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Health Risks and Environmentally Friendly Alternatives to Chemical Use in Agriculture

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ABSTRACT

The use of chemicals in agriculture is a common practice to increase crop yields, but it can cause serious problems for human health and the ecosystem. The purpose of this study was to investigate the effects of chemical use, including the health risks faced by farmers and the community and the resulting pollution. This study analyzed various sources of information on the impacts of chemicals using literature study methods, such as acute and chronic health disorders and decreased biodiversity. The results showed that although chemical pesticides can increase agricultural yields, unmanaged use can result in poisoning, pollution of water, soil, and air, and damage to the ecosystem. This study recommends the implementation of integrated pest management (IPM) methods and the use of more environmentally friendly bio-pesticides. The findings of this study are expected to provide guidance for sustainable agricultural policies and raise awareness of the health and environmental hazards caused by pesticide use in Indonesia

INTRODUCTION

The use of chemicals in the agricultural sector has become commonplace in various countries, including Indonesia. Pesticides are applied to protect plants from pests, diseases, and weeds that can reduce agricultural yields. However, excessive and irregular use of pesticides causes various problems, especially those related to human health and the environment. Exposure to pesticides can pose a risk of various diseases, ranging from mild health disorders to serious and chronic diseases, such as cancer. Therefore, it is important to understand more about the consequences of pesticides and find more environmentally friendly alternatives. Modern agriculture that relies on chemical pesticides can usually increase production efficiency. By utilizing pesticides, farmers can increase crop yields and meet the increasing need for food. However, the negative impact of using these pesticides is environmental pollution, which includes contamination of water, soil, and air. Pesticide residues left in soil and water can threaten biodiversity and damage the ecosystem as a whole.

One of the major adverse effects of synthetic pesticide use is the reduction in biodiversity. Suryani and colleagues observed that pesticide use can result in the death of non-target organisms, including beneficial insects and natural predators of pests. This can disrupt the balance of nature (Suryani et al., 2020; Suryani, 2020). This situation has the potential to trigger a higher spike in pest populations, creating a greater dependence on synthetic pesticides. In addition, the use of hazardous pesticides such as carbofuran can cause severe environmental damage, including water and soil pollution, as well as the accumulation of hazardous residues in the food chain (Alfiansyah, 2023; Fitriadi and Putri, 2016). Although pesticides have a significant role in increasing agricultural yields, if their use is not managed properly, it can have serious environmental impacts. Therefore, it is very important to implement a more sustainable approach to pest control, including the use of environmentally friendly pesticides and providing education for farmers to minimize negative effects on the environment and human health.

In addition to the impact on the environment, pesticide use also has a significant effect on public health. Farmers and agricultural workers are often exposed to pesticides directly, either through the skin or through breathing. This can cause various health problems, such as acute poisoning, skin irritation, respiratory disorders, and, in more severe situations, organ damage. Long-term exposure can increase the likelihood of chronic diseases, including hormonal problems and other disorders. According to Ihsan et al., the use of pesticides aims to eliminate weeds and other organisms that can damage agricultural products, which in turn can increase crop yields (Ihsan et al., 2022). However, excessive use of pesticides can cause poisoning in farmers and environmental pollution. Liem noted that agricultural workers who routinely use organophosphate pesticides are at high risk of experiencing serious health problems due to exposure to these chemicals (Liem, 2021). This shows that although pesticides can increase agricultural yields, the potential health risks should not be ignored.

Awareness of the dangers of pesticide use for health and the environment in Indonesia is still very low. Many farmers do not get the right information about how to use pesticides safely and do not use adequate personal protective equipment. In addition, regulations related to pesticide use are often ineffective in monitoring the types and amounts of pesticides used in the field. This condition has a negative effect on communities living around agricultural land. From a health perspective, improper use of pesticides can result in poisoning and other health problems.

Mutia and Oktarlina noted that chronic pesticide poisoning is a serious issue among farmers, who often lack adequate knowledge of safe use (Mutia and Oktarlina, 2020). In addition, research by Ibrahim and Senoaji revealed that pesticide use can disrupt ecosystems, such as reducing biodiversity by destroying natural enemies of pests (Ibrahim and Senoaji, 2022). This has the potential to increase the number of pests, creating a cycle of higher dependence on pesticides.

The need for more environmentally friendly alternatives in controlling insects and plant diseases is increasingly urgent. One method that can be chosen is to apply an integrated pest management (IPM) method that integrates various techniques, such as the use of natural pesticides, crop rotation, and biological control. The use of IPM has the potential to reduce dependence on chemical pesticides and reduce health risks and negative impacts on the environment. Erawati stated that the indiscriminate use of synthetic pesticides can cause residues in agricultural products, environmental pollution, and death in non-target organisms (Erawati, 2023). On the other hand, Nurjannah et al. emphasized the importance of detecting pesticide residues in food, because these residues can be risky to human health (Nurjannah et al., 2020). This shows that the use of pesticides not only affects the health of farmers, but also consumers and the ecosystem as a whole.

The use of natural pesticides or bio-pesticides is now an attractive option. Bio-pesticides generally come from plants or microorganisms that are environmentally friendly and do not leave harmful residues. For example, extracts from certain plants that have the ability to fight pests can be an effective solution without harming the environment. However, there are challenges in the use of bio-pesticides, namely their effectiveness which may not be as strong as chemical pesticides, so further research is needed. One of the main challenges is the variation in the composition and levels of active ingredients in bio-pesticides. According to Hanudin et al., the level of effectiveness of bio-pesticides is highly dependent on the type of microbe or natural material used, which can vary in their ability to control pests (Hanudin et al., 2018). For example, bio-pesticides made from tobacco extracts from cigarette butt waste show potential, but their effectiveness can vary depending on the manufacturing method and levels applied (Siswoyo et al., 2018). This indicates that the development of bio-pesticides requires further research so that their consistency and effectiveness can be ensured.

Technological developments present new opportunities to create more environmentally friendly and sustainable agricultural solutions. Innovations such as environmental measuring devices, Internet of Things (IoT)-based crop monitoring systems, and data processing can make it easier for farmers to manage agricultural land in a more effective and eco-friendly way. This technology allows for proper monitoring so that pesticides are used only when absolutely necessary. The level of education of farmers and access to information on the safe use of pesticides greatly influences reducing risks to health and the environment, including self-protection when spraying pesticides. Government policies that support sustainable agriculture are also important factors in reducing the negative effects of pesticide use. The government can encourage the use of more environmentally friendly pesticides by providing incentives, subsidies for organic products, or strict regulations on hazardous pesticides. With the implementation of stricter regulations, it is hoped that farmers can reduce the use of chemical pesticides and switch to safer methods.

Incentives for farmers to switch to organic farming methods can increase the use of environmentally safe pesticides. Manalu stated that these incentives can be in the form of financial assistance or training that provides farmers with an understanding of the benefits and uses of plant-based pesticides (Manalu, 2020). By providing these incentives, the government or related organizations can encourage farmers to reduce the use of chemical pesticides that are harmful to the environment. This is in line with Meliansyah's findings, which emphasize that understanding environmentally friendly products can influence farmers' interest in switching to organic farming methods (Meliansyah, 2023). Therefore, the right incentives can encourage awareness and acceptance of environmentally friendly pesticides.

LITERATURE REVIEW

The increasing demand from consumers for safe and chemical-free food products is also driving the transition to more environmentally friendly farming methods. Today, consumers are increasingly aware of the health effects of pesticide use and are more likely to choose organic products that are much healthier. This provides an incentive for farmers to find safer ways to produce food. Strict restrictions on the use of hazardous pesticides can support the transition to more environmentally friendly pesticides. Alfiansyah emphasized the need for stricter regulations in regulating the use of hazardous chemical pesticides, so that the industry is encouraged to create and produce safer pesticides (Alfiansyah, 2023). Therefore, this study is very important to investigate the health risks associated with the use of pesticides in agriculture and to find more environmentally friendly solutions. This effort is not only beneficial for farmers, but also for the general public who consume agricultural products. In addition, it is hoped that this research can contribute to reducing the negative impacts of pesticides and supporting sustainable agriculture in the future.

METHODOLOGY

The increasing demand from consumers for safe and chemical-free food products is also driving the transition to more environmentally friendly farming methods. Today, consumers are increasingly aware of the health effects of pesticide use and are more likely to choose organic products that are much healthier. This provides an incentive for farmers to find safer ways to produce food. Strict restrictions on the use of hazardous pesticides can support the transition to more environmentally friendly pesticides. Alfiansyah emphasized the need for stricter regulations in regulating the use of hazardous chemical pesticides, so that the industry is encouraged to create and produce safer pesticides (Alfiansyah, 2023). Therefore, this study is very important to investigate the health risks associated with the use of pesticides in agriculture and to find more environmentally friendly solutions. This effort is not only beneficial for farmers, but also for the general public who consume agricultural products. In addition, it is hoped that this research can contribute to reducing the negative impacts of pesticides and supporting sustainable agriculture in the future.

This study uses a literature review method. A literature review for research related to pesticide use in the agricultural sector, health risks, and more eco-friendly alternatives begins with formulating specific research objectives and questions. The questions asked focus on the health effects and environmental impacts of pesticide use, as well as more environmentally friendly pest control options. In the next step, researchers search for relevant data sources, such as journals, scientific articles, and books that discuss the impacts of pesticides, especially on humans and the surrounding environment. After collecting literature, the next stage is to select and filter sources based on the level of relevance, year of publication, and credibility of the author. The literature is then analyzed and categorized by theme, for example the health effects of pesticides, environmental pollution, and alternative methods such as pest control using a biological approach. This stage is crucial for finding trends, identifying gaps in research, and potentially conflicting views.

The results of this literature review are then summarized in the form of a synthesis, where various results from various sources are combined to find common patterns and gaps in research. This synthesis also aims to serve as a basis for developing a theoretical or conceptual framework, which includes key concepts such as the effects of pesticides on health and the environment and alternative pest control methods. Finally, this research is presented in a systematic report that includes an introduction, literature search methods, analysis results, and conclusions. The conclusion of this literature review includes a summary of important results and opportunities for further research that can address gaps or challenges in this field, thus providing direction for research efforts or practical applications in the field of agriculture.

RESULTS AND DISCUSSION

This study reveals that the use of chemical pesticides in the agricultural sector has shown serious impacts on human health, the environment, and ecosystem stability. Exposure to pesticides, both directly experienced by farmers and indirectly through residues in food products, increases the likelihood of chronic diseases, sudden poisoning, and other health problems. In addition, pesticide use also contributes to the pollution of water sources, soil, and air, and disrupts the balance of the ecosystem by harming non-target organisms.

Tabel 1. Chemical Dependence Data

Year	Region	Use (Kg/Ha)
2019	World	2,2
2020	World	2,29
2021	World	2,35
2022	Amerika	5,11
2022	Oceania	1,98
2022	Asia	1,87
2022	Eropa	1,64
2022	Africa	0,69
2023	Global	2,37

Source: Food and Agriculture Organization (FAO)

This table illustrates the changing global trend in chemical pesticide use, with a gradual increase from 2.2 kg/ha in 2019 to an estimated 2.37 kg/ha in 2023. In 2022, pesticide use varied across regions, with the Americas having the highest rate (5.11 kg/ha), while Africa had the lowest rate (0.69 kg/ha). Oceania, Asia, and Europe were around the global average. These differences may be due to farming methods, regulations, and access to pesticides in each region.

Table 2. Hasil Analisis

Research Aspect	Chemical Pesticides	Eco-Friendly Alternative
Health Impact	Increases the risk of chronic diseases such as cancer (WHO and FAO, 2020)	Minimal side effects on human health (Isman, 2017)
Environmental Impact	Water, land and air pollution (Rahman et al., 2018)	Environmentally friendly, leaves no harmful residue (Desneux et al., 2019)
Effectiveness	Effective in pest control with high yields (WHO and FAO, 2020)	Effectiveness depends on the type of pest and environmental conditions (Isman, 2017)

Supporting Technology	Does not require special technology	IoT and environmental sensors for more precise control (Sankaran et al., 2019; Almeida et al., 2021)
Policy and Support Needs	Strict regulations are needed to limit use (Mancini et al., 2020)	Supporting sustainable agricultural policies and subsidies for natural products (Mancini et al., 2020)

The use of pesticides in agriculture has a major impact on human health. WHO and FAO inform that exposure to high levels of pesticides can increase the likelihood of chronic diseases, including cancer and hormonal disorders (WHO and FAO, 2020). In addition, traces of pesticides in the environment can cause water and soil pollution, which can be harmful to the surrounding ecosystem (Rahman et al., 2018). As a safer option, environmentally friendly pest control methods, such as natural pesticides and integrated pest management (IPM), are gaining attention. Based on research by Isman (2017), extracts from several types of plants have been proven effective as natural pesticides without leaving harmful residues.

In addition, the implementation of IPM, which includes crop rotation and the use of natural enemies of pests, can also help reduce dependence on chemical-based pesticides (Desneux et al. , 2019).

Recent technologies such as the Internet of Things (IoT) and environmental sensors contribute to reducing pesticide use by precisely monitoring crop conditions and only applying pesticides when needed (Almeida et al. , 2021). These innovations provide farmers with the opportunity to reduce negative effects on the environment and human health (Sankaran et al. , 2019). The findings of this study also emphasize the importance of government intervention in supporting sustainable agricultural techniques. The government can help by providing subsidies for organic products and implementing strict regulations on the use of chemical pesticides to support the transition to safer methods (Mancini et al. , 2020). Education and training for farmers on the risks of pesticides and more environmentally friendly options is also urgently needed.

Health Impact of Chemicals on Humans

Chemical pesticides are often used in agriculture because of their high ability to control pests and increase crop yields. However, their effects on human health are very worrying. The theory of toxicological exposure explains that direct contact or residue from pesticides can cause problems in various human body systems, such as the nervous system and endocrine system. The World Health Organization and research by Rahman and team (2018) support this by showing that pesticides can cause health problems, ranging from sudden poisoning to cancer due to prolonged exposure. Farmers who are frequently exposed to pesticides, either through the skin or breathing, are at high risk of experiencing serious health problems. According to the theory of occupational health, agricultural workers who come into contact with pesticides without proper protection will be directly affected by these hazardous chemicals. The use

of pesticides that are not strictly monitored also increases the risk to consumers due to residues in contaminated food. This is in accordance with the theory of residual exposure, which states that pesticide residues left in food can accumulate in the human body. In addition, the impact of pesticides on health is not only experienced by workers in the agricultural sector, but also by the surrounding community.

According to the view in environmental epidemiology, the presence of chemicals such as pesticides in the air and water can affect the health of the wider population. Data from WHO and FAO support the existence of health hazards around agricultural areas that use a lot of pesticides, which strengthens the opinion that there needs to be stricter regulations to protect the public from these negative effects. The use of pesticides in agricultural practices has a significant impact on human health, especially for farmers and people who are directly exposed. Exposure to pesticides can cause various health problems, both temporary and long-term, which will affect the quality of life and overall public health. One of the most common health problems due to pesticide exposure is poisoning. According to research conducted by Ihsan and colleagues, pesticides are hazardous substances that can cause health problems, ranging from mild to severe, even potentially life-threatening (Ihsan et al, 2022). Poisoning can occur due to direct contact with pesticides during application, or through consumption of agricultural products contaminated with pesticide residues. Research by Fikri shows that the use of pesticides in high doses can cause dependency and increase health risks for farmers (Fikri, 2021). This suggests that a lack of understanding of how to use pesticides safely may contribute to poisoning incidents.

Environmental Impact of Pesticide Use

Pesticide use not only affects human health but also causes damage to the environment. The chemical cycle theory in the environment explains how pesticides can enter the soil, water, and air, then spread throughout the ecosystem. A report from the European Environment Agency in 2019 showed that pesticides pollute water sources, damage soil quality, and threaten biodiversity by disrupting non-target organisms such as pollinating insects. In addition to polluting soil and water, pesticide residues also affect air quality, especially in dense agricultural areas. The air pollution theory explains that pesticide particles carried by the wind can pollute the air and be inhaled by humans and animals, potentially causing respiratory problems and other diseases. This impact can be felt in the long term, because pesticides left in the soil or plants can accumulate along the food chain, which threatens environmental sustainability.

Based on the concept of toxic ecology, the toxic effects of pesticides on non-target organisms affect the balance of the ecosystem. When some organisms, such as insects or soil microbes, are exposed to pesticides, there can be disruptions in the food chain that impact the entire ecosystem. Research by Desneux et al. (2019) supports this understanding, by showing that the use of chemical pesticides has long-term effects on biodiversity and ecosystem stability, further emphasizing the need for sustainable agricultural methods. The concept of toxic ecology is a way of understanding the consequences of chemicals, including pesticides, on organisms and ecosystems. This approach focuses on the relationship between

chemicals and the environment, and how exposure to these substances can affect the health of individuals, populations, and the overall balance of the ecosystem. One of the important points in the theory of toxic ecology is the understanding of how pesticides can affect various levels of biological organization, from individuals to communities and ecosystems. According to Widyanti et al., inappropriate use of pesticides can cause various health problems for farmers, such as respiratory disorders, nervous disorders, and skin problems (Widyanti et al. 2021). This shows that exposure to pesticides not only affects individuals but can also have an impact on the health of farmers as a whole.

Developing Environmentally Friendly Alternatives in Pest Control

Pest control in a more environmentally friendly way, such as the use of natural pesticides and integrated pest management (IPM) approaches, provides a safer and more sustainable option. According to the principles of agroecology, agricultural activities should pay attention to the balance of the ecosystem while minimizing negative impacts on the environment. The use of natural pesticides, such as plant extracts that have anti-pest characteristics, is in line with the principles of agroecology which emphasize the use of natural resources to reduce dependence on chemicals. The IPM approach that combines biological, mechanical, and physical techniques in dealing with pests is supported by the theory of sustainable agriculture. The goal is to reduce the use of chemical pesticides and replace them with more environmentally friendly methods, such as crop rotation, the release of natural enemies of pests, and more intensive pest monitoring. Research by Mancini et al. (2020) shows that IPM can reduce dependence on pesticides without sacrificing crop yields.

In the development of technology, the concept of green technology encourages the use of technology such as IoT to monitor plant conditions directly. This allows the use of pesticides only when needed, thereby reducing waste and impact on the environment. According to Sankaran et al. (2019), the application of IoT and environmental sensors in the agricultural sector can improve pest management in a more efficient and environmentally friendly way, supporting the transition to more sustainable agricultural practices. One real example of this concept is the development of a smart farming system that uses IoT to monitor various environmental parameters that affect plant growth. For example,

CONCLUSION AND RECOMMENDATION

By utilizing sensors connected to the internet, farmers can get direct data on plant conditions, such as soil moisture, temperature, and nutritional needs. In addition, Rasna and Alam showed that an IoT-based smart farming system can control and monitor soil moisture using the fuzzy method, which allows automatic watering when soil moisture is below a specified level (Rasna and Alam, 2022). This not only increases the efficiency of water use but also ensures that plants get enough water for their growth.

FUTHER STUDY

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