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Health and Environmental Risk Assessment due to Pesticide Exposure in Agricultural Communities: A Review of the Literature

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Abstract

The use of pesticides in agriculture increases productivity but also poses significant health and environmental risks, particularly in farming communities with high exposure levels. Most previous studies have examined health or environmental effects separately, creating a gap in understanding the combined risks faced by vulnerable populations. This study seeks to assess both health and environmental risks of pesticide exposure and identify contributing factors through a literature review. A total of 50 scientific journals were reviewed, with 10 articles selected based on inclusion criteria and analyzed using a descriptive-thematic approach. The findings indicate that pesticide exposure is linked to acute poisoning, neurological symptoms, respiratory problems, and potential reproductive or developmental disorders in children. Chronic risks are most evident among farmers, children, and pregnant women, largely due to limited use of personal protective equipment, long spraying duration, and weak regulatory control. Environmentally, pesticide residues accumulate in soil, water, and aquatic ecosystems, contributing to degradation and biodiversity loss. Overall, the study highlights that pesticide exposure presents dual risks to human health and the environment, underscoring the need for integrated risk assessment, longitudinal studies, and stronger, sustainable management policies.

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Introduction

The use of pesticides in the agricultural sector is a common practice around the world, especially in developing countries that rely heavily on agricultural production. Pesticides have an important role to play in controlling pests and increasing productivity, but overuse, uncontrollability, and lack of worker protection can have a serious impact on human health and environmental sustainability.

Various studies have proven that exposure to pesticides, especially organophosphates and carbamates, is closely related to decreased blood cholinesterase activity, which is an important biomarker for detecting toxicity. Studies in Ghana and Mexico show that farmers who do not use personal protective equipment (PPE) adequately have a higher risk of developing cholinesterase depression, accompanied by clinical symptoms such as dizziness, fatigue, and muscle tremors (Ntow et al., 2009). In Indonesia, a study in Jember reported a significant association between the frequency and duration of spraying with neurobehavioral disorders, especially if PPE was not used (Pawestri & Sulistyaningsih, 2021).

The risk of exposure to pesticides is not only limited to farmers as direct users, but also threatens vulnerable groups in agricultural communities, including children and pregnant women. Exposure to residues can occur through food, water, air, or contact with contaminated environments. The impact caused includes an increased risk of babies with low birth weight, neurodevelopmental disorders, and mental and emotional health problems in the later stages of life (Serrano-Medina et al., 2019).

In addition, the use of pesticides also has serious consequences for the environment. Chemical residues that accumulate in soils and waters can disrupt the balance of ecosystems by destroying soil microorganisms, reducing biodiversity, and threatening non-target organisms such as fish and other aquatic fauna. Some studies report that pesticide residue levels in farmland often exceed safe thresholds, leading to degradation of soil quality, food chain pollution, and disrupted ecological stability (Jayasekara & Ratnayake, 2022).

Although various studies have examined the impact of pesticides on human health as well as the environment, most research is still partial and not integrated. Previous studies have generally focused on one aspect, such as health biomarkers or environmental pollution, without linking the two within the framework of risk assessment. In addition, there is not much literature that examines the pathways of exposure, the level of group vulnerability, and the ecological implications systematically using the health and environmental risk assessment.

Based on this, this study was designed to comprehensively review the scientific evidence on pesticide exposure in agricultural communities with an emphasis on a risk assessment approach. This review integrates health and environmental aspects through the stages hazard identification, exposure assessment, dose–response assessment, and Risk characterization. The results are expected to provide a strong scientific basis for the development of mitigation strategies, worker protection, and the formulation of more sustainable agricultural policies.

Methods

This study uses a literature review design with a health and environmental risk assessment approach. Articles were searched through PubMed, ScienceDirect, SpringerLink, and Google Scholar with keywords related to pesticide exposure, health risk, environmental risk, and agricultural communities. From the 50 articles obtained, a selection was made based on title, abstract, and content. The inclusion criteria are research articles or reviews that discuss pesticide exposure in the agricultural community, English or Indonesian. Articles that are irrelevant, duplicate, or without agricultural community data are excluded. After the selection process, 10 main articles were obtained for analysis.

Data Analysis

The selected articles are analyzed narratively and thematically based on the framework Risk assessment which includes: Hazard Identification (dominant pesticide type and toxicity mechanism), Exposure Assessment (pathway and level of exposure, vulnerable groups), Dose–Response Assessment (relationship between exposure levels and health/environmental impacts), Risk Characterization (estimation of the level of risk and its implications).

The analysis was conducted to identify research patterns, gaps, and integrate findings from various studies, so as to obtain a comprehensive picture of health and environmental risks due to pesticide exposure in agricultural communities

Results

Table 1. Systematic Review

Title, Author, Location and Year	Method	Key Results				Conclusion
		Hazard Identification	Display Rating	Dose–Response	Risk Characterization	
Occupational pesticide exposure and health symptoms among farmers in Palestine, Iyad Ali, Palestine (2024)	Cross-sectional, 1.105 percent, online survey.	Exposure to pesticides (various types) → cardiovascular, dermatological, neurological, hematological effects	Survey 1,105 farmers; frequency, length, PPE data	There is no reference value; Clear Exposure-Symptom Relationship	High health risks in farmers without PPE	Pesticide exposure without PPE is associated with cardiovascular, neurological, and dermatological symptoms; education and the use of PPE reduces the risk.
Impact of pesticides on farmers: A case study in the highlands , Syahrul Basri et al. Gowa,	Descriptive survey on vegetable farmers.	Chemical pesticides → acute poisoning (dizziness, nausea, headache)	Spraying without PPE, high dose & frequency	No data other than poisoning symptoms were reported in 24.7% of respondents	High acute risk, especially in farmers who do not use complete PPE; Good personal hygiene (72.6%) reduces partial	24.7% of farmers experienced acute poisoning (dizziness, nausea, headache); Good

Title, Author, Location and Year	Method	Key Results				Conclusion
		Hazard Identification	Display Rating	Dose–Response	Risk Characterization	
South Sulawesi (2024)					risk	personal hygiene lowers the risk partially.
Occupational health complaints and demographic features of farmers exposed to agricultural chemicals during agricultural activities, Venugopal et al. Karnataka, India (2025)	Cross-sectional, farmer health questionnaire.	Respiratory, neurological, musculoskeletal, skin, thyroid, kidney effects	Work display without adequate protection	Chronic ↔ exposure to certain diseases	High chronic health risk	Chronic exposure increases respiratory, neurological, renal, and skin complaints; high risk in long-term workers.
Pesticide Exposure Factors Related to Neurological Symptoms in Pesticide Spraying Farmers, Dhody Ardi Pratama et al, Renting a place in East Lombok, Indonesia (2021)	Cross-sectional, analysis of the relationship between long working and frequency of spraying with neurobehavioral symptoms.	Effects of neurobehavioral pesticides	Working duration, spray frequency, no protection	Significant relationship between ↔ duration of exposure to nerve symptoms	Medium-high risk in long-term workers	The longer and more often you are exposed, the higher the neurobehavioral symptoms.
The Impact of the Use of Chemical Pesticides on Soil and River Water Quality in Agricultural Areas, Dhaifulloh et al. Java(2024)	Environmental studies, soil and river water quality analysis.	Degradation of groundwater and river quality due to pesticides	Environmental exposure through runoff & infiltration	There are no quantitative data on doses, referring to the ecological and health impacts of various studies	High environmental risk (aquatic & soil)	Pesticides degrade soil & water quality, posing a high ecological risk.
Groundwater pollution due to the use of	Groundwater quality field study	Groundwater pollution, threats to ecosystems &	Exposure through contaminated groundwater	There are no formal dose data, the	High health & ecological risks	Pesticides pollute groundwater and threaten

Title, Author, Location and Year	Method	Key Results				Conclusion
		Hazard Identification	Display Rating	Dose–Response	Risk Characterization	
pesticides and industrial wastes that threaten the sustainability and welfare of the indaragiri hilir community, Apriani et al, Indragiri Hilir, Riau (2024)		public health		relationship between the effects of exposure is explained through ecological impact		public health and ecosystems.
Impact of pesticide use in agricultural activities on the environment and health, Bilker roensis sinambela, Brebes (2024)	Farmer surveys + environmental observations.	Contamination of soil, water, degradation of non-target organisms	Exposure through direct contact during spraying without PPE, soil and water contamination on agricultural land	There were no data on dose, exposure-effect relationship seen from the prevalence of health symptoms (75% of farmers experienced nausea, vomiting, dizziness, itching)	Moderate-high health risks in farmers without PPE; High environmental risks in agricultural areas with excessive use of pesticides	75% of farmers experience symptoms of poisoning; moderate-high health risks and high environmental risks.
The Fate of the Environment and Sustainable Pesticide Management in Soil: A Critical Review Focused on Sustainable Agriculture, Aniruddha Sarker et al, Global (2024)	A literature review on the fate of pesticides in soil.	Contamination of soil, water, decline in biodiversity, bioaccumulation	A literature review on the fate of pesticides in soil: transport, transformation into toxic metabolites, persistence, and bioaccumulation; exposure through soil residues to subsequent crops and environmental organisms	The exposure-effect relationship is discussed through the risk of residues exceeding the maximum limit and potential toxicity of metabolites	High environmental risks in intensive farming areas; potential health risks due to crop consumption with residues exceeding the MRL; mitigation recommendations through the implementation of *Good Agricultural Practice*, sustainable soil	Pesticides pollute soil & water, degrade biodiversity, potentially pose health risks if residues > MRL.

Title, Author, Location and Year	Method	Key Results				Conclusion
		Hazard Identification	Display Rating	Dose–Response	Risk Characterization	
					management, and metabolite monitoring	
Priority use of pesticides in the Citarum Hulu Watershed, Indonesia, Rosetyati, R. Utami et al. Citarum huluindonesia Watershed (2020)	Field surveys & environmental distribution modelling; HQ & RQ analysis.	Identification of 47 active ingredients of pesticides; 16 priorities with high potential risks to humans & ecosystems	Use of field survey data, national databases, & distribution models in the environment (water, soil); Estimated pollution load to rivers	Using toxicological reference values (HQ, RQ) based on international regulations (US EPA, EFSA)	16 pesticides are categorized as high risk to aquatic ecosystems; some are also risky to human health through water and food; Recommendations for management priorities and usage reduction	16 active ingredients of pesticides pose a high risk to aquatic ecosystems and human health.
Health risk assessment of pesticide exposure to farmers around rice farming areas in ogan ilir regency, south sumatra, indonesia, Maksuk et al., Ogan Ilir Regency, South Sumatra, Indonesia 2024	Cross-sectional, test of the activity of farmer blood cholinesterase.	Exposure to pesticides (organophosphates and carbamates) → health symptoms associated with cholinesterase inhibition	Measurement of blood cholinesterase activity in farmers; questionnaire related to length of work, frequency of spraying, and use of PPE	Cholinesterase activity decreases with increasing duration and frequency of exposure; compared to normal threshold values	High health risks; most farmers are in the mild-medium poisoning category, especially in those who do not consistently use PPE	The majority of farmers experience mild-moderate poisoning; high risk in those who do not consistently use PPE.

Discussion

The study summarized the findings of ten articles that met the inclusion criteria and comprehensively described the health and environmental risks posed by pesticide exposure in agricultural communities. The results of the review show a relatively consistent pattern, namely high exposure to farmers due to intensive pesticide use and minimal protection, accompanied by ecological impacts in the form of soil and water pollution. This is in line with previous reports that developing countries face higher risks due to weak pesticide regulations and low access for farmers to personal protective equipment (Phung et al., 2012).

However, there are variations in the types of pesticides studied, the methods of measuring exposure, and the observed health and environmental outputs. To facilitate understanding, the following discussion is prepared based on four main aspects, namely pesticide exposure, health risks, environmental risks, and health and environmental risk assessment.

Exposure to Pesticides in Agricultural Communities

The results of the review showed that the main source of pesticide exposure in agricultural communities came from direct spraying in the field, which caused dermal contact and inhalation in workers. Secondary exposure pathways are reported through residues in surface water and groundwater,

as well as soil contamination that then enters the food chain. Ecological studies also confirm that runoff and pesticide infiltration from agricultural land contribute to environmental pollution (Ahmad Dhiyaul Dhaifulloh et al., 2024)

These findings are consistent with global studies that say that environmental exposure from pesticide transport can be long-lasting and have an impact on cross-regional ecosystems. Exposure patterns differ between groups. Smallholders and field workers face the highest exposure due to the long duration and frequency of spraying with low use of personal protective equipment (PPE). Meanwhile, family members, especially children and women, are exposed through the home environment, food, and water sources around farmland. The main factors that affect the level of exposure are the type of pesticide used, the intensity and frequency of spraying, and the behavior and compliance of farmers with the use of PPE (Sinambela, 2024)

Health Risks

Acute exposure to pesticides causes a variety of symptoms, including headaches, dizziness, nausea, skin and eye irritation, and respiratory distress. Field studies show that most farmers report acute symptoms, especially workers without complete PPE, with the prevalence of poisoning reaching a quarter to three-quarters of respondents (Basri et al., 2024). These findings reinforce the hypothesis that long-term exposure may cause cumulative systemic effects, in line with the results of an international cohort study that reported an increased risk of hematological cancer and endocrine disorders.

Chronic exposure is associated with neurobehavioral, respiratory, musculoskeletal, skin, thyroid, and kidney disorders. Research shows a significant association between duration of exposure and neurobehavioral symptoms, while other studies highlight a multi-system chronic risk in workers with long-term exposure (Pratama & Setiani, 2021). Studies in India also confirm that long-term exposure in agricultural workers increases the risk of multi-system diseases, including respiratory, neurological, and kidney disorders (Venugopal et al., 2025). The findings in Ogan Ilir show that farmers with a high duration and frequency of spraying experience a decrease in blood cholinesterase activity, so the majority are in the category of mild to moderate poisoning, especially if they are not consistent in using PPE (Maksuk et al., 2024)

Vulnerable groups include women, children, and the elderly. Children and pregnant women are exposed through environmental and food residues, while elderly farmers are more susceptible to neurological disorders due to long-term exposure. Results between studies were relatively consistent, although there was variation in the types of outcomes reported (Apriani et al., 2024). The implication is that vulnerable groups need to be prioritized in public health interventions

Environmental Risks

Pesticide residues accumulate in soil, water, and air, threatening local ecosystems. Studies in the Citarum Hulu watershed found many active ingredients, some of which pose a high risk to aquatic ecosystems as well as human health (Utami et al., 2020).

Impacts on non-target organisms are seen in the decline of soil biodiversity, disturbance of aquatic organisms, as well as threats to beneficial insects and birds. These changes in environmental quality also have an indirect impact on public health, for example through drinking water pollution and degradation of agricultural land quality (Sarker et al., 2024). These findings are consistent with FAO and WHO reports that ecosystem degradation due to pesticides can reduce food security, reduce land productivity, and pose indirect health risks through the water and food cycle.

Health Risk Assessment (HRA)

Hazard identification revealed that organophosphates, carbamates, and a number of other active ingredients dominate the use of pesticides in agricultural communities. A number of studies have mapped high-risk active ingredients for humans and ecosystems so that they become management priorities (Ali, 2024)

The dose–response relationship is strongly indicated in neurobehavioral disorders: the longer and more frequent exposure, the higher the level of symptoms. Some studies have also shown a gradation of symptoms according to the intensity of exposure and use of PPE (Sinambela, 2024).

Exposure assessments show that the main routes of pesticide entry are dermal and inhalation in workers, as well as oral through food and water for family members. However, most studies are still limited to qualitative assessments, so quantitative estimates (HQ, HI, cancer risk) are rarely reported. This limits the generalization power of outcomes to public health risks at large.

Limitations and Implications

This article only reviews 10 journals so it may not be fully representative of the whole evidence. The majority of studies are observational and rely on self-reports, making them vulnerable to information bias. In addition, few studies present quantitative data on health risk assessment, and geographic coverage is more dominant in developing countries. Therefore, the results of this study must be

interpreted carefully, but still make an important contribution in emphasizing the urgency of strengthening pesticide regulations, increasing the use of PPE, and the need for routine biomonitoring.

Future research directions need to be focused on: (i) the use of biomarkers and biomonitoring to assess the internal dosage of pesticides, (ii) quantitative risk analysis based on HQ, HI, and cancer risk, (iii) longitudinal design to strengthen the exposure–dose–effect relationship, and (iv) multi-country studies to illustrate pesticide risk on a global scale.

Conclusion

This study confirms that agricultural communities face health and environmental risks due to exposure to pesticides, either directly through spraying or indirectly through soil, water, and food. Acute exposure causes neurological and respiratory symptoms, while chronic exposure has an impact on multi-system disorders, especially in children, women, and the elderly. The accumulation of pesticides also reduces environmental quality and biodiversity.

Government and relevant authorities need to strengthen regulations on the use of high-risk pesticides, increase farmers' education on the use of personal protective equipment, and monitor pesticide residues. Advanced research With biomonitoring and quantitative risk analysis, it is necessary to strengthen scientific evidence and support pesticide exposure mitigation policies.

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