KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF SCIENCE

CONCENTRATION OF ORGANOCHLORINE INSECTICIDE RESIDUES IN TOMATO (*LYCOPERSICON ESCULENTUM)* FRUIT: A CASE STUDY AT AKUMADAN IN THE OFFINSO NORTH DISTRICT OF ASHANTI REGION

BY

TWUM BENJAMIN TAWIAH

JULY, 2011

CONCENTRATION OF ORGANOCHLORINE INSECTICIDE RESIDUES IN TOMATO *(LYCOPERSICON ESCULENTUM*) FRUITS: A CASE STUDY AT AKUMADAN IN THE OFFINSO NORTH DISTRICTOF ASHANTI REGION.

A THESIS SUBMITTED TO THE DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY,

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (ENVIRONMENTAL SCIENCE)

COLLEGE OF SCIENCE

BY

TWUM BENJAMIN TAWIAH

(BED TECH)

TECHNOLOGY EDUCATION

UEW – KUMASI

JULY, 2011

DECLARATION

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in the university or elsewhere except where due acknowledgement has been made in the text.

------------------------------------ ------------------------------------

Twum Benjamin Tawiah Date

(Student)

------------------------------------ ------------------------------------

Mr. Stephen Akyeampong Date

Department of Theoretical and Applied Biology

KNUST, Kumasi

(Supervisor)

------------------------------------ ------------------------------------

Dr. P.K. Baidoo Date

Department of Theoretical and Applied Biology

KNUST, Kumasi

(Head of Department)

ABSTRACT

This study was conducted to determine the prevalence of pesticide use, sources of information on pesticide use, attitudes underlying failure to use protective equipment and levels of pesticide residues in tomatoes at Akumadan, in the Ashanti Region of Ghana. Liquid-Liquid extraction procedure was employed and extract clean up was done using ethyl acetate, sodium bicarbonate and solid phase extraction. In all 200 tomato samples were collected from 10 farms and analyzed for pesticides residues by gas chromatography equipped with electron capture detector. Fifty farmers were selected to respond to a questionnaire. Seventeen (17) different organochlorine pesticide residues namely p, p-DDT, p, p-DDE, o,p'-DDD, p,p'-DDD alpha – HCH, beta – HCH, Hexachlorobenzene, Aldrin, trans-Nonachlor, Heptachlor, trans – Chlordane and trans – Heptachlor epoxide were detected. The temperature of injector operating in a split less mode was held at 225^{o} C and electron capture detector was set a 300^{o} C. The concentrations of organochlorines pesticide residues in the tomato ranged from 0.0079 to 40.97 ug/kg. With the exception of Aldrin with a mean concentration (0.0079ug/kg) below the WHO maximum residue limit (MRL) of (0.01 µ/kg) the mean concentration for all the other organochlorines detected were above their respective permissible limits. The continuous consumption of such foods with high pesticide levels can accumulate and could result in detrimental chronic effects of the consumer.

DEDICATION

This thesis is dedicated to Mr. and Mrs. William Antwi for their love, patience and tolerance during the period of my education.

ACKNOWLEDGEMENTS

I owe a great deal of gratitude to God Almighty for granting me good health throughout the study period that enabled me to accomplish this project. I am grateful to Mr. Stephen Akyeampong (supervisor) who supervised this work. His constructive criticism, comments and advice helped to shape this thesis.

I am also grateful to all lecturers of Theoretical and Applied Biology Department especially those who taught me in class and those who offered suggestions during the presentation sessions.

I thank Offinso North District Assembly and Akumadan Traditional Council for granting me permission to undertake the research in their area not forgetting the farmers who offered their farms especially Mr. Owusu Mensah, Mr. Robert Adjei and Mr. Richard Kyeremeh for permitting me to observe them on their farms.

I am also appreciative of the encouragement of my mother Madam Alice Pinamang and foster parents Mr. and Mrs. William Antwi, my brothers and sisters (Juliana, James, Rose, Edward, Attah, and Appiah). All my efforts would have achieved little without the strong spiritual and moral backing of my beloved wife, Comfort Buonti Twum. She was a real source of motivation. My children: William Antwi Twum and Juliana Pinamang Twum supported and encouraged me. These cherished people deserve my thanks.

I am indebted to the scientists at the Chemistry Department of Ghana Atomic Energy Commission especially Miss Harriet Kuranchie Mensah and Mr. Crentsil Kofi Bempah. .

I also appreciate the contribution of colleagues and friends in the production of this research work, notably Joseph Dankwah, Kofi Ampofo Nuako, Johannes Rushman and Christiana Dabanka.

My gratitude would not be fully paid if the names of Johnson Nti Peprah, Lee Gilbert, Appah Ebenezer Kumi and Michael Appiah were missed out. They neatly typed this work.

Finally, I thank all others whose contribution sneaked in unnoticed.

TABLE OF CONTENTS

CHAPTER THREE

CHAPTER 4

CHAPTER FIVE

CHAPTER 6

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

1.1 **BACKGROUND TO THE STUDY**

From time immemorial, human beings have been engaging in farming as an economic venture. Lionell (1969) indicated that socio-economic conditions in the community propel people to engage in all kinds of activities. Ghana has a wide variety of soil environments on which a range of crops are cultivated. The farmers cultivate a wide variety of crops in different parts of the country for food and other needs including selling for money. This fulfills the assertion by George (1976) that most occupations peculiar in a community are due to the natural abundance of the raw materials in that community.

The various groups of crop cultivated in various parts of Ghana are cash crops such as cocoa, fruit crops such as mango and orange, cereals and grains such as rice, maize and millet and vegetables such as tomatoes, cabbage, carrot and groundnut.

Among the various farming activities, vegetable cultivation is very prominent in most parts of the country. In the past, vegetable cultivation in Africa was on subsistence basis where families cultivate vegetables that they require for their own consumption.

Cities in developing countries including Ghana are experiencing rapid population growth with its accompanying growth in civilization and rapid social interactions. In Ghana the urban population is growing at an estimated annual rate of 42% compared with an overall population growth of 2.7% (Ghana Statistical Service, 2002),This is coupled with the challenging needs of individuals and society.

Large scale vegetable production therefore emerged out of necessity to satisfy the increasing and varied needs of society. With the increase in population coupled with modernization, farmers realized the need to apply chemicals to their crops in order to increase yield and prevent invasion by pests. It is estimated that as much as 45% of the world's crop are destroyed by pests and diseases (Bhanti and Taneja, 2007).

Potent agrochemicals are therefore used irrespective of whether they have been approved for vegetable production or not. Danso *et al.*, (2002) pointed out that farmers mix cocktails of various chemicals to increase the potency.

The commonest agro- chemicals that farmers have embraced are pesticides.
Since the introduction of pesticides into farming, pesticides have undergone extensive chemical modification to make compounds that are more toxic to crops and less rapidly degraded (Muller-Beilshmit, 1990).

The World Health Organization (WHO) and Food and Agriculture Organization (FAO) of United Nations organization attribute great significance to the pesticides in the field of vector control especially in tropical countries (Baygon, 1996).

In Africa and Ghana in particular because of farming and the prevalence of mosquitoes, pesticides have become major chemicals used in homes and agriculture. Due to the high specific effectiveness and reliability, pesticides are currently used throughout the world in agriculture, horticulture and forestry as well as for domestic, hygiene and veterinary purposes.
Pesticides are the only chemicals which are deliberately made to be toxic and introduced directly into the environment. They are used in agriculture, homes and in urban areas to kill or control insects and weeds. (Danso *et al*.,)

As a result of pest attack on crops, several pesticides have been produced and sold on the markets in Ghana. When a crop is treated with a pesticide very small amount of the pesticide or its metabolites can remain in the crop after it is harvested (Corrigan, and Seneviratna, 2008).

Pesticide residues in food items have been a major concern to environmental and consumer groups because of the health problems they can pose to humans (Ejobi *et al*., 1996). In order to avert any environmental and health disaster, it is essential that pesticide residue levels in crops be monitored and appropriate mechanisms to reduce its effects be put up before it gets out of hand. Cowen (1971) pointed out that when problems are found too late, a pattern has already been created and secondary consequences can be disastrous. Storage and other post-harvest practices prior to further management of the product as well as household and industrial food processes may alter pesticide residues as compared with raw crops via chemical and biochemical reactions (hydrolysis, oxidation, microbial degradation etc.) as well as physicochemical processes (volatilization, absorption etc). Although these processes usually lead to reduction in any residues left in crops at harvest (Kaushik *et al*., 2009, Holland *et al*., 1994), in some cases those reactions and processes may concentrate residues in the processed food product.

The production of dry foods and refined vegetable oil can be intoxicated by a more toxic by-products or metabolites of the pesticides parent compound on the raw crops. (Amvrazi and Albalis, 2008, Lentza-rizos *et al*., 2006, Holland *et al*., 1994). These considerations suggest that effects of post harvest practices and food processing should be taken into account on the fate of a pesticide residues during dietary intake exposure assessments so as to ensure consumer safety.

1.2.0 PROBLEM STATEMENT

Vegetable cultivation serves as a source of livelihood to some farmers in Ghana. Most farmers use synthetic pesticides to control pests on vegetables in order to increase yield. The low cost and potency of these chemicals makes them attractive to farmers. Due to the indiscriminate use of the pesticides in terms of wrong concentration and frequency of application, residues are left in crops. The main concern is that the levels of pesticide residues in the crops can have adverse effects on human health.

1.3 OBJECTVES OF THE STUDY

1.3.1 General objective

The main objective of the study was to determine the levels of organochlorine pesticide residues in tomato fruits.

1.3.2 Specific objectives

The following were the specific objectives of the study, to:

1. determine the prevalence of pesticides used for tomato farming at Akumadan.
2. establish the sources of information on pesticides used by farmers at Akumadan.
3. determine the attitudes; underlying the failure to use protective equipment.
4. determine the concentration of organochlorine residues in tomato fruits.
5. establish the health problems farmers at Akumadan experience after pesticide application.

1.4 JUSTIFICATION OF THE STUDY

Pesticides have been used extensively in most vegetable cultivating communities in Ghana but very little information on environmental levels of their residues is available.

The research provide information to help make assessments of the levels of pesticide residues in crops and its impact on public health, agriculture, and the environment.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 PESTICIDE

A pesticide is any substance or mixture of substances intended to prevent, destroying, repell or mitigate any pest. It may be a chemical substance, biological agent (such as virus or bacterium) antimicrobial disinfectant or device used against any pest. (Wikipedia, 2010).

Food and Agricultural Organization (FAO) has defined pesticide as any substance intended for preventing, destroying or controlling pests. This include vectors of human or animal disease, unwanted species of plants or animals causing harm or interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products. or animal feedstuffs. The term include substances intended for use as a plant growth regulator, defoliant, desiccant or agent for thinning fruit or preventing the premature fall of fruit and substances applied to crops either before or after harvest to protect the commodities from deteriorating during storage and transport.(WHO/FAO, 2005)

Pests include insects, plants, pathogens, weeds, molluscs, birds, mammals, fish, nematodes, (roundworms) and microbes that destroy property, spread disease or are vector for disease or cause nuisance.(FAO/WHO 1998). Pests have been a threat to humans because of their destructive activities and the economic damage they cause to agricultural products before and after harvesting. The pathogens they transmit and the parasitic mode of life, some of them live infect human beings with diseases. Widespread use of pesticide is therefore due to the advantages they offer. They are effective and reliable in keeping crops healthy and prevent them from being destroyed by pests infestation. They work fast in emergency situations especially when crops are under immediate threat of infestation. It is estimated that about one thousand four hundred (1400) pesticide ingredients are used in the agricultural sector. (Kolpin *et al., 1998*). Ghana currently consumes about 25% of these pesticides produced. (Ntow, 2005).

Notwithstanding the beneficial effects of pesticides, their adverse effects on environmental quality and health have been well documented worldwide and constitute a major issue that gives rise to concerns at local, regional, national, and global scales (Planas *et al.*, 1997, Ntow, 2001, Kidd *et al.*, 2001, Huber *et al.*, 2000, Cerejeira *et al.*, 2003).

Residues of pesticide contaminate soils and water, persist in the crops, enter the food chain and are finally ingested by humans with foodstuffs and water.

Furthermore, pesticides can be held responsible for contributing to biodiversity losses and deterioration of natural habitat (Sattler *et al.*, 2006).There have been reported instances of pest resurgence, development of resistance to pesticides, secondary pest outbreaks and destruction of non target species.

Despite the fact that pesticides are also applied in other sectors, agriculture can undoubtedly be seen as the most important source of pesticide discharge into the ecosystem. (Hoyer and Kratz, 2001 cited in Sattler *et al.*, 2006).

Tomato, eggplant, pepper and onion are grown in all ten regions in Ghana. However, some regions are more efficient and specialized in the production of only one or two of the above four crops.

One of the biggest problems confronting vegetable farmers in Ghana is diseases and pests which ravage their crops. Vegetables generally attract a wide range of pests and diseases and can require intensive pest management (Dinham, 2003).

The improper pests control practices in vegetable production in Ghana include application of highly toxic pesticides which are most of the time misapplied and which results in pesticide contamination of the produce itself as well as the environment. Whilst Ghana's elite is becoming increasingly concerned about the adverse effect of pesticide on the environment and the health of the country resources, little scientific research has been done to address the issue. (Ntow, 2001).

Within the context of efforts to achieve safe, sound and sustainable production of vegetables, safe pesticide management plays a crucial role. Pesticide management includes all aspects of the safe, efficient and economic use in handling of pesticides (Bull, 1982). Proper use of pesticides in Ghana means taking into account the health, social and economic realities of life. It implies using pesticides which can safely be applied and only when necessary in the appropriate health, social and environmental context. (Osafo and Frempong, 1998)

2.2 History of Pesticides

Before 2000 BC, humans had utilized pesticides to protect their crops. The first known pesticide is elemental sulphur dusting used in ancient summer about 4,500 years ago in ancient Mesopotamia. By the 15th century, toxic chemicals such as arsenic, mercury and lead were being applied to crops to kill pests. In the 17th century, nicotine sulphate was extracted from tobacco leaves for use as an insecticide. The 19th century saw the introduction of two more natural pesticides; pyrethrum which was derived from chrysanthemums, and rotenone, which was derived from the roots of tropical vegetables. Until the 1950s, the arsenic-based pesticides were dominant. Paul Muller discovered that DDT was a very effective insecticide. Organochlorines such as DDT were dominant but they were replaced in the US by organophosphates and Carbarmates by 1975. (Holland et al 1994). Since then pyrethrum compounds have become the dominant insecticides. Herbicides became common in the 1960s, led by "triazin and other nitrogen based compounds, carboxylic acids such as 2, 4 dichlorophenoxyacetic acid and glyphosphate.

In the 1940s, manufacturers began to produce large amounts of synthetic pesticides and their use became widespread. Some sources considered 1940s and 1950s to have been the start of the pesticide era. Pesticide use has increased 100-fold since 1950s and 2.3 million tonnes of industrial pesticides are now used each year. Seventy five percent of all pesticides in the world are used in developed countries, but use in developing countries is increasing. In 2001 EPA stopped reporting pesticide use statistics. The only comprehensive study of pesticide use trends was published in 2003 by the National Science Foundation's Centre for Integrated Pest Management. (Dunlap, 1981).

In the 1960s, it was discovered that DDT was preventing many fish-eating birds from reproducing which was a serious threat to biodiversity. Rachel Carson wrote the best selling book "Silent Spring" about biological magnification. It was a relief to Environmentalist when the Agricultural use of DDT was banned under Stockholm Convention on persistent organic pollutants, but it is still used in some developing nations.

2.3 Classification of Pesticides

Pesticides can be classified in so many ways. Pesticides can be classified by target organism, chemical structure and physical state. Pesticide can also be classified as inorganic (Synthetic) or organic (Biological). Biopesticides includes microbial pesticides and biochemical pesticides. Plant- derived pesticides or botanicals have been developing rapidly. These include pyrethroids, rotenoids, and nicotinods.

Pesticides can be grouped into the chemical families. Prominent among these are organochlorines, organophosphates and carbamates. Pesticides can be classified based upon their biological activity, function or application method. Pesticides move inside plant following absorption by the plant. This movement is outward. Another means of classifying pesticides is the mode of action. This includes stomach poisons (they have to be eaten), contact poisons (they work via the skins), and fumigants (they produce vapour that kills the organism). Again, pesticides are classified based on the target range: Broad spectrum pesticides (chemicals that kill a wide range of pests) Selective pesticides (chemicals that kill only a specific pest or group of pests).

Another means of classifying pesticides is based on how it is formulated. This includes: liquid, powders, granules, baits, dust, smoke, generators, and ultra low volume (ulv) liquids. Pesticides are also classified based on the toxicity class it belongs. The World Health Organisation (WHO) has developed the following toxicity class for chemical pesticides as follows:

- Class 1A: Extremely hazardous
- Class 1B: Highly hazardous
- Class II: moderately hazardous
- Class III: slightly hazardous
- Class IV: Product unlikely to present acute hazard in normal use

Another means of classifying pesticides is whether it is allowed to use. This include,

- Registered pesticides
- Banned pesticides

According to Pesticide Control and Management Act (1996) (Act528), only the registered products are allowed to be use.

Pesticides are also classified according to their persistence, their concentration, how they are used and their container size (OPAC, 2010).

The classification of pesticide product is important. It restricts the use of pesticides by people, promotes safe use of pesticides and better protects the environment and human health. It also requires manufacturers to improve pesticide labels to prevent product misuse (WHO/FAO, 2005).

2.4. Uses of Pesticides

Pesticides are used generally to control organisms considered harmful to biodiversity and their products. In the third world countries, the loss of crops due to pests, plants diseases and competition from weeds is enormous. According to the United State of America Data Programme (2003) pesticides are used to kill mosquitoes that can transmit deadly diseases like West Nile virus, yellow fever and malaria. They can also kill bees, wasps or ants that cause allergic reactions. Pesticides can protect animals from illnesses that can be caused by parasites such as fleas. Pesticides can prevent sickness in humans that could be caused by mouldy food. Pesticides can be used to clear roadside weeds, farm weeds and weeds that may cause environmental damage. Pesticides are also commonly applied in ponds and lakes to control algae and plant such as wiregrasses that can interfere with activities like swimming and fishing and cause the water to look or smell unpleasant. Pests such as termite which can damage the wooden structures of a house such as ceilings, doors, and window frames may be controlled by pesticides. Pesticides are used in grocery stores and food storage facilities to manage rodents and insects that infest food such as grain thus minimizing post harvest losses (Clarke *et al.*, 1997). A study conducted by. Adeyeye and Osibanjo (1999) found out that not using pesticides reduced crop yields by about 10%. Another study conducted by Repto and Balige (1996) found out that a ban on pesticides in the United States of America may result in a rise of food prices, loss of jobs and an increase in Global hunger. Even though World Health Organization has given stronger support to the use of pesticides to fight malaria, each use of the pesticide carries some associated risks. However, proper pesticide use decreases these associated risks to a level deemed acceptable by Pesticide Regulatory Agencies such as United State Environmental Protection Agency. Widespread use of pesticides therefore is due to the advantages they offer, that is keeping crops healthy and prevent them been wasted by diseases and infestation.

2.5. Types of Pesticides

There are different types of pests that invade and destroy crops, carries vectors and destroys wood and wood products. These include insects, plant pathogens, rodents, birds and weeds. Some pests are just a nuisance. However, some present healthy hazard and others may bite or sting. The various types of pesticides and the specific pest each control is shown below:

- Insecticides---> insects
- Fungicides-----> fungi
- Herbicides-----> weeds
- Avicides-------> birds
- Bactericides---> bacteria
- Matricides-----> mites
- Molluscicides--> snails
- Nematicides---> nematodes
- Foeticides-----> rodents
- Virucides -----> virus
- Algaecides-----> algae

2.5.1: Insecticides

An insecticide is a natural or man-made preparation that is used to kill or otherwise control the population of insects. Instead of killing insects, an insecticide may work to prevent them from reproducing. Insecticides are generally classified as either organic or inorganic. Organic insecticides always contain carbon whiles inorganic do not contain carbon. Organic insecticides are grouped into synthetic (man – made) and natural insecticides consisting mainly of organochlorine insecticides, organophosphorus insecticides, *carbamates and pyrethroids.*

2.5.2: Organochlorine insecticides

They are chemical compounds formed from atoms of hydrogen, carbon, oxygen with the addition of chlorine. They break down slowly and can remain in the environment long after application and in organisms long after exposure. The most notorious organochlorine is the insecticide dichlorodiphenyltrichloroethane (DDT). Promoted as a 'cure all' insecticide in the 1940s, other commonly known organochlorines include toxaphene and methoxychlor Lindane endosulfan, dicotol, chlordane, heptachlor, Aldrin and dieldrin. Organochlorine insecticides are mostly used in agriculture to kill insects in vegetables, fruits, cereals, grain and cotton as well as ornamental shrubs, trees and vines. It was also the chemical of choice for the control of mosquitoes until the 1960s. (Gibson *et al.*, 1987). Organochlorine pesticides were extensively used by most Ghanaian farmers due to their low cost, high efficacy and its wide range suitability to plants (Osafo and Frempong, 1998). These pesticides were greatly used in most farming communities in the Western, Ashanti and Brong Ahafo regions of Ghana (Amoah *et al.*, 2006) in vegetable production, cocoa farms and mixed crop farms (Gerken *et al.,* 2001, Ntow *et al.,* 2006). Organochlorine pesticides such as DDT, Lindane and Endosulfan were also employed to control ectoparasites of farm animals and pets in Ghana (Ntow *et al.,* 2006). Pesticides have also been used to control black flies along the banks of the Tano and Pra rivers (Ntow, 2001).

Organochlorines are fairly complex, stable compounds and therefore persist for a long time in the environment either in their original form or as stable metabolites. Their persistence make them capable of bioaccumulating in the tissues of human beings such as breast milk and blood (William *et al., 2008)* via the food chain. As a result of its position in the food chain (End of the food chain), man is greatly exposed to the effect of the micro pollutants by eating foods either from contaminated earth or water (Belta *et al*., 2006, Raposo and Nilva *2007).* They are poorly biodegradable and have high lipid solubility (Mbakaya *et al.*, 1994). Higher levels have been formed in human beings (Ejobi *et al.,* 1996, Skaare *et al.,* 1988, Weisenberg *et al.,* 1985).The organochlorine pesticides are broad spectrum insecticides and are the most widely used in many countries including Nigeria for agricultural purposes and control of mosquitoes (Belta *et al.,* .2006, Blaso *et al*., 2005). Organochlorine pesticides are very stable compounds and they have been cited that the degradation of DDT (Dichlorodiphenyltrichloroethane) in the soil ranges from 4-30years. Other chlorinated stable compounds also remain for many years after application, due to their high resistance to biological and chemical degradation. (Afful *et al*., 2010). Despite the fact that the use of certain organochlorine pesticides is prohibited in many countries including Ghana, these compounds have been detected in the environment (Rajendran and Subramanian, 1997).

The use of organochlorines has occasionally been accompanied by risks to human health and the environment because of their toxic potential, high persistence, bioconcentration and especially their non-specific toxicity (Krauthacker *et al.,* 1998, Barriada Pereira *et al.,* 2005). Unfortunately pesticides use have been abused since most pesticides users are ignorant or have little knowledge about these chemicals. Some farmers are of the view that the more or as often as they apply pesticides the greater the chances of higher yield and also destroying crop pest (Ntow *et al.,* 2006). They have no idea of the half lives of these chemicals nor the dangers they pose when misused. The deleterious effects of these organochlorine pesticides on wild life primarily led to their ban from routine use in the US and many other countries in 1970's and 1980's (Dunlap, 1981).With the exception of endosulfan which was considered for restricted use in 2008, Ghana has banned the use of many organochlorine pesticides since 1985.

The developed nations like U.S.A, Japan and Western Europe have put in place measures for pesticide control and monitoring in the environment accompanied by continuous regular survey studies and monitoring programmes (Luke *et al.,* 1988, Fontcuberta *et al.,* 2008). In contrast, there is very little information on the levels of pesticide usage in developing countries like

Ghana. This may be due to lack of financial support for scientific research, environmental policy and regulation for control and monitoring the environment. In countries where they exist, agencies responsible lack the capacity to ensure compliance and enforcement of regulations (Belta *et al*.,).

Regrettably, as indicated earlier, even though organochlorines are banned from importation, sales and use, third world nations continue to use them. For example in Ghana, there are evidence of their continued application to crops, vegetables and fruits. Few studies conducted so far in Ghana revealed levels of organochorine pesticides in water, segments, food and vegetable (Osafo and Frempong, 1998; Ntow, 2001., Darko and Aquaah, 2006), which are emanating from current and past use of these chemicals. Moreover, pesticide residues in food materials are not properly monitored nor controlled in Ghana and limited information is available for the level of pesticide residues in food. Thus, in Ghana there have been less surveillance programmes for pesticides levels in foods, hence the paucity of data on the dietary intake of pesticides by the Ghanaian population.

2.5. Movement of Organochlorine Insecticides in the Environment

Organochlorine insecticides enter the environment as the consequences of human activities in the following ways:

- Deliberate application of the insecticide. This is the major source of environmental contamination.
- The deposits results from the application of chemicals to control agricultural pests and causes public health problems.
- Misplacements and leakage during transportation, distribution or storage processes related to the manufacture of insecticides.

These insecticides enter the environment and are absorbed by various constituents of the environment and transported to other places mainly by air and water movements. They are picked up by various biological systems and are at the same time chemically or biologically transformed to other nontoxic or toxic compounds in the environment (Aroud *et al.,* 2007, Raposo and Nilva, 2007) calculated that roughly 10,000kg/yr of pesticides are transported by the Mississippi river system to the Gulf of Mexico.

The widespread use and disposal by farmers, institutions and the general public provides other possible sources of pesticides in the environment. Pesticides which are sprayed can move through the air and eventually end up in other parts of the environment such as in soil or water. Pesticides which are applied directly to the soil may be washed off the soil to nearby bodies of surface water or may percolate through the soil to lower soil layers and groundwater. The application of pesticides directly to bodies of water for weed control or indirectly as a result of leaching from runoff may lead to build up of pesticides in water, but may also contribute to the levels through evaporation (Darko and Aquaah, 2006). This list of possibilities suggests that the movement of pesticides in the environment is very complex with transfers occurring continually among different environmental compartments. In some cases, these exchanges occur not only between areas that are close together (such as a local pond receiving some of the herbicide application on adjacent land) but also may involve transportation of pesticides over long distances.

Since, organochlorines are very resistant to degradation by any means and thus remains unchanged in the environment for long periods of time, they can move over long distances (Fleming *et al.,* 1994). Knowledge of organochlorine pesticide movement in the environment is necessary to minimize unnecessary release into the environment.

2.7. Toxicity of organochlorine pesticides

Organochlorines are the most successful, profitably utilized and commercialized group of pesticides. They have gained huge popularity and prominence in a short span of time by virtue of their ability to control all kinds of pest including insects, fungi and rodents.

Toxicity of an individual pesticide to the pest is prominently determined by its structure, a different moiety attached to the parent compound, their special arrangement within molecules, nature of substituents, polarity, symmetry and asymmetry of molecules, the solubility and sorption values (Belta *et al.*, 2004) .Toxicity may be defined as the quality of being poisonous or harmful to animals or plants (FAO/WHO, 1998). Toxicity of pesticides can be measured in several ways but generally based on test results on rats and other animals. Acute toxicity of a substance is characterized by LD_{50} (lethal dose). (Berger, 1988).

LD_{50} is the dosage of pesticide (mg/kg body weight) needed to kill 50% of tested animals. The smaller the LD_{50} the more toxic the chemical is. Toxicity results obtained are only guidelines. A pesticide that is poisonous to rats is not necessarily equally poisonous to people or other animals. It can therefore be used to estimate the hazard of a particular poison. To estimate the lethal dose of humans, the LD_{50} should be multiplied by the body weight in kg (Berger, 1988).Chronic toxicity is the propensity to cause long term delayed effects, following repeated low level exposure.

The most widely used toxicological measurement of chronic toxicity is the reference dose (RFD). The reference dose is derived by taking the highest that has no observable adverse effect in tested animals and declining it by a safety factor typically 100. The results in theory represent doses that exert unappreciable risks to humans, although the uncertainties inherent in extrapolation from animals to humans must be acknowledged. As with the LD_{50}, the smaller the RFD, the more toxic the chemical is (Caudle *et al*., 2005).

Pesticides due to their great structural variety affects systems of humans and animals in many places through a variety of reaction mechanisms (Jayashree *and Vusudevan* 2007). Poor nutritional status, extreme physical stress and a high rate of infectious diseases many affect persons detoxification and excretion capacities (Ntow *et al.*, 2008). The United Nations (U.N) has warned that about 30% of pesticides marketed in developing nations contain toxic substances which pose a serious threat to both human health and the environment (WHO/UNDP, 1990). Organochlorine pesticides have become ubiquitous contaminant and have been implicated in a broad range of deleterious health effects in laboratory animals and man. The toxic effects include reproductive failure (AICRP, 2000), immune system malfunction (Kolpin *et al.,1998*), endocrine disruption (Ize *et al.*, 2007) and breast cancer (Garabrant *et al.*,1992). Studies in developing countries have related long term pesticide exposure to cancer, adverse reproductive effect and damage to the immune system and death (Maroni and Fiat 1993, Repto and Balige, 1996).

Twelve farmers in the Upper East Region of Ghana died as a result of misapplication of pesticides (Ghanaian Times, 2010).

The WHO has indicated that the total worldwide pesticide poisoning could be as high as 2 million cases a year with twenty thousand poisoning resulting in death (WHO/UNDP, 1990).
The social impact of these poisoning fatalities is immeasurable, as it is usually the man who also happens to be the head of the family who is poisoned leaving the woman and children to face destitution.

2.8. Other Problems Associated with Pesticide Usage in Developing Countries

2.8.1 Exports to Countries without Pesticides Control

Most countries do not have the infrastructure or the resources to adequately regulate and monitor the availability and use of pesticide. The FAO/WHO (1998) study found 81 countries with no detectable pesticide control measures.

In 2005, FAO estimated that there were still some 45 countries that have no detectable regulations, though many of these nations are in the process of setting up some form of control (WHO/FAO, 2005). In its drive to increase food production, to feed the growing population, Ghana has been receiving tonnes of pesticides in its various forms for use in agriculture (Afful *et al*., 2010). These products come into the country in the form of purchased products, donations and /or grants in support of agriculture.

2.8.2 Effects of pesticides on Beneficial, Non – targeted Organisms

When pesticides, toxic to organisms end up in the environment, they may kill non – targeted beneficial organisms. Studies in India showed that mosquito consuming exotic fish species and natural enemies of urinary schistosomiasis cannot survive in the water due to intensive pesticide application (Aroud *et al.,* 2007). Bioaccumulation and biomagnification usually occurs as the pesticides travel higher up the food chain with detrimental effects on higher organisms especially man (William *et al.*, 2008). The effect on man is compounded by the fact that drinking water is usually taken directly from streams, rivers or lakes, instead of from ground water as is usually the case in Ghana. The presence of pesticides in soil can alter the composition and circulation of nutrient (Ntow, 2001). It may also exert subtle effects on the organism's activities. This may degrade soil fertility, ultimately producing an essentially biological sterile soil (Bariada – Pereira *et al.*, 2005).

2.8.3 Destruction of Natural Antagonist Pest

A great disadvantage of almost all commonly used insecticide is their low selectivity. Most of the important persistent insecticide tends to be broad spectrum. (Colborn, and Smolen, 1996) As such they are indiscriminate in their actions, often killing beneficial organisms with the same facility as they destroy the pest. This has the serious disadvantage of removing biological control for a considerable period and may thereby result in a later outbreak of pest. The non-selective effects of most pesticides results in the profound long – term disturbance of the ecosystem.

Studies on pests and beneficial organisms before and after the use of insecticide have shown that and application of insecticides may virtually estimate the natural enemies of a pest, eventually leading to an increase in the occurrence of pest. (Danso, *et al.*, 2000). It is possible to develop and promote the use of selective products, but the danger is that resistance to the product will develop faster. Moreover, selective products are more expensive and entail higher application cost if a large number of insect pest invade. Pesticides manufacturers therefore are generally not interested in producing selective pesticides for economic reasons. The demand is usually too low to justify the development cost (Darko and Aquaah, 2006)

2.8.4 Development of Resistance to Pesticides.

Resistance to insecticides according to Caudle *et al*., (2005) is the ability of an insect population to develop the ability to survive a toxic dose that was originally lethal for the majority of individuals. The continuous presence of poison in the environment is known to lead to the development of the resistant strains of the pest, which is both more difficult and more costly to control.

When a crop is sprayed with chemicals, it is never possible to kill all the pests. The ones which escaped will be few hidden, those carrying resistance gene when the survivor breed, a large number of their off springs develop resistance character, escapes the next spray and the process is repeated. After several generations, there shall exists a population all fully resistant to the insecticide and this resistant population will build up fast when sprays are applied too frequently or when it often happens, a farmer increases the amount of the concentrate (active ingredient) in a spray in the hope of quicker or more wholesale effect. (Depury, 1985)

Genetically acquired resistant of insects to insecticide toxicity continue to be the most serious obstacle to the successful use of chemicals (Metcalf, 1982). The rate at which resistance is built up depends on the amount of pesticides applied and the frequency of application (Okorley and Kwarteng, 2002). The current situation regarding resistance development especially in Africa is not known since few laboratories are following this topic (Afram *et al.*, 1999).

In Ghana, development of resistant is suspected for the white fly and diamond back moth (Afram *et al.*, 1999).

2.9 REGULATIONS ON PESTICIDE USE

Pesticide regulation works to protect health and our environment by promoting safe and proper use of pesticides (Hanson, 1988).

Though pesticide regulation differs from country to country, pesticides are traded across international borders.

To deal with inconsistencies in regulations among countries, delegates to a conference of the United Nations, food and agricultural organization adopted international code of conduct on the distribution and use of pesticide in 1995 to create voluntary standards of pesticide regulations for different countries. The code was updated in 1998 and 2002. (WHO/FAO, 2005)

The food and agricultural organization (FAO) claims that the code has raised awareness about pesticide hazards and decreased the number of countries without restrictions on pesticide use. (WHO/FAO, 2005). Other efforts to improve international trade are United Nations London Guidelines for the exchange of information on chemicals in international trade and limited Codex Alimentarius Commission.

The former seeks to implement procedures for ensuring that prior uniformed consent exist between countries buying and selling pesticides whilst the latter seeks to creates uniformity for maximum levels for pesticide residue. Both initiatives operate on voluntary basis. Pesticide safety education and pesticide applicator regulations are designed to protect the public from pesticide misuse but do not eliminate all misuse (Youdeowei, 1989).

2.9.1 Regulations on Pesticides Use In Ghana

In Ghana, pesticide control and management Act (1996) (Act 528) makes the Environmental Protection Agency (EPA) the lead agency responsible for a comprehensive pesticide regulation programme. (PCMA, 1996).

EPA has the sole authority and responsibility to register all pesticides imported, exported, manufactured, distributed, advertised, sold and used in Ghana. They Act provide for the control, management and regulation of pesticides in Ghana and to provide for related matters.

The objective of regulating pesticides is to protect society from the adverse effects of pesticide without denying access to the benefits of their use. The four main parts of the act are as follows:

- Part I: Regulation of pesticide
- Part II: Licensing of pesticide dealers
- Part III: Enforcement and penalties
- Part IV: General provisions

Section1 of Act 528 states that no person shall import, export, manufacture, distribute, advertise, sell or use any pesticide in Ghana unless the pesticide has been registered by EPA. Registration enables authorities to exercise control over quality, use, levels, place, labeling, packaging, advertising and disposal of pesticides thus ensuring that the interest of the end users are properly protected.

In addition to submitting an application form, the applicant is required to submit scientific evidence or data in a dossier to support all claim for efficiency and safety of the product to be registered. The dossier must contain sufficient information to effectively address all pertinent issues regarding safety and efficiency. Chemical control and management centre of the EPA receives all applications.

Subcommittees of Pesticides Technical Committee (PTC) evaluates the applications and submit reports to the PTC. PTC then makes recommendations to the EPA. Board based on the report of the subcommittee. (PCMA, 1996).

EPA Board takes the final decision to register or deny registration of the pesticide. Even though Act 528 was promulgated in 1996, a number of problems prevented the full and effective implementation of its provisions. Between 2003 and 2004, full operationalization of the Act was initiated. (EPA Ghana, 2008)

Other agencies and organizations that are helping EPA in its implementations are Ghana Ports and Harbors' authority (GPHA), Customs Exercise and Preventive Service (CEP'S), Ghana Standards Board (GSB), Ministry of Food and Agriculture (MOFA) and Factory Inspectorate Department of Ministry of Employment and Social Welfare. According to Youdeowei, (1989), the effective control of pesticides in developing countries remains poor due to shortage of personnel, lack of infrastructure, transportation, equipment, very low budgetary allocations and lack of residue analysis facilities.

Abate (1996) also pointed out that even though there are regulations concerning the use of pesticides, there are still some pesticides in use that have been restricted in some developing countries. There is therefore the need to review safety precautions on the use of pesticides in Ghana. The abuse, misuse and the use of a large range of pesticides of moderate to high toxicity in the country, implies high exposures and possible poisoning potentials and would suggest the need for more control and monitoring at national and local levels. An immediate priority in Ghana is an urgent requirement for sustained, low cost and well targeted training interventions.

2.10 Alternative Methods of Pest Control

Many farms are pestered by pests. Pests are annoying and bothersome. The effective control of pests such as weeds, insects and disease is critical to ensuring healthy crops and enhance agricultural productivity (Mah, *et al.*, 2001)

Various pests control methods have been adopted. One is the use of chemical pesticides which is still the most common method in many countries (Hussein, 1999). This is because it is cheap and often very effective (Mobbd Narow, *et. al.*, 2002). The effective use of chemical pesticides in protecting crops, however, has masked the negative impacts associated with their use. For farmers, the most serious issue is the development of resistance by pest to the chemicals, secondary pest outbreak and health hazards associated with the application of chemicals (Magnaye, 2006). For consumers, the main problems are pesticide residues in food and environmental degradation (Persley, 1999)

Because of such concerns, there is a great deal of interest in applying non-chemical pest control methods. Non-chemical pest control methods have many advantages compared to chemical treatments. They are generally effective for longer periods of time. (Lingappa, 2001). They are less likely to create hardy pest population that develop the ability to resist pesticides and can be used with fewer safeguards, because they are generally thought to pose virtually no hazards to human health or environment (Lenne, 2000). Chemical methods are not necessarily the best method of pest control (Pearce, 2002).

A number of different approaches are available and have been used and proved efficacious in some countries worldwide (Waterhouse, 1992). These include biological control, mechanical and cultural practices.

2.10.1 Biological Control Methods

Biological control refers to the deliberate introduction, use or encouragement, of natural enemies of a pest to reduce pest abundance (Waterhouse, 1992).

Biological control agents may be classified as parasites (parasitoids), predators, phytophagous, insects and insect pathogens such as viruses, fungi, bacterial, protozoa and nematodes (Ooi and Shepard, 1994).

Four types of biological control are recognized namely; Classical biological control, inundative method of biological control, augmentation method and management method.

a. Classical Biological Control

It involves the introduction of natural enemies to a new location where they did not originate or do not occur naturally. The idea is to lower permanently the equilibrium position of the pest to a non economic level (Ooi and Shepard, 1994). Under favourable conditions, beneficial species released in sufficient numbers will successfully colonize and become an integral part of the ecosystem. Classical biological control is long lasting and inexpensive. Classical biological control has been successful in the introduction of vedalia beetle (*Rodolia cardinali*) from Australia to California to control the cottony cushion scale, Kenya purchasi on citrus (Mittal, 1998). Control of the prickly pear weed (*Opuntia inermis*) in Australia was achieved with the introduction of the moth *Cactoblastis cactorum* (Liew, *et al*., 1999)

b. Inundative Biological Control

This involves rearing large numbers of biological control agents and releasing them into the field (Lim and Chong, 1987). They reported the periodic release of *trichogrammatoidea Bactrae fumata* to control the cocoa pod borer.

c. Augmentative Biological Control

This involves the introduction of beneficial insects at a time when pest populations are about to build up. An example of augmentative biological control is the encouragement of the black ant, (*Dolichoderus thoracious*) to manage cocoa muriad pest (Khoo and Chung, 1989). This involves the establishment of nest of the ant in cocoa plant. Liew, *et al.*, (1999) also found that the black ants could control the cocoa pod borer.

d. Conservation Of Natural Enemy

This involves creating situations favourable to colonization of crops by resident natural enemies. A variety of management activities can be used to optimize the survival and for effectiveness of natural enemies. Conservation activities might include reducing or eliminating insecticide application to avoid killing natural enemies, staggering harvest dates in adjacent fields or rows to ensure a constant supply of host (prey) or providing alternative sources to improve survival of beneficial species (Liew, *et al.*, 1999).

2.10.2 Cultural Methods

Cultural control is the use of farming techniques or cultural practices associated with crop production, designed to make the environment difficult for the survival of pests. It involves the manipulation of the environment to the disadvantage of the pest (Harender Raj, *et al.*, 1997). The environment is changed by altering farming practices at the correct time so as to kill the pest or slow down their multiplications. Some example of cultural control methods are given below;

a. Crop Rotation:

This is the system of farming where different crops are grown on the same piece of land in a definite order or cycle. Monocropping, rationing and growing the same crop year after year to favour pest build up. It should therefore be avoided. The population of the fungus,

Fusarium spp can be reduced when soil is kept fallow, compared to growing successive pigeon pea in the same soil.

Pigeon pea →fallow → chillies and pigeon pea →fallow →tobacco cropping pattern appreciably reduces *Fusarium spp*. (Dasgupta *et al.*, 1992). Growing maize, chicken crop sequence decreases root knot nematodes population in chick pea (AICRP, 2000)

b. Planting Time:

Planting time has been exploited by many entomologists and pathologists to check insect pest and diseases, for instance, sowing black grain (*Phaseolus mungo*) in the second forth night of June reduces the folia disease in the hill region of Uttar Pradesh (Mittal, 1998). The pigeon pea *Fusarium* wilt is reduced when the crop is sown after July and also by sowing under rain fed conditions in Kanpur, Uttar Pradesh, North India (Choudhry, *et al.*, 2001).

c. Tillage Practices:

Full ploughing with a furrow turning plough by the end of the cropping season is advocated to expose diapausing insect stages in several agro – ecosystems. The tillage practices expose the larvae and pupae of pest insects like cutworms (*Agrotis spp*.) hairy caterpillars (*Amsacta spp*.) grasshoppers (*Hieroglyphus spp*.) and locusts (*Locusta spp*.) either to inimical conditions or to predators like insectivorous birds.

d. Trap Cropping:

Trap cropping is yet another technique to successfully suppress pest or pathogens. Planting highly preferred in and around a cotton field in Tumkur, India served as a trap crop for boll worms (Lingappa, 2001). Variation in attractiveness of crops for egg laying or larval feeding is exploited as effective to concentrate early pest populations on selected plants. The major benefit of this is that either the insect can be collected manually or control measures with bio agents or chemical can be applied to a limited area, thus avoiding chemical application to the entire area. Trap crops may also attract natural enemies by the presence of semio →chemicals, thereby enhancing the effectiveness of natural crop (Lingappa, 2001).

2.10.3 Mechanical methods

a. Collecting and killing

Collecting and killing of moths of red – headed hairy caterpillar, (*Amasacta albistriga*), pigeon pea and chicken pod borer have been reported from the endemic areas of Karnata, Korala Andhru Pradesh in south India. (Harender, *et al.*, 1997). The practice of collecting and destroying in huge numbers the eggs, grown – up larvae and adults of pests like grasshoppers, locusts, hairy caterpillars on bunds, sticks, weeds is common (Lingappa, 2001). The larvae can be collected by collecting the plants and by sweeping the larvae fallen underneath the plants.

b. Hot water treatment

Sugarcane sets treated in hot water for ten minutes controls whit smuts (*Ustilago seitaminea*) in Gurajat (Wala, *et al.*, 1992). It is a recommended practice.

c. Soil solarisation

Sterilizing of soil by solarisation is practiced in vegetable farm and to a limited extent in tobacco and vegetable nurseries (Amarasiri *et al.*, 1990). Beds are first moistened and then covered with black polythene for 5 – 7days. If diseases were observed during the previous season, the process is repeated after turning the soil.

2.10.4 Integrated pest control methods

Indiscriminate and injudicious use of chemical pesticides in agriculture have resulted in adoption of Integrated Pest Management (IPM) as cardinal principle and main plank of plant in the overall crop production program (Guo *et al.*, 2005). Integrated Pest Management involves the combination of different control methods as appropriate, taking into consideration the local conditions of agriculture and pest occurrence. Integrated Pest Management was developed as a means of improving efficiency of pest control, while at the same time keeping the cost of environmental damage of the pest control method to the minimum (FAO, 1979).

None of the available pest control methods can totally eliminate vector transmitted diseases or the losses that occur in crop yield (FAO, 1979). The development of integrated systems has resulted in a better use of external inputs as fertilizers and pesticides (De Jager, *et al.*, 2004). Analysis of IPM at the farm level show positive results in several nations in different crops (Power and Kenmore, 2002, Bandong *et al.*, 2002).

Whether integrated approaches will be successful depends on several factors including local and national policies, institutional frameworks, aid agencies and donor organizations (Dohing and Wage Makers, 1998, McCain, 2005) IPM is really just good common sense. Institutions that have adopted IPM programs not only report a reduction in their use of pesticides, but a significant improvement in their level of pest control.

CHAPTER THREE
3.0 METHODO LOGY

3.1 Description of the study area

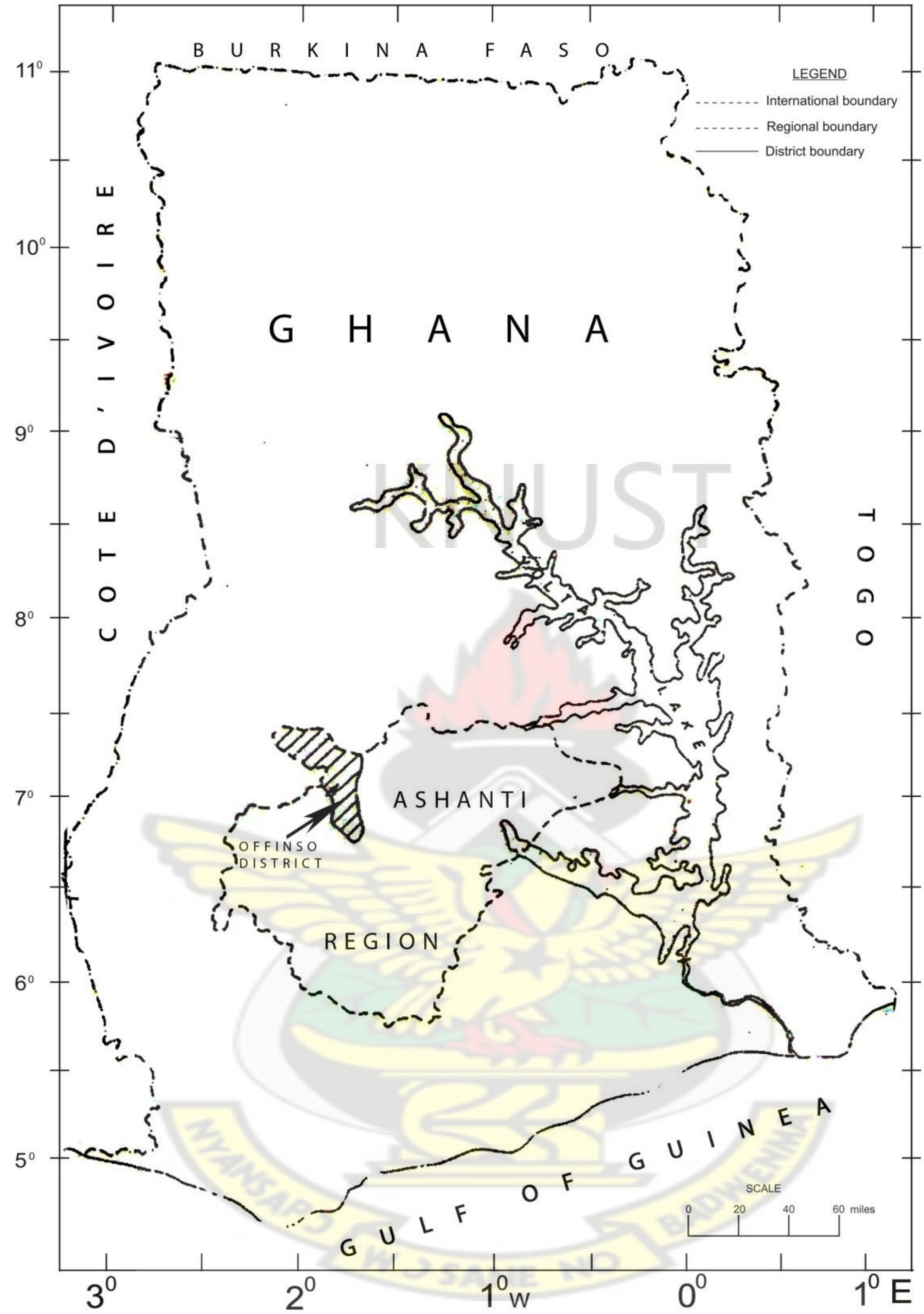
The study was conducted at Akumadan, a prominent farming community in the Offinso North District of Ashanti Region about 95km north –west of Kumasi, the administrative capital of Ashanti. It is on the Kumasi-Techiman main road.

Akumadan experiences hetero-ethnic inhabitation with a population of about two thousand seven hundred of which about 85% engage in vegetable cultivation. The major vegetables cultivated are pepper, garden eggs, okra and tomatoes with tomato constituting about 80 % ((Ntow *et al*., 1998, Osafo and Frempong, 1998).Other crops cultivated are maize, cassava, plantain and cocoa.

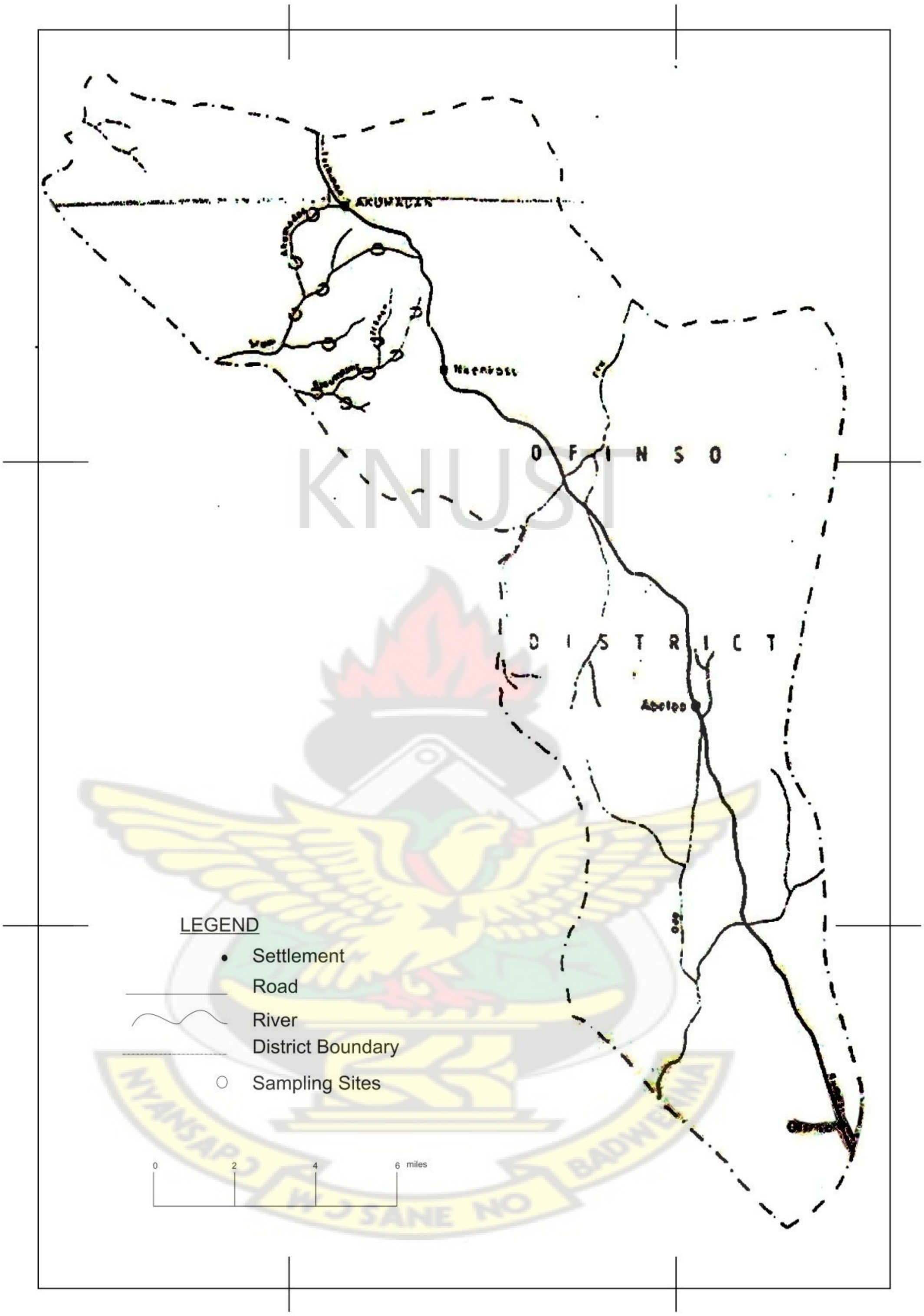
The soil type is mainly coarse grain sandstone and deep red clay loam. The natural vegetation is semi-deciduous forest type most of which have been lost due to extensive farming and logging activities. Akumadan lies in the transitional zone of Ghana with two rainfall seasons: major and minor with a mean maximum of 120mm and 200mm respectively. The major season begins from April to July. A short dry season occurs in August and the minor season is from September to October each year. Tomato growing season runs through the years as follows

- Major season (Abiribra): March to June.
- Mini season (Adantam): June to September.
- Mid season (Fube): September to December.
- Minor season (Petia): December to February.

Map 1: Map of Ghana showing the study area



Map 2: Map showing the sampling sites in the Offinso North District.(Ashanti Region)



3.2. Questionnaire Administration

A total of fifty farmers from Akumadan were selected and interviewed by using closed and open ended questionnaire. The questionnaire was translated into the local language but care is taken to retain their original meaning.

The questionnaire sought to obtain information about age, sex, educational background, frequency of pesticides use, source of information on pesticide use, handling of personal pesticide application. The questionnaire informations were validated by observing five farmers on their farms. (Appendix 1).

3.3. Laboratory Analysis

3.3.1 Sampling

A total of 200 tomato fruits were collected from 10 farms selected from Akumadan to assess the accumulation of pesticides in them. They were wrapped in aluminium foil in the farm, labeled with a unique sample identity and placed in a zip lock bag. They were then placed in an ice chest box containing ice blocks. The samples were transported to the Chemistry Laboratory of Ghana Atomic Energy Commission and kept refrigerated at 5ºC within 24 hours from the time of their collection from the farms.

3.3.2 Cleaning of Equipment

All the equipment to be used for extraction and cleaning were rigorously scrubbed with tap water and detergent. The equipment were rinsed three times with tap water and twice with distilled water. They were again rinsed with acetone. The equipment were placed overnight in an oven at 150ºC and stored in dust free cabinets.

Twenty fresh tomato fruits from a farm were shredded and homogenized using a glass blender. Approximately 20.0g of the homogenized sample were macerated with 40ml of ethyl acetate in a separatory funnel. 5.0g of sodium bicarbonate was added to neutralize the acid content and 20.0ml of sodium sulphate was added to absorb the moisture content. The contents were shaken for 10 minutes and allowed to settle for 5 minutes. The organic phase of the sample was decanted into a round bottomed flask. Re-extraction was done two times using 40ml ethyl acetate. The three extracts were combined and the solvent evaporated using rotary evaporator. The extract was transferred into a clean-up column.

The clean up column was packed with 1.5g of flourisil and 0.5g of charcoal powder that was activated at 130ºC. The column was conditioned using 4ml of ethyl acetate.

The samples were dried using the rotary evaporator model and the residues were packed for analysis using 10ml iso octane.

3.3.4 Gas Chromatographic Analysis of Chlorinated Residues

The residues were analyzed by Varian gas chromatograph CP-3800 equipped with ^{63} Ni, electron capture detector that allowed the detection of contaminants even at trace level concentrations (in the lower micrograms per gram range) from the matrix to which other detectors do not respond. The GC conditions and the detector response were adjusted so as to match the relative retention time and response The conditions used for the analysis were capillary column coated with ZB-5(30m*0.25mm, 0.25Nm film thickness). Carrier gas and make-up gas was nitrogen at a flow rate of 1.0 and 29ml/min respectively). The temperature of injector operating in split less mood was held at 225^0 C, oven temperature was at 225^0 C and electron capture detector was set at 300^0 C respectively. The column oven temperature was programmed as follows: 60^0 C for 2 mins: and at 180^0 C/min up to 300^0 C. The injection volume of the GC was 1.0 NL.

3.4. Statistical analyses

The results of the levels of pesticide concentration in tomato fruits in farms sprayed two weeks before harvesting and farms sprayed three weeks before harvesting were analyzed using T-test SPSS. T –test was used because the comparison involved only two independent locations.

If the P – value associated with the T- test is less than 0.05, then there is evidence that the means are significantly different at the significance level reported by the P- value.

If the P- value associated with the T- test is greater than 0.05 then there is no enough evidence that the means are significantly different at the significance level reported by the P-value. The questionnaire responses were analyzed using excel.

CHAPTER 4

4.0 RESULTS

4.1 Personal Information on Farmers at Akumadan :

Table 1: Personal Information on Farmers at Akumadan

SEX	FREQUENCY	RESPONDENTS (%)
Male	43	86
Female	7	14
Age Profile		
40-60	11	22
20-40yrs	37	74
Above 60	2	4
Education		
Some form of formal education	41	82
No formal education	9	18
Status of farmer		
Farm owners	44	88
Labourers	6	12
TOTAL	50	100

4.1 PREVALENCE OF AGROCHEMICALS USED

According to the farmers, pesticides are available on the open market even through most of them are expensive.

The farmers use a wide range of pesticides of different names and active ingredients. The bases of the various trade names most commonly used were identified as organophosphorus, carbamates and organochlorines. The details of pesticides used in Akumadan and its toxicity are shown in Table 2 and 3.

Table 2: Chemicals Used By Farmers and Their Active Ingredient

Trade	WHO classification	active ingredient
Karate	1B	Lambda-cyhalothrine
Dithane	111	Mancozeb maneb
Thiodan	1B	Thiophanater-methyl
Furadan	11	Copper hydroxide
Actellic	11	Pirimphos-methyl
Callisulfan	1B	Endosulfan
Lindane	1B	Lindane
Polytrine	11	Cypermetrim
Ridomil plus	111	Copper oxy chloride

SOURCE: (WHO 1998)

Table 3: WHO Classification of Pesticides

WHO Class	Meaning
111	Slightly hazardous
11	Moderately Hazardous
1B	Highly Hazardous
1A	Extremely Hazardous

SOURCE: (WHO 1998)

4.2 Farmers Sources of Information on Pesticides use in Crop Production.

All the tomato farmers interviewed in Akumadan were convinced that pesticides' spraying was necessary for higher yield. When farmers were asked their source of information on the use of pesticides, the responses are indicated in a pie chart below. Most of the farmers get information on pesticide usage from fellow farmers. Only few obtain information from government institutions.

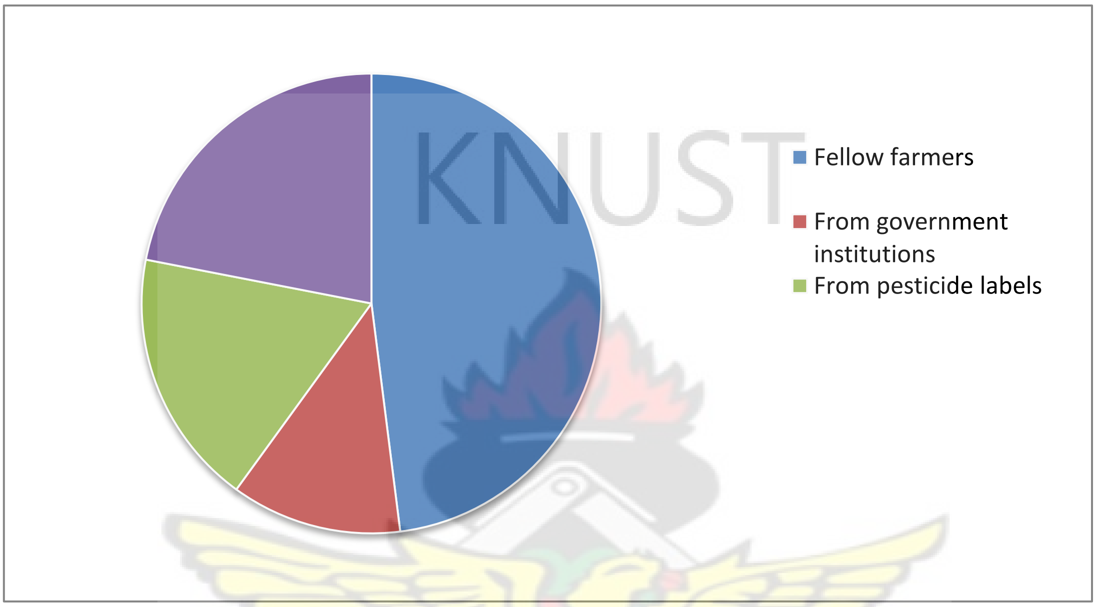


Fig1: Sources of information on pesticide use on crops.

4.3: Handling of Personal Protective Equipment

The responses of respondents concerning the kind of protective equipment used when applying pesticides, are shown in the bar chart below (Fig.4). Many of the farmers (48%) use overcoat when handling chemicals in the farm. However only few (2%) used all the required protective clothing and materials.

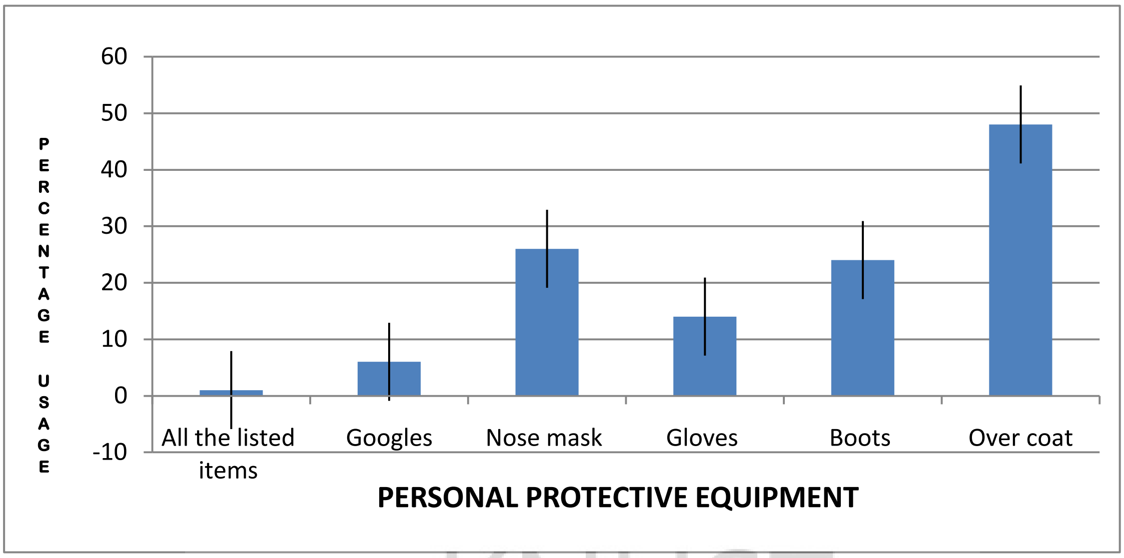


Figure 4: Use of personal protective equipment

4.4 Knowledge of Route of Exposure

Data collected on knowledge of route of exposure of pesticides from respondents is indicated in a bar graph below. All the respondents (100%) indicated that gastro-intestinal tract is the utmost route of exposure of pesticides through swallowing. (fig.3.) Only (31%) mentioned the skin as of exposure.

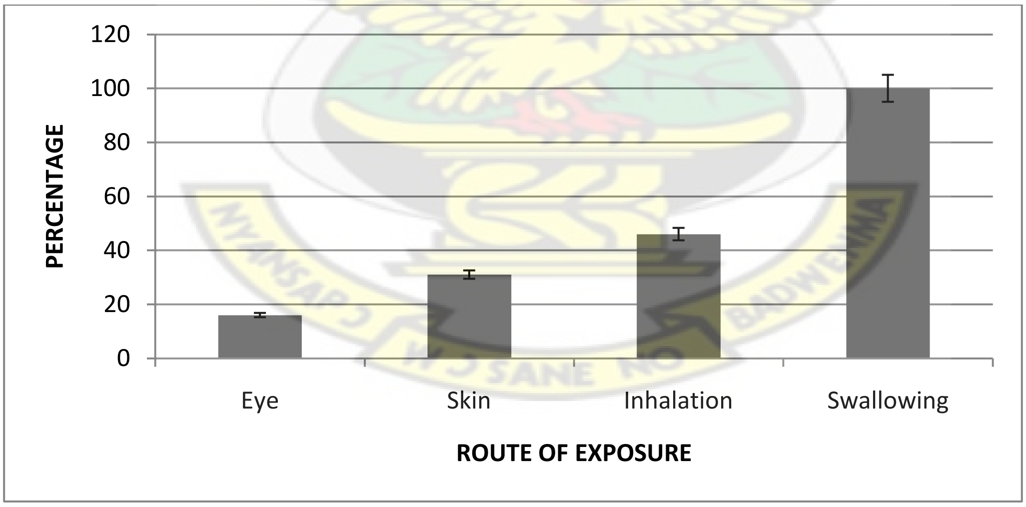


Figure 3: Route of Exposure of Pesticides to Farmers.

4.5: Health Problems Experienced After Application of Pesticides

All the respondents agreed that pesticide application has an effect on their health. When Farmers were asked the health problems they experienced after the application of pesticides, the responses were as indicated in the bar chart below.(Fig 6):

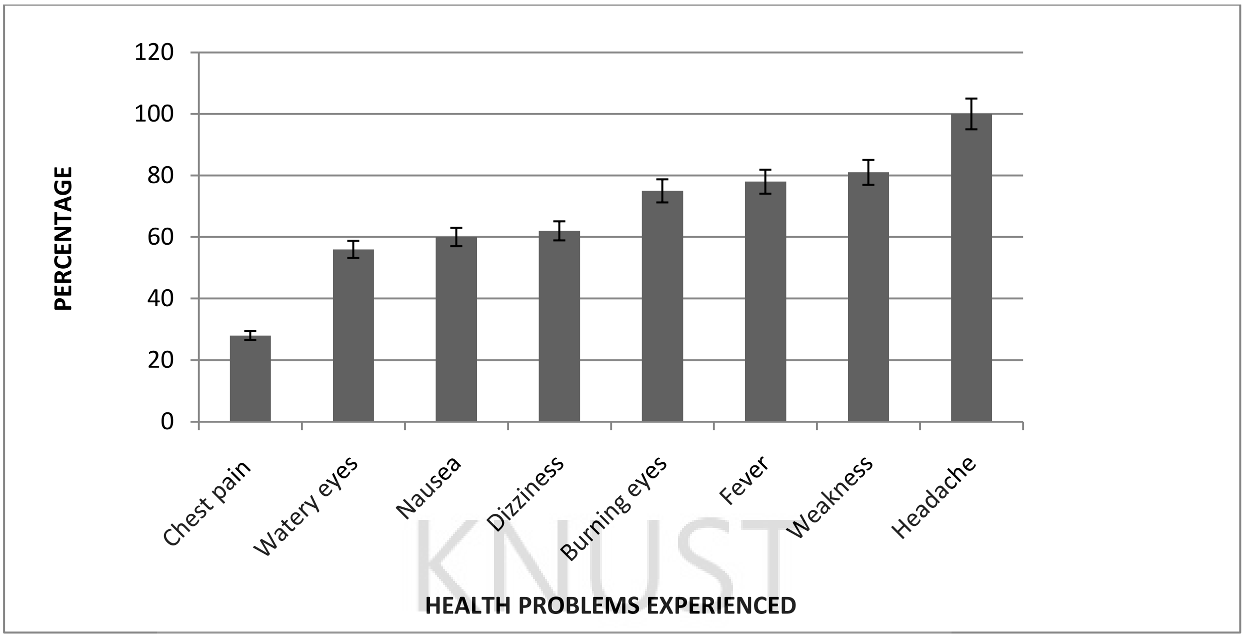


Figure 4: Health Problems Experienced After Application of Pesticides

Headache, fever, body weakness and burning eye appeared to affect most of the farmers after they handle pesticides in their tomato farms. Only 25% however complained of chest pain after contact with the chemicals.

4.7: Concentration of organochlorine residues in tomato fruits

Incidence of pesticide residue in the fruit samples analyzed are presented in Table 4. In all 200 samples of fruits were collected for pesticide analyses. Organochlorine residues were detected in all the 200 samples. Exactly seventeen residues were detected. The predominant pesticides where α-HCH, β-HCH (Iindane), heptachlor, Aldrin, trans- Nonachlor, p,p'-DDT, O,p'- DDT , and pp'-DDT. They were present in tomato samples from all the sample locations.

Heptachlor epoxide was also found in only sample at location 2. With the exception of sample site F where concentration level of aldrin was below maximum residue limit 0.01ug/kg, all the other chemicals were above the maximum residue limits. Two of the inactive metabolites of DDT (pp'- DDT, pp'-DDE) were detected in all the tomato samples analyzed.

Table 4: Concentration (µg/kg) of organochlorine pesticide residue in tomato fruits (5 Treatments in each location)

Name of pesticide	Locations	Mean	Std. Deviation	Std. Error Mean	MRL (µg/kg)
alpha-HCH	1	0.17	0.06	0.03	0.01
	2	0.34	0.18	0.08	
Hexachlorobenzene	1	0.05	0.08	0.04	0.01
	2	4.19	8.98	4.02	
beta-HCH	1	0.09	0.21	0.09	0.01
	2	0.51	0.31	0.14	
gamma-HCH	1	1.85	0.99	0.44	0.01
	2	2.98	0.43	0.19	
delta-HCH	1	2.40	1.27	0.57	0.01
	2	2.83	0.82	0.37	
Heptachlor	1	3.36	1.31	0.59	0.01
	2	4.21	2.13	0.95	
Aldrin	1	0.28	0.21	0.09	0.01
	2	0.49	0.30	0.14	
trans-Heptachlor epoxide	1	0.05	0.12	0.05	0.01
	2	0.00	0.01	0.00	
trans-Chlordane	1	0.04	0.06	0.03	0.01
	2	0.07	0.16	0.07	
Op’-DDE	1	0.00	0.00	0.00	0.05
	2	0.10	0.23	0.10	
trans-Nonachlor	1	0.40	0.18	0.08	0.01
	2	0.29	0.21	0.09	
pp’-DDE	1	0.34	0.15	0.07	0.05
	2	0.20	0.07	0.03	
Dieldrin	1	0.02	0.04	0.02	0.01
	2	0.00	0.00	0.00	
Op’-DDD	1	0.04	0.04	0.02	0.01
	2	8.20	18.31	8.19	
pp’-DDD	1	0.00	0.00	0.00	0.05
	2	5.68	12.59	5.63	
Op’-DDT	1	1.75	3.56	1.59	0.05
	2	1.84	1.47	0.66	
pp’-DDT	1	3.24	1.62	0.73	0.05
	2	3.06	1.41	0.63	

KEY:

MRL = Maximum Residue Limits

µg/kg = Microgram per Kilogram

Location 1 = Farms that were sprayed two weeks before harvesting.

Location 2 = Farms that were sprayed three weeks before harvesting

CHAPTER FIVE

5.0 DISCUSSION

5.1 Personal information of farmers

The Questionnaire showed that most of the farmers are males. Even though those in the pesticide industry argue that pesticides are essential in developing countries to feed the rapidly growing population, sale of pesticides multiplied in Africa fivefold, but food production decreased when average rainfall reduced in a particular year (Pimentel *et al*., 1980). Pesticides are not the necessary input to increase food production. At least not in a way such as the quantity currently used. Pesticide use therefore needs to be reduced in order to reduce negative effects on both farmers and consumers.

Most farmers have had some form of education 41(82%) but they did not go beyond elementary level. This is in contrast to cotton farmers in Benin where most of them have had no formal education. (Schwab *et al*., 1995).

The pesticide labels are too technical to be understood by the farmers. They have had little training on the use of pesticides. Inadequate training on effective use of pesticides coupled with inability to properly read and understand accounted for rampant misuse. Extensive and sustained education by the Ministry of Food and Agriculture through the Agricultural Extension Officers on safe use and hazards of pesticides use would be very beneficial.

5.2. Prevalence of pesticides used.

Though farmers claim not to use WHO category 1A pesticides, 64% of them use 1B pesticides

According to EPA Ghana, 63.5% of the pesticides imported belong to WHO categories 1B and 11 (Ntow, 2005). The use could have negative effects on the environment due to their persistent nature. Farmers should thus be discouraged from using them. Farmers sometimes mix up different pesticides before applying them on crops. Such mixtures could result in the possibility of creation of synergic effect as reported by Adeyeye and Osibango (1999).

In an attempt to produce more potent mixtures by preparing pesticides cocktail, Akumadan tomato farmers may end up producing dangerous toxins which could have serious effects on the farm produce rendering them unsafe for human consumption. In addition it could affect several non target but ecologically important animal and insect species in the communities of the farms.

5.3. Sources of information on pesticide use to farmers.

Most farmers get information on pesticides use from fellow farmers 24(48%). The allegation by farmers that few Extension Officers work on contract for a fee may be true in the sense that assistance from Government workers is free but only 12% of farmers get help through this means. Farmers therefore do not get the right information. Considering the widespread inability of farmers to read and understand instructions on pesticide labels and the low number of Agricultural Extension Officers as compared to numerous farmers, it is not surprising that farmers do not get the right information on safe use of chemical products they purchase from shops. There is the likelihood of increasing pesticides poisoning which could have otherwise been prevented. Ministry of Food and Agriculture (MoFA) should employ more Extension Officers to help the farmers. The District Assembly could also motivate the Extension Officers to maximize their efforts.

5.4. Practices Encouraging Exposure to Pesticides.

The interview to provide data on exposure to pesticides was not only limited to 50 farmers interviewed but also extended to their families who worked on the farm and other farm hands. Farmers who store pesticides in their homes exposed the entire household to the pesticide. Impacts of pesticide use thus affect a wider group. Use of pesticide is usually done without all the necessary precautions. For example, none of the farmers interviewed and those observed used all the listed protective equipment. The use of personal protective equipment did not have any bearing on ones educational background. For example only 2% of the respondents claimed to have all the personal protective equipment. Farmers complained that the use of the personal protective equipment makes them uncomfortable when spraying. This means that failure to use the personal protective equipment is not only attributable to the inability to purchase them. This present data agrees with an earlier study by Ntow (2001) who found the same minimal use of protective equipment among farmers in Akumadan. This situation is common in developing countries. For example, in Benin, many farmers who grow cotton sprayed 4-6 times per season, neither have training in spraying nor use personal protective equipment (Schwab *et al., 1995).* Leaking spraying equipment according to the farmers was one of the main paths through which farmers are exposed to chemicals. The use of leaking spraying equipment which exposes users to pesticide had also been reported by Ntow (2005). The frequent application rates (at least six times per season) coupled with the fact that 50% of the farmers cultivate tomatoes 3 seasons annually imply that exposure to pesticide occur throughout the year. Respondents' knowledge of route of exposure to pesticides were poor. This is because even though, the skin is the primary route of exposure, all the farmers interviewed indicated that the primary route of exposure is the mouth.

5.5: Health Problems Experienced After Pesticides Application.

Prevalence of reported symptoms (headache, nausea, vomiting) experienced by farmers after pesticide application shows clearly that pesticide usage is a health problem. Clarke *et al., (*1997) reported similar incidence of the above symptoms in workers exposed to pesticides. Their perception that effects of the chemical on their health are temporally especially in the initial stages of application shows that the farmers are ignorant about the dangers of pesticide application. Farmers' education on acute and chronic health risk of pesticide application and exposure expected to be undertaken by the Primary Health Care

Division of the Ministry of Health was virtually nonexistent. The responses given by the farmers that they report to hospital only in severe cases of ailment suggested that many cases of intoxication due to pesticides application are not reported. This findings agrees with the observation of Clarke *et al.,* (1997) that though the number of poisoning cases is believed to have increased considerably over the years, no data exists on them. They however are of the perception that those health problems do not have any serious effects on them. They also claim that those effects are transient especially in the initial stages of the application. Farmers should therefore be educated on the possible acute and chronic health impact of pesticides used and ways of minimizing those impacts.

5.6. Pesticide Residue in Tomatoes

DDT was detected in the tomato fruits from akumadan although DDT is perceived not to be widely used in tomato farming. The concentration of lindane and DDT were higher.(8.109ug/kg and 3.66ug/kg). This could be accumulated in the food chain due to bioaccumulation. The difference in the concentration at the two locations suggested that the residues undergo some degree of degradation. However, the differences are insignificant. The differences in concentrations of O,P'- DDT, P,P' DDE may be due to the fact that the chemicals have different degradation rate. The variations in the residue levels among the individual farmers were expected because most farmers use different pesticide concentrations at different stages of cultivation.

Concentration of lindane (3.6612µg/kg) and p,p' - DDE (0.5812µg/kg) were above levels(2.5ug/kg and0.1ug/kg) found in tomatoes from Akumadan by Ntow, (2001). The absence of endrin in the analysed samples might suggest photodecomposition of endrin.

The presence of metabolites of DDT (o,p'-DDT, p,p'-DDT, p,p'-DDE) in samples analyzed suggested that DDT which is a banned chemical is being used extensively in the Ghanaian agricultural sector vegetable cultivation. Chlordane was detected at mean concentration of 0.04 µg/kg in the tomato fruits.

Chlordane persists for more than twenty years in some soil (Bervanan *et al*., 1981) thus chlordane level in the fruits may be the result of past usage. Higher level of chlordane of 3.1 ng/g wet weight was reported in meat in Australia (Kannan *et al*., 1994).

Furthermore, results from the residue analyzed confirm the previous findings on the use of pesticides in Ghana by Awumbila and Bokuma (1994). They found 20 different pesticides were used, with organochlorine (Lindane) being the most widely distributed and applied pesticides in Ghana.

Comparing the results with similar one carried in Nigeria where lindane mean concentration was 0.002µg/kg (Adeyeye and Osibanjo, 1999) the tomatoes in Akumadan could be considered as highly contaminated with lindane. Hexachlorobenzene (HCB) was present in most tomato samples even though this compound has not been available in local agricultural practices. HCB is an industrial waste product and a contaminant in some pesticide (1-3%) and may thus find its way into the environment (Skaare *et al*., 1988)

The variation in the residue levels among the individual farmers were expected because most farmers use different pesticide concentrations at different stages of cultivation. The comparison of the concentrations of p,p'- DDD and o,p-DDE in samples from locations1 and 2 suggested that DDT metabolized to pp – DDD and Op – DDE occurs between 8 and 14 days of application.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

Results of this study show that residues of organochorine pesticides are present in tomato fruits produced at Akumadan. These residues have originated from agricultural activities in the area because of their persistent. These residues might reach the top of the food chain by bioaccumulation. It is expected that an appreciable build-up of residues with time will occur because of the continuous use of pesticides. This may pose serious public health problems.

To forestall a health disaster, it is essential that a system of monitoring of residues in the key component of food chain is encouraged so as to generate data for policy making and curtailment of the use of some of these pesticides. There is also the need for stricter control on the use of pesticides on food crops. Akumadan farmers suffer health problems as a result of the use of agro-chemicals. Much work therefore needs to be done to establish agro-chemical related diseases among Akumadan tomato farmers. Information concerning the dangers of pesticide use, recommendations for minimizing each use and alternative measures must be made available to the pesticides users in Akumadan by the Ministry of Food and Agriculture (MoFA). The Ministry of Health should equip laboratories in Akumadan hospital so as to aid in proper diagnosis of pesticides poisoning. MoFA should deploy more Agricultural Extension Officers to the Akumadan area to educate and monitor the farmers on proper use of pesticides. The Ministry of Health should also equip the laboratory in Akumadan hospital so as to aid in proper diagnosis of pesticides poisoning cases. Pesticide manufacturers should send out train personnel to educate agro-chemical sellers.

A sense of responsibility of the use of personal protective equipment (PPE) should be included in the educational package. Council for Scientific and Industrial Research (CSIR) should collaborate with Ministry of Food and Agriculture to develop and provide PPE that are suitable to the climatic conditions of Ghana. This proposal agrees with the findings of

(Schwab, et al., 1995) which emphasize the provision of affordable PPE appropriate to the climatic and socio-cultural environment of pesticides users. Legislation on importation, distribution, sale and use of WHO class 1B and 11 should be enforced at all levels by law enforcing agencies. Alternative form of pest control should be sought by Environmental Protection Agency (EPA). For example, the introduction of biological control of pest on large scale suggested by Ooi and Shepard (1994) should be revisited and implemented.

Promotion of long term benefits of use of organic pesticides should be made available with emphasis on health and economic benefit.

Future monitoring programs should cover pesticides like organophosphates, carbamates, and pyrethroids as they are also by many farmers in the country.

REFERENCES

Abate, T. (1996). Ethiopian experience with pesticides. No foundation for food. Pesticides News, 33:12-13.

Adeyemi, D., likpo, G., Anyakone, C., Limyimamdu, J. (2008). Organochlorine pesticide residues in fish samples from Lagos lagoon, Nigeria. Journal of environmental science 4:649-653.

Adeyeye, A., and Osibango, O. (1999). Residues of organochlorine pesticides in fruit, vegetables and tubers from Nigeria market. The Science of Total Environment 231,227-233.

Afful S, Anim A, and Serfor-Armah Y. (2010) Spectrum of organochlorine pesticides residue of fish samples from the densu basin. Research Journal Environmental Science 2(3):133-138.

Afram, J., Ofosu, G. K., and Antwi, E. (1999). Regulations of dangerous pesticides in Ghana. Pesticide Action Network (PAN) Africa pp. 4-8.

Amarasiri, S. L., Nagarajah, S., Perera, B. M. K. (1990): Rice congress, 1990. Department of agriculture, Sri Lanka pp.226

Amoah, P., Drechsel, P., Abaidoo, R. C., and Ntow, W. J. (2006). Pesticides and packaging contamination of vegetables in Ghana's urban market. Archives for Environmental Contamination and Toxicology 50:1-6.

Amurazi, E and Albarus, T. (2008). Multiclass pesticide determination in olives and their processing factors in olive oil. Journal of Agricultural and Food Chemistry. 56 :5700 – 5709

Aroud, M., Douki, W., Rhim, A., Najjar, M. F., and Gazzah, N. (2007). Multi residue analysis of pesticide residue in fruits and vegetables by gas chromatography, mass spectrometer. Journal of Environmental Science and Health 42:179-187

Awumbila, B., and Bokuma, E. (1994).Survey of pesticides use in the control of ecto parasites of farm animals in Ghana. Tropical animal Health and production 26:7-12

Bandong, J. P., Canapi, B. L., Dela Cruz, C. G., Litsinger, J. A. (2002). Insecticide Decision Protocols: a case study of untrained Filipino rice farmers. Crops protection. 21, 803-816.

Barriada-Pereira, M., Gonzalez Castro, M. J., Muniteque-Lorento, D., Fernandez-Fernandez, E. (2005). Organochlorine pesticide accumulation and degradation product in vegetables samples of a contamination area in Galatia. 58,1571-1578.

Baygon, S. (1996). Household insecticide http://www.baygon .com/ngcontent.cfm

Belta GD, Likata P, Bruzzese A, Naccarri, F (2006) level and congener pattern of PCBs and OCPs residues in blue fin tuna (Thunnus thynnus) from the streets of Massina (Sicily, Italy) Environ.Chem. Ecotoxicol 32:705-710

Berger, L. R. (1988). Suicides and pesticides in Sri Lanka. America Journal of Public Health 78, 826-828

Bervanan, R. and F. Matsumara. (1981). Metabolism of cis and trans chlordane by soil organisms. J. Agric. Food Chem., 29: 84-89.

Bhanti, M., and Taneja, A. (2007). Contamination of vegetables of different seasons with organophosphurus pesticides and related health risks assessment in northern India 69(1):63-68.

Blaso, C., Font, G., and Pico, Y. (2005). Analysis of pesticides in fruits by pressurize liquid and liquid chromatography-ion trap-triple stage mass spectrometry. Journal of Chromatographic Analysis 1098:323-328.

Bozongo, J. C., Donkor A. K., Nartey V. K., and Larceda, L. D. (2004). Mercury pollution in Ghana: a case study of environmental impact of artisanal gold mining in the sub-Saharan Africa (pp. 135-136)

Bull, D. (1982). A growing problem:pesticides and the third world poor, Oxfam, Oxford pp.192

Caudle, W. M., Jason, R. R., Mizheng, W., and Gary, W. (2005). Perinatal Heptachlor Exposure Increases Expression of Presynaptic Dopaminergic Markers in Mouse Stratium. Neurotoxicology 26 (2005), 721-728.

Cerejeira, M. J, Viana, P., Batista, S., Silva E., Valerio, M. J., Silva, A, Ferreira, M. and Silva-Fernandez, A. M. (2003). Pesticides in Portugese surface and ground waters. 37:1055-1063.

Choudhry, R G., Vishwadhar, T., Kumud., K. (2001). Influence of Dates of Sowing and Moisture Regimes in Pigeon Pea on Population Dynamics of Fusarium udam at different soil strata; Phytopathology 54 (I): 44-48.

Chowdhury, A. P., Gautan, A. K., and Bhatnagar, V. K. (1990). Lindane induced changes in morphology and lipids profile of testes in rats. Bromedica Brochimica Acta 49: 1059-1065.

Clarke, E., Levy, E. K., Spurgeen, L. S., and Calvert, L .A .(1997). The problems associated with pesticide use by irrigation workers in Ghana, Occupational Medicine: 47;301-308.

Colborn, T., and Smolen, M. J. (1996) Epidemiological Analysis of Persistent Organochlorine Contaminants in Ceteceans. Revised Environmental Contamination and Toxicology., 146:91 102.

Corrigan, P. J., and Seneviratna, P. (2008). Occurrence of organochlorine residues in Biology and Management of Rice insects, pp.585-612, widely Eastern LTD, new Delhi, India . Organisms. J. Agric. Food Chem., 29: 84-89.

Cowen, D. (1971). Effect of trading activities on education Macmillan press pp.38

Danso, G., Drechsel, P., and Fialor S. C. (2002). Perception of organic agriculture by urban vegetable farmers and consumers in Ghana. Urban Africa Magazine 6:23-24.

Darko, G., and Aquaah, S. O. (2006). Levels of organochlorine pesticides residues in meat. International Journal of Environmental Science and Technology 4521-524

Dasgupta, A. Chakrabarty, A., and Sengupta, P. K. (1992). Effect of crop sequence on the Population of *Fusarrium udum* in soil journal. Mycopathological Research 30(1): 37-42.

De Jager, A., Onduru, D., Walaga, C., (2004). Facilitating learning in soil fertility management; accessing potentials of low – external input technologies in east Africa farming systems. Agricultural systems 79,205-223.

Depury, J. S. (1985). Crop pest of east Africa. John Wiley and Sons, N.Y. PS -10.

Dinham, B. (2003). Growing vegetables in developing countries for local, urban populations and expert markets: problems confronting small-scale producers. Pest Management Science 59:575-582.

Dunlap, T. R. (1981). DDT; scientists, Citizens and public policy. Princeton University press, Princeton, New Jersey.

Ejobi, F., Kanja L. W., Kyule M. N., Mullar P, Krϋger J, and Latigo, A. A. R. (1996) Organochlorine pesticide residues in molthen milk in Uganda Environmental Contamination and Toxicology 56: 873-880

Environmental Protection Agency Ghana. (2008). Register of pesticides as at 3[1st] December 2008 under part 11 of the environmental protection agency act, 1994 (ACT 490).

FAO. (1979). Guidelines for integrated pest control. Rome Food and Agricultural Organization of the United Nations pp.115.

FAO. (1981).Corporate document repository : water pollution in Ghana http://www.FAO document repository.htm

FAO/WHO, (2008). Food standards programme. Codex Alimentarius, vol. 11. Pesticide residues in food. US Department of Agriculture (1994) Special Project in Integrated Pest Management Program. Extension Service. (Washington D.C: 1994).

FAO/WHO. (1998). Joint FAO/WHO Food standards programme Codex Alimentarius Commission pesticide residues in Food maximum residue levels (546pp) Rome. FAO publishing Division.

Fleming, L., Marn J. B., Briggle, T., and Sanchez , J. R. (1994). Parkinson disease and brain levels of organochlorine pesticides. Annual Neurological Journal 36:100-103.

Fontcuberta, M., Arwues, J. F., Villabi J. R., Martinez. M., Centrich, F., and Serrahina, E. (2008). Chlorinated organic pesticides in marketed food: Barcelona, 2001-2006. Science of the Total Environment , 389,52-57.

Garabrant, D. H., Held, J., Langholz, B., Peter, J. M., Mark, T. M. (1992). DDT and related compounds and risk of pancreatic cancer. Journal of national cancer institute 84:764-741

George, S. (1976). Social competence and mental, handicap. London Baillieve Tindal

G**erken, A., Sublo J. V., and Brawn, M. (2001).** Pesticide policy in Ghana, MoFA/PPRSD, ICP project. Pesticide policy project / GTZ. Accra, Ghana

Ghana Statistical Services. (2002). 2000 population on housing census: Summary report of final results: Ghana Statistical Service.

Ghanaian Times. (2010) www.newtimes.com.gh ISSN: 0855-1502. No. 1,561,221 pp.26

Gibson, S. M., Hoss, V. G., and Laserter, L. J. (1987). A guide to toxic chemicals, Environmental Health, Information Centre. Texas 3, 86-89.

Guo, Z., and Tan. R. Q. F. (2005). Stakeholders and institutional analyses on rural – urban development in Nanjing. SEARUSYN report, pp.41 www.searo.org.

Hanson, M. (1988). The first three years of implementation of the World Bank pesticide guidelines institute for consumer policy research. San Francisco. PP 11-13.

Harender Raj. M. L., Bharwa. L., Sharman N. K. (1997). Soil Solarization for the control of Damping off of Different vegetable crops in the Nursery; Indian phytopathology 50(4) 524 – 528.

Holland, P. T., Hamulton, D., Ohlin, B., and Skidmore, M. (1994). Effect of storage and processing on pesticide residues in plant products, Pure and Applied Chemistry, 66, 335-356

Hoyer, A., and Kratz, M. (2001). Organochlorine exposure and risk of breast cancer. Lancet352: 1816 – 1820

Huber, A., Bach, M., and Frede, H. G. (2000). Pollution of surface waters with pesticides in Germany: modeling non point surface input. Agricultural Ecosystem and Environment. 80:191-204.

Hussein, M. Y. (1999). Managing and Exploitation of Bioresearches for effective Biological Control. Regional perspective and Malaysian Initiative. Proceeding of the symposium for biological control in the tropics pp.1 – 4, MARDI, Serdang.

Indian Institute of Pulsed Research (2001): Annual report 2001. All Indian coordinated research project, (AICRP) on Chick pea, Kanpour, pp. 124.

Ize lyamu, O. K., Abia, I. O., Eqwalchide, P. A. (2007). Concentrations of residues from organochlorine pesticides in water and fish from some rivers in Edo state, Nigeria international journal for physical science 2:9.

Jayasheree, R. and Vusudevan, N. (2007): Effects of tween 80 added to the soil on degradation of endosulfan by *Pseudomonas aeruginosa*. Int. J. of environment science and technology 4(2): 203-210.

Kanja, L. W., Skaare, J. U., Ojwang S. B. O., Miata, C. K . (1992). A comparison of organochlorines pesticide residues, maternal blood, cord blood, and human milk from mother/infant pairs. Archives of environmental contamination and toxicology 2:21-24.

Kannan, K., S. Tanabe, R. Williams J. and Tatsukawa R., (1994). Persistence organochlorine residues in foodstuffs from Australia, Papua New Guinea and Solomon Island Contaminated ion levels and human dietary exposure. Sci. Total Environ., 153: 29-49.

Kaushik, G., Satya, S., and Naik, S. N. (2009). Food processing a tool to pesticide residue dissipation – A review, Food Research International, 42 (January 2009) , 0963-9969

Khoo, K. C., and Chung G. F. (1989). Use of the black cocoa ant o control mired damage in cocoa: planter, Kuala Lumpur 63:370 -383.

Kidd; K. A., Boots man, H. A. Hesslein, R. H., Muir D. C. G., and Hecky R, E . (2001). Biomagnifications of DDT, through the benthic and pelagic food webs of lake malaw, East Africa: Importance of trophic level and carbon source Environmental Science and Technology :35;14-20.

Kolpin Dw, Thurman EW, Lungart SM (1998) The environmental occurrence of herbicides: the importance of degradates in ground water. Bull. Envrwn. Contam. Toxico 1.35:385-90

Krauthacker, B., Reiner, E., Votava – Raic, A. (1998) Organochlorine pesticides and PCBs in human milk from mothering nursing hospitalized children. Chemosphere 37 (I): 27-32

Lenne, J. (2000). Pest and poverty: the continuing need for crop protection research outlook on agriculture 29:235-250.

Lentza – Rizos, C., Avramides, E. J., Kokkinaki, K. (2006) .Residues of Azoxyshobin from grapes to raisins, Journal of agricultural and food chemistry, 54: 138-141 l. Sci. Total Environ., 153: 29-49.

Liew, V. K., Sukri, T. I., Ahmad, F. Z., Leong, C. W., and Khoo, C. K .(1999). Control of the Cocoa Borer (Conopomorpha Cramerella) with the black cocoa ant (Dolichodamus Thoracicus) in two types of agro – eco system. International Conference on Plant Protection in the tropics. pp. 109 – 113, 15-18 March 1999, Kuala Lumpur, Malaysia.

Lim, G. T., and Chong, T. C. (1987). Biological control of Cocoa Pod Borer by Periodic Release of Trichogrammatoidea bactrae fumata. Nagaraija in Sabah, Malaysia. Management of the Cocoa Pod Borer pp.71 – 81.

Lingappa, S. (2001). Tools for the management of Helicoverpa in cotton. National seminar on sustainable cotton production to meet the requirement of industry 3-4 october 2001 Mumbal; India

Lionell, P. (1969). Factors affecting education of good leap. Macmillan Press. London pp.109.

Luke, M. A., Matsumoto, H. T., Cairns, T., Hundley, H. K. (1988). Levels and incidence of pesticides residues in various foods analyzed by the Luke multi residues methodology for fiscal years 1982 to 1986. Journal of Association of Analytical Chemistry 71:415-433.

Magnaye, L. V. (2006). The impact of tissue cultured plants in the ongoing irradiation and rehabilitation programme in the Philippines. pp. 86- 88.

Mah, S. Y., Mohamad Roff, M. N., and Jamalindin, S. (2001). An Integraated Pest Management Package for Chilli, MARDI Occasional paper 1/2001, MARDI Serdang, pp 7.

Maroni, M., and Fiat A. (1993). Health Effects in man from long term exposure to pesticides: a review of the 1975-1991 Literature. Toxicology 78, 1-174.

Mbakaya, C. F. L., Ohayo - Miotoko G. J. A., Ngow, V. A. F., Mbabazi .R., Simwa, J. M., Meada, D. N., Stephens, J., Hakuza, H. (1994). The status of pesticide usage in East Africa. Africa Journal Health Science 1:37-41.

McCain, L. (2005). Transaction cost of pesticide policies of Vietnam. Society and Natural Resources, 18, 759-766.

Metcalf, R. L. (1982). Changing role of insecticides in crop protection. Annual Review of Entomology. 25:119-256.

Mittal, R. K. (1998). Cultural Management of Folia Diseases of Black – gram in hills of Uttar Pradesh, Vivekanda Poorvatiya Krishi Sanstan, Almor pp. 23-26.

Mobhd-- Narow, H., Hussan, A. K., and Sajap, A. S. (2002). Field Efficancy of Nucleopolyhedrouims against Armyworm Spodoptura litura on tobacco. Journal of Tropical Agriculture and Food Science (30) 1.

Mullar-Beilschmut. K .(1990). Pesticides in developing countries. Environmental Justice Foundation. Journal of pesticides reform v. 10 pp.58.

Ntow W. J. (2001). Organochlorine pesticides in water, sediments crops and human fluids in a farming community I Ghana Archives of Environmental Contamination and Toxicology. 40: 557-563

Ntow W. J. (2005). Pesticide residues in Volta Lake Ghana. Lakes and Reservoirs Management 10:243-248.

Ntow, W. J. (1998). Pesticide misuse at Akumadan to be tackled. NARP news letter 3(3):3

Ntow, W. J., Gijzen., H. J., and Drechsel, P. (2006). Farmer perceptions and pesticide use practices in vegetables production in Ghana Pest Management Science 62: 356-365

Okorley, E. L., and Kwarteng, J. A. (2002). Current status of the use of pesticides in urban and peri-urban vegetable production in the central region of Ghana. RESEAU/SADOAC workshop on sustainable food security in West Africa.

Ooi, P. A., and Shepard, B. S. (1994). Predators and parasitoids of Rice Insect Pest.

OPAC. (2010) Classification of pesticide. www.opac.gov.on.ca.

Osafo, A. S., and Frempong, E. (1998). Lindane and endosufan residues in water and fish in Ashanti region of Ghana. Journal of the Ghana Science Association 135-140.

PCMA. (1996). Pesticides control and management ACT, 1996. (ACT 528). http://faolex.fao.org/docs/pdf/gha10692pdf.

Pearce, F. (2002). Reaping the Rewards. New Scientist p. 12.

Persley, G. J. (1999). Agricultural biotechnology and the poor promethean science. Proceeding of an international conference pp: 3-21.22 October 1999, Washington, D.C (http://www.cgiar.org/boitech/rep01001/persley.pdf

Pimental, D., Andor, D., Dyson – Hudson, R., Gallahan, D., Jocobson, S., Irish, M., Kroop, S., Moss, A., Schraner, L., Shepard, M., Thompson, T., Vinzant, B. (1980). Environmental and Social Cost of Pesticides: a preliminary assessment , 126-140.

Pimentel, D., and Grenier, A. (1997). Environmental and socio economic cost of pesticide use. Economic and environmental benefits, John Wiley and Sons, Chichester, pp.51 -78

Planas, C, Caixada J. Santos, F. J., and Rivers, J. (1997). Occurrence of pesticides in Spanish surface waters. Analysis by high-resolution grass chromatography coupled to mass spectrometry. Chemosphere 34:2393-2406.

Power, A. G., and Kenmore, P. (2002). Exploiting interactions between planned and unplanned diversity in agro eco systems: What do we need to know? In: Uphoff, N (Ed.) Agro Ecological Innovations. Earth scan, London, pp.233-242.

Rajendran, B., and Subramanian A. N. (1997). Chlorinated pesticide residues in water from river raveri, south India. Chemistry and Ecology, 13:225-236.

Raposo Jr L. J., Nilva R. (2007). Determination of organochlorine pesticides in groundwater samples using solid-phase-micro extraction by gas chromatography-electron capture detection. 72:1833-1841.

Repto, R., and Balige, S. S. (1996). Pesticides and immune system. The public health risk. World Resource Institute Washington. residues in foodstuffs from Australia, Papua New Guinea and Solomon Island Contamination.

Sattler, C., Kächete, H., and Verch, G. (2006). Assessing the intensity of pesticide use in Agriculture. Agriculture Ecosystems and Environment. pp.46-49

Schwab, A., Jager, I., Stoll G., Gorgen R., Prelexler, S., Altenburger, R. (1995) Pesticides in Tropical Agriculture pp. 38-43.

Skaare, J. U., Tuveng J. M., and Sande, H. A. (1988). Organochlorine pesticides and polychlorinated biphenyls in maternal adipose tissue, blood, milk and cord blood from mothers and their infants living in normal Archives of Environmental Contamination and Toxicology 17:55-63.

USA data programme (2003). Hazardous Air Pollutants. Washington, D.C: United States Code 42 USC 7412. http://www.4.law.corned.edu/uscode/

Wala, D. G., Joshi, K. R., Prajapati, K. S., Salanky, K. U., and Sufulparu, A. N. (1992). Control of sugarcane smut by physical and chemical methods. Indian Journal Mycology and Plant Pathology 22(3):74.

Waterhouse, D. F. (1992). Biological control: A viable strategy for the tropics pp. 1-13 the Malaysian plant protection society, Kuala Lumpur.

Weisenberg, E., Arad, I., Graver, F., Sahin, Z. (1985). Polychlorinated biphenyls and organochlorine insecticides in human milk in Israel Archive of Environmental Contamination and toxicology 14:517-521.

WHO. (1988) Environmental Health criteria No. 78, Dithiocarbamale pesticides, ethylenethiourea and Propylene thiourea: A general introduction. World Health Organization, Geneva 1988.

WHO/FAO. (2005). Codex Alimentarius Commissions Food and Agriculture Organization of the United Nations agenda item 7a. Joint FAO/WHO Food Standards Programme codex committee on pesticide residue 37th session. The Haque 18-23rd April.

WHO/UNDP. (1990) Public health of pesticides use in agriculture in collaboration with UN Envital programme, pp 128.

Wikipedia. (2010). http//en,Wikipedia.org/wiki/pesticide.

William, J., Tagoe, L., Drechsel, P., Kelderman, P., Gyzen, H., and Nyarko, E. (2008). Accumulation of persistence organochlorine Contaminants in milk and serum of farmers from Ghana 106:17-26.

Youdeowei, A. (1989). Provisional report on pesticide management in Anglophone West Africa. Prepared for FAO, Rome.pp.96-101

APPENDIXES

APPENDIX ONE:

THESIS QUESTIONNAIRE FOR TOMATO FARMERS AT AKUMADAN.

DEAR RESPONDENT.

This is a summary of the opinion of tomato farmers on the agro chemistry used protective measures employed. You have been selected at random to answer the following questions.

Your answers will be heated in the strictest confidence. The survey will be meaningful for you to give honest answers.

A: PERSONAL INFORMATION.

1. Age……………………

2. Sex……………………

3. What is your level of education?

A. University

B. Polytechnic

C. Training College

D. SHS

E. Tech/Voc/Com

F. Middle/JHS

G. Primary

H. Illiterate

B: GENERAL INFORMATION ON FARMS.

4. Are you a farm owner? [ ] Yes [ ] No.

5. Do you grow only tomatoes? [ ] Yes [ ] No.

6. If no what other crops do you grow? …………………………………

7. How many growing seasons do we have in a year? …………………………..

8. What is the size of your farm? ………………………………………

9. What is the quality of your soil? ……………………………………

A. very good B. good C. poor D. very poor

10. How do you test this?

[ ] colour [ ] texture [ ] moisture content

Others…………………………………………

11. Do you use any soil improvement method?

[ ] Yes [ ] No

12. If yes, what do you use?

[ ] fertilizer [ ] manure [ ] crop rotation [ ] mulching

Others…………………………………………..

C: AGROCHEMICALS USED.

13. Which of the following agrochemicals do you use on your farm and how often?

AGROCHEMICALS	TICK	FREQUENCY OF APPLICATION
Herbicides		
Atrazine		
Glyphosphate		
Paraquat		
Insecticides		
DDT		
Atelic		
Commando		
Karate		
Thuonox		
Heptachlor		
Coutizeed- Powder		
Kombat		
Couti-Halthorn		
Lambda		
Sunpyritos		
Dursban 24		
Boos Combi(1		
(Parathion)		
Fungicides		
Cocobre		
Dithane		
Champion		
Kocide		

14. For how long have you handled pesticides below?

A. 1 year **B**. 1-5 years **C**. 6-10 years **D**. above 10 years

15. Are you able to read and understand the instructions of pesticides labels?

[ ] Yes [ ] No

16. If no, who provides you with the information?

A. Other farmers **B**. Chemical sellers **C**. Friends **D**. Extension Officers

17. Do you normally mix two or more pesticides in other to enhance its effect?

[ ] Yes [ ] No

18. If yes, what chemicals do you normally mix?

…………………………………………………..

D: PROTECTIVE MEASURES EMPLOYED.

19. Please indicate the protective clothing you employ when applying pesticides in the table below.

PROTECTIVE CLOTHING	DURING MIXING	DURING APPLICATION
Goggles		
Gloves		
Nose mask		
Boots		
Overcoat		

20. How long does it take to harvest crops after application?

[ ] 1 week [ ] 2 weeks [ ] 3 weeks [ ] 4 weeks

21. What health problems do you experience?

…………………………………………………………………….

APPENDIX TWO

QUESTIONNAIRE RESULTS

A: SOURCE OF INFORMATION ON PESTCIDES USE

SOURCE	FREQUENCY	PERCENTAGE
Fellow farmers	= 24	= 72.8
From	=6	= 43.2
From pesticides labels	= 9	= 64.8
From shop keepers	= 11	= 79.2

B: PERSONAL PROTECTIVE CLOTHING USED

PERSONAL PROTECTIVE EQUIPMENT	FREQUENCY	PERCENTAGE
Goggles	3	6
Boots	13	26
Nose mask	7	14
Gloves	12	24
Over coat	24	48
All of item	1	2

C: ROUTE OF EXPOSURE

ROUTE	FREQUENCY	PERCENTAGE
Eye	8	16
Inhalation	23	46
Skin	19	36

D: WHO CLASSIFICATION OF PESTICIDES

WHO Class	Meaning
111	slightly hazardous
11	moderately hazardous
1B	highly hazardous
1A	extremely hazardous

E: Health Problems Experienced After Pesticide Application

Health Problem	Frequency	%
Headache	50	100
Fever	39	78
Weakness	40	81
Watery eyes	28	56
Dizziness	31	62
Burning eyes	37	75
Nausea	30	60
Chest pain	14	28

APPENDIX THREE

RESULTS OF LABORATARY ANALYSIS

A: Concentrations (ug/kg) of organochlorine pesticide residue in tomatoes

	Sample Location									
Name of Pesticide	A	B	C	D	E	F	G	H	I	J
alpha-HCH	0.1339	0.2842	0.1672	0.1521	0.1277	0.2111	0.1191	0.4360	0.3413	0.5819
hexachlorobenzene	ND	0.0779	ND	ND	0.1859	ND	ND	ND	20.2500	0.6853
beta-HCH	ND	0.4676	ND	ND	ND	0.3795	0.0664	0.7309	0.5012	0.8613
gamma-HCH (lindane)	1.5137	3.5232	1.1626	1.9195	1.1254	3.1043	2.7497	2.8249	3.6612	2.5358
delta-HCH	1.4258	3.4208	4.0406	2.0111	1.1332	2.9872	1.4988	2.9200	2.9434	3.7783
Heptachlor	3.7751	4.7175	3.9537	3.1309	1.2444	2.5470	1.4113	5.0359	5.7419	6.3185
Aldrin	0.0539	0.5889	0.3606	0.2467	0.1414	0.0079	0.4076	0.6894	0.5855	0.7692
trans-Heptachlor epoxide	ND	0.2744	ND	ND	ND	ND	ND	ND	ND	0.0139
trans-Chlordane	ND	ND	ND	0.1420	0.0567	ND	ND	0.0100	ND	0.3521
o,p-DDE	ND	ND	ND	ND	ND	ND	ND	0.5119	ND	ND
trans-Nonachlor	0.2601	0.5812	0.5635	0.4038	0.1905	0.3112	0.2105	ND	0.5772	0.3577
p,p-DDE	0.2579	0.6149	0.3065	0.2681	0.2585	0.2719	0.0938	0.1894	0.2008	0.2382
Dieldrin	ND	0.0918	ND	ND	ND	ND	ND	ND	ND	ND
o,p-DDD	0.0270	0.0671	0.0876	0.0185	ND	0.0535	ND	ND	ND	40.9500

p,p-DDD	ND	ND	ND	ND	ND	ND	ND	0.2158	ND	28.2000
o,p-DDT	ND	0.3608	0.0112	0.2512	8.1099	0.0000	1.8826	1.3923	1.8104	4.0996
p,p-DDT	4.5622	3.3623	2.0982	5.0277	1.1707	1.7938	1.2894	4.0612	3.7942	4.3449

ND – Not Detected

B: INDEPENDENT SAMPLES TEST

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
alpha-HCH	Equal variances assumed	3.984	.081	-1.907	8	.093	-0.165	0.086	-0.364	0.035
	Equal variances not assumed			-1.907	5	.115	-0.165	0.086	-0.388	0.058
Hexachlorobenzene	Equal variances assumed	6.950	.030	-1.029	8	.334	-4.134	4.018	-13.400	5.131
	Equal variances not assumed			-1.029	4	.362	-4.134	4.018	-15.290	7.021
beta-HCH	Equal variances assumed	.716	.422	-2.474	8	.038	-0.414	0.167	-0.801	-0.028
	Equal variances not assumed			-2.474	7	.043	-0.414	0.167	-0.810	-0.018
gamma-HCH	Equal variances assumed	1.626	.238	-2.331	8	.048	-1.126	0.483	-2.240	-0.012
	Equal variances not assumed			-2.331	5	.063	-1.126	0.483	-2.336	0.083
delta-HCH	Equal variances assumed	2.582	.147	-.624	8	.550	-0.422	0.676	-1.980	1.136
	Equal variances not assumed			-.624	7	.553	-0.422	0.676	-2.025	1.182

Heptachlor	Equal variances assumed	3.098	.116	-.758	8	.470	-0.847	1.117	-3.423	1.730
	Equal variances not assumed			-.758	7	.475	-0.847	1.117	-3.516	1.823
Aldrin	Equal variances assumed	.626	.452	-1.301	8	.230	-0.214	0.164	-0.592	0.165
	Equal variances not assumed			-1.301	7	.234	-0.214	0.164	-0.601	0.174
trans-heptachlor expoxide	Equal variances assumed	6.393	.035	.948	8	.371	0.052	0.055	-0.075	0.179
	Equal variances not assumed			.948	4	.396	0.052	0.055	-0.100	0.204
trans-chlordane	Equal variances assumed	2.092	.186	-.434	8	.676	-0.033	0.075	-0.206	0.141
	Equal variances not assumed			-.434	5	.682	-0.033	0.075	-0.224	0.158
OP-DDE	Equal variances assumed	7.111	.029	-1.000	8	.347	-0.102	0.102	-0.338	0.134
	Equal variances not assumed			-1.000	4	.374	-0.102	0.102	-0.387	0.182
trans-nonachlor	Equal variances assumed	.018	.895	.884	8	.402	0.109	0.123	-0.174	0.391
	Equal variances not assumed			.884	8	.403	0.109	0.123	-0.176	0.393
PP-DDE	Equal variances assumed	1.895	.206	1.892	8	.095	0.142	0.075	-0.031	0.316

INDEPENDENT SAMPLES TEST Contd.										
	Equal variances not assumed			1.892	5	.112	0.142	0.075	-0.046	0.331
Dieidrin	Equal variances assumed	7.111	.029	1.000	8	.347	0.018	0.018	-0.024	0.061
	Equal variances not assumed			1.000	4	.374	0.018	0.018	-0.033	0.069
OP-DDD	Equal variances assumed	7.079	.029	-.997	8	.348	-8.161	8.187	-27.041	10.719
	Equal variances not assumed			-.997	4	.375	-8.161	8.187	-30.892	14.571
PP-DDD	Equal variances assumed	7.110	.029	-1.010	8	.342	-5.683	5.629	-18.664	7.298
	Equal variances not assumed			-1.010	4	.370	-5.683	5.629	-21.313	9.946
OP-DDT	Equal variances assumed	2.313	.167	-.052	8	.959	-0.090	1.723	-4.065	3.884
	Equal variances not assumed			-.052	5	.960	-0.090	1.723	-4.439	4.258
PP-DDT	Equal variances assumed	.040	.846	.195	8	.850	0.188	0.961	-2.029	2.404
	Equal variances not assumed			.195	8	.850	0.188	0.961	-2.037	2.412

C: T – test of mean concentration of beta. HCH in locations 1 And 2

Location	Mean	degree of freedom	Significance
1	0.09	8	0.0422
2	0.51		

P70.05 = not significant, thus there is no significant difference in the concentration of beta – HCH in the two locations.

D: T – test of mean concentration of gamma – HCH in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	1.85	8	0.238
2	2.98		

P> 0.05= not significant, thus there is no significant difference in the concentration of gamma- HCH in the two locations

E: T – test of mean concentration of delta HCH in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	2.40	8	0.147
2	2.83		

P> 0.05= not significant, thus there is no significant difference in the concentration of delta – HCH in the two locations

F: T – test of mean concentration of Heptachlor in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	3.36	8	0.116
2	4.21		

P> 0.05= not significant, thus there is no significant difference in the concentration of Heptachlor in the two locations.

G: T – test on mean concentration of Aldrin in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	0.28	8	0.452
2	0.49		

P> 0.05= not significant, thus there is no significant difference in the concentration of Aldrin in the two locations

H: T-test on mean concentration of trans – Heptachlor epoxide in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	0.05	8	0.035
2	0.00		

P< 0.05= Significant, thus there is a difference in the concentration of Heptachlor epoxide in the two locations.

I: T – test on mean concentrations of trans – Chlordane in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	0.04	8	0.186
2	0.07		

P> 0.05= not significant, thus there is no significant difference in the concentrations of trans – chlordane in the two locations

J: T – test on mean concentrations of Op' – DDE in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	0.00	8	0.029
2	0.10		

P< 0.05=- significant, thus there is difference in the concentrations of Op' – DDE in the two locations.

K: T – test on mean concentration of trans – Nonachlor in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	0.40	8	0.895
2	0.29		

P> 0.05= not significant, thus there is no significant difference in the concentration of trans – Nonachlor in the two locations.

L: T – test on mean concentration of pp'- DDE in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	0.34	8	0.206
2	0.20		

P> 0.05= not significant, thus there is no significant difference in the concentration of pp'-DDE in the two locations.

M: T – test on mean concentration of Dieldrin in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	0.02	8	0.029
2	0.00		

P< 0.05= significant, thus there is a difference in the concentration of Deldrin in the two locations.

N: T- test of mean concentrations of Op' –DDE in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	0.04	8	0.29
2	8.20		

P< 0.05= significant, thus there is a significant difference in the concentration of Op' –DDD in the two locations.

O: T – test on mean concentrations of pp' – DDD in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	0.00	8	0.029
2	5.68		

P< 0.05= significant, thus there is a significant difference in the concentration of pp'- DDD in the two locations.

P: T – test on mean concentration of Op'- DDT in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	1.75	8	0.167
2	1.84		

P> 0.05= not significant, thus there is no significant difference in the concentrations of Op'-DDT in the two locations.

Q: T – test on mean concentration of pp' –DDT in locations 1 and 2

Location	Mean	Degree Of Freedom	Significance
1	3.24	8	0.846
2	3.06		

P> 0.05= not significant, thus there is a significant difference in the concentration of pp' –DDT in the two locations.