



Comparative Analysis of Open Burning and Triple Rinsing Method for Empty Pesticide Container Management: A Review

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Abstract

In order to reduce environmental pollution and associated health risks, managing empty pesticide containers is a crucial part of agricultural waste disposal. The open-burning method and the triple rinsing method, two regularly used approaches to empty pesticide container management, are compared in this study. Empty pesticide containers are burned using the open burning technique to reduce their volume and make disposal easier. On the other hand, the triple rinsing method focuses on washing pesticide residues from containers with water to neutralize them and make them safe for recycling or disposal. This study compares two approaches' environmental impacts, financial viability, and safety factors. Air pollution emissions, residue containment, recycling possibilities, and practicability of operation are all considered in the analysis. Based on the findings, it is concluded that while the open-burning method may be advantageous in removing pesticide residue, the triple-rinsing method is a more secure and environmentally friendly option for managing empty pesticide containers. Alternative strategies that can overcome the drawbacks of both techniques and offer a complete answer for pesticide container management require more study.

Subject Areas

Environmental Management

Keywords

Pesticide Containers, Disposal, Triple Rinse, Open Burning, Pesticide Waste

1. Introduction

Empty pesticide container management is a severe environmental issue requiring

careful consideration and practical solutions. The open-burning and triple-rinsing methods are the two often employed techniques for removing empty pesticide containers. We may evaluate each strategy's influence on the environment, safety concerns, and general effectiveness by comparing its advantages and disadvantages. Policymakers, agricultural professionals, and environmentalists looking for environmentally friendly ways to manage pesticide containers will find this analysis helpful. We can better comprehend the environmental impact, safety ramifications, effectiveness, and regulatory compliance of the open burning and triple rinsing methods for managing empty pesticide containers. Considering these factors, this analysis helps stakeholders make well-informed decisions and implement sustainable practices that reduce environmental harm and safeguard human health.

According to scientific papers, most farmers dispose of pesticide containers in water canals, streams, or neighboring vegetation, sell them to trash purchasers, dump them on the farm, or burn them. **Table 1** is an example of some countries' common disposal techniques. These are prevalent circumstances in the majority of developing countries. The majority of farmers are aware of incorrect disposal procedures that harm the environment's ecology.

2. Environmental Impact

Pesticide container disposal errors can seriously affect the environment, resulting in pollution and ecosystem harm. Managing unused pesticide containers involves either triple rinsing or open burning. Both approaches have different effects on the ecosystem in any case. Containers for pesticides are lit on fire in the open to burn away any remaining chemicals. Pollutants and harmful gases may be released into the atmosphere as a result of this technique. Volatile organic compounds (VOCs) and particulate matter, two harmful substances that can contribute to air pollution, are frequently found in pesticides (Garbounis *et al.*, 2022) [7]. These contaminants may negatively impact air quality and human health, resulting in respiratory troubles and other health concerns. A further factor in climate change is the production of greenhouse gases during combustion.

Table 1. Common practices of pesticide container management in some countries.

Country	Streams/canals/ bushes (%)	Reuse (%)	Burial (%)	Burning (%)	References
Pakistan	-	18	-	-	Kumar <i>et al.</i> 2008 [1]
Pupua New Guinea	44	-	-	9	Gaber and Abdel-Latif 2012 [2]
Greece	33	-	30	18	Damalas <i>et al.</i> 2008 [3]
Ghana	-	22	25	53	Yeboah <i>et al.</i> 2021 [4]
Costa Rica	14	-	-	-	Jallow <i>et al.</i> 2017 [5]
Uganda	19	-	-	-	Jallow <i>et al.</i> 2017 [5]
India	-	-	48	-	Mohanty <i>et al.</i> 2013 [6]

A technique called triple rinsing involves thoroughly rinsing pesticide containers thrice times to get rid of any residue. This approach lowers the possibility of immediate pollution but still has adverse environmental effects. If the rinsate is not adequately managed, it might contaminate water bodies since it contains traces of pesticides. Pesticides can be toxic and persistent, and their introduction into aquatic environments has the potential to harm aquatic life, upset food webs, and taint water supplies. Even in trace doses, pesticides can have long-lasting effects on aquatic life, reducing biodiversity and disrupting ecosystems. Furthermore, contaminated soil might arise from inappropriate pesticide container disposal, regardless of the technique utilized (Marnasidis *et al.*, 2018) [8]. Pesticide residues may seep into the soil, reducing its fertility and causing dangers to microorganisms, plants, and animals. Water pollution problems can be worsened by contaminated soil, leading to groundwater contamination.

Promoting more environmentally friendly methods is essential to reducing the effects of pesticide container disposal on the environment. The above involves promoting substitute container materials that are safer to recycle or dispose of in the trash, implementing effective recycling procedures, and educating pesticide users on the significance of responsible container management. Regulatory controls and stringent enforcement of proper disposal procedures can further lessen the impact of pesticide container waste on the environment. Incorrect pesticide container disposal can cause pollution and harm to ecosystems. Open burning, and triple rinsing adversely affect the environment, including air pollution, contaminated water, and degraded soil. Implementing more sustainable techniques and creating awareness are crucial to ensure efficient management of pesticide container trash and lessen its environmental effects (Staudacher *et al.*, 2020) [9].

2.1. Open Burning Method

Empty pesticide containers can be disposed of by open burning, which involves igniting the containers outdoors. Empty containers are gathered and ignited in an open fire as part of the procedure. This practice has several serious downsides and raises environmental and health problems, even though it may seem convenient and economical. The simplicity and convenience of using the open-burning technique are advantages. Farmers and people living in rural areas can use it because it does not need specific equipment or infrastructure (Goburdhun *et al.*, 2019) [10]. The requirement for storage space and other concerns connected with keeping empty containers on-site are also reduced by open burning, which can swiftly clear many empty containers.

However, there are significant drawbacks to open burning. First off, it pollutes the air and emits poisonous gases. Volatile organic compounds (VOCs), such as dioxins and furans, are released when plastic containers are burned. These contaminants can harm the environment and human health, increasing air pollution and respiratory issues. There are concerns that burning residual pesticides in containers can lead to the release toxic polychlorinated dibenzo-p-dioxins (PCDDs),

polychlorinated dibenzofurans (PCDFs) either through vaporization of trace pesticide by products or through formation from pesticides as precursors. (Ramadan *et al.*, 2022) [11]. Persistent organic pollutants (POPs) like dioxins and furans are regarded as very harmful compounds because they are resistant to various factors of biochemical and photolytic degradation (El-Shahawi *et al.*, 2010) [12]. These are persistent to soils, sediments, and air for several decades. Having high toxicity and long persistency in the environment they accumulate in the fatty tissues of humans and animals resulting into many behavioral, reproductive and developmental changes. The major issue of PCDDs/PCDFs is due to their extreme persistency in the environment causing toxicity and cancer to living organisms and can potentially cause cancer (Mukerjee, 1998) [13]. Dioxin and furans are family of chlorinated hydrocarbon compound which are categorized into three main classes as: polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and dioxinlike polychlorinated biphenyl (DL-PCBs). PCDDs and PCDFs are produced from different anthropogenic activities like forest fires, domestic and hazardous waste combustion (Fernández-González *et al.*, 2015) [14]. A huge amount of hazardous waste, which is openly burned without any safety measure, produces huge quantity of Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDFs).

Additionally, open burning does not destroy the pesticide residues in the containers. Pesticides that are not wholly burned can leak dangerous chemicals into the air and surrounding environment. These substances harm ecosystems by contaminating soil, water supplies, and vegetation and may even enter the food chain. Additionally, open burning lacks effective control methods, which can lead to unintentional fires and the spread of unchecked flames. The above poses a risk to adjacent towns, buildings, and natural habitats and the possibility of larger-scale wildfires (Sooriyaarachchi *et al.*, 2019) [15].

Open burning may provide a quick fix for empty pesticide container management, but it has more drawbacks than positives regarding the environment and human health. Open burning is an unsafe practice due to the production of poisonous gases, the ineffective removal of pesticide residues, and the possibility of uncontrolled fires. Investigating different disposal techniques is essential; one such technique prioritizes environmental and human health protection, known as the triple rinsing method.

2.2. Triple Rinsing Method

A study by the Packaging Expert Group of the European Crop Protection Association (ECPA) showed that triple-rinsing and pressure rinsing remove over 99.99% of the original content from containers with superior “rinsability” and “drainability” (Table 2). Triple-rinsing by farmers and other users has been identified as a key for successful container collection and recovery schemes. The triple rinse approach is highly advised for treating empty pesticide containers. It is a meticulous cleaning procedure that aids in removing any pesticide residue or

Table 2. Percent of pesticide residue removed by triple rinsing (Herzfeld *et al.*, 1993) [16].

Pesticides	Containers	(%) of Removal
2 - 4 D	2.5 gallons plastic	99.9999
Pendimethalin	2.5 gallons plastic	99.9969
Alachlor	5.0 gallons metal	99.9998
Glyphosate	1.0-gallon plastic	99.9989
Metolachlor	2.5 gallons plastic	99.9999
Carbofuran	2.5 gallons plastic	99.9993

traces from the container, reducing the possibility of contamination and environmental degradation. Three clean water rinses in a row usually make up the procedure. The container is first entirely emptied to ensure that no pesticide is still present. Then, it is filled with clean water to a level of about one-fourth of its capacity. The container is shaken ferociously for at least 30 seconds to ensure the water covers all surfaces and corners. After draining the washed water, the procedure is carried out twice, using fresh water each time. The container should be fully clear of pesticide residues following the third rinse.

The triple-rinsing technique has many advantages. First, it lessens the chance that anybody handling the containers during later handling or disposal will unintentionally come into contact with pesticides. Pesticide residues are eliminated, reducing the possibility of environmental pollution and safeguarding both ecosystems and human health. Adopting appropriate rinsing recommendations also encourages responsible pesticide application and helps achieve compliance with regulatory regulations. However, it is crucial to recognize the triple rinsing technique's drawbacks. Although it works well to eliminate most pesticide residues, it sometimes leaves some behind, mainly if it is concentrated or highly persistent. Additional steps may be necessary in such circumstances. It is also important to remember that the triple-rinsing technique is only effective on pesticide containers and cannot work on containers for other dangerous chemicals.

It is essential to follow precise rinsing instructions to enhance the triple rinsing process's effectiveness. Users must carefully read and follow the pesticide label instructions, which frequently include detailed instructions on rinse techniques. For each rinse, it is crucial to use sufficient clean water and thoroughly shake the container to clean all regions thoroughly. Additionally, the rinsed water must be appropriately disposed of following local pesticide waste disposal laws. A triple-rinsing method is valuable for handling empty pesticide containers (Khan. *et al.*, 2021) [17]. It has advantages, including lowering the possibility of contamination and encouraging prudent pesticide application. It is crucial to understand its limitations and adhere to suitable rinsing instructions to achieve successful residue removal. Users of pesticides can support safer handling, disposal, and environmental protection by meticulously applying this technique. **Figure 1** below demonstrates triple rinsing.

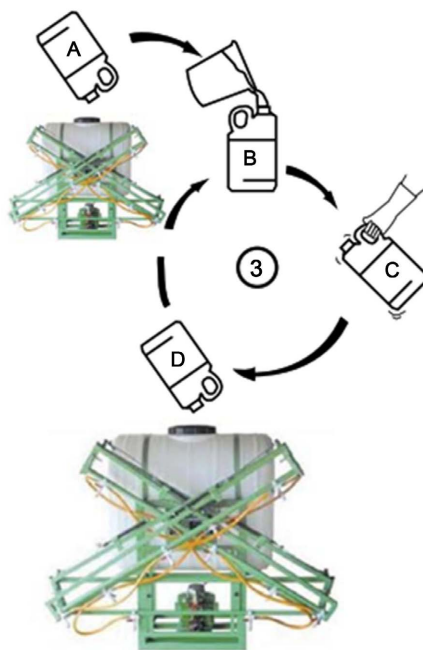


Figure 1. Triple rinsing procedure diagram.

Triple rinsing is a three-stage manual rinsing process. The empty container is 1/4 filled with clean water, the cap replaced and the container shaken, rotated, rolled and inverted vigorously for at least 30 seconds. The rinsate is then added to the spray tank, allowing the container to drain for at least 30 seconds after the flow has stopped. The rinsing procedure is then performed two more times before the container is allowed to completely dry. For containers that are too large to shake: Empty remaining contents into the application equipment or a mix tank, fill the container 1/4 full with clean water, replace and tighten bungs, tip the container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds, tip container over and repeat so the clean water gets into all corners. Drain the container for 30 seconds after the flow has stopped. Repeat 3 times. Ensure thread and bungs are thoroughly clean. Larger drums are usually recycled so their bungs should be reinserted after cleaning and drying. Cleaning a container by triple rinsing involves twice as many steps and takes about four times as long as pressure rinsing. However, it does not need any special equipment [16].

Disposing of the washing rinsates to non-cropped areas is a risky practice. From the standpoint of practicality and economy, rinsing with clean water in the field at the site of application seems to be the most preferred method of decontamination, since the rinsates can be added to the spray tank and further utilized or disposed of over wide areas (Braun *et al.*, 1983) [18]. Other methods of rinsate disposal such as flushing the tank in a barnyard or draining the “dilute” material in a convenient place are illegal and they present a threat to surface and ground water, as well as other parts of the environment. Dumping the empty containers by the field or throwing (Damalas *et al.* 2008) [3].

3. Comparative Analysis

First, serious worries exist about the open-burning method's effects on the ecosystem. Containers for burned pesticides can discharge poisonous gases and other pollutants into the air, causing air pollution and perhaps endangering people's health. On the other hand, the triple-rinsing technique concentrates on thoroughly cleaning containers, lowering the possibility of lingering pesticides contaminating the environment. As a result, triple rinsing is a more environmentally responsible choice. The second important factor to take into account is safety. Due to the chance of mishaps like fires and explosions, open burning can be dangerous. Furthermore, it puts people in danger of health by exposing them to harmful vapors. The triple rinse technique, in contrast, encourages safety by reducing exposure to dangerous compounds and safeguarding workers and the neighborhood (Coldwell *et al.*, 2020) [19].

Cost-effectiveness is still another crucial element. Since open burning involves little workforce and equipment, it may initially be a cost-effective option. However, it ignores the possible long-term costs associated with health effects and environmental harm. Triple rinsing is cost-effective in the long run because it reduces the need for remediation and health-related costs, although needing more water and cleaning supplies. Finally, regulatory compliance is quite essential while assessing these techniques. Due to the emission of pollutants and harmful materials, open burning breaches environmental restrictions. However, regulatory obligations, including those for waste management and pollution control, follow triple rinsing practices. The triple rinsing technique guarantees compliance and averts potential legal repercussions by following rules.

Regarding environmental impact, safety, cost-effectiveness, and regulatory compliance, triple rinsing outperforms open burning compared to managing empty pesticide containers that involve open burning. Open burning may appear economical initially, but it seriously affects the environment and people's health. On the other hand, the triple-rinsing approach supports environmental sustainability, places safety first, is cost-effective in the long run, and complies with legal requirements (Patel *et al.*, 2021) [20]. It is advised to follow the triple rinse procedure for empty pesticide container management to reduce adverse effects and provide a more sustainable approach.

4. Best Practices and Recommendations

Effective pesticide container management is essential to reduce the adverse effects on the environment and assure safety. The triple rinsing approach is a better practice when compared to the open burning method. Triple rinse minimizes leftover pesticide concentration by properly rinsing the containers three times with water. This approach is preferable since it complies with local laws in many countries and is more environmentally friendly. It also permits recycling containers constructed of appropriate materials, such as plastic or glass. By adopting this strategy, pesticide users can reduce the possibility of contamination, en-

courage recycling, and guarantee adherence to local laws regarding responsible pesticide container management (Li *et al.*, 2021) [21].

5. Conclusion

The comparative study of the Triple Rinsing Method and the Open Burning Method for empty pesticide container management concludes by emphasizing the need to adopt proper disposal procedures. Despite being practical, the open-burning method has serious adverse effects on the environment and human health since it releases toxic compounds and pollutes the air. The Triple Rinsing Method, on the other hand, which entails rinsing the containers more than thrice, turns out to be a safer and more environmentally friendly choice (Oyedele *et al.*, 2021) [22]. It successfully eliminates pesticide residues, lowering the risk of soil, water, and wildlife pollution. By highlighting the need to implement suitable practices like the Triple Rinsing Method, we can ensure that empty pesticide containers are disposed of properly, limiting environmental impact and safeguarding human health.

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Conflicts of Interest

The author declares no conflicts of interest.

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