Journal of Tropical Resources and Sustainable Science
Website : http://journal.umk.edu.my/index.php/jtrss/
eISSN : 2462-2389
Vol: 13, Issue 1, 2025, 95-103
DOI: 10.47253/jtrss.v13i1.1259

RESEARCH ARTICLE

A Systematic Review of Empty Pesticide Container (EPC) Practices and Associated Factor in Agriculture Sector

Hanania Mirza Mustafa[1,*], Latifah Abd Manaf[1] and Abu Hanifah Mohammad Ramli[1]

[1]Faculty of Forestry & Environmental, Universiti Putra Malaysia, 43400, Serdang, Selangor, Malaysia

ARTICLE HISTORY
Received : 30 January 2024
Accepted : 26 August 2024
Online : 30 June 2025

KEYWORDS
pesticide packaging waste, agriculture waste, farmers, agriculture sector, environmental effect

☒ * **CORRESPONDING AUTHOR**
Hanania Mirza Mustafa
Faculty of Forestry & Environmental, Universiti Putra Malaysia, 43400, Serdang, Selangor, Malaysia.
Email: hananiamirza19@gmail.com

ABSTRACT

This systematic literature review explores the current state of empty pesticide container (EPC) disposal practices among farmers and the factors influencing these practices. The review identified 34 research articles and official reports that examined EPC disposal methods in the agricultural sector. The findings revealed that leaving empty containers at the farm and throwing them in irrigation canals were common disposal practices in several countries, posing environmental risks. Recycling and selling EPC were less prevalent, highlighting the need for improved infrastructure and awareness. Factors such as age, education, knowledge, training, facilities, and government regulations were found to influence farmers' disposal practices. The review underscores the importance of education, training, awareness campaigns, and supportive policies in promoting proper EPC disposal. Future research should address the identified limitations and explore the environmental and health impacts of different disposal methods in diverse contexts.

© 2025 UMK Publisher. All rights reserved.

1. INTRODUCTION

Pesticides are integral to modern agriculture, horticulture, forestry, and public health due to their efficacy in preventing and mitigating pest-related issues, which directly contributes to increased agricultural productivity and food security (Patarasiriwong et al., 2013). They help maintain healthy crops, leading to increased yields and higher productivity. By targeting pests, pesticides protect crops from extensive damage and contribute to food security (Ppop et al., 2014). Another crucial role of pesticides is disease prevention. They can effectively manage and prevent the spread of plant diseases caused by fungi and bacteria, safeguarding crops from infections that can result in crop failure. Pesticide particularly help control the growth of weeds, reducing competition for resources like water, sunlight, and nutrients. This promotes the healthy growth of crops and boosts overall yields. Moreover, pesticides also play a role in post-harvest protection. They prevent infestations by insects and pests during storage and transportation, ensuring that harvested crops remain viable and marketable for extended periods (Damalas et al., 2008; Shende & Bagde, 2013; Tudi et al., 2021).

However, it is important to use pesticides responsibly, considering integrated pest management strategies and following recommended practices to minimize environmental impact and ensure safety (Pretty & Pervez, 2015; Hajjar et al., 2023). Despite these benefits, the pervasive use of pesticides has sparked significant concern regarding their adverse effects on ecosystem health and human well-being (Nicolopoulou-Stamati et al., 2016; Rani et al., 2021). In highly industrialized countries and developing nations alike, the nature and focus of pesticide waste problems may differ, but the underlying challenges remain (Felsot et al, 2003). The mismanagement of pesticide waste in developing countries is particularly concerning, as farmers often face exposure to toxic chemicals that are banned or restricted in other countries (Bagheri et al., 2021). Inaccurate application techniques, poorly maintained spraying equipment, insufficient storage practices, disposal of empty pesticide container (EPC) and the reuse of old EPC for food and water storage further contribute to the exposure risks faced by farmers (Nwadike et al., 2021; Bagheri et al., 2022; Yawson, 2022).

Additionally, the improper management of EPC poses significant issues in agriculture, and it is crucial to address them. Empty pesticide containers, if not handled and disposed of properly, can contribute to environmental pollution and health risks. (Aiwerasia, 2002; Mohanty et al., 2013; Mergia et al., 2021). These containers may still contain residual pesticide residues, which can leach into the soil and

water sources, leading to contamination (Marnasidis et al., 2018). This contamination can have adverse effects on soil fertility, nearby water sources, and aquatic life that may absorb pesticide residues (Jin et al., 2018). Furthermore, the reuse of EPC for food and water storage is a common practice in some areas, particularly in developing countries (Zyoud et al., 2010). This practice can lead to unintentional exposure to pesticide residues, posing health risks to individuals who consume contaminated food or water. Such exposure can have acute and chronic health effects on farmers and their families (Boedeker et al., 2020). Addressing the issues of EPC is crucial for safeguarding human health, promoting environmental sustainability, and supporting responsible agriculture. Proper handling and disposal practices for EPC can protect farmers, agricultural workers from toxic residues and also reducing the risk towards environment (Karasmanaki et al., 2021). The adoption of recycling practices for EPC has emerged as a promising strategy to control nonpoint source pollution and provide alternative sources for basic materials (Xu et al., 2021; Raza et al., 2023). Dispite that, the extent to which end-users in different regions embrace and adopt EPC recycling practices remains unclear. In countries such as China, waste pesticide packaging has become a significant obstacle despite efforts by the government to control pollution (Yan et al., 2022). The absence of a standardized recycling system for empty pesticide containers adds further complexity to the situation (Li et al., 2023). Furthermore, estimating EPC generation indices is challenging, as it requires considering specific crops, areas, and the number of farmers involved. Accurate estimations are crucial for developing efficient and targeted management programs (Marnasidis et al., 2018).

Therefore, this systematic literature review (SLR) is essential as it comprehensively evaluates current practices for the disposal of empty pesticide containers (EPC) within the agricultural sector, identifying critical factors influencing these practices. Understanding these factors is crucial for mitigating environmental contamination and safeguarding public health, particularly in regions where agricultural practices may not adhere to stringent safety.

2. MATERIALS AND METHODS

2.1 Objective

This paper aims to review at all research articles related to EPC disposal method in agriculture sector around the world and make a list of the relevant factors that affect EPC disposal practices among farmers.

2.2. Search strategy and inclusion criteria

The quality appraisal of the included studies was conducted using a systematic approach to ensure the reliability and validity of the findings. Each study was evaluated based on predefined criteria, including the methodological rigor, relevance to the research questions, and the clarity of reported outcomes. Studies were rated on a scale, with high-quality studies receiving more weight in the synthesis of results. This appraisal process was essential to ensure that only robust and credible evidence contributed to the final conclusions of this review.

The search terms for PRISMA analysis are grouped into relevant subjects (i.e., empty pesticide container, pesticide bottle waste), study area (i.e., agriculture area) and focus of study (i.e., waste management, practices). The search terms are focused and restrictive, for example, ‘pesticide packaging waste,’ ‘empty pesticide container’, ’pesticide bottle waste’, ‘pesticide contamination’, ‘pesticide waste practices’, ‘pesticide waste handling’, ‘pesticide waste management’, ‘pesticide management in agriculture area’, etc. The search terms also include targeted population ‘farmers’, ‘agriculture worker’, and ‘farm workers’.

The inclusion criteria are 'type of study'; only primary research articles with field data and official reports from trusted sources are included. Article types such as reviews, editorial materials, news items, book chapters and notes are removed. Furthermore, this study is focusing on only empty pesticide container, pesticide bottle or pesticide container waste. Also, only papers stated the measure, handling, practices, factor, and impact of EPC disposal included. Articles and reports will be screened thoroughly on their tittle, abstract and content to be included in this paper. All articles and report were limited to 5 years for publishing data from 2018 to 2022. This review were limited to studies published in English. This decision was made to ensure consistency in the evaluation process and to facilitate the comprehensive synthesis of the literature. Articles in other languages were excluded due to the potential for translation inaccuracies that could affect the interpretation of results.

2.3 PRISMA statement result

As part of the initial review, an abstract was reviewed to verify that the research paper was relevant to the review paper topic. Following this, just 190 records passed the second, more stringent screening, and the remaining 5 research were discarded. During this phase, 70 full-text articles were obtained and their eligibility for inclusion was verified. After the eligibility stage, only 34 papers were chosen relevant to the meta-analysis and passed the inclusion criteria; the remaining 36 research were removed as shown in figure 1. Since meta-analysis usually requires a minimum of two studies to collect data and synthesis evidence, the database search was terminated without further results.

 © 2025 UMK Publisher. All rights reserved.

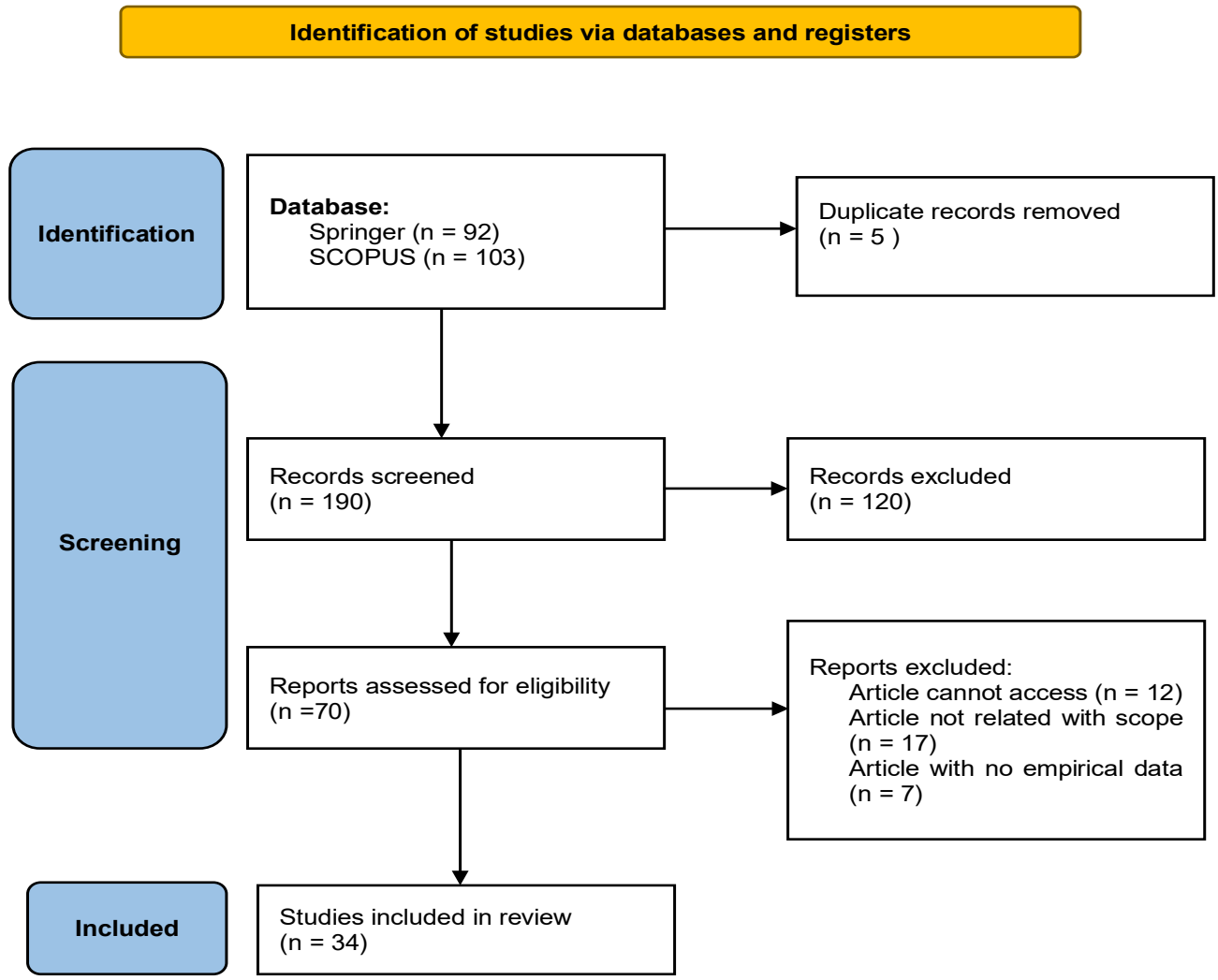

Figure 1: PRISMA statement results for this meta-analysis

3. RESULT AND DISCUSSION

This section discussed empty pesticide container (EPC) disposal practices among farmers and factors influencing these practices. Farmers commonly leave EPCs at their farms, leading to environmental risks, while some throw them in irrigation canals or bury them, potentially contaminating water, and soil. Recycling and selling EPCs are less common. Factors influencing disposal practices include age, education, knowledge, training, facilities, incentives, local authorities, government regulations, attitudes, experience, awareness, and EPC size and norms. Proper disposal is essential to avoid environmental and health hazards, and educational efforts and supportive policies are crucial to promoting safe practices among farmers.

3.1 Isolation and identification of isolated bacteria

The data presented in Table 1 provides an overview of the percentage distribution of various empty pesticide container (EPC) disposal methods across different countries. These methods include recycling, selling, leaving at the farm, throwing in irrigation canals, reusing for food/water, burying, burning, disposing with household waste, throwing away in other places, reusing for other purposes, and other miscellaneous methods (Imoro, et. al., 2019). The percentages reflect the prevalence of each disposal method within the respective countries. Among the observed disposal methods, leaving empty containers at the farm emerged as the most common practice, particularly in Ethiopia, Ghana, and Cameroon, where high percentages were reported. This suggests that a significant proportion of farmers in these regions dispose of pesticide containers by simply leaving them on their farm premises. However, this practice poses environmental risks, as improper management can lead to soil and water contamination if not handled appropriately.

Throwing empty containers into irrigation canals was also reported by several countries, with Vietnam and Pakistan showing high percentages. This disposal method can have detrimental effects on water quality and potentially harm aquatic life and ecosystems. Burying empty containers was found to be another prevalent practice, notably in Cameroon, Malaysia, Iran, and Turkey. Improper burial can pose risks of soil and groundwater contamination if adequate disposal techniques are not followed. Burning empty containers was

 © 2025 UMK Publisher. All rights reserved.

reported in countries such as Ghana, China, and Iran. While burning may seem convenient, it can release harmful chemicals into the air and contribute to air pollution. Recycling and selling empty pesticide containers were less commonly reported practices, with recycling having relatively low percentages across all countries. Encouraging recycling initiatives and establishing proper infrastructure for container collection and recycling can help mitigate the environmental impacts associated with EPC disposal. Reusing containers for other purposes, such as repurposing them for different uses, was reported in countries like Cameroon, China, Nigeria, and Iran. Moreover, countries like Ethiopia, Vietnam, and Nigeria reported relatively high percentages of reusing pesticide containers for food and water storage Burning or burying EPCs are appropriate and safe disposal methods (Sabran & Abas, 2021). However, the FAO/WHO recommends sending EPCs to waste management or recycling organizations instead, as burning or burying them in fields is not allowed. In Vietnam, Nguyen et al. (2021) found that farmers often dispose of EPCs by burying or burning them with household waste, without following proper treatment or using the triple rinsing method, resulting in emissions.

Table 1: EPC disposal method in agriculture sector

No	Study	Country	*n*	Burry (%)	Burn(%)	Throw at farm (%)	Throw in irrigation canal (%)	Dispose with household waste (%)	Throw at other places (%)	Reuse for food or water storage (%)	Reuse for other purposes (%)	Sell (%)	Recycle (%)	Handed to environmentalist for proper management (%)	Other (%)
1	Bagheri et al., 2018	Iran	200	30.2	17.0	32.8	10.0	-	-	-	10.0	-	-	-	-
2	Sharafi et al., 2018	Iran	311	9.0	19.9	8.4	2.6	41.2	-	-	15.1	3.9	-	-	-
3	Öztaş et al., 2018	Turkey	420	13.6	41.2	-	-	30.9	-	-	10.0	-	-	-	4.3
4	Imoro et al., 2019	Ghana	100	13.0	20.0	64.0	-	-	-	-	3.0	-	-	-	-
5	Mequanint et al., 2019	Ethiopia	409	13.4	-	49.6	-	46.0	-	16.4	-	-	-	-	-
6	Miyittah et al., 2020	Ghana	300	8.7	6.0	46.7	-	-	17.3	20.7	-	-	-	-	-
7	Mubushar et al., 2019	Pakistan	195	-	-	73.8	-	-	-	-	1.5	-	-	-	-
8	Sosan et al., 2020	Nigeria	112	7.1	23.2	30.4	1.8	-	20.5	-	-	8.0	-	-	1.8
9	Tambe et al., 2019	Cameroon	104	-	37.6	53.8	-	-	-	-	3.50	-	-	4.8	-
10	Kumari et al., 2021	India	96	12.0	65.0	13.0	-	-	-	-	5.0	5.0	-	-	-
11	Mehmood et al., 2021	Pakistan	307	21.82		53.0	-	-		-	18.0	7.0	-	-	-
12	Mergia et al., 2021	Ethiopia	210	1.9	-	91.9	2.9	-	-	-	1.9	1.4	-	-	-
13	Nguyen et al., 2021	Vietnam	100	22.0	42.0	48.0	68.0	-	-	-	6.0	14.0	-	-	-
14	Sabran & Abas, 2021	Malaysia	360	31.90		-	-	68.1	-	-	-	-	-	-	-
15	Asmare et al., 2022	Ethiopia	36	27.8	35.5	9.4	-	-	-	41.0	-	22.6	-	-	-
16	Huang and Elahi, 2022	China	256	44.27	16.21	30.34	-	6.64	0.26	-	-	-	2.34	-	-
17	Shahbaz et al. 2022	Pakistan	384	1.85	-	31.5	22.02	5.77	-	16.35	-	15.21	7.26	-	-
18	Sonhafouo-Chiana et al. 2022	Cameroon	232	7.6	14.2	-	-	31.3	36.0	-	-	-	10.9	-	-

Many farmers in low-income countries tend to reuse EPCs for household or farm purposes, as observed by Mehmood et al. (2021), Mergia et al. (2021), Sharafi et al. (2018), and Tambe et al. (2019). However, studies by Madaki et al. (2023), Miyittah et al. (2020), and Shahbaz et al. (2022) highlight that farmers also reuse EPCs for food and water storage. As a response, an increasing number of governments have prioritized the recycling and disposal of pesticide packaging. Statistics from PAMIRA Institution in Germany indicate that 78% of EPCs were recovered in 2017. Brazil achieved an 87% recovery rate in 2005 through the National Institute of Empty Container Treatment (inpEV), which

 © 2025 UMK Publisher. All rights reserved.

received EPC disposal agreements from 99% of pesticide manufacturers, distributors, and farmers. The Canadian Pesticide Industry Association's Stewardship First project recycled 73% of EPCs in 2011. It is important to note that there is variability in disposal practices among different countries, influenced by cultural, economic, and regulatory factors.

3.2. Factors of EPC disposal practices among farmers

Figure 2 shows the bar chart representing the factors influencing EPC disposal methods among farmers. This visualization clearly shows the impact of each factor, with "Knowledge" being the most significant and "Income," "Crop type," "Perception of Consequences of Behavior," and "Container Size" being among the least influential.

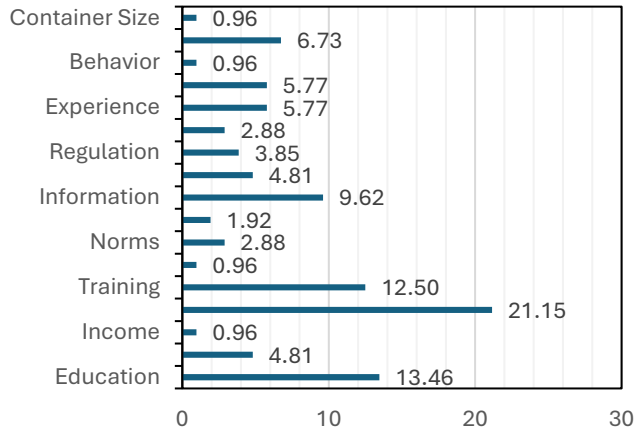

Figure 2: Factor of EPC disposal method among farmers

3.2.1 Age

Bondori et al., (2019) stated that in their study, farmers' age siginificantly impact the behavior in EPC disposal. That statement is supported by Nwadike et al., (2021) that indicate there was a noteworthy correlation ($p > 0.038$) between the age of farmers and their inclination to utilize EPC for secondary purposes. It was shown in Mehmood et al., (2021) study that farmers' age was an important factor of whether they used safety equipment and the least common procedures for disposing of pesticide containers, suggesting that more seasoned farmers had a deeper grasp of the risks associated with pesticide usage. While age is an important factor, the data suggests it has a moderate influence (4.81%) compared to other factors like knowledge.

3.2.2 Education status

The significant positive impact of education level and EPC disposal pratices found Kumari et al., (2021); Mequanint et al., (2019); Ponce-Caballero et al., (2022); Sabran & Abas, (2021). Figure 2 emphasizes this, showing that education influences 13.46% of the disposal methods among farmers. Subjects with a certificate or higher educational status were 6 times more likely to exhibit improved pesticide handling and storage practices compared to those who were unable to read and write. Farmers with higher education demonstrate safer practices than those with less education (Bondori et al., 2019; Mergia et al., 2021; Yawson, 2022). Mehmood et al., (2021) also stated farmers that educated often have a greater understanding of pesticide hazards, encouraging them to utilize safety equipment and apply proper disposal techniques when disposing of EPC.

3.2.3 Knowledge and information

Knowledge has the most significant influence on EPC disposal practices, accounting for 21.15% according to the bar chart in Figure 2. This aligns with the findings of Kumari et al., 2021; Mequanint et al., 2019; Mergia et al., 2021; Moda et al., 2022; Mubushar et al., 2019; Öztaş et al., 2018; Sabran & Abas, 2021. In Mequanint et al., (2019) study, participants with good knowledge had 3.23 times higher likelihood of better pesticide handling and storage practices compared to those with poor knowledge. Imoro et al., (2019) stated that the majority of farmers that cannot read, are unable to follow prescribed pesticide practises, resulting in incorrect pesticide use including EPC disposal that leads to environmental and health risks. It was supported by the study from Bondori et al., (2019) and Khuhro et al., (2020). Knowledge of safe disposal of EPC is crucial for farmers to reduce the risk of adverse health effects, ensure a safer working environment, and minimize the impact towards the environment (Bondori et al., 2019; Mequanint et al., 2019; Öztaş et al., 2018; Sabran & Abas, 2021; Teshome et al., 2023). Bagheri et al., (2018) studies at Ardabil province, Iran has stated information factor also affect the farmers EPC disposal practices. The majority of farmers acquired pesticide information from pesticides sellers and they only recommended pesticides and not contain any safety precautions since retailers assumed farmers could manage the EPC handling (Mergia et al., 2021; Oludoye et al., 2021; Sonhafouo-Chiana et al., 2022). According to Madaki et al. (2023), most farmers value information from both pesticide distributors and government organizations. Meanwhile from Yawson, (2022) found that, farmers try to find information and knowledge of pesticide and EPC practices from internet.

3.2.4 Training

Training is vital for effective EPC disposal, influencing 12.50% of disposal behaviors as shown in Figure 2 (Kumari et al., 2021; Tambe et al., 2019; Teshome et al., 2023). Proper training significantly impacts EPC disposal practices (Bagheri et al., 2018; Bondori et al., 2019; Karasmanaki et al., 2021; Moda et al., 2022; Oludoye et al., 2021). Mehmood et al. (2021) found that integrated pest management training positively affects safe pesticide and

 © 2025 UMK Publisher. All rights reserved.

EPC disposal methods. Sánchez-Gervacio et al. (2021) demonstrated that farmers receiving targeted pesticide safety instruction (Intervention Group) exhibited better EPC disposal practices compared to those who did not receive such instruction (Reference Group). However, current training provided by pesticide importers often excludes small-scale farmers and lacks specific content on EPC disposal (Oludoye et al., 2021). To address this issue, it is recommended that training programs be expanded to include small-scale farmers and emphasize EPC disposal techniques. Developing standardized training modules that cover comprehensive disposal practices could enhance effectiveness and ensure all farmers receive the necessary guidance (Lelamo, et al., 2023; Mubushar, et. al., 2019).

3.2.5 Facilities and incentive

The availability of facilities and incentives significantly impacts EPC disposal practices, accounting for 4.81% and 2.88% of the variance, respectively, as illustrated in Figure 2. The lack of appropriate facilities for safe EPC disposal is a notable issue, with farmers expressing a preference for easily accessible disposal sites that adhere to legal and municipal standards (Li et al., 2023; Nguyen et al., 2021). Monetary incentives play a crucial role in encouraging EPC recycling. Specifically, farmers are more inclined to engage in EPC recycling when offered financial subsidies rather than facing punitive measures. This relationship is particularly evident when considering the scale of farming operations. For instance, subsidies are more effective in motivating large-scale farmers to participate in recycling programs. Large-scale farmers, who often have more resources, are generally more responsive to financial incentives that offset recycling costs. Conversely, small-scale farmers, who may have fewer resources and face greater financial constraints, are less motivated by monetary incentives alone (Yawson, 2022; Li et al., 2021). To improve recycling rates among both large-scale and small-scale farmers, it is essential to design incentive programs that are tailored to the specific needs and financial capabilities of different farming scales. This could involve providing targeted subsidies to small-scale farmers or offering additional support, such as technical assistance and infrastructure improvements, to ensure that recycling programs are accessible and effective across all farm sizes (Li et. al., 2023; Xu et al., 2021).

3.2.6 Local authorities, Government, Regulation

The role of local authorities and government in regulating EPC disposal is crucial, yet it accounts for only 3.85% of the influence on disposal practices, as illustrated in Figure 2. While the section previously emphasized the lack of training provided by authorities, it is equally important to understand the broader regulatory landscape and its limitations. One of the primary reasons for the inadequate regulation of EPC disposal is the lack of comprehensive national environmental policies that specifically address the issue (Li et. al., 2023; Petruk et. al., 2020). Many existing regulations focus on broader environmental protection goals but fail to provide clear guidelines or mandates for the disposal of EPCs. This regulatory gap can be attributed to several factors, including the complexity of coordinating policies across various governmental agencies, limited financial and human resources, and the varying levels of priority given to pesticide management across different regions (Oludoye et al., 2021). The challenges of coordinating policies across agencies, limited resources, and the low prioritization of pesticide management further hinder the development of effective regulation (Hu, et. al., 2022; Petruk, et. al., 2020). Moreover, enforcing these regulations is particularly difficult in rural farming communities due to infrastructure limitations, insufficient training, and budget constraints (Andersson & Isgren, 2021). In addition, the lack of consistent and reliable data on pesticide usage and EPC disposal further complicates the development of targeted regulations that could address the specific needs of different agricultural sectors (Bagheri et al., 2018). Governments may also be reluctant to impose stringent regulations that could impact agricultural productivity, especially for small-scale farmers (Xu, et al., 2021; van der Berg, et al., 2020). To overcome these challenges, it is essential for governments to create clear, enforceable guidelines for EPC disposal, enhance the capacity of local authorities, and foster collaboration between stakeholders to develop practical, sustainable regulatory frameworks.

3.2.7 Attitude

Farmers' attitudes towards EPC disposal are a crucial factor influencing their practices, accounting for 5.77% of the overall impact, as shown in Figure 2. While the training they receive and their life experiences contribute to shaping these attitudes, these influences are often inconsistent and limited in effect. Mequanint et al., (2019) stated that farmers with a positive attitude were 1.77 times more likely to exhibit better pesticide handling and storage practices compared to those with a negative attitude. Contradictly from the study of (Jambari et al., 2020) over fifty percent of the farmers respondents in this study showed a lack of concern for proper practice. For instance, while some farmers may develop positive disposal practices through direct experience, others may continue to engage in unsafe practices due to ingrained habits or a lack of reinforced training (Bondori et al., 2019). To shape farmers' positive attitudes towards proper EPC

 © 2025 UMK Publisher. All rights reserved.

disposal, it is essential to consider a broader range of influencing factors. Social norms, peer influence, and community engagement have been identified as significant drivers of behavior change (Zhang, et al., 2023; Xu, et al., 2021; Zhang & Zhao, 2019). According to Yawson (2022), farmers who perceive that their peers value proper disposal methods are more likely to adopt similar practices themselves. Additionally, targeted educational campaigns that highlight the environmental and health risks associated with improper EPC disposal can reinforce positive attitudes and motivate change (Mequanint et al., 2019). Studies by Sosan et al. (2020) further emphasize that continuous, context-specific training, tailored to the local culture and farming practices, is vital in fostering long-term attitudinal shifts. Therefore, a multifaceted approach that combines training, community-based interventions, and consistent reinforcement of positive behaviors is necessary to instill and sustain proper EPC disposal practices among farmers.

3.2.8 Experience

The findings from Bondori et al., (2019), Ponce-Caballero et al., (2022), and Yawson (2022) implies that as farmers become more experienced in farming, they show strong environmental behavior with respect to pesticide use. Thus, is has been shown in Figure 2 where 5.77% experience in farming plays a notable role in EPC disposal practices. The elder farmers get their awareness or knowledge from direct experience and observation, which has been accumulated through time and shifted as it was handed along through generations (Sabran & Abas, 2021). The majority of farmers have chosen the types of pesticides they will use based on their experience over the years, and this influence their decision regarding their EPC disposal practices (Sonhafouo-Chiana et al., 2022; Sosan et al., 2020).

3.2.9 Awareness

Awareness regarding the safe disposal of EPCs has been identified as a critical factor, influencing 6.73% of disposal behaviors, according to the data presented in Figure 2 (Sosan et al., 2020). Studies indicate that farmers often possess limited awareness of correct disposal procedures, which correlates with their engagement in improper EPC disposal practices (Sabran & Abas, 2021). Notably, farmers with a highess awareness of environmental contamination risks associated with pesticide use are more likely to participate in EPC recycling programs (Li et al., 2023; Raza et al., 2023; Yawson, 2022). However, it is crucial to acknowledge the findings of Miyittah et al. (2020), who highlight that awareness and understanding of the harmful impacts of pesticide usage do not necessarily translate into proper pesticide usage and disposal. This suggests that awareness alone may be insufficient to drive behavioral change. For instance, Nguyen et al. (2021) found that although many farmers were informed about the health risks associated with pesticides and expressed a willingness to learn more, this did not always lead to the adoption of safe disposal practices. Therefore, while awareness is a significant component, it must be complemented by practical training, ongoing support, and incentives to ensure that knowledge is effectively translated into action.

3.2.10 EPC size and norms

EPC size and societal norms collectively influence disposal practices, though they account for a smaller percentage, with EPC size at 0.96% and norms not explicitly highlighted in the chart. Nonetheless, a significant correlation between container size and recycling intention was discovered for containers between 100 ml and 500 ml and majority of EPC waste came from tiny, difficult-to-recycle containers (Li et al., 2023). Farmers norms affect their intention toward safe EPC diposal practices. Raza et al., (2023) states that the Pakistani society based on cooperation and synergy affects the actions of end users is how their friends see the practices of pesticides and disposal of EPC implemented.

4.0 CONCLUSION

The data from the relevant studies consistently demonstrates that farmers commonly engage in improper empty pesticide container (EPC) disposal methods, including throwing them at farms, irrigation canals, or other places, reusing them for food, water, or other purposes, and disposing of them with household waste. Additionally, the majority of studies emphasize the significant impact of farmer education, knowledge, information, and training on EPC disposal practices. To effectively improve EPC disposal and foster farmers' compliance with proper disposal methods, it is crucial to implement education and training initiatives that enhance farmers' understanding and promote safe disposal practices. Continuous awareness campaigns and training programs should involve pesticide suppliers, local authorities, and government agencies, providing comprehensive information on EPC disposal procedures and methods. It is also important to regularly update the training content and materials, considering the various types of EPC materials and the specific facilities available in different agricultural areas. Furthermore, local authorities and governments should incentivize farmers to participate in EPC recycling programs and actively encourage proper disposal practices. In conclusion, the implementation of effective education, awareness campaigns, and well-established waste management infrastructure is essential for mitigating the

 © 2025 UMK Publisher. All rights reserved.

negative environmental and health impacts associated with improper EPC disposal. Encouraging the adoption of sustainable practices, such as recycling and responsible handling, can contribute to a more sustainable and environmentally friendly agricultural sector.

ACKNOWLEDGEMENT

This research was fully supported by Graduated Research Fellowship funded by Universiti Putra Malaysia.

REFERENCES

Aiwerasia, V. N. (2002). Health impact of exposure to pesticides in agriculture in Tanzania. Tampere University Press.

Alizah, A., & Nurulhasni, S. (2015). Mismanagement of Chemical Agriculture in Malaysia from Legal Perspective. Procedia Economics and Finance, 31, 640-650.

Andersson, E., & Isgren, E. (2021). Gambling in the garden: Pesticide use and risk exposure in Ugandan smallholder farming. Journal of Rural Studies, 82, 76-86. https://doi.org/10.1016/J.JRURSTUD.2021.01.013.

smare, B. A., Freyer, B., & Bingen, J. (2022). Pesticide Use Practices among Female Headed Households in the Amhara Region, Ethiopia. Sustainability, 14(22), 15215.

Bagheri, A., Emami, N., Allahyari, M. S., & Damalas, C. A. (2018). Pesticide handling practices, health risks, and determinants of safety behavior among Iranian apple farmers. Human and Ecological Risk Assessment, 24(8), 2209–2223.

Bagheri, A., Emami, N., & Damalas, C. (2021). Farmers' behavior towards safe pesticide handling: An analysis with the theory of planned behavior. Science of The Total Environment, 751, 141709.

Bagheri, A., Emami, N., & Damalas, C. (2022). Monitoring point source pollution by pesticide use: An analysis of farmers' environmental behavior in waste disposal. Environment, Development and Sustainability, 1-16.

Boedeker, W., Watts, M., Clausing, P., & Marquez, E. (2020). The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. BMC public health, 1, 1-19.

Bondori, A., Bagheri, A., Allahyari, M. S., & Damalas, C. A. (2019). Pesticide waste disposal among farmers of Moghan region of Iran: current trends and determinants of behavior. Environmental Monitoring and Assessment, 191(1).

Damalas, C., Telidis, G., & Thanos, S. (2008). Assessing farmers' practices on disposal of pesticide waste after use. Science of the total environment, 390 (2-3), 341-345.

Felsot, A., Racke, K., & Hamilton, D. (2003). Disposal and degradation of pesticide waste. In Reviews of Environmental Contamination and Toxicology (Vol. 177). New York: Springer. doi:https://doi.org/10.1007/0-387-21725-8_3

Hajjar, M., Ahmed, N., Alhudaib, K. A., & Ullah, H. (2023). Integrated Insect Pest Management Techniques for Rice. Sustainability, 15(5), 4499.

Hu , N., Zhang, Q., Li , C., & Sun, H. (2022). Policy intervention effect research on pesticide packaging waste recycling: evidence from Jiangsu, China. Frontiers in Environmental Science, 10, 922711.

Huang, S., & Elahi, E. (2022). Farmers' Preferences for Recycling Pesticide Packaging Waste: An Implication of a Discrete Choice Experiment Method. Sustainability, 14(21), 14245.

Imoro, Z. A., Larbi, J., & Duwiejuah, A. B. (2019). Pesticide availability and usage by farmers in the Northern Region of Ghana. Journal of Health and Pollution, 9(23), 1–8.

Jambari, N. S. A., Samad, N. I. A., Anua, S. M., Ruslan, R., & Hamzah, N. A. (2020). Knowledge, Attitude and Practice (KAP) on pesticide exposure among farmers in Kota Bharu, Kelantan. Malaysian Journal of Medicine and Health Sciences, 16, 56–62.

Jin, S., Blueming, B., & Mol, A. (2018). Mitigating land pollution through pesticide packages–The case of a collection scheme in Rural China. Science of the Total Environment, 622, 502-509.

Karasmanaki, E., Dimopoulou, P., Vryzas, Z., Karipidis, P., & Tsantopoulos, G. (2021). Is the environmental behavior of farmers affecting their pesticide practices? A case study from Greece. Sustainability, 13(3), 1452.

Kumari, D., Sebastian, A. J., & John, S. (2021). Pesticide handling practices and health risks among the apple orchard workers in Western Indian Himalayan region. Human and Ecological Risk Assessment, 27(1), 15–29.

Lelamo, S., Ashenafi, T., Ejeso, A., Soboksa, N. E., Negassa, B., & Aregu, M. B. (2023). Pesticide use practice and associated factors among rural community of Malga District, Sidama Regional State, South Ethiopia. Environmental health insights, 17, 11786302231157226 .

Li, Y., Wang, Y., Han, X., Wang, H., & Fu, J. (2023). A study of intention to recycle pesticide packaging among rural farmers in China based on the logistic model. Environmental Research Communications, 5(4), 041004.

Madaki, M. Y., Lehberger, M., Bavorova, M., Igbasan, B. T., & Kächele, H. (2023). Effectiveness of pesticide stakeholders' information on pesticide handling knowledge and behaviour of smallholder farmers in Ogun State, Nigeria. Environment, Development and Sustainability, 26, 17185-17204.

Marnasidis, S., Stamatelatou, K., Verikouki, E., & Kazantzis, K. (2018). Assessment of the generation of empty pesticide containers in agricultural areas. Journal of environmental management, 224, 37-48.

Mehmood, Y., Arshad, M., Mahmood, N., Kächele, H., & Kong, R. (2021). Occupational hazards, health costs, and pesticide handling practices among vegetable growers in Pakistan. Environmental Research, 200(December 2020). https://doi.org/10.1016/j.envres.2021.111340

Mequanint, C., Getachew, B., Mindaye, Y., Amare, D. E., Guadu, T., & Dagne, H. (2019). Practice towards pesticide handling, storage and its associated factors among farmers working in irrigations in Gondar town, Ethiopia, 2019. BMC research notes, 12, 1-6.

Mergia, M. T., Weldemariam, E., Eklo, O., & Yimer, G. (2021). Small-scale farmer pesticide knowledge and practice and impacts on the environment and human health in Ethiopia. Journal of Health Pollution, 11(30), 210607.

Mohanty, M., Behera, B., Jena, S., Srikanth, S., Mogane, C., Samal, S., & Behera, A. (2013). Knowledge attitude and practice of pesticide use among agricultural workers in Puducherry, South India. Journal of forensic and legal medicine, 20(8), 1028-1031.

Miyittah, M. K., Kwadzo, M., Gyamfua, A. P., & Dodor, D. E. (2020). Health risk factors associated with pesticide use by watermelon farmers in Central region, Ghana. Environmental Systems Research, 9(1). https://doi.org/10.1186/s40068-020-00170-9

Moda, H. M., Anang, D. M., Moses, N., Manjo, F. M., Joshua, V. I., Christopher, N., Doka, P., & Danjin, M. (2022). Pesticide Safety Awareness among Rural Farmers in Dadinkowa, Gombe State, Nigeria. International Journal of Environmental Research and Public Health, 19(21).

Mubushar, M., Aldosari, F. O., Baig, M. B., Alotaibi, B. M., & Khan, A. Q. (2019). Assessment of farmers on their knowledge regarding pesticide usage and biosafety. Saudi Journal of Biological Sciences, 26(7), 1903–1910.

Nguyen, T. T., Cao, S. D. H., Thi, Q. A. N., Phan, P. T., Tran, N. T., Tran, L. B., Le, T. T., Tran, Q. T., & Nguyen, N. H. (2021). Current Status of the Management of Plant Protection Product Containers in Cho Moi District, An Giang Province, Vietnam. Nakhara: Journal of Environmental Design and Planning, 20, 1–14.

Nicolopoulou-Stamati, P., Maipas, S., Kotampasi, C., Stamatis, P., & Hens, L. (2016). Chemical pesticides and human health: the urgent need for a new concept in agriculture. Frontiers in public health, 4, 148.

Nwadike, C., Joshua, V., Doka, P., Ajai, R., Hashidu, U., Gwary-Moda, S., . . . Moda, H. (2021). Occupational safety knowledge, attitude, and practice among farmers in northern nigeria during pesticide application—a case study. Sustainability (Switzerland), 13(18), 10107.

Oludoye, O. O., Robson, M. G., & Siriwong, W. (2021). Using the socio-ecological model to frame the influence of stakeholders on cocoa farmers' pesticide safety in Nigeria: Findings from a qualitative study. Risk Management and Healthcare Policy, 14, 2357–2368

Öztaş, D., Kurt, B., Koç, A., Akbaba, M., & Ilter, H. (2018). Knowledge level, attitude and behavior of farmers in the Çukurova region about the use of pesticides. 2018, A462.3-A462. https://doi.org/10.1136/oemed-2018-icohabstracts.1315

Patarasiriwong, V., Wongpan, P., Korpraditslkul, R., & Jeerapong, L. (2013). Pesticide packaging waste management model for Thailand. Journal of Environmental Science and Engineering, B2, 1-6.

Petruk, R., Petrushka, I., & Pohrebennyk, V. (2020). Environmental safety management of used packaging of pesticides and other dangerous substances. Environmental Problems, 1 (5), 2020, 5(1), 30-34.

Ponce-Caballero, C., Cardeña-Echalaz, F., Giácoman-Vallejos, G., VEGA DE LILLE, M., & Góngora-Echeverría, V. R. (2022). Pesticide Management and Farmers

 © 2025 UMK Publisher. All rights reserved.

Perception of Environmental and Health Issues Due To Pesticide Use in the State of Yucatán, Mexico: a Study Case. Revista Internacional de Contaminacion Ambiental, 38, 289–300. https://doi.org/10.20937/RICA.54134

Ppop, J., Pető, K., & Nagy, J. (2014). Impact of pesticide productivity on food security. Sustainable Agriculture Reviews, 13, 19-33.

Pretty, J., & Pervez, B. (2015). Integrated pest management for sustainable intensification of agriculture in Asia and Africa. Insects, 6(1), 152-182.

Rani, L., Thapa, K., Kanojia, N., Sharma, N., Singh, S., Grewal, A., . . . Kaushal, J. (2021). An extensive review on the consequences of chemical pesticides on human health and environment. Journal of Cleaner Production, 283, 124657.

Raza, A., Naqvi, S., Mehdi, M., Usman, M., Ali, S., Shah, A., & Hussain, B. (2023). An Analysis of the Circular Economy Practices of Pesticide Container Waste in Pakistan. Recycling, 8(1), 4.

Sabran, S. H., & Abas, A. (2021). Knowledge and Awareness on the Risks of Pesticide Use Among Farmers at Pulau Pinang, Malaysia. SAGE Open, 11(4). https://doi.org/10.1177/21582440211064894

Sánchez-Gervacio, B. M., Legorreta-Soberanis, J., Bedolla-Solano, R., Rosas-Acevedo, J. L., Valencia-Quintana, R., Juárez-López, A. L., & Paredes-Solís, S. (2021). Impact of a Non-Formal Environmental Education Program on safe handling of pesticides among Mexican subsistence farmers: a participatory pilot study. Human and Ecological Risk Assessment: An International Journal, 27(6), 1636-1654.

Sharafi, K., Pirsaheb, M., Maleki, S., Arfaeinia, H., Karimyan, K., Moradi, M., & Safari, Y. (2018). Knowledge, attitude and practices of farmers about pesticide use, risks, and wastes; a cross-sectional study (Kermanshah, Iran). Science of the Total Environment, 645, 509–517. https://doi.org/10.1016/j.scitotenv.2018.07.132

Shahbaz, P., Ul Haq, S., Boz, I., & Aziz, B. (2022). Land tenure status based pesticide use knowledge of vegetable farmers. International Journal of Vegetable Science, 28(3), 247-258.

Shende, N. V., & Bagde, N. T. (2013). Economic consequences of pesticides use in paddy cultivation. Am Int J Res Hum Arts Soc Sci, 4, 25-33.

Sonhafouo-Chiana, N., Nkahe, L. D., Kopya, E., Awono-Ambene, P., Wanji, S., Wondji, C., & Antonio-Nkondjio, C. (2022). Rapid evolution of insecticide resistance and patterns of pesticides usage in agriculture in the city of Yaoundé, Cameroon. Parasites & Vectors, 15(1), 1-15.

Sosan, M. B., Oladepo, O. W., & Ajibade, T. S. (2020). Assessment of pesticide wastes disposal practices by cocoa farmers in southwestern Nigeria. Journal of Solid Waste Technology and Management, 46(2), 230–238. https://doi.org/10.5276/JSWTM/2020.230

Tambe, A. B., Mbanga, B. M. R., Nzefa, D. L., & Nama, M. G. (2019). Pesticide usage and occupational hazards among farmers working in small-scale tomato farms in Cameroon. Journal of the Egyptian Public Health Association, 94(1), 0–6. https://doi.org/10.1186/s42506-019-0021-x.

Teshome, Z. A., Argaw, A. B., & Wanore, W. W. (2023). Pesticide Utilization, Practices, and Their Effect on Honeybees in North Gonder, Amhara Region, Ethiopia. Advances in Agriculture, 2023. https://doi.org/10.1155/2023/9971768

Tudi, M., Daniel Ruan, H., Wang, L., Lyu, J., Sadler, R., Connell, D., & Phung, D. (2021). Agriculture development, pesticide application and its impact on the environment. nternational journal of environmental research and public health, 18(3), 1112.

van der Berg, H., Gu, B., Grenier, B., Kohlschmid, E., Al-Eryani, S., Bezerra, H., Nagpal, B., Chanda, E., Gasimov, E., Velayudhan, R., & Yadav, R. (2020). Pesticide lifecycle management in agriculture and public health: Where are the gaps?. The Science of the Total Environment, 742. https://doi.org/10.1016/j.scitotenv.2020.140598.

Xu, X., Zhang, Z., Kuang, Y., Li, C., Sun, M., Zhang, L., & Chang, D. (2021). Waste pesticide bottles disposal in rural China: Policy constraints and smallholder farmers' behavior. Journal of Cleaner Production, 316, 128385.

Yan, L., Zhao, X., Zhang, D., Deng, J., & Zhang, Y. (2022). Associated Factors of Pesticide Packaging Waste Recycling Behavior Based on the Theory of Planned Behavior in Chinese Fruit Farmers. Sustainability, 14(17), 10937.

Yawson, D. (2022). Pesticide Use Culture among Food Crop Farmers: Implications for Subtle Exposure and Management in Barbados. Agriculture, 12(2), 288.

Zhang, Y., Zhang, M., Weng, Z., Gao, X., & Liao, W. (2023). The Influence of Social Norms and Environmental Regulations on Rural Households' Pesticide Packaging Waste Disposal Behavior. Sustainability, 15(22), 15938.

Zhang, Z., & Zhao, L. (2019). Voluntary monitoring of households in waste disposal: An application of the institutional analysis and development framework. Resources, Conservation and Recycling, 143, 45-59.

Zyoud, S., Sawalha, A., Sweileh, W., Awang, R., Al-Khalil, S., Al-Jabi, S., & Bsharat, N. (2010). Knowledge and practices of pesticide use among farm workers in the West Bank, Palestine: safety implications. Environmental health and preventive medicine, 15, 252-261.

 © 2025 UMK Publisher. All rights reserved.