) was used to target the sugarcane smut over the solid ground. Its mode of action involves inhibiting ergo sterol synthesis in fungal cell membranes. Applied as a foliar spray or seed treatment, Propiconazol provides systemic protection, translocating within the plant. The production for the year 2021 was 800 mounds. While effective, its repeated use can contribute to the development of resistant fungal strains which may affect the next harvest. In the year 2022, this pesticide was replaced by the farmers by the horticulture pesticide. As stated in the methodology, the data was collected by local farmers and this information did not contain the particular name of the horticulture pesticide that was used in the year 2022. For this reason, the total yield was the only parameter used for the analysis which was 1000 mounds. This particularly suggests that the use of horticulture pesticide proved fruitful for the overall yield but still it was replaced by the farmers because of a number of reasons. Horticulture pesticides cause environmental contamination through soil, water and air. They persist in the environment and bioaccumulation is a common problem of these pesticides. Thus they cannot be used for prolonged durations because they damage the soil health making the lands barren long before they are due. Lastly, in the year 2023, the pesticide opted for sugarcane yield was Sempra mainly because it is cost effective as compared to the previous two pesticides. Sempra is priced at 750Rs/liter so it was more economical for the farmers. Sempra is used to control annual dicotyledons and grasses in winter and spring cereals. It is Halosulfuron Methyl 75% Wg. The production using this pesticide decreased the yield by 100 mounds giving a total sugarcane output of 900 mounds which is still greater than Propiconazol. The major drawback of this herbicide is that it may affect other plants in its vicinity if not used in accordance to the recommended guidelines. There is a high possibility that it may persist in the soil and water causing harm to the soil micro-organisms, aquatic life and ground water. This residual activity continues upto several weeks ultimately demolishing the soil health

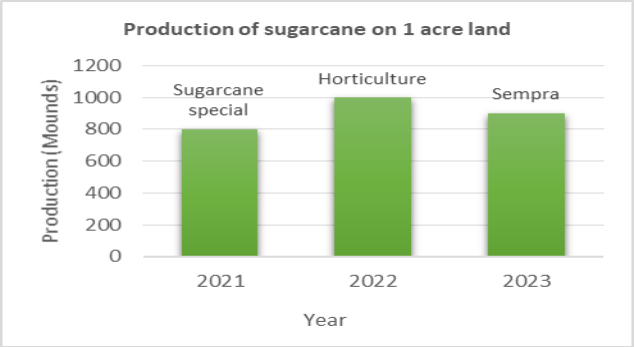

Figure 5: Sugarcane production over three years

4.3 Unveiling the impact of pesticides on potato production:

Three pesticides were used for potato production over a span of three consecutive years starting from 2021 upto 2023. Firstly, in the year 2021, a total yield of 200 mounds across an area of 1 acre was noted using Emesto 24 FS (a fungicide). Fungicide use entails costs, such as product acquisition, application charges, and possible labor expenditures. However, if the fungicides successfully prevent disease and aid in a bountiful potato harvest, the economic impact is favorable. In this case, it gave rise to residue in the potato crop. In the year 2022, King Pokair was used as an alternative giving a potato production of 180 mounds followed by its destructive consequences resulting in leaching and runoff. It was replaced by Antracol in 2023. Antracol is a brand name for a fungicide containing the active ingredient probineb. Probineb is a dithiocarbamate fungicide used to control various fungal diseases in crops. The final yield for the year 2023 was 200 mounds. No effective increase in yield was noticed ultimately leading to the answer that soil quality damaged over the years using different pesticides.

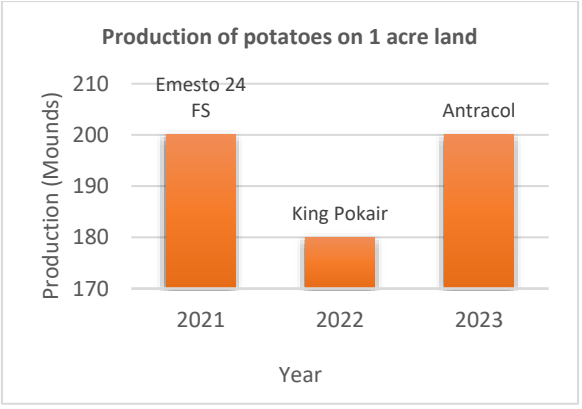

Figure 6: Potato production over three years

5. Conclusions:

This review outlined the use, contamination, and environmental impacts of pesticides in Pakistan, focusing on a case study of Jalalpur Nangyana in Sargodha. Every pesticide had its

drawbacks. It was also inferred that the cultural practices and weather across this particular region were not subject to great deviation, but the yield was not very satisfactory which resulted in the subsequent replacements of pesticides. Although there is some information available on the use, contamination, and exposure to pesticides in Pakistan, there hasn't been enough research done on the topic to fully understand the situation. We recommend that significant efforts be made to investigate Pakistan's current pesticide contamination status and related health issues based on previous research. To precisely ascertain Pakistan's current pesticide usage, contamination level, and exposure, studies must be carried out.

6. Recommendations for future:

The root cause of pesticide pollution must be addressed. On the very base, farmers and agrarians are not educated enough about the issue. Farmers and agrarians are only looking forward to increasing the crop production no matter what it leads to. There should be proper seminars and consultations before any agricultural project commences. Moreover, it is recommended that all environmentalists include this issue in their research projects and find pest control alternatives for a more sustainable agriculture. Integrated Pest Management (IPM) is a sustainable approach to pest control and should be promoted. IPM aims to minimize the environmental impact of pest management, reduce reliance on chemical pesticides, protect human health, and enhance economic sustainability. It promotes a holistic and balanced approach to pest control, emphasizing long-term effectiveness and community involvement. These are common practices in developed countries with sustainable agriculture. By taking these steps, we will not only enjoy our better agricultural but also cultivate a greener future for generations to come.

Conflict of interest: This study has no conflict of interest.

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