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ENVIRONMENTAL CONTAMINATION RISKS ASSOCIATED WITH PESTICIDES EMPTY CONTAINERS AND OBSOLETE PESTICIDES HANDLING IN GASABO DISTRICT

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ABSTRACT:
The study was about environmental contamination risks associated with pesticides empty containers and obsolete pesticides handling in Gasabo District. The specific objectives were to make the analysis of the pesticide's empty containers and obsolete pesticides management in Gasabo District; to examine environmental contamination risks affecting Gasabo District; and to evaluate relationship between pesticides empty containers and obsolete pesticides management and environmental contamination risks in Gasabo District. The study applied quantitative approach, where target population was 162 people in environmental management and protection, and Agro-dealers from Gasabo District. The stratified and simple random sampling techniques were applied to select 115 respondents as sample size. The questionnaire; interview guide; and document review were instruments of data collection, while data analysis methods were descriptive statistics method and correlation analysis methods. Findings revealed that p-value equaled 0.043 less than Alpha of 0.05. This is an indicator of existing association or relationship between pesticides empty containers and obsolete pesticides handling and Environmental contamination risks in Gasabo District, where the level of relationship equals $r^2 = .590^{**}$ located in interval statistic of Pearson legend from [.50 - .75] categorized as positive and high correlation. Therefore, there is a significant relationship between Environmental contamination risks and Pesticides empty containers and obsolete pesticides handling in Gasabo District.
Key words: *environmental; contamination risks; pesticides; empty containers; obsolete pesticides*

INTRODUCTION:

Despite all the guidelines and recommendations, attention to the problems associated with empty packaging has not been adequate, especially in developing countries of EAC regional; the pesticide regulators, advisers, distributors and end users urgently have unclear advice on how to minimize the accumulation of pesticide-related waste and how best to deal with any waste that is generated in most of the countries in regional. Guidance is often unclear, wrong in too many cases, and completely lacking. Advice in particular, on ways in which pesticide end users can safely dispose of empty pesticide containers and unwanted or obsolete pesticides are all unclear and unimplemented. The safe management and disposal of pesticide-related waste are not provided and coordinated by regulatory authorities, pesticide distributors and suppliers (Ibitayo O., 2006).

Developing countries represent 25% of global pesticide use, but account for 50% of pesticide poisoning, and over 70% of pesticide related fatalities. 70% are substandard pesticides (produced by non-members of crop life), with 100,000 tons of obsolete pesticides. Pesticides used in developing countries are often more toxic and contaminated that those in OECD countries. The use and economic value of pesticides empty containers in developing countries often leads to theft, sale and illegal trafficking. One has to put this in the local context in Mozambique one large drum costs USD 50, which is approximately one month's wage for a farm worker. Used pesticide containers are often smuggled illegally across the border for sale (Alexandre R., 2015). Typical problems include; i) incorrect storage of pesticide products (inside the home next to a sleeping baby, under the house where children and livestock have easy access), ii) use of pesticides empty containers for water and food storage (e.g., an empty pesticide container being used to draw water from a well), and iii) inappropriate disposal (e.g., burning or burying obsolete pesticides and containers in open field or a shallow pit) (African Farming and Food Processing, 2013).

In Rwanda, pest pressure is among the main threats to crop production in Rwanda while one way to increase food availability is to improve the management of pests. There are estimated to be around 67,000 different crop pest species including plant pathogens, weeds, invertebrates and some vertebrate species and together they cause about a 40 per cent reduction in the world's crop yield (Nkurunziza M., 2015). One of the ultimate objectives of the Government of Rwanda is to keep food security on track. Crop yield losses to pests undermine its targets for food security, which is the case of for example, maize lethal necrosis disease (Adams et al., 2014) and cassava brown streak virus (Ntawuruhunga and Legg, 2007). Similarly, other constraints such as inclement weather, poor soils and farmers' limited access to technical knowledge present a threat to crop production (Speranza *et al.*, 2008).

The use synthetic pesticides in Rwanda seems to be at both extremes. Some farmers do not apply pesticides to protect crops (e.g.: small scale farmers in subsistence food crops production) while few farmers that produce cash crops (e.g.: coffee, potato, fruits and vegetables) rely most on synthetic pesticides for crop protection (Rukazambuga Ntirushwa Daniel., 2013). Poor management of agricultural inputs (e.g., pesticides, herbicides and fertilizers) causes soil degradation and water pollution, decreasing agricultural productivity and reducing resilience to future environmental shocks (MINIRENA, 2013). The challenge is the limited availability of plant protection products and the lack of alternative solutions such as biological control products in link with current regulations that restrict or ban the use of highly toxic pesticides for the protection of the environment and compliance to international agreements on the use of pesticides (MINIRENA, 2013).

PROBLEM STATEMENT:

Wherever pesticides are used, pesticides empty containers are generated. Obviously, no country can eliminate the problem of used pesticide containers in a single, or even a series, of disposal operations. It's an ongoing problem; one that poses a serious threat to the environment and public health. The empty pesticide containers are highly valued property. Even though it is usually impossible to remove all traces of toxic chemicals from pesticide containers, people often use them for storing fuel or even food and water (Karangwa A., *et al*., 2012). When measures are taken to dispose of containers, often they are not appropriate. For example, many pesticide suppliers and national authorities recommend the burying or burning of waste pesticides empty containers. But buried chemical waste can contaminate soil and groundwater, while burning pesticides and containers releases highly toxic fumes. Often pesticides, pesticides empty containers and contaminated materials are dumped in landfills or other general waste collection sites (FAO, 2018). Most of the sites aren't designed to prevent toxic materials from leaking into the ground or being washed out by rain into water bodies (FAO, 2018).

Mismanagement of pesticides empty containers of pesticides in Rwanda especially in Gasabo District, has posed a risk to the environment and the health of people in those areas in previous years ago, due to that issues Government has promoted of the adaption the policies and guidelines to mitigate such problems. Despite the guidelines elaborated by Government to control pesticides empty containers of pesticides in Rwanda and environmental protection, the attention to the existing problem is still inadequate in some areas. The study was undertaken for evaluating the causes of accumulation of obsolete and unwanted pesticides in Gasabo District; how was environmental contamination risks affecting Gasabo District; the roles of national and local authorities for pesticides empty containers and obsolete pesticides management in Gasabo District and lastly, how pesticides empty containers and obsolete pesticides management can influence environmental contamination risks in Gasabo District.

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RESEARCH OBJECTIVES:

General objective was to assess the environmental contamination risks associated with pesticides empty containers and obsolete pesticides handling in Gasabo District. This study had the specific objectives:

[1] To analyze the pesticides empty containers and obsolete pesticides management in Gasabo District
[2] To examine the environmental contamination risks affecting Gasabo District
[3] To evaluate relationship between environmental contamination risks and pesticides empty containers and obsolete pesticides management in Gasabo District

RESEARCH QUESTIONS:

1) What are the pesticides empty containers and obsolete pesticides management in Gasabo District?
2) What are the environmental contamination risks affecting Gasabo District?
3) What is the relationship between environmental contamination risks and pesticides empty containers and obsolete pesticides management in Gasabo District?

CONCEPTUAL FRAMEWORK MODEL:

In respect of this study, the designed conceptual framework presents two categories of variables including pesticides empty containers and obsolete pesticides handling which is independent variables, and environmental contamination risks is as dependent variable.

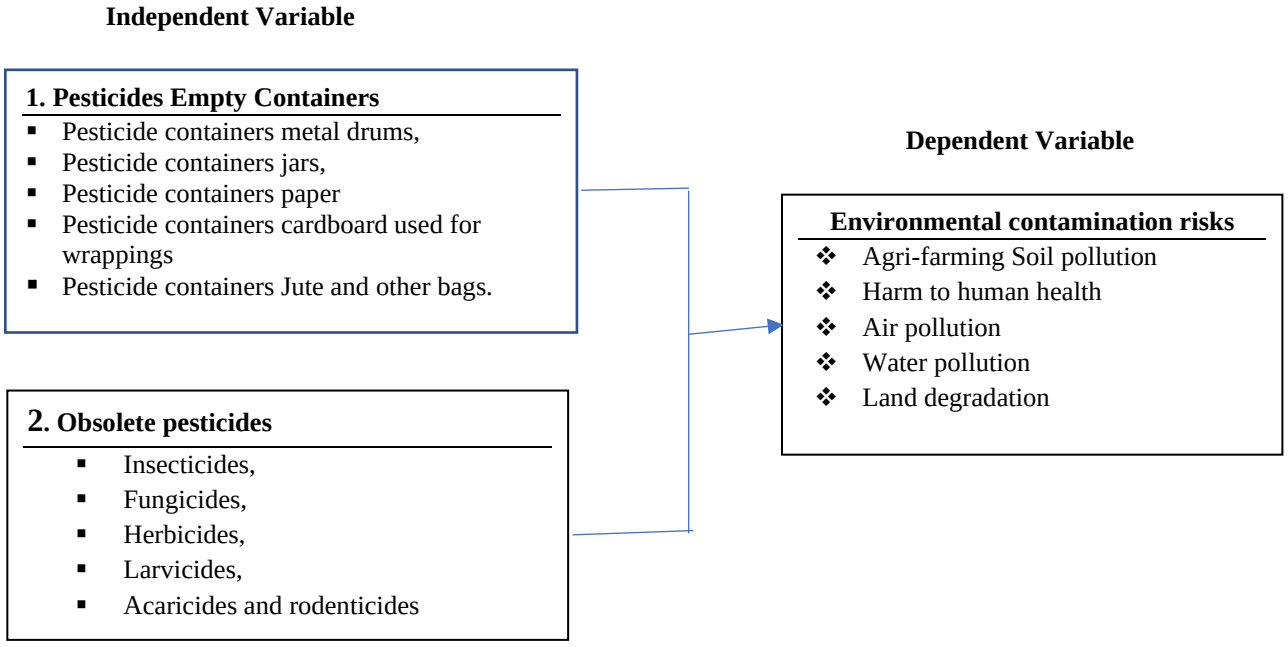

Figure 1: Conceptual Framework

Source: *Researcher Conceptualization (2023)*

LITERATURE REVIEW

a. Causes of accumulation of obsolete and unwanted pesticides

Obsolete pesticides are defined as stocked pesticides that can no longer be used for their original purpose or any other purpose and therefore require disposal (Kennedy, 2018). Common causes of this situation include the following the product has been withdrawn for health or environmental reasons; the product has deteriorated as a result of improper or prolonged storage and can no longer be used according to its label specifications and use instructions,

nor can it easily be reformulated to become usable again; the product is not suitable for its original use and cannot be used for another purpose, nor can it easily be modified to become usable (Kennedy, 2018).

A product has deteriorated when it has undergone chemical and/or physical changes that result in phytotoxic effects on the target crop, or an unacceptable hazard to human health or the environment; the product has undergone an unacceptable loss of biological efficacy because of degradation of its active ingredient and/or other chemical or physical changes; its physical properties have changed to such an extent that it can no longer be applied with standard or stipulated application equipment; damaged containers have leaked, exposing products; products are no longer needed for their intended use; too much of a product has been supplied and it cannot all be used; materials have been contaminated by spilled pesticides; and pesticides empty containers need to be disposed (Kerle E. and Vogue, 2017).

Obsolete pesticides are also correctly referred to as pesticide waste. Another term used is unwanted pesticides, a broader definition than obsolete pesticides. Although there is no immediate use for these products, they may still be in good condition and may be potentially usable without compromising environmental or occupational safety (Krauskopf, M.D. 2017). Such products should not be regarded as obsolete so long as it has not been established that there are no solutions to the impediments hindering their use (such as more effective distribution, repackaging, procurement of different application equipment or reformulation of the product to make it usable with available application equipment, or alternative use). Therefore, unwanted pesticides are not necessarily obsolete (Krauskopf, M.D. 2007).

Banning of Products: According to Kathiresan A. (2010) in many countries, where a range of products has been banned or withdrawn for health or environmental reasons, the fate of existing stocks in the country is often given scare consideration. Stocks remain where they are stored and eventually deteriorate. This particularly applies to organ chlorine compounds that are part of strategic stocks for locust control.

Insufficient storage capacity for pesticides: According to (Kevin Chen, 2010) Government authority responsible for national pesticide stocks often does not have sufficient storage capacity to store all its pesticides safely. Many stores are poorly constructed, have insufficient ventilation, are too hot and/or do not have concrete floors. Because of space constraints, pesticides are often not properly stacked, thereby reducing access to products and making it difficult to monitor the condition of containers.

Staff not trained in stock management: Storekeepers of major stores and those responsible for national stocks are often not familiar with the rules for good stock management (proper stacking, product segregation, principle of "first in-first out", etc.). Leakage and spills may not be cleaned up immediately because staff have not been trained how to handle them, or because the necessary materials and protective gear are not available. Contamination and improper stacking may affect the condition of other products and may impede a consistent application of the principle of "first in, first out" (Kevin Chen, 2010).

Inappropriate handling during transport: Krauskopf, (2007) argued that drums and other packaging materials are often damaged through rough handling or in transport. When drums are battered, their inner and outer coatings may be damaged, which accelerate corrosion and shorten their life. Unnecessarily long periods of exposure to direct sun during transit is another important factor that affects both the container and its contents.

Unavailability of analytical facilities: Because laboratory facilities for pesticide quality control are not available in most developing countries, it may be difficult to determine whether a pesticide may still be used after its indicated shelf-life has expired. Inadequate labelling and the absence of a date of manufacture/release on labels or on the container may complicate the matter. For this reason, there is often an understandable tendency to deviate from the principle of "first in-first out" and to use a newer product to be certain of its effectiveness; this practice leads to prolonged storage of older products (Kerle E. and Vogue, 2017).

Inappropriate active ingredient or formulation: Examples of cases where products have been considered unsuitable include the active ingredient of a donated product was not evaluated in the recipient country and field trials were required before it could be approved for use. This took time and the product started to deteriorate. The product was not effective against the target pest or against the weed it was supposed to destroy; or it had unacceptable side-effects (e.g. it appeared to have phytotoxic effects on the crop itself).

Impractical package size or poor container quality: According to (Landis, Wratten, and Gurr 2010) bulk quantities of pesticides are commonly supplied in 200-litre metal drums. For countries without good repackaging facilities this may create problems if the pesticides are intended for use by plant protection staff, extension staff or small-scale farmers. In order to transfer the contents of large drums into smaller packages, large quantities of small empty containers, a pump, labels, etc. are needed (Landis, Wratten and Gurr 2010).

Missing or incomplete labels: The pesticides are not used because the potential user does not know the specifications of the product, or how to apply it, since labels are missing or incomplete, are illegible (as a result of rain, sunlight, leakage), or are in a language alien to the user (Landis, Wratten and Gurr 2010).

Insufficient communication between aid agency and recipient country: In several cases, the quantity, active ingredient, formulation or packaging of donated pesticides are inappropriate for the intended use. Such mistakes occur because of a lack of detailed specifications in requests for pesticide donations and/or a lack of background information and justification. On their part, aid agencies often make insufficient efforts to obtain such information before processing requests for pesticide donations (Muthumeenakshi, et al., 2017).

Fraudulent practices of unreliable suppliers: Miono DW., (2014) stated that fraudulent practices of unreliable suppliers are also known of consignments that have not been used because the product had been adulterated by an unreliable supplier in order to increase profits and was no longer suitable for the intended purpose.

b. ***Hazards connected to obsolete Pesticide***

Leaking drums and torn bags can seriously affect the occupational health of staff working at the storage site and of others who happen to come in contact with the pesticides. They often pose a broader general danger to public health and the environment (Lohr Park, 2012).

Factors determining the level of hazard include the quantity of pesticides, the condition of containers and packaging and the degree of leakage; the place of storage (inside or outside a store) and the floor material of the storage site (degree of impermeability); the toxicity of the products; the behavior of the product in the environment (persistence, mobility in soil, solubility in water, volatility); the location of the storage site (some are located in or near urban areas); the groundwater level and proximity of the storage site to water bodies (some stores are located on irrigation schemes, near rivers or in ports) (Lohr Park, 2012).

Contamination of groundwater or soil can occur through seepage of leaked pesticides into the ground or runoff during heavy rains. Poisoning of people or animals can occur through direct contact with the product, inhalation of vapors, drinking of contaminated water, or eating of contaminated food (Miono DW., 2014). Other hazards include fire hazard; several examples are known of pesticide stores that have caught fire as a result of poor maintenance of stores and/or stocks.

The environmental contamination caused by fires can be widespread; unauthorized use of pesticides. The obsolete stocks gradually decreased as a result of pilfering. Unauthorized or inappropriate use of pesticides is a notable cause of accidents or contamination; improvised disposal. In several cases pesticides have been disposed of by burying or open burning, which may cause severe environmental contamination (Miono DW., 2014).

c. Ten rules for proper pesticide storage and stock management

Muthumeenakshi, *et al.,* (2017) argued the principles for storage management should be adhered to in order to keep pesticide stocks in good condition and to enable staff to take appropriate action in the event of leakage or other emergencies.

1. Pesticide stores should not be located in or near densely populated urban areas, or near water bodies.
2. The storage capacity (total storage surface) should be sufficient to store the total stock of pesticides at any time.
3. Each store should have at least the following basic provisions:
    - Sufficient ventilation to avoid unnecessarily high temperatures.
    - Floors made of, or covered by, impermeable concrete or cement. (As a temporary measure, floors may be covered by a large thick polythene sheet.)
    - Ramps at entrances to contain any major leakage within the store.
    - Doors that are lockable and have danger signs, bars across ventilation holes and windows to prevent unauthorized entry.
4. The floor of the store should have a layout of separate blocks with aisles between them. The outline of these blocks should ideally be marked with paint on the floor. Each block should contain only one product. There should be sufficient space between blocks to move containers freely, enable inspection of containers and treat leakage. Drums should be stacked in such a way that each individual drum can be inspected from the aisles between the blocks (Mwanauta, and Ndakidemi, 2015).

5. Pesticide stores should only contain pesticides. All other goods or objects should be removed.
6. Obsolete pesticides should be segregated from operational stocks.
7. Each store should have the following materials and equipment to deal with emergencies:
    - A few bags of sawdust and/or sand to absorb leaked or spilled pesticides.
    - A number of empty drums (preferably salvage drums that can contain a whole 200-litre drum) to repackage heavily damaged or leaking containers.
    - Empty polythene bags to repackage damaged sacks or other materials.
    - Shovel and brush.
    - Fire extinguisher.
    - Protective clothing for staff to enable them to deal with emergencies (nitrile or neoprene gloves, rubber boots, overalls, goggles, vapour masks or half-face respirators with organic vapour cartridges).
    - Tap, or container with water, to wash hands and face in the case of contamination.
8. The contents of leaking or heavily damaged containers should be repackaged in appropriate containers. Repackaged pesticides should be relabeled immediately. Stores should be inspected regularly. Any leakage or contamination should be cleaned up immediately.
9. Storekeepers should keep a record of stocks in their custody. The authority concerned should keep a central record of all stocks kept in the country. Recorded data should include i) incoming pesticides arrival date, formulation, quantity, unit size, date of manufacture/factory release, supplier, origin; ii) outgoing pesticides date, formulation, quantity, unit size, destination. Records should be updated regularly.
10. The principle of first in-first out should be applied consistently. In other words, old consignments should always be finished before using newly arrived consignments (Mwanauta, and Ndakidemi, 2015).

d. **Environmental contamination risks**

The improper management of wastes generated in health care facilities severely affect the health of caregivers, patients and individual members of the community. It also has an adverse impact on the environment. In addition, pollution from inadequate treatment of waste can indirectly affect the health of the community. Throughout the world, an estimated 16 billion injections are administered annually (WHO Report, 2012). Needles and syringes that are not disposed of properly, pose a grave hazard to public health due to the risk of injury and infection and due to the opportunities for re-use. Sharps waste, although produced in small quantities, is highly infectious. Poorly managed, discarded syringes expose health care workers, waste handlers and the community to infections.

Contaminated needles and syringes represent a particular threat as they may be scavenged from waste areas and dump sites and be reused. Based on a global review carried out in 2000, WHO estimated that injections with contaminated syringes caused21 million hepatitis B virus (HBV) infections (32% of all new infections); two million hepatitis C virus (HCV) infections (40% of all new infections); and 260 000 HIV infections (5% of all new infections) (Yvan JF, *et al.* 2013).

Unusable pesticides pose even greater risks to people, animals and the environment than do products in good condition. Obsolete products include the many pesticides that have been banned or severely restricted because of their high toxicity or environmental persistence. Unlabeled products and pesticides that have been transferred into unmarked containers can be mistaken for other substances such as fuel, cleaning products or even drinks. Leaking containers and spilled pesticides can release noxious vapors' and come into contact with other materials such as food, clothing and furniture, causing serious health problems to people or animals, even when contact has been very brief (Yvan JF, *et al.* 2013).

EMPIRICAL REVIEW

Alexandre Rutikanga (2015) studied pesticides use and regulations in Rwanda Status and potential for promotion of biological control methods. The economy of Rwanda has made impressive progress as a result of political stability since after the 1994 genocide. The long-term development goals of Rwanda are embedded in the vision 2020, which is a strategy to transform the country from a low-income agriculture-based economy to a knowledge-based, service-oriented and a middle-income country. The agricultural sector contributes 33% to the Growth Domestic Product (GDP) and particularly contributed 1.3% to its growth of 6.8% recorded in 2014, which was nearly the same contribution as the industry (1.7%). The success story of the agricultural development is linked to current efforts to transform agriculture such as the land consolidation under the Crop Intensification Program (CIP). The consolidated production of priority crops brought in significant increase in yield and food availability. This production increase has been associated with an increase in input use including fertilizers and pesticides. Previous studies reports that a 1% growth in crop yields, is associated with a 1.8% growth in pesticide use per hectare.

Based on the current trends of agriculture growth in Rwanda, which may stimulate increased pesticide use, a study has been conducted to assess the status of Pesticide use, regulations and the potential of promoting biological control methods in Rwanda. Available information on official websites of Ministries in Rwanda, International and regional organizations have been used as information sources. Pesticide regulations in place in Rwanda undergone a scrutiny analysis and compared with similar policies regionally and in other African countries as well as with international agreements on pesticides and environmental management. In addition, the analysis of pesticide regulations in Rwanda was performed following the (1) guidance on pest and pesticide management policy development of the international code of conduct on the distribution and use of pesticides under the food and agriculture of the United Nations, and (2) the guidelines for pesticide policy studies published by Hanover University, Germany.

The results revealed that pesticide policies in Rwanda are well developed, embedded in a consistent legal and institutional framework. They are connected from the National constitution, throughout international/regional pesticide management agreements and environmental protection policy to detailed regulations of pesticides from registration to the disposal off of obsolete and pesticide containers. However, some gaps have been noted mainly on the regulation of the Maximum Residue Levels, use of personal protection gears, preventing pesticide resistance and use and registration of bio-pesticides. Research to collect information on the magnitude of the issues raised above as gaps, has been recommended to guide formulation of related regulations towards compliance to international agreements, reducing pesticides poisoning to humans, livestock and the environment as a whole (Alexandre Rutikanga, 2015).

According to Omar Huici *et al*, (2017) management of empty pesticide containers, a study of practices in Santa Cruz, Bolivia. The aims are the mismanagement of pesticides empty containers of pesticides, posing a risk to the environment and the health of people, has motivated the promotion of international policies and guidelines to mitigate such problems. Despite these guidelines, attention to this problem is inadequate in Bolivia. The objective was to study the knowledge and practical management of the containers and to implement a responsible management plan for empty pesticide containers. Methods used in this study implemented the project from 2014 to 2016 in 2 municipalities of the department of Santa Cruz. Integral and participatory processes of information, education, and training were used. A questionnaire study among pesticide users was used to investigate knowledge and management of the empty pesticide containers. Results show that the authorities and the population responded to the program by taking a critical and active approach to the problem, improving their responsible practices, and 5500 kg of pesticides empty containers were collected. The cross-sectional study showed that 93% of the pesticides empty containers were disposed of in vulnerable places; 62% of the population did not know what triple washing is; 60% felt discomfort, headache, and/or dizziness while using pesticides; and 31% of the pesticides empty containers had pesticide residue inside them. Conclusions, the study illustrates a complex situation, mainly caused by lack of knowledge and clear guidelines. They are recommended documentation of the social, economic, and productive characteristics of the region before any municipal program action is undertaken. The key element to sustainable change is an informed and coordinated participation of all actors (Omar Huici *et al*, 2017).

Ishmael Kosamu (2010) studied a critical review of the status of pesticide exposure management in Malawi. Pesticides pose a significant risk to humans and the environment. This paper analyzes the measures used to manage pesticides in Malawi. Malawi's regulatory authority of pesticides, the Pesticides Control Board (PCB), faces a number of challenges including lack of facilities for analyzing pesticides and inadequate personnel to conduct risk assessment of pesticides. The PCB needs to provide access to information and opportunities among the public to make contributions regarding requirements, processes and policies for assessing pesticide risk and efficacy. There is also a need to enhance the capacity of PCB to assess pesticide poisoning in workers, monitor pesticide residues in food and environmental contamination, as well as to control the illegal importation and sale of pesticides. Just like in other countries such as South Africa, India and Sri Lanka, Malawi urgently needs to implement measures that can restrict the importation, production, sale and use of very toxic pesticides. Malawi also needs to develop measures for the effective management of pesticide waste containers as well as obsolete pesticides, where potential solutions include reducing the purchase of (unneeded) pesticides, treatment of obsolete pesticides in high-temperature cement kilns, as well as requesting pesticide dealers to adopt life-cycle management of their products (Ishmael Kosamu, 2010).

RESEARCH DESIGN AND METHODS

The study applied qualitative and quantitative approaches**.** Target population was 162 people including 71 employees from the companies in collection of wastages from homes of Gasabo district, 12 staff of Gasabo District Office of environmental management and protection; and 79 Agro-dealers of Gasabo District. This study applied the stratified and universal sampling technique to select all 162 respondents. Data was collected relatively quickly because the researcher would not need to be presented when the questionnaires were completed. In this study, face-to-face conversation was done between researcher and five end users/agriculturists of Gasabo District. Documents targeted were available reports in the period from 2017-2020 related to environmental contamination risks, and causes of accumulation of obsolete and unwanted pesticides in Gasabo District; and the roles of national and local authorities for pesticides empty containers and obsolete pesticides management in Rwanda. Technically, data processing implied the editing, coding, recording, classification and tabulation of collected data.

SPSS IBM 22.0 version was used as software for analysis. Descriptive Statistics methods were describing environmental contamination risks, and causes of accumulation of obsolete and unwanted pesticides in Gasabo District; and the roles of national and local authorities for pesticides empty containers and obsolete pesticides management in Rwanda. It was in that case descriptive statistical showed the frequencies, and percentages on data gathered from the field. A correlation coefficient was a numerical measure of some type of correlation, meaning a statistical relationship between two variables. The variables were two columns of a given data set of observations, often called a sample, or two components of a multivariate random variable with a known distribution.

RESULTS AND DISCUSSIONS:

Data were gathered from respondents in three weeks of responding the questions constituted the questionnaire. Findings indicated participation rate of 100.0% of responding, and data were analyzed quantitatively using computer software of SPSS IBM version 23.0. The results of this study were presented and interpreted in accordance with research objectives comprised the analysis of the pesticides empty containers and obsolete pesticides management; examining the environmental contamination risks affecting Gasabo District, and evaluating relationship between environmental contamination risks and pesticides empty containers and obsolete pesticides management in Gasabo District. Findings confirmed that there are both men and women in Pesticides empty containers and Obsolete Pesticides handling in Gasabo District. This is confirmed by 63 or (i.e., 38.9%) of respondents were males, and also 99 or (i.e., 61.1%) of respondents were females. In Gasabo District, they respect Rwandan gender law which expects 30% of gender balance in different activities. This could help them to manage pesticides empty containers and obsolete pesticides and solve the environmental contamination risks that can affect Gasabo District.

The Pesticides Empty Containers and Obsolete Pesticides Handling in Gasabo District

The used high-quality plastic and metal empty pesticide containers have considerable value to small scale farmers in developing countries like Rwanda for use as storage containers in the same way that new plastic bottles purchased from container stores in the developed nations have to their developed country counterparts. Findings from interviewed respondents in this study conducted at Gasabo District show their perception of respondents on the pesticides empty containers and obsolete pesticides handling or management in Gasabo District as in table 1.

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Table 1: Findings on perception of respondents on Pesticides Empty Containers and Obsolete Pesticides handling in Gasabo District

Findings in Pesticides Empty Containers and Obsolete Pesticides handling in Gasabo District	SA		A		N		D		SD	
	fi	%	fi	%	fi	%	fi	%	fi	%
Products have already been bought are subsequently banned and cannot be used in Gasabo District;	39	24.1	74	45.7	32	19.8	12	7.4	5	3.1
Products have exceeded their use-by date and should no longer be used in Gasabo District,	40	24.7	68	42.0	29	17.9	18	11.1	7	4.3
Products have deteriorated physically or chemically to a degree that makes them unusable in Gasabo District,	41	25.3	65	40.1	34	21.0	15	9.3	7	4.3
Products cannot be identified because they have no label, the label is in the wrong language or it cannot be read;	40	24.7	69	42.6	32	19.8	15	9.3	6	3.7
Damaged containers have leaked, exposing products in Gasabo District,	45	27.8	66	40.7	28	17.3	20	12.3	3	1.9
Products are no longer needed for their intended use in Gasabo District,	32	19.8	58	35.8	39	24.1	30	18.5	3	1.9
Too much of a product has been supplied and it cannot all be used in Gasabo District,	32	19.8	53	32.7	44	27.2	31	19.1	2	1.2
Materials have been contaminated by spilled pesticides;	32	19.8	55	34.0	45	27.8	28	17.3	2	1.2
Pesticides empty containers need to be disposed of, in Gasabo District,	32	19.8	55	34.0	45	27.8	28	17.3	2	1.2
Pesticides empty containers are not valued or often recycled for other uses in Gasabo District,	33	20.4	51	31.5	45	27.8	31	19.1	2	1.2
Obsolete pesticides and containers are often unwilling to declare or dispose of them in Gasabo District.	41	25.3	73	45.1	34	21.0	12	7.4	2	1.2

Source: *Data from field, (May, 2022)*

Results in Table 1 present the perception of respondents on pesticides empty containers and obsolete pesticides handling in Gasabo District. The study findings stated that products have already been bought are subsequently banned and cannot be used in Gasabo District as confirmed by 69.8% of respondents strongly agreed and agreed. The products have been exceeded their use-by date and should no longer be used in Gasabo District, as strongly agreed and agreed by 24.7% and 42.0% respectively in total of 66.7%. Products have deteriorated physically or chemically to a degree that makes them unusable in Gasabo District, stated by 65.4% of respondents comprising 25.3% of respondents strongly agreed and 40.1% of respondents agreed. Products cannot be identified because they have no label, the label is in the wrong language or it cannot be read, strongly agreed and agreed by 24.7% and 42.6% of respondents. Damaged containers have leaked, exposing products in Gasabo District, confirmed by 68.5% of respondents who strongly agreed and agreed. The products are no longer needed for their intended use in Gasabo District, stated by 55.6% of respondents strongly agreed and agreed. Too much of a product has been supplied and it cannot all be used in Gasabo District, strongly agreed and agreed by 52.5% of respondents. Materials have been contaminated by spilled pesticides, confirmed by 53.7% of respondents who strongly agreed and agreed. Pesticides empty containers need to be disposed of, in Gasabo District, strongly agreed and agreed by 53.7% of respondents. Pesticides empty containers are not valued or often recycled for other uses in Gasabo District, stated by 51.9% of respondents. Obsolete pesticides and containers are often unwilling to declare or dispose of them in Gasabo District, confirmed by 70.4% of respondents in Gasabo District.

The environmental contamination risks affecting Gasabo District

The study found that farming sector in Gasabo District has the country's highest use of pesticides, followed by the western province. After commercial crops of coffee and tea, the following crops, potato, vegetables and rice receive the highest quantities of pesticides used in Rwanda. This province and these crops would provide a suitable environment to pilot test a collection, transport, cleaning and recycling initiative.

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Table 2: Findings on perceptions of Respondents on the environmental contamination risks affecting Gasabo District

	SA		A		N		D		SD	
perceptions of Respondents on Environmental contamination risks	**fi**	**%**	**fi**	**%**	**fi**	**%**	**fi**	**%**	**fi**	**%**
Unusable pesticides pose risks to people, animals and environment than those products in good condition in Gasabo District,	30	18.5	72	44.4	35	21.6	23	14.2	2	1.2
Obsolete products which have been banned, they have high toxicity or environmental persistence in Gasabo District,	29	17.9	76	46.9	34	21.0	21	13.0	2	1.2
Unlabeled products and pesticides have been transferred into unmarked containers can be mistaken for other substances such as fuel, cleaning products or even drinks,	27	16.7	75	46.3	35	21.6	23	14.2	2	1.2
Leaking containers and spilled pesticides can release noxious vapours and come into contact with other materials like food, clothing and furniture causing serious health problems;	36	22.2	85	52.5	29	17.9	11	6.8	1	.6
Badly stored pesticides are likely to deteriorate and become unusable or obsolete in Gasabo District,	29	17.9	88	54.3	31	19.1	13	8.0	1	.6
Pesticides are causing generation of hazardous and solid waste, and natural resource depletion,	28	17.3	102	63.0	25	15.4	5	3.1	2	1.2
Leaking pesticides leach into water contaminated underground aquifers, rivers, and even other water;	28	17.3	107	66.0	22	13.6	4	2.5	1	.6
Pesticides in water can damage or destroy aquatic life and affect people and livestock if the water is used for drinking, irrigation or washing,	32	19.8	103	63.6	22	13.6	4	2.5	1	.6
The pesticides and their containers are continually buried on the same site become severely contaminated and unusable,	46	28.4	84	51.9	30	18.5	2	1.2	0	0.0
The pesticides and their containers cause soil degradation and soil erosion in Gasabo District,	37	22.8	80	49.4	28	17.3	16	9.9	1	.6
The pesticides and their containers cause deforestation, and climate change in Gasabo District,	49	30.2	71	43.8	29	17.9	13	8.0	0	0.0
There is loss of biodiversity, and water pollution and access in Gasabo District,	38	23.5	77	47.5	33	20.4	14	8.6	0	0.0
Pesticides, and their containers affect urban pollution and natural resources pressures in Gasabo District.	35	21.6	70	43.2	33	20.4	21	13.0	3	1.9

Source: *Data from field, (May, 2022)*

Findings in Table 1 show the perceptions of respondents on the environmental contamination risks affecting Gasabo District where they confirmed that there are unusable pesticides pose greater risks to people, animals and the environment than do products in good condition in Gasabo District, confirmed by 63.0% of respondents including 18.5% strongly agreed and 44.4% of respondents agreed. Obsolete products have been banned have high toxicity or environmental persistence in Gasabo District, confirmed by 64.8% of respondents strongly agreed and agreed. Unlabeled products and pesticides have been transferred into unmarked containers can be mistaken for other substances such as fuel, cleaning products or even drinks, strongly agreed and agreed by 63.0% of respondents. Leaking containers and spilled pesticides can release noxious vapors and come into contact with other materials such as food, clothing and furniture causing serious health problems, as confirmed by 74.7% of respondents who strongly agreed and agreed. Badly stored pesticides are likely to deteriorate and become unusable or obsolete in Gasabo District, as confirmed by 72.2% of respondents.

Pesticides are causing generation of hazardous and solid waste, and natural resource depletion, as stated by 80.2% of respondents. Leaking pesticides can leach into water to contaminate underground aquifers, rivers, and even other water, as agreed and strongly agreed by 83.3% of respondents. Pesticides in water can damage or destroy aquatic life and affect people and livestock if the water is used for drinking, irrigation or washing, stated by 83.3% of respondents who strongly agreed and agreed. The pesticides and their containers are continually buried on the same site become severely contaminated and unusable, as confirmed by 80.2% of respondents. The pesticides and their containers cause soil degradation and soil erosion in Gasabo District, stated by 72.2% of respondents. The pesticides and their containers cause deforestation, and climate change in Gasabo District, agreed and strongly agreed by 74.1% of respondents. The 71.0% of respondents stated there is loss of bio-diversity, and water pollution and access in Gasabo District. Pesticides, and their containers affect urban pollution and natural resources pressures in Gasabo District, as confirmed by 64.8% of respondents.

The relationship between environmental contamination risks and pesticides empty containers and obsolete pesticides management in Gasabo District

Findings on the relationship between environmental contamination risks and pesticides empty containers and obsolete pesticides management in Gasabo District were determined by correlation coefficient test results as detailed in table 3.

Table 3: Correlation Coefficient

		Pesticides empty containers and obsolete pesticides handling	Environmental contamination risks
Pesticides empty containers and obsolete pesticides handling	Pearson Correlation	1	.043
	Sig. (2-tailed)		.590
	N	162	162
Environmental contamination risks	Pearson Correlation	.043	1
	Sig. (2-tailed)	.590	
	N	162	162

***. Correlation is significant at the 0.05 level (2-tailed).*

The Pearson correlation measures the strength of the linear relationship between two variables. It has a value between -1 to 1, with a value of -1 meaning a total negative linear correlation, 0 being no correlation, and + 1 meaning a total positive correlation. Therefore, the findings in Table 3 present p-value that equals 0.043 which is less than Alpha of 0.05. This is an indicator of existing association or relationship between pesticides empty containers and obsolete pesticides handling and Environmental contamination risks in Gasabo District, where the level of relationship equals $\mathbf{r^2}$ = .590** which is located in interval statistic of Pearson legend from [.50 - .75] categorized as positive and high correlation. This helps to confirm that there is a significant relationship between Environmental contamination risks and Pesticides empty containers and obsolete pesticides handling in Gasabo District.

CONCLUSION AND RECOMMENDATIONS:

Conclusion

The pesticide industry in Rwanda is not well developed and is mainly represented by importer, exporter and manufacturing companies, including four big companies of pesticides (Agrotech, Balton, Agropy and ITG). Agropy is the only company that manufactures and exports pesticides. There is a campaign going on to invite dealers to join RAIDA. This action is supported by the Rwanda government, which aims to increase the public-private sector dialogue. RAIDA's mandate is to provide advocacy and to professionalize the sector as well as providing trainings on using Agro-chemical inputs to protect the environment. RAIDA is able to reach many shop owners and dealers and advocates for dealers' responsibility for good practices and compliance to the regulations. This initiative was supportive to the work of the regulators and inspectors of Agro chemical inputs. The findings of this study confirmed that p-value equals 0.043 which is less than Alpha of 0.05. This is an indicator of existing association or relationship between pesticides empty containers and obsolete pesticides handling and Environmental contamination risks in Gasabo District, where the level of relationship equals $\mathbf{r^2}$ = 0.590** which is located in interval statistic of Pearson legend from [.50 - .75] categorized as positive and high correlation.

Recommendations

Agriculture represents the primary engine for economic growth in Rwanda and organic agriculture is seen as a key to add value to Rwandan agricultural exports, and to gain access to new markets. There are the needs to facilitate the supply of organic pesticides and fertilizers, credits and seeds. The higher education sector and research institutions should be encouraged and supported in working together to carry out research, development and knowledge transfer activities relevant to the less or non-hazardous chemicals and training to support the development of agroecological products. The pesticides industry needs to be more environmentally friendly with more emphasis on Agro-ecological products. The government needs to find ways to motivate producers and encourage financing for business start-up in the sector of Agro-ecological input. The transport infrastructure needs to be improved to support commercialization of the agroecological inputs. The government needs to explore ways to set barriers to the importation of hazardous of agrochemicals and harmful products to market in Gasabo District.

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