LANCASTER ENVIRONMENT CENTRE
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Assessing pesticide use, Human exposure and environmental fate in Nigeria

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Abstract

Over the years, oil has been the major source of revenue in Nigeria. Agriculture has been recommended as an alternative viable option, for this to be achieved the sustainable use of pesticides has to be key. Pesticides are used by farmers to ward off pests in farms, however it has been reported that these pesticides are inappropriately used which could adversely affect the environment and could potentially endanger humans exposed to them through their consumption of fruits and vegetables. This research aimed to investigate pesticide use among farms and its impact on the environment. 486 farmers in Akwa Ibom state were interviewed and 185 farmers representing the geo political zones of the country were equally interviewed. Field observations were also done and among other things, it revealed some farmers did not receive training on pesticide application. Soil samples were analysed to ascertain their levels of concentrations. It was found that pesticides usage is high as almost every farmer made use of pesticides, the chemicals were mostly misused. Farmers are constantly exposed to chemicals and levels of concentration of the pesticides were generally within the maximum residue levels and below the WHO recommended maximum limits and impliedly did not pose any significant threats. There is also a tendency that the area considered as 'non-farm' is not the case as some sections of those areas used to have farms situated in them and may not reflect the current practice, hence reasons for of the concentration levels found therein. The reported concentrations of the metabolites of DDT suggest that it is from either historical usage or the illegal usage of these pesticides or even a case of both factors. The research showed that most farmers did not receive training on pesticide application and the authorities mandated with carrying out enforcement in this regard by regulating the way it is used, need to do more.

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List of Papers and Declaration

Ekeoma I. Ogwo, Kirk T. Semple and Crispin J. Halsall. Pesticide use and environmental contamination in Nigeria and West Africa

Ekeoma I. Ogwo designed the study, developed the questionnaires with the help of Kirk T Semple and Crispin J. Halsall The data was collected, analysed and reported under their supervision.

Ekeoma I. Ogwo, Kirk T. Semple and Crispin J. Halsall. Deriving Pesticide Exposure Doses for the Nigerian Public

Ekeoma I Ogwo designed, conducted and reported this research with the supervision of Kirk T. Semple and Crispin J. Halsall

Ekeoma I. Ogwo, Kirk T. Semple and Crispin J. Halsall. A comprehensive survey of smallholder farmers in Akwa Ibom State and some other states (Nationwide), to understand farming practices and associated pesticide use in Nigeria.

Ekeoma I. Ogwo designed and developed the questionnaire with Edu Inam. The data was collected, analysed and reported by Ekeoma I. Ogwo with the supervision of Kirk T. Semple and Crispin J. Halsall

Ekeoma I. Ogwo, Kirk T. Semple and Crispin J. Halsall. Assessment of Residual Pesticides in Soils from Commercial Farms in Akwa Ibom State.

Ekeoma I. Ogwo designed, conducted and reported this research with the supervision of Kirk T. Semple and Crispin J. Halsall

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List of Acronyms and Abbreviations

ADI	Acceptable Daily Intake
DDT	Dichlorodiphenyltrichloroethane
DNA	Deoxyribonucleic acid
EDC	Endocrine Disrupting Chemicals
EDI	Estimated Daily Intake
FAO	Food and Agriculture Organisation
GC/MS	Gas Chromatography/Mass spectrometer
GDP	Gross Domestic Product
HCH	Hexachlorocyclohexane
LEC	Lancaster Environment Centre
MRL	Maximum Residual Limit
NAFDAC	National Agency for Food and Drug Administration and Control
NESREA	National Environmental Standards and Regulations Enforcement Agency
OCP	Organochlorine Pesticides
PAN-UK	Pesticide Action Network – United Kingdom
POP	Persistent Organic Pollutant
PPE	Personal Protective Equipment
TDI	Tolerable Daily Intake
UN	United Nations
UNEP	United Nations Environment Programme
UNICEF	United Nations International Children's Emergency Fund

Structure of Thesis

This thesis provides a detailed assessment on the status of pesticidusage in Nigeria; examining aspects of broader environmental contamination to current use practices and human exposure through consumption of local foodstuffs. General information, data on use and environmental monitoring, as well as scientific understanding of pesticide exposure and fate of is lacking for Nigeria, as well as the whole of west Africa. This is of concern as evidence from the UN's Food & Agriculture Organisation indicates that pesticide sales and use has increased markedly for this region over the last 30 years. The thesis therefore attempts to review existing knowledge regarding the levels and trends of pesticide usage, particularly for the older organochlorine insecticides, in different environmental compartments. **Chapter I**, titled *Pesticide use and environmental contamination in Nigeria and West Africa:* examines the legacy of pesticide use, summarising concentration data from the limited studies that have examined these chemicals in various environmental media over the last 40 years, and setting the context with regards to the status of Nigerian agriculture and the regulatory framework aimed to ensure safe pesticide use. It is evident that information regarding contemporary exposure to the Nigerian public who consume fresh produce, likely sourced from smallholder agriculture, is lacking. **Chapter II** therefore describes a study that determines pesticide exposure doses ("*Deriving Pesticides Exposure Doses for the Nigeria Public*") .In this chapter, estimated daily intake of pesticides present in the different food stuffs cultivated and consumed within Benin City, Nigeria were reported. The Estimated daily intake of the various pesticides in the different food products were compared to the acceptable daily intake in the foods and a conclusion reached. The need to observe and have a first hand experience of information on how smallholder farmers engaged in farming in order to give more informed recommendations necessitated the need to undertake a survey in **Chapter III** titled **"***A comprehensive survey of smallholder* *farmers in Akwa Ibom State and some other states(Nationwide), to understand farming practices and associated pesticide use in Nigeria"*

This is a report from data obtained using structured interview schedules that targeted 486 respondents in 6 agricultural zones within the state. It provides an insight to how farming operations are carried out in Akwa Ibom state of Nigeria and report written from data obtained using structured interview schedules that targeted 185 household heads farmers in farming communities across the country. Field observations were also reported and reports on their experiences with the use of pesticides. Having done the survey and understood their farming practices, there was need to find out if there was any correlation between the activities of these farmers and the actual levels of concentrations analysed. The soil is therefore assessed for organochlorine pesticides in **Chapter 4** titled *"Assessment of Residual Pesticides in Soils from Commercial Farms in Akwa Ibom State, Nigeria"*. In this chapter, soil samples from 6 agricultural zones within Akwa Ibom are collected, extracted and analysed for certain target pesticides with results to show for it. There are also background/Non-farm samples included in the report. The levels of concentration generally are found to be within the Maximum residual levels of organochlorine Pesticides within Europe and other parts abroad.

Chapter 5 Conclusions & Recommendations

Overview of my Research

The use of pesticides in some developing countries is now an environmental problem due to a number of factors. This research was borne out of the fact that in a country that Agriculture is advocated to rival the oil industry in being the main stay of Nigeria's income, then sustainable use of the pesticides would be paramount.

In developing countries like Nigeria, most of the farmers are illiterate and do not know how to safely handle these chemicals as we know they are mainly the ones that use the pesticides. Therefore, the research looked into how much the regulators mandated by the government e.g. National Environmental Standards and Regulations Enforcement Agency (NESREA) enforce the users of these pesticides do so in line with best practices.

Some surveys were done to confirm the way people generally went about their use of pesticides and to determine the extent pesticide use has fared over the past decade. Data were also gathered to ascertain pesticide exposure doses for the Nigerian public. Soil samples were also collected from different farm locations within the country and analysed for pesticides.

The aim of my research was to gain a contemporary assessment of pesticide use and contamination of the wider Nigerian environment and quantify typical human exposure doses through consumption of locally grown produce for select chemicals. It is anticipated that the science developed here can be used at the national level to develop and inform pesticide-use policy within Nigeria.

Objectives include:

- To review reported levels of pesticide concentrations in a variety of environmental media in West Africa over the past three decades to: (i) statistically summarise concentrations for key pesticide groups (e.g. the older organochlorine insecticides vs contemporary OP/carbamate/pyrethroid insecticides); (ii) to seek evidence of whether pesticide use has increased, decreased or stayed the same for key chemicals of concern; (iii) identify knowledge gaps and recommend research priorities to address these gaps.

- To take a field survey about pesticide use around some selected farms in Nigeria.
- To initiate a monitoring programme of locally grown foodstuffs (fruit & vegetables) to measure levels of a selection of current use insecticides, to: (i) compare to European foodstuffs and EU ‘maximum residue level’ standards; (ii) calculate human exposure doses based on typical child/adult consumption patterns for staple food stuffs acquired from open market or from farm.

Chapter 1

PAPER 1

Pesticide use and Environmental Contamination in Nigeria and West Africa

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1.1. Abstract

This review examines aspects of agriculture across West Africa with regards to pesticide use with a focus on Nigeria. Small–holder farming is the mainstay of agricultural output in many West African countries and is possibly heavily reliant on pesticide technologies to ensure sufficient crop yields. There is evidence of increasing pesticide sales/usage in several West African countries over the last two decades and it is plausible that much of this increased use will be in small-holder farming. Residue monitoring in a variety of environmental matrices and foodstuffs is lacking and much of the existing data is based on *ad-hoc* studies (summarised from 1990 onwards) that report concentrations of legacy persistent organochlorine pesticides in the main. The levels of chemicals such as hexachlorocyclohexanes (HCHs), chlordanes, DDTs and aldrin/dieldrin in soil, freshwater and air are similar to or lower than those observed in contemporary European/North American studies, indicating lower use of these chemicals and/or relatively faster loss or degradative processes in tropical/subtropical regions. The occurrence of these pesticides in crop/foodstuffs is of concern, as in some cases concentrations exceed European maximum residue levels (MRLs), indicating that consumption of locally harvested produce could be a significant dietary exposure route. While regulatory bodies do exist in West African countries, the continued availability and use of banned substances like organochlorine pesticides is of concern. We recommend that planned investments into the agriculture sector within countries like Nigeria should also include strengthening regulatory agencies and community level training programmes regarding pesticide use.

1.2. Introduction

The use of pesticides is low across the whole of Africa when compared to quantities used in other continents or regions of the world (Agrow, 2006). According to Agrow (2006), only 2-4% of global pesticide production is used in Africa, although significant differences are clearly apparent between countries and regions (e.g. South Africa and West Africa). However, in parts of Africa there are concerns over high pesticide exposure, particularly occupational exposure, due to a variety of reasons ranging from poor agricultural-use practices, insufficient regulation and lack of knowledge amongst user groups that reinforces a legacy of poor-use, storage and disposal practices (Sankoh et al., 2016).

Synthetic pesticide use in Africa has occurred since the 1940s with major uses in agriculture, livestock development and disease-vector control (Wandiga., 2001). Organochlorine insecticides (OCs) dominated insect-pest control until the 1980s, followed by a rise in other insecticide classes, such as organophosphorus and carbamate insecticides, due to international restrictions on OCs and the rise in insect resistance to this chemical class (Wandiga., 2001). For example, in Kenya, importation of organophosphorus pesticides ensued after it was observed that ectoparasites such as the tick had growing resistance to organochlorine pesticides (Wandiga., 2001). Therefore development of pest resistance to specific pesticides necessitated introduction of new types of pesticides like carbofurans, carbamates among others (Wandiga., 2001).

In Africa, particularly large parts of West Africa, the agricultural sector is an essential part of the economy, vital for food security (Quinn et al., 2011). Furthermore, Nigeria (the most populous country in Africa(https://www.cia.gov/) has developed a strategy to shift its economy away from dependence on oil and expand and modernise its agricultural sector (Muhammad-Lawal et al., 2016). Coincidentally, FAO pesticide usage data reveals a large increase in pesticide use, particularly for herbicides, in many West African countries since the early 2000s (FAO., 2013). In many African countries there are now regulatory agencies whose remit covers environmental protection, sustainable pesticide use and safe-use practices. An example is the National Environmental Standards & Regulations Enforcement Agency (NESREA) in Nigeria, although their effectiveness is often hampered by lack of funding (Ubajaka et al., 2015). African governments readily sign conventions and international agreements, but these may be weakly implemented, while other important alternative international instruments and multilateral environment agreements often remain unratified, under-resourced or both (Bornman et al., 2017)

The aim of this review is to highlight current practices in pesticide use with regard to the changing nature of agriculture across West Africa, and to place this use in the context of wider environmental contamination brought about through pesticide use in recent decades. Therefore data on pesticide concentrations, particularly older organochlorine insecticides (see Tijani., 2006) are provided for different environmental compartments so that the legacy of pesticide use can be compared to other regions. This review attempts to draw together a wide range of literature, particularly journal papers that report pesticide measurements in an array of different environmental matrices from 1990 onwards. However, it also draws on literature that details aspects of agricultural practice in West African countries in order to provide some context to pesticide use and practices across this region.

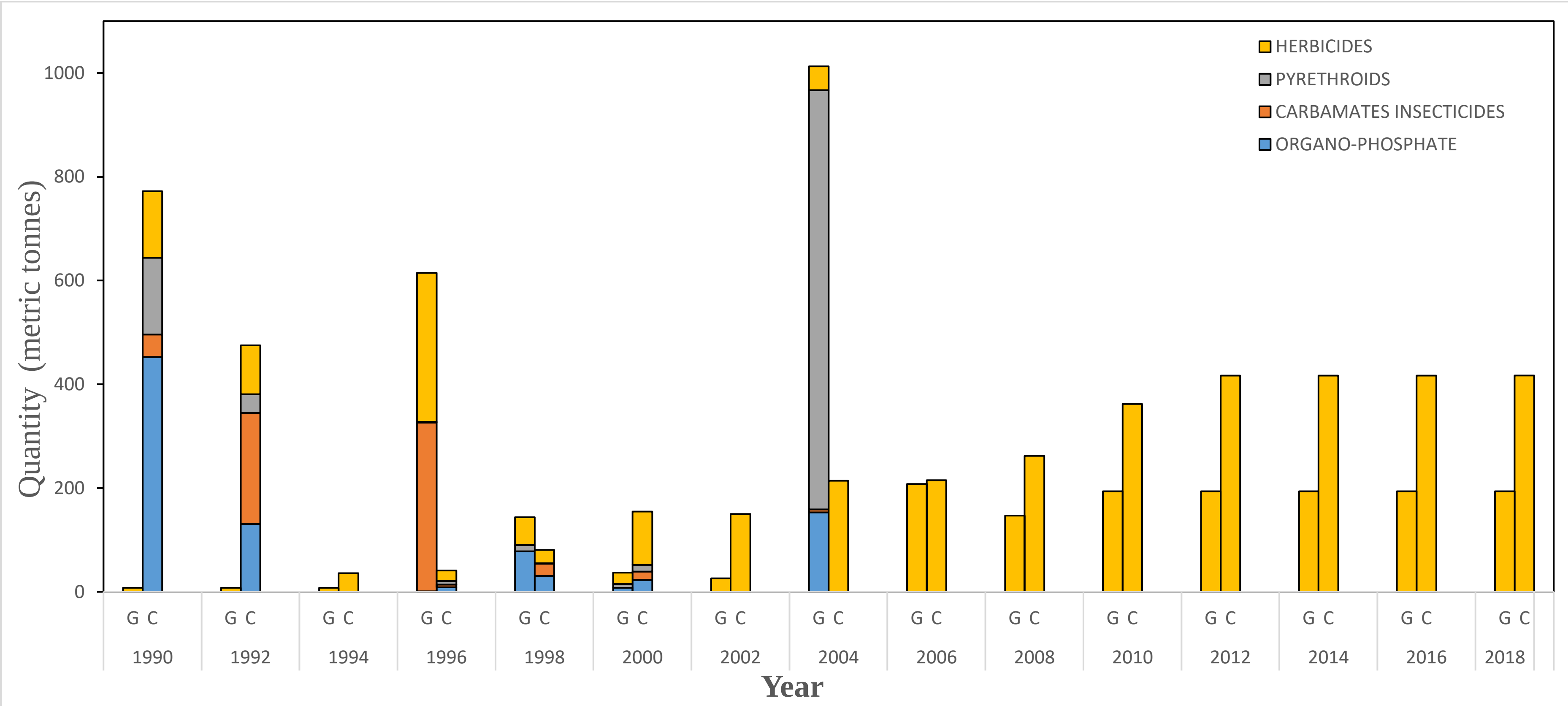

Figure 1.1: Pesticide use in two West Africa countries: Ghana (G) and Cameroon (C). Data reported comprises quantities of pesticides used in or sold to the agricultural sector

Figure 1 shows pesticide use in Ghana and Cameroon from 1990-2018 and illustrates that pesticide use varied markedly from year to year prior to 2000, with only herbicide use reported from ~2000 onwards which has generally increased with successive years. The figure also shows that Cameroon clearly used more pesticides than Ghana, which is possibly a reflection of the country's population size in comparison with Ghana. Since the early 2000s herbicide use appears to dominate pesticide use with increasing use of herbicides from 2004 onwards. This may reflect the introduction of no-till farming whereby farmers attempt to preserve nutrients, soil structure and water in the soil without tilling (Nata et al., 2014). Instead it is plausible that farmers are increasingly reliant on herbicides to control weed species on their farms.

1.3. Agriculture in Nigeria: a case study of the most populous country in West Africa.

1.3.1. Overview of the Nigerian economy and agricultural growth

Agriculture is an important sector in the Nigerian economy, providing employment, helping to eradicate poverty and contributing to the growth of the economy. Notwithstanding the contribution of the oil sector to the Nigerian economy over the past three decades, the agricultural sector is arguably the most important sector of the economy (Olajide et al., 2012). With the demand for food increasing, the country does have the available land and resources to increase crop yields in order to meet self-sufficiency as well as guarantee food security in light of a growing population (Izuchukwu., 2011). For Nigeria to sustain self-sufficiency, attention has turned from relying on the importation of staple food stuffs, like rice, to domestic production. The contribution of agriculture to Nigeria's Gross Domestic Product (GDP) has remained stable between 30-42%, but importantly, agriculture employs 65% of the labour force in Nigeria, compared to only 23% in oil (Emeka., 2007). The strong correlation established between Nigeria's total GDP and the agricultural output suggests that the prospects of the non-oil sector, and the overall economy in general, are closely tied to the performance of the agricultural sector (Olajide et al., 2012)

Studies have shown there is a positive relationship between gross domestic product (GDP) and the three independent variables of domestic savings, government expenditure on agriculture and foreign direct investment in agriculture (Izuchukwu., 2011). Efforts have been made in promoting investment and export diversification in the agricultural sector, with successive governments aiming to reposition agriculture so that it can meet domestic food needs as well as export food stuffs (Olukunle, 2013). The Nigerian government is making efforts in boosting the agricultural industry through financial incentives such as grants, loans offered at subsidised rates to farmers and funding from foreign agencies such as the World Bank. The World Bank funds several schemes in Nigeria aimed at boosting agriculture, including centres offering equipment and farm machinery at greatly subsidised rates to farmers (Eze et al., 2010). The increase in domestic rice production has led to new problems that require additional investments in order to be solved. For example, the processing capacity for rice is limited, whereby rice milling cannot keep up with production and this is compounded to some extent by frequent power outages (Ajala et al., 2015).

1.3.2. Chemicals and pesticide management

Pesticides in West Africa are not only used in agriculture, they are also used in anti-mosquito campaigns and for nuisance-insect eradication. Domestic use is also commonplace for the purpose of controlling pests and diseases (Pålsson et al., 1999). In Nigeria, like other West African states, there is no regulatory body whose overall remit covers all aspects of pesticide products, their application and use as well as their risk assessment, although two organisations, the National Agency for Food & Drug Administration and Control (NAFDAC) and NESREA (see Figure 2) cover many of these aspects. NAFDAC approves the registration of pesticides and in doing so ensure the pesticides are manufactured and sold through established and approved practices. NESREA has the responsibility for the protection and development of the environment, biodiversity, conservation and sustainable development of Nigeria's natural resources. Some functions of NESREA are to:

a. Enforce compliance with policies, standards, legislation and guidelines on water quality, environmental health and sanitation, including pollution;

b. Enforce compliance with any legislation on sound chemical management, safe use of pesticides and disposal of spent packages thereof amongst others.

1.4. Small holder Farms

Small holder farms in Nigeria, like other developing countries, dominate the agricultural economy and over 80% of the farming population in Nigeria are associated with small holder farms (Afolabi., 2010) . According to the UN's Food & Agricultural Organisation (FAO 2010) agriculture in Nigeria is predominantly on a smallholder basis with 90% of farm holdings comprising < 2 hectares in size (Onubuogu et al., 2014). One of the problems facing small holder farms is inadequate investment despite the fact that smallholder farms produce the bulk of the food consumed locally (Anyiro et al., 2011). Access to credit for small holder farmers is regarded as being instrumental in driving agricultural productivity (Rooyen., 2009).

In Nigeria, smallholder agriculture generally relies on the use of traditional technologies which are linked to low productivity. The use of traditional tools and the lack of mechanisation in farming activities areis still common practices in most rural areas. Nonetheless, relatively new technologies in the form of pesticides play an important role in smallholder agriculture which is detailed in the following sections. The use of banned pesticides occurs in smallholder agriculture across West Africa with continued sale by merchants. This ensures that these chemicals remain in circulation with continued primary sources into the environment with the potential risk of residues on food crops and contamination of local environments (Sankoh et al., 2016)

The challenges that pests pose on crop production and yields ensures that pesticide use is widespread on smallholder farms with pest control a perennial challenge for farmers in Africa. (De Bon et al., 2014). The reduction of food supply due to pests can lead to malnutrition and inadequate access to food and therefore the prevention of pest-induced food crop losses at pre- and post- harvest stages is an integral part of the millennium development goal to ensure food security and poverty reduction (De Bon et al., 2014). In tropical areas, fruits and vegetables are highly vulnerable to increased pest infestation from adjacent non-agricultural land with total failure/loss for some crops a common occurrence (De Bon et al., 2014). In developing countries in general, smallholder farmers are often poorly educated and in many cases are not aware of how agrochemicals should be safely handled, applied or disposed of correctly (Sankoh, et al., 2016). The unsafe application and exposure to these agrochemicals can have negative health impacts upon farmers and agricultural workers on both larger commercial farms and on small-holder farms (Marquis., 2013). Furthermore, exposure to pesticide residues in locally-sourced foodstuffs is resulting in negative health impacts in local populations (Sankoh et al., 2016). In May 2004, Nigeria ratified the Stockholm convention on Persistent Organic Pollutants (POPs), although in addition to this, some pesticides have been banned by the National Agency for Food and Drugs Administration and Control (NAFDAC). In 2008, a 'food poisoning' incident arising through the ingestion of pesticide-contaminated beans resulted in multiple deaths. High levels of certain pesticides were reported by the Bekwarra local government of Cross river state in food produce from the open markets around Taraba, Benue and Gombe states(Adegbola et al., 2011). Some of these banned pesticides include aldrin, binapacryl, captafol, chlordane, chlordimeform, DDT, dieldrin, dinoseb, ethylene dichloride, heptachlor, lindane, parathion, phosphamidon, monocroptophos, methamidophos, chlorobenzilate, toxaphene, endrin, endosulfan, technical-HCH. While chemicals like DDT and other organochlorine insecticides (e.g. UNEP Stockholm Convention, Annex A/B POPs) have been banned within Nigeria and other West African countries, there is concern that unlike some other African countries, Nigeria is absent in the list of countries granted permission by the United Nations World Health Organisation to control malaria-carrying mosquitoes through the use of DDT (Offoboche., 2005). Currently there is some evidence that banned substances like Aldrin etc are still in use within West African smallholder agriculture and measures to prevent their circulation and use have not been that successful (Adegbola et al., 2011).

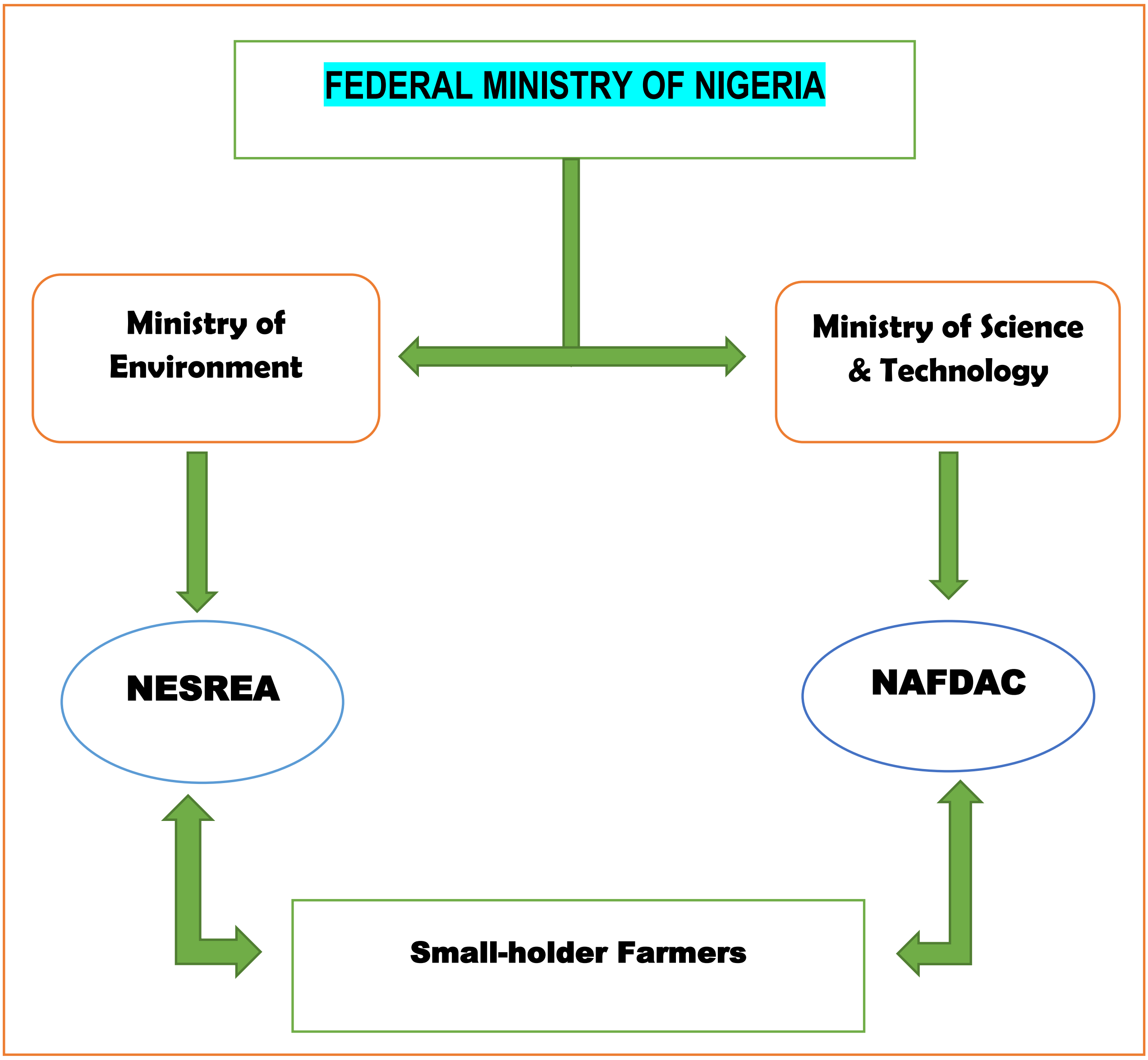

Figure 1.2: Pesticide management of small holder farmers in Nigeria. NESREA-National Environmental Standards and Regulations Enforcement Agency. NAFDAC-National Agency for Food and Drug Administration and Control

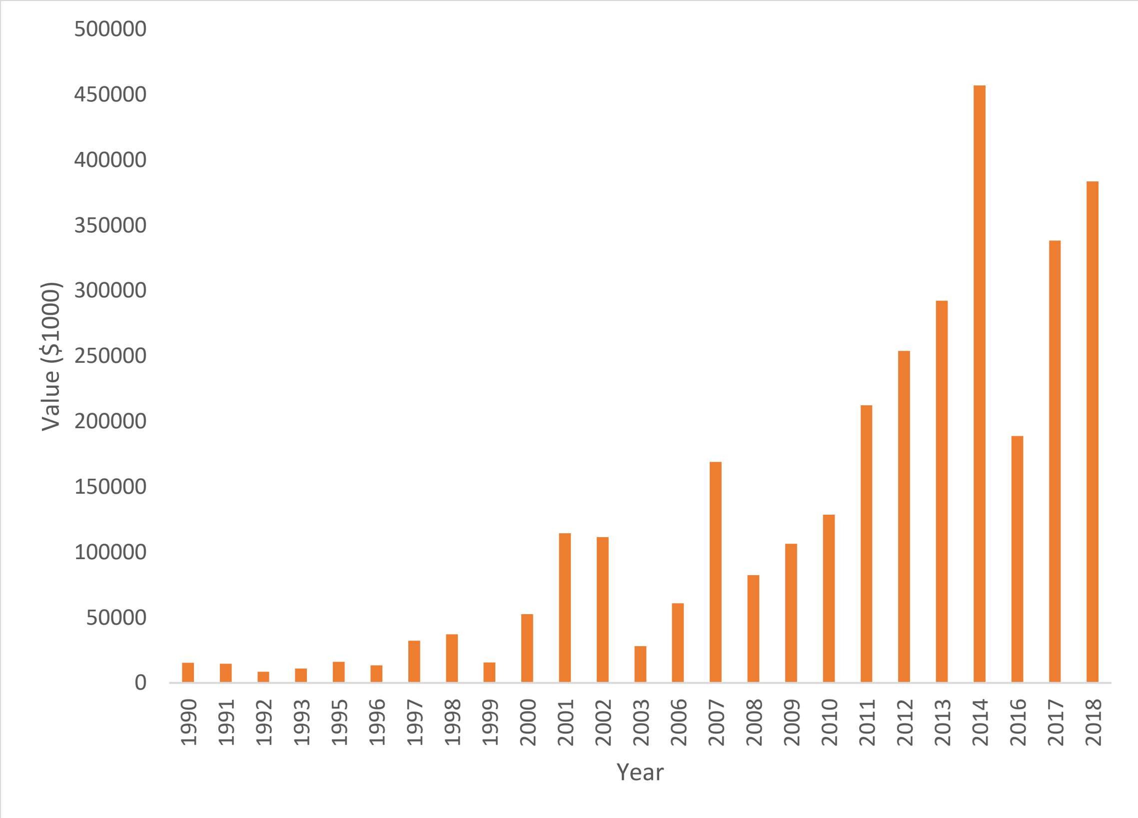

Figure 1.3: Import Value of pesticide trade in Nigeria from 1990-2018 (FAO, 2018)

Figure 1.3 shows value of pesticide imports to Nigeria from 1990-2018. The values of these imports have increased markedly from the late 1990s onwards indicating in general, a growing domestic market and demand, although this is erratic, possibly reflecting those years when pest problems are significant and hence pesticide demand is high. Illegal imports of banned pesticides is likely to be continuing as these products are available at rural market places across the country (https://wedocs.unep.org), even though the costs of these products are unlikely to be reflected in the FAO data presented in Figure 1.3.

1.5. Pesticide levels in the Nigerian/West African environment

While pesticides have been used across West Africa since the 1950s, there are no systematic environmental monitoring programmes that the authors are aware of, that establish levels in different environmental compartments or foodstuffs. Instead, there are a number of investigations based largely on university groups measuring pesticide concentrations in *ad-hoc* studies that cover a variety of environmental compartments from air to sediments as well as human foodstuffs. Selecting studies published since 1990, we have grouped studies according to the environmental compartment and provide summary statistics of pesticide concentrations. A comprehensive array of studies has been identified but these were not selected from a systematic survey of the published literature. However, there are sufficient data here to provide insight into levels observed in the West African environment and to allow us to put this region into context with other regions globally.

Table 1.1: Pesticide concentrations measured in soils and freshwater sediments (ug/kg)

Country	Pesticide	Concentration	Year	Soil/Sediment	Reference
Nigeria	Lindane/γ-HCH	7.55-141.10	2008	Soil[1]	Darko et al., 2008
Nigeria	Lindane/γ-HCH	0.33-0.35	2015	soil	Tongo et al., 2015
Nigeria	p,p'-DDT	0.304-1.08	2015	Sediment	Ibigbami et al., 2015
Nigeria	Aldrin	0.22-1.66	2015	soil	Ibigbami et al., 2015
Nigeria	Aldrin	0.13-0.40	2015	soil	Tongo et al., 2015
Nigeria	Heptachlor	0.68-9.1	2015	Soil	Ibigbami et al., 2015
Ghana	Lindane	0.40-0.80	2012	soil	Kuranchie Mensah et al., 2012
Ghana	p,p'-DDT	0.44-28.62	2012	sediment	Kuranchie Mensah et al., 2012
Ghana	Endosulfan	0.20-0.47	2012	soil	Kuranchie Mensah et al., 2012
Ghana	Aldrin	<LOD-0.005	2008	soil	Darko et al., 2008
Benin	Lindane	0.10-0.33	2008	Soil	Pare et al., 2008
Ghana	Aldrin	<LOD-0.005	2008	soil	Darko et al., 2008
Benin	Lindane	0.10-0.33	2008	Soil	Pare et al., 2008
Benin	p,p'-DDT	0.35-0.85	2008	Soil	Pare et al., 2008
Benin	p,p'-DDT	<0.1-526	2006	soil	Ondo et al., 2006
Benin	Endosulfan	0.20-0.55	2008	Soil	Pare et al., 2008
Benin	Chlorpyrifos	140-410	2008	Soil	Pare et al., 2008
Burkinafaso	Endosulfan	0.20-0.40	2006	Soil	Ondo et al., 2006

LOD= Limit of detection

Table 1.2: Pesticide concentrations (µg/kg) in soil from a selection of different countries.

Locations	(DDTs)	HCHs	Soil/sediment	Reference
China	18-142	0.03-2.4	Soil	Nakata et al 2005
New Zealand	30-34500	ND	soil	Gaw et al 2006
South California (USA)	0.11-44.8	0.1-0.54	soil	Kannan et al 2003
Georgia	0.34-33.6	0.1-0.54	soil	Kannan et al 2003
Brazil	0.12-11.01	0.05-0.92	soil	Rissato et al 2006

ND-Not detected DDTs-comprising DDDs and DDEs. HCHs-the isomers, α,β and,δ

Table 1.3: Pesticide concentrations (mean or range) in human/livestock foodstuffs and plants (µg/kg)

Countries	Pesticide	Mean or range	Year	Foodstuff	Reference
Nigeria	□-HCH	19	2015	Cowpea grains	Sosan et al., 2015
Nigeria	α-HCH	37	2015	Dried yam chips	Sosan et al., 2015
Nigeria	Endosulfan	0.157-1.06	2015	Fish	Ibigbami et al., 2015
Nigeria	DDT	53	2015	Cowpea grains	Sosan et al., 2015
Ghana	Lindane	ND	2011	Carrot	Bempah et al., 2011
Ghana	Lindane	0.16-16.2	2016	Carrot	Bempah et al., 2016
Ghana	Endrin	2	2011	Cabbage leaf	Bempah et al., 2011
Ghana	Endrin	42	2011	Cabbage	Bempah et al., 2011
Ghana	Heptachlor	44	2011	Cabbage	Bempah et al., 2011
Zambia	Dichlorvos`	24	2017	Cabbage	Mwanya et al.,2017
Zambia	Dichlorvos	0.36	2017	Cabbage	Mwanya et al.,2017
Zambia	Dichlorvos	30	2017	Cabbage	Mwanya et al.,2017
Nigeria	Endosulfan	10.42-111.57	2012	Elephant grass	Sojinu et al.,2012
Nigeria	α-HCH	14.41-99.15	2012	Elephant grass	Sojinu et al.,2012

ND-Not detected, DDT comprising DDEs and DDDs

Table 1.4: EU Maximum residue levels (MRLs) (µg/kg) of selected pesticides in certain foodstuffs (FAO, 2013)

PESTICIDE	FOODSTUFF	MRL
Lindane	Carrot	10
Heptachlor	Lettuce & Salad plants	10
Endrin	Cabbage	10
DDT	Cowpea	10
Dichlorvos	Cabbage	10
Dichlorvos	Tomatoes	10
Dichlorvos	Oranges	10
Endosulfan	Fish	10

Table 1.5: Concentrations of pesticides measured in fresh water systems (µg/L)

Country	∑HCH	∑DDT	Chlordanes	Lindane	Reference
SouthAfrica	NR	0.0055-0.04	0.0206	NR	Fatoki et al., 2004
Tanzania	NR	NR	BDL-0.81	BDL -3.66	Mohammed et al., 2014
Tanzania	ND-200	ND-1600	NR	NR	Henry et al.,2003
Ghana	0.02-1.07	ND-0.02	ND-0.12	NR	Kuranchie-Mensah et al., 2012
South Africa	29.6 − 156	147-468	0.7 − 2.7	NR	Wepener et al., 2011
Tanzania	ND-200	ND-1600	NR	NR	Henry et al., 2003

DDTs-comprising DDDs and DDEs. HCHs (S α, β and g isomers), Chlordanes- (*Cis*- and *trans*-Chlordane and *cis*- and *trans*-Nonachlor
ND-Not detected
NR – not reported
BDL-Below detection limit

Table 1.6: Atmospheric concentrations of pesticides (ng/m3) (passive sampling network)

Country	(HCH)	Endosulfan	DDT	HCB	Dieldrin	Reference
Congo	12.9	40-695	16.9	1.7	14.4	Klanova et al., 2009
Egypt	60.3	48-152	38.3	17.8	1.2	Klanova et al., 2009
Nigeria	6.9	0.8-33	6.4	1.8	0.5	Klanova et al., 2009
Senegal	20.1	182-210	411	2.8	46.5	Klanova et al., 2009
Ghana	9.1	0.8-450	12.1	12.1	2.75	Klanova et al., 2009
Ethiopia	16.5	99.6-190	108	3.2	0.8	Klanova et al., 2009
Lake Victoria	2.63	89.8	78.3	NA	NA	Arinaitwe et al., 2016
Lake Victoria	6.76	101	130	NA	NA	Arinaitwe et al., 2016
Lake Victoria	NA	23.7	106	NA	NA	Arinaitwe et al., 2016
Ghana	∑DDT	∑HCH	Dieldrin	Endosulfan	HCB	References
Congo	0.0874	0.0053	0.0228	0.0015	0.0124	White et al., 2020

Nigeria	NA	NA	NA	NA	3.0	White et al., 2020
Ethiopia	0.138	0.0146	0.0045	0.0243	0.0169	White et al., 2020

NA-Not available, ∑DDT- O,P’-DDD, O,P’-DDE, O,P’-DDT, P,P’-DDD,P,P’-DDE, P,P’-DDT ∑HCH- (α,β,γ,δ)

The pesticide concentrations found in some of the plant and foodstuffs (fruits and vegetable) exceeded the EU's maximum residue levels (MRLs) and also more than the acceptable daily intake (ADI).

Table 1.1 shows that among the pesticides listed, Chlorpyrifos, an organophosphorus insecticide, which is widely used to control a variety of insect pests in agriculture and ecto-parasites on livestock had the highest concentrations in soil, ranging from 140-410 µg/kg. The presence of OCPs in sediments indicates the wider distribution of these chemicals, most likely through runoff from agricultural areas, but also through atmospheric deposition and subsequent particle settling in aquatic systems. In Table 1.2 the HCH residues conducted were lower than those of almost all locations except for South California and Georgia (USA). According to Cavanagh et al. (1999) organochlorine concentrations in soils from tropical regions were observed to be low due to relatively rapid evaporation following application and accompanied by relatively rapid biodegradation compared to temperate soils. The table shows that the concentrations of HCHs were lower than the DDTs. This may reflect lower use of HCHs compared to DDT formulations but over time these differences are more likely to reflect varying physicochemical properties, with HCHs having higher vapour pressures, aqueous solubilities, lower soil-water distribution ratio (K_d)and likely higher biodegradability compared to DDTs (Loganathan et al., 1994)

1.6. Measurements of pesticide residues in food stuffs.

The concentrations of pesticides in selected foodstuffs are provided in Table 1.3. The concentrations observed in foodstuffs are likely to reflect localised use and application of the pesticides rather than wider background contamination. According to Sankoh et al (2016), who investigated chlorpyrifos use in Sierra Leone, the residues of this chemical in vegetables reflected the quantity of the chemical applied. The presence of ‘legacy’ organochlorine pesticides, like DDT in foodstuffs is worrisome, as having been long prohibited in Nigeria and in most European countries, their continued presence demonstrates continued illegal use or application. Reasons for high levels recorded in foodstuffs could be the minimum time allowed between the spraying of the pesticides and harvesting (Fantke et al., 2011) this is practised by many small holder farmers on the assumption that this will help conserve the vegetables before taking them to market. The presence of the chemicals and more so at high levels constitutes a problem since this produce is consumed fresh with minimal processing (washing etc). Poor pesticide handling practiced by farmers, as well as ineffective regulations in West African countries, like Nigeria, increases the prevalence of these pesticides and the risk of residues on common foodstuffs. Table 1.4 provides the EU’s Maximum Residue Levels (MRLs) tolerated for a selection of organochlorine and organophosphorus pesticides for a variety of foodstuffs. In many cases the mean or upper range concentrations for the pesticides reported in African foodstuffs in Table 1.2 exceed their corresponding MRL values. Table 1.5 shows that DDTs and HCHs were among the most prevalent pesticides detected in freshwater. Findings from the study of Wepener et al. (2011) indicated that pesticide residues in the sample area in South Africa emerged from agricultural run-off and deposits from agricultural soils. In the study of Henry et al., (2003), the pesticide concentrations for HCHs and DDTs were 200µg/L and 1600µg/L respectively. These levels were higher than those reported for water bodies in Banjul and Dakar,- the respective capital cities of Gambia and Senegal (Manirakiza et al., 2003). HCHs have been used worldwide as an insecticide since the 1950s. Similarly, DDT was used extensively for insect control from the 1950s onwards and is still used in certain African regions against mosquitoes for malaria control, along with other insecticides (see White, 2017). Lindane was detected in one of the sites for water in Tanzania with a concentration of (3.66 µg/L) above the permissible limit of (2µg/L) (FAO/WHO., 2002).

Residues from these very persistent chemicals will therefore be present in a variety of environmental matrices for many years to come and tearing apart the signal of 'legacy use' from fresh applications, particularly in foodstuffs, is an important challenge.

From Table 1.6, HCB had the highest air concentration recorded in Egypt. The highest concentrations in air for DDT and Endosulfan were observed in Senegal and Ethiopia. In the study of Klanova et al. (2009), DDT concentrations were 411 and 108 ng/m^3 for Senegal and Ethiopia respectively and for Endosulfan the range of concentrations for Senegal and Ethiopia were 182-210 and 99.6-190 ng/m^3 respectively. Arinaitwe et al. (2016) state that airborne levels of endosulfan increase during the wetter months and *vice versa* which is consistent with increased pesticide application in agricultural fields during the rainy season.

High agricultural activity is a precursor to pesticides residues in the atmosphere as seen in the Lake Victoria basin which is an agriculturally important region which experiences high pesticide use particularly during the rainy season (Shorett et al., 2010). Due to OC pesticide widespread use for the control of agricultural pests in Africa, they are among the most environmentally prevalent and widely studied POPs across the continent. (White et al., 2018). Previous studies across Africa have found atmospheric concentrations of HCHs to be either equal to or lower than those of DDT and Endosulfan (White et al., 2018). In the atmosphere, DDT is consistently detected at elevated levels in the atmosphere across Africa with high concentrations in some studies ranging from 1.88-8 ng/m$^{3.}$ The atmospheric burden of DDT has been attributed to its widespread use in agriculture across the continent but also to its current exemption in the Stockholm Convention on POPs for the control of the malarial mosquito. This has resulted to a shift in the most elevated concentrations from rural to urban sites (Adu-kunmi et al., 2012) likely due to its continued use for indoor residual spraying (Arinaitwe et al., 2016; Bird., 2017).

Transport pathways of pesticides

Pesticides do not only accumulate in the crops, they can also be transported through air, soil and water over long distances.. The main sources of air pollution b agrochemicals are via ground or aerial spraying. Airbone pesticides can migrate over considerable distances. On the other hand, dissolved pesticides and peticides bound to soil particles can be transported in the river, accumulating in river sediments.

Soil contamination mainly occurs when pesticides are applied directly to soil to protect crops. The uptake and translocation of toxic compounds from soil to plants is determined by the physicochemical properties of the pesticides e.g pesticide mobility in soil, solubility, soil composition, pH, temperature and moisture content, plant transpiration rate, plant growth, variety of fruits and vegetable. The soil composition is an important factor: humic acids and colloidal clay can serve as adsorbent for certain pesticides. Strong adsorption of pesticides onto soil particles may result in lower uptake of the pesticides by plants. Cultivation techniques contribute to an increase in bioconcentration of pesticides by plants. For instance, insecticides and fungicides are detected more frequently in tomatoes grown in greenhomes than in field-grown ones.

As pesticides also move up the food chain, biomagnification occurs. Insignificant concentrations of pesticides enter into the food chain at a low trophic level but they increase cumulatively at higher trophic levels.

1.7. Conclusion

Agriculture in West Africa is dominated by small holder farms, although in countries like Nigeria government strategy is now aimed at increased investment and regulation of agriculture involving small holder farmers. Widespread pesticide use is common in smallholder farming, with increasing sales/imports of pesticides, particularly herbicides, in recent decades across West Africa. The availability, storage, application and disposal of these pesticides in small holder farming raises concerns about occupational exposure, pesticide residue occurrence on foodstuffs and wider contamination of the environment. It is evident that there is paucity of data on monitoring of pesticide residues (Okoya et al., 2013). Routine monitoring of pesticide residues in air, water, soil and foodstuffs is not apparent, although *ad-hoc* studies do provide insight into concentrations of chemicals in these media across several West African countries, particularly for the more persistent, OC pesticides. In soil and water, contemporary concentrations of OC pesticides are akin or lower than those measured in European studies although for some foodstuffs concentrations exceed EU maximum residue levels, raising concerns for a dietary source of these chemicals to populations consuming produce from local markets. Ntow et al., (2006) demonstrate that farmers not trained in sound pesticide use often make poor decisions, leading to inappropriate pesticide applications that may lead to high pesticide residues on harvested produce and destruction of non-target organisms (e.g. beneficial insects in the case of insecticides). In Nigeria, like other West African countries, produce grown for domestic markets is rarely monitored for pesticide residues. Furthermore, poor crop storage facilities, often forces farmers to sell at peak times when harvest output is high and prices are low, and this may be another risk factor that contributes to higher pesticide residues on harvested produce.

While regulatory agencies like Nigeria's NAFDAC and NESREA do provide a framework for better management of pesticide availability and use, an effective regulatory regime to instil training with regards to pesticide use and ensure banned substances are kept out of domestic markets is lacking. Many pesticides which are banned internationally are still being used illegally across West Africa indicating that law enforcement is not adequate and the chief reason why small-scale traders e.g. 'roadside sellers' engage in the trade indiscriminately.

Recommendations from this review include:

- Routine monitoring of foodstuffs and exposure assessments of currently used pesticides (CUPs)
- There should be community-based pesticide use training programmes
- Better enforcement of laws preventing use of banned substances
- There should be refresher courses for the staff of regulatory bodies like NAFDAC and NESREA
- There should be more research geared towards studying the impact of pesticides use on the health of the people.

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Chapter 2

PAPER 2

Deriving Pesticides Exposure Doses for the Nigeria Public

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2.1. Abstract

Pesticides which are chemicals widely used in the preservation of crops and prevention of pests have been known to have adverse effects in humans and they are found in different foods in varying amounts. This has informed the need to determine the daily intake of these pesticides as they are also known to bioaccumulate and are biomagnified up the food chain. The aim of this study was therefore to determine the estimated daily intake (EDI) of various pesticides in different food products cultivated and consumed in Nigeria. Some studies were reviewed and the estimated daily intakes were computed using the mean pesticide residue concentration found in the different food samples. The result showed that while the EDI of some pesticides were found to be above their acceptable daily intake, majority were below. The three pesticides lindane, aldrin and dieldrin were found to be the most common pesticide above the Acceptable daily intake (ADI) in the foods. The EDI of the pesticides in the kola nut, watermelon and bitter kola samples were generally low and most of the pesticides in the tubers had values above the acceptable daily intake. In conclusion, more efforts are required in ensuring proper agricultural techniques are employed especially in the use of pesticides.

Keywords— pesticide, estimated daily intake, Aldrin, dieldrin, lindane, acceptable daily intake

2.2. Introduction

Pesticides are used for insect control and to increase crop yield in Agriculture. Global efforts towards the eradication of hunger and the need to meet the ever growing demand for food according to Wumbei et al. (2018) has led to the liberal use of pesticides in both developed and developing countries as pesticides have been made more affordable and accessible to farmers. The shift in policies to meet the food demand has led to the use of pesticides in sectors that it had previously not been used, for example in Ghana, pesticides were only used in planting certain crops but some restrictions have been reduced to accommodate more use (Wumbei et al., 2018).

Different types of pesticides are used in fighting vectors and protecting crops and they can be classified according to the target organism e.g. herbicides, insecticides and fungicides or according to their chemical identity e.g. organophosphates, organochlorines, carbamates and pyrethroids (Nicolopoulou-Stamati et al., 2016; Maton et al., 2016; Mazlan et al., 2017). The Organochlorines are used because according to Alle et al. (2009) they not only prevent endemic diseases by eradicating the causative vectors, and have acute and chronic effects on non-targeted organisms. These pesticides are ubiquitous in nature and are known to have harmful effects, this informed the decision to restrict their use and monitor the quantity used in farming.

There is also a ban or restriction on the use of the very toxic pesticides which include mirex, hexachlorobenzene (HCB), dichlorodiphenyltrichloroethane (DDT), heptachlor, aldrin, hexachlorocyclohexane (HCH), toxaphene, endrin, dieldrin and chlordane pesticides by the Federal Government of Nigeria due to the adverse effects produced (Mazlan et al., 2017; Ojo, 2016). The guidelines on the use of pesticides are contained in the Stockholm Convention in 2001, the Strategic Approach to International Chemicals Management and the Rotterdam Convention (United Nations Children's Fund (UNICEF), 2018; Alle et al., 2009). However, many farmers in Nigeria still use these chemicals as studies have shown (Egwaikhide et al.,2018; Akinloye et al., 2011).

Transport pathways of pesticides

Pesticides do not only accumulate in the crops, they can also be transported through air, soil and water over long distances. The main sources of air pollution by agrochemical are via ground and aerial spraying. Airbone pesticides can migrate over considerable distances. On the other hand, dissolved pesticides and pesticides bound to soil particles can be transported in the river accumulating in river sediments. Soil contamination mainly occurs when pesticides are applied directly to soil to protect crops. The uptake and translocation of toxic compounds from soil to plants is determined by the physicochemical properties of the pesticides Pullagural et al., (2018) e.g pesticide mobility in soil, solubility, (abiotic factors)- soil composition, pH, temperature and moisture content, plant transpiration rate, plant growth, varieties of fruits and vegetables Hwang et al., (2017). Cultivation techniques contribute to an increase in bioconcentration of pesticides by plants.

The pesticides contained in foods are biomagnified up the food chain and accumulate in breast milk, adipose tissue, human blood and animal tissue according to Ikpesu and Ariyo (2013). The organochlorides and HCHs are lipophilic and therefore get concentrated in fatty foods which are then biomagnified (Alle et al., 2009).

The concentration of pesticides found in foods is of great concern because of the adverse effects of these pesticides, these food products are contaminated with pesticides either during planting, through the soil, water or as a repellent of pests during planting or storage to prevent infestation and destruction (Ogah and Coker, 2012).

A study by Alle et al. (2009) was done to determine the pesticide content of organochlorines pesticides in 40 samples of maize and rice and the results were all below the MRL set by the World Health Organization (WHO) and the Food and Agricultural Organization (FAO). The types of pesticides found included the HCH and its isomers, DDT and its derivatives, endosulfan, Aldrin, dieldrin and endrin. It was also noted that the pesticide types were considered to be uniformly distributed across the different areas. Wumbei et al. (2018) assessed the pesticide residue in yam tubers from selected markets in Ghana and Belgium. Out of the 25 pesticides screened, 11 types of pesticides were detected. The result also showed that 46% of the samples had one or more pesticides although all were below the European Union (EU) Maximum Residue limit (MRL). The pesticides with the highest residue concentration were fenpropimorph, cadusafos and fenitrothion. Nineteen different types of vegetables obtained from different cities in China were analysed and found to contain organochlorine pesticides, with the pesticide content of one sample exceeding the Chinese MRL (Odhiambo et al., 2009). Kanda et al. (2012) investigated the pesticide contamination in different food products such as tomatoes, beets, onions, lettuce, chilli peepers and so on from markets in Togo and found different types of pesticide residues, though mostly organochlorine pesticides. Even kola nuts have been reported to contain pesticides as evidenced by the work of Aikpokpodion et al. (2013) in which kola nuts bought from markets in Ogun, Osun and Oyo states were found to contain chlordane, alachlor and endosulfan residues in varying degrees.

In Nigeria pesticides are used for a variety of reasons such as pest, fungus and weed control etc. In the study by Nsikak and Aruwajoye (2011) Capsicum annuum L. and Solanum lycopersicum L., bought from Ota, the Western part of Nigeria were assessed for organochlorine pesticides contamination and the result showed the presence of organochlorine pesticides, they were mostly below the FAO maximum residue limit with exception to the concentration of HCH and trans-nonachlor.

Pesticides have been known to cause many adverse effects and about 15,000 metric tons of pesticides are imported into Nigeria on a yearly basis according to Erhunmwunse et al. (2012). This is worrisome because between 10,000 and 20,000 metric tons of pesticides, particularly HCH and DDT were used between 1951-1984 in Sichuan, China and they are still being detected in the surface soil even after a ban was placed on their use over 20 years ago (Odhiambo et al., 2009). This shows the persistent nature of these pesticides, and the study further reported the presence of residual contents of DDT which exceeded the Chinese MRL of 50ng/g in the agricultural soils in some areas.

Pesticides are carcinogenic in nature being rated by the World Health Organization (WHO) as class 1 (extremely toxic) or class 2 (slightly toxic) according to their toxicity. They have been linked to cancer, birth defects, diabetes, allergy reactions, weakened immune system, neurological damage, morbidity, depression, dermatitis, cardiovascular diseases and hormonal disorders (Erhunmwunse et al., 2012; Andersson et al., 2014; Alle et al., 2009). They have different effects at different stages, like Organochlorines have been reported as being toxic to unborn babies by causing a disruption in their Deoxyribonucleic acid (DNA) structure. They have also been reported to cause convulsions, respiratory issues, vomiting and headaches (Oyeyiola et al., 2017).

In the review by Erhunmwunse et al. (2012) on pesticide residue content in 217 food items in Nigeria, Dieldrin, Aldrin and DDT were found to be above the MRL. This supported the study by Ikpesu and Ariyo (2013) that opined that pesticides are prevalent in different aspects of the environment due to the misuse of the chemicals. Incidences of poisoning from eating foods contaminated by pesticides are cited by Ikpesu and Ariyo (2013). Instances like the hospitalization of the family of a cocoa farmer for eating a leaf vegetable contaminated with lindane pesticide, also the popular cases of a death and 23 reported cases of vomiting caused by the contamination of several batches of noodles with carbofuran pesticide (Oyeyiola et al., 2017) and the poisoning of 120 girls from the Government Girls' Secondary School by beans having extremely high levels of lindane. Other cases are reported of both adult and children dying from eating beans porridge and moin moin made from beans suspected to be poisoned in Cross River and Adamawa States.

The quantity of pesticides used and the rates vary among farmers and it was found in the study by Rahman and Chima (2017) that the highest use of pesticides was found among the yam and cassava farmers with the production of yam having the highest concentration. There was a positive correlation between the use of pesticide and the cost of yam, but cassava production was seen to reduce with pesticide use.

The knowledge that pesticides are harmful and that they bioaccumulate informs the need to determine the estimated daily intake (EDI) of these pesticides in the various food items because it is known that the dose or concentration is the major factor in determining the toxicity of a chemical. Also taking subtle doses of these chemicals daily through the food we eat predisposes us to chronic effects like cancer according to Andersson et al. (2014)

This work was therefore aimed at determining the estimated daily intake of various food products cultivated and sold in Nigerian markets.

2.3. Literature Review

Ogah and Coker 2012 quantified the carbamate and organophosphate pesticide residue content in white maize bought from seven wholesale markets located in Lagos State. Selection of the grain was done ensuring samples represented all areas in the state. The mean pesticide residue content is presented in Table 2.1, and they can all be seen to be below the MRL with few slightly exceeding it. However, in the study, the maximum concentration was presented and it was noted that most of the pesticide residue concentrations exceeded the MRL with exception to malathion, parathion and pirimiphos-methyl which were found to be below the MRL. Also, pirimiphos-methyl pesticide was the major pesticide found in the maize samples with 43% occurrence. Nsikak and Aruwajoye (2011) determined the organochlorine pesticide residue concentration in Solanum lycopersicum L. (tomato) and Capsicum annum L. (chili pepper) bought from different markets in Ota, the western part of Nigeria. It was observed that most of the pesticides found in the food products were either restricted or banned under the Stockholm Convention. The mean concentrations of the pesticide residue are presented in Table 2.2. Sosan et al (2015) assessed the level of pesticide contamination in samples of yam and cowpea acquired from markets in Ile-Ife. The γ-HCH found in 90% of the yam samples and all the samples of cowpea grains exceeded the European union MRL, and though the use of this pesticide has been banned in Nigeria this study also proves that it is still very much in use. The mean concentration of pesticide residue is presented in Table 2.3. Egwaikhide et al. (2018) assessed the concentration of organochlorine pesticide residue in different vegetables (Pumpkin leaves, water leaves, pepper, tomatoes, and Spinach) from 3 markets namely New market, main market and the yam market) in the Wukari environs in Taraba State. It was noted that the vegetables are cultivated close to water bodies such as streams or surface water due to town run off which are used for irrigation. The pesticide residue contained in the vegetables were said to have either come from the water, because it was reported that the water contained significant levels of organochlorine pesticides or from the pesticides used during farming, or in the case of endrin which was found to have the highest concentration, from illegal dumpsites. From the results, pepper was seen to have the highest concentration of organochlorine pesticides while the water leaf had the lowest concentration. In the study by Mahmud et al. (2015) watermelon samples gotten from the Krigasawa, Katakam and Mashangwari agricultural locations in Gashua, Bade local Government Area (LGA) of Yobe State were assessed for organophosphorus and pyrethroid pesticide residues. The study noted that the pesticides found in the watermelon were much higher than the MRL with the highest concentration being found in the watermelon peel. The mid-range concentration of pesticides contained in the water melon samples is presented in Table 2.4. Aikpokpodion et al. (2013) examined the levels of pesticide residue in kola nuts purchased from markets in Oyo (Beere, Oja Oba, Orita-mefa and Oritamerin markets), Ogun (Mamu, Ilishan and Shagamu markets) and Osun (Orafidina and Ekusa markets) States. According to the study, pesticides are used to prevent destruction from kola nut weevils *Sophrorhinus spp* and *Balnogastris kolae*. In Table 2.5, the mean concentration of pesticide residues contained in the kola nuts are presented and it can be seen that endosulfan pesticide residue is the most common among the sample and has the highest concentration. Although, it is lower than the MRL of 0.1mg/kg, according to the study its presence is still of concern because kola nut is eaten raw without any heat treatment. In a study by Ilabor and Mayah (2015) the pesticide residue concentration of organochlorine pesticides were determined and the results presented in Tables 2.6, 2.7 and 2.8. The samples of fruits and tubers were bought from markets in the Northern part of Delta State. The low values recorded were due to the high water and low lipid content of the samples according to the study. The guava had the highest DDT residue concentration while banana had the highest Aldrin pesticide residue concentration. The kola nuts had the highest total HCH concentration which was lower than the concentration recorded in Sosan and Oyekunle (2017). Among the tubers cassava had the highest concentration of DDT, while cocoyam samples had the highest concentration of total HCH. Certain areas had higher concentration of pesticides in White yam samples like the Asaba metropolis which according to the study was due to the source of the yam. In the vegetables it was observed that the green leaf had the highest concentration of DDT while the Aldrin, pp-DDE and total DDT were below the detectable limit in the onion samples.

Table 2.1: Mean Pesticide Residue Concentration found in White Maize Samples(**Ogah and Coker (2012)**

Pesticide Residue	MRL (mg/kg)	Mean conc (mg/kg)
Cabaryl	0.05	0.0383
Carbofuran	0.1	0.0841
Chlorpyrifos	0.05	0.048
Diazinon	0.02	0.0212
Dichlorvos	2	1.1272
Fenitrothion	0.01	0.012
Malathion	8	1.5652
Parathion	0.05	0.0426
Pirimiphos-methyl	5	1.4554

Table 2.2: Mean Pesticide Residue Concentration found in Tomato and Chili pepper at Market Location, Ota Western, Nigeria (Adapted from Nsikak and Aruwajoye, 2011)

Pesticide	**Analyte**	***S. lycopersicum***	***C. annuum***
		Mean conc (mg/kg)	Mean conc (mg/kg)
Hexachlorobenzene	HCB	0.048	0.048
α- hexachlorobenzene	α- HCH	ND	ND
β- hexachlorobenzene	β-HCH	0.023	2.015
δ-hexachlorohexane	δ-HCH	0.024	1.595
γ- hexachlorohexane	γ-HCH	ND	ND
	Dieldrin	0.024	0.019
dichloro-diphenyldichloroethylene	p,p´-DDE	0.058	0.056
dichloro-diphenyldichloroethane	p,p´-DDD	0.086	ND
dichloro-diphenyltrichloroethane	p,p´-DDT	0.046	0.081
	Trans-nonachlor	0.039	0.059

ND: Not detected

Table 2.3: Mean Pesticide Residue Concentration found in Yam and Cowpea grains at Wholesale traders in Odo Ogbe and Better life markets, Ile-Ife, Nigeria (Sosan et al., 2015) and Olufade et al., 2014)

Pesticide	**Dried yam chips**	**Cowpea grains**
	Mean conc (mg/kg)	Mean conc (mg/kg)
α HCH	0.037	0.019
β-HCH	0.033	0.047

γ-HCH	0.042	0.085
δ-HCH	0.147	0.062
Methoxychlor	0.048	0.042
dichloro-diphenyldichloroethylene p,p'-DDE	0.054	0.073
dichloro-diphenyldichloroethane p,p'-DDD	0.086	0.159
dichloro-diphenyltrichloroethane p,p'-DDT	0.042	0.053
Aldrin	0.58	0.177
Dieldrin	0.036	0.056
Heptachlor	0.354	0.402
Endrin	0.158	0.152
Chlordane	0.08	0.154
Endosulfan	0.345	0.227

Table 2.4: Mean Pesticide Residue Concentration found in Watermelon at Market location:

Pesticides	**Mashangwari**	**Katakam**	**Krigasawa**
Organochlorine Pesticide	Mid-range conc (μg/kg)	Mid-range conc (μg/kg)	Mid-range conc (μg/kg)
Dichlorvos	0.32	0.46	0.43
Diazinon	0.49	0.41	0.36
Chlorpyrifos	0.51	0.90	1.0
Fenitrothion	0.36	0.52	0.42
Malathion	0.31	1.21	0.96

Fenthion	0.34	1.45	1.04
Pyrethroid Pesticides			
Cypermenthrin	0.28	0.25	0.21
Bifenthrin	0.17	0.15	0.095
Permethrin	0.17	0.19	0.16
Deltamethrin	0.15	0.17	0.11

Mashangwari, Katakam, Krigasawa agricultural locations in Gashua, Bade LGA in Yobe State (Mahmud

Table 2.5: Mean Pesticide Residue Concentration found in Kola Nut Samples at Market location: South western states (Aikpokpodion et al., 2013)

	Osun	**Ibadan**	**Ogun**
Pesticide	Mean conc (µg/kg x 10^{-3})	Mean conc (µg/kg x 10^{-3})	Mean conc (µg/kg x 10^{-3})
Alachlor	106	-	132
Endrin	104	-	-
Chlordane	109	116	111
Endosulfan	1808	1413	1527

- = Not given

Table 2.6: Mean Pesticide Residue Concentration found in Tubers at Market location: Delta North Senatorial District (Ilabor and Mayah, 2015)

Tubers	**White Yam**	**Cocoyam**	**Sweet potato**	**Cassava**
Pesticide	Mean conc. (mg/kg)	Mean conc. (mg/kg)	Mean conc. (mg/kg)	Mean conc. (mg/kg)
Total HCH	0.015	0.0181	0.0121	0.0105
Aldrin	0.004	0.0095	0.004	0.0045
Dieldrin	0.023	0.0502	0.015	0.031
pp-DDE	0.0115	0.0162	ND	0.0205
Total DDT	0.0261	0.0195	ND	0.0407

ND = Not detected

Table 2.7: Mean Pesticide Residue Concentration found in Fruit Samples at Market location: Delta North Senatorial District (Ilabor and Mayah, 2015)

Fruits	*Pineapple*	*Guava*	*Sweet orange*	*Banana*	*Plantain*	*Kola nut*	*Bitter kola*
Pesticide	*Mean conc (mg/kg)*	*Mean conc (mg/kg)*	*Mean conc (mg/kg)*	*Mean conc (mg/kg)*	*Mean conc (mg/kg)*	*Mean conc (mg/kg)*	*Mean conc (mg/kg)*

HCB	*ND*	*ND*	*0.0013*	*ND*	*0.0012*	*0.0014*	*0.0015*
Lindane	*0.0018*	*0.0035*	*0.0014*	*0.0025*	*0.0014*	*0.1104*	*0.005*
Total HCH	*0.0024*	*0.0042*	*0.0017*	*0.0063*	*0.0022*	*0.1255*	*0.005*
Aldrin	*0.0016*	*0.0015*	*0.0015*	*0.0024*	*0.0016*	*ND*	*ND*
pp-DDE	*0.0021*	*0.0029*	*0.0012*	*0.0018*	*0.0021*	*ND*	*ND*
Total DDT	*-*	*0.0201*	*0.0054*	*0.0034*	*0.002*	*ND*	*ND*

ND = Not detected

ND = Not detected
- = Not given

Table 2.8: Mean Pesticide Residue Concentration found in Vegetables at Market location: Delta North Senatorial District (Ilabor and Mayah, 2015)

Vegetables	**Onion**	**Water leaf**	**Red Pepper**	**Tomato**	**Okro**	**Pumpkin Leaves**	**Spinach**
Pesticide	Mean conc (mg/kg)	Mean conc (mg/kg)	Mean conc (mg/kg)	Mean conc (mg/kg)	Mean conc (mg/kg)	Mean conc (mg/kg)	Mean conc (mg/kg)
HCB	ND	0.0013	0.0014	0.003	0.0016	ND	0.0015
Lindane	0.0013	0.002	0.0016	0.0015	0.0025	0.002	0.0025

Total HCH	0.007	0.003	0.0035	0.003	0.0045	0.0025	0.0022
Aldrin	ND	0.0016	0.0016	0.0015	0.0016	0.0015	0.0055
pp-DDE	ND	0.0013	0.0075	0.005	0.0012	0.0015	0.0035
Total DDT	ND	0.0135	0.0014	0.0701	0.006	0.018	0.0722

2.4. Methodology

2.4.1. Research Area

Nigeria is the most populated country and the second largest economy in Africa with a population of over 158 million people and an annual growth rate of 2.5%. It has thirty- six states, one capital and seven hundred and seventy-four local government areas (Organization for Economic Cooperation and Development (OECD), 2012). It is home to a diverse group of people from different tribes and religions with the predominant ethnic groups being Hausa, Yoruba and Igbo. According to the National Bureau of Statistics (NBS), Agriculture contributed 19.17% to the nominal GDP for the first quarter of 2016 (NBS, 2016). The map of Nigeria showing the different states is presented in Figure 1.

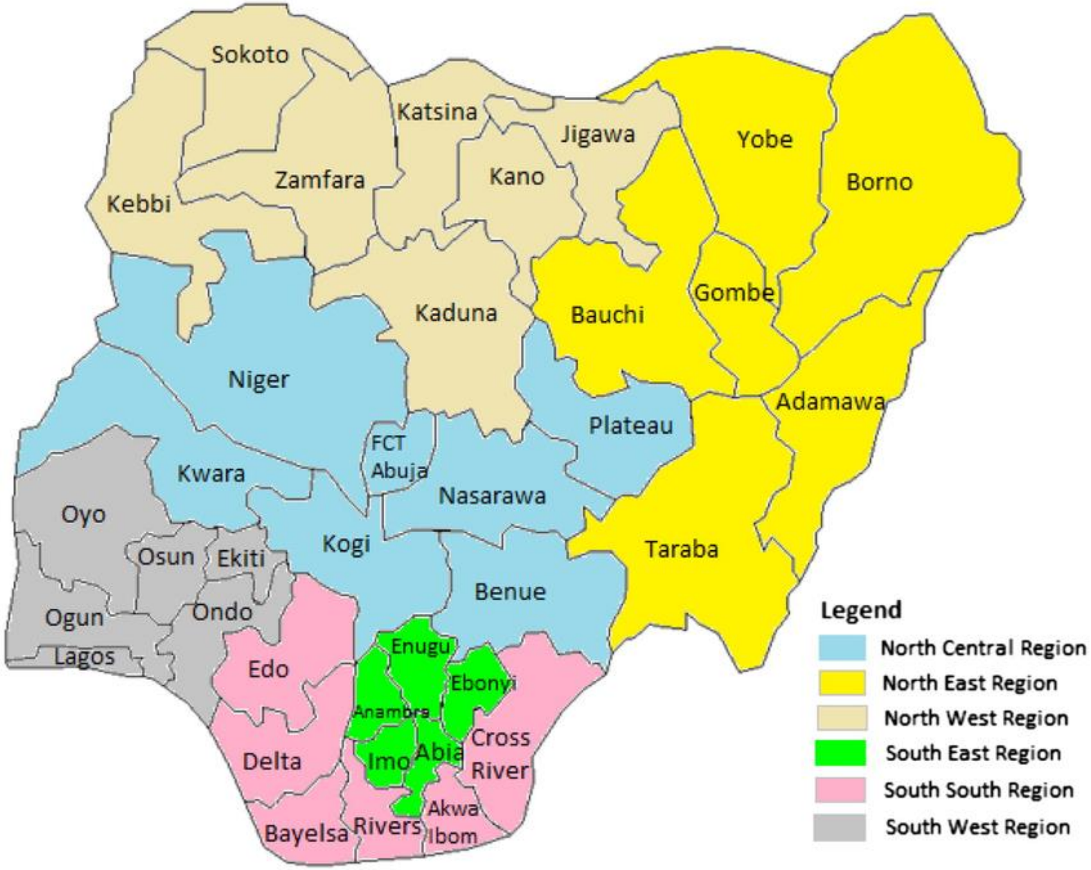

Figure 2.1: Map of Nigeria showing the various States
Source: Gayawan and Turra (2015)

2.4.2. Research Design

This study was performed using secondary data which included previous studies that determined the pesticide residue contents of food stuffs cultivated and sold in Nigeria. Seven studies were reviewed and analysed to determine the estimated daily intake of various pesticides. The formula for determining EDI is presented below.

$$\text{EDI} = \frac{Prc \times Fcr}{Bw}$$

Prc = Pesticide residue concentration (mg/kg)

Fcr = Food consumption rate (kg/day)

Bw = Body weight (kg)

The food consumption data aids researchers in risk assessments and in assessing dietary exposure to toxic chemicals (Szucs *et al*., 2013). The food consumption data used in this study was obtained from The Global Environment Monitoring System (GEMS) Food Cluster Diets (Verger, 2012) and the body weight used for adults was 60kg (Ogah *et al*., 2012; Oyeyiola *et al*., 2017). The food consumption rate for the different foods being analysed in this study is presented in Table 2.9. The EDI was compared against the acceptable daily intake (ADI) for humans which is the level of chemical intake that can be taken every day over a lifetime without any substantial risk to health (Australian Pesticide and Veterinary Medicines Authority, 2017).

Table 2.9: Food Consumption Data

Food	Type of Food	Consumption data (g/day)
White yam, Potatoes, Cocoyam and Cassava	Roots and Tubers (raw or boiled)	165.9
Maize, Cow pea grains	Cereals and grains	330.5
Kola nut, Bitter Kola nut	Tree Nuts	6.7
Tomato, Chili Pepper, Okro	Fruiting Vegetables	24.2
Watermelon	Fruiting Vegetable, cucurbits	6.2
Guava, Pineapple, Banana, Plantain	Tropical fruits	74.5
Sweet Orange	Citrus fruits	20.8
Pumpkin leaves, Water leaves, Spinach	Leafy Vegetables	0.5
Onions	Bulb Vegetables	11.3

Source: Verger (2012)

2.5. Discussion

The estimated daily intake and the acceptable daily intake (ADI) of the pesticides from the different food products is presented in Tables 2.10-2.17 (Oyeyiola et al., 2017; Australian Pesticide and Veterinary Medicines Authority, 2017). The EDI of the pesticide dichlorvos found in maize samples was higher than the ADI in Table 2.10, while in Table 2.11 all pesticides were below the ADI. The EDI of Aldrin, heptachlor, endrin and pesticides in yam and cowpea grains, and the EDI of chlordane in only cowpea grains was above the ADI as seen in Table 2.12. In the watermelon and Kola nut samples presented in Tables 2.13 and 2.14, all pesticides were below the ADI. The EDI of aldrin, dieldrin, pp-DDE, total DDT pesticides found in the tubers in Table 2.15 were all above the ADI. This shows the level of pesticide used in cultivating tubers. There was only one exception in the cassava samples in which the EDI of the total DDT pesticides was below the ADI. In Table 2.16 the EDI of aldrin and pp-DDE pesticides were above the ADI in the pineapple, banana and plantain, while, in the guava samples, the EDI samples of the lindane, Aldrin, pp-DDE and total DDT were above the ADI. In the sweet orange samples only the EDI of the Aldrin pesticide was above the ADI while the EDI of the lindane pesticide was above the ADI in the kola nut samples. The EDI of all pesticides in the bitter kola samples were below the ADI. In Table 2.17 the EDI of the pp-DDE pesticide in the red pepper and tomato samples, and the EDI of the total DDT pesticide in the tomato and spinach samples were above the ADI. The results shown are cause for concern and should lead to a probe into the farming practices in Nigeria because according to the Australian Pesticide and Veterinary Medicines Authority (2017) when proper agricultural techniques are used the pesticide residue concentration is either below the permissible limit or not detected. The tolerable daily intake (TDI) as seen in some tables are used in place of ADIs for pesticides which have been banned in farming but are still observed due to past use and the persistent nature of the pesticides. Lindane, aldrin and dieldrin pesticides were observed to be widely used and abused as they were the pesticides seen to be present in quantities above the ADI. Table 2.8 shows results of pesticide concentration levels in vegetables and fruits are generally lower than that of tubers and grains which corroborates the study of Oyeyiola et al, 2017. The study looked into Estimated daily intake of pesticides as there are not so many studies that considered that in Nigeria previously.

Table 2.10: Estimated Daily Intake of pesticides from White Maize

Pesticide Residue	ADI (mg/kg/bw/d)	EDI
Cabaryl	0.008	0.000211
Carbofuran	0.003	0.000463
Chlorpyrifos	0.003	0.000268
Diazinon	0.001	0.000117
Dichlorvos	0.001	0.006209
Fenitrothion	0.002	0.000066
Malathion	–	0.008622
Parathion	–	0.000235
Pirimiphos-methyl	0.02	0.008017

Table 2.11: Estimated Daily Intake of pesticides from Tomato and Chili pepper

Pesticide	Analyte	ADI (mg/kg/bw/d)	*S. lycopersicum*	*C. annuum*
			EDI	EDI
Hexachlorobenzene	HCB	0.015	0.000019	0.000019
α- hexachlorobenzene	α- HCH	0.015	ND	ND
β- hexachlorobenzene	β-HCH	0.015	0.000009	0.000813

δ-hexachlorohexane	δ-HCH	0.015	0.000010	0.000643
γ- hexachlorohexane	γ-HCH	–	ND	ND
	Dieldrin	0.0001	0.000010	0.000008
dichloro-diphenyldichloroethylene	p,p´-DDE	0.001	0.000023	0.000023
dichloro-diphenyldichloroethane	p,p´-DDD	0.001	0.000035	ND
dichloro-diphenyltrichloroethane	p,p´-DDT	0.02	0.000019	0.000033
	Trans-nonachlor		0.000016	0.000024

ND: Not detected

Table 2.12: Estimated Daily Intake of pesticides from Yam and Cowpea grains

Pesticide	**ADI (mg/kg/bw/d)**	**Dried yam chips**	**Cowpea grains**
		EDI	EDI
α HCH	0.015	0.000102	0.000105
β-HCH	0.015	0.000091	0.000259
γ-HCH		0.000116	0.000468
δ-HCH	0.015	0.000406	0.000342
Methoxychlor	0.1 (TDI)	0.000133	0.000231

dichloro-diphenyldichloroethylene p,p'-DDE	0.001	0.000149	0.000402
dichloro-diphenyldichloroethane p,p'-DDD	0.001	0.000238	0.000876
dichloro-diphenyltrichloroethane p,p'-DDT	0.02	0.000116	0.000292
Aldrin	0.0001 (TDI)	0.001604	0.000975
Dieldrin	0.0001 (TDI)	0.000100	0.000308
Heptachlor	0.0005 (TDI)	0.000979	0.002214
Endrin	0.0002 (TDI)	0.000437	0.000837
Chlordane	0.0005 (TDI)	0.000221	0.000848
Endosulfan	0.006	0.000954	0.001250

TDI = Tolerable Daily Intake

Table 2.13: Estimated Daily Intake of pesticides from Watermelon

Pesticides	ADI (mg/kg/bw/d)	Mashangwari	Katakam	Krigasawa
Organochlorine Pesticide		EDI	EDI	EDI
Dichlorvos	0.001	0.000033	0.000048	0.000044
Diazinon	0.001	0.000051	0.000042	0.000038
Chlorpyrifos	0.003	0.000053	0.000093	0.000103
Fenitrothion	0.002	0.000038	0.000054	0.000044
Malathion		0.000033	0.000126	0.000100
Fenthion		0.000035	0.000150	0.000108
Pyrethroid Pesticides				
Cypermenthrin	0.05	0.000029	0.000026	0.000022
Bifenthrin	0.01	0.000016	0.000016	0.000010
Permethrin	0.05	0.000018	0.000020	0.000017
Deltamethrin	0.01	0.000016	0.000018	0.000012

Table 2.14: Estimated Daily Intake of pesticides from Kola Nut

Pesticide	ADI (mg/kg/bw/d)	Osun	Ibadan	Ogun

		EDI	EDI	EDI
Alachlor		0.000012	-	0.000015
Endrin	0.0002 (TDI)	0.000012	-	-
Chlordane	0.0005 (TDI)	0.000012	0.000013	0.000012
Endosulfan	0.006	0.000202	0.000158	0.000171

- = Not given

Table 2.15: Estimated Daily Intake of pesticides from Tubers

Tubers	**ADI (mg/kg/bw/d)**	**White Yam**	**Cocoyam**	**Sweet potato**	**Cassava**
Pesticide		EDI	EDI	EDI	EDI
Total HCH		0.050046	0.050047	0.033457	0.029033
Aldrin	0.0001	0.026268	0.026268	0.011060	0.012443
Dieldrin	0.0001 (TDI)	0.138803	0.138803	0.041475	0.085715
pp-DDE	0.001	0.044793	0.044793	ND	0.056683
Total DDT	0.02	0.053916	0.053918	ND	0.112536

ND = Not detected

Table 2.16: Estimated Daily Intake of pesticides from Fruit

Fruits	**ADI (mg/kg/bw/d)**	**Pineapple**	**Guava**	**Sweet orange**	**Banana**	**Plantain**	**Kola nut**	**Bitter kola**
Pesticide		EDI	EDI	EDI	EDI	EDI	EDI	EDI
HCB	0.015	ND	ND	0.000451	ND	0.00149	0.000156	0.000168
Lindane	0.003	0.002235	0.004346	0.000485	0.003104	0.001738	0.012328	0.000558
Total HCH		0.002980	0.005215	0.000589	0.007823	0.002732	0.014014	0.000558
Aldrin	0.0001	0.001987	0.001862	0.000520	0.002980	0.001987	ND	ND
pp-DDE	0.001	0.002608	0.003601	0.000416	0.002235	0.002608	ND	ND
Total DDT	0.02	-	0.024958	0.001872	0.004222	0.002483	ND	ND

ND = Not detected
- = Not given

Table 2.17: Estimated Daily Intake of pesticides from Vegetables

Vegetables	**ADI(mg/ kg/bw/d)**	**Onion**	**Water leaf**	**Red Pepper**	**Tomato**	**Okro**	**Pumpkin Leaves**	**Spinach**
Pesticide		EDI	EDI	EDI	EDI	EDI	EDI	EDI

HCB	0.015	ND	0.000010	0.000565	0.00121	0.000645333	ND	0.000013
Lindane	0.003	0.000244	0.000017	0.000645	0.000605	0.001008333	0.000017	0.000021
Total HCH		0.001318	0.000025	0.001411	0.00121	0.001815	0.0000201	0.000018
Aldrin	0.0001	ND	0.000013	0.000645	0.000605	0.000645333	0.000013	0.000046
pp-DDE	0.001	ND	0.000011	0.003025	0.002017	0.000484	0.000013	0.000029
Total DDT	0.02	ND	0.0135	0.0014	0.028274	0.00242	0.00015	0.0722

2.6. Conclusion

The estimated daily intake of pesticides present in the different food stuffs were majorly low showing some progress in the proper use of pesticides in farming, however more efforts are needed in order to produce food free from these pesticides especially tubers. It also highlights the need to limit use of these chemicals especially the very harmful ones as they are persistent in nature and remain in the soil and water long after use. The farmers do not give the required attention to these products being majorly consumed locally in Nigeria, since they do not go through the interntional market that may reject the product because of high pesticide residues. Therefore, there is need to enforce regulations regarding its usage. There is also need for routine monitoring programs for the pesticide residues in food items in order to prevent, reduce and control the pollution and to minimize health risks.

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Chapter 3

PAPER 3

A comprehensive survey of smallholder farmers in Akwa Ibom State and some other states (Nationwide), to understand farming practices and associated pesticide use in Nigeria

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3.1. Abstract

Commonly used pesticides and handling practices among farmers were investigated in agricultural zones of Akwa Ibom State, Nigeria in which there were 486 respondents. Another Nationwide survey representative of the six geo-political zones in Nigeria with 185 respondents was done. In the Akwa Ibom survey, direct field observations and answers to a semi structured questionnaire showed that Pyrethroids are the most wildly used pesticide. Most farmers have not received training on pesticide application. Overall, 68% of the farmers use personal protective equipment (PPE) during pesticide application. Most farmers (75%) do not monitor or test their farm produce for pesticide residues, most of those who do, find low levels of concentration of pesticide residues. Results showed that most important crops were pumpkin (Leavy green vegetable), maize and cassava in reverse order of importance. 80% of the farmers use knapsack sprayer to apply pesticides. Overall, most farmers prefer to apply pesticides twice in a planting season while sending products to the market for sales within 3 weeks after pesticide application. The results showed that the awareness of farmers and authorities needs to be raised regarding use of PPE and correct procedures when handling pesticides and there should also be strict enforcement of monitoring.

Keywords-Pesticide, personal protective equipment, pyrethroids, pesticide residues

3.2. Introduction

Agriculture in Nigeria is dominated by smallholder farms with ~90% of individual farm holdings being < 2 ha in size. Approximately 80% of the farming population work on smallholder farms, producing the bulk of food consumed locally across Nigeria. Agriculture is dominated by small holder farmers who occupy the majority of land and see to the production of most of crop and livestock products. The key challenge of the smallholder farmers is the fact that the productivity can be low owing to their lack of access to markets and credit facilities and technology. That has still not deterred the farmers who are most smallholder farmers. The recent surge in food prices coupled with the fact that there is need to have alternative source of livelihoods to oil which has remained the mainstay is enough motivation for the farmers.

For there to be effective farming done, there is a corresponding need for the pesticides to be used sustainably as there has been a general lack of information regarding the extent of pesticide use in-country. It is against this background that two surveys were carried out. One of the surveys was centred around the Niger delta region-particularly in Akwa Ibom state, while the other though with less number of respondents had a more nation-wide representation. It is hoped that these surveys could be used to inform the regulators about the general pesticide use practices and possibly help set national policy or targets in determining what is being used by whom, how it is used and for what purposes. Smallholders generally rely on traditional technologies to undertake farming with low levels of mechanisation. Agriculture plays a key role in poverty eradication and sustainable development but due to pests, losses are often incurred. The use of pesticides is a common practice globally and even though it is an effective way to combat pests yetit has the potential to adversely impact human, animal and the ecosystem(Aktar, Sengupta et al. 2009).

Despite smallholder farmers relying on low technology or traditional practices to farm, they appear to rely on agrochemicals and modern plant protection products to deal with pest problems affecting their crops. The extent of this use and the array of products used however is not widely known according to the authors' knowledge, which is the rationale behind the questionnaire survey. . Small-scale farmers were both interviewed and given paper questionnaires. Pesticide use by smallholder farmers is complicated based on the pesticide products available in local markets, the crops being grown and the range of pests affecting these crops. In addition, compared to larger farms or plantations, pesticide use may be haphazard , poorly controlled and likely to lead to high operator exposure and generally a greater risk of exposure to the smallholder farm family and the local environment (Akinyemi, 2017)

Objectives

- To study the prevalence of pesticide use among small holder farmers
- To observe how pesticides are handled among the farmers

3.3. Methodology

Study Area: The study focused on commercial farms in Akwa Ibom State. Akwa Ibom nicknamed: "Land of Promise" is a state in Nigeria, located in the coastal southern part of the country, lying between latitudes $4^{o}32'$N and $5^{o}83'$N, and longitudes $7^{o}25'$E and $8^{o}25'$E. The state is bordered on the east by Cross River State, on the West by Rivers State and Abia State, and on the South by the Atlantic Ocean and the Southernmost tip of Cross River State. It has a total area of 7.081km^2 (2,734sqm$_I$) with a population of over 5 million people and more than 10 million people in the wider diaspora. It was created on the 23rd of September, 1987 from the former Cross River State and is currently the highest oil and gas producing state in the country. The state's capital is Uyo. Along with English, the main spoken languages are Ibibio, Annang, Eket and Oron Language. Akwa Ibom State is divided into three soil classification zones. In each zone, a team of interviewers visited small holder farmers.

Questionnaire:The farmers were interviewed using a structured interview (contained in the appendix) The structured questionnaires targeted a total of within the selected areas. The final total number of respondents was determined by the number available and also willing to participate. The schedule used for the interviews was translated into 'pidgin english'. Focus group discussions were also held with target groups not covered by the interviews. Communications were mainly in pidgin and translated to Hausa, Igbo and yoruba languages. The discussions were held in an informal way. The young farmers had their interview conducted where most young men and boys gather for their leisure time. For the women, their interviews were conducted in the morning before starting their domestic work. In the questionnaires, respondents were asked the names and types of crops and typical pest problems, which is intended to allow scientists/agronomists to get insight into most prevalent pest types and hence the data could be used to develop alternative strategies to combat these pests rather than solely on pesticide use. The interviews aimed among otherpoints to explore awareness of pesticide prescription and handling practices. The interviews and questionnaires explored the farmers' awareness and perceptions of (i) types of agricultural pesticides, knowledge of pesticides sold at their shops; seasonality use of the pesticides, The interviews explored awareness and perceptions regarding different agricultural pesticides use and storage methods. Direct observations of agricultural practices in the farms, including handling and disposal practices of the pesticides were also done. Furthermore, the interviews cosidered, the pesticides used on the crops, the types of equipment they use during application, whether or not they have been trained on pesticide application. The interviews were questionnaires with open-ended and semi structured questions. In each agricultural zone, a team of interviewers visited the users of pesticides. In the questionnaires, they were asked the names of crops they treated the pesticides with, the pesticides used on the crops, the types of equipment they use during application, whether or not they have been trained on pesticide application.   The ages of the farmers were also ascertained in the interviews which showed it was dominated by male older farmers as explained in the demographics section.

3.4. Results for Akwa Ibom Survey

Discussion The interviews showed that the local farmers used different types of pesticides to assess and determine their pesticide application approaches.

3.4.1. Demographics of the respondents

“The majority of the respondents (herein called ‘farmers’) were male and aged from 45-55. The percentage of female farmers was 31.5% . The range of their ages was also the case across the six Agricultural zones. The least involved among the respondents are those between the ages of 16-25 years old. Most of the respondents were involved in farming both for food and business purposes. About 58.9% of farmers did not have a formal/informal training on pesticide application; this is often the case among farmers, which in turn imparts negatively on pesticide use. This is also seen in this study (Ackerson and Awuah 2010)

3.4.2. Crops and farming practices

Most of the respondents cultivate more than one type of crop. Overall, 285 of the farmers (59%) grew cereal crops mostly cassava and maize. Most farmers prepared their land in November and December, planted in January and harvested in may or June. For the dry season, farms were prepared around may, planted in June and then harvested in October.

3.4.3. *Pests and pesticides applied*

The highest proportion of pesticides surveyed/reported were insecticides. This was the case as used by most farmers especially vegetable growers. Most insecticides had a single active ingredient. Though some farmers were of the impression that a mix of different active ingredient would make for a more potent/effective pesticide. This is always based on head knowledge as the farmers always had the impression that having been involved in farming for many years that their experience could be applied to other things such as the knowledge of the right mix of dosage of pesticides that would work effectively.

3.4.4. *Patterns of pesticide use*

Most of the farmers reported applying insecticides twice in a planting season or anytime there were pests. Some farmers also frequently sprayed herbicides to prevent or delay the growth of weeds.

“since pesticides are not as effective as they have known it to be, I always try to apply it more often to increase the potency as there are lots of pests attacking the farm and its products”.

The results of a survey carried out to document the pattern of pesticide used in Akwa Ibom State are presented in Tables 3.1-3.21. The survey consisted of 486 respondents in 6 agricultural zones in Akwa Ibom. Majority of respondents were males (68%). Most of the respondents were 46-55 years of age. Types of pesticides used in the different zones varied widely. Important crops: pumpkin (leafy green vegetable), maize, and cassava, in descending order of importance. In the farmers’ opinion, pesticides remain active after application only in one planting season. Most farmers apply over 250 ml of pesticide formulation/m^2 with the majority of farmers (~80%) using a knapsack sprayer for pesticide application. The remaining 20% use hand pump. Overall, 68 % of farmers use PPEs during pesticide application. Most farmers prefer to apply pesticides twice per planting season. Most farmers do not receive training on pesticide application. Most farmers (75%) do not monitor or test their farm produce for pesticide residues. Most farmers who monitor or test their produce find low-level concentrations of pesticides. There was a lack of formal training among most farmers as can be seen in the study of (Ibitayo 2006). Particularly, Uyo had the highest number of farmers who have not received any form of training followed by Oron .Which is a major reason why pesticides are used inappropriately. This is capable of resulting in health hazards such as seen in (Jeyaratnam, Lun et al. 1987) Generally, as seen from the survey, farmers send their produce to the market within three weeks of pesticide application, which could lead to consuming foodstuffs with high levels of pesticide concentrations. The survey also stated that most farmers do not monitor or test their produce for pesticide residues, while those who do, find the residues to be at low levels as seen in (Table 3.12), this is unlike the study of (Aiyesanmi et al., 2012) where concentrations were high and so had potential dangers it may pose to the soil organisms by way of translocation of residues from the soil into other crops that may be intercropped within the farms. It was observed that the farmers were given more to wearing long sleeved shirts than personal protective equipment (PPE) and majority of the farmers practised this. This finding however demonstrates that skin absorption, not inhalation is the right knowledge of pesticide route of absorption, which is consistent with some other studies regarding handling of pesticides by rural farmer such as Burleigh, Vingnanakulasingham et al. (1998);(Berg 2001, Matthews, Wiles et al., 2003). From interactions, some of the farmers had their storage facilities in their houses just like in (Stadlinger et al., 2011) where they had prioritised for that purpose and normally placed out of reach of children.

Table 3.1: Demographics of the survey number of respondents (percentage of total))

Zone:	Uyo	IkotEkpene	Abak	Etinan	Eket	Oron	Total
	(n=241)	(n=63)	(n=51)	(n=35)	(n=43)	(n=53)	(n=486)
Gender							
Male	173(71.8)	39(61.9)	37(72.5)	18(51.4)	27(62.8)	39(73.6	333(68.5)
Female	68(28.2)	24(38.1)	14(27.5)	17(48.6)	16(37.2)	14(26.4)	153(31.5)
Age (years)							
16-25	5(2.1)	1(1.6)	0(0.0)	0(0.0)	3(7.0)	0(0.0)	9(1.9)
26-35	21(8.7)	7(11.1))	7(13.7)	7(20.0)	5(11.6)	0(0.0)	47(9.7)
36-45	51(21.2)	13(20.6)	7(13.7)	6(17.1)	14(32.6))	5(9.4))	96(19.8)
46-55	119(49.3)	34(54.0)	31(60.8)	21(60.0)	17(39.5)	38(71.7)	260(53.5)
≥56	45(18.7)	8(12.7)	6(11.8)	1(2.9)	4(9.3)	10(18.9)	74(15.2)

Table 3.11: Percentage frequency of pesticides used in six agricultural zones of AkwaIbom State

Pesticide	Uyo222	IkotEkpene85	Abak47	Etinan55	Eket52	Oron163	Total624
Decis(Pyrethroid)I	36(16.2)	6(7.1)	8(17.0)	16(29.1)	10(19.2)	0(0.0)	76(12.2)
Attack(Permethrin)I	11(5.0)	3(3.5)	4(8.5)	2(3.6)	1(1.9)	0(0.0)	21(3.4)
DD force (Dichlorvos)I	7(3.2)	5(5.9)	8(17.0)	1(1.8)	8(15.4)	1(0.6)	30(4.8)
TermextermicotChlorpyrifos) I	70(31.5)	3(3.5)	9(19.1)	5(9.1)	1(1.9)	46(28.2)	134(21.5)
Kambat-combat(Cypermethrin) I	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.9)	0(0.0)	1(0.2)
Furadan (Carbofuran)I	3(1.4)	1(1.2)	3(6.4)	3(5.5)	1(1.9)	4(2.5)	15(2.4)
Karate(lambda-cyhalothrin) I	4(1.8)	10(11.8)	3(6.4)	16(29.1)	15(28.8)	3(1.8)	51(8.2)
Apron-plus(Mefenoxam)F	5(2.3)	1(1.2)	4(8.5)	0(0.0)	1(1.9)	1(0.6)	12(1.9)
Nuvacrun(Monocrotophos)I	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.6)	1(0.2)
Aldrin aldrinduvct(Aldrin) I	1(0.5)	0(0.0)	1(2.1)	0(0.0)	0(0.0)	1(0.6)	3(0.5)

Cyper force (Cypermethrin)I	0(0.0)	7(8.2)	0(0.0)	0(0.0)	2(3.8)	1(0.6)	10(1.6)
Insect powder(Carbamate) I	2(0.9)	0(0.0)	0(0.0)	0(0.0)	1(1.9)	2(1.2)	5(0.8)
Dimetrin (Deltamethrin) I	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.6)	1(0.2)
Super karto	0(0.0)	14(16.5)	0(0.0)	1(1.8)	0(0.0)	1(0.6)	16(2.6)
Ambush (Permethrin) I	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.6)	1(0.2)
Actron 40	0(0.0)	2(2.4)	0(0.0)	0(0.0)	1(1.9)	1(0.6)	4(0.6)
Best (Imidacloprid) I	14(6.3)	3(3.5)	1(2.1)	2(3.6)	2(3.8)	46(28.2)	68(10.9)
Basudin (Diazinon) I	4(1.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4(0.6)
Premextangrama run	3(1.4)	7(8.2)	0(0.0)	0(0.0)	0(0.0)	1(0.6)	11(1.8)
Gramazon (Paraquat) H	4(1.8)	0(0.0)	0(0.0)	0(0.0)	2(3.8)	48(29.4)	54(8.7)
Others	58(26.1)	23(27.1)	6(12.8)	9(16.4)	6(11.6)	4(2.5)	106(17.0)

I-Insecticide, H-Herbicide, F-Fungicide

Table 3.12: Farmers' response to most important economic crops for pesticide application is AkwaIbom State

	Uyo241	IkotEkpene63	Abak51	Etinan35	Eket43	Oron53	Total486
Cassava	85(35.3)	33(52.4)	23(45.1)	12(34.3)	25(58.1)	52(98.1)	230(47.3)
Maize	166(68.9)	39(61.9)	20(39.2)	16(45.7)	19(44.2)	49(92.5)	309(63.6)
Pumpkin	162(67.2)	29(46.0)	27(52.9)	23(65.7)	26(60.5)	50(94.3)	317(65.2)
Okro	4(1.7)	0(0.0)	3(5.9)	1(2.9)	2(4.7)	1(1.9)	11(2.3)
Plaintain	0(0.0)	0(0.0)	2(3.9)	0(0.0)	1(2.3)	2(3.8)	5(1.0)
Melon	28(11.6)	13(20.6)	5(9.8)	1(2.9)	9(20.9)	2(3.8)	58(11.9)
Cucumber	11(4.6)	1(1.6)	1(2.0)	1(2.9)	1(2.3)	2(3.8)	17(3.5)
Water leaf	0(0.0)	0(0.0)	0(0.0)	1(2.9)	1(2.3)	1(1.9)	3(0.6)
Tomatoes	12(5.0)	2(3.2)	1(2.0)	4(11.4)	0(0.0)	3(5.7)	22(4.5)
Pepper	4(1.7)	1(1.6)	0(0.0)	3(8.6)	2(4.7)	1(1.9)	11(2.3)
Others	72(29.9)	15(23.8)	13(25.5)	2(5.7)	7(16.3)	48(90.6)	157(32.3)

Table 3.13: Farmers' opinion on period in which pesticides will remain active

	Uyo191	Ikot Ekpene59	Abak29	Etinan33	Eket37	Oron52	Total401
Not known	17(8.9)	2(3.4)	4(13.8)	1(3.0)	0(0.0)	50(96.2)	74(18.5)
On maturity / harvesting	17(8.9)	18(30.5)	12(41.4)	12(36.4)	14(37.8)	1(1.9)	74(18.5)
One planting season	104(54.5)	34(57.6)	11(37.9)	25(75.8)	22(59.5)	1(1.9)	187(46.6)
Others	53(27.7)	5(8.5)	2(6.9)	5(15.2)	1(2.7)	0(0.0)	66(16.5)

Table 3.14: Quantity (dosage) of pesticides use per square metres of farmland

Dosage	Uyo133	Ikot Ekpene28	Abak21	Etinan21	Eket15	Oron50	Total280
20-25 ml	61(45.9)	1(2.6)	0(0.0)	2(9.5)	0(0.0)	2(4.0)	66(23.7)
51- 100 ml	17(12.8)	1(2.6)	1(2.6)	0(0.0)	0(0.0)	0(0.0)	19(6.8)
101-150 ml	28(21.1)	13(34.2)	8(23.8)	5(23.8)	6(40.0)	0(0.0)	60(21.6)
151-250 ml	27(20.3)	23(60.5)	13(60.5)	13(61.9)	9(60.0)	48(96.0)	127(45.7)
Above 250 ml	0(0.0)	0(0.0)	1(4.8)	1(4.8)	0(0.0)	0(0.0)	4(1.4)

Table 3.15: Method of pesticides application in Akwa Ibom State

Equipment	Uyo183	Ikot63 Ekpene	Abak31	Etinan33	Eket37	Oron7	Total354
Hand pump	42(23.0)	13(20.6)	8(25.8)	4(12.1)	4(12.1)	3(42.9)	74(20.9)
Knapsack	141(77.0)	50(79.4)	23(74.2)	2.9(87.9)	33(89.2)	4(57.1)	280(79.1)

Table 3.16: Use of personal protective equipment(PPE) during pesticide application in Akwa Ibom

PPE usage	Uyo201	Ikot55 Ekpene	Abak32	Etinan34	Eket37	Oron33	Total392
Used	102(50.7)	51(92.7)	27(84.4)	30(88.2)	29(78.4)	29(87.9)	268(68.4)
Not used	99(49.3)	4(7.3)	5(15.6)	4(11.8)	8(21.6)	4(12.1)	124(31.6)

Table 3.17: Frequency of pesticides application within a planting season in Akwa Ibom

Frequency	Uyo193	Ikot58 Ekpene	Abak31	Etinan34	Eket35	Oron7	Total358
Once	32(16.6)	5(8.6)	3(9.7)	6(17.6)	4(1.4)	2(28.6)	52(14.5)
Twice	82(42.5)	27(46.6)	11(35.5)	19(55.9)	7(20.0)	0(0.0)	146(40.8)
3 time	8(4.1)	11(19.0)	5(16.1)	3(8.8)	4(11.4)	0(0.0)	31(8.7)
As need rises	43(22.3)	11(19.0)	6(19.4)	0(0.0)	11(31.4)	5(71.4)	76(21.2)
>3 times	28(14.5)	4(6.9)	6(19.4)	6(17.6)	9(25.7)	0(0.0)	53(14.8)

Table 3.18: Time allowed after pesticides application before sending products to the market

Time interval	Uyo	Ikot Ekpene	Abak	Etinan	Eket	Oron	Total
1 week	32(16.0)	9(15.3)	1(3.1)	1(2.9)	2(5.4)	0(0.0)	45(12.2)
2-3 weeks	110(55.0)	38(64.4)	23(71.9)	28(80.0)	29(78.4)	5(71.4)	233(63.0)

4 weeks and above	58(29.0)	12(20.3)	8(25.0)	6(17.1)	6(16.2)	2(28.6)	92(24.9)

use/application

Table 3.19: Farmers who have received formal or informal training on pesticide

Training	Uyo226	Ikot60 Ekpene	Abak45	Etinan35	Eket39	Oron47	Total452
Trained	43(19.0)	51(85.0)	21(46.7)	26(74.3)	18(46.2)	11(23.4)	170(37.6)
Not trained	183(81.0)	9(15.0)	24(53.3)	9(25.7)	21(53.8)	36(76.6)	282(62.4)

Table 3.2: Pesticides monitoring/testing in farm produce before sales

Monitoring	Uyo207	Ikot61 Ekpene	Abak36	Etinan35	Eket39	Oron7	Total385
Not monitored/ tested	151(72.9)	49(80.3)	30(83.3)	31(88.6)	25(64.1)	5(71.4)	291(75.6)
Monitored/ tested	56(27.1)	12(19.7)	6(16.7)	4(11.4)	14(35.9)	2(28.6)	94(24.4)

Table 3.21: Outcome (in terms of levels) of pesticides monitoring/testing in farm produce

Level	Uyo	Ikot Ekpene	Abak	Etinan	Eket	Oron	Total
High	4(2.8)	0(0.0)	2(7.7)	0(0.0)	0(0.0)	0(0.0)	6(2.1)
Medium	7(4.9)	10(19.2)	0(0.0)	0(0.0)	4(16.7)	3(60.0)	24(8.5)
Low	133(92.4)	42(80.8)	24(92.3)	30(100.0)	20(83.3)	2(40.0)	251(89.3)

Pesticides Safety and Application: This survey showed that the label and safety instructions were not always followed when pesticides are purchased. Written safety instructions were only in English and majority of the smallholder farmers were incapable of reading English.

The pesticides were reported according to the trade name of the locally available product. The farmers' knowledge about the chemicals used was very limited and knew only the commercial names. Most farmers as reported by (Stadlinger et al., 2011)applied pesticides twice during the planting season and some others 1-3 times during the period. (Table 3.17). Majority of the farmers are of the opinion that the pesticides remain active only in one planting season. It was also gathered from (Table 3.11) that for Uyo zone, Decis being the trade name for Pyrethroid (insecticide)is the most common pesticide, for Abak zone DD *Force* and *Decis* are the most commonly used pesticides. *Decis* (Pyrethroid) seems to be widely used, the physical properties of being found to be stable and persisting in the environment for a long time being the major reason it is so (Elliott et al., 1978)

The equipment mostly used and preferred was the Lever-operated knapsack sprayer and it is known to be efficient The use of the knapsack sprayer in itself presents some danger to the user, since it is prone to leakage, especially as the sprayer ages Matthews et al. (2003) identified causes of leakage from the knapsack and have emphasised the need to provide better-quality equipment at an acceptable cost that will be more durable in a hot and humid tropical environment such as Africa. In addition, during spraying, farmers do not distinguish between target and non-target crops. Non-target susceptible crops are therefore also exposed to the pesticide.

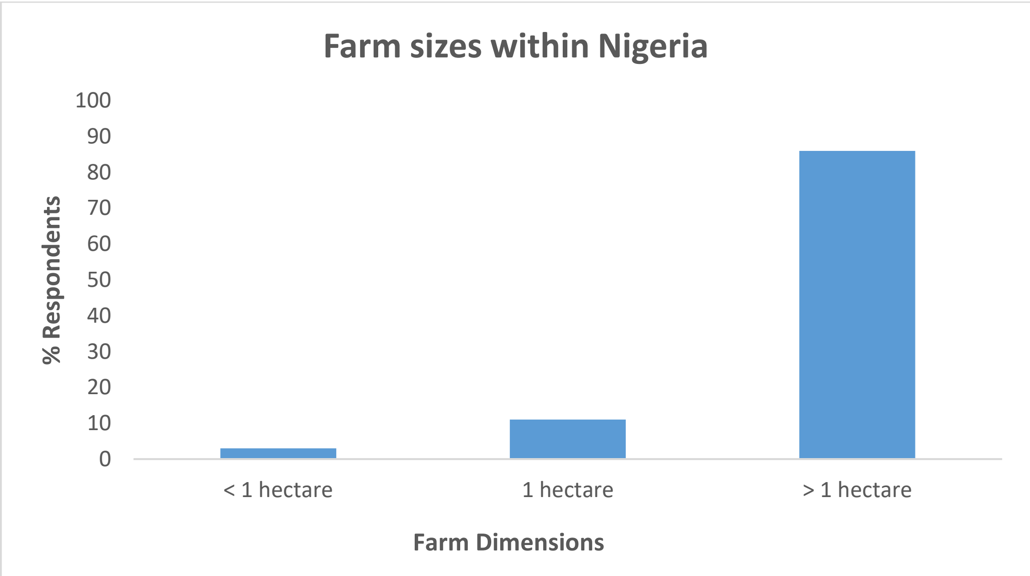
Overall, 68% of farmers use Personal protective equipment during pesticide application which offers some form of encouragement unlike the findings by (Okoffo et al., 2016)

Farmers do not follow recommended frequencies of pesticide application by Government agencies for crops (Denkyirah et al., 2016). This often leads to cases of misuse, overuse and indiscriminate application with no regard to chemical of use.

3.5. Nationwide Survey

Due to lack of information on practices surrounding farming and the use of pesticides, a survey (Nationwide) was undertaken in the form of questionnaires distributed to 185 farmers in four distinct geographic regions of Nigeria; North, South, East and West, Benue state (Makurdi) being representative of the North, Edo state (Benin) being representative of South, Imo State (Owerri) being representative of East and Oyo state (Ibadan) being representative of the west. These regions are typical of Nigerian agriculture as they are smallholder farms located in the remote areas, representative of farming with pesticides fully in use. The purpose of the survey was to illustrate how pesticides are being used and the impact on both the people and the environment. The questionnaire was written in English but the interviews were conducted in ‘pidgin’. These farmers were interviewed to ascertain the following information: pests experienced in the farms and the category of pesticides applied on them, sizes of farms and types of crops grown. Their method of disposing of the remaining pesticides, The survey revealed that some of the crops seen are among the key crops found in Nigeria (Nations 2017). About 90% of the respondents had farm sizes >1 hectare but < 10 hectares compared to farm holdings in Europe the average agricultural holdings of 16 hectares.(Explained 2015) as seen inFAO for other African countries (FAO, 2017)

Figure 3.1: An indication of farm size in Nigeria based on a survey of 185 farmers across four agricultural regions of Nigeria



3.6. Results and Discussions

It was generally gathered from the interviews that pesticides increase crop yield and reduce losses. It was equally found that those exposed to pesticides, cut across people who are within the workforce age in Nigeria, as some boys of 16 years of age and men of 65 years were actively engaged in farming, women were also involved in farm activities such as weeding, planting and harvesting which corroborates the study of (Oluwole et al ., 2009) suggesting that farming families in Nigeria are in contact with pesticides.. Table 3.22 Lists the major pesticide products returned from the survey. Out of 185 respondents a common list of 13 products were identified (Table 3)indicating a low number of plant protection products with regards to the number in use. The feedback from the interviews and survey showed that a variety of pesticides such as Cypermethrin, Glyphosate and Carbendazim with trade names as ‘Dragon’, ‘Round up’ and ‘Fungu-force’, respectively, among others are in use by farmers. The survey also showed that application of these pesticides is not limited to any particular season (wet or dry) as it is conducted all through the year and is dependent on the crop grown. The survey clearly showed that over the past decade, pesticide use has been on the increase and dependent on the crop. It was generally revealed (anecdotally) from the interview with farmers that the outgone year (2016) witnessed the highest attack of pests on crops. From the interviews and survey conducted, all respondents were of the view that the pesticides used kill both target and non- target organisms. It was revealed that farmers do not follow label instructions, the number/ diversity of products use is more on the larger farms than the smaller ones. It was equally revealed that 90% of the respondents had no formal training. Those who were trained, received an informal training through untrained farmers as in Sankoh et al., (2016), In some areas, the pesticides are also used for hunting bush meat and some fish. This information was gleaned from follow up interviews. Some of the pesticides like Acifluorfen with the trade name ‘Tackle’ is banned in the EU while Permethrin's use is restricted, yet these pesticides are still wildly used in Nigeria as is made evident from the survey. The results also indicated a lack of knowledge and also a lack of training among users of pesticides (farmers) which corresponds with the findings of a study/research in Zambia (Mwanja et al., 2017)

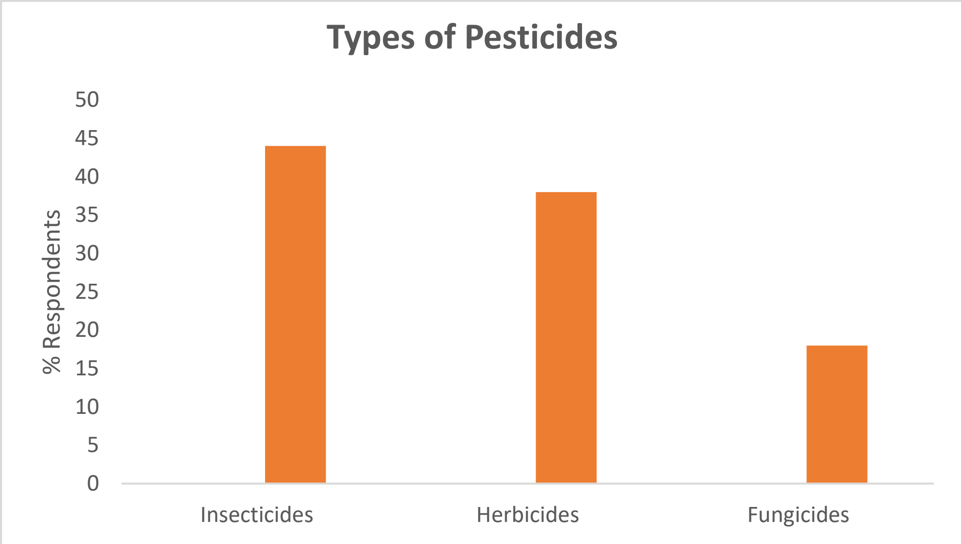
The aspect that has to do with training is central to what can be obtained generally with respect to the use of pesticides and mainly among the farmers. This has a way of influencing other aspects like ;use of personal protective equipment, ways of disposing pesticides, ways of storing the pesticides among othersThe majority interviewed took the wearing of personal protective equipment as being optional citing reasons such as; financial difficulties, inconveniences/irritations experienced in having it on.

The farmers stored the pesticides within their homes as they did nott have specific locations for storage. They did so in their houses for fear of the pesticides being stolen if left within the farming area, an act that has the potentials of exposing people (users and non- users) to hazards especially children (Tijani 2006) These are some of what the farmers had to say:

"*I am a Nigerian and also an African, we are strong natured, wearing of personal protective equipment (PPE) can be very inconveniencing. I only make sure I wash my hands after the application of pesticides".*

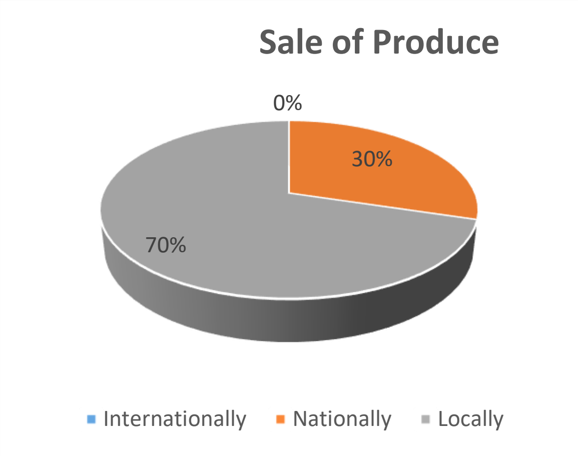
"I normally drink a cup of milk daily after dealing with pesticides as I believe it has a way of neutralising the toxic effects of the pesticides in my system"

Figure 3.2: Indication of extent of use of the category of pesticides across the four agricultural zones in Nigeria



From the survey conducted, like the study of (Ngowi et al., 2007) insecticides were the highest occurring with herbicides following closely while fungicides were the least, this is not exactly what we see from (FAO 2013) where herbicides were mostly used in African countries like Ghana which could be as a result of different agricultural practice

Figure 3.3: Percentage of respondents on where pesticides are sold and disposed



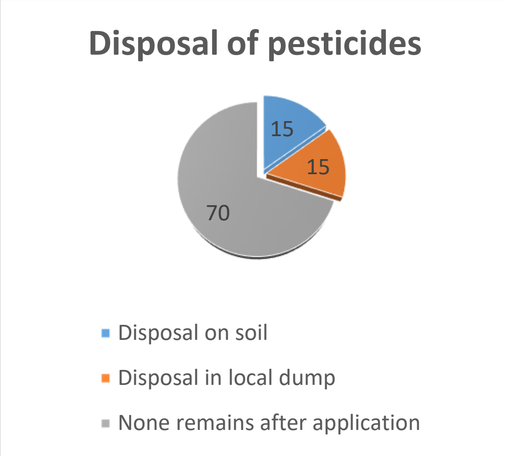


Table 3.22: List of the pesticide products in use in the representative regions for the field survey in Nigeria

	Trade Name	Active Ingredient
1.	Dragon (I)	Cypermethrin
2.	Delta force (I)	Deltamethrin
3.	Lara force (I)	Pyrethroid
4.	Imiforce (I)	Imidacloprid
5.	Uproot (H)	Clethodim
6.	Quick action (I)	Imidacloprid

7.	Attack (I)	Permethrin
8.	Round up (H)	Glyphosate
9.	Force up (H)	Glyphosate
10.	Fungu- Force (F)	Carbendazim
11.	Termex (I)	Chlorpyrifos
12.	Tackle (H)	Acifluorfen
13.	Butaforce (H)	Butachlor

H=Herbicide, I = Insecticide, F = Fungicide

Table 3.23: List of common crop types grown in the surveyed regions

SN.	Crop types
1.	Water melon(Citrullus lanatus)
2.	Cucumber(Cucumis Sativus)
3.	Yam(Dioscorea)
4.	Plantain(Musa paradisiaca)
5.	Melon(Cucumis Melo)
6.	Okro (Abelmoschus esculentus)
7.	Pepper(Capsicum)
8.	Cassava(Manihot esculenta)

9. Garden egg(Solanum melongena)

3.7. Conclusion

This study has shown that majority of the farmers are using pesticides and that a wide range of current use pesticides is in use. The storage, handling and application methods are inappropriately done and have also shown that farmers now have to be educated on best practices in the application of these pesticides and also on the need to always wear personal protective equipment when necessary. During the application of these pesticides, farmers often inhale the pesticides and these have a tendency to endanger the respiratory systems of the farmers.The surveys showed that a greater number of those involved in smallholder farming are men. The Akwa Ibom survey particularly showed that these were men at older ages, The survey also showed that it is generally believed that pesticides can only be active within one planting season which suggests more application of pesticides would be required in subsequent seasons for it to be effective. The Akwa Ibom survey shows that Insecticides are predominantly in use by the small holder farmers while the nationwide survey shows a blend of Insecticides, herbicides and fungicides being used

This chapter is intended to review pesticide use in Nigeria . Many factors come into play in this, ranging from the types and sizes of farms, types of pesticides, how they are handled and the potential impacts of pesticides in the environment. Results from the two surveys of 671 farmers capturing both Akwa Ibom state and nationwide, revealed that pesticides are misused and abused which is attributed to farmers not being educated and lacking formal training on the use of pesticides. The survey also ascertained the knowledge and perception farmers had about pesticides

Therefore, the need to train farmers cannot be over-emphasised. There has been a significant increase of pesticide use across the years (Damalas et al., 2019), which further buttresses the fact there has been an increase in pesticide use over the past decade. The Nigerian Government is not enforcing laws enough, and that is chiefly the reason most of the traders and road side sellers engage in the trade indiscriminately

3.8. Recommendations

- The Nigerian Government should strive to improve the regulation of pesticides use and control the approach to the import of pesticides.
- Farmers should be trained on the handling of pesticides before being allowed to do so on their farms.
- Pesticides sales should not be done openly in local markets by petty traders
- There is need for manufacturers to use more of pictorials to demonstrate the safe handling of pesticides
- There should be a synergy between the Nigerian government and agricultural based institutions to train more personnel on pesticide usage.

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Chapter 4

PAPER 4

Assessment of Residual Pesticides in Soils from Commercial Farms in Akwa Ibom State.

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4.1. Abstract

Globally, pesticides are listed in the class of chemicals known as "hazardous chemicals". They are classed as hazardous chemicals because they are characteristically toxic and persistent, hence possess the ability to bioaccumulate (build up in fatty tissues in individual organisms) and concentrate further or biomagnify up food chains. Most of the chemicals used as pesticides such as aldrin, chlordane, dieldrin, endrin, heptachlor, mirex, toxaphene, etc. are banned chemicals. Thus, without good and conscientious management practices, these hazardous chemicals and their wastes can pose significant risks to human health and the global environment. Soil has been identified as a sink from which pollutants can be released into air and water. Farmers use pesticides to control the outbreak of pests and diseases of crops in farmlands, sometimes without proper

education on application protocols. These have led to contamination of foods with high levels of pesticides and subsequent death of consumers of such foods. The objective of this study was to evaluate the levels and distribution of organochlorine pesticides in commercial farms across six (6) agricultural zones of Akwa Ibom State, Nigeria. Soil samples were collected and analysed using GC-MS for quantification of the levels of residual organochlorine pesticides. The average levels of residual organochlorine pesticides in the farms were highest for Obokitu agricultural zone (27,730ng/kg) with a-HCH and lowest for same pesticide was in OGU(147.47ng/kg)s indicating variability and possible differences in amounts of pesticide applied in these zones.

4.2. Introduction

Nigeria is an agrarian nation with about sixty percent of her population constituted by farmers, who engage in cropping and animal rearing. Farming and animal husbandry are prone to pest and vector attacks which inflict heavy economy losses on the practitioners, hence, necessitating application of control measures including use of hazardous chemicals.

Historically, chemical pesticides have contributed to the protection of crop, human and animal health against pest destruction and vector infestation. Although Nigeria is not a producer of chemical pesticides, her demands for pest/vector control in Agriculture and other sectors are met marginally by few local formulators and majorly through imports from exporting countries in Europe, Asia and South America. Hence, vast quantities are being procured in Nigeria by Governments and private merchandise.

Use of pesticides in the agricultural sector has provided enormous benefits, increased production and quality, as pests and disease damage up to one-third (1/3) of crops in the growth, harvest and storage phases (Tadeo, 2008). Pesticides are substances meant for attracting, seducing, and then destroying any pest. They are a class of biocide. (www.panna.org/pesticides-big-picture/pesticide-101). The Food and Agricultural Organization (FAO of UN) defines pesticide as any substance or mixture of substances intended for preventing, destroying, or controlling any pest, including vectors of human or animal diseases, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transporting or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. The term also includes substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport. In agricultural crop production, the term " pest" is used in the broad (FAO of UN) concept to refer to unwanted arthropod pests (insects, mites and millipedes), pathogens (viroids, viruses, bacteria, fungi, algae, and nematodes), vertebrates (rodents and birds), parasitic flowering plants and non-parasitic weeds, both annuals and perennials.

Pesticides are widely applied to protect plants from disease, weeds and insect damage, and usually come into contact with soil, where they undergo a variety of transformations that provide a complex pattern of metabolite (Andreu et al., 2004). The intensive use of pesticides has resulted in the contamination of soil, water and sediments (Singh, 2001; Ware et al., 1986). Pesticides may reach the soil and sediment compartments via different routes. The most direct route involves their application to soils for the control of weeds or micro organisms (e.g. herbicides) and the indirect route involves application to the aerial parts of plants to control pests and diseases. After the application of a pesticide, it may meet a variety of fates, such as loss to the atmosphere through volatilization or breakdown by photolysis, retention by soil materials (involving adsorption and desorption processes), transportation by run-off or leaching to the surface and ground water (Saltzman et al., 1986; Vander Hoff et al., 1999). This presents a problem for the supply of drinking water to the populace. Many of the pesticides are transported to the environment while freely dissolved in water or bound to suspended sediments. As a consequence, pesticides are frequently detected in soil, sediments and other environmental matrices, where the risk they may pose has to be controlled.

Objectives

- **To determine the level of peticides in the environment**

- **To establish if there are pesticide residues in non -farm areas/locations**

4.3. Literature Review

The global drive for industrialization, economic development, improved food supply and better quality of human lives have catalyzed large-scale commercial production of synthesized hazardous chemical substances and their systematic multifarious applications in all sectors of human endeavors, namely: industry, agriculture, mining, public utilities and health care delivery system, among others. Consequently, the global output of hazardous chemicals increased approximately 10 - fold between 1970 and 2010, while millions of people throughout the world lead richer, more productive and more comfortable lives because of the thousands of chemicals on the market today (UNEP, 2018)

Hazardous chemicals are often divided into three categories: pesticides, industrial chemicals, and unintentionally produced by-products. Some of these chemicals are characteristically toxic and persistent, hence possess the ability to bioaccumulate (build up in fatty tissues in individual organisms) and concentrate further or biomagnify up food chains. These chemicals belong to a genre, known as Persistent Organic Pollutants (POPs). Thus, without good management practices, these hazardous chemicals and their wastes can pose significant risks to human health and the environment especially the poorest members of the global community. POPs-derived pollution burdens and accompanying adverse toxicological and environmental implications have become the focus of growing national and international concerns, as priority hazardous chemicals. These, consequently, triggered concerted and targeted efforts of the international community to consistently call for concerted global actions, with a view to reducing and eliminating releases of these chemicals and the consequent threats they pose to the environment of the whole globe (UNEP 2018). It has been empirically observed that POPs exposure could cause birth defects in humans/animals and is also associated with some forms of cancer, immunological and reproductive disorders, damage to the central and peripheral nervous systems and a diminishing of intelligence, among others.

These international institutional attempts to reduce risks associated with hazardous human -made chemicals that pose a direct threat to human health and the environment. The continuous infiltration of POP-chemicals into developing countries like Nigeria and their unceasing use in pest/vector control and other endeavours poses major public health and environmental concerns, due to gaps in infrastructural/regulatory capacities for ensuring their safe use and disposal (UNEP, 2018).

Soils can play an important role in the global fate and distribution of pollutants since they have been identified as a sink from which pollutants can be released into water or air (Shegunova et al., 2007). Organochlorine Pesticides (OCPs) such as dichlorodiphenyltrichloroethane (DDT) and hexachlorocyclohexane (HCH) are of significant concern and have been studied extensively in the last several decades due to high toxicity, long environmental half-lives and long-scale transportation ability. The compounds can be transferred from soil into food chains, and enter aquatic environments through effluent release, atmospheric deposition, run off and other means (Bakan and Ariman 2004). Dichlorodiphenyltrichloroethane (DDT) was listed on the Stockholm convention as one of the 12 persistent organic pollutants (POPs) in 2004 and Hexachlorocyclohexane (HCH) (ie α, β, y HCH -lindane) were added to the list in 2009.

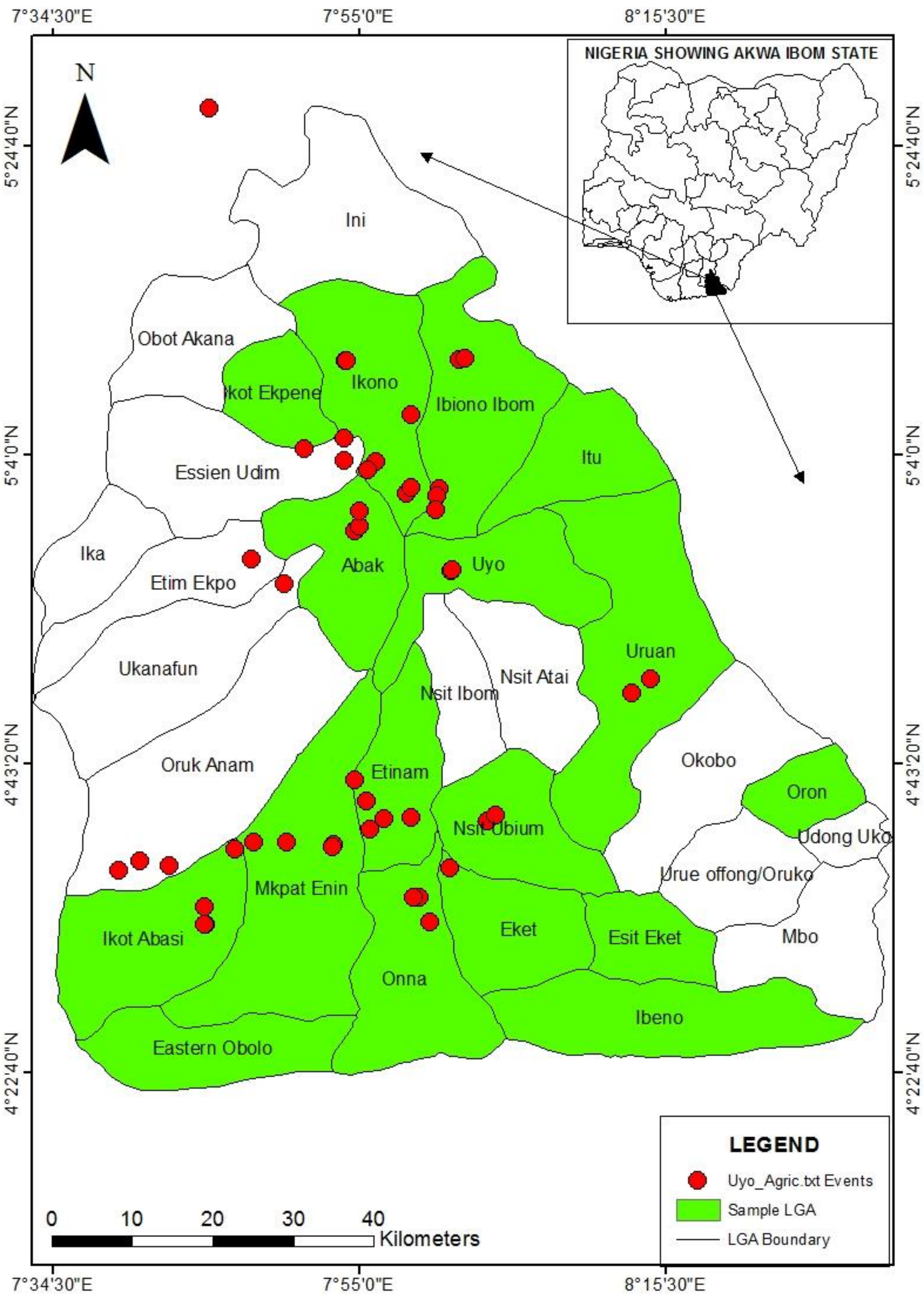
Persistent organic pollutants (POPs) are toxic synthetic organic chemical that are used in industry and agriculture, as well as created unintentionally through chlorine combustion processes (EPA, 2002). They are particularly harmful because by their nature, they are highly soluble in lipids, allowing them to accumulate in fatty tissues and thus biomagnify up the chain. This is why they are of particular threat to high level predators (including humans). They are also extremely resistant to biodegradation, and are able to travel through the atmosphere and be deposited far from their source regions (Ritter et al., 1995). POPs pose a particular threat to both wild life and humans. Health issues associated with POPs in both humans and wildlife include immune dysfunction, thyroid and vitamin deficiencies, reproductive impairments, infant mortality and deformities, population declines in certain species etc have been observed as a result. (Ritter et al., 1995).

The Yangtze River Delta (YRD) region lies in the east of China, holding the highest density of population and fastest economic developing provinces in China. Agriculture in this region is intensive and highly productive, thus large amount of DDT and HCH pesticides have been intensively used historically as an insecticide on croplands, such as cotton and Paddy fields, to increase agricultural production (Li et al. 2008; Li et al., 1999, Zhang et al., 2009). Previous study in the YRD region showed that large applications of dicofol in agricultural practice especially in cotton cultivation have resulted in serious DDT pollution (Yang et al., 2008). Thus, protection of the soils surrounding the YRD is of great importance for safeguarding the aquatic environment and food quality produced in this region.

4.4. Methodology

Study Area: The study focused on commercial farms in Akwa Ibom State. Akwa Ibom nicknamed: “Land of Promise” is a state in Nigeria. It is located in the coastal southern part of the country, lying between latitudes 4^{o}32’N and 5^{o}83’N, and longitudes 7^{o}25’E and 8^{o}25’E. The state is bordered on the east by Cross River State, on the West by Rivers State and Abia State, and on the South by the Atlantic Ocean and the Southernmost tip of Cross River State. It has a total area of 7.081km^2 (2,734sqm$_I$). Akwa Ibom is one of Nigeria’s 36 State, with a population of over 5 million people and more than 10 million people in diaspora. It was created on the 23rd of September, 1987 from the former Cross River State and is currently the highest oil and gas producing state in the country. The state’s capital is Uyo. Along with English, the main spoken languages are

Ibibio, Annang, Eket and Oron Language. Akwa Ibom State is divided into three soil classification zones. Samples were collected from each of the zones.



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Ini
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Ikono
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Etim Ekpo
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Figure 4.1: Map of Akwa Ibom State showing sampling locations

4.4.1. Materials and Method

To investigate the levels of pesticides, soil samples were collected from different farm areas and locations within Akwa Ibom State of Nigeria and analysed by gas chromatography mass spectrometry (GC/MS).

Sample Collection: Each sample was made from a mixture of five subsamples collected from five spots of an area of about $5m^2$. All soil subsamples were collected at a depth of 0-55 cm using a soil auger. Fresh soil samples (about 1kg) were transported to the laboratory in polyethylene zip-lock bags, lyophilized, sieved through a 2-mm mesh, and stored at 4^0C in pre-cleaned glass jars until analysis. These were then stored in the freezer and transported to Lancaster University for further analytical processes.

Sample preparation: Soil samples from the freezer were allowed to thaw. Some of the materials used in sample preparation include Glass jars, wash bottles with Acetone. Na_2S0_4 (baked at 450^{o}C), Spatulas, Aluminium foil pan. 20g of soil was weighed into a cellulose thimble and mixed with Na_2S0_4 to achieve a free-flowing powder, thereafter, it was spiked with 25ul recovery standard.

Sample extraction: Soxhlet extractor and round-bottom flask were rinsed with acetone, ~300ml Dichloromethane (DCM) was measured out into the round-bottom flask and some anti-bumping granules added. The soxhlet was now tightened and switched on, leaving it to run for 16 hours. ~1ml of Iso-octane was added and was split with the remaining half to be used for analysis involving oxygenated samples. 7.5 ml vial was used for that. The round bottom flasks were now rotor vapored for each of the samples and then transferred to a 7.5ml vial with 3 washings using Hexane. This was further reduced under Nitrogen gas (N_2) to ~1ml.

Clean up step 1 (Acid Silica column)

A waste jar was placed under the glass column, with the glass column and round-bottom flask rinsed with acetone and then hexane. ~150 ml of hexane was poured into a 250ml conical flask, 1cm of Na_2S0_4 was added to the column, 8g of acid silica was then added followed by 8g of activated silica, then finished off with another ~1cm of Na_2S0_4. The columns were carefully washed through into waste jar with 1-2 volumes of hexane -not disturbing the Na_2S0_4 too much.

When hexane reached the top of the Na_2S0_4 layer, the labelled clean round-bottom flask was placed under the column and applied using a glass Pasteur pipette. For the first washing, ~1ml of hexane was added to the sample using a second glass pipette and then washing transferred to the column using the first pipette to avoid contamination of the clean hexane. The washing was repeated two more times. The hexane from the 250ml conical flask was carefully poured in until the 150ml was used. When all the solvent had gone through the column, the round-bottom flask was removed and closed up with a stopper.

1ml of Iso-octane was added to reduce the risk of the sample going dry during the evaporation steps and then the solvent is rotor vapored to ~5ml, samples transferred to solvent rinsed and labelled 7.5ml vials, with at least 3 hexane washings and sealed using the acetone rinsed aluminium foil under the cap. The sample is then evaporated under a gentle stream of nitrogen to 0.5ml.

Clean-up step 2: GPC column

The sample vials were rinsed with acetone and hexane, then the GPC-columns filled with Hexane/DCM 1:1, with the tap opened, released solvent into waste jars, which were exchanged with waste vials, added samples with glass pipette without disturbing the bio-

beads, three washings of Hexane/DCM were added with the tap opened and closed during the washings. The waste vial was filled until the 15ml marking and then tap was closed. The labelled sample vial under the column and tap opened before filling the vial up to 30ml marking, topping up the column with solvent whenever needed. The sample vials were removed, covered with acetone-rinsed aluminium foil before reducing the volume under a gentle stream of N_2 to 0.5-1ml. 25µl "keeper" was added to GC-vial, The keeper consists of a solvent with low volatility (dodecane) and contains internal standard ($^{13}C_{12}$-PCB141(25pg/µL)) samples were added with glass pipette, using small volumes of the solvent, 3 washings of hexane were added. These samples were then reduced under N_2 until only 25ul keeper is left. The vials were now closed with cap and analysed in the GC-MS.

4.4.2.GC/MS Analysis

Analysis of extracts was performed using a Thermo GC-MS (Trace GC Ultra - DSQ) (Xcalibur software Version 1.4.x) operating in electron impact mode (70 eV) and equipped with an Agilent CP-Sil 8 CB 50 m × 0.25 mm capillary column with 0.12 µm film thickness. A 10-point mixed calibration standard in n-dodecane was used for quantification (10−450 pg µL−1 for OCPs, 10−120 pg µL−1 for PCBs, and 10−1250 pg µL−1 for PBDEs, respectively). Chemical concentrations presented in this study were corrected for recovery, but not blank corrected. The instrument was run in EI (electron impact) and SIM (single ion monitoring) mode at a source temperature of 250 °C.

4.4.3.Quality control and Quality Assurance (QC/QA)

Analytical procedure used was done with strict quality control and assurance measures. All the glasswares were washed thoroughly and oven dried. To find out the cross-contamination and interferences, a solvent and procedural blank were analysed with each set of samples. The compounds of interest in samples were identified by their retention times matching with those of reference standards under specified chromatographic condition. To ensure instrument precision, a quality control (QC) standard consisting of a calibration range of 2-200pg/uL

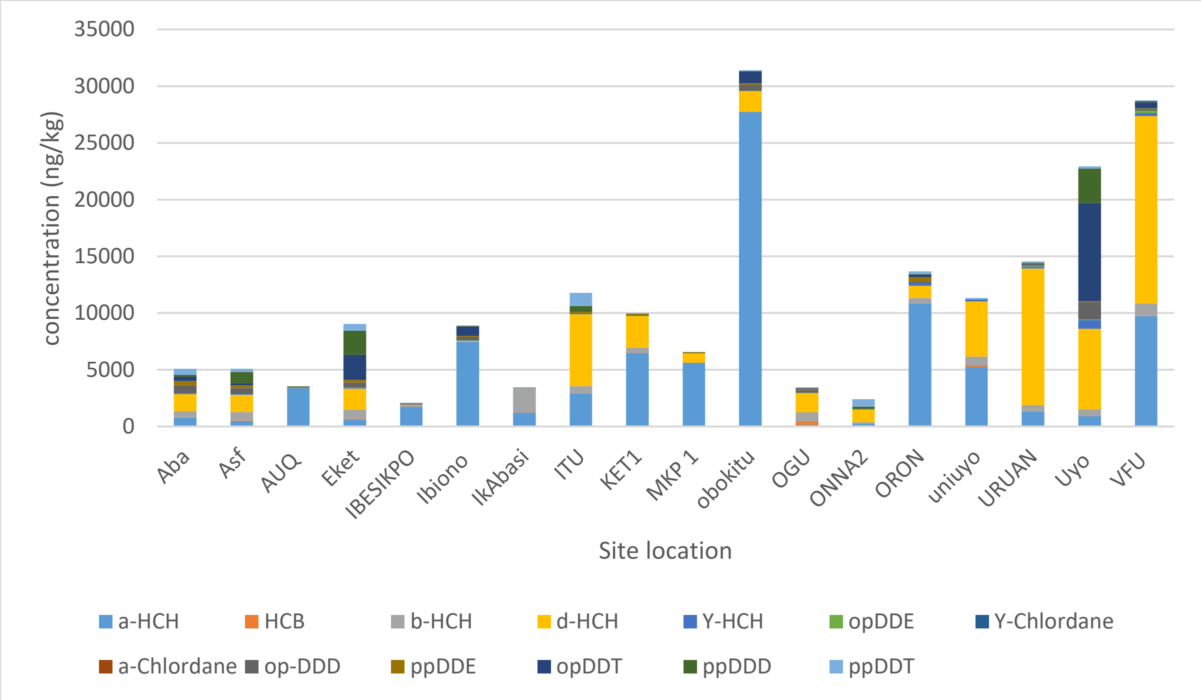

Figure 4.2: Mean concentrations of pesticides in farm soils

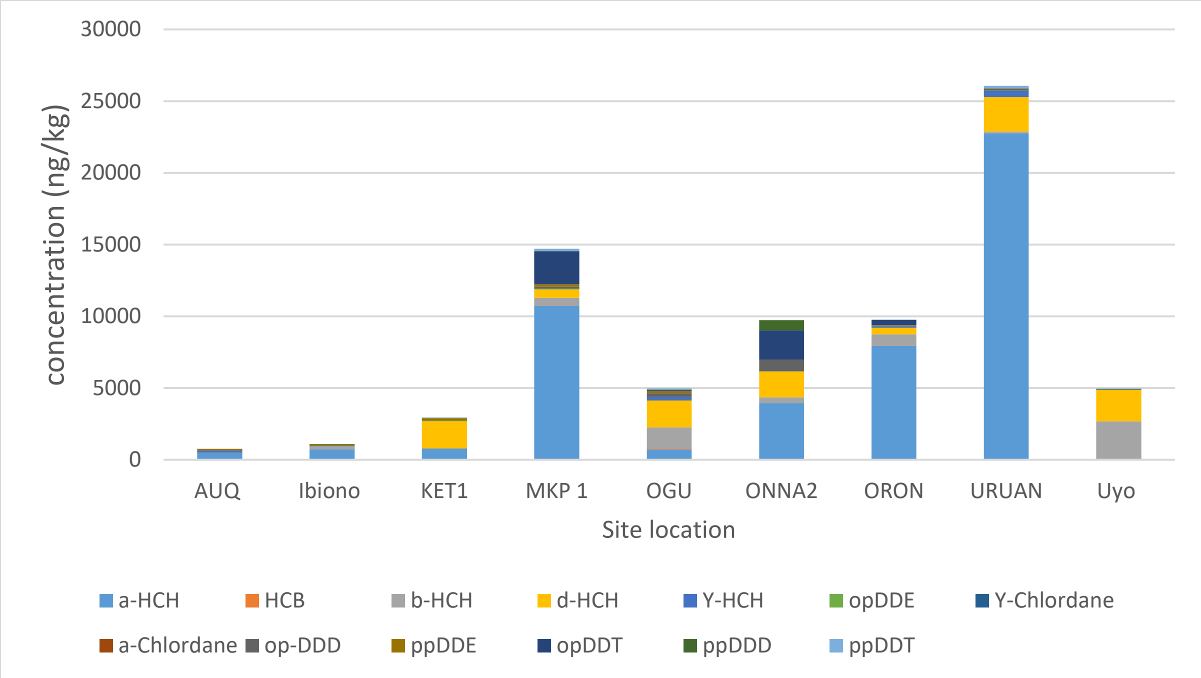

Figure 4.3: Mean concentration of pesticides in Non-farm/Background soils

Table 4.1: Mean concentration of Farm Soil Chemicals

	a-HCH	HCB	b-HCH	d-HCH	Y-HCH	opDDE	Y-Chlordane	a-Chlordane	op-DDD	ppDDE	opDDT	ppDDD	ppDDT
Aba	807.73	16.97	536.24	1488.68	109.51	ND	18.12	6.92	656.96	363.68	377.4536	176.19	519.46
Asf	508.11	57.77	712.70	1513.00	87.01	8.00	11.13	4.45	506.78	207.30	207.9021	972.33	282.29
AUQ	3357.81	2.57	4.16	ND	40.16	40.55	ND	ND	58.84	11.98	ND	8.00	ND
Eket	607.55	74.61	792.24	1875.17	76.81	14.00	10.59	4.66	423.67	210.61	2234.853	2123.84	586.00
IBESIKPO	1735.51	1.50	213.00	ND	4.72	3.87	2.03	0.70	8.44	70.11	ND	6.29	47.34
Ibiono	7474.92	1.96	100.60	ND	2.65	17.78	1.46	1.05	318.08	68.79	823	53.00	20.00
IkAbasi	1231.00	1.00	2135.00	ND	6.00	10.00	ND	ND	ND	13.00	ND	ND	47.00
ITU	2878.81	2.20	684.98	6331.00	8.75	23.25	6.00	0.83	45.94	93.69	ND	537.50	1175.00
KET	6460.90	2.84	489.00	2799.32	8.50	16.50	2.00	ND	21.42	109.09	ND	25.00	70.00
MKP	5627.00	2.00	ND	809.00	ND	15.00	ND	ND	8.00	86.00	ND	ND	36.00
obokitu	27730.00	2.00	ND	1842.00	ND	19.00	7.00	2.00	543.00	101.00	1075	13.00	60.00
OGU	147.47	305.68	808.16	1651.27	41.11	29.34	12.00	2.89	203.36	112.01	55.90097	23.99	68.88
ONNA	224.00	1.00	153.00	1090.00	ND	57.00	ND	ND	ND	ND	ND	239.00	635.00
ORON	10851.87	9.97	475.61	1064.00	278.11	8.98	6.00	2.70	73.71	392.70	230.0437	50.78	224.84
uniuyo	5270.00	141.00	756.00	4861.00	95.00	2.00	ND	1.00	58.00	15.00	ND	ND	119.00
URUAN	1343.78	32.34	514.28	12046.33	167.41	56.22	10.00	4.00	166.19	56.82	ND	47.83	106.34
Uyo	909.00	15.00	609.00	7085.00	765.00	40.00	11.00	ND	1534.00	75.00	8676.00	3018.00	198.00
VFU	9713.95	35.84	1074.89	16555.68	235.44	238.30	4.59	2.32	116.95	58.00	541.0754	126.17	35.00

Table 4.2: Mean concentration of non- Farm Soil pesticides

	a-HCH	HCB	b-HCH	d-HCH	Y-HCH	opDDE	Y-Chlordane	a-Chlordane	op-DDD	ppDDE	opDDT	ppDDD	ppDDT
Ibeno	480.00	2.00	20.00	ND	147.00	ND	ND	ND	ND	112.00	ND	ND	ND
Ibiono	747.00	2.00	191.00	0.00	22.00	ND	ND	ND	ND	90.00	ND	49.00	ND
KET	777.00	3.00	0.00	1908.00	0.00	32.00	ND	ND	7.00	182.00	ND	ND	36.00
MKP	10731.00	4.00	551.00	587.00	ND	47.00	14.00	5.00	123.00	162.00	2309.00	24.00	157.00
OGU	747.00	60.00	1462.00	1863.00	248.00	ND	12.00	4.00	252.00	151.00	69.00	28.00	90.00
ONNA	3958.00	ND	399.00	1815.00	ND	ND	5.00	3.00	805.00	ND	2026.00	711.00	ND
ORON	7938.00	1.00	819.00	448.00	68.00	8.00	2.00	2.00	38.00	62.00	366.00	ND	8.00
URUAN	22770.00	23.00	75.00	2415.00	450.00	13.00	11.00	4.00	97.00	28.00	ND	32.00	138.00
Uyo	43.00	5.00	2630.00	2201.00	12.00	2.00	ND	ND	2.00	21.00	ND	14.00	59.00

Table 4.3: Range of Pesticide concentration residues in Farm soils **SITES/N/S**	**RANGE (HCHs)(ng/kg)**	**RANGE(HCB)(ng/kg)**	**RANGE(CHLORDANES) (ng/kg)**	**RANGE(DDTs)(ng/kg)**
ABA (2)	7-1673	5-29	5-22	ND-657
ASF (4)	ND-1513	1-226	ND-18	ND-2818
IBENO (2)	ND-6589	2-4	ND	ND-80
EKET (7)	ND-2046	2-416	ND-23	ND-6083
IBESIKPO(2)	ND-2061	1-2	ND-3	ND-87
IBIONO(3)	ND-149	ND-4	ND-2	ND-77
IKABASI (1)	ND-2135	1*	ND	ND-13
ITU (3)	4-6331	ND-4	ND-6	ND-1718
EKET (2)	ND-4989	3	ND-2	ND-108
MKPAT ENIN (1)	ND-5627	2	ND	ND-86
OBOKITU (1)	ND-27730	3	2-7	13-1075
OGU (3)	ND-2799	2-907	ND-13	ND-224
ONNA (1)	ND-1090	1*	ND	ND-635
ORON (4)	ND-41398	2-21	ND-14	ND-817
UNIUYO (1)	95-5270	141	ND-5	ND-119
URUAN (3)	41-5421	21-63	ND-10	ND-391
UYO (1)	609-7085	15	4-11	40-3018

VIKA FARMS URUAN (2)	15-31158	32-40	2-5	ND-238

N/S Number of samples
ND Not detected

4.5. Results and Discussion

The presence of pesticide in background/non farm soil is an indication there was cross contamination and/or previous contamination within the experimented plot. In an attempt to assess residues in 'background' sites, some samples were collected. Surprisingly, high levels of pesticides were found in a few places (Table 4.2) α-HCH in Mkpat Enin (MKP) and URUAN sites had the most abundant arithmetic mean. These high residues likely represent chemicals that may have accumulated after years of transport and deposition from nearby agricultural areas (Harner T et al., 1999)

Pesticide analysis showed varied concentration of Hexachlorocyclohexane (HCH), α-HCH being the most abundant of the isomers of HCH and indeed the entire pesticides seen in the distribution. The presence of lindane in the soil samples may suggest the historical use or illegal use of technical HCH mixtures in the study area. Obokitu had the highest of concentration of α-HCH, Ikabasi had the highest concentration of b-HCH. Vita Farms, Uruan (VFU) had the highest concentration of δ-HCH, while Uyo had the highest concentration of γ-HCH. The presence of high α-HCH residues with respect to gamma-HCH in soil samples can be attributed to two major factors, the different degradation rates and variable physicochemical properties of the isomers. HCH isomers are stable and have the potential to be transported over long distances and to bioaccumulate in organisms. β-HCH may accumulate relative to other isomers while the δ—HCH is rarely found in the environment except when there is a fresh release

p,p′-DDT occurred in some of the soil samples. The presence of *p,p′*-DDT in the soil samples might be as a result of its previous use in the studied farms. However, the fact that *p,p′*-DDT residue occurred in some of the studied soils suggests that most farmers in the study area still use technical DDT even after it has been officially discontinued as restricted chemical for use (Adu-Kumi et al., 2010). According to GNIP (2007), DDT has officially not been imported into Ghana since year 2002, and as such, any incident of current use may be attributed to illegal importation. The continued use of DDT by the farmers could be due to addiction to the insecticide based on their easy accessibility and efficacy. It could also be that, new pesticides having DDT as its active ingredient but with different brand names were sold to farmers. The concentrations of the DDT isomers were generally lower than that of the isomers of HCH in the samples analysed. p,p'- DDE is the most persistent metabolite due to its high lipophilicity and lower activity. Uyo had the most concentrations for op'DDT, pp'DDD and op'DDD as 8676, 3018 amd 1534ng/kg respectively, which is a pointer to the fact that there must have been a previous history of DDT as DDT is said to have been banned which presupposes that there should not have been a recent use. AUQ, received the least deposition of the pesticides apart from α-HCH which is the most occurring. The agricultural soils under study had varied concentrations of HCH residues. The alpha isomer was detected in the largest number of samples followed by δ-HCH, β-HCH and γ-HCH. The concentration of total HCH ranged from (ND -41398 ng/kg). All four isomers were generally found together. The greatest abundance of total HCH was detected in samples from Oron. The use of commercial pesticides over a period of decades is likely the main cause of the presence of HCH in agricultural soil (Covaci et al., 2001). The proximity of Obokitu to Oron locations reflects in the level of concentration of pesticide residues of alpha- HCH. As the mean concentrations of α-HCH in those locations in Table 4.1 suggest.

In the study of Li Zhang et al., (2006) the total HCH concentration in the crop soil ranged from 50-24100 ng/kg also the levels of chlordanes in the soil samples ranged from < DL to 13,700 ng/kg which shows the values of concentrations of pesticide residues were higher than the ones got in this study. In a similar manner the total DDT in the study ranged from 22,301-232,000(ng/kg) which was higher than the findings from our study.In the study of (Mahmood et al., 2014) DDTs had a mean of 103,000ng/kg with its different isomers also having individual values of concentration of pesticide residues higher than the isomers of DDT in our study as seen in Table 4.1.

4.6. Conclusion

This chapter has shown that banned pesticides like DDT are still being illegally imported into the country (Nigeria). The need to train and/or retrain farmers cannot be overemphasised and it is evident from this research.

Overall, the levels of pesticides were generally within the lowest ranges compared to those reported in the literature and as such do not pose any significant risk as at the time of this research. The levels of pesticides found in background soil or non-farm locations is an indication of the continuing use of pesticides or historical use. It was also seen that the presence of αHCH isomers known for their stability shows they can be transported over long distances and also can bioaccumulate in organisms.

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Chapter 5

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The extent of the impact of the use of pesticides in Nigeria is not to be considered to be worth much significance and consequently may not have attracted the attention of policy makers because it has not yet been seen as priority.

This research was aimed at assessing pesticide use in Nigeria. To achieve this, surveys were held at two different times within the country and small- holder farmers were interviewed using semi structured questionnaires. Focus group discussions and field observations were undertaken. From the findings obtained in the surveys, it is seen from FAO that that there has been increase in the number of pesticides used but that has not been matched by a corresponding number of monitoring undertaken by the government, the conclusions taken are discussed as follows;

5.1.1. Handling

It is evident from the research that storage, preparation and application methods are not appropriate. Farmers stored pesticides in awkward places like in their houses, From the group discussions also and direct observations, farmers handle pesticides without personal protective equipment thereby exposing themselves to harmful chemicals. Most of them do not comply with the set standards in preparing them.

5.1.2. Prevalence of pesticide use among farmers

Based on the finding, pesticides are widely used in Nigeria. The study showed that beyond Agriculture, it was also deployed in curbing mosquitoes and Malaria. It was established that pesticide usage over the last decade had been on the increase. It was clear that the Government was not seen to be willing to enforce laws to regulate the use of pesticides.

5.1.3. Impact of Pesticides on the Environment and deriving of its exposure doses.

The estimated daily Intake (EDI) of pesticides in the study were seen to be majorly low, even though a few were found to be above their acceptable daily intake(ADI) , that is also the situation found with the levels in the environment. The levels were found to be generally low, with quite a few found to be on the high side when also compared to levels found elsewhere. It is also ironic to see that despite the fact that there is an obvious dearth of sufficient training given to farmers and other users of pesticides, which should imply that this would give rise to inappropriate methods applied in the handling resulting in high -level concentration found in these pesticides.

5.2. Recommendations

- Pesticides should be handled and distributed by trained personnel and should not be sold openly in local markets by unlicensed traders
- Farmers should be trained on the handling and application of pesticides before usage on their farms.
- Education should be given to farmers regarding the dangers of pesticides and provisions made to them of personal protective equipment.
- Manufacturers should add labels such as pictograms to aid illiterate farmers understand how to safely handle pesticides.
- There are other wide range of pesticides in use in Nigeria, though this study/research was limited organochlorine pesticides. It is recommended that further studies be done to study the behaviour of other pesticides in the environment.
- There is need for a more comprehensive survey by way of a follow up to the one already done
- Pesticide monitoring in soil, crops, water (farm/stream run off) is needed
- A more extensive food survey is required
- Research on Eco-toxicological impact of these pesticides is needed.

Appendices

APPENDIX A

PESTICIDE USE SURVEY IN NIGERIA

Purpose of Survey: To study how pesticides are used and the impact on people and the environment.

PhD RESEARCHER: Ekeoma I. Ogwo

CONTACT DETAILS: 07033808597, isyeke@yahoo.com

Note: [a] This survey is clearly for academic purposes only and shall be treated anonymously

[b] Please answer the questions ticking as many boxes as possible where applicable in the questions and return after two days.

Date__/___/______ Name of city/ town/ village……………………………………………………………….. ………………………………..

Designation of respondent ……………………………………………………………Sex Male ☐ ☐ Female.

Age: Below 30 ☐ B 30-50 ☐ C 50-60 ☐ D Above 60 ☐

Number of people in the house hold: Men…………………. Women…………………. Children (Under 18)………………….

1. How big is your farm? < 1 Hectare ☐ 1 Hectare ☐ > 1Hectare ☐
2. Do you apply any pesticides in your farm? YES/NO......................
3. What types of pesticides do apply? INSECTICIDES / FUNGICIDES / HERBICIDES (Weed killer) RODENTICIDES e.g. Rat Killer)
4. What are the main crops you grow?...

   ....

   ....
5. What are your pest problems? ....

   ....

   ....
6. Where do you sell your crops/produce? Locally ☐ Nationally ☐ Internationally ☐
7. Which pesticides do you use most frequently...

   ....

   ....
8. How do you store the pesticides/chemicals?...

   ....

   ....
9. How do you apply these pesticides? By hand (back pack) ☐ Use of tractor/sprayer ☐

   other ☐...
10. At what time of the year do you apply these pesticides? Dry season ☐ rainy season ☐

    Other times ☐
11. Have you ever received any form of training?...

    ....

    ....

12. Do you use Personal Protective Equipment (PPE) during application?................................

....

....

13. What are the main pests that you target e.g. (Insects, mould, weeds)..............................

....

....

14. Do the pesticides kill any other organisms different from the target pests?.......................

....

....

15. How do you dispose of the remaining pesticide after application?...................................

....

....

16. Are there other benefits got from the use of pesticides apart from eradication of pest?....

....

....

17. Over the last 10 years, would you say that your use of pesticides has:

☐ Stayed the same

☐ Increased

☐ Decreased

Any other information you may wish to add..

....

....

APPENDIX B

Faculty of Science and Technology Research Ethics Committee (FSTREC)

Lancaster University

Application for Ethical Approval for Research

This form should be used for all projects by staff and research students, whether funded or not, which have not been reviewed by any external research ethics committee. If your project is or has been reviewed by another committee (e.g. from another University), please contact the FST research ethics officer for further guidance.

In addition to the completed form, you need to submit **research materials** such as:

i. Participant information sheets
ii. Consent forms
iii. Debriefing sheets
iv. Advertising materials (posters, e-mails)
v. Letters/emails of invitation to participate
vi. Questionnaires, surveys, demographic sheets that are non-standard
vii. Interview schedules, interview question guides, focus group scripts

Please note that **you DO NOT need to submit pre-existing questionnaires or standardized tests** that support your work, but which cannot be amended following ethical review. These should simply be referred to in your application form.

Please submit this form and any relevant materials by email as a SINGLE **attachment** to *fst-ethics@lancaster.ac.uk*

Section One

Applicant and Project Information

Name of Researcher:

Project Title:

Level: Masters, PhD, Staff

Supervisor (if applicable):

Researcher's Email address:
Telephone:
Address:

Names and appointments/position of all further members of the research team:

Is this research externally funded? If yes,

ACP ID number:
Funding source:
Grant code:

Does your research project involve any of the following?

☐ Human participants (including all types of interviews, questionnaires, focus groups, records relating to humans, use of internet or other secondary data, observation etc.)

☐ Animals - the term animals shall be taken to include any non-human vertebrates, cephalopods or decapod crustaceans.

☐ Risk to members of the research team e.g. lone working, travel to areas where researchers may be at risk, risk of emotional distress

☐ Human cells or tissues other than those established in laboratory cultures

☐ Risk to the environment

☐ Conflict of interest

☐ Research or a funding source that could be considered controversial

☐ Social media and/or data from internet sources that could be considered private

☐ any other ethical considerations

Yes – complete the rest of this form

No – go to Section Five

Section Two

Type of study

☐ Includes *direct* involvement by human subjects. ***Complete all sections apart from Section 3.***

☐ Involves *existing documents/data only*, or the evaluation of an existing project with no direct contact with human participants. ***Complete all sections apart from Section 4.***

Project Details

1. Application is for an individual study ☐ for a programme of studies ☐

2. Anticipated project dates (month and year)

Start date: End date:

3. Please briefly describe the background to the research (no more than 150 words, in lay-person's language):

4. Please state the aims and objectives of the project (no more than 150 words, in lay-person's language):

5. Methodology and Analysis:

Section Three

Secondary Data Analysis

Complete this section if your project involves *existing documents/data only*, or the evaluation of an existing project with no direct contact with human participants

1. Please describe briefly the data or records to be studied, or the evaluation to be undertaken.

2. How will any data or records be obtained?

3. Confidentiality and Anonymity: If your study involves re-analysis and potential publication of existing data but which was gathered as part of a previous project involving direct contact with human beings, how will you ensure that your re-analysis of this data maintains confidentiality and anonymity as guaranteed in the original study?

4. What plan is in place for the storage of data (electronic, digital, paper, etc)? Please ensure that your plans comply with the Data Protection Act 1998.

5. What are the plans for dissemination of findings from the research?

6a. Is the secondary data you will be using in the public domain? YES/NO

6b. If NO, please indicate the original purpose for which the data was collected, and comment on whether consent was gathered for additional later use of the data.

7.What other ethical considerations (if any), not previously noted on this application, do you think there are in the proposed study? How will these issues be addressed?

8a. Will you be gathering data from discussion forums, on-line 'chat-rooms' and similar online spaces where privacy and anonymity are contentious? YES/NO

If yes, your project requires full ethics review. Please complete all sections.

Section Four

Participant Information

Complete this section if your project includes *direct* involvement by human subjects.

1. Please describe briefly the **intended human participants** (including number, age, gender, and any other relevant characteristics):

2. How will participants be **recruited** and from where?

3. Briefly describe your **data collection methods**, drawing particular attention to any potential ethical issues.

4. Consent

4a. Will you take all necessary steps to **obtain the voluntary and informed consent** of the prospective participant(s) or, in the case of individual(s) not capable of giving informed consent, the permission of a legally authorised representative in accordance with applicable law? **YES/ NO**

If yes, please go to question 4b. If no, please go to question 4c.

4b. Please explain the procedure you will use for **obtaining consent**?. If applicable, please explain the procedures you intend to use to gain permission on behalf of participants who are unable to give informed consent.

4c. If it will be necessary for participants to take part in the study **without their knowledge and consent at the time**, please explain why (for example covert observations may be necessary in some settings; some experiments require use of deception or partial deception – not telling participants everything about the experiment).

5. Could participation cause **discomfort** (physical and psychological eg distressing, sensitive or embarrassing topics), **inconvenience or danger beyond the risks encountered in normal life**? Please indicate plans to address these potential risks. State the timescales within which participants may withdraw from the study, noting your reasons.

6. How will you protect participants' **confidentiality and/or anonymity** in data collection (e.g. interviews), data storage, data analysis, presentation of findings and publications?

7. Do you anticipate any ethical constraints relating to **power imbalances or dependent relationships**, either with participants or with or within the research team? If yes, please explain how you intend to address these?

8. What potential **risks may exist for the researcher** and/or research team? Please indicate plans to address such risks (for example, noting the support available to you/the researcher; counselling considerations arising from the sensitive or distressing nature of the research/topic; details of the lone worker plan you or any researchers will follow, in particular when working abroad.

9. Whilst there may not be any significant direct **benefits to participants** as a result of this research, please state here any that may result from participation in the study.

10. Please explain the **rationale for any incentives/payments** (including out-of-pocket expenses) made to participants:

11. What are your plans for the **storage of data** (electronic, digital, paper, etc.)? Please ensure that your plans comply with the Data Protection Act 1998.

12. Please answer the following question *only* if you have not completed a Data Management Plan for an external funder.

12.a How will you make your data available under open access requirements?

12b. Are there any restrictions on sharing your data for open access purposes?

13. Will **audio or video recording** take place? ☐ no ☐ audio ☐ video

13a. Please confirm that portable devices (laptop, USB drive etc) will be **encrypted** where they are used for identifiable data. If it is not possible to encrypt your portable devices, please comment on the steps you will take to protect the data.

13b. What arrangements have been made for **audio/video data storage**? At what point in the research will tapes/digital recordings/files be destroyed?

13c. If your study includes video recordings, what are the implications for participants' anonymity? Can anonymity be guaranteed and if so, how? If participants are identifiable on the recordings, how will you explain to them what you will do with the recordings? How will you seek consent from them?

14. What are the plans for dissemination of findings from the research? If you are a student, mention here your thesis. Please also include any impact activities and potential ethical issues these may raise.

15. What particular ethical considerations, not previously noted on this application, do you think there are in the proposed study? Are there any matters about which you wish to seek guidance from the FSTREC?

Section Five

Additional information required by the university insurers

If the research involves either the nuclear industry or an aircraft or the aircraft industry (other than for transport), please provide details below:

Section Six

Declaration and Signatures

I understand that as Principal Investigator/researcher/PhD candidate I have overall responsibility for the ethical management of the project and confirm the following:

- I have read the Code of Practice, Research Ethics at Lancaster: a code of practice and I am willing to abide by it in relation to the current proposal.
- I will manage the project in an ethically appropriate manner according to: (a) the subject matter involved and (b) the Code of Practice and Procedures of the University.
- On behalf of the University I accept responsibility for the project in relation to promoting good research practice and the prevention of misconduct (including plagiarism and fabrication or misrepresentation of results).
- On behalf of the University I accept responsibility for the project in relation to the observance of the rules for the exploitation of intellectual property.
- If applicable, I will give all staff and students involved in the project guidance on the good practice and ethical standards expected in the project in accordance with the University Code of Practice. (Online Research Integrity training is available for staff and students here.)
- If applicable, I will take steps to ensure that no students or staff involved in the project will be exposed to inappropriate situations.

☐ Confirmed

Please note: If you are not able to confirm the statement above please contact the FST Research Ethics Committee and provide an explanation.

Student applicants:

Please tick to confirm that you have discussed this application with your supervisor, and that they agree to the application being submitted for ethical review ☐

Students must submit this application from your Lancaster University email address, and copy your supervisor in to the email in which you submit this application

All Staff and Research Students must complete this declaration:

I confirm that I have sent a copy of this application to my Head of Department (or their delegated representative) . **Tick here to confirm** ☐
Name of Head of Department *(or their delegated representative)*

Applicant electronic signature: Click here to enter text. Date