# IMPACT OF AGROCHEMICALS APPLICATION ON HUMAN HEALTH AND THE ENVIRONMENT OF BADEGGI AND ENVIRONS, NIGER STATE, NIGERIA

**BY**

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## ABSTRACT

The occurrence of agrochemicals in our environment as a result of the indiscriminate or intentional use has resulted in its persistence in the environment, thereby affecting the ecosystems and non target organisms in the study area. Therefore this study examine impact of agrochemicals application on human health and the environment in Baddegi and environs, Niger State, Nigeria. The materials and methods used in this study include questionnaire and oral interview. The method of data analysis used in this study include frequency percentage, 5-point likert type scale, mean and 3-point likert scale. The finding revealed that major reason for application of agrochemical was increase yield which ranked the highest with 203 respondents, control pests and diseases ranked second with 67 respondents and improve appearance for marketability ranked the least with 11 respondents. As revealed in the study, type of agrochemicals to apply in farms were determine through use own experience, asks what other farmers have used, as advised by extension officer and experiments on different types then choose. The finding revealed that 292 respondents affirmed that their exist health problems associated with the use of agrochemicals in the study area and 49 respondents said they do not suffer any health problem due to the use of agrochemicals. These health problems include skin, eye, stomach and respiratory irritations. As revealed in the study, rating the risk of agrochemicals effects on soil, air, surface water, aquatic organism and birds were done in four categories. Moderately harmful ranked the highest with 153 respondents and not harmful ranked the least with 42 respondents. Surface water ranked the highest on the effect of agrochemical with 87 respondents and air ranked the least affected component of the environment. This implies that all the components of the environment were effected with agrochemicals in the study area as affirmed by the respondents. It’s therefore recommended that agricultural stakeholders such as the Ministry of agriculture to carry out sensitization campaigns to educate farmers on proper and efficient use of agrochemicals to improve productivity as well as prevent adverse environmental and human health effects.

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# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background of the Study

The rapid expansion of the agricultural sector in Nigeria has resulted in increased demand for agrochemicals (Ariga *et al.,* 2016). The use of agrochemicals has many benefits, increased crops and animal yields and reduced post-harvest losses (Oerke *et al.,* 2014). The benefits associated with the use of agrochemicals have resulted in an increase in the importation of assorted agrochemicals in the Country. According to Singh *et al.,* (2014), 371886 metric tonnes of fertilizers were imported in Nigeria, 271,886 more than that used in 2010. Nigeria‘s fertilizer market was liberalized during the early 2010s when price and marketing controls, licensing arrangements and import permits and quotas were eliminated (Ariga *et al*., 2016). Also according Tegemeo Institute, Egerton University, usage of assorted fertilizer went slightly above 400,000 metric tonnes (Mathenge, 2009). Approximately 8,370 tonnes of pesticides with a value of ₦4.68 billion were imported into the country in 2015 (Birech *et al*., 2016).

Agrochemicals are highly toxic and have been associated with serious human health and environmental damages (Briggs *et al.,* 2009). Extensive use of agrochemicals in the agricultural fields is among the most prominent sources of ground water contamination (Singh *et al.,* 2014). According to Konradsen *et al*., (2017), about one-half of the human poisonings occur more in less-developed countries, even though these places account for only 20% of the world's use of pesticides. Many chemical substances identified as persistent organic pollutants (POPs) under the Stockholm Convention are still being used in agriculture and industry and these results in negative health and environmental consequences (Ashburner and Friedrich, 2011).

Today all over the world consumers are becoming increasingly aware of the importance of food safety and are therefore demanding high standards in marketed and processed foods with emphasis also on agricultural practices with minimum detrimental impact on the human health and environment (MOA, 2014). Previous pilot studies on pesticide handling in most developing countries like Nigeria, showed that once the product reaches retailers shelf, level of control is usually very minimal.

According to the latest estimates, approximately 2.36 billion kilograms of Agro Chemicals were used worldwide in 2007, producing a business worth of $40 billion USD – this is a fifty-fold rise in the amounts of Agro Chemicals used internationally since 1950 (Environmental Protection Agency, 2011). Patterns of consumption have been shifting as well in developing countries, their global share of Agro Chemicals use has doubled in the past three decades, going from 20% to 40% (Promise, 2016). Particularly in the seven countries of the Central American Isthmus (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama), as well as other African countries like Egypt, Kenya, Senegal Burkina Faso and Nigeria, there has been a steady increase in the use of Agro Chemicals, reaching its peak in 2011 with imports of 46 tons kg of active ingredient, which are formulated in 85 plants in these countries (Promise, 2016). Agro Chemicals are a vital component of modern farming. About one-third of the agricultural products in the world are produced by using Agro Chemicals (Liu *et al.,* 2012). Nonetheless, concerns about the impacts of these products on human health have increased over the past several years (Van der Werf, 2016; Wilson and Tisdell, 2011; Pimentel, 2015). Exposure to dangerous Agro Chemicals due to inappropriate use or protection cause a wide range of negative health and environmental effects. Among the possible outcomes, acute poisonings are the most likely to be detected and have been identified as a major health concern in the developing world (Kishi and

Ladou, 2011). Acute pesticide poisoning (APP) or clinic cases is the severe poisoning which occurs after exposure to a single dose of pesticide. The appearance of symptoms may be sudden and dramatic or they may be delayed.

Reported symptoms of acute pesticide poisoning include: fatigue, headaches, body aches, skin discomfort, skin rashes, feelings of weakness, circulatory problems, dizziness, nausea, vomiting, impaired vision, cramps, etc., and in severe cases, coma and death (Alavanja *et al.*, 2014). Also, there is evidence that exposure to Agro Chemicals may cause chronic effects on health such as cancer (Kristensen *et al.,* 2016; Hardell, 2013; Gilden *et al.,* 2010), interference with the development of children and fetus during pregnancy (Frederick, 2015; Sanborn *et al.,* 2017) as well as disruption of the reproductive, endocrine, immune and central nervous system (Ascherio *et al.,* 2016; Ismail *et al.,* 2012). There are currently few reliable estimates as to how many people per year suffer from Agro Chemicals related health effects. One of the latest estimates of acute poisoning cases worldwide was done by the WHO/UNEP Working Group on Public Health Impact of Agro Chemicals Used in Agriculture in 2010. The global estimate for Agro Chemicals-related health effect was about three million cases of severe poisonings, with 99 percent of these fatalities occurring in developing countries (WHO, 2010). One must keep in mind that these estimates are based on hospital admissions and probably underestimate the actual number of Agro chemicals poisonings. In fact, in developing countries where there is insufficient regulation, lack of surveillance systems, little to no enforcement and inadequate access to information systems, the incidences are presumed to be higher (IFCS, 2013). Studies from developing areas in Central America (El Salvador and Nicaragua) and other African countries (Senegal, Nigeria) have indicated an overall incidence rate of 35 per 100 000 for APP in the general population (Henao and Arbelaez, 2012). Poisoning incidences in agriculture occur even more often as a result of careless handling of Agro Chemicals usually on the part of operator error due to willful negligence, lack of information or lack of training (Koh and Jeyaratnam, 2016; Reeves and Schafer, 2013). For example, leakages from joints in the application equipment may often cause farmers to come into direct skin contact with large amounts of a pesticide. Similarly, clogged or unsuitable nozzles on the spraying equipment affect the quality of application and increase the degree of exposure. Changes in the wind speed and direction during spraying can result in chemicals and other pesticides absorption in the respiratory tract. Application on extremely hot and dry days promotes fertilizer and pesticide drift which also increases exposure. Spraying from the air can create a risk for farmers who are not involved in the operation, including the population at large. All the above situations which are common during pesticide application in the farm may result in direct and prolonged exposure of farmers to Agrochemicals which may in turn affect their health. Farmers' knowledge of the potential hazards of pesticide handling is important for the prevention of exposure to these harmful chemicals. Levels of knowledge regarding routes of exposure to Agro Chemicals and specific health effects of Agro Chemicals may vary considerably among farmers. Studies conducted in the Gaza Strip reported high levels of knowledge on the health impact of Agro Chemicals (Yassin *et al.,* 2012). Similarly, good knowledge about the acute health effects of Agro Chemicals and their exposure routes have been found among pesticide applicators in Ecuador (Hurtig *et al.,* 2013). Moderate or low levels of knowledge about pathways of absorption of Agro Chemicals and of potential symptoms following exposure were found among farm workers in Egypt (Stewart, 2016), and Ghana (Clarke *et al.,* 2017). Agro Chemicals remain today the choice of many farmers despite the increase of pesticide-related diseases and the presence of alternative methods to control pest such as biological control, genetic control and IPM, because they are cost-effective, easily available, and display a wide spectrum of bioactivity (De A *et al.*, 2014).

Niger State in central Nigeria main economic activities is agricultural related including mixed farming (crops and livestock keeping). Major cash crops include coffee, tea and horticultural production with maize, beans and potatoes grown mainly as food crops (Booker *et al.*, 2009). Major livestock cash enterprises include dairy cows, poultry, pigs, bees with fish farming also being promoted. Pesticides, fertilizers, animal feeds and veterinary drugs are normally purchased through farm inputs retail outlet stockiest commonly known as ―Agrovets in trading centres. The study thus sought to determine the farmers knowledge, attitude and practices with regard to use of agrochemicals in crop production in Baddegi and environs, Niger State and their potential impact on environment and human health.

## 1.2 Statement of the Research Problem

Several studies have been identified with impacts of agrochemicals on human health and the environment both nationally and internationally and those researchers include Erhunmwunse, Dirisu and Olomukoro (2012); Aikpokpodion, Lajide, Ogunlade, Ipinmoroti, Orisajo, Iloyanomon and Fademi (2015); Ize-Iyamu, Abia and Egwaikhide, (2011); Leonila (2012); Maton (2016) and Gupta (2012). Based on these researches, a gap have been identify which is impact of agrochemicals application on human health and the environment in Baddegi and environs, Niger State, Nigeria. The links between pesticides and human health were suspected as early as the 1960s and 1970s. US epidemiologists observed an unusual rise in Non-Hodgkin’s Lymphoma in areas of high pesticide use (Gupta, 2012). A number of more recent studies and reviews bring to light some critical health implications of pesticide exposure.

The occurrence of pesticides in our environment as a result of the indiscriminate or intentional use has resulted in its persistence in the environment, thereby affecting the ecosystems and non target organisms in the study area. Acute and chronic pesticide poisoning usually results from consumption of contaminated food, chemical accident in industries and occupational exposure in agriculture. About 15,000 metric tons of pesticides comprising about 135 pesticide chemicals are imported annually into the country (Nigeria). They are the major causes of cancer, cardiovascular disease, dermatitis, birth defects, morbidity, impaired immune function, neurobehavioral disorder and allergy sensitization reaction. In Nigeria, food test carried out on 217 different food items revealed the presence of DDT, Aldrin and Dieldrin to be above maximum allowable concentration level which ranged from 1.2- 2160μg kg-1. The detection of these pesticides in soil, drinking water and other animals is of great interest. The failure to establish data-base from past incidents in order to avert future occurrences has posed a huge problem to the society at large. The need for epidemiological data collection from past exposure, development of less toxic pesticides and legal requirement regarding toxicological and ecological effect before the importation of pesticides into the country will further reduce the impact of toxic pesticides on human health in the study area (Aikpokpodion *et al.,* 2015).

Farmers tend to rely on pesticides as the primary pest control measure (Horne *et al.*, 2008). While stringent measures are enforced during formulation, manufacture and registration of pesticides, it is the responsibility of the end user or buyer at retail level to ensure the chemical is used as prescribed. However in with increased use of agrochemicals, their safe usage of is increasingly gaining importance globally because of their potential adverse environmental and health effects. The increased use of agrochemicals and in inappropriate methods may be harmful to human and the environment. The study therefore will aim at assessing the farmers‘

knowledge, attitudes and practices in regard to the use of agrochemicals, types used and sources of information on use of agrochemicals and therefore inform on the environmental and health risks associated with the practices.

Continuous use of agrochemical against agricultural pest and disease vectors poses serious threats upon both human health and environment in the study area. It is very difficult to find out the impact of human health and the environment in the study area due to inadequate awareness, training and limited knowledge for using agrochemicals. Agrochemical users in the study area are also vulnerable to agrochemical related health problems due to inadequate regulatory and preventive mechanisms. As such the study will looks into these research problems which are in line with the research question of the study as indicated in section 1.4.

**1.3 Justification of the Study**

The researcher expects the study outcome to contribute significantly to information and knowledge on the potential risks to the environment and human health arising from the farmers' use of agrochemicals in their crop farming systems.

The present study will makes an important contribution to an improved understanding of the effects of agrochemicals on the environment and human health in Nigeria-Such an understanding is necessary for training on the safe use of agrochemicals.

The study will generate specific information on the types and quantity of agrochemicals to be used in a specific area. The information is important to agricultural extension officers to formulate the most economical and safe ways of using agrochemicals in Baddegi Town of Niger State and other parts of Nigeria.

The study will generate information on the impacts of agrochemicals on human health and the environment information can be used by other scholars as literature review form basis for further research.

The research outcome can thus be used by Ministry of Agriculture, agrochemical companies and other stakeholders to raise awareness of the need for safe handling and the use of agrochemicals by the farming communities through training and information dissemination for human and environmental safety. This information will be useful to the government and other stakeholders in developing appropriate policies to enhance environmental and human safety in agrochemicals use for sustainable agricultural production.

**1.4 Research Questions**

The research questions for this study will include the followings:-

i. What are the farmers' knowledge on agrochemicals applications in crop production?

ii. What are the types and quantities of agrochemicals used by farmers in their major production processes in the study area?

iii. What are the agrochemicals application impact on human health and environment in the study area?

iv. What are adaptation strategies on the impact of agrochemical application in the study area?

**1.5 Aim and Objectives of the Study**

The aim of the research is to examine the impact of agrochemical application on human health and the environment of Badeggi and environs, Niger State, Nigeria. The specific objectives are:

i. To examine the farmers' knowledge on agrochemicals applications in crop production.

ii. To examine the types and quantities of agrochemicals used by farmers in their major production processes in the study area.

iii. To analyze the use agrochemical application impact on human health and environment in the study area.

iv. To examine the adaptation strategies on the impact of agrochemical application in the study area.

## 1.6 Scope and Limitation of the Study

The scope of this study is concentrated on the impact of agrochemical application on human health and the environment in Badeggi and environs, Niger State, Nigeria. The study also collected hospital records related to the study area. The study considered health related diseases mention in questionnaire base on agrochemical application in the study area as well as changes farmers have notice in the environment.

## 1.7 The Study Area

### 1.7.1 Location of the study area

Baddegi is located within Latitude $9^0$ 30" 10N to 90 68" 10N and Longitude $6^0$ 50" 23E to $6^0$ 90" 13E. It is located at an elevation of 118 meters above sea level and its population amounts to 11,657 in 2015. The area geographically shares boundaries with Edati Local Government to the west of Bida Local Government Area, to the north Bida Local Government, to the east Agaie Local Government and Katcha at the south west (Ndaman, 2011).

The region is dissected by two major rivers that is Kaduna and the river Gbako. The river Kaduna takes its source from the high Hausa plans. River Kaduna is found to the west of the river Gbako, and these two rivers together drains most of the Bida L.G. A., they ultimately drain their contents into the river Niger to the south. The Kaduna and Gbako rivers flow over sedimentary rock for most of their course. They deposit a large amount of sediments on their flood plains and this provides the cultivated filed for guinea corn cultivation in Bida (Ndaman, 2011).

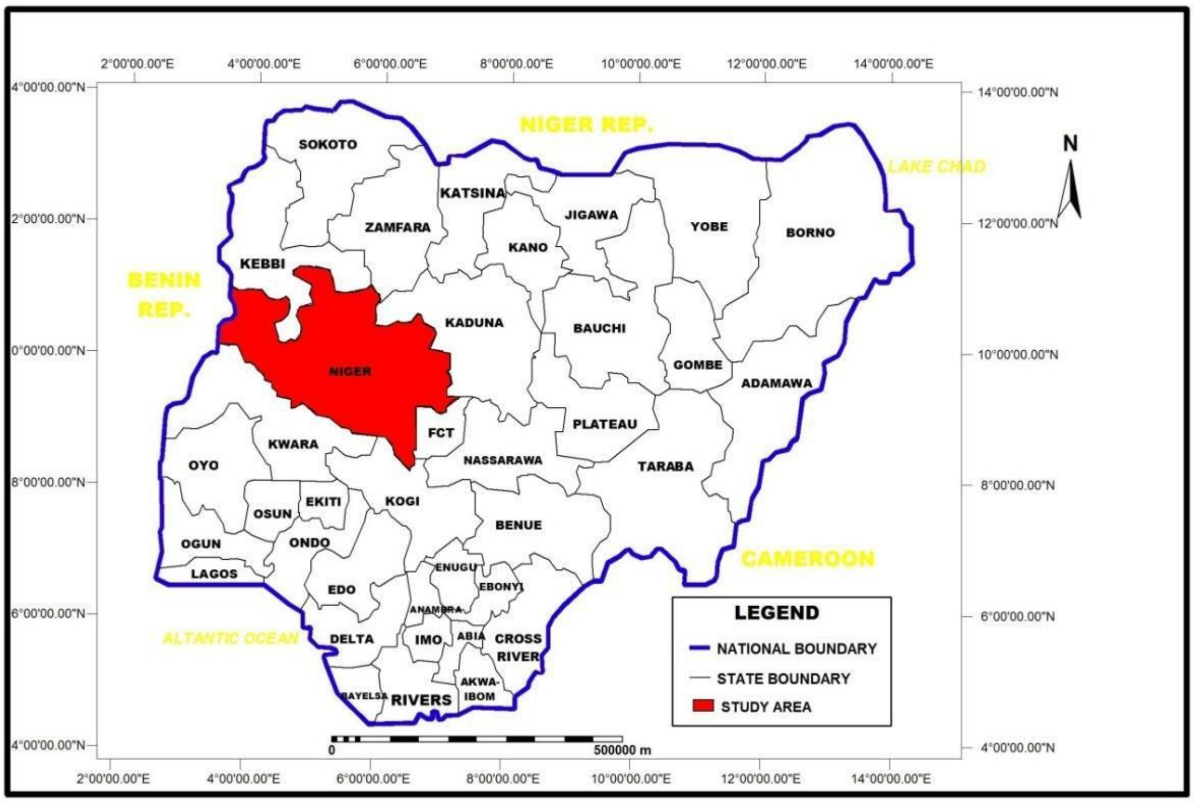


**Figure 1.1: Location of Niger State in Nigeria**

**Source: Niger State Geographic Information System (2018)**

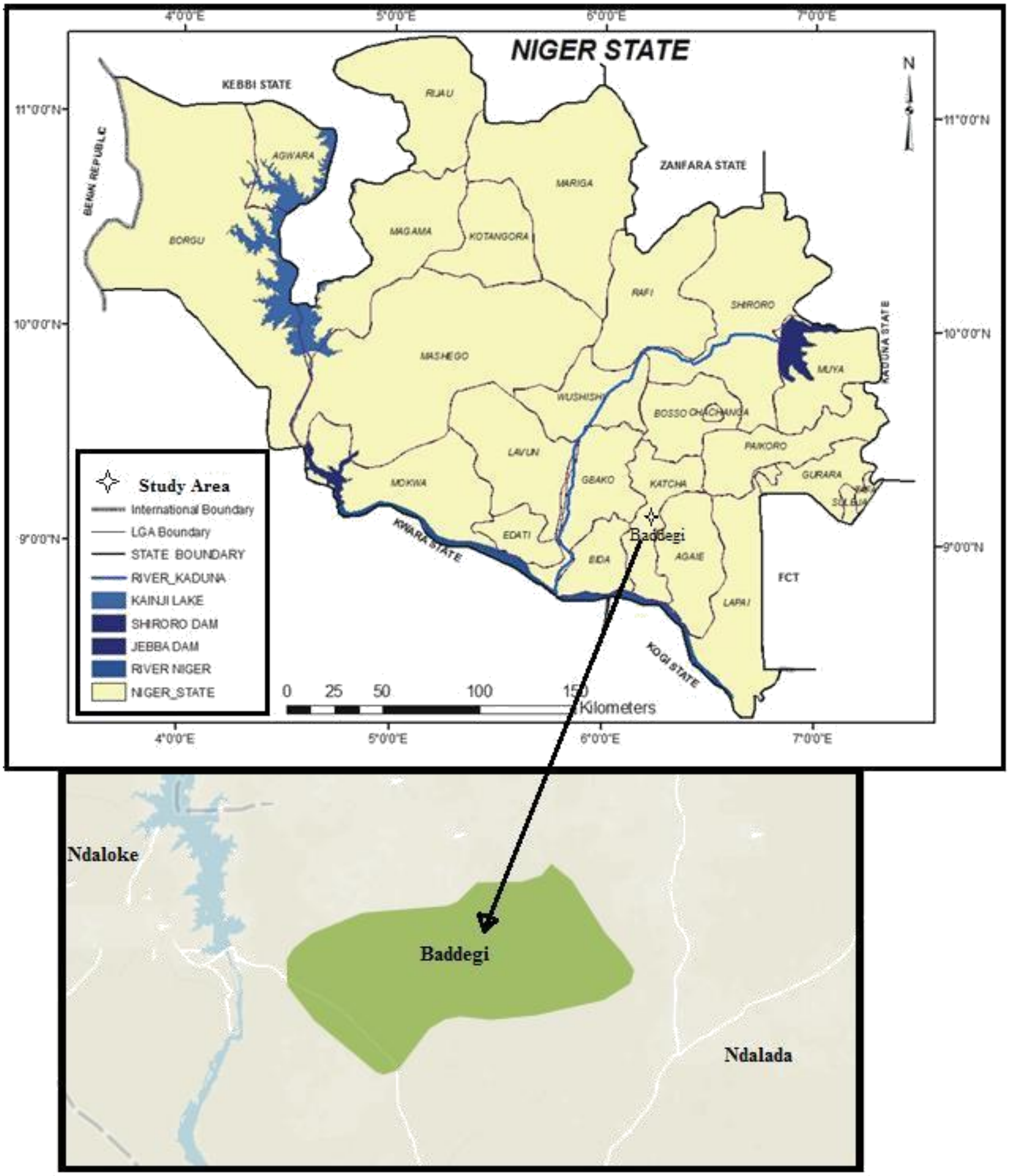


**Figure 1.2: Map of the Study Area**

**Source: Niger State Geographic Information System (2018)**

### 1.7.2 Climate of the study area

The study area experiences distinct dry and wet seasons with annual rainfall varying from 1,100mm in the Northern part of the State to 1,600 mm in the southern parts. The maximum temperature is recorded between March and June, while the minimum is usually between December and January. The rainy season lasts for about 150 days in the Northern parts of about 120 days in the Southern parts of the State. Generally, the climate soil and hydrology of the State permit the cultivation of most of Nigeria’s staple crops and still allows sufficient opportunities for grazing, fresh water fishing and forestry development. The characteristics of some aspects of rainfall variation in Bida, (study area) in particular in relation to the cultivation of rice in lowland area, are the focus of this study. According to Musa (2016), rainfall amount is not agricultural problem to man but the distribution of the amount on a month to month. The study is located in the northern part of the country, which is characterized by dry season of seven month, usually between October/November and April/May.

### 1.7.3 Geology of the study area

The geology of the study area falls within the Niger Valley/trough which is believed to be structurally developed. During the Tertiary and possibly the interglacial periods of the Quaternary glaciations, the Niger Valleys, otherwise known as the Niger trough, were transgressed by the waters of the Atlantic Ocean. As a result, marine sediments form the dominant surface geology of much of Bida Area. The study area is generally under lain by three principal rock units as follows:-

- Crystalline basement complex.
- Cretaceous sediments.

- Alluvial deposits.

**(a) Crystalline basement complex**

The above rock units have different characteristics and water bearing potentials. About 60% of the study area is under lain by crystalline complex rocks which are believed to be of pre-Cambrian age. The basement complex rocks occur in the northern and southern parts of the study area (Adefolalu, 1999). The basement complex rocks have been broadly divided into three groups namely:-

- Magnetite Gneisses
- Quartzite and Schist’s
- Granite rocks.

Each of the groups can further be subdivided according to composition:-

The Magnetite gneisses:- are of the veined variety, which have been formed by lit-par-lit injection of foliation planes of metamorphic host rocks, exhibit little met somatic effect on their formation which is often on their formation by veins of granites and pegmatite. The acid component is mostly of quartz fields and granite minerals while the basic components are of intermediate rocks mostly quartz diorite. The schist and quartzite occur in beds or ridges which run in a general NNE-SSW direction as in Zungeru, Kagara, and Shiroro (Adefolalu, 1999).

Granite rocks-is widely spread in Niger State and is of the older granite suite of pa-Africa organic age. Grain size range is from fine to medium. They are exposed in massive or isolated form in part of the state forming highland areas such as Paiko, Kusheriki, Libehi, etc. Crystalline basement complex rocks in their unaltered form are regarded as aquiclude and are of no hydro-geological importance. But secondary processes like deformation and weathering have given these rocks units some degree of porosity and can be regarded as aquifer. Two main aquifer units in the basement complex area are:

(i) The weathered unconsolidated materials or the over burden or the top residual soil.

(ii) Partly weathered and fractured basement, which is normally found below viable aquifer units in the basement complex of the study area are found within the fractured basement. Granite gneisses and magmatic rocks are readily weathered and usually contain fractures and so they store water in weathered and fractured zones. The schist belts on the other hand and dense rocks, which are resistant to weathering and have low permeability. Although they are fractured, little ground water is expected in the areas under lain by such rocks (Adefolalu, 1999).

**(b) Cretaceous Sediments**

The cretaceous sediments rest uncomfortably on the basement complex. The main formation is the Nupe sand-stone, which comprises fieldspastic sand stones, silt stones and clays deposited in the Niger trough (Green, 2015). Experience from ground water development Agencies in Niger State has shown that Nupe basin or formation contains a large amount of water, but no attempt has so far been made to quantify the reserve. Depth to unconfirmed water is quite variable ranging from only few metres to over 20 meters. Auriferous layers have been met at various depths and there is no rule as to where the best aquifer may be found until detailed hydrological studies on Nupe sand stone aquifer system have been done (Green, 2015). Several rivers and streams traversing the Nupe sand stone are perennial in nature, indicating that they are receiving affluent seepage (base flow) from the aquifer. Regional flow direction is towards the River Niger.

### (c) Alluvial Deposit

A long the bank of major rivers and their tributaries in the study area, recent deposits of alluvia are found. They vary in thickness from a thin cover of sand in the smallest tributary to as thick as 40 meters along the main river valley. Alluvial sediments consist of unconsolidated grounds, fine to coarse sands, silts and clays of recent age. Most of the alluvial deposits in the state are within the flood plain of Rivers, Niger, Kaduna, Gbako, Abba Mariga, and Kontagora. Alluvial sediments are found parallel to the matured stage of the river course where deposition and depositional features are pronounced. As a result of river meander, in most cases, there is hydraulic continuity between aquifer in alluvial sediment and river bed such that infiltration from the river bed can take place. Alluvial sediment is found parallel to the matured stages of the river courses where deposition and depositional features are pronounced. The plains are generally low lying with pocket of ox-bow lake formed as a result of river meander. In most cases, there is hydraulic continuity between aquifers in alluvial sediments and river bed such that infiltration from the river bed can take place by influent seepage where the ground water level in the aquifer lies below the water level in the river or stream and vice-versa by effluent seepage. Aquifers within the alluvial deposits bordering River Niger, Kaduna and Gbako have considerable yield because of hydraulic continuity with these rivers, the static water level in most of the tube wells range between 0.5 meters to 2.0 meters. The condition is important since it forms the drilling of functional and reliable source of water in the case of irrigation system (Adefolalu, 1999).

### 1.7.4 Vegetation of the study area

Baddegi vegetation is that of the southern Guinea Savannah. Persistent clearance of the vegetation that led to the development of regrowth vegetation at various levels of several development, but more importantly, parklands with grasses ideal for animal grazing during their early growth. The grasses however grow very tall, coarse and tough on maturity. The scattered trees are mainly those of economic value and include locust bean, shear butter, mango, silk cotton, et cetera. These trees produce valuable fruits, wood and fibre which can be utilized for small scale cottage industries. The current vegetation can be termed the drying era where more defoliation and deforestation give way to Shrub/Sahel vegetation. According to Adefolalu (1999), this leads to reduction in water shed areas and the surface water bodies are thereby exposed and formed ponds. The vegetation of the state can generally be described as a typical Guinea Savanna with a mixture of trees, shrubs and tall grasses. The southern part of the state encompassing Lavun, Edati, Gbako, Bida, Agaie, Katcha, Mokwa and Lapai Local Government Areas, including the southern parts of Rafi, Mariga, Chanchaga, Gurara and Suleja Local Government Areas, have a relatively dense structure which became dense further south in some parts of Lapai where the tree species are taller and closer. The northern parts of Rijau, Rafi, Magama, Mariga, Shiroro and Rafi Local Government Areas together with some parts of Kontagora and Mashegu Local Government Areas are relatively more open with widely sparse scattered trees amidst grasses. There are fringing forests, in Lavun, Gbako, Edati, Katcha, Bida, Lapai and Agaie Local Government Area. Pocket of forests, occur in Chanchaga, Bosso, Paikoro, Gurara, Rafi, Wushishi and Suleja Local Government Areas (Adefolalu, 1999).

### 1.7.5 Soil of the study area

The two main types of soils in Bida are the sedimentary belt in the southern and south western extremities of the area and the pre-Cambian basement complex rock country which accounts for more than 80 percent of the area. Like most alluvial soils, the soil in the study area is the flood plain type and is characterized by considerable variations. The soil is of two main types which could be used for agriculture and are rich in minerals for the manufacture of various products. The two types of soil are: The Ku-soil which has little hazards and the Ya-soil which has a better water holding capacity. The plains of the study area have the most fertile soils and the best agricultural lands of all plains of the study area while the high sand content of most soils within the study area accounts for the relatively high erosion status (Green, 2015).

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Conceptual Framework

#### 2.1.1 Agrochemical

Agrochemical can be referred to as chemical product used in agriculture to enhance production and they include fertilizer, pesticides, insecticides, herbicides, fungicides and nematicides (Alavanja *et al.,* 2013). An agrochemical is any substance used to help manage an agricultural ecosystem, or the community of organisms in a farming area. Unfortunately, when pesticides are applied onto a surface, they travel outside their intended area of use by air, soil or water. This is one common way in which chemical pesticides cause collateral damage, beyond their intended use.

Agrochemicals is an important agricultural support industry and boosts agriculture, while preventing, reducing and eliminating the impact of disasters to increase food output and safety. Chemical pesticides not only deplete the nutritional value of our food, but they also contaminate it. Research has consistently found pesticide residues in a third of food, including apples, baby food, bread, cereal bars, fresh salmon, lemons, lettuces, peaches, nectarines, potatoes and strawberries. While pesticides are designed to kill living organisms, they are certainly not meant to enter our bodies (Beane *et al.,* 2015).

#### 2.1.2 Irrigational Farming

Irrigational farming is the artificial application of water to land for the purpose of agricultural production. Effective irrigational farming will influence the entire growth process from seedbed preparation, germination, root growth, nutrient utilisation, plant growth and regrowth, yield and quality (Hoppin *et al.,* 2012).

Irrigation farming is the application of controlled amounts of water to plants at needed intervals for maximum agricultural production (Alavanja *et al.,* 2013). Irrigation helps to grow agricultural crops, maintain landscapes, and revegetate disturbed soils in dry areas and during periods of less than average rainfall. Irrigation also has other uses in crop production, including frost protection, suppressing weed growth in grain fields and preventing soil consolidation (Alavanja *et al.,* 2013).

## 2.2 Effect of Chemical Fertilizers on Human Health

A wide range of subjects are included in this category. We considered studies whose subjects are not only people who spray pesticides, but also who mix and load the pesticides, sow pesticide-seeds, weed and harvest sprayed crops, and clean and dispose of containers. A total of 122 studies were found. Most of the statistically significant results are pesticide-specific so it is not possible to generalize regarding health effects of pesticides.

### 2.2.1 Cancer

Cancer associated with pesticide exposure is one of the most studied topics related to pesticides' toxicity during the last decade. Of the studies found, 43 analyze the relation between direct exposure to pesticides and the risk of cancer. Most of the studies use the Agricultural Health Study (AHS) data. No unanimous agreement has been reached: 12 of the studies report no significant evidence of increased risk of cancer among farmers exposed to pesticides compared with the risk of the general population (De Roos *et al.,* 2015; Greenburg *et al.,* 2018; Lynch *et al.,* 2016), while the rest of the studies (31) conclude that exposure to certain pesticides significantly increases the risk of cancer (Alavanja *et al.,* 2013; Beane *et al.,* 2015). The heterogeneity of the results is related to the type of cancer being analyzed as well as the nature of the pesticides.

### 2.2.2 Depression and neurological deficits

The evidence found in 3 studies suggests that high-intensity and cumulative pesticide exposure contributes to depression among pesticide applicators (Kamel *et al.,* 2013). Different studies have been carried out analyzing the effects of pesticide exposure on neurological function. Evidence relating long durations of farm work with decreasing levels of performance has been found, and one relevant factor might be chronic exposure to pesticides (Kamel *et al.,* 2013). Results are mixed depending on the pesticide being analyzed: some of them suggest that neurological symptoms are associated with cumulative exposure, but this is true only for some fumigants and insecticides (Kamel *et al.,* 2015), and some pesticides, such as triallates, have no effect at all (Sathiakumar *et al.,* 2014).

### 2.2.3 Diabetes

More recent studies look for a link between diabetes risk and pesticide exposure. Exposure to organochlorine compounds is associated with increased prevalence of diabetes (Cox *et al.,* 2017) as well as handling organophosphate insecticides (Montgomery *et al.,* 2013). All the studies in this section find a significant association between pesticide exposure and diabetes, but the number of studies (3) is not large enough to formulate a general conclusion.

### 2.2.4 Respiratory diseases

There were 13 studies about respiratory diseases and its relation to pesticide exposure. Most of them suggest an increased risk of respiratory diseases such as rhinitis (Slager *et al.,* 2013), asthma (Hoppin *et al.*, 2012), bronchitis (Hoppin *et al.*, 2017c), farmer's lung (Hoppin *et al.*, 2017a), and wheeze (Hoppin *et al.*, 2012). However, Fieten et al. (2012) highlights the fact that it is not possible to establish a causal relationship, and 2 studies do not support a significant association (Boers *et al.*, 2018).

### 2.2.5 Women specific disorders

There were five studies in which the authors analyze the relationship between pesticide exposure and women specific disorders. Regarding the age at menopause the results are mixed: Farr et al. (2016) finds that exposure is associated with a higher age at women's menopause, while Akkina et al. (2014) reports the opposite result. The rest of the studies find that pesticide exposure is a cause of hormonal disorders (Farr *et al.*, 2014), but it has no effect on delayed conception in pregnant women (Lauria *et al.*, 2016).

### 2.2.6 General health, multiple diseases, and others

In this section we included studies that analyze the impact of pesticide exposure on general health or on several diseases. There are studies of diseases such as hepatitis, dyspnea (Azmi *et al.*, 2016), hearing loss, myocardial infarction (Dayton *et al.*, 2010), thyroid disease (Goldner *et al.*, 2010), sperm quality (Perry *et al.*, 2011), and of general measures such as human health hazard levels and even suicides (Beard *et al.*, 2011). Some studies highlight that precautionary measures have a significant impact on the relationship between pesticides and disease (Sekiyama *et al.*, 2017), while others find significant interaction effects on health of pesticide exposure and genetic polymorphisms (Lacasaña *et al.*, 2010b). New studies include clever techniques to analyze the effects of pesticides, such as invitro tests (Orton *et al.*, 2011) that enhance the identification of pesticides' effects.

## 2.3 Health Effects of Pesticides on Members of a Community with Indirect Exposure

There were 64 studies (33.5% of the total) analyzing the impact of pesticides on the health of people with indirect exposure (Carreon *et al.,* 2015). The subjects of these studies include farmers' family members or people living in rural areas where there is an intensive use of pesticides.

### 2.3.1 Cancer

We found 16 studies on cancer risk and indirect pesticides exposure among which no consensus is reached. For example, while 5 studies find evidence associating pesticide exposure (environmental, or prenatal) with increased risk of childhood leukemia (Ferreira *et al.,* 2013). Pearce et al., (2016) reports no significant association. In total, there are 3 studies whose evidence suggests no significant association between increased risk of cancer and indirect pesticide exposure (Carreon *et al.,* 2015), while the rest conclude the opposite, at least for some specific pesticides.

### 2.3.2 Depression and neurological deficits

There were 11 studies examining whether neurological effects are related to indirect pesticide exposure. The studies look at the risk of depression for spouses of pesticide applicators (Beseler *et al.,* 2016), decreases in neurobehavioral development (Bouchard *et al.,* 2011; Eskenazi *et al.,* 2010; Harari *et al.,* 2010), Parkinson's disease (Yesavage *et al.,* 2014), and the effect on children's IQ scores (Rauh *et al.,* 2011) . Even when exposure is indirect the risks of neurological damage may increase, especially for children whose exposure takes place during early stages of fetal development (Eskenazi *et al.,* 2010).

### 2.3.3 Diabetes

Only 2 studies were found looking at increased risk of diabetes, and both conclude that pesticide exposure can be associated with an increased risk of diabetes (Everett *et al.*, 2010; Son *et al.*, 2010). The number of related studies is too small to end up with a general conclusion, but this should motivate more research regarding this type of risk.

### 2.3.4 Respiratory diseases

It was surprising to find only 1 study looking at the risk of respiratory diseases (Balluz *et al.*, 2010). This study suggests that the health complaints reported by employees at a health center whose first floor was used as a mixing area for pesticides 20 years before, were precipitated by environmental and psychological factors, more than actual exposure to pesticides. More evidence is needed to come up with a general conclusion.

### 2.3.5 General health, multiple diseases, and others

While some studies find no long-term health risks from potential inhalation of pesticides (Murphy and Haith, 2017), or no association between birth weight and pesticide related activities during early pregnancy, others find significant effects over certain variables, such as body mass index (Burns *et al.*, 2012), endocrine performance and fetal growth (Wickerham *et al.*, 2012). Recent studies look at the effect of indirect exposure on health outcomes taking into consideration genetic heterogeneity among subjects (Andersen *et al.*, 2012).

## 2.4 Health Effects of Pesticides on Consumers

Although we expected to have more studies in this section, only 5 studies were found (2.6% of the total) and most of them related to cancer risk. Main results are presented in Table 3 in the appendix.

### 2.4.1 Cancer

The studies on cancer analyze the risks associated with the consumption of specific products which have some pesticide residues. These consumption products include: fish (Li *et al.,* 2018), water, seafood and milk or other dairy products (Pandit and Sahu, 2012). In general these studies find a small but statistically significant association between cancer risks and some specific pesticide residues, such as DDT and DDD (dichlorodiphenyldichloroethane), but not for other organochlorines. Specifically PCBs (polychlorinated biphenyls) present a higher risk for consumers (Li *et al.*, 2018).

### 2.4.2 General health, multiple diseases, and others

Only 1 study was found analyzing pesticide residue concentration in vegetables and finds that the risk posed to consumers varies with the season (Bhanti *et al.*, 2017). The winter season has the highest pesticide concentrations in vegetables that might accumulate in the person's body and lead to fatal consequences in the long run. However, only methyl parathion residues have a significant hazard index, so this result is also pesticide-dependent.

## 2.5 Effects of Chemical Fertilizers on Environment

Although it is beneficial to use chemical fertilizers, but there are also drawbacks like possible toxic nature of that chemical to humans and also to other animals and also alteration in the ecosystem because of effects of residues. Soil bacteria which are under persistent stress of pesticides having capability to decompose these toxic compounds into non-toxic products (Savitha and Saraswati, 2012).

Generally, all chemical pesticides used are toxic but they take a significant contribution in the fulfillment of large amount and continuous supply of food for whole world's population (Savitha and Saraswati, 2012).

Hayo et al., (2016) found that lethal effects of insecticides along with its additives are not specifically confined to target pest alone but in the course non target organisms are also affected. However, according to different types of pollutions in environment, tremendous applications of chemical pesticides and also other agricultural chemicals not just restrict growth of plants and productivity but can cause carcinogenesis as well as mutagenic effects on non-target micro-organisms.

Although organophosphorus insecticides are commonly taken as safe for human use, various researchers have found that exposure of very high levels of these insecticides may lead to health related problems to humans. Such health problems involve immune suppression, toxicity due to bioaccumulation and hormonal imbalance; disruption in nervous system, neurological toxicity, damage to spleen and cancer generation. Along with this other organisms like aquatic animals, most insects and especially other beneficial organisms are highly sensitive to the poisonous impacts of these types of insecticides (Hayo *et al.*, 2016).

Persistence of insecticides and their residues remained in soil not just affects growing crops plants but also gives adverse impacts on human health and animals because of bioaccumulation and saturation of residues of pesticides in crop plants (Savitha and Saraswati, 2012).

Various investigations on volunteers resulted in, exposure of respected insecticides as carbamates and organophosphates for long time; lowered the cholinesterase activities in blood without clinical manifestations (Aldridge, 2011).

An enzyme, acetyl cholinesterase (AchE) functions in termination of acetylcholine neurotransmission, which is released at choline nerve endings in reply with stimulation from nervous system. Hence reduction of activity of AchE enzyme leads to number of impacts occurring from extensive nervous stimulation and finally resulted in failure in respiratory activity and death (Costa, 2011).

From previous results as well as findings, it is very interesting and also dangerous to speculate lowered total protein of serum is because of decreased albumin synthesis in liver and increase in alpha globulins because of prolonged organophosphate pesticide exposures (Savitha and Saraswati, 2012).

Pesticidal residues inhibit many steps in the heme biosynthesis and this might be lead to inverse physiological manifestations. Also, toxic effect of pesticide residues may lead to occurrence of anaemic condition because there is interference in Haemoglobin biosynthesis in exposed body and decreased life span of circulating erythrocytes (Ray, 2012).

Major types of pesticides applied in grape wine yards are organochlorines, organophosphates, nitro and chlorophenols, carbamates and these pesticide exposures represent more potential health problems for sprayers and handlers in grape gardens (Diaz, 2018). There are different factors which affects the concentrations of pesticide exposure during the application of these pesticides in agriculture. It was detected that high level of exposures takes place with the sprayers as well as workers during handling and mixing of the concentrated pesticide solutions (Wolfe *et al.*, 2017). The effects produced by certain pesticides are mostly bio-chemicals which specifically include enzyme activities like its induction and inhibition. These effects of used chemicals can be diagnosed by observing biochemical alterations even though most adverse clinical health hazards taken place (WHO, 2012).

The major health hazards caused by organophosphates on human being are inhibition of cholinesterase, altered liver function due to contact of these organophosphate pesticides only or combining them with organochlorines (WHO, 2013).

Patil et al., (2013) have also reported that application various pesticides in grape gardens shown biochemical effects on sprayers and observed, long lasting exposure of different pesticides of grape gardens on handlers and sprayers affected their liver, biosynthesis of heme and decreased level of serum cholinesterase.

Recently, different research from various regions of the world found that hazardous impacts of insecticides on human being, specially by illuminating free radical mechanism and it is detected by by-product's of lipid peroxidation and its direct measurement like malondialdehyde (Feng *et. al.,* 2017).

Exposure of insecticide residues also cause adverse effects during pregnancy which could results into mental retardation, developmental disorders, behavioural disorders reproductive organ anomalies and various forms of endocrine disruptions on the offspring (Patil *et al.*, 2013).

These chemicals are not easily degradable and cause adverse effects on plants, animals and human through the process of bioaccumulation. Humans exposed to these insecticides and their additives show severe stomach lesions, hyperplasia, ulceration characterized by inflammation and necrosis (US and EPA 2016).

Feng et al. (2017) discovered in the studies involving survey of effects of long term exposures of organophosphorus pesticides on pre-school children through diets in Washington State noticed detectable levels of chlorpyriphos in some diets.

Bharadwaj and Garg (2012) detected residues of Chlorpyriphos ethyl in thermal mineral water in Greece. Nazia et al. (2013) reported that 39.6 per cent of the commercial pasteurized milk samples in Mexico contained detectable levels of organ phosphorus pesticide residues and in some samples; Chlorpyriphos exceeded the maximum residue levels. Nazia et al. (2013) reported presence of OP and OC residues of insecticides in breast milk samples in Bhopal. They observed that it is very dangerous that through feeding breast milk to infants, they take about 8.6 times more Endosulfan and about 4.1 times more Malathion. OC and OP residues of insecticides in market meat samples were monitored by Lydy and Linck (2013). Chlorpyriphos residues were present in both chicken and mutton samples. About 0.455 µg/g of residues of Chlorpyriphos were present in 99 per cent of the samples.

Ahmad et al. (2016) The main factor behind damaging effects of pesticides on the terrestrial as well as aquatic ecosystems from their use are that, they are very persistent and applied mostly as preventative tools instead curing agent in controlling insects, extremely toxic to fish and many of these pesticides have observed to be biomagnified in large organisms.

Lydy and Linck (2013) studied the toxicity of organophosphate insecticides and their additives on insecticides on insects and found that these cause metabolic disturbance causing production of toxic products which leads to death. Persistence of these used organ phosphorus insecticides after consumption with grass chippings and roots was well studied earlier.

Sengupta and his co-workers (2009) reported the impacts of Quinalphos (organophosphrous insecticide) on microbes and their activities in soil of tropical region. They observed that, the carbon content of microbial biomass in soil was higher importantly along time up to 1 month for all doses of treatment process designating that adaptation of microorganisms to utilize respective pesticide as their growth sources. Then, MBC rate was observed to be decreased, as Quinalphos get saturated with time and persist there.

Soil microorganisms which are important in nitrification, breakdown of cellulose, turnover of organic matter and other biological materials may also be adversely affected by pesticides. These soil applied pesticides also affect the virulence of the bacteria, reduction-oxidation enzymes and nitrogen fixing activity of Rhizobium (Paromenskaya, 2017). Organ phosphorus types of insecticides like Dimethoate, Quinalphos, Diazinon, as well as Chlorpyriphos have found different impacts on soil environments particularly on soil microorganisms. Effect of organ phosphorus insecticide on soil enzymes was studied (Nazia *et al.*, 2013).

Bharadwaj and Garg (2012) reported that addition of insecticides affects the major microbial parts of an ecological niche and therefore impacts are more specifically detected on soil functions and biotransformation processes in the soil. This tremendous application of insecticides in all agriculture fields also hampered growth of symbiotic nitrogen fixing bacteria.

Nazia et al. (2013), studied the growth and tolerance of bacterial communities in soil with reference to pesticides. This study sum up the information of the nature of organophosphate insecticides, their effect on growth and survival of efficient bacterial species of soil that is Acinetobacter species and Xanthomonas species.

### 2.5.1 Persistence and bioaccumulation of pesticides

Environmental contamination of insecticides is widely studied because of their extensive use and persistence in gardens, agricultural crops and soil. Due to their chemical structures and formulations, insecticides interpret a group of toxicant which shows capacity of variable persistence for photochemical and also for biochemical degradation (Khan and Francis, 2015).

There is persistence of insecticides in soil under various field conditions and also reported that approximately 95% of its residues persist in the environment like soil (Balwinder *et al.*, 2016).

These applied insecticides disturb the delicate balance and functioning of ecosystem (Khan and Francis, 2015). Balwinder *et al.,* (2016) found that, from the total application of insecticide into the farm only 0.1% of insecticide reaches the target organism whereas rest ultimately enter soil or aquatic ecosystem, where if it is not metabolized or detoxified it may persist for longer periods and results in to bioaccumulation by various organisms. Bioaccumulation is the accumulation of a substance in a biological tissue (Balwinder *et al.,* 2016).

Malinowski, (2010) reported there are various factors responsible for accumulation of insecticides in the tissues of an organism as: the concentration of pollution in the water, the age and sex of the organism and the water temperature as if the metabolism of the organism increases. There are many factors, by which activity of insecticides is determined, like mechanisms of action of active ingredients, the type of formulation, defense reactions of target insects, way of application, group of respected insecticide, atmospheric water content and soil temperature. If these factors are not at specific levels insecticides lose their activity and remain there in soils for long terms (Malinowski, 2010).

The huge amounts of insecticides are used on fruits and because many fruits are directly consumed, insecticide residues cause very harmful effects on human. The analysis of residues of chlorpyriphos, carbofuran and other pesticides on tomatoes, cucumber and strawberries was done by technique of GC-MS analysis and concluded that amongst them tomatoes shown less concentration of insecticidal components while strawberries showed greater number and level of insecticide residues (Haroune *et al.,* 2012).

There are different types of pests and insects which are resistant to various groups of pesticides and insecticides. This is resulted into the findings that, these chemicals are not decomposed in that environment by any process. These persistent and non-degradable compounds can be degraded by soil microbial activities (Haroune *et al.,* 2012).

The large deposition of these insecticide additives in agriculture farm yards results in the infertility of soil, so the deteriorating health of soils and plants has therefore, drawn the attention of researchers as to how the soil fertility and associated microbial activities can be protected (Haroune *et al.,* 2012).

### 2.5.2 Degradation and bioremediation of pesticides

For determining the long term persistence of organic chemicals in soil, natural water or sediment, it is essential for studying microbial activity (residing within that ecosystem) in overall process of degradation. The pesticide degradation rates in a soil depend on various components involving density of population and microbial activity in transformation of pesticides, bioavailability of pesticide and pH, temperature and soil water content as soil parameters (Parkin and Daniel, 2014).

Saraswat and Gaur (2015) described that there are different methods some physical and some chemical which can be used for treatment of contaminated soils with toxic compounds but these are found bonded specified matrix or may be transferred from one state to another state, thus bio-transformation is required. Thus treatment of hazardous chemical contaminated soil and water by biological means consist the conversion of complex toxic chemicals into non-toxic compounds. In view of this fact, biological degradation, specifically degradation by microorganisms has proved to be more reliable method for removal of insecticides. Several reports suggest that soil bacteria play significant role in detoxifying and degrading residues of organophosphorus insecticides in the environment (Saraswat and Gaur, 2015).

In biodegradation process, usually the respective insecticide serves as energy and carbon source for selected bacteria, involving required enzymes synthesis (Saraswat and Gaur, 2015).

The activity and specificity of these microbial enzymes against these persistent compounds varies from bacteria to bacteria and this non specificity during metabolism gives important biochemical activities for xenobiotic compound degradation in soil as well as water (Knackmoss, 2011). Biodegradation of persistent compounds by various enzyme activities is a very important tool for their complete removal from the contaminated environment (Knackmoss, 2011).

Pesticides persist in environment and major environmental concern is the aquatic ecosystem contamination because of pesticide runoff from production plants, accidental spills, agricultural runoff and many other resources (Knackmoss, 2011). There is an ultimately increasing interest and need to discover convenient, safe to carry out and economically cheap methods for pesticide removal (Kearney and Wouchope, 2012). For this reason, biological techniques such as phytoremediation and bioremediation are ecologically safe and cheap methods of detoxification and decontamination of a pesticide polluted environment such as soil (Kearney and Wouchope, 2012).

The pesticides used on grapes does not readily disappear from the environment i.e. soil, soil microorganisms from grape wine yards may be responsible for the disappearance from that environment, because these soil micro organisms are under persistent pesticide stress (Knackmoss, 2011).

Even though many of the soil microorganisms have degradation abilities (like mineralization, biotransformation and immobilization) specifically soil microbes serve a significant action in these biological cycles as well as for feasible biosphere development (Diaz, 2014).

Wuertz and Mergeay (2017) described, bacteria which survive in pollutant contaminated soils depend on their inherent structural as well as biochemical features, physiological and also genetic resistance ability consisting of cultural alterations in bacterial cells as well as modifications in environment.

But previous studies on soil bacteria have shown that pesticides regulate soil microbes by detrimental effects on their survival, morphological and biochemical characteristics, resulted in reduced biomass of microbial diversification (Wuertz and Mergeay, 2017).

Also earlier results indicated, long lasting stress of thermal temperature; extremes of pH or pollution of chemicals usually resulted in species diversity, change in metabolism and presence of plasmid in soil bacteria populations. These tremendous uses of pesticides without considering their effects have possible sources of ecosystem imbalance with their gene activities. Bacteria in soil which are in persistent stress of pesticides are adapted for degradation of these hazardous compounds into non-hazardous forms (Wuertz and Mergeay, 2017).

An important aspect of studying soil bacteria diversity in stressed environment such as pesticides, heavy metals and antibiotics that exposure of soil to these stress that leads to an increase in number of plasmid in bacterial communities in respective polluted environment. Several reports have observed, raise in number of plasmids for e.g. Pesticide resistance may be found without any stress while other researchers have observed increase in plasmid number is due to adaptation to stressed environment (Wuertz and Mergeay, 2017).

Soil microorganisms most specifically bacteria can utilize a range of natural as well as synthetic organic chemicals, adaptation of these microbes to pesticides can lead to a take chance to find the abilities of bacteria in degradation as well as to prepare pure microbial cultures or their consortium in treatment of contaminated sites and also degradation of toxic chemicals (Diaz, 2014).

Michelic and Luthy (2012) found that toxic compound degradation by microorganisms that is biodegradation can be specified as lowering the complex structure of chemicals by biological catalysis. There are a number of possible routes of removal of toxic substrates from a contaminated environment including biotransformation (e.g. Dehalogenation) mineralization (i.e. complete biodegradation), assimilation as nutrient into microbial biomass, volatilization, polymerization, leaching and sorption (Diaz, 2014). Commonly the method consists of monitoring of microbiological degradation of xenobiotic compounds by determining the residual concentration.

According to Racke and Frink (2014), a lowered concentration of the toxic insecticidal chemical does not necessarily mean that the environmental hazard is reduced instead; the respective chemical may be converted to other forms. The biological degradation of pesticides is variable because of differences in molecular structure as well as in chemical and physical properties (Sinton *et al.,* 2016). Biodegradation is the only way to minimize the burden of pesticides and their toxicity in agricultural land as grape wine yards. As bacteria present in soil have capability to degrade or metabolize virtually all synthetic as well as natural components as their growth sources. Thus, by detecting impacts of various physicochemical factors on decomposition, specific and efficient biodegradation technique can be employed (Rokade and Mali, 2013). The biodegradation of pesticides by microorganisms in soil systems is mostly studied as compare to compost piles, because soils typically have high microbial species diversity (Rokade and Mali, 2013). The pesticides applied to soil or sprayed on plants can be metabolize as nutrient material by soil micro organisms and decomposition can be carried out which led into production of new compounds that proved to be detrimental to crops rather than original molecule so, consortium of bacteria is useful for biodegradation.

Veena *et al.*, (2012) has studied the influence of consortia of beneficial rhizosphere microorganisms on growth and uptake of nutrients by crop plants. The result of the studies have revealed that by increasing the use of complex type of consortia with more number of beneficial organisms enhanced the biomass, growth and nutrient uptake of sorghum plants. Therefore, it is very essential to give due importance to this issue. The microbial degradation of these insecticides is an alternative as it is cost effective compared to chemical methods of detoxification. Moreover, it is beneficial from community health point of view because there is no secondary pollution. In this view, some soil microorganisms ultimately account for the degradation of the insecticides (Lemmon and Pylypiw, 2012).

Biodegradation is generally the dissolution of materials by bacteria or by other organism (Diaz, 2018). The factors which are involved in insecticide disappearance are photochemical mechanisms biotransformation, physical mechanisms chemical mechanisms, bioremediation and microbial degradation. Biotransformation is most commonly used mechanisms by soil microorganisms. It involves the minor or complete modification of structure of toxicological pollutants through biological processes by the activity of enzymes. These biological processes results in complete transformation of organic into inorganic molecule or into new organic molecule or may lead to minor modification (Brookes, 2014). Bioremediation is a comparatively recent and useful gaining to the series of clean up techniques currently used to repair and rehabilitate polluted sides. Many processes of collection, diffusion, landfill disposal, burning of material and removal by easily dilution or withdrawal of pollutants or conversion of these to other environmental system (Bouwer, 2012).

Soil micro organisms react with every matter in the environment, involving anthropogenic compounds that are poisonous to higher organism excepting some synthetic organic polymers. Autochthonous micro organisms of soil system can metabolize anthropogenic organic materials and raw hydrocarbon chemicals to carbon dioxide and inorganic salts (Bouwer, 2012).

By various activities human, organic matter like chemical fertilizers and pesticides have contaminated environment and also public programmes have exerted considerable attention in cleaning of polluted environment. Frequently, bioremediation is applied as comparatively new process for treating pollutants. Hence, during 1891 first sewage processing plant by biological means was developed in Sussex, UK. The bioremediation technology was applied since past hundred years and now a day application of micro organisms to overcome environmental pollutants with different kinds of toxic compounds is considered (Atlas and Philip, 2015).

Bioremediation is considered to be the selective isolation of specific biological markers as bacteria for good results of the bioremediation. It is being used for the destruction of chemicals in soil, sludges, ground water, gases and industrial water systems (Atlas and Philip, 2015). In soil system mainly in the rhizosphere and endorhizosphere regions microorganisms can degrade different xenobiotic compounds in consortium and return nutrients to the mineral salts used by the crop plants. These rhizospheric microorganisms especially bacteria have developed genetically determined system against toxicants due to their continuous exposure to such environmental stresses. Several pure bacterial isolates from the soil bacteria have selected with capacity to metabolize respective pesticide as a growth factors source. A recent result of study on cultivating previously non-cultivable bacteria with enriched environment as natural system in the laboratory which gives several new chemical degrading bacteria with their isolation and characterization (Shakoori *et al.*, 2010).

Amongst microorganisms, soil bacteria are most widely used for remediation purpose because they use pesticides as energy. Also, some fungal species including Phanerochaete chrysosporium, Trametes hirsutus, Cyanthus bulleri and Phanerochaete sordia which are capable of degrading some types of insecticides. Pesticides mainly degraded by soil bacteria like Pseudomonas and Bacillus and this variation is because of the wide range of enzymes present and secreted by these types of bacteria (Shakoori *et al.*, 2010).

Some natural bacteria occurring in soil are able to degrade some organophosphate insecticides like Quinalphos and Dichlorvas (Abdel-El-Haleem, 2013). Biodegradation of Diazinon an organophosphorus insecticide by different species of Serratia and Pseudomonas was also studied and these isolated strains of bacteria can be used in bioremediation of soils contaminated with Diazinon.

Several microorganisms especially bacteria have isolated and cultivated from various regions of the world with amazing property to degrade xenobiotics contaminants like pesticides. These bacteria belong to genera Pseudomonas, Ralstonia, Arthrobacter and Rhodococcus, Acinetobacter, Spingomonas, Brevunidimonas, Bacillus, Planococcus, Marinococcus and Acetobacter, Desulfitobacterium, Agrobacterium, Caulobacter, Flavobacterium, Methylobaterium, Fusarium, Terrabacter and Alcaligenes (Abdel-El-Haleem, 2013). The transgenic plants containing the genes of insecticide degradation have also been used. The first microbial gene expression factor was designed to negate chemically induced gene repression in 1994 and it was used to promote rapid microbial degradation of persistent organic chemicals in treated soils. Soil microorganisms including some Acinetobacter species have also been pulled increasing interest in the biotechnological and environment related applications. Few specific species of Acinetobacter genus are included in decomposition of various contaminants as chlorinated biphenyl and biphenyls (Abdel-El-Haleem, 2013).

Ning et al. (2010) concluded that Xanthomonas strain isolated from soil degrade Dichlorvas but not able to decompose chlorpyriphos. Similar report also given the effects of organophosphate insecticides on bacterial cultures from halophilic alkaline soil of Banasthali region. This distinction in Xanthomonas strains indicated that these types of insecticides had either inhibitory or stimulatory impacts on various groups of microbes.

Khoshkholgh Pahlaviani et al. (2012) reported cypermethrin insecticide degradation by indigenous bacteria isolated from top soil of cultivated field in North of Iran. The used pesticides persist in the soil. Hence, isolation and cultivation of endogenous bacteria which are capable of utilizing toxic insecticides has attained a considerable interest because of these soil bacteria give an ecologically friendly process of bioremediation in situ. Autochthonus microbial populations in some contaminated sites have developed over time passes for adaptation to chemical pollutants. Therefore, these contaminated regions are more efficient ecological niches to enrich or isolate bacterial species able to degrade organophosphate insecticides.

Abilities of bacterial species to metabolize insecticides as their carbon and energy source were demonstrated in many instances by using soil enriched techniques. By using soil enrichment technique, Shakoori et al., (2010) was cultivated and selected sixteen strains of bacteria capable of metabolising Quinalphos and Carbosulfan (an organophosphorus and a carbamate respectively) as carbon and energy source in carbon source deficient M9-medium.

Mixed culture as well as consortium of microorganisms was used for the study of pathways of endosulfan metabolism. The degradative genes of pesticides in microbial calls have been detected to be situated on transposons, plasmid genetic material or on chromosomes (Kummerer, 2014). The expanding field of biotechnology helped to raise the idea that microbial enzymes and engineered microbes could be control the circumstances of pesticides in the environments. By taking into consideration that a bacterium which is genetically modified as a manufactured item Anand Chakrabarty has awarded the first patent for his work on living organisms because he had inserted four different types of plasmids into a single bacterial species related to metabolism of hydrocarbons while there is still doubt about using genetically modified micro-organisms for environmental bioremediation. Interesting investigation about enzyme activities of degradation factors for metabolism is observed with genetically engineered bacteria cultivated in laboratory scale bioreactors. It was found that there is an adverse effect of grape replant on the microbial community of soil, its structure and also diversity (Xiu-wu Guo *et al.,* 2011). The soil of the replant vineyard has higher diversity of bacteria the previous result showed that the plant growth was suppressed by wine replanting. Also the fungal and bacterial diversity increased as the period of grape planting extended. This microbial diversity in the rhizosphere soils is greater than that in non-rhizosphere soils (Xiu-wu Guo *et al.,* 2011).

### 2.5.3 Biodiversity of soil bacteria

Agricultural soil system consists of different types of microorganisms including bacteria isolated from any natural environmental system. These soil microbes play many significant roles in nutritional cycling that are major contributor of balanced ecosystem in life of every organism on our earth, where microbes are necessary (Kummerer, 2014).

Rhizosphere bacteria (the bacteria present in the region of soil near the plant roots) have potential to degrade/detoxify insecticides persistent in soil. Also these bacteria from wine yards have potential ability for biological regulation of unwanted plants in wine yards. These soil microorganisms give more fertility to soil and also serve as a general indicator of environmental contaminants usually plasmid containing bacteria (Arias *et al.,* 2015).

Seybold et al. (2011) described, microorganisms in soil play necessary role in elemental cycles as well as also making of structured soil. Also these soil microorganisms are required for the global Carbon, Nitrogen, Phosphorus cycling and assimilation of necessary nutrient elements from organic matter pool of soil. As a matter, important activities in soil are totally connected to important functions of soil system that plays in elemental cycles. Hence, it seems logical that when there is evaluation of toxic pollutant impacts upon soil, the important functions of soil system and its components should be of significantly related. The healthy state of soil ecosystem is usually defined as proper functioning of that ecosystem with its microbial community. Health of this active and important living source is very much significant for the ecosystem as well as global balance. Soil micro-organisms also regulate ecosystems on above ground by supporting crop health nutritive level of crops, soil structure and its productivity.

Pace (2017) reported, there are nearly 5000 species of soil bacteria have been discovered and all living organisms present on earth based on various activities of microbes, but many manmade processes, like agriculture, city development, use of chemical pesticides, fertilizers or ecosystem pollutions can possibly cause effects on diversity of microbes in soil and also it interferes ecosystems in below and above ground. These soil bacteria are predominantly considered responsible for process as transformation of organic material, decomposition of phosphorus, formation of decomposed organic matter (humus) and also from composite parent chemicals formation of other elements, nitrogen fixing property and converting insoluble nitrogen interlockers' inorganic material to simple soluble products for crop use (Lambert *et al.,* 2010).

The bacteria and fungi groups in soil play an important role in various different biogeochemical cycle as carbon, nitrogen and sulphur cycles and these are influenced by the indiscriminate and unplanned use of agrochemicals. These used insecticides accumulate in the surface soil and interferes with the metabolic activities of microorganisms in soil. The noticeable heterogeneity of endogenous microbes in rhizosphere and in surface soil reach unstable state as the pesticides contact these areas, only those microbial groups remain there and further grow which are resistant to applied pesticides (Lambert *et al.,* 2010). Soil microorganisms specifically bacteria and fungi are important in soil fertility and hence in crop production. But applications of chemical pesticides cause effects on the microbial communities' present in that specific ecological niche and thus at the same time affects the biotransformation reaction occurring in soil (Lambert *et al.*, 2010).

One of the most important objectives in microbiological ecological study is the determination of diversity of microbial species, and the condition for discovering microbial community diversity study is to determine their properties and identify their representative single member. Techniques most frequently used in scientific classification which can be used in distinguishing organisms from such groups, but these methods need pure cultures of isolates which are isolated from various samples of environment (Lambert *et al.,* 2010).

**2.6 Review of Related Literature**

Eifediyi, Omondan, Takim and Animashaun (2014) studied an assessment of the use of agrochemicals among small-scale farmers in Esanland, Nigeria. Raising farmer's productivity has been recognized as a sustainable route to food security in Africa. Therefore, making pest control less arduous would enable the farmer's increase farm size and productivity. To this end, a survey was conducted in the 2012 farming season to determine the use of agrochemicals by farmers in Esan land, Edo State, Nigeria. A structured questionnaire was administered to farmers in Edo Central Senatorial District of Edo State, Nigeria which comprises five local government areas, namely, Esan South-East, Esan West, Esan North-West, Esan Central and Igueben. Three communities were selected at random in each of the local government areas and questionnaires were administered to the selected farmers in each community with the assistance of Agricultural Development Project (ADP) personnel and community leaders. Elicited information include farmer's literacy level, farm size, use of agrochemical, weed control technologies used, source of information, source of herbicide, hiring and frequency of herbicide usage in different crops. Data were analyzed and presented as percentage of released used questionnaire. Generally return rate was 100% of administered questionnaire and all were usable. The survey showed that most of the farmers were male (78 %) within the age of 36 – 55 (52.4 %) and 40.7 % were secondary school dropouts. Most of the farmers surveyed owned an average of 1 to 2 ha of farm land and 65 % used agrochemical products while 46% of agrochemical users used herbicide for weed control. Percentage frequency of respondents which had used agrochemical was 64.5% in Esanland. Across the local government areas, Esan West had the highest percentage frequency of 73.4% followed of Esan Central with 68.4% while Esan South East had the lowest percentage frequency of about 58%. Herbicides and fertilizers were the most used agro chemicals with 46.4% and 41.6% of respondents that used agrochemicals in Esanland; Esan west and Esan North-East local government areas had the highest respondents. The quantity of herbicide used by most farmers was small with 88.8% of respondents using 1-3 liters or kg of product. Farmers who used quantities of product greater than 3 liters or Kg but less than 5 liters or Kg of product were about 11% and most of them were in Esan west and Esan Central. Usage of herbicide among respondents was often seasonal (30.6%), than regular (24.0%) and occasional (25.4%). The regular and occasional users were more in Esan central and Esan west, respectively. Most farmers (88%) used between 1 - 3 litres of various herbicidal products. Limited access to credit facilities was the major constraint to herbicide usage in Esanland. Farmers are therefore encouraged to organize themselves into cooperative societies to enable them attract incentives while Edo State government should subsidies procurement of agrochemical products.

Gitahi (2014) assessed the risk of agrochemicals on the environment and human health- in Mukaro Location, Nyeri County, Kenya. Agriculture sector in Kenya has remained pivotal to the national economy with a direct relationship between its performance and overall national economic growth. Agricultural production is nonetheless constrained by various diseases, insect pests, and low soil fertility thus necessitating mitigation by use of agrochemicals which are, however, potentially harmful to man and the environment. The broad objective of this research was to assess the human and environmental health risks posed by the use of agrochemicals within Mukaro location of Nyeri County of Kenya. This study was undertaken in a period of four months between August and November 2014. Six sub-locations out of twenty two were randomly selected in the location and a total of 370 respondents used in the study. Multistage sampling was exercised during selection of the sampling units while simple random sampling was used to obtain the households that participated in the interview. Data was collected through interviews by use of structured questionnaires. Key informants interviews were conducted with the aid of a questionnaire. Direct observation was important in verifying some of the information collected during household interviews. Data collected was summarized, organized and cleaned using SPSS version 20. Analysis was done to establish relationships between variables and the results presented in frequency tables, graphs and narratives. The findings show that 80% of famers had little knowledge on the use of agrochemicals,52% of the farmers used agrochemicals in order to increase yield as well as to control pest and disease,69% of farmers had some ailment they attributed to the use of agrochemicals, 96.6 % had eye irritation and 48% had skin irritation. The proportions of the farmers ratings of the risks of the agrochemicals on human health differed significantly p ($X^2 \geq 55.210$, 2df) =0.0001, α 0.05. The study also established that 69% of farmers had not received training on agrochemicals usage, effects on human health and on the environment. Farming experience influenced the respondents' perception on agrochemicals risk on the environment significantly p ($X^2 \geq 19.500$, 4df)=0.0001, α 0.05.The study concluded that farmers have inadequate knowledge, attitude and practices with regard to use of agrochemicals in crop production thus result in adverse environmental and human health effects. The farmers applied pesticides without adequate understanding of pest ecology, economic injury level, types of pesticides to control specific insect pests, their quantities and methods of application, time lapse between and spraying and precautionary safety measures needed during routine application in anticipation of pest (disease, insect) outbreaks in the area. From the findings the research recommends that sensitization campaigns to educate farmers on proper and efficient use of agrochemicals to improve productivity as well as prevent adverse environmental and human health effects should be done. The study also recommends for the adoption and use of the appropriate training and information dissemination methods on agrochemicals to the farmers.

Kesner and Pierre (2015) worked on the analysis of pesticide use and incidences of diseases in the region of Rincón de Santa María. Heavy use of toxic pesticides in agriculture worldwide has raised serious concerns about health issues. The World Health Organization (WHO) estimates that acute pesticide poisoning (APP) affects 3 million people and accounts for 20,000 unintentional deaths per year, with 99 percent of these fatalities believed to be in developing countries. In Panama, several diseases related to pesticide poisonings have been reported. In El Rincón de Santa María in particular, a small town in the province of Herrera surrounded by vast industrial monocultures, farmers misuse pesticides and do not follow safety procedures for application despite being informed about negative health effects of these products. Consequently, both acute and chronic cases of pesticide-induced illness are common in this area. This research project therefore aims to examine the perception, knowledge and practices associated with the use of pesticides in the area of Rincón the Santa Maria, as well as the awareness of farmworkers with regard to the possible side effects of these chemicals on human health. This project was done over the course of four months, from January to April 2015. Several semi-structured interviews were conducted among government entities in the study area including MINSA and MIDA to obtain information pertaining to health and agriculture respectively. A survey questionnaire was also distributed among 30 farmworkers in the community to assess their knowledge, perception and awareness with regard to handling of pesticides. Out of the 30 questionnaires distributed, 20 were retrieved, for a response rate of 66%. Eleven (55%) of the respondents were men and 7 (45%) were women. The median age was 43 years (Q1= 36 years, Q3= 50 years). All of the respondents have had at least primary education, only seven (35%) had secondary education and none had attended post-secondary education. The surveys revealed that even amongst the agricultural workers who receive training on pesticide use, there seems to be a lack of information about the potential hazards of pesticides on health. The main sources of information for the workers were the MIDA, the pesticide vendors and the MINSA. The absence of traditional media as a source of information might indicate that public-awareness campaigns using these channels might be unlikely to reach the main actors (the agricultural workers). Although there seems to be a consensus in the respondents towards the necessity of more educational workshops, further clarification is needed in regard to the contents of these workshops in order to meet the needs and concerns of the farm workers. More in-depth face-to face interviews with the producers would allow the assessment of these needs and could be the entry point towards a more participatory education. Additionally, this study did not cover the perceptions and knowledge of the producers regarding the environmental impacts on pesticides. The integration of the environmental component to this study would help in building a holistic assessment of the agricultural situation in that region.

Rim-Rukeh, Ikhifa and Okokoyo (2016) analysed the effects of agricultural activities on the water quality of Orogodo River, Agbor Nigeria. The paper assessed the effects of agricultural activities on the water quality of Orogodo River. The study included 100 farmers that were chosen randomly from Agbor and Owa communities to answer questions concerning agricultural practices in terms irrigation (methods and frequency) and the types of fertilizers. It was clear that most of the farmers employ irrigation methods and fertilizers that have the potential to cause water pollution. Five sampling stations were identified along the length of the river to determine the physico-chemical characteristics of the water body. In order to collect information on agricultural practices of the area, a well-structured questionnaire which focused on (i) irrigation methods (ii) irrigation frequency and (iii) type of fertilizers was developed. The information about farming practices were consistent with earlier report. Variations of the parameters along the length of the river were attributed to runoff from farmlands and the ability of the river to undergo self-purification. At sampling station A, physicochemical parameters were found to be within the safe limits for drinking water. At sampling stations B, C and D physico-chemical parameters show a high level of pollution. These higher levels of studied parameters can be attributed to farming activities along the bank of the river. At point E the water sample was of good quality showing that the river body has high degree of self-purification. It can be concluded from the results of this study that at sampling point A, Orogodo River belongs to class 1, that is excellent water quality. However at point B, C and D the values of the measured parameters correspond to rivers undervery heavy pollution from non-point sources of agricultural operations, through the release of animal waste run-off and control other human activities to ensure that run off water have a minimal effect on the water quality of Orogodo River.

Jimoh, Ayodeji and Mohammed (2013) analysed the effects of agrochemicals on surface waters and groundwater in the Tunga-Kawo irrigation scheme, Nigeria. The Tunga-Kawo Dam has a reservoir capacity of 22 miles, and was designed to irrigate 900 ha of land in the Midland region of Nigeria. The paper examined the quality of surface water and groundwater within the scheme. In particular, the seasonal variation of the concentrations of nitrate, phosphate, dissolved oxygen and hydrazine during the year 2000 is discussed. Three sample points: SF1, SF2 and SF3, were selected for monitoring the surface water quality at the upstream, impounded water and downstream sections, respectively. The quality of groundwater was monitored using samples from a well near the dam (GW2) and the downstream section (GW3). Water samples were taken on a weekly basis from the sample points during the year 2000. It was found that the concentrations in the surface water were higher than the WHO standards for drinking water. For example, the nitrate level in SF3 increased from 0.0 mg l-1 before application of fertilizer to 74.1 mg $l^{-1}$ after fertilizer was applied, while the phosphate level rose from 1.2 mg $l^{-1}$ to 19.2 mg $l^{-1}$ during the same period. Similarly, the level of hydrazine increased from 62 μg $l^{-1}$ to 102 μg $l^{-1}$. In particular, the concentrations of the determinants in the samples from the downstream section exceeded those in the impounded water and water from the upstream section. In addition, the level of DO at the downstream section SF3 was lower than that of the upstream section. The level was lower than the minimum level required to support a balanced population of desirable flora and fauna. This difference was attributed to the agrochemicals used by the farmers. Although the quantity of fertilizer applied by the farmers is below the quantity required for optimum yields, the excess chemicals in surface and groundwater could be attributed to the techniques and timing of application. The magnitude of these impacts can be reduced by efficient methods of source control of the pollutants.

# CHAPTER THREE

## 3.0 MATERIALS AND METHODS

### 3.1 Sources of Data

The sources of data used include primary and secondary.

#### 3.1.1 Primary sources of data

The primary data for the study were sourced using structured questionnaire, oral interview and field survey which were the main instruments for data collection. It was used to elicit responses from the respondents which was mainly for the farmers using agrochemicals in their farms to enhance production in the study area.

#### 3.1.2 Secondary sources of data

The major secondary data source include collection of hospital records related to the impacts of agrochemical application in the study area, others include information from Badeggi research institute, dissertations, textbooks, journals, unpublished texts, published texts, collection of e-books and the internet.

### 3.2 Instrument for Data Collection

Three instrument for data collection was used and they include GPS, questionnaire and oral interview. These methods were used to achieve four stated objectives of the study.

#### 3.2.1 Questionnaire design

The questionnaire survey is one of the effective instruments of data collection. Face-to-face interviews, telephone interviews, mail questionnaires, and internet questionnaire are various modes of questionnaire survey (Habiba *et al.,* 2012). In order to allow the investigator to collect the most accurate data from a target population, questionnaire must be unbiased (Manandhar *et al.,* 2011).

The questions that were included in the questionnaire are farmers' knowledge, attitudes and practices on agrochemicals applications in crop production; types and quantities of agrochemicals used by farmers; agrochemicals impact on human health and environment in the study area and finally the questionnaire also looks at questions pertinent to adaptation strategies put in place to reduce the impact of agrochemical usage in the study area. The questionnaire was divided into five sections and they include

**Section A:** Deals with the personal data of the respondents and demographic characteristics.

**Section B:** Consists of farmers' knowledge, attitudes and practices on agrochemicals applications in crop production.

**Section C:** Deals with the types and quantities of agrochemicals used by farmers.

**Section D:** Concerns with agrochemical application impact on human health and environment in the study area.

**Section D:** Deals adaptation strategies put in place to reduce the impact of agrochemical application in the study area.

### 3.2.2 Oral interview

An oral interview is a effective research technique which help the interviewer access his or her information needed to carry out his research effectively and efficiently. This instrument involved personal meetings with designated farmers using agrochemical in their farms, victims of agrochemical application impact, precisely household heads and farmers in the study area and their traditional ruler. The information generated from oral interview were integrated to that of questionnaire information and were analyzed using frequency percentage. Each farmer as well as village head were interview face to face with the help of pre-tested questionnaire, which was both close-ended and open-ended questions.

### 3.3 Sampling

#### 3.3.1 Sample size

Sample size was drawn using Yard's formula. This formula is concerned with applying a normal approximation with a confidence level of 95% and a limit of tolerance level (error level) of 5%. Sample points for this study include farmers using agrochemical and village head.

To this extent the sample size is determined by $n = \frac{N}{1+Ne^2}$ ----------------(i)

Where: n = the sample size

N = population (population of farmers using agrochemical in the study area as well as the village head)

e = the limit of tolerance (0.05)

Therefore, $n = \frac{11,657}{1+ 11,657(0.05)^2} = \frac{11,657}{1 + 11,657(0.0025)} = \frac{11,657}{1 + 29.1} = \frac{11,657}{30.1}$ = 387 respondents

The study respondents were 387 and simple random sampling was used to distribute the questionnaires among the respondents. Three hundred and forty one questionnaires were returned which the study based his analysis on.

### 3.3.2 Sampling technique

Simple random sampling was used for this study. To conduct a simple random sample of this study, the researcher first prepares an exhaustive list (sampling size) of all members of the population of interest. From this list, the sample was drawn so that each person or item has an equal chance of being drawn during each selection round and the samples may be drawn with or without replacement.

## 3.4 Data Analysis and Presentation

Data collected using questionnaire and oral interview were analysed statistically through frequency percentage, 3-point likert scale and statistical mean in the study area.

**Examine the farmers knowledge on agrochemicals applications in crop production, 5-point Likert type scale was used to achieve objective one.**

This objective was achieved using a 5-point Likert type scale with response options as strongly agree (SA) = 5; agree (A) = 4; don't know (DK) = 3; disagree (D) = 2 and strongly disagree (SD) =1.

$$\text{Mean value } (x) = \frac{5+4+3+2+1}{5} = \frac{15}{5} = 3$$

Therefore any variable with mean score ≥3 was considered a good option while those with mean scores less than 3 was regarded as not good option. Each of the five responses would have a numerical value which was used to measure the attitude under investigation.

**Determine the types and quantities of agrochemicals used by farmers in their major production processes in the study area, frequency-percentage was used in achieving this objective.**

Frequency-percentage technique was adopted as one of the techniques for the analysis. The analysis of frequency percentage is one of the first techniques for analyzing research data that were collected through the use of questionnaire. The frequency-percentage technique is relatively easy to present, analyze and interpret. Frequency-percentage was used to achieve objective two of the study.

$$\text{Frequency-percentage} = \frac{\text{Number of observed}}{\text{Total Number}} \times \frac{100}{1}$$

**Analyse the use agrochemicals impact on human health and environment in the study area, frequency-percentage and mean were used for this analysis.**

Data will be collected through the use of questionnaire; frequency-percentage and mean were used to achieve this objective.

$$\text{Frequency-percentage} = \frac{\text{Number of observed}}{\text{Total Number}} \times \frac{100}{1}$$

The statistical mean technique below was used to add value to what was obtain in the research question for this objective.

$$\bar{x} = \frac{\sum x}{n} - - - - - - - - - - (iii)$$

Where x is the mean of the research question and n = number of respondents.

**Examine the adaptation strategies put in place to reduce the impact of agrochemical usage in the study area, 3-point likert scale was used for analysis.**

This objective was achieved using a 3-point Likert type scale with response options as very good adaptation (VG) = 3, good adaptation (G) = 2 and not good (NG) =1. The mean value of the responses was calculated thus:

$$\text{Mean value } (x) = \frac{3+2+1}{3} = \frac{6}{3} = 2$$

Therefore any variable with mean score ≥2 was considered a good adaptation while those with mean scores less than 2 was regarded as not good adaptation. The adaptation strategies include planting drought resistance varieties, planting of early maturity varieties, continues awareness on the impact of agrochemicals on human health and environment and increase level of awareness on farmers to follow procedures to handle agrochemicals.

The research encompasses many data, thus data analysis were presented in tables, pictures and graphical illustrations.

## CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSIONS

The results and discussions in this section covered the four objectives of this study.

### 4.1 Examine farmers knowledge on agrochemicals applications in crop production in the study area

In line with objective one, Table 4.1 revealed farmers knowledge on problems affecting crops in the study area.

**Table 4.1: Farmers Knowledge on Problems Affecting Crop Production**

| Options | SA (5) | A (4) | DK (3) | D (2) | SD (1) |
|---|---|---|---|---|---|
| Soil fertility loss | 89 | 2 | 0 | 0 | 0 |
| Diseases | 37 | 0 | 0 | 0 | 0 |
| Pests | 49 | 23 | 0 | 0 | 0 |
| Weeds | 111 | 30 | 0 | 0 | 0 |
| Total | 286 | 55 | 0 | 0 | 0 |

Note: strongly agree (SA) = 5; agree (A) = 4; don't know (DK) = 3; disagree (D) = 2 and strongly disagree (SD) = 1

**Source: Field Survey (2019)**

As revealed in Table 4.1, weeds ranked the highest common problem affecting crops with 111 respondents strongly agreed, soil fertility loss ranked second with 89 respondents strongly agreeing and diseases ranked the least with 37 respondents strongly agreeing. This implies that the major problem affecting crops in the study area was weeds based on farmers knowledge. This was equally shown in plate I of the study.

**Plate I: Respondent applying agrochemical on weeds**

**Source: Field Survey (2019)**

Plate I shows one of the respondents applying agrochemical to grasses for the purpose of agricultural activities. The sample population affirmed that grasses was major problem to crop production which need to be cleared in the farms.

As revealed in Table 4.2, sources of farmers knowledge on agrochemical application in crop production include agricultural extension officers, radio, other farmers, researchers, agrochemical stockiest and internet. As indicated in Table 4.2, agric extension officers ranked the highest source of farmers knowledge on agrochemical application with 167 sample population, agrochemical stockiest ranked second with 58 sample population and radio ranked the least with 17 sample population. This implies that the major source of farmers knowledge on agrochemical application in the study area was agricultural extension officers.

**Table 4.2: Sources of farmers knowledge on agrochemical application**

| Options | SA (5) | A (4) | DK (3) | D (2) | SD (1) |
|---|---|---|---|---|---|
| Agricultural ext. officers | 14 | 153 | 0 | 0 | 0 |
| Radio | 17 | 0 | 0 | 0 | 0 |
| Other farmers | 11 | 13 | 0 | 0 | 0 |
| Researchers | 12 | 21 | 0 | 0 | 0 |
| Agrochemical stockiest | 31 | 27 | 0 | 0 | 0 |
| Internet | 19 | 23 | 0 | 0 | 0 |
| Total | 104 | 237 | 0 | 0 | 0 |

**Source: Field Survey (2019)**

As revealed in Table 4.3, the reason(s) why the respondents used agrochemicals (Fertilizers and Pesticides) in their farms include to increase yields, to control pests and diseases, to improve appearance‘(spotlessness) for marketability and better price and advised to do so by extension agents. Increase yield ranked the highest with 203 respondents, control pests and diseases ranked second with 67 respondents and improve appearance for marketability ranked the least with 11 respondents. This implies that the major reason for application of agrochemicals was for increased yield in the study area.

**Table 4.3: Reasons for application of agrochemicals by the farmers in the study area**

| Options | SA (5) | A (4) | DK (3) | D (2) | SD (1) |
|---|---|---|---|---|---|
| Increase yields | 14 | 203 | 0 | 0 | 0 |
| Control pests and diseases | 67 | 0 | 0 | 0 | 0 |
| Improve appearance‘(spotlessness) for marketability | 11 | 13 | 0 | 0 | 0 |
| Advised to do so by extension agents | 12 | 21 | 0 | 0 | 0 |
| Total | 104 | 237 | 0 | 0 | 0 |

**Source: Field Survey (2019)**

As revealed in Figure 4.1, rating the knowledge of agrochemicals users in the study area were categorise into five and they include negligible, very little, little, enough and more than enough.

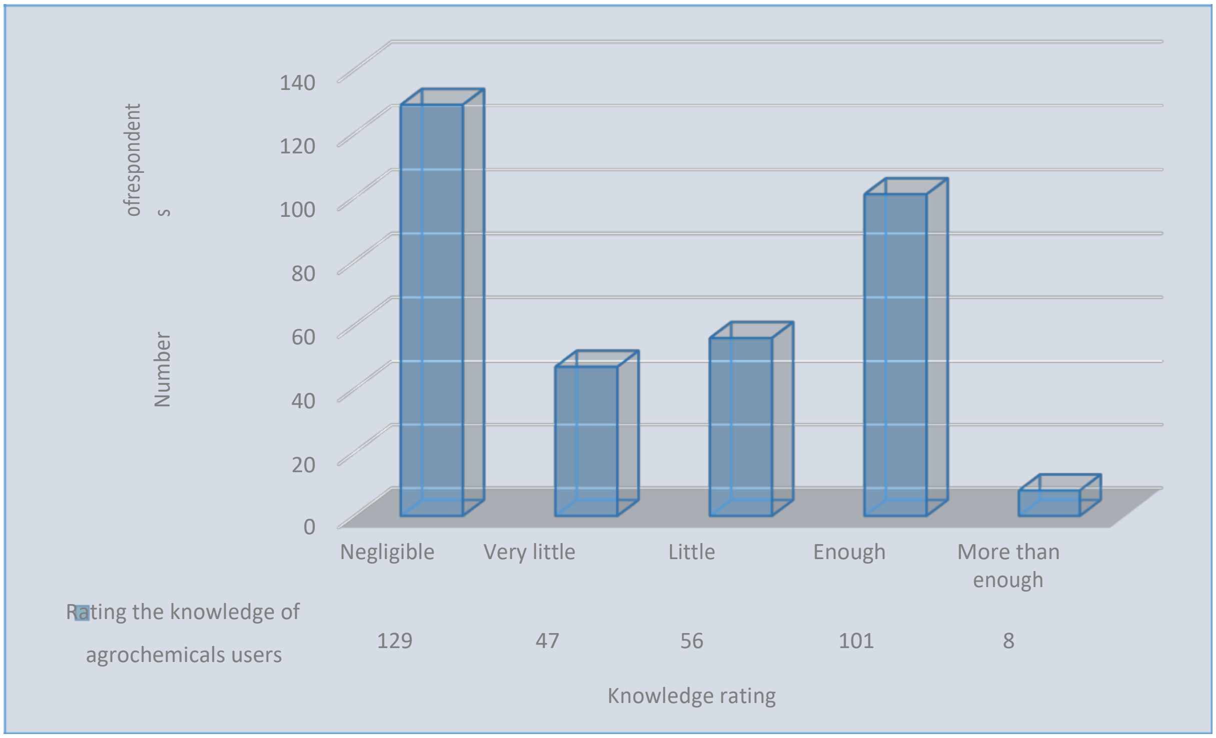


**Figure 4.1: Rating the knowledge of agrochemicals users in the study area**

**Source: Field Survey (2019)**

Negligible ranked the highest with 129 respondents, enough ranked second with 101 respondents and more than enough ranked the least with 8 respondents. This implies that the knowledge of agrochemicals users in the study area was negligible which is not good at all considering the impact of agrochemicals on the environment as well as on people when it's not used properly.

### 4.2 Examine the types and quantities of agrochemical used by farmers in their major production processes in the study area

In line with objective two which was to determine the types and quantity of agrochemical in the study area. As revealed in Table 4.4, type of agrochemicals to apply in farms were determine through use own experience, asks what other farmers have used, as advised by extension officer and experiments on different types then choose. As advised by extension officer ranked the highest with 211 respondents, asks what other farmers have used ranked second with 65 respondents, used own experience ranked third with 21 respondents and experiment on different types then choose ranked the least with 3 respondents. This implies that the type of agrochemical to apply in farms were determine by the advised of extension officers in the study area. The names of agrochemicals used in the study area include Glyphosate, Orizo plus, Urea, NPK, Gamaline, Butter clow, etc.

**Table 4.4: How the farmers determine the type of agrochemicals to apply in their farms**

| Options | SA (5) | A (4) | DK (3) | D (2) | SD (1) | Freq. | % |
|---|---|---|---|---|---|---|---|
| Use own experience | 11 | 21 | 0 | 0 | 0 | 32 | 9.4 |
| Asks what other farmers have used | 65 | 0 | 0 | 0 | 0 | 65 | 19.1 |
| As advised by extension officer | 211 | 18 | 0 | 0 | 0 | 229 | 67.2 |
| experiments on different types then choose | 3 | 12 | 0 | 0 | 0 | 15 | 4.3 |
| Total | 104 | 237 | 0 | 0 | 0 | 341 | 100 |

**Source: Field Survey (2019)**

As revealed in Table 4.5, the types of agrochemicals used in the study area include pesticides, herbicides, fertilizers and fungicides. Fertilizers ranked the highest agrochemicals used by the sample population with 139 respondents, herbicides ranked second with 95 respondents, pesticides ranked third with 82 respondents and fungicides ranked the least with 25 respondents.

This implies that fertilizers (NPK and Urea) is the major agrochemicals used in the study area. The types of pesticides used by the respondents in the study area include Glyphosate, Orizo plus, Gamaline, Paraquat, Propanil, 2,4-D Amine, Dichlovos, Mancozeb and Butachlor. The types of herbicides used in the study area Simaxine, Interceptor, Gallant NF, Buster, Versatil and Terbuthylazine. The types of fungicides used in the study area include Polyoxin-D, 42-S Thiram, Actigard 50 WG, Agclor 310 and Actinovate AG.

**Table 4.5: Types of agrochemical used in the study area**

| Options | SA (5) | A (4) | DK (3) | D (2) | SD (1) | Frequency | Percentage (%) |
|---|---|---|---|---|---|---|---|
| Pesticides | 61 | 21 | 0 | 0 | 0 | 82 | 24.0 |
| Herbicides | 79 | 16 | 0 | 0 | 0 | 95 | 27.9 |
| Fertilizers | 111 | 28 | 0 | 0 | 0 | 139 | 40.8 |
| Fungicides | 13 | 12 | 0 | 0 | 0 | 25 | 7.3 |
| Total | 264 | 77 | 0 | 0 | 0 | 341 | 100 |

**Source: Field Survey (2019)**

As revealed in Table 4.6, not reading the instructions on the label before using a particular agrochemical ranked the highest with 287 respondents and reading the instructions on the label before using a particular agrochemical ranked the least with 54 respondents. This implies that majority of respondents do not read neither no how to read the instructions before usage which in turn affect the environment negatively as well as their health.

**Table 4.6: Revealed whether the farmers read the instructions on the label before using a particular agrochemical in their farms**

| Options | Frequency | Percentage (%) |
|---|---|---|
| Yes | 54 | 15.8 |
| No | 287 | 84.2 |
| Total | 341 | 100 |

**Source: Field Survey (2019)**

As revealed in Table 4.7, understanding the instructions specified for chemical/pesticide usage ranked the highest with 47 respondents and not understanding the instructions specified for chemical/pesticide usage ranked the least with seven respondents. This implies that majority of those who read the instructions understand them as specified for chemical/pesticide user in the study area.

**Table 4.7: Revealed the farmers understanding the instructions specified for agrochemical usage**

| Options | Frequency | Percentage (%) |
|---|---|---|
| Yes | 280 | 97.6 |
| No | 61 | 2.3 |
| Total | 341 | 100 |

**Source: Field Survey (2019)**

As revealed in Table 4.8, quantity of liquid agrochemical used per hectare ranges from 250mg/hectare to 400mg/hectare. 301 – 400mg/hectare ranked the highest with 259 respondents and 250 – 300mg/hectare ranked the least with 82 respondents. This implies that majority of the respondents applied agrochemical wrongly do to their inadequate knowledge required for agrochemical amount for a particular purpose. This agreed with the work of Abdel-El-Haleem (2013); Aikpokpodion *et al.*, (2015); and Alavanja (2014).

**Table 4.8: Quantity of liquid agrochemical used/hectare**

| Options | Frequency | Percentage (%) |
|---|---|---|
| 250 – 300 | 82 | 24.0 |
| 301 – 400 | 259 | 76.0 |
| Total | 341 | 100 |

**Source: Field Survey (2019)**

As revealed in Table 4.9, quantity of solid agrochemical used per hectare ranges from 50kg/hectare to 400kg/hectare. 251 – 400kg/hectare ranked the highest with 188 respondents and 50 – 100kg/hectare ranked the least with 52 respondents. This implies that majority of the respondents applied solid agrochemical wrongly do to their drive for optimum yield which in turn impact on the environment and human health negatively. This agreed with the work of Alavanja (2014) and Aikpokpodion *et al.*, (2015).

**Table 4.9: Quantity of solid agrochemical used/hectare**

| Quantity (kg) | Frequency | Percentage (%) |
|---|---|---|
| 50 – 100 | 52 | 15.2 |
| 101 – 250 | 101 | 29.6 |
| 251 – 400 | 188 | 55.2 |
| Total | 341 | 100 |

**Source: Field Survey (2019)**

### 4.3 Agrochemicals impact on human health and environment in the study area

As indicated in Figure 4.2, the effect of agrochemicals on the environment was rated into four categories. Moderately harmful ranked the highest with 153 respondents, very harmful ranked second with 81 respondents, not harmful at all ranked third with 61 respondents and slightly harmful ranked the least with 46 respondents. This implies that the respondents affirmed that agrochemicals used in the study area affects the environment negatively as it was affirmed in Table 4.12.

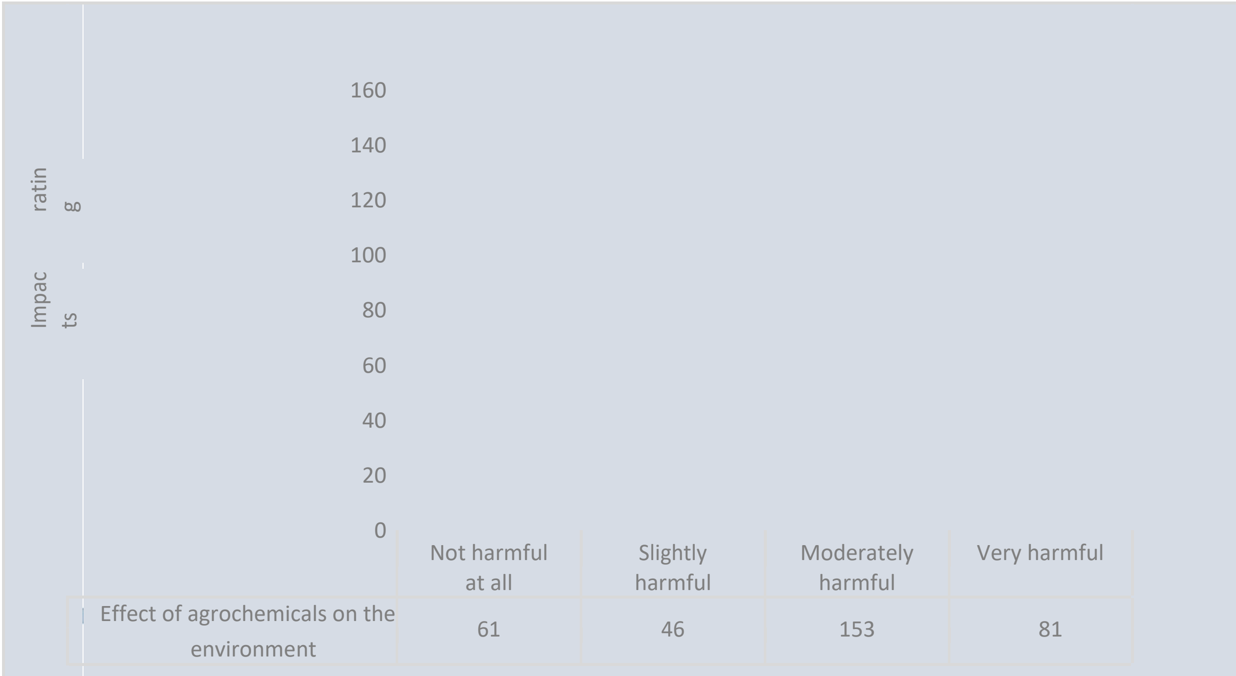


**Figure 4.2: Rating the risk of agrochemical effects on the environment**

**Source: Authors (2019)**

As indicated in Figure 4.3, the effect of agrochemicals on the human health was rated into four categories. Very harmful ranked the highest with 133 respondents, moderately harmful ranked second with 85 respondents, slightly harmful ranked third with 74 respondents and not harmful at all ranked the least with 49 respondents. This implies that the respondents affirmed that agrochemicals used in the study area affects human health negatively.

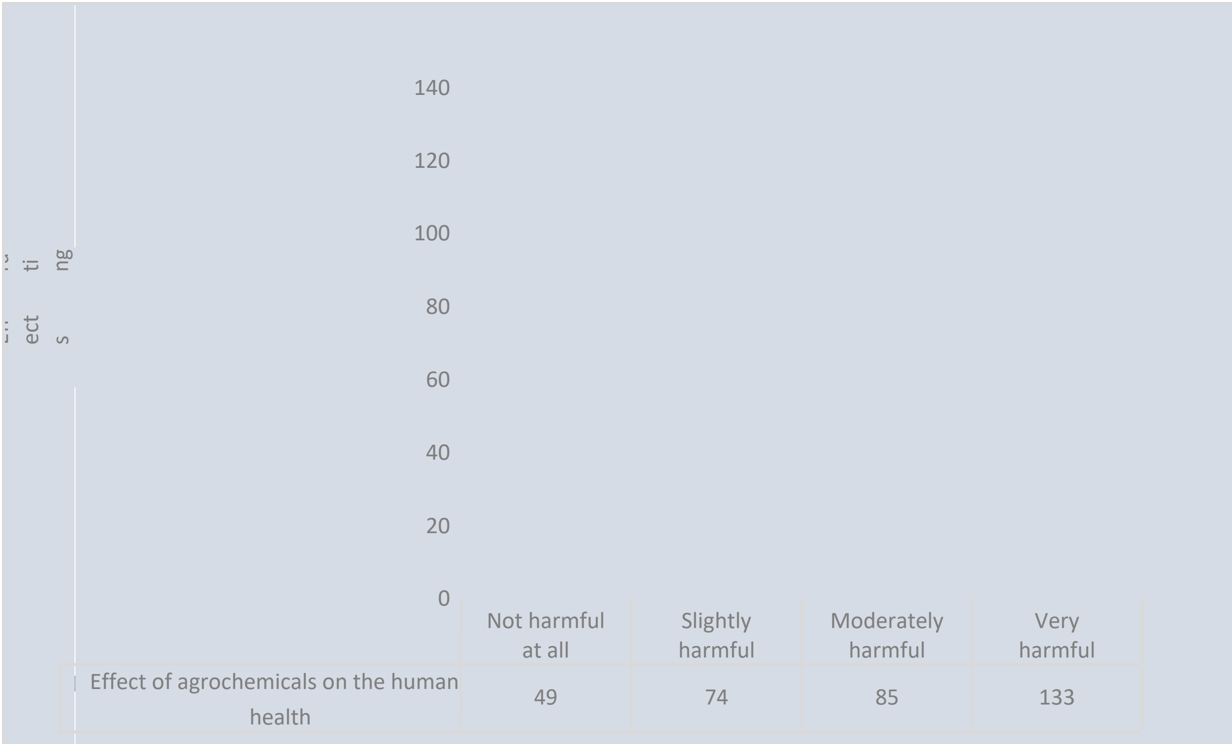


**Figure 4.3: Rating the risk of agrochemical effects on the human health**

**Source: Authors (2019)**

As revealed in Table 4.10, 292 respondents affirmed that their exist health problems associated with the use of agrochemicals in the study area and 49 respondents said they do not suffer any health problem due to the use of agrochemicals. These health problems include skin, eye, stomach and respiratory irritations. The details of these health problems were given in Table 4.11.

**Table 4.10: Presence of ill health problems associated with the use of agrochemical**

| Options | Frequency | Percentage (%) |
|---|---|---|
| Yes | 292 | 85.6 |
| No | 49 | 14.4 |
| Total | 341 | 100 |

**Source: Field Survey (2019)**

As revealed in Table 4.11, skin related diseases ranked the highest with 101 reported cases, stomach related diseases ranked second with 56 cases, respiratory diseases ranked third with 21 cases and eyes related health challenges ranked the least with 19 cases. Majority of these cases were reported by farmers that were using agrochemicals in the study area. This implies that there were human health cases associated agrochemical usage.

**Table 4.11: Reported health problems associated with agrochemical usage**

| Months | Skin | Eyes | Stomach | Respiratory irritations |
|---|---|---|---|---|
| January | 3 | 0 | 4 | 0 |
| February | 1 | 0 | 1 | 1 |
| March | 0 | 0 | 0 | 3 |
| April | 8 | 3 | 2 | 0 |
| May | 13 | 1 | 4 | 2 |
| June | 10 | 6 | 7 | 5 |
| July | 7 | 2 | 14 | 3 |
| August | 21 | 1 | 5 | 2 |
| September | 14 | 0 | 9 | 0 |
| October | 17 | 4 | 7 | 1 |
| November | 5 | 2 | 3 | 3 |
| December | 2 | 0 | 2 | 1 |
| Total | 101 | 19 | 56 | 21 |

**Source: Badeggi Primary Healthcare, 2019**

As revealed in Table 4.12, rating the risk of agrochemicals effects on soil, air, surface water, aquatic organism and birds were done in four categories. Moderately harmful ranked the highest with 153 respondents and not harmful ranked the least with 42 respondents. Surface water ranked the highest on the effect of agrochemical with 87 respondents and air ranked the least affected component of the environment. This implies that all the components of the environment were effected with agrochemicals in the study area as affirmed by the respondents.

**Table 4.12: Revealed rating the risk of agrochemicals effects on soil, air, surface water, aquatic organism and birds**

| Options | Not harmful | Slightly harmful | Moderately harmful | Very harmful |
|---|---|---|---|---|
| Soil | 7 | 21 | 35 | 31 |
| Air | 1 | 5 | 16 | 6 |
| Surface water | 13 | 6 | 87 | 37 |
| Aquatic organism (fish) | 19 | 14 | 11 | 25 |
| Birds | 2 | 0 | 4 | 2 |
| Total | 42 | 46 | 153 | 100 |

**Source: Field Survey (2019)**

## 4.4 Adaptation Strategies Put in Place to Reduce the Impact of Agrochemical Usage in the Study Area

As revealed in Table 4.13, planting of early maturity varieties ranked the highest with 120 sample population, planting drought resistant varieties ranked second with 101 sample population and continues awareness on the impact of agrochemicals ranked the least with 13 sample population. This implies that the major adaptation strategy was planting of early maturity varieties in the study area to enhance crop production.

**Table 4.13: Adaptation Strategies put in place in the study area**

| Adaptations | VG (3) | G(2) | NG (1) |
|---|---|---|---|
| Planting drought resistant varieties | 101 | 21 | 0 |
| Planting of early maturity varieties | 120 | 16 | 0 |
| Continues awareness on the impact of agrochemicals | 13 | 28 | 0 |
| Increase awareness on handling of agrochemicals | 27 | 15 | 0 |
| Total | 261 | 80 | 0 |

**Source: Field Survey (2019)**

As revealed in Figure 4.4, empty agrochemical containers/bottles were dispose into the disposal pit, throw in the latrine, just discard them in the farm, destroy and burn or bury and keep for re-use. Just discard them in the farm ranked the highest with 203 respondents, throw in the latrine ranked second with 61 respondents, disposing into the disposal pit ranked third with 49 respondents and keep for re-use ranked the least with five respondents. This implies that majority of the respondents dispose their empty bottles of agrochemicals in their farms and this will lead to increase of plastic waste in their farms.

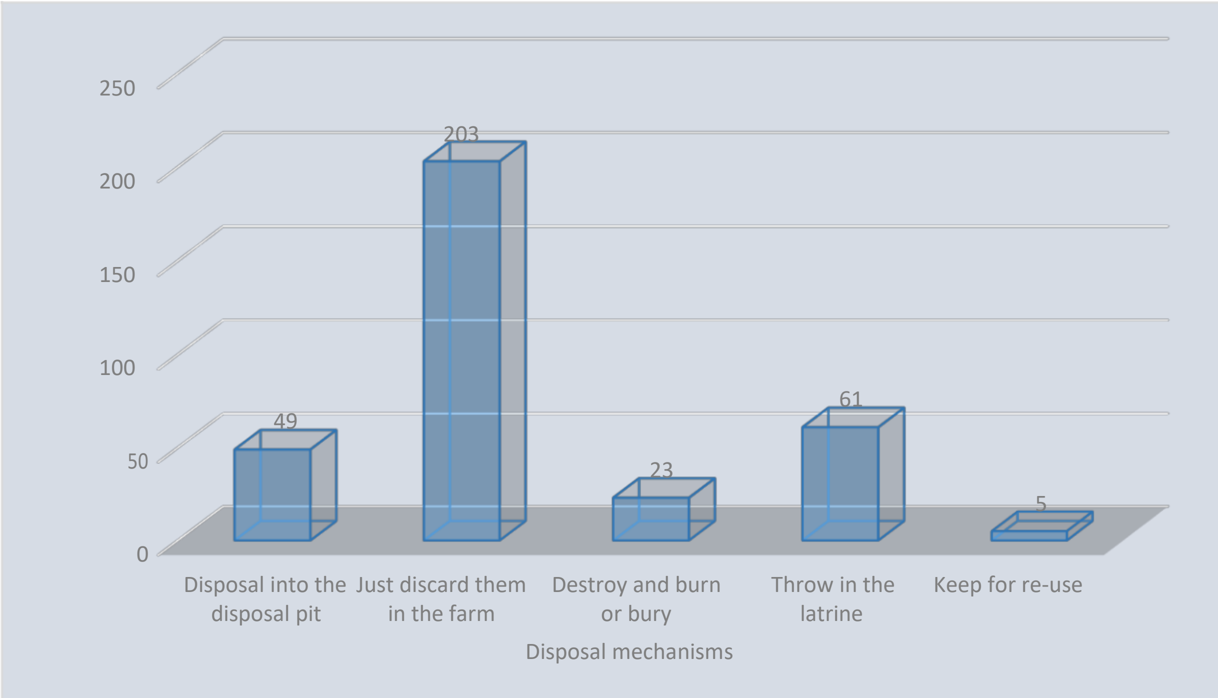


**Figure 4.4: Disposal mechanism of empty agrochemical containers/bottles**

**Source: Field Survey (2019)**

As revealed in Figure 4.5, discard them in the farm ranked the highest with 203 respondents, dispose in latrine ranked second with 63 respondents and discard in nearby bushes/roadsides ranked the least with 24 respondents. This implies that the major disposal mechanism for spoilt/expired agrochemicals was discarding them in the farm which was not environmental friendly in the study area.

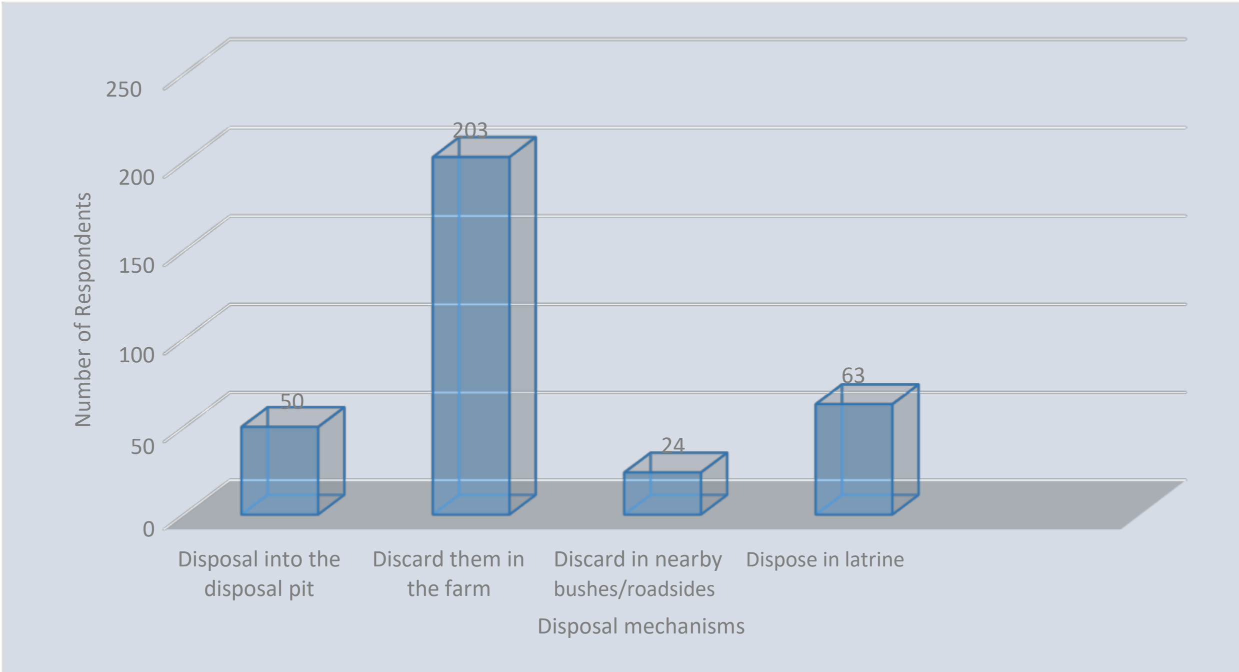


**Figure 4.5: Disposal mechanism of spoilt/expired agrochemicals**

**Source: Field Survey (2019)**

As indicated in Table 4.14, the options available after using agrochemicals was washing hands with soap. Never ranked the highest with 232 respondents and always ranked the least with 13 respondents. This implies that majority of the respondents never wash their hands after handling agrochemicals in the study area.

**Table 4.14: Washing of hands after handling agrochemicals**

| Options | Frequency | Percentage (%) |
|---|---|---|
| Never | 232 | 68.0 |
| Sometimes | 96 | 28.2 |
| Always | 13 | 3.8 |
| Total | 341 | 100 |

**Source: Field Survey (2019)**

The respondents also said they eat, drink and sleep inside the room agrochemicals were located as well as when handling agrochemicals in the study area. This finding agreed with the work of Ariga, Jayne and Nyoro (2016); Erhunmwunse, Dirisu and Olomukoro (2012); and Gilden, Huffling and Sattler (2010).

## 4.4 Summary of Findings

The summary of findings for this study include:

a) The results shows that weeds ranked the highest common problem affecting crops with 111 respondents strongly agreeing, soil fertility loss ranked second with 89 respondents strongly agreeing and diseases ranked the least with 37 respondents strongly agreeing. This implies that the major common problem affecting crops in the study area based on farmers knowledge was weeds.

b) The finding revealed that increase yield ranked the highest with 203 respondents, control pests and diseases ranked second with 67 respondents and improve appearance for marketability ranked the least with 11 respondents. This implies that the major reason for application of agrochemicals was for increased yield in the study area.

c) Negligible ranked the highest with 129 respondents, enough ranked second with 101 respondents and more than enough ranked the least with 8 respondents. This implies that the knowledge of agrochemicals users in the study area was negligible which is not good at all considering the impact of agrochemicals on the environment as well as on people when it’s not used properly.

d) As revealed in Table 4.5, the types of agrochemicals used in the study area include pesticides, herbicides, fertilizers and fungicides. Fertilizers ranked the highest agrochemicals used by the sample population with 139 respondents, herbicides ranked second with 95 respondents, pesticides ranked third with 82 respondents and fungicides ranked the least with 25 respondents. This implies that fertilizers (NPK and Urea) is the major agrochemicals used in the study area. The types of pesticides used by the respondents in the study area include Glyphosate, Orizo plus, Gamaline, Paraquat, Propanil, 2,4-D Amine, Dichlovos, Mancozeb and Butachlor. The types of herbicides used in the study area Simaxine, Interceptor, Gallant NF, Buster, Versatil and Terbuthylazine. The types of fungicides used in the study area include Polyoxin-D, 42-S Thiram, Actigard 50 WG, Agclor 310 and Actinovate AG.

e) The finding also revealed that not reading the instructions on the label before using a particular agrochemical ranked the highest with 287 respondents and reading the instructions on the label before using a particular agrochemical ranked the least with 54 respondents. This implies that majority of respondents do not read neither no how to read the instructions before usage which in turn affect the environment negatively as well as their health.

f) As revealed in Table 4.9, quantity of solid agrochemical used per hectare ranges from 50kg/hectare to 400kg/hectare. 251 – 400kg/hectare ranked the highest with 188 respondents and 50 – 100kg/hectare ranked the least with 52 respondents. This implies that majority of the respondents applied solid agrochemical wrongly do to their drive for optimum yield which in turn impact on the environment and human health negatively. This agreed with the work of Alavanja (2014) and Aikpokpodion *et al.,* (2015).

g) As indicated in Figure 4.1, the effect of agrochemicals on the environment was rated into four categories. Moderately harmful ranked the highest with 153 respondents, very harmful ranked second with 81 respondents, not harmful at all ranked third with 61 respondents and slightly harmful ranked the least with 46 respondents. This implies that the respondents affirmed that agrochemicals used in the study area affects the environment negatively.

h) The result also shows that very harmful ranked the highest with 133 respondents, moderately harmful ranked second with 85 respondents, slightly harmful ranked third with 74 respondents and not harmful at all ranked the least with 49 respondents. This implies that the respondents affirmed that agrochemicals used in the study area affects human health negatively.

i) As revealed in Table 4.11, skin related diseases ranked the highest with 101 reported cases, stomach related diseases ranked second with 56 cases, respiratory diseases ranked third with 21 cases and eyes related health challenges ranked the least with 19 cases. Majority of these cases were reported by farmers that were using agrochemicals in the study area. This implies that there were human health cases associated agrochemical usage.

j) The finding revealed that 292 respondents affirmed that their exist health problems associated with the use of agrochemicals in the study area and 49 respondents said they do not suffer any health problem due to the use of agrochemicals. These health problems include skin, eye, stomach and respiratory irritations.

k) As revealed in Table 4.8, rating the risk of agrochemicals effects on soil, air, surface water, aquatic organism and birds were done in four categories. Moderately harmful ranked the highest with 153 respondents and not harmful ranked the least with 42 respondents. Surface water ranked the highest on the effect of agrochemical with 87 respondents and air ranked the least affected component of the environment. This implies that all the components of the environment were effected with agrochemicals in the study area as affirmed by the respondents.

l) As revealed in Table 4.9, 109 respondents affirmed that they take precaution to ensure they not harmed when applying agrochemicals and 232 respondents said they do not precaution when applying agrochemicals in the study area. The precaution taken by the respondents was wearing protective gears like nose mask, eye google, robber gloves, long sleeved overall, hat/headscarf as well as protective shoes. This implies that majority of the respondents do not take precaution when applying agrochemicals in the study area which was the root cause of the health problems mentioned in section 4.2 of the study.

m) The result also revealed that negligible ranked the highest with 129 respondents, enough ranked second with 101 respondents and more than enough ranked the least with 8 respondents. This implies that the knowledge of agrochemicals users in the study area was negligible which is not good at all considering the impact of agrochemicals on the environment as well as on people when it's not used properly.

n) As revealed in Figure 4.4, empty agrochemical containers/bottles were dispose into the disposal pit, throw in the latrine, just discard them in the farm, destroy and burn or bury and keep for re-use. Just discard them in the farm ranked the highest with 203 respondents, throw in the latrine ranked second with 61 respondents, disposing into the disposal pit ranked third with 49 respondents and keep for re-use ranked the least with five respondents. This implies that majority of the respondents dispose their empty bottles of agrochemicals in their farms and this will lead to increase of plastic waste in their farms.

o) As indicated in Table 4.10, the options available after using agrochemicals was washing hands with soap. Never ranked the highest with 232 respondents and always ranked the least with 13 respondents. This implies that majority of the respondents never wash their hands after handling agrochemicals in the study area. The respondents also said they eat, drink and sleep inside the room agrochemicals were located as well as when handling agrochemicals in the study area.

p) As revealed in Table 4.13, planting of early maturity varieties ranked the highest with 120 sample population, planting drought resistant varieties ranked second with 101 sample population and continues awareness on the impact of agrochemicals ranked the least with 13 sample population. This implies that the major adaptation strategy was planting of early maturity varieties in the study area to enhance crop production.

# CHAPTER FIVE

## 5.0 CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

Agrochemicals have played a key role in providing reliable supplies of agricultural produce at prices affordable to consumers, improving the quality of produce, and ensuring high profits to farmers. In conclusion, the study found out that farmers had inadequate knowledge, poor attitude and practices with regard to use of agrochemicals in crop production that resulted in adverse environmental and human health effects.

The types and quantities of agrochemicals used by the farmers do not conform to recommendations as they merely used agrochemicals in order to increase yield by controlling pest and disease and to improve marketability of their outputs without much regard of these products adverse effects to the environment and human health. It was therefore concluded that the farmers lacked adequate knowledge in determining the quantities of agrochemicals used during application. Farmers were not well sensitized on safety precautions procedures while mixing, spraying and disposing spoilt and expired chemicals as well as empty agrochemical containers wearing of protective gear while handling the pesticides posing danger to humans and environment.

The study revealed that the farmers lacked knowledge of adverse agrochemicals impacts on various environmental matrices including soils, air, surface and underground waters, terrestrial and aquatic organisms. The farmers were sorely using pesticides for pest and disease control without incorporating alternative and less injurious methods such as Integrated Pest Management

(IPM). It was thus concluded the farmers lacked adequate capacity on environmental and human health effects associated with agrochemical use in crop production.

## 5.2 Recommendations

Based on summary of findings and conclusion of this study, the following recommendations were made to reduce the impact of agrochemicals on human health and the environment in Badeggi and environs, Niger State.

1) This study recommend that agricultural stakeholders such as the Ministry of agriculture to carry out sensitization campaigns to educate farmers on proper and efficient use of agrochemicals to improve productivity as well as prevent adverse environmental and human health effects.
2) Farmers who wish to increase yield, to control pest and disease and improve marketability of their outputs should seek advice from agricultural stakeholders such as area agricultural officers so as to have adequate understanding of pest ecology, economic injury level, types of pesticides to control specific insect pests, use pesticides as recommended in quantities and methods of application, time lapse between last picking and spraying and take precautionary measures.
3) Niger State government and agrochemical dealers in the State should ensure that farmers access services such as seminars and on-site training so as to educate majority of farmers who have not received any training on agrochemicals usage and their effects on human health and on environment.
4) The development of new agrochemicals with novel modes of action and improved safety profiles and the implementation of alternative cropping systems that are less dependent

on agrochemicals could minimize exposure to pesticides and the undesirable effects of exposure on human health.

## REFERENCES


Abdel-El-Haleem, D. (2013). Monitoring health implications of pesticide exposure in factory workers in Pakistan. *Environmental Monitoring and Assessment*, 168(1), 231–240.

Adefolalu, D.O. (1999). "Rainfall Patterns in the Coastal Areas of Nigeria". *Nigerian Geographical Journal*, 26, 153-170.

Ahmad, E. A., Jenkins, J. J. and Vogue, P.A. (2016). Understanding pesticide persistence and mobility for groundwater and surface water protection. Oregon State University Extension Service, EM8561-E.

Aikpokpodion, F., Lajide, D., Ogunlade, S., Ipinmoroti, O., Orisajo, P., Iloyanomon, K. and Fademi, K.G. (2015). Pesticides and atopic and non-atopic asthma among farm women in the Agricultural Health Study. *American Journal of Respiratory and Critical Care Medicine,* 177(1), 11–18.

Akkina, J. E., Reif, J. S., Keefe, T. J. and Bachand, A. M. (2014). Age at natural menopause and exposure to organochlorine pesticides in Hispanic women'. *Journal of Toxicology and Environmental Health, Part A,* 67(18), 1407-1422.

Alavanja, M.C.R. (2014). Health Effects of Chronic Pesticide Exposure – Cancer and Neurotoxicity. *Annu. Rev. Pub. Healt.* 25, 155-167.

Aldridge, F. (2011). Hazardous exposure and lung disease among farm workers. *Clinics in Chest Medicine*, 13(2), 311–328.

Andersen, S. and Gabson, H. (2012). A cross sectional study of triallate exposure and neurological health among workers at a pesticide manufacturing and formulating facility. *Occupational and Environmental Medicine,* 61(1), 936–944.

Arias, R. and McLaughlin, J. R. (2015). 'Multiple myeloma and exposure to pesticides: a Canadian case-control study'. Journal of Agromedicine, 17(1), 40-50.

Ariga, J. M., Jayne T. S. and Nyoro, J. K. (2016). Factors driving the growth in fertilizer consumption in Nigeria, 1990–2015: Sustaining the momentum in Nigeria and lessons for broader replicability in Sub-Saharan Africa. Working Paper 24.Tegemeo Institute. Nairobi, Kenya: Egerton University.

Ascherio, A., Chen, H., Weisskopf, M.G., Schwarzschild, M.A. and Thun, M.J. (2016). Pesticide exposure and risk for Parkinson's disease. *Annals of Neurology*, 60 (2), 197–203.

Ashburner, J. and Friedrich, T. (2011). Improving handling of pesticides application equipment for the safety of applicators. *Journal of pesticide management*, 1, 9–11.

Ashraf, U. and Routray, P. (2013). Effect of pesticide residues on health and different enzyme levels in the blood of farm workers from Gadap (rural area) Karachi-Pakistan. *Chemosphere,* 64(1), 1739–1744.

Atlas, S. and Philip, W. (2015). Pesticide exposure in male farmers and survival of in vitro fertilized pregnancies'. Human Reproduction, 19(6), 1331-1337.

Balluz, L., R. Philen, J. Brock, K. Falter, M. Kiefer, R. Hart, and R. Hill, R. (2010). Health Complaints Related to Pesticide Stored at a Public Health Clinic. *Environmental Research,* 82(1), 1–6.

Balwinder, C., Samanic, D., Sandler, A., Blair, A. and Alavanja, M. (2016). Pesticide Use and Breast Cancer Risk among Farmers' Wives in the Agricultural Health Study. *American Journal of Epidemiology,* 161(2), 121–135.

Beane, G. and Nyambo, B. (2015). Vegetable IPM in Africa: current status and future prospects with emphasis on eastern and southern Africa. *Acta Hort. (ISHS),* 513, 99-104.

Beseler, C., L. Stallones, J. Hoppin, M. Alavanja, A. Blair, T. Keefe, T. and Kamel, F. (2016). 'Depression and Pesticide Exposures in Female Spouses of Licensed Pesticide Applicators in the Agricultural Health Study Cohort'. *Journal of Occupational and Environmental Medicine,* 48(10), 1005–1013.

Bhanti, S. and Yildirim, I. (2017). Fruit-growers perceptions on the harmful effects of pesticides and their reflection on practices: The case of Kemalpasa, Turkey. *Crop Prot.,* 26, 917–922.

Bharadwaj, S. and Garg, U. (2012). Pesticide residue levels in Zoia river catchment. Kenya Agricultural Research Institute (KARI), Moi University.

Birech, T. and Bernhard, F. (2016). Towards reducing synthetic pesticide imports in favour of locally available botanicals in Nigeria**.** Conference on International Agricultural Research for Development. Bonn, October 11-13, 2016.

Briggs, D. J. and F. M. Courtney (2009). *Agriculture and Environment.* New York: Longman.

Boers, D., L. van Amelsvoort, C. Colosio, E. Corsini, S. Fustinoni, Campo, L. and Van Loveren, H. (2018). Asthmatic symptoms after exposure to ethylenebisdithiocarbamates and other pesticides in the Europit field studies. *Human and Experimental Toxicology,* 27(9), 721-727.

Booker, O., Beatrice, W. and Gem, A. K., (2009). The Role and Performance of Ministry of Agriculture in Nyeri district. Unpublished.

Bouchard, M., J. Chevrier, K. Harley, K. Kogut, M. Vedar, N. Calderon, C. Trujillo, C. Johnson, A. Bradman, D. Boyd, B. and Eskenazi, B. (2011). 'Prenatal Exposure to

Organophosphate Pesticides and IQ in 7-Year-Old Children'. *Environmental Health Perspectives*, 119(8), 1189–1195.

Bouwer, Q. (2012). Breast cancer risk and historical exposure to pesticides from wide-area applications assessed with GIS. *Environmental Health Perspectives*, 112(8), 889.

Burns, J., P. (2009). Serum concentrations of Organochlorine pesticides and growth among Russian Boys. *Environmental Health Perspectives*, 120(2), 303–308.

Carreon, T., M. Butler, A. Ruder, M. Waters, K. Davis-King, G. Calvert, P. Schulte, B. Connally, E. Ward, W. Sanderson, E. Heineman, J. Mandel, R. Lorton, D. Reding, K. Rosenman, and Talaska, G. (2005). 'Gliomas and Farm Pesticide Exposure in Women: The Upper Midwest Health Study'. *Environmental Health Perspectives,* 113(5), 546– 551.

Clarke, E.E.K., Levy, L.S., Spurgeon, A. and Calvert, I. A. (2017). The problems associated with pesticide use by irrigation workers in Ghana. *Occup Med*, 47, 301–308.

Costa, P. (2011). Hearing loss among licensed pesticide applicators in the agricultural health study. *Journal of Occupational and Environmental Medicine*, 50(7), 817–826.

Cox, S., Niskar, A., Narayan, V. and Marcus, M. (2017). Prevalence of Self-Reported Diabetes and Exposure to Organochlorine Pesticides among Mexican Americans: Hispanic Health and Nutrition Examination Survey, 1982-2004. *Environmental Health Perspectives*, 115(12), 1747–1752.

De Alavanja, G. (2014). Cancer Incidence among Glyphosate-Exposed Pesticide Applicators in the Agricultural Health Study. *Environmental Health Perspectives*, 113(1), 49–54.

De, A., Bose, R., Kumar, A. and Mozumdar, S. (2014). *Targeted Delivery of Pesticides Using Biodegradable Polymeric Nanoparticles.* London: Springer Briefs in Molecular Science.

De Roos, A., A. Blair, J. Rusiecki, J. Hoppin, M. Svec, M. Dosemeci, D. Sandler, D. and Alavanja, M. (2015). Cancer Incidence among Glyphosate-Exposed Pesticide Applicators in the Agricultural Health Study. *Environmental Health Perspectives*, 113(1), 49–54.

Diaz, T. (2018). Pesticides and Cancer. *Cancer Causes and Control*, 8(3), 420–443.

Eifediyi, A., Omondan, S., Takim, O. and Animashaun, F. (2014). Assessment of the use of agrochemicals among small-scale farmers in Esanland, Nigeria. *American Journal of Epidemiology*, 160(12), 1205–1214.

Environmental Protection Agency (2011). Health impacts of pesticide use in Carchi farm populations". In Economic, Environmental and Health Tradeoffs in Agriculture: Pesticides and Sustainability of Andean Potato Production. ed.C. C. Crissman, J. M. Antle, and S. M. Capalbo. Boston, USA, Kluwer Publishers.

Erhunmwunse, N.O., Dirisu, A. and Olomukoro, J.O. (2012). Implication of pesticide usage in Nigeria. *Bmc Neurology,* 8(1), 6-15.

Eskenazi, B., K. Huen, A. Marks, K. Harley, A. Bradman, D. Boyd Barr, and N. Holland: (2010). 'PON1 and Neurodevelopment in Children from the CHAMACOS Study Exposed to Organophosphate Pesticides in Utero. *Environmental Health Perspectives*, 118(12), 1775–1781.

Everett, C. and E. Matheson, E. (2010). Biomakers of pesticide exposure and diabetes in the 1999-2004 National Health and Nutrition Examination Survey. *Environmental International*, 36(1), 398–401.

Farr, S., Cai, J., Savitz, D., Sandler, D., Hoppin, J. and Cooper, G. (2016). Pesticide Exposure and Timing of Menopause. *American Journal of Epidemiology,* 163(8), 731–742.

Farr, S., Cooper, G., Cai, J., Savitz, D. and Sandler, D. (2014). Pesticide Use and Menstrual Cycle Characteristics among Premenopausal Women in the Agricultural Health Study. *American Journal of Epidemiology,* 160(12), 1194–1204.

Feng, L., O. Gomez-Marin, O., Zheng, D., Ma, F. and Lee, D. (2017). National Health Interview Survey Mortality Among US Farmers and Pesticide Applicators. *American Journal of Industrial Medicine,* 43(1), 227–233.

Ferreira, J. D., Couto, A. C., Pombo-de-Oliveira, M. S. and Koifman, S. (2013). Brazilian Collaborative Study Group of Infant Acute Leukemia: 'In utero pesticide exposure and leukemia in Brazilian children< 2 years of age'. *Environmental Health Perspectives*, 121(2), 269.

Fieten, K., H. Kromhout, Heederik, D. and Van Wendel, B. (2012). Pesticide Exposure and Respiratory Health of Indigenous Women in Costa Rica. *American Journal of Epidemiology*, 169(12), 1500–1506.

Frederick, S. (2015). Environmental Estrogenic Chemicals: Their Impact on Embryonic Development. *Human and Ecological Risk assessment*, 1(2), 3-15.

Gilden, R.C., Huffling, K. and Sattler, B. (2010). Pesticides and health risks. *Journal of Obstet Gynecol Neonatal Nursing,* 39 (1): 103–10.

Gitahi, M.W. (2014). The risk of agrochemicals on the environment and human health- in Mukaro Location, Nyeri County, Kenya. Thesis submitted in partial fulfillment for the award of the degree of Master of Environmental Science in the School of Environmental Studies, Kenyatta University, Kenya.

Green, F. (2015). *Rainfall, urbanization and occurrence of floods.* In Perspectives in Applied Climatology Lighthouse Publishers. 15 pp.

Greenburg, D., J. Rusiecki, S. Koutros, M. Dosemeci, R. Patel, C. Hines, Hoppin, J. and Alavanja, M. (2018). Cancer incidence among pesticide applicators exposed to captan in the Agricultural Health Study. *Cancer Causes and Control*, 19(10), 1401–1407.

Gupta, P. (2012). Cancer incidence among pesticide applicators exposed to captan in the Agricultural Health Study'. *Cancer Causes and Control*, 19(10), 1401–1407.

Habiba, R., Canfield, V. and Henry, J. P. (2012). 'Maternal pesticide exposure and neural tube defects in Mexican Americans'. Annals of Epidemiology 20(1), 16-22.

Harari, R., J. Julvez, K. Murata, D. Barr, D. Bellinger, F. Debes, F. and Grandjean, P. (2010). 'Neurobehavioral Deficits and Increased Blood Pressure in School-Age Children Prenatally Exposed to Pesticides'. *Environmental Health Perspectives*, 118(6), 890–896.

Hardell, L., Eriksson, M. and Nordstrom, M. (2013). Exposure to pesticides as risk factor for non-Hodgkin's lymphoma and hairy cell leukemia: pooled analysis of two Swedish case-control studies. *Leuk Lymphoma*, 43(5), 1043-1049.

Haroune, N. Mathur, N. and Srivastava, A. (2012). Health risks of employees working in pesticide retail shops: an exploratory study'. *Indian Journal of Occupational and Environmental Medicine*, 13(3), 121–126.

Hayo, D., Haghiri, M. and McNamara, M. L. (2016). Predicting Consumers' Acceptability of Pesticide-Free Fresh Produce in Canada's Maritime Provinces: A Probit Analysis. *Journal of International Food & Agribusiness Marketing*, 19(4), 45–59.

Henao, S. and Arbelaez, M.P. (2012). Epidemiological situation of acute pesticide poisoning in the Central American Isthmus, 1992-2000. *Pan American Health Organization (PAHO) PLAGSALUD. Epidemiol Bull*, 23, 5-9.

Horne, P.A., Page, J. and Nicholson, C. (2008). When will IPM strategies be adopted? An example of development and implementation of IPM strategies in cropping systems. *Australian Journal of Experimental Agriculture*, 48, 1601 – 1607.

Hoppin, J. and Egwaikhide, P.A. (2012). Concentrations of residues from organochlorine pesticide in water and fish from some rivers in Edo State, Nigeria. *Int. J. Physical Sci*., 2, 237-241.

Hoppin, J., D. Umbach, G. Kullman, P. Henneberger, S. London, Alavanja, M. and Sandler, D. (2017a). Pesticides and other agricultural factors associated with self-reported farmer's lung among farm residents in the Agricultural Health Study. *Occupational and Environmental Medicine*, 64(1), 334–342.

Hoppin, J., D. Umbach, S. London, P. Henneberger, G. Kullman, Alavanja, M. and Sandler, D. (2017c). Pesticides and atopic and non-atopic asthma among farm women in the

Agricultural Health Study. *American Journal of Respiratory and Critical Care Medicine,* 177(1), 11–18.

Hurtig, A. K., Sebastian, M. S., Soto, A., Shingre, A., Zambrano, D. and Guerrero, W. (2013). Pesticide use among farmers in the Amazon Basin of Ecuador. *Arch Environ Health*, 58, 223–228.

Intergovernmental Forum on Chemical Safety (IFCS) (2013). Acutely toxic pesticides: initial input on extent of problem and guidance for risk management. Fourth session of the Intergovernmental Forum on Chemical Safety. Doc number: IFCS/FORUM-IV/10w.

Ismail, S. and Yildirim, I. (2012). Fruit-growers' perceptions on the harmful effects of pesticides and their reflection on practices: The case of Kemalpasa, Turkey. *Crop Prot.*, 26, 917-922. doi:10.1016/j.cropro.2012.08.006.

Ize-Iyamu, Y., Abia, P. and Egwaikhide, J. (2011). Association between organophosphate pesticides exposure and thyroid hormones in floriculture workers. *Toxicology and Applied Pharmacology*, 243(1), 19-26.

Jimoh, O.D., Ayodeji, M.A. and Mohammed, B. (2013). Effects of agrochemicals on surface waters and groundwater in the Tunga-Kawo irrigation scheme, Nigeria. *Hydrological Sciences Journal*, 48(6), 1013-1025.

Kamel, F., A. Rowland, L. Park, K. Anger, D. Baird, B. Gladen, T. Moreno, Stallone, L. and Sandler, D. (2013). Neurobehavioral Performance and Work Experience in Florida Farmworkers. Environmental Health Perspectives, 111(14), 1765–1772.

Kamel, F., L. Engel, B. Gladen, J. Hoppin, M. Alavanja, M. and Sandler, D. (2015). Neu- rologic symptoms in Licensed Private Pesticide Applicators in the Agricultural Health Study. *Environmental Health Perspectives*, 113(7), 877–882.

Kearney, T. and Wouchope, G. (2012). Agrochemicals pose health risks to coffee factory workers in Githunguri, Kenya. *International Journal of Environmental Health Research*, 3, 73-81.

Kesner, D. and Pierre, U. (2015). Analysis of pesticide use and incidences of diseases in the region of Rincón de Santa María. *American Water Works Journal,* 81(1), 43-52.

Khan, D. and Francis, T. (2015). Monitoring health implications of pesticide exposure in factory workers in Pakistan. *Environmental Monitoring and Assessment*, 168(1), 231–240.

Khoshkholgh Pahlaviani, I. and Alavanja, M. C. (2012). Pendimethalin exposure and cancer risk among pesticide applicators: a report from the US-based agricultural health study. *Annals of Epidemiology*, 14(8), 608.

Kishi, P. and Ladou, H. (2011). Information and farmers attitudes about pesticides, water quality, and related environmental effects. *Agriculture, Ecosystems and Environment,* 73, 227–236.

Knackmoss, R. (2011). Environmental Impacts of Enhanced-Efficiency Nitrogen Fertilizers Online. Crop Management doi:10.1094/CM-0730-02-RV.

Koh, D. and Jeyaratnam, J. (2016). Pesticides hazards in developing countries. *Sci Total Environ*, 188, S78–S85.

Konradsen, F. (2017). Acute Pesticide poisoning – a global public health problem. *Danish medical Bulletin*, 54(1), 58-59.

Kristensen, P., Andersen, A., Irgens, L.M., Bye, A.S. and Sundheim, L. (2016). Cancer in offspring of parents engaged in agricultural activities in Norway: incidence and risk factors in the farm environment. *International Journal of Cancer,* 65(1), 39-50.

Kummerer, H. (2014). Aromatic amine pesticide use and human cancer risk: results from the U.S. Agricultural Health Study. *International Journal of Cancer*, 124(5), 1206–1212.

Lambert, U.; Baker, B.P.; Benbrook, C.M.; Groth, E. and Lutz Benbrook, K. (2010). Pesticide residues in conventional, integrated pest management (IPM)-grown and organic foods: insights from US data sets. *Food Addit. Contam*, *19*, 427-446.

Lauria, L., Settimi, L., Spinelli, A. and Figà-Talamanca, I. (2016). Exposure to pesticides and time to pregnancy among female greenhouse workers. *Reproductive Toxicology*, 22(3), 425-430.

Lemmon, U. and Pylypiw, T. (2012). Pyrethroid pesticide exposure and risk of childhood acute lymphocytic leukemia in Shanghai. *Environmental science and technology,* 46(24), 13480-13487.

Leonila, P. (2012). The relationship of land use practices to surface water quality in the Upper Oconee Watershed of Georgia. *Journal for Ecological Management,* 128(1-2), 39-48.

Li, X., He, J. and Li, S. (2018). Isolation of chlorpyrifos degrading bacterium *Sphingomonas sp* strain Dsp-2 and cloning of the mpd gene. *Res. Microbiol.* 158:143-149.

Liu, J., Niu, F., Guo, S. and Sun, X. (2012). Exposure to organochlorine pesticides is an independent risk factor of hepatocellular carcinoma: A case–control study'. *Journal of Exposure Science and Environmental Epidemiology*, 22(6), 541-548.

Lydy, R. and Linck, J. (2013). Pesticide exposure and cancer among rural workers from Bariri, Sao Paulo State, Brazil. *Environment International*, 31 (5), 731-738.

Lynch, S., J. Rusiecki, A. Blair, M. Dosemeci, J. Lubin, D. Sandler, J. Hoppin, Lynch, C. and M. Alavanja, M. (2016). Cancer Incidence among Pesticide Applicators Exposed to Cyanazine in the Agricultural Health Study. *Environmental Health Perspectives,* 114(8), 1248–1252.

Malinowski, I. (2010). Effects of occupational exposure to organophosphate pesticides on nerve and neuromuscular function. *Journal of Occupational and Environmental Medicine,* 44(4), 352-357.

Manandhar, W.J., Tagoe, L.M. and Drechsel, P. (2011). Occupational exposure to pesticides: Blood cholinesterase activity in a farming community in Ghana. *Arch Environ Contam Toxicology,* 56:623-630. doi:10.1007/s00244-007-9077-2, PMid:19112562.

Mathenge, K. (2009). Tegemeo institute, Egerton University. Paper presented at the 6th National Fertilizer Conference in Kenya, on ―Towards Increased Use of Fertilizer and Improved Seed for Food Security and Economic Growth, KARI headquarters, Nairobi, Kenya, August 20-21.

Maton, S. (2016). Effects of Pesticide Applications on Respiratory Health of Ethiopian Farm Workers. *International Journal of Occupational and Environmental Health,* 8(1), 35–40.

Michelic, C. and Luthy, K. (2012). Pesticide Usage and Its Association with Health Symptoms among Farmers in Rural Villages in West Java, Indonesia. *Environmental Sciences,* 14(1), 23–33.

Ministry of Agriculture (2014). Economic review of Agriculture; The central planning and project monitoring unit, Kilimo House Cathedral Road, Nairobi, Kenya.

Montgomery, M., F. Kamel, T. Saldana, Alavanja, M. and Sandler, D. (2013). Incident Diabetes and Pesticide Exposure among Licensed Pesticide Applicators: Agricultural Health Study, 1993-2013. *American Journal of Epidemiology,* 167(10), 1235–1246.

Murphy, P. and Haith, S. (2017). Valuation of Biodiversity Effects from Reduced Pesticide Use. *Integrated Environmental Assessment Management*, 2(2), 174–181.

Musa, B. (2016). Water pollution by agriculture. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 363, 659-666.

Nazia, S. and Alavanja, M. (2013). Pesticide Use and Cutaneous Melanoma in Pesticide Applicators in the Agricultural Health Study. *Environmental Health Perspectives,* 118(6), 812–817.

Ndaman, G. (2011). Effects of climatic variability on water supply in Bida area of Niger State. Unpublished thesis from Geography Department, IBB University, Lapai.

Ning, E., Stallone, L. and Sandler, D. (2010). Neurobehavioral Performance and Work Experience in Florida Farmworkers. *Environmental Health Perspectives,* 111(14), 1765–1772.

Niger State Geographic Information System (2018). Development of Niger State map.

Oerke, E.C., Dehne, H. W., Schonbeck, F. and Weber, A. (2014). *Crop production and Crop protection, Estimated losses in major food and cash crops*. Elsevier Sciences B.V. Ameterdam (Publisher), Amsterdam-Lausanne-New York-Oxford-Shannon-Tokyo.

Pace, F. (2017). Monitoring of pesticide residues in fresh peaches produced under conventional and integrated crop management cultivation. *Food Addit. Contam, 21*, 670-677.

Pandit, D. and Sahu, T. (2012). Pesticide Biodegradation: Mechanisms, genetics and strategies to enhance the process. *Intech. Open Sci. Open mind,* 3, 251-287.

Parkin, G. and Daniel, S. (2014). Biodegradation of Pesticides, Pesticides in the Modern World-Pesticides Use and Management, Dr. Margarita Stoytcheva (Ed.) ISBN: 978-953-307-459-7.

Paromenskaya, R. (2017). Environmental effects of pesticides. Department of Entomology and Horticultural Science, North Carolina State University.

Patil, S., Moase, C. and Peter, C. (2013). A Review of Pesticide Exposure and Cancer Incidence in the Agricultural Health Study Cohort. *Environmental Health Perspectives,* 118(8), 1117–1125.

Pearce, M. S., Hammal, D.M., Dorak, M.T., McNally, R. J. and Parker, L. (2016). 'Paternal occupational exposure to pesticides or herbicides as risk factors for cancer in children and young adults: a case-control study from the North of England'. *Archives of Environmental and Occupational Health,* 61(3), 138-144.

Pimentel, D. (2015). Environmental and socio-economic costs of pesticide use. In D. Pimentel, ed. Techniques for Reducing Pesticides: Environmental and Economic Benefits. Chichester, England: John Wiley & Sons. In press.

Promise, H. (2016). Soft-Tissue Sarcoma and Pesticides Exposure in Men: Results of a Canadian Case-Control Study'. *Journal of Occupational and Environmental Medicine,* 53(11), 1279-1286.

Racke, A. and Frink, P. (2014). The Impact of Chronic Pesticide Exposure on Neuropsychological Functioning. *Psychological Record,* 63(1), 23-29.

Rauh, V., S. Arunajadai, M. Horton, F. Perera, L. Hoepner, D. Barr, D. and Whyatt, R. (2011). 'Seven-Year Neurodevelopmental Scores and Prenatal Exposure to Chlorpyrifos, a Common Agricultural Pesticide. *Environmental Health Perspectives*, 119(8), 1196–1201.

Ray, S. (2012). Pesticide sprayers‘ knowledge, attitude and practice of pesticide use on agricultural farms of Ethiopia. *Occupational Medicine,* 52(6), 311–315.

Reeves, M. and Schafer, K. S. (2013). Greater risks, fewer rights: US farm workers and pesticides. *International Journal of Occupation, Environment and Health*, 9, 30–39.

Rim-Rukeh, A., Ikhifa, O. G. and Okokoyo, A. P. (2016). The Effect of Urban Runoff Water and Human Activities on some Physico-chemical Parameters of the Epie Creek in the Niger-Delta. *Journal of Applied Sciences and Environmental Management,* 5, 47-55.

Rokade, O. and Mali, S. (2013). Chemical crop protection research and development in Europe. *Develop. Crop Sci., 25*, 49-55.

Sanborn, M., Kerr, K.J., Sanin, L.H., Cole, D.C., Bassil, K.L. and Vakil, C. (2017). Non-cancer health effects of pesticides: systematic review and implications for family doctors. *Can Fam Physician,* 53(10), 1712–1720.

Saraswat, F. and Gaur, U. (2015). Environmental fate and toxicology of organophosphate pesticides. *J. Geological Soc. London,* 157(4), 859-876.

Sathiakumar, N., E. Delzell, P. MacLennan, M. Anne, N. Rosenberg, H. Cheng, H. and Myers, S. (2014). A cross sectional study of triallate exposure and neurological health among workers at a pesticide manufacturing and formulating facility. *Occupational and Environmental Medicine,* 61(1), 936–944.

Savitha, S. and Saraswati, O. (2012). Valuing fatal risks to children and adults: Effects of disease, latency, and risk aversion. *Journal of Risk and Uncertainty,* 40, 57–83.

Sengupta, D. and Singh, H. (2009). Environmental Impacts of Enhanced-Efficiency Nitrogen Fertilizers Online. Crop Management doi:10.1094/CM-0730-02-RV.

Seybold, W.P.; Greaves, J. and Tatchell, G.M. (2011). Microbial biopesticides for integrated crop management: An assessment of environmental and regulatory sustainability. *Trends Food Sci. Technol.*, *19,* 275-283.

Shakoori, M., Alavanja, M. and D. Sandler: 2010, ‘Retinal Degeneration and Other Eye Disorders in Wives of Farmer Pesticide Applicators Enrolled in the Agricultural Health Study’. American Journal of Epidemiology 161(11), 1020–1029.

Singh, B. K., Walker, A., Alun, J., Morgan, W. and Wright, D. J. (2014). Biodegradation of Chlorpyrifos by *Enterobacter* Strain B-14 and Its Use in Bioremediation of Contaminated Soils. *Journal of Applied Environmental Microbiology*, 70, 4855–4863.

Sinton, J.B. and S. Singh. (2016). Effect of 2,4-dichlorophenoxyacetic acid and maleic hydrazide on growth of bluegreen algae (cyanobacteria) Anabaena doliolum and Anacystisnidulans. Sci. Cult., 55:459–460.

Slager, R., J. Poole, t. LeVan, D. Sandler, Alavanja, M. and Hoppin, J. (2013). Rhinitis Associated with Pesticide Exposure among Commercial Pesticide Applicators in the Agricultural Health Study. *Occupational and Environmental Medication*, 66(11), 718–724.

Son, H., S. Kim, J. Hang, Y. Chang, S. Park, S. Lee, D. Jacobs, D. and Lee, D. (2010). Strong associations between lowdose organochlorine pesticides and type 2 diabetes in Korea. *Environmental International*, 36(5), 410–414.

Stewart, D J. (2016). Pesticide use, habits and health awareness among Egyptian farmers. *Ambio*, 25, 425–426.

US and EPA (2016). Recent developments in molecular techniques for identification and monitoring of xenobiotic-degrading bacteria and their catabolic genes in bioremediation. *Appl. Microbiol. Biotechnol.* 60, 45-59.

Van der Werf, D. (2016). Agricultural exposure to carbamate pesticides and risk of non-Hodgkin lymphoma. Journal of Occupational and Environmental Medicine, 43(7), 641-649.

Veena, H. G., Kearney, G. and Asal, N. (2010). Associations of Serum Concentrations of Organochlorine Pesticides with Breast Cancer and Prostate Cancer in US Adults. *Environmental Health Perspectives*, 118(1), 60–66.

World Health Organisation (2010). WHO gives indoor use of DDT a clean bill of health for controlling Malaria. Division of Environmental Health, WHO, 1211 Geneva 27, Switzerland.

World Health Organisation (2012). Pesticide exposure and genotoxicity correlations within a Greek farmers' group. Division of Environmental Health, WHO, 1211 Geneva 27, Switzerland.

World Health Organisation (2013). The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 2013. Geneva, Switzerland: World Health Organization, 2014.

Wickerham, S. and David, P. (2012). Interaction of Atrazine with soil microorganisms: Population changes and accumulation. *Candian J. Microbiol.* 24, 1145-1152.

Wilson, J. and Tisdell, H. (2011). Pesticide Use and Cutaneous Melanoma in Pesticide Applicators in the Agricultural Health Study'. *Environmental Health Perspectives*, 118(6), 812–817.

Wolfe, Y., Chen, T., Islam, A., Ahmed, A. and Ahsan, H. (2017). A prospective study of the synergistic effects of arsenic exposure and smoking, sun exposure, fertilizer use, and pesticide use on risk of premalignant skin lesions in Bangladeshi men. *American Journal of Epidemiology*, 173(2), 183-191.

Wuertz, H. and Mergeay, G. (2017). Identification of determinants of pesticide exposure among Kenyan Agricultural workers using empirical modeling. *Annals of Occupational Hygiene*, 43, 8519-8525.

Yassin, M. M., Abu Mourad, T. A. and Safi, J. M. (2012). Knowledge, attitude, practice, and toxicity symptoms associated with pesticide use among farm workers in the Gaza Strip. *Occup Environ Med*, 59, 387–393.

## APPENDIX I

## QUESTIONNAIRE ON IMPACTS OF AGROCHEMICALS APPLICATION ON HUMAN HEALTH AND THE ENVIRONMENT IN BADEGGI AND ENVIRONS, NIGER STATE, NIGERIA

Please answer the following questions sincerely. Tick or write when applicable.

**SECTION A: PERSONAL DATA**

(1) Name of Respondent ……………………………………………………………………

(2) Level of education (a) Primary (  ) (b) Secondary (  ) (c) Tertiary (  ) (d) None (  )

(3) Sex (a) Male (  ) (b) Female (  )

(4) Crops growing in the farm ………………………………………………………………….

(5) Common problems (soil fertility levels, diseases, insects, weeds ) affecting crops

(6) Types and names of agrochemicals usually used- fertilizers, insecticides, fungicides, herbicides. …………………………………………………………………………………

(7) Number of years of farming experience with use of agrochemicals …………………………………………………………………………………………

**SECTION B: FARMERS' KNOWLEDGE, ATTITUDES AND PRACTICES ON AGROCHEMICALS APPLICATIONS IN CROP PRODUCTION; TYPES AND QUANTITIES OF AGROCHEMICALS USED BY FARMERS IN THEIR MAJOR PRODUCTION PROCESSES IN THE STUDY AREA**

(1) What is the reason(s) why you use agrochemicals (Fertilizers and Pesticides) in your farm?

1=to increase yields (  )

2=to control pests and diseases (  )

3=to improve appearance‘(spotlessness) for marketability and better price ( )

4= advised to do so by extension agents ( )

5=other (specify) ……………………………………………………………………………….

(2) How do you determine the type of agrochemicals to apply in your farm?

1=use own experience ( ) 3=asks what other farmers have used ( )

2=as advised by extension officer ( ) 4=experiments on different types then choose ( )

(3) Before using an agrochemical do you check if it is currently approved for the intended specific target/insect, disease or weed?

1=Yes ( ) 0=No ( )

(4) Do you read the instructions on the label before using a particular agrochemical?

1=Yes ( ) 0=No ( )

(5) If yes, do you understand the instructions specified for chemical/pesticide usage?

1=Yes ( ) 0=No ( )

(6) Do you subsequently follow the instructions as prescribed?

1=Yes ( ) 0=No ( )

(7) How do you measure the required agrochemical amount for a particular purpose?

……………………………………………………………………………………………………

(8) Please provide the following information about agrochemicals you used in your farm in recent seasons.

| Date or Season | Target crop | Fertilizer used | Pesticide used | Amount applied (kg/litres) | Number of application to harvest | Area covered |
|---|---|---|---|---|---|---|
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |

**SECTION C: AGROCHEMICALS IMPACT ON HUMAN HEALTH AND ENVIRONMENT IN THE STUDY AREA**

(9) How would you rate risk effects of agrochemicals on the environment?

1=Not harmful at all ( ) 2= slightly harmful ( ) 3= moderately harmful ( )

4= very harmful ( )

(10) How would you rate risk effects of agrochemicals on the human health?

1=Not harmful at all ( ) 2= slightly harmful ( ) 3= moderately harmful ( )

4= very harmful ( )

(11) Have you suffered ill health problems you associate with agrochemical use?

1=Yes ( ) 0=No ( )

(12) Which below are the human ill health symptoms you have experienced and associated with use of agrochemicals?

1= skin irritation (e.g. rash, itching, burning or prickling) ( )

2= eye irritation (impaired vision, redness) ( )

3= stomach irritation (nausea, vomiting, diarrhea, excessive salivation, abdominal pain) ( )

4= respiratory irritation (chest pain, cough, running nose, wheezing, difficulties in breathing, throat irritation) ( )

(13) How would you rate the effects of agrochemicals on the following factors?

| | Not harmful | Slightly harmful | moderately harmful | Very harmful |
|---|---|---|---|---|
| Soil | | | | |
| Air | | | | |

| | | | | |
|---|---|---|---|---|
| Surface water | | | | |
| Aquatic organism (fish) | | | | |
| Birds | | | | |
| | | | | |

**SECTION D: ADAPTATION STRATEGIES PUT IN PLACE TO REDUCE THE IMPACT OF AGROCHEMICAL USAGE IN THE STUDY AREA**

(14) Do you take precaution to ensure the organisms are not harmed when applying Agrochemicals/pesticides?

(15) What are the measures you undertake to avoid harming the human being?

………………………………………………………………………………………………

……………………………………………………………………………………………….

(16) How would you rate your knowledge on appropriate use of agrochemicals?

1= Negligible ( ) 2=very little ( ) 3= little ( ) 4=enough ( )

5= more than enough ( )

(17) As an applicator, which of the following protective clothing do you used when spraying

1= Long sleeved overall ( ) 2= Rubber gloves ( ) 3= Nose mask ( )

4= Goggles ( ) 5= Hat/headscarf ( )

(18) What do you do with empty agrochemical containers/bottles?

1=Dispose into the disposal pit ( ) 4=throw in the latrine ( )

2=just discard them in the farm ( ) 5=Keep for re-use ( )

3=Destroy and burn or bury ( )

(19) How do you dispose any spoilt/expired agrochemicals?

1=Dispose into the disposal pit ( ) 2= discard them in the farm ( )

3=dispose in latrine ( ) 4=discard in nearby bushes/roadsides ( )

(20) Do you wash your hands with soap every time you handle agrochemicals?

1=Never ( ) 2=Sometimes ( ) 3=Always ( )

(21) Do you eat or drink while inside the store or when handling chemicals?

1=Never ( ) 2=Sometimes ( ) 3=Always ( )