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Impacts of the Inappropriate Use of Pesticides in Family Farming: Case Study in the Pateguane Lowland – Morrumbene, Mozambique

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Abstract

This study aims to analyze the effects of the inappropriate use of pesticides in agriculture practiced by farmers in the Pateguane Lowland, Morrumbene District. Specifically, it seeks to verify the concentrations used in preparation and application, the environmental impacts, and the effects on the health of exposed farmers. The data reveal that incorrect pesticide use represents a serious risk to public health and the environment. The majority of the 60 farmers surveyed, use the pesticides at higher concentrations than recommended, due to inadequate dilution, which increases the toxicity of the solutions. The pesticides identified in use included cypermethrin, acetamiprid, carbaryl, and methamidophos. Notably, cypermethrin is classified as a Class II (moderately hazardous) substance according to WHO standards, while methamidophos is prohibited due to its high toxicity and potential harm to human health and ecosystems. None of the farmers were observed using personal protective equipment (PPE), leading to direct exposure to hazardous chemicals. Moreover, 100% of the farmers reported not using personal protective equipment (PPE), directly exposing themselves to contamination. Symptoms of poisoning were reported by many: 58.4% with allergies, 30% with dizziness, and 11.6% with headaches. The disposal of empty packaging is done improperly: 45% leave them exposed to the open air, 38.3% bury them, and 16.7% burn them, practices that contribute to soil, water, and air pollution. A lack of technical training, supervision, and proper guidance was also observed, exacerbating the risks.

Keywords: Pesticides; Public health; Environmental impact; Chemical exposure

1. Introduction

The use of pesticides in agriculture is a widespread practice around the world [1,15], being essential for controlling pests, diseases, and weeds, which significantly contributes to increased agricultural productivity. However, when these products are used improperly — whether due to lack of technical knowledge, absence of personal protective equipment, or the use of unauthorized substances — the associated risks multiply, severely affecting the environment and human health, especially in rural communities that lack information [1,16].

In the Pateguane Lowland region, located in the District of Morrumbene, Inhambane Province, agriculture stands as one of the primary economic activities, largely practiced on a small scale. Within this context, families frequently resort to the empirical use of pesticides, often without formal training or access to technical guidance. Even when some knowledge of recommended practices exists, it is not always followed—either due to limited resources, lack of supervision, or a tendency to prioritize immediate results over long-term safety. As a result, the use of pesticides often occurs without adherence to standardized procedures, increasing the risks to human health and the environment. This reality has contributed to the intensification of environmental and public health risks, as the use of banned pesticides can occur.

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Improper pesticide use can disseminate through communities, establishing itself as a common and persistent practice. The government has carried out several awareness campaigns for farmers [3-9], however, the lack of effective supervision and regular ongoing training programs for farmers further worsens the situation, perpetuating dangerous practices and hindering the implementation of safer and more sustainable farming methods. Therefore, the relevance of studies that investigate and document these practices becomes evident, as they provide a basis for public policies and intervention strategies aimed at promoting public health, protecting the environment, and strengthening safe agriculture.

According to the World Health Organization (WHO), the use of pesticides must follow strict safety criteria, as the degree of toxicity and level of exposure are key factors in determining the risks these products pose to humans. To guide safe use, WHO provides an international classification of pesticides based on their acute toxicity, serving as a reference for technicians, specialists, and health authorities in controlling and regulating these substances [9,10]. However, the effectiveness of these guidelines [13] depends primarily on their local implementation and the training of end users — aspects still weak in the reality of the Pateguane Lowland.

2. Materials and Methods

The research adopted a mixed-methods approach, utilizing multiple techniques for data collection and analysis. Direct observation was conducted in the Pateguane Lowland region, where the researcher visited farming sites to observe firsthand the preparation, handling, and application of pesticides by local farmers. This allowed for a detailed understanding of the practices employed in the field.

Additionally, a structured survey was administered to a sample of 60 farmers of both sexes, representing the entire farming population in the lowland area. The questionnaire included both open- and closed-ended questions, designed to capture information on pesticide use, handling practices, and perceived health effects. The methodological process was carefully planned to ensure data accuracy, while maintaining participant anonymity and obtaining informed consent for the use and publication of the findings.

3. Results and discussion

The results presented refer to the concentrations used by the farmers, observing the level of compliance with preparation guidelines, the use of personal protective equipment (PPE), and the method of pesticide container disposal. These aspects were analyzed to assess the farmers' level of commitment to their own well-being and to consumer health.

3.1. Concentrations Used by Farmers

Field surveys and direct observations of 60 farmers in the Pateguane Lowland revealed significant deviations from manufacturer-recommended pesticide concentrations (**Table 1**). The data show that many farmers are using pesticides at concentrations far exceeding safe or recommended levels, raising serious concerns regarding environmental and human health risks.

For instance, in the case of cypermethrin, classified as Class II (moderately hazardous) [26,27], 71.6% of farmers reported using 15 mL per 20 liters of water (0.75 mL/L), while the recommended concentration is 15 mL per 100 liters (0.15 mL/L) [3,4], indicating a fivefold increase over the guideline. Similarly, acetamiprid, a Class III (slightly hazardous) pesticide [1,2], was being used at 2 mL/L (50 mL in 25 L of water), in contrast to the recommended 0.5 mL/L (50 mL in 100 L) [5,6], representing a fourfold increase in concentration. Use of carbaryl, which falls under Class Ib (highly toxic) [1,2], was also concerning. About 25% of the surveyed farmers applied it at 0.075 mL/L (0.75 mL in 10 L), whereas the recommended dosage is only 0.0075 mL/L (0.75 mL in 100 L) [7,8], amounting to a tenfold increase. Finally, methamidophos, a Class Ia pesticide (extremely toxic) [1,2], was used by 3.4% of farmers at 0.03 mL/L (0.75 mL in 25 L), while the recommended level is 0.0075 mL/L (0.75 mL in 100 L) [9,10], resulting in a fourfold increase.

These findings highlight a critical gap between actual pesticide application practices and safety guidelines, underlining the urgent need for targeted farmer education, improved regulatory enforcement, and accessible guidance on safe pesticide use. [26,27,28]

Table 1 Difference Between Pesticide Concentrations Applied by Farmers and Official Recommendations

pesticides	Recommended Concentrations	Concentrations Used by Farmers	Pest	Crop	Percentage (%)
Cypermethrin	15 mL/100 L=	15 mL/20 L	Caterpillars; thrips	Onion	71.6% —
Acetamiprid	50 mL/100 L	50 mL/25 L	Aphids; moths; aphids	Kale	
Methamidophos	0.75 mL/100 L	0.75 mL/10 L	Insects; ants	Tomato	25%
Carbaryl	0.75 L/100 L	0.75 L/25 L	Caterpillars	Kale, tomato	3.4%

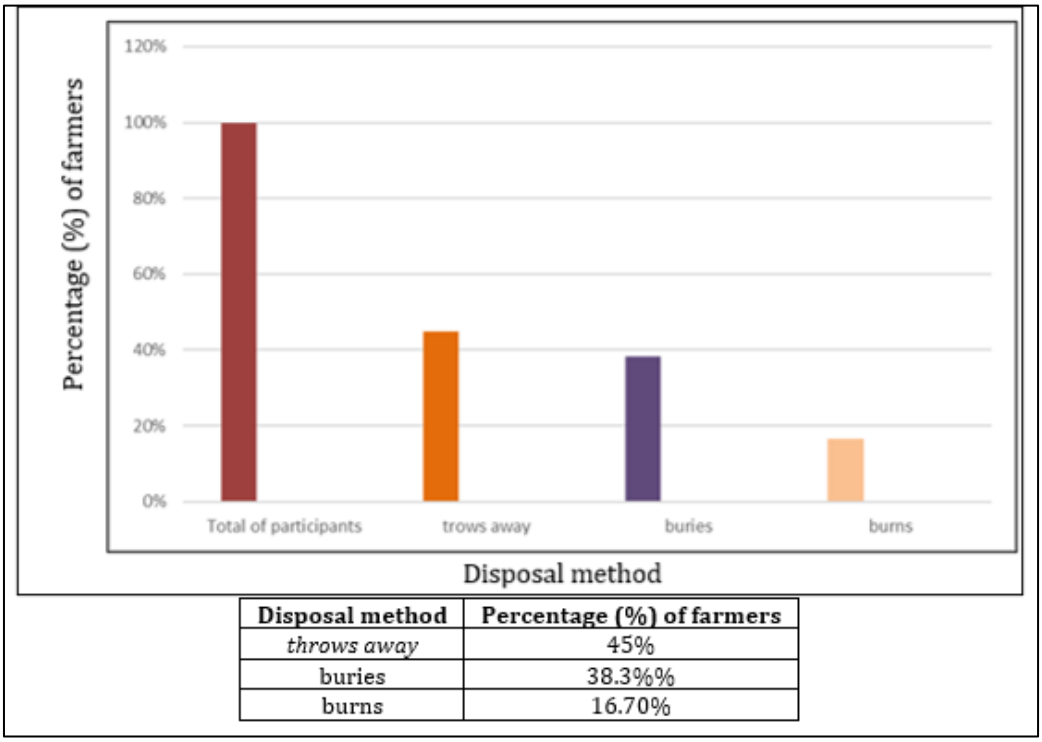
In general, it was observed that farmers tend to reduce the amount of the recommended quantity of water used for dilution, which significantly increases the concentration of the pesticides applied. This practice heightens the risks to human health and the environment, indicating an improper and potentially dangerous use of these substances.

Although the use of pesticides is extremely important for controlling diseases, pests, and weeds in crops, it requires that applicators have a basic understanding of the mode of action, recommended concentrations, timing and season of application, product formulation (wettable powder, emulsifiable concentrate, dry powder), toxicological classification, and safety precautions during and after application.

The lack of technical information, combined with poor oversight and limited farmer training, directly contributes to this improper use. Even worse, many believe that increasing the concentration leads to greater effectiveness of the product, when in fact, this practice undermines agricultural sustainability, endangers the environment, and promotes the emergence of resistant pests [17].

Therefore, the safe and effective use of pesticides depends not only on their availability but primarily on the continuous training of farmers, access to clear and accurate information, and the joint efforts of public and private institutions in raising awareness and regulating the use of these chemical substances in rural areas.

3.2. Disposal of Waste and Empty Containers



Disposal method	Percentage (%) of farmers
throws away	45%
buries	38.3%%
burns	16.70%

Figure 1 Final destination of packaging

The improper disposal of empty pesticide containers is one of the most concerning practices observed in the Pateguane Lowland, considering the environmental and public health risks this behavior poses according to DAMALAS, *et al* [18] improper disposal of pesticide wastes can create hazards for humans and the environment. According to the collected data (**Figure 1**), about 45% of farmers leave containers out in the open, exposed to the environment (**Figure 2**). This practice encourages the improper reuse of these containers for other domestic or agricultural purposes, which significantly increases the risk of human and environmental contamination.

Figure 2 Empty packages discarded in the lowland fields

Other 38.3% of respondents choose to bury the containers, which, although it reduces direct exposure, does not eliminate the problem, as the chemical residues present can remain in the soil for many years. In addition, the soil impermeabilization caused by the containers may hinder water infiltration during the rainy season, affecting groundwater recharge and soil quality.

Meanwhile, 16.7% of farmers reported burning the containers—an extremely harmful practice, since plastics and pesticide residues release toxic gases, such as dioxins, furans, and volatile organic compounds, these pollutants contribute to air pollution, respiratory problems, and even cancer risks. Burning also contaminates nearby soil and water through fallout [19,20]. These data highlight a lack of guidance and clear policies regarding the proper final disposal of pesticide containers.

In Mozambique, there is no effective and specific legislation focused on the management and recycling of these containers, leaving farmers uninformed and without safe disposal alternatives. This regulatory gap contributes to significant environmental damage, such as soil and water pollution, and to public health risks, especially in rural communities where contact with these substances is more direct.

Given this scenario, it is essential to implement awareness and training programs for farmers, promoting safe practices such as triple rinsing of containers, temporary storage in appropriate locations, and delivery to collection points or recycling programs, when available. Moreover, it is urgent that national authorities develop and enforce specific regulations for the disposal and management of hazardous waste in the agricultural sector as a way to promote more sustainable and safer farming practices for all.

The disposal of pesticide residues and empty containers must comply with legal and technical standards to avoid serious harm to human health, wildlife, soil, and water resources. Improper practices such as abandonment, burning, or reuse of containers aggravate environmental risks and compromise public health.

Empty containers should be sent to specialized collection centers after performing triple rinsing, a procedure that involves fully emptying the container into the sprayer tank, adding water up to one-quarter of the container's capacity, shaking for 30 seconds, and repeating the process at least three times. The container should then be perforated to prevent reuse.

Proper final disposal requires the joint efforts of various actors, including manufacturers, distributors, farmers, regulatory agencies, and environmental managers

The implementation of these practices is essential to promote sustainable agriculture, reducing the negative impacts of pesticides on the environment and on the health of both rural and urban populations.

3.3. Personal Protective Equipment in Pesticide Handling

Personal protection when handling pesticides is a critical factor for rural workers' safety, as it aims to minimize the risks of direct exposure to toxic chemical substances. To assess the use of personal protection measures, this study relied on surveys conducted with farmers in the Pateguane Lowland and on direct observations during crop spraying activities.

The results were alarming: 100% of the 60 farmers surveyed stated that they do not use any type of personal protective equipment (PPE), as shown in Graph 2. Field observation confirmed this finding, revealing that farmers apply pesticides without gloves, masks, goggles, aprons, or boots, exposing themselves directly to the chemicals. Many reported a lack of financial resources to purchase the necessary equipment, which further worsens the situation, given the dangers involved.

This lack of protection poses a serious health risk [21], as frequent exposure to pesticides can cause birth defects, cancer [22], neurological, respiratory, dermatological, and reproductive disorders [23]

Even though they are aware of the existence of protective equipment, farmers reported not understanding its true importance or how to use it correctly. This reveals a significant gap in training and awareness among rural producers regarding safe farming practices.

In the **Figure 3** farmers are observed applying pesticides without using any form of protection, reinforcing the urgent need for educational interventions and public policies focused on occupational health in rural areas.

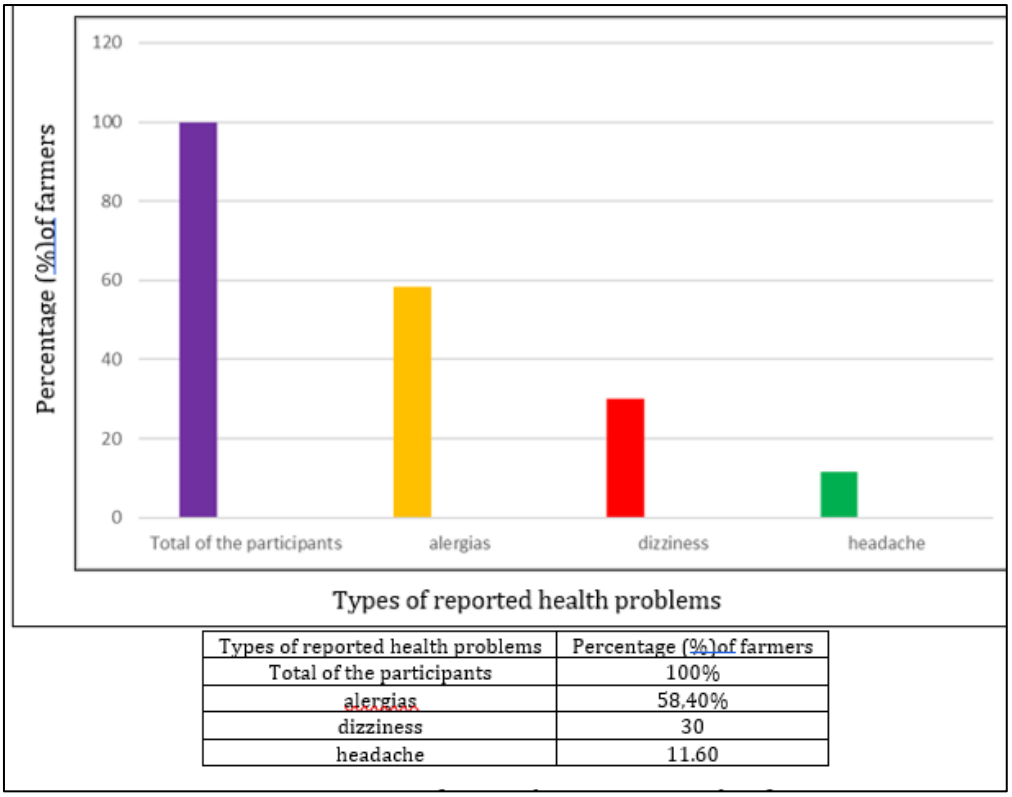
Figure 3 Pesticide application without the use of protective equipment and reduced presence during the activity

3.4. Impactos dos Pesticidas na Saúde Individual dos Agricultores

Constant and unprotected exposure to pesticides has caused serious health impacts on farmers in the Pateguane Lowland. According to data obtained through surveys (Figure 4), 58.4% of respondents reported episodes of allergic reactions, 30% reported dizziness, and 11.6% reported headaches after contact with chemical products. These symptoms are typical of acute poisoning, caused by direct absorption of toxic substances through respiratory, dermal, or oral routes [24].

It was also observed that most farmers experience symptoms almost immediately after handling pesticides. However, there are no formal clinical records of poisoning, as they do not use to undergo medical examinations for proper diagnosis. The lack of medical follow-up and official records hinders the early identification of chronic poisoning cases and prevents the adoption of effective preventive measures.

Chronic effects, which appear after weeks, months, or years of exposure, may lead to liver and kidney damage, neurological changes, hormonal disorders, genetic alterations, and even cancer [25]. These more severe effects are often silent and cumulative, typically requiring specific laboratory tests for detection. So, it is essential for farmers to remain attentive to any changes in their bodies and to seek medical assistance when necessary. Furthermore, educational campaigns and preventive health programs in rural areas are urgent and necessary to raise awareness among farmers about the risks of continuous pesticide exposure and the importance of undergoing regular medical check-ups.



Types of reported health problems	Percentage (%)of farmers
Total of the participants	100%
alergias	58,40%
dizziness	30
headache	11.60

Figure 4 Symptoms of pesticide poisoning within farmers

4. Conclusions

Based on the results obtained, it is concluded that farmers in the Pateguane Lowland region, in the district of Morrumbene, use pesticides in concentrations higher than those recommended on the labels. Examples include:

Cypermethrin: 15 mL/20 L (recommended: 15 mL/100 L), Acetamiprid: 50 mL/25 L (recommended: 50 mL/100 L); methamidophos: 0.75 mL/10 L (recommended: 0.75 mL/100 L), carbaryl: 0.75 L/25 L (recommended: 0.75 L/100 L). These practices result in increased toxicity of the applied solutions, putting both farmers' health and environmental balance at risk.

The identified impacts include: On the environment: soil degradation, loss of terrestrial and aquatic biodiversity, contamination of groundwater;,On farmers' health: total absence of the use of Personal Protective Equipment (PPE), resulting in symptoms of acute poisoning such as allergies, dizziness, and headaches.The improper use of pesticides represents a significant risk to both public health and the local environment.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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