DISPOSAL OF USED FUMIGANT CONTAINERS IN ZAMBIA

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ABSTRACT

Fumigation involves the use of a highly toxic pesticide known as a fumigant, to kill target organisms under airtight conditions. After fumigation, the residual containers left are classified as hazardous wastes. Such wastes enter our environment owing to improper disposal of the containers and poses a huge threat to public health and the environment. This study assessed the methods of disposal of fumigant containers practiced in Zambia and the extent to which fumigators comply with Zambian environmental regulations.

Both qualitative and quantitative data collection approaches were used and purposive sampling helped in establishing the fumigant package disposal sites. Data was collected from 15 districts along the line of rail, from Livingstone to Chingola. Participants constituted 25 fumigators and 50 assistants conducting fumigation in the 15 districts. Data from 25 questionnaires distributed to the fumigators was analyzed using the Statistical Package for Social Science (SPSS) version 20 alongside Excel 2010.

The findings revealed that 68 % always buried the fumigant containers in a 1-meter-deep pit. However, through observations, 17 fumigators from the 15 districts disposed the containers on open surfaces despite being aware of the environmental regulations. On the other hand, the Zambia Environmental Management Agency visited only 48 % of fumigators' premises. Only 21 % of fumigators were compliant with the law in their disposal methods while the remaining 79 % were non-compliant. Though fumigators were trained before engaging in fumigation activities, they took little useful action for safe disposal of fumigant containers. Findings in this study require immediate enactment laws that will help abolish unsafe disposal of fumigant containers in Zambia. Further, trained fumigators and not their assistants should conduct disposal of fumigant containers. The Zambia Environmental Management Agency should intensify their inspections combined with law enforcement and standard fumigant disposal protocols must be devised and made available to the fumigators.

Key Words: Disposal, Fumigant, Containers.

INTRODUCTION

Maize is a staple food in Zambia (JICAF, 2008) and as such, protection against storage pests is critical. It is the major crop stored by the Zambian Government through the Food Reserve Agency (FRA) for the strategic national reserve. In 2007, FRA purchased about 396, 000 tons of maize (JICAF, 2008). Maize grain is stored in concrete silos and storage sheds in bags. The main method used to control storage pests is fumigation.

The Zambia Agriculture Research Institute (2012) defines fumigation as the use of a lethal gas to kill pests in an airtight environment. Fumigation involves the use of a broad-spectrum pesticide known as a fumigant, which is a chemically simple molecule that exerts potent and wide-ranging effects on the target organisms (Knowles, 2005). Knowles, (2005) further highlights that fumigants diffuse as separate molecules, which empowers them to pierce through the material being fumigated. Good fumigants must be highly toxic as to serve their intended purpose of killing pests. The most common fumigant currently in use is Aluminium phosphide, which produces highly toxic and flammable phosphine gas upon reacting with water or moisture in the air.

According to Nthenga (2015), the public has been increasingly concerned about the adverse effects of pesticides on human health and the environment. This has resulted in favoring methods that can rid the use of these materials. Nevertheless, the need for chemical pesticides, particularly fumigants, is likely to continue for many years to come because fumigants have unique capabilities that permit use in numerous situations where other forms of control are not feasible or practical (Food and Agriculture Organization (FAO), 2008). Thus, fumigants will continue being, with the consequent increase in fumigant residues. These fumigant residues are hazardous wastes that require safe disposal methods to avoid polluting or damaging the environment.

Apart from the aforementioned, the New Jersey Department of Health & Senior Services (2005) stated that Aluminium phosphide can affect humans when inhaled, can irritate the skin

and eyes when contact occurs, can irritate the nose, throat, lungs causing coughing or breathlessness and long term exposure can damage the lungs, liver and kidneys. Water contaminated with Aluminium phosphide also affects aquatic life even killing it, while creating a problem for people or children who are exposed to it. However, like many other developing countries, Zambia is faced with the issue of safe disposal of Aluminium phosphide (Nthenga 2015).

The need for any person to work in agreement with the state in ensuring the country has a clean, safe and healthy environment is provided for in the Zambian laws (Environmental Management Act, 2011). Further, Environmental Management (Licensing) Regulations provide the available disposal options for pesticides, their residues and wastes from toxic substances (*Environmental Management Licensing Regulations 2013* (SI 2013/ 112). The question is how relevant are the disposal options provided to the fumigators? To answer this question, this study sought to uncover how the legalized fumigators were disposing the fumigant containers with the residual powder and whether their methods of disposal complied with the environmental regulations.

MATERIALS AND METHODS

The study adopted a mixed methods approach in which both qualitative and quantitative data was collected using primary and secondary sources of data collection. Primary data collection methods considered included face to face personal interviews, non-participant observations, admission of structured questionnaires and laboratory assessments. Due to financial restrictions, purposive sampling was adopted for interviews, questionnaire distribution and checking of disposal sites of fumigant containers in fifteen (15) districts lying along the line of rail, running from Livingstone to Chingola (Figure 1). Twenty-five (25) fumigators and Fifty (50) assistants participated in the study. Data collected through questionnaires were analyzed using the *Statistical Package for Social Science (SPSS)* version 20 (SPSS) alongside Excel 2010.

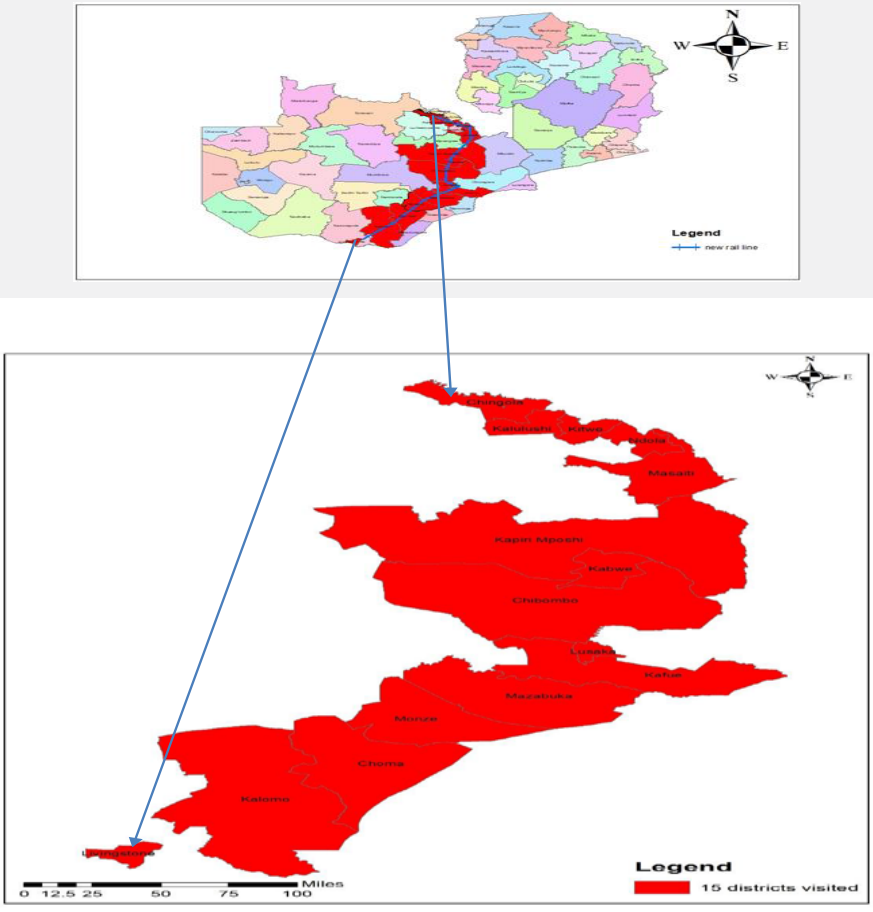

Figure 1: Study area showing the region of the line of rail and the 15 districts visited

RESULTS

In using questionnaires, the key information obtained was on the methods of disposal of the fumigant containers and their residues and the level of ccompliance of fumigators with regulatory bodies.

The study reviewed that only 32 % of the 25 fumigators visited were personally responsible for disposing of the fumigant containers after fumigation. However, 64 % left the responsibility to their assistants while 4 % allowed other people to do the disposal on their behalf (Table 1).

Table 1: Those responsible for disposal of fumigant residues

	Frequency	Percent (%)
Fumigator him/herself	8	32
Support personnel to fumigator	16	64
Others specify	1	4
Total	25	100

As shown in Table 1, more than half of the fumigators (64 %) left the process of disposal of fumigant residues to their assistants and only 32% of the fumigators indicated that they either participate or were present during the process of the disposal of fumigant containers and residues. One of the common methods of getting rid of the fumigant containers with their residues is the open area including rubbish pit. As shown in Table 2, 76 % of the fumigators were involved in throwing the fumigant containers in open air or rubbish pits while the remaining 24 % rarely used the recommended methods of disposal.

Table 2: Those that throw the residues in an open area or rubbish pit

	Frequency	Percent (%)
Always	19	76
Often	6	24
Total	25	100

The results of the questionnaire survey also showed that only one fumigator representing 4 % of the total fumigators, returned fumigant containers for recycling (Table 3).

Table 3: Those that returned empty containers for recycling

	No. of Fumigators	Percent (%)
Always	1	4
Often	6	24
Never	18	72
Total	25	100

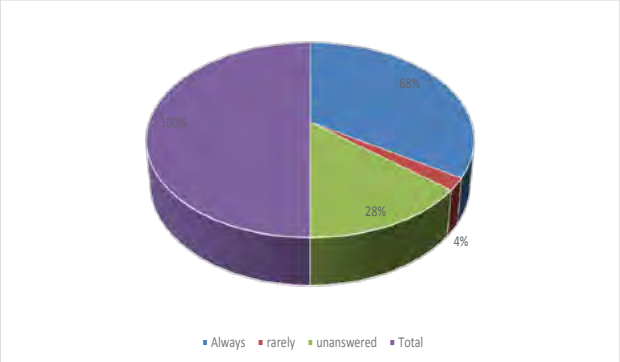

Figure 2: Those that buried in a 1m dip pit

Triple rinsing empty containers is necessary because it reduces the toxicity of any residual powder that may remain inside the container. The process can allow for residues to be classified as non- hazardous wastes thus reducing the potential hazard it creates for human health and the environment. Triple rinsing also does not require any complicated mechanism. Fumigators who triple rinsed empty fumigant containers before disposal accounted for 16.7 % and those that did not triple rinse empty containers accounted for 83.3 % as shown in Figure 3.

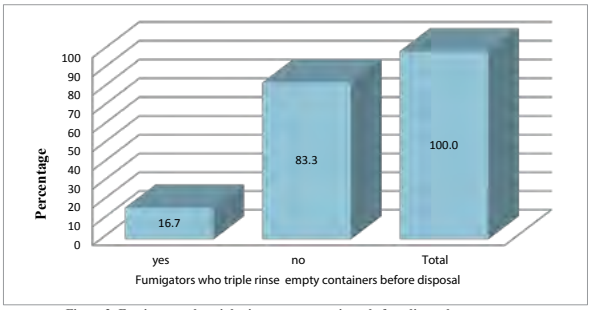

Figure 3: Fumigators who triple rinse empty containers before disposal

For fumigators to responsibly dispose of the fumigant containers and the residues, the role of regulators is vital. This study used the number of ZEMA's inspection of fumigators and the punitive measures it gives for non-compliance as a way of understanding the regulator's effectiveness in this regard. For inspections, 52 % of fumigators

indicated that they have never been inspected by ZEMA while 28 % acknowledged being rarely inspected and 20 % have only been inspected once (Figure 4). On the other hand, fumigators indicated that they have never been penalised nor did they have knowledge of anyone having been penalised.

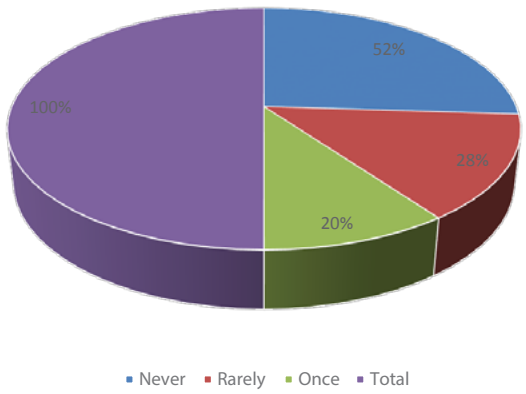

Figure 4: How many times ZEMA conducted inspections per year

Apart from the failure by the regulator to enforce the law and regulations, fumigators also had reasons which they thought made them not comply with regulations on the disposal of fumigant containers. As shown in Figure 5, the majority of the fumigators did not comply with regulations on disposal methods due to either negligence or incompetent personnel used in the fumigation process. The two reasons accounted for 41.7 % and 29.2 % respectively, making a total of 70.9 %. Fumigators who felt the recommended methods of disposal were difficult to follow accounted for 8.3 % while 20.8 % felt both use of incompetent personnel and negligence contributed to non-compliance and 0.03 % of the fumigators were not sure.

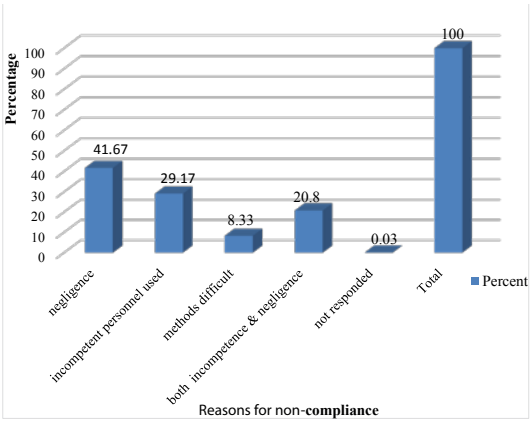

Figure 5: Why Fumigators do not comply with regulations on disposal

Using observation, the conditions under which disposal of fumigation pesticide containers with their residues were conducted, were noted as shown in Figures 6, 7 and 8. Figure a and b indicate that some fumigators disposed of the fumigant containers at dumpsites. Such dumpsites are not legally prescribed by the regulatory authorities but are as a result of the fumigator's initiative. Some fumigators did follow the regulation of puncturing the empty containers before disposal. However, some after puncturing handed over the empty containers to businessmen that in turn sell them to scrap metal dealers. However, some containers (tins) were disposed of on open surfaces without even puncturing (Figure 7 (a)) and domestic rubbish pits (Figure 7 (b)).

Figure 6: Dumpsite for fumigant containers (a) and crushed containers for disposal (b)

Figure 7: Disposal of containers in open area (a) and freshly buried rubbish pit used for disposal of empty containers (b)

In some cases, fumigators disposed of empty containers in rubbish pits just near homes. Figure 7b shows one such site which the assistants to fumigators buried upon realizing that the researcher was collecting data on disposal of fumigation pesticide residues. Observations also revealed that fumigators disposed of pesticide residues by burying them in bushes away from human habitation as shown in Figure 8.

Figure 8: Bush fumigant containers burial site - new (a) and old (b)

DISCUSSION

Those responsible for disposal of fumigant residues

From table 1, more than half of the fumigators, left the process of disposal of fumigant residues to their assistants. Such assistants were not trained by relevant institutions to carry out fumigation and may have lacked knowledge on the importance of safe disposal, leading to mal-practice in disposal methods practiced. Assistants may lack the urge to manage and use fumigant residues in a safe, legal and responsible way, including the returning of the empty containers for appropriate recycling or disposal. This explains why disposal of empty pesticide containers can be done even on open surfaces without rinsing them. The unavailability of fumigators during disposal can be attributed to the fact that, one fumigator may be responsible for fumigation in a number of districts. As such, being a business man, his main concern is having a successful fumigation conducted, because that is where his payment comes from, unlike what happens after fumigation has been conducted. This indicates that fumigators leave the fumigation site immediately after the fumigation process begins and would not return after the seven days of the fumigation process have elapsed.

However, fumigators, as employers of these assistants have the responsibility to train them on proper handling of fumigants and disposal

of residues. This is important because the risks with handling such hazardous wastes would be appreciated resulting in compliance with regulations. Fumigators should thus ensure that every one of their employees' is made aware of the risks associated with poor disposal of fumigant containers and their residues (WHO, 2011).

Those that throw the residues in an open area or rubbish pit

Results in Table 2 show that open fields saved as an option for disposal. This is possibly because such fields were readily available and could be found near the fumigation sites. As such, fumigators found it easier to simply throw the residues in such places, thus contaminating the environment.

The Environmental Management Act does not provide for disposing hazardous wastes in open areas or fields. Any such disposal of fumigant residues is thus illegal and calls for penalty charges by ZEMA. Disposal in open fields contaminates the environment thus putting humans at a risk of being exposed to Aluminium phosphide. Since the residues are exposed on the surface, it is easy for people to come in direct contact with them. The study found that some people picked the empty containers and re-used them for domestic purposes such as drinking water. This exposed humans to fumigant residues through pathways such as inhalation and ingestion. Unfortunately, children are susceptible to ingestion and direct skin contact because in their daily activities, they have a tendency to have frequent hand- to -mouth contact and introduce non -food items into their mouth. Soil, sediments or dust can also act as agents for human exposure to fumigant residues disposed of in open fields if one accidentally ingests it or have direct skin contact.

Since all fumigators undergo training on good fumigation practices, including recommended disposal methods, this indicates that mal-practice in disposal of fumigant residues occurs even when fumigators have the full knowledge of what is right. The reason behind could be that fumigators deliberately do not want to follow stipulated regulations on disposal.

Those that returned empty containers for recycling

A very environmentally friendly way of handling the fumigant containers is by returning them to the manufacturers for recycling. Recycling can greatly reduce the amount of material to be disposed of, if many fumigators practiced it. Moreover, in this practice, there is no loss of the raw material and it is a highly recommended option over the options where the material is destroyed or unavailable for use. Unfortunately, it requires that the fumigator plans an efficient schedule for return and put in place cost measures for the same. This explains the reason why only one fumigator had adopted this method of disposal.

Those that buried in a 1m dip pit

Burying of the containers at 1m deep is said to prevent them from being washed away to contaminate other important natural resources (Graver et al. 2000). The Environmental Management Act (2011) recommends burying after triple rinsing has been done. However, FAO (2008) recommended that burial of fumigant packaging be prohibited even though rinsing had been done. This can be supported because burying possibly uses up land that is so scarce and the empty containers can remain buried indefinitely since they are made of material that is not easily biodegradable.

How many times ZEMA conducted inspections per year

The Environmental Management Act (2011) governs the disposal of fumigation pesticide residues in Zambia in order to protect or improve the quality of the environment. It has stipulated five methods that fumigators can adopt as their disposal options. These are incineration; inertisation; encapsulation; recycling and triple rinsing. The FAO (n.d.) showed that governments have the responsibility to safeguard the environment by making sure that there is proper treatment and safe disposal of hazardous wastes such as fumigant residues. Government should ensure that any disposal of fumigation pesticide residues is carried out in line with national and regional regulations, relevant international

standards and Multi-national environmental agreements such as the Basel convention.

ZEMA may lack the capacity to carry out regular checks to ensure compliance, either due to a lack of seriousness to enforce the law, shortage of expertise or due to financial constraints. As such, it failed to penalise any fumigators in order to enforce the laws related to disposal of fumigation pesticide residues in Zambia. With fumigators being left unpunished for any unsafe disposal conducted, the trend is bound to continue, thus increasing on the number of residues posing a great danger to the environment.

Why Fumigators did not comply with regulations on disposal

The results in Figure 5 indicate that fumigators agreed to either having incompetent personnel in fumigation activities or just being negligent as regards following regulations on disposal of fumigant residues. The fumigators together with their assistants may simply have been careless, not being interested in following regulations. This may be because the training provided to the assistants by the fumigators, may not be sufficient to help them realise the dangers behind unsafe disposal. It can be concluded that the recommended methods were not difficult to follow because only a minority felt they were difficult. ZEMA failed to penalise any fumigators in order to enforce the laws related to disposal of fumigation pesticide residues in Zambia.

CONCLUSION

Disposal of fumigant containers and the residues has emerged as an important human and environment health that both fumigators and the public may actually be exposed to. The Zambian fumigators were well trained by the Zambia Agriculture Research Institute in collaboration with the Zambia Environmental Management Agency to carry out safe disposal of fumigant related residues but they failed to make use of the knowledge acquired. Instead, disposal was mostly left to their assistants who due to lack of training, saw no need for safe disposal.

Most fumigators did not comply with recommended disposal options because of the use of assistants who were incompetent to carryout fumigation and also due to negligence by fumigation personnel. Apart from that, there was no central disposal system where fumigators could take their wastes for collection. So the closest that came to their mind was burial. Meanwhile, the containers disposed though punctured were usually not triple rinsed leaving them under the class of hazardous waste.

The trend in disposal of fumigation pesticide residues is likely to continue because ZEMA rarely carries out inspections to determine whether fumigators complied with regulations on disposal of fumigant containers and residues. Further, no known fumigator had ever been penalised for non-compliance.

Findings in this study require immediate enactment laws that will help abolish unsafe disposal of fumigant containers in Zambia. Disposal of fumigation pesticide residues should always be conducted in the presence of trained fumigators. Further, regulating against burial of all containers should be done, with the Extended Producer Responsibility (EPR), which allows fumigators to take empty pesticide containers to the agro dealers who should in turn take them back to the manufacturers, being promoted and prioritised by ZARI and ZEMA. The Zambia Environmental Management Agency should intensify their inspections combined with law enforcement and standard fumigant disposal protocols must be devised and made available to the fumigators.

REFERENCES

FAO. (2008). *International Code of Conduct on the Distribution and Use of Pesticides.* Guidelines on Management Options for Empty Pesticide Containers. FAO, Rome, Italy.

FAO. (ND). *Manual of Fumigation for Insect Control*. FAO, Rome, Italy. Retrieved from www.fao.org. Retrieved on 23/11/2018

Graver J.V. and Whittle C.P (2000). *Phosphine Residues Remaining in Aluminium Phosphide Preparations after Burial.* CSIRO Division of Entomology, Stored Grain Research Laboratory, Canberra ACT 2601, Australia.

JICAF, (2008). *Introduction, 2nd and 3rd chapter, and Conclusion from original book of "The Maize in Zambia and Malawi*. Association

for International Collaboration of Agriculture and Forestry. Akasaka, JAPAN. Retrieved from: http://www.jaicaf.or.jp. Retrieved on 13/11/2016

Knowles D.A. (2005). *New Developments in Crop Protection Product Formulation*. PJB Publications. UK.

New Jersey Department of Health and Senior Services (2005). *Hazardous Substance Fact Sheet on Aluminium Phosphide.* 20859-73-8

Nthenga I., (2015). *Analysis of policy on the management of agricultural pesticide use in Zambia*. Thesis Report (unpublished).

The Environmental Management Act No. 12 of 2011. Government Printers. Lusaka Zambia.

The Environmental Management Licensing Regulations, 2013. (Statutory Instrument No. 112 of 2013). Lusaka. Government Printers.

World Health Organisation (WHO (2011). *Waste from health-care activities*. Fact sheet N°253 of November 2011.

Zambia Agriculture Research Institute (2012). *Fumigation Manual*. (unpublished)