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Investigation of Synthetic Pesticides Use in Isoka District of Muchinga Province in Zambia.

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Abstract

Purpose: Different countries use different kinds of pesticides which affect the environment and animals in many different ways. The purpose of this study was to analyse pesticide use in Isoka district of Muchinga Province.The objectives were to identify commonly used synthetic pesticides and assess how farmers store them.

Methodology: We collected primary data using well-structured questionnaires from 60 vegetable farmers in four agricultural camps. A cross-sectional survey design was employed and data were analysed using frequency and percentages of descriptive statistics. A p -value with test of significance of 0.05 was used.

Findings: The commonly used Synthetic pesticides were found to be neonicotinoid 35% .Others that were found to be in use were ; Organophosphates 16%, Organochlorines 3% , Pyrethroids 10% , and Macrocyclic lactones 22% .The Unknown were 7% and carbamates 7% . The farmers kept their pesticides in their homes 53% and in their gardens 47%.

Unique contribution to the theory, practice and policy: Neonicotinoid synthetic pesticides were the commonly used pesticides. Farmers kept synthetic pesticides in homes where they lived with children. Because of the effects that pesticides have to the environment, animals and man, this study recommend the need to sensitize farmers on the correct use so that exposure and further contamination of water, soil and vegetables are reduced .Farmers should construct separate store rooms where the said chemicals should be kept.There is need to strengthen institutional collaboration between Zambia environmental management agency and ministry of agriculture.

Key words: *Investigation, Synthetic Pesticides, Isoka District, Use*

1.0 Introduction

Zambia is endowed with a large land resource base of 42 million hectares of which only 1.5 million hectares are cultivated every year. The agricultural output contributes a great portion to Zambia's Gross Domestic Product (MCTI, 2021). As such, agriculture has continued to receive priority attention by the government through increased budget support aimed at increasing agriculture productivity to ensure food security, income generation, creation of employment opportunities and poverty reduction (ZDA, 2014). However, the agriculture sector has witnessed the use of chemical pesticides in order to protect the crops from pest that reduce the quality and quantity of the agricultural products (ZDA, 2014)

Pesticides are a group of chemicals used for the control of insects, weeds, fungi, bacteria (IPEN, 2019).The historical background of pesticides used in agriculture dates back to the beginning of agriculture itself with the use of sulfur to control insects and mites. It became more pronounced over time due to the growing pest population coupled with decreasing soil fertility and the development of agricultural techniques (Muir, 2002). Since they were introduced on the market in 1947, synthetic pesticides have been extensively used to reduce crop losses and improve production (Tilman, 1999).

Despite their use,they pose challenges to the environment, animals and humans.Sharma and Patil (2018) reports that ,the indiscriminate use of synthetic pesticides in agriculture may have detrimental effects on the product and the environment.Unfortunately most of the people who are affect by fatal pesticide poisoning are from low and middle income countries (Kaur et al ,2023). Zambia is not exceptional. The world health organisation's reports that every year about 250,000 people die from poisoning and out of this number synthetic pesticides cause about 150,000.(WHO,2020).

When there is entry of synthetic pesticides into the body ,there is danger that is caused to human health.(Rahman et al,2015;Damalas ,2011;Santaweesuk et al ,2019).The effects that results include dizziness, difficulty in breathing ,dermatological problems,Birth defects,cancers,hormonal change,reproductive disorder and disorders of the nervous system may also results.(Sefa et al ,2015;Kapeleka et al ,2019 & Rijal et al ,2018)

Globally, pesticides have now become an integral part of our modern life and are used to protect agricultural land, stored grain, flower gardens as well as to eradicate the pests transmitting dangerous infectious diseases (Gill and Garg, 2014). Suwanaruang (2023) claim the most extensively used pesticides globally are carbamate and organophosphate due to their low environmental persistence.

In Philippines,among 17 synthetic pesticides applied, the most frequently used were methomyl , chlorpyrifos , triazophos, and cypermethrin (Sheryl et al ,2023).In India, Chandra et al (2021) revealed the use of various synthetic chemical pesticides in the farming system including the banned organochlorines such as endosulphan, polydol and DDT. Rajmohan et al (2020) reports that around two million tonnes of pesticides are produced and utilized worldwide every year. Amongst this, 24% are consumed by the United States, 45% of the total are utilized in the European countries and 25% of the remaining are consumed by

the other parts of the world. Lindane, Dichlorodiphenyltrichloroethane (DDT), and malathion are the most commonly used pesticides that counted for 70% of total pesticide use.In Viet Nam, Nguyen et al (2024) reports that among many kinds of pesticides, Organophosphorus has been used in many countries since the 1960s while carbamates since the 1970s .According to WHO (2008) ,Studies from Sri Lanka suggest that Organophosphate are the commonly used pesticides for both intentional and unintentional poisoning.

In Tanzania pesticide formulation used by farmers were insecticides (59%), fungicides (29%) and herbicides (10%) with the remaining 2% being rodenticides (Ngowi et al, 2007)

In South Africa, over 105 neonicotinoid pesticides insecticides are in use (Academy of Science of South Africa, 2019). According to Malambo et al ,(2019), organophosphates are the most widely used. Pesticides such as organophosphates are highly toxic naturally but do not persist in the environment, unlike Organochlorines that tend to be persistent in the environment.

In Zambia pesticide use has a history marked by increased imports and usage in agriculture and public health and there has been increase in herbicides and insecticide imports especially from 2007 to 2013 (Cabi, 2023).This increase indicate a greater availability to farmers.

Most pesticides are designed in such a way that they disturb the physiological activities of the target organism, leading to dysfunction and reduced vitality (Jayaraj et al, 2016). Several incorrect applications of chemical pesticides lead to some levels of contaminants in final products and environmental persistence (Bakirci et al, 2014). Scientific understanding of the effects of pesticides on human health and their mechanisms of action has expanded rapidly, with studies revealing statistical associations between pesticide exposure and enhanced risks of developmental impairments, neurological and immune disorders and some types of cancer (Thompson, et al, 2015). The residues of synthetic pesticides may constitute a significant source of contamination to environmental compartments such as water and soil. This may become a threat to the relationship that exist between plants and animals in the ecosystem. The objectives of this study were to identify the commonly used synthetic pesticides and to assess how the pesticides are stored. It is important to understand pesticides commonly used so that safety and effective pest control are guaranteed by enabling proper application, minimizing risk to humans and environmental health and choosing appropriate control methods in times of use.

2.0 Materials and Methods.

2.1 Study Design

We employed a cross-sectional survey design. The adopted research design involved the collection of primary data at a particular point in time that is useful in obtaining facts and perceptions of the respondents. This was combined with explorative approaches through in-depth interviews that revealed more about the synthetic pesticides commonly used in Isoka District.

2.2 Study Area

The study area for the current study was Isoka District found in Muchinga Province. Isoka District (10°2'4"S, 32°6'1"E) is located in the North Eastern part of Zambia, in Muchinga Province (Figure 3.2). It is bordered by Nakonde District to the North, Chinsali District to the West, Chama District to the South and Malawi to the East. Isoka District was chosen as the study site because the researcher observed indiscriminate use of pesticides. A tropical climate prevails which is characterized by high rainfall (1000 mm to 1500 mm annually) and is restricted to the period of November to April with temperatures ranging from 17 to 28 °C. May to July is cool and dry with temperatures ranging from 11 to 25 °C. August to October is hot and dry and temperatures range from 13 to 30 °C. In most of Isoka District soil is either clay to loamy or loamy to sandy. The top soil is loose and is raised by the wind in the dry season. The study took place in four Agricultural Camps of the District namely Kafwimbi, Isoka Central, Lualizi and Kapililonga as shown in figure below .

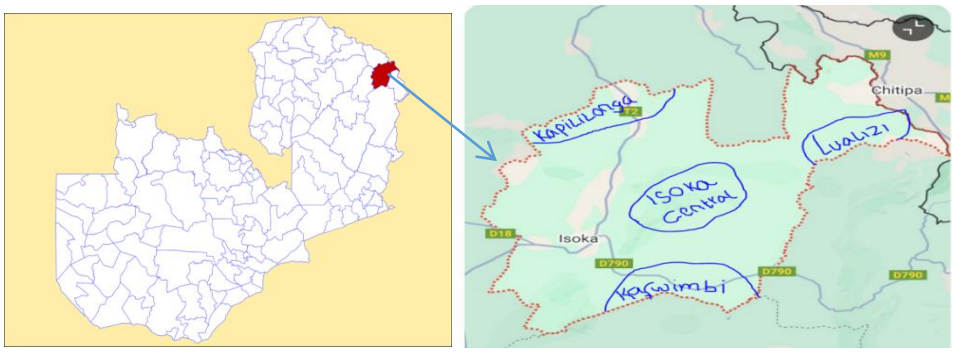

Figure 2.1 Location of study area.

2.3 Target Population

This study targeted the farmers in the agricultural camps in Isoka District and their gardens so that the Pesticides used were thoroughly investigated.

2.4 Sample Size of farmers

The mple ize was obtained using Cochran's formula in its modification state.

n= N/1+ (N/1000) where n = sample size, N=population size.

n = 60/1+ (60/1000)

n= 60

Thus, he ample size for his tudy was 60 vegetable farmers

2.5 Identification and sampling of the study area

Purposive sampling was used where agricultural camps such as Lualizi, Kapililonga ,Isoka central and Kafwimbi were used because they are the camps that were easy to reach at the time data collection took place . The choice of these study areas was in part influenced by the researcher's knowledge of the study area.

2.6 Identification and recruitment of participants

In identifying and recruiting participants convenience sampling of the Non-probability sampling method was used. Participants from the four (4) camps were recruited based on who was available and willing to take part in the study. The study was first explained to the people and then consent forms were given to them and those that signed the consent forms were the ones that were recruited as participants to the study.

2.7 Sampling Procedure

Systematic sampling of proposed areas from selected study regions was applied. However, purposive sample selection to areas with extensive cultivation of vegetables was a useful technique. Every 'nth' consecutive site was drawn starting with a randomly selected number between one and 'n'.

2.8 Data Analysis

Data analyses were performed through SPSS version 20 and Excel statistical packages of 2013. All the data collected through fields were initially coded and summarized in tables. The Descriptive statistics such as frequency and percentage were the useful parameters of interest proposed under this study to analyse pesticide use.P- value with level of significance of 0.05 were also used ($P < 0.05$).

2.9 Ethical Considerations

Before the ministry of Agriculture was informed of the research undertaking, Ethical clearance was obtained from Excellence in Research Ethics and Sciences (ERES). Ref.no.2022-Aug-017.All Participants were informed about the survey before participating and had the right to withdraw at any point in time during the survey. The farmers were made to sign an informed consent before being enrolled in the study.

2.10. Inclusion and Exclusion Criteria

Those who were included in the study are the farmers who lived in the study area for more than two years and took part in the farming activities supported by the ministry of agriculture where synthetic pesticides where used. Additionally this study included only those farmers that were present at the time data collection took place and they signed consent forms, the farmers who did not live in the area for more than two years and were not taking part in the farming activities were not recruited in this study.

2.11 Questionnaire Survey

The style and the language in the questionnaire were modified and simplified in relation to the title under study. Some questions for the farmers were converted into their local language so that they could understand quickly .The questionnaire for the farmers captured data on the demographic characteristics, types and storage of pesticides.

3.0 Results

3.1. Demographic characteristics of farmers in Isoka District

Table 3.1 Demographic Characteristics of Farmers

Variable	Category	Frequency	Percent (%)	P-Value
Age group	26 ≤ 35 years	18	30	
	36 ≤ 50 years	32	53	0.033
	> 50 years	10	17	
Sex	Males	40	67	0.78
	Females	20	33	
Farming Status	Full-time	41	68	0.003
	Part-time	19	32	
Period of Farming	2-5 years	13	22	
	6- 10 years	5	8	0.796
	>10 years	42	70	
Source of Drinking Water	Stream/River	11	18	
	Tap Water	3	5	0.694
	Well/Borehole	46	77	
Type vegetables of grown	Cabbage	13	22	
	Chinese	12	20	
	Okra	2	3	
	Onion	1	2	0.585
	Rape	11	18	
	Tomato	21	35	
Frequency of application	1-10 times	27	45	
	11-20 times	15	25	0.141
	21-30 times	8	13	
	31-40 times	6	10	
	≥ 41 times	4	7	

The farmers who took part in this study were in the age group of between twenty six and thirty five years 30 percent .Those in the age group of between thirty six and fifty years were 53 percent and 17 percent were above fifty years with p -value of 0.033.The male who took part in this study were were 67 percent while females were 33 percent .The full-time farmers were 68 percent while 32 percent were part time farmers.Farmers that had been farming for more than 10 years were were 70 percent of the total participants while 22 percent had been farming for two to five years and 8 percent had been farming for six to ten years.The farmers used different sources of drinking water with well or borehole 77 percent .stream or river 18 percent and tap water 5 percent .Different crops that the farmers grew included Tomatoes 35 percent ,cabbage 22 percent and chines vegetables 20 percent .Farmers applied chemical pesticides for one to ten times 45 percent ,eleven to twenty times 25 percent and twenty one to thirty times 13 percent .In this study 7 percent of the farmers applied pesticides for more than fourty one times.There was an association between pesticides use and age group ($P< 0.05$) and also pesticides use and farming status (p-value 0.003).

3.2 Types of pesticides commonly used by farmers in Isoka District.

Table 3.2. Type of pesticides commonly used by farmers in Isoka District.

Pesticides	Frequency	Percent (%)
Organophosphates	10	16
Organochlorines	2	3
Pyrethroids	6	10
Neonicotinoids	21	35
Macrocyclic Lactones	13	22
Carbamates	4	7
Unknown	4	7
Total	60	100

Classes of pesticides that were found to be in use were: Organophosphates totaling 16 percent (Fenamiphos, Malathion, Monocrophotos, Profenofos, Pirimiphos-methyl). Organochlorines pesticides totaling 3 percent (Paraquat, Hexachlorocyclopentadiene, Dichlorvos). Pyrethroid pesticides totaling 10 percent (Cypermethrin, Lambda-Cyhalothrin, D-phenothrin). Furthermore, Neonicotinoid pesticides totaling 35 percent (, clothianidin, Imidacloprid and Thiamethoxam) were found to be in use. Other types of pesticides that were found to be in use belonged to the Macrocyclic lactones 22 percent (Emamectine Benzoate, Abamectin). Seven percent were indicated as insecticides not known. Seven percent were found to belong to carbamates though they were found combined with other formulations.

3.3. Pesticide Use and their storage in Isoka District.

Figure 3.1. Storage of pesticides in Isoka District

The farmers in Isoka District were found to store pesticides in their homes 53 percent and in their gardens 47 percent . Inside the houses, containers of pesticides were kept in the bedrooms where the farmers slept with their children. The containers were found kept under the bed. They also kept some foods in the same houses. Some of the containers were found tightly closed but some were found leaking posing a risk of contamination. The container for soft drink containing pesticides were found buried in the soil within the Garden. The pesticide were bought in small quantities according to the amount the farmers managed.

Figure 3.2 Empty containers of pesticides found thrown within the gardens.

Some of these containers were later picked and washed to be reused for keeping salt and even for drinking water.

Figure 3.3: Containers of pesticides found kept in the sack.

The sacks were found to be rotten and pesticide label almost scratched out. The caps for the containers were not tightly caped and had small leakage.

4.0 Discussion

The objectives of this study were to identify commonly used synthetic pesticides in Isoka District of Muchinga province in Zambia. Based on the results of this study on table 3.1.There were 53% of the farmers who took part in the farming activities that were aged between 36 and 50 years with association between pesticide use and age group P< 0.05. Youths (30%) also took part in the farming activities and were aged between 26 and 35 years. Male farmers (67%) dominated in the farming activities with no association with pesticide use. The results of this study reveals that 67% of the farmers were full time and 33% were part time farmers. In this study area 70% of the farmers had been farming for more than 10years and in their farming activities they grow crops that include cabbage (22%), tomatoes (35%) and Chinese vegetable (20%) most frequently. On these crops, 45% of the farmers spray 1 to 10 times, 25% spray 11 to 20 times while 7% spray more than 41 times. This use of pesticides may contribute to the accumulation of pesticides in crops and further pose health challenge to the people consuming these crops .

The results of this study as indicated in table show that the commonly used class of pesticides are Neonicotinoid (35%),Macrocyclic lactones (22%) and Organophosphates (16%).Some farmers (7%) did not know the type of pesticides that they sprayed on the crops. Because it is important to know the type of pesticides that one is using in order to reduce on the risk and also to help in terms of dealing with the poisoning cases in situations where a farmer is poisoned ,The use of unknown pesticides may pose risk to the farmers.

Moreover, the farmers were found to keep pesticides in their homes (53%) while others kept their pesticides in the gardens (47%).Those that were kept in the gardens were found stored in the bottles for energy drinks and buried in the soil. Some pesticides were found kept in the

Saks that were almost rotting figure 3.3.The labels on the containers were almost fading and difficult to read the instructions for use.

While the results of suwanaruang (2023) show that carbamates and organophosphates were the most extensively used pesticides, the results of the present study has shown that in Isoka District ,the neonicotinoids and Macrocyclic lactones are the frequently used pesticides. Moreover, the results of the present study contradicts those of Sheryl et al (2023) who found that out of the 17 synthetic pesticides ,methomyl, chlorpyrifos, triazophos belonging to organophosphates and cypermethrin belonging to the pyrethroids were the most frequently used pesticides. In India,Chandra et al (2012) revealed that some of the pesticides used in farming belonged to the organochlorines that were banned for use. The results our study are not in line with these results. Further, the results of the present study contradict the results of Rajmohan et al (2020) who reported Malathion and Lindane as the commonly used pesticides. While the results of Nguyen et al (2024) indicate that organophosphates and carbamates have been used in most countries and WHO (2008) further reports the use of organophosphates in Sri Lanka, the results of the present study has indicated decrease in the use of both Cabamates and organophosphates. However, the results of our study are in line with those of Academy of science of South Africa (2019) who reported use of over 105 neonicotinoids in South Africa. The results of our study build on the existing evidence of Academy of science of South Africa on the use of Neonicotinoids. Our study provides a new insight into the trend in the use of pesticides especially the major classes such as Neonicotinoids, carbamates, organochlorines, organophosphates and pyrethroids together with the storage of pesticides in which most of the farmers keep pesticides in their homes. When these pesticides are kept in homes with poor ventilation, the most vulnerable group of people such as the pregnant mothers, the children and elderly are affected because of the increase exposure to the pesticides. These pesticides cause both acute and chronic illnesses .Sharma and Patil (2018) reports that, the indiscriminate use of synthetic pesticides in agriculture may have detrimental effects on the product and the environment. This product may be consumed by the people and further give rise to health problems. The results of Kaur et al (2023) show that most of the people who are affected by fatal pesticide poisoning are from low and middle income. Of these countries Zambia is not exceptional. With regard to the report by World health organisations that every year about 250,000 people die from poisoning and out of this number synthetic pesticides cause about 150,000 (WHO,2020),it is very important that the results of this study are considered on account that farmers are given information on the proper storage and handling of pesticides. While previous studies have focused on the knowledge, attitudes, practices and general contamination to the environment these results demonstrate that farmers do not know how to keep pesticides and that in the way they hand these pesticides, they increase exposure and put the vulnerable population at risk and also the environmental compartments such as water, soil and vegetables.

5.0 Conclusion and Recommendation.

5.1 Conclusion

This study concludes that synthetic pesticides commonly used in Isoka District were the Neonicotinoid although other pesticides types were also found to be in used .Some farmers used pesticides they did not know.These pesticides were used on crops mostly tomatoes, cabbage ,chines vegetable and rape. The farmers keep their Synthetic pesticides in their homes. This study further concludes that although organochlorines and organophosphates were not frequently used by farmers, the farmers are still using these pesticides on their crops.

5.2 Recommendations

(i)There is need for sensitisation to farmers on the correct way of handling Neonicotinoid pesticides and provide education on health effects of pesticides to humans and the Environment.

(ii)There is need to conduct health risk assessment and also check the level of pesticides in the urine and blood of the farmers who use these pesticides.

(iii) Farmers should construct separate store rooms outside their houses in order to reduce on the exposure.

(iii) There is need to check the level of pesticides in the water, soil and the vegetables that the farmers use.

(iv) The effective education and outreach programmes by the ministry of agriculture and health can help increase awareness about pesticides use in Isoka District.

(v) There is need for institutional collaboration between Zambia environmental management agency and ministry of agriculture.

Author contribution

All authors contributed equally to the production of the manuscript

Declaration of competing interests

The authors declare no conflicts of interest in the present study.

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Statement of ethical approval

The present research work does not contain any studies performed on animals or human subject by any of the authors.

Statement of Informed Consent

Informed consent were obtained from all individual participant included in the study.

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