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Organophosphorous Insecticide Residues in Tomatoes and Cabbage Sold At Nkawkaw Market in the Eastern Region of Ghana

A Thesis Submitted to the Department of Theoretical and Applied Biology, College Of Science, Kwame Nkrumah University of Science and Technology, Kumasi, in Partial Fulfillment of the Requirements For the Award of the Degree of Master of Science

(Environmental Science)

BY

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ORGANOPHOSPHOROUS INSECTICIDE RESIDUES IN TOMATOES AND CABBAGE SOLD AT NKAWKAW MARKET IN THE EASTERN REGION OF GHANA

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DECLARATION

It is hereby declared that this thesis is the outcome of research work undertaken by the author; any assistance obtained has been duly acknowledged. It is neither in part nor whole been presented for another degree elsewhere.

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DEDICATION

To the glory of Almighty God, I dedicate this research to my lovely wife Mrs. Hellen Coffie and our sons Benjamin Coffie and Desmond Antwi Boasiako Coffie

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ABSTRACT

The use of insecticides in controlling different types of pest is one of the essential measures of modern food crops production. However, the residue resulting from misapplication of pesticides on vegetables is a crucial concern not only to the people of Ghana but the international community at large. The aim of this project was to determine the usage of organophosphorus insecticides, the types and their residue levels in tomatoes and cabbage sold at the Nkawkaw market. The objectives were to determine: the sources of production of Cabbage and Tomato sold at the Nkawkaw market, the types of Organophosphate insecticides sold to tomato and cabbage farmers by the agrochemical sellers, the frequency and times of administration by the farmers and the concentrations of Organophosphate insecticides identified in the Cabbage and Tomato sold in the above mentioned market.

Questionnaire interviews showed that of fifty sellers, only 17 (34%) dealt with the farmers directly, while 33 (66%) took their suppliers from those who go to the farmers directly (middle women). Out of the seventeen (17) farmers, eleven (65%) have their farms located in Nkawkaw and nearby areas; three (18%) of them have their farms in the Asante Akim District, whilst the remaining three (18%) have their farms at Kumawu in the Ashanti region. It was also realized that, farmers sprayed their vegetables throughout the growing season of the crop. Most of the pesticides used by the farmers were organochlorine.

From the results of the laboratory test, only Ethoprophos and Phorate with mean concentrations of <0.01 and 0.02mg/kg respectively were detected in the cabbage samples. Malathion, Chlorpyrifos and Profenofos with their mean concentrations as <0.01, <0.01 and 0.47mg/kg respectively were detected in the tomato samples.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Nkawkaw market in the Kwahu West Municipality of the eastern region of Ghana is one of the markets which serve most of the people in Kwahu especially during the Easter festivities. Among the produce sold in this market are tomatoes (*Lycopersicum esculentum*), cabbage (*Brasica oleracea varcapitata*), garden eggs (*Solanum melondena*), water melon (*Ctrullus vulgaris*), onion (*Allium cepa*) etc. All these produce are grown under protection from insect pests, using different types of organophosphorous insecticides.

Organophosphorous (OP) compounds are the most widely used group of insecticides in the world (http://en.wikipedia.org/wiki/organophosphate). Organophosphorous insecticides degrade rapidly by hydrolysis on exposure to sunlight, air, and soil, although small amounts can be detected in food and drinking water (http://en.wikipedia.org/wiki/organophosphate). Their ability to degrade makes them an attractive alternative to the persistent organochlorine insecticides, such as DDT, aldrin, and dieldrin. Although organophosphorus degrades faster than the organochlorines, they have greater acute toxicity, posing risks to people who may be exposed to large amounts (http://en.wikipedia.org/wiki/organophosphate). Commonly used organophosphorus insecticides include parathion, malathion, methyl parathion, chlorpyrifos, fenitrothion etc. Their acute toxicity causes a hazard both to professional and amateur users. Organophosphorus insecticide self-poisoning is an important clinical problem in rural regions of the developing world, and kills an estimated 200,000 people every year (http://www.ncbi.nlm.nih.gov/

pmc/articles/pmc2493390/). Most of the farmers spray the insecticides just before harvesting. This practice leads to both insecticide deposition and residual effects on the consumable parts of the crop. Organophosphorus insecticides have a wide range of pest control applications as contact, systemic and fumigant insecticides. Recently OPs have been in the news because of health concerns following their use in vegetable crop production. In humans, poisoning symptoms include: excessive sweating, salivation and lacrimation, nausea, vomiting, diarrhoea, abdominal cramp, general weakness, headache, poor concentration and tremors. In serious cases, respiratory failure and death may occur. Acute health problems such as abdominal pain, dizziness, headaches, nausea, vomiting, as well as skin and eye problems may occur in workers that handle pesticides (http://en.wikipedia.org/ wiki/health_effects_of_pesticides#cite_note-6). In China, an estimated half a million people are poisoned by pesticides each year, 500 of whom die (http://en.wikipedia.org/wiki/health_effects_of_pesticides#cite_note-6). Pyrethrins, insecticides commonly used as common bug killers, can cause a potentially deadly condition if breathed in (http://en.wikipedia.org/ wiki/ health_effects_of_pesticides# cite_note-7).

Other consequences may follow high acute exposures. From one to several weeks after exposure, organophosphate - induced delayed neuropathy (OPIDN) [nerve damage] may set in (http://en.wikipedia.org/wiki/organophosphate-inc). This may begin with burning and tingling sensations and progress to paralysis of the lower limbs. OPs work by inhibiting important enzymes of the nervous system which play a vital role in the transmission of nerve impulses. Nerve impulses usually travel along neurons (nerve cells) by way of electrical signals. However, at a junction between two neurons (a synapse) and between a neuron and a muscle (neuromuscular junction) the impulse is transmitted in the form of a chemical substance (neurotransmitter). The neuro-transmitter operating in the autonomic nervous system, neuromuscular junctions and parts of the central nervous system is acetylcholine which is released by cholinergic neurons. It is broken down and inactivated in milliseconds by the enzyme cholinesterase. With exposure to OPs, the enzyme is unable to function and a build-up of acetylcholine occurs, which causes interference with nerve impulse transmission at nerve endings (http://www.pan-uk.org/pestnews/Active/organoph.htm).

1.2 Statement of problem

Most crops are treated with insecticides at least three times in a growing season, to control or prevent pest attack or damage. Insecticides enable farmers to produce some crops in areas that otherwise would not be suitable for increased crop yields, to protect the crops against pest attack and damage, to preserve product quality, and extend shelf life. At the same time, pesticides can pose risks if used improperly or too often. It is desirable to reduce our exposure to potentially risky chemicals; questions about pesticides and food are of concern to humans (www.cdpr.ca.gov).

Insecticide levels tend to decline over time as the residues break down and crops are washed and processed before reaching the market place. So, while small amounts of pesticides may be consumed regularly, levels are usually well below legal limits by the time food reaches the grocery store.

Pesticides should be among the most regulated products in our country. Before a pesticide can be used in Ghana, it must be evaluated and licensed by both the

Environmental Protection Agency (EPA) in Ghana and the Food and Drugs Authority as well as Ghana Standards Authority. The manufacturer must present test data to show the pesticide will not pose unacceptable risks to workers, consumers, or the environment. Organochlorine insecticides have often been preferred for the control of pests of crops including vegetables due to their persistence and effectiveness in controlling various pests. This situation is true of vegetable crops such as cabbage and tomato grown in Ghana. The less persistent and perhaps more easily degradable but equally effective organophosphorous insecticides have less often been preferred for analysis because of cost.

1.3 Justification

The present study would provide data on the type of organophosphorous insecticide residues in tomato and cabbage sold in Nkawkaw market to enable the scientific community assess the extent of contamination of these vegetables that are sold in the market. It will guide policy makers in instituting measures to protect vegetable consumers and also regulate pesticides in the country.

1.4 Aim and Objectives

Aim

The aim of the present study, therefore, was to determine the usage of organophosphorous residue levels in tomatoes and cabbage sold at Nkawkaw market.

Specific Objectives

These were to determine:

1. The sources of production of Cabbage and Tomato sold in the Nkawkaw market.

2. The types of Organophosphorous insecticides sold to tomato and cabbage farmers by the agrochemical sellers,
3. The frequency and times of application of the insecticides by the farmers.
4. The concentrations of Organophosphorous residue levels identified in the vegetables.

CHAPTER TWO

LITERATURE REVIEW

2.1 Tomato Production in Ghana

Tomato provides good nutritional balance to families as well as boosts their income and hence standard of living (http://gains.org.gh/articles/gjas_v35_p11_22.pdf). Tomato *(Lycopersicum esculentum)* production in Ghana is characterized by low yields, hence requires high fertilizer input. This is compounded in the long run by production shocks due to environmental pressures such as drought, pests and diseases (http://www .ajol .info /index.php/acsj/article/viewFile/74131/64792). Tomatoes among other vegetables are more susceptible to these biotic constraints than other crops. Chemical pesticides and, to a limited extent, integrated pest management practices have been applied to control the pests and diseases but with limited success. Pesticides usage has been ineffective, leading farmers to apply high dosage (http://www. ajol.info/index.php/acsj/ article/ view File/74131/64792). Prevention of pests and diseases in tomato is extremely important (http://www.journeyto forever .org/farm _library /AD17.pdf). Practically all pests and diseases can be adequately controlled by applying synthetic chemical pesticides. However, most pesticides are costly and are sometimes very harmful to humans and the environment, so their use should be restricted to emergency cases (http:// www.journeytoforever.org/ farm_library/AD17.pdf).

2.2 Cabbage Production in Ghana

Cabbage is a biennial vegetable with a short, thickened stem surrounded by a series of overlapping, expanded leaves which form a compact head. Head shape may be pointed or round. It is a cool-season crop generally requiring 60 to 100 days from sowing to reach market maturity, depending on the variety (http:// neomedpharma.com /_zusatz/ algifol/ research/ scientific-publications/ cabbage.html). Cabbages are among the most important vegetables in Africa in general and Benin in particular especially for lower income farmers. The importance of this vegetable is probably greater as its production is a source of income for farmers most affected by poverty, the youth, and most especially, women who paradoxically play an important role in agricultural production (http://www.modernghana.com/news/240144/1/iitarecords-breakthrough-against-pest-devastating.html).

There are a number of plant diseases that limit cabbage production; these include black rot, black leg, *Alternaria* leaf spot, wirestem, and downy mildew (http://www.aces.edu). On a global scale, chemical control is estimated to cost about $1billion annually with a baggage of health and environmental risks, which include pollution, destruction or death of non-target species including useful insects and therefore the reduction of biodiversity (http://www.modernghana. com/news/ 240144/1/iita-records-breakthrough-against-pest-devastating.html).

2.3 Synthetic Chemical Pesticides

Synthetic chemical pesticides are developed by researchers working for chemical companies, and are sold by these companies. Examples of synthetic insecticides are confidor, dursban, akate master, kombat, polytrine, DDT. These chemicals can be toxic (sometimes very toxic) to human and animal life. They are most effective in controlling pests and diseases, but they also kill the pest‗s natural predators, causing a serious resurgence of some pests when not applied at the right time, in the right way and in the right dosage rate per hectare. Because they leave residues they also can do harm to humans and the environment, and therefore should be applied judiciously and only in cases of emergency (http://www.journeytoforever. org/ farm_library/ AD17.pdf).

2.4 Organochlorine insecticides

Organochlorine insecticides are chlorinated hydrocarbons used extensively from the 1940s through the 1960s in agriculture and mosquito control. Representative compounds in this group include DDT, methoxychlor, dieldrin, chlordane, toxaphene, mirex, kepone, lindane, and benzene hexachloride. As neurotoxicants, many organochlorine insecticides were banned in the United States, although a few are still registered for use in this country.

People can be exposed to organochlorine insecticides through accidental inhalation exposure in an area where the insecticides were recently applied. The chemicals can also be ingested in fish, dairy products, and other fatty foods that are contaminated. Organochlorine insecticides accumulate in the environment. They are very persistent and move long distances in surface runoff or groundwater. Prior to the mid-1970s, organochlorines resulted in widespread reproductive failure among birds because birds laid eggs with thin shells that cracked before hatching (Hansen, 1999).

Exposure to organochlorine insecticides over a short period may produce convulsions, headache, dizziness, nausea, vomiting, tremors, confusion, muscle weakness, slurred speech, salivation and sweating (http://en.wikipedia.org/ wiki/ health_ effects_of_pesticides # cite_ note-6).

Long-term exposure to organochlorine insecticides may damage the liver, kidney, central nervous system, thyroid gland and bladder. Many of these insecticides have been linked to elevated rates of liver or kidney cancer in animals. There is some evidence indicating that organochlorine insecticides may also cause cancer in humans (Hansen, 1999).

Organochlorines can be measured in fat, blood, urine, semen, and breast milk. Samples of blood and urine are easy to obtain, and levels in these samples may help show low, moderate or excessive exposure. However, the tests cannot show the exact amount of chemical to which a person was exposed, or predict the chance of health effects in this person (http://www.cdc.gov/exposurereport/pdf/FourthReport.pdf).

2.5 Poisoning from Pesticides

According to Werner *et al*. (1995) pesticides are chemical poisons used to kill certain plants, fungi, insects, or other animals. In recent years, the increasing misuse of pesticides has become a big problem in many developing countries. These dangerous chemicals can cause severe health problems. Many of them are extremely dangerous. Villagers often use them without knowing their risks, or how to protect themselves while using them. As a result many persons become very ill, blind, sterile, paralyzed, or their children may have birth defects. Also, working with these chemicals, or eating foods sprayed with them, sometimes causes cancer. Many organophosphorous are potent nerve agents, functioning by inhibiting the action of acetylcholinesterase in nerve cells (Bonner, *et al*. 2007). They are one of the most common causes of poisoning worldwide, and are frequently intentionally used in suicides in agricultural areas (http://versita.metapress.com/content/g4470858487t28u4/).

Organophosphorous insecticides can be absorbed by all routes, including inhalation, ingestion, and dermal absorption. Their toxicity is not limited to the acute phase, however, and chronic effects have long been noted.

2.6 Types of Organophosphorus insecticides Used in Crop Production

Organophosphorus insecticides affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. They were developed during the early 19th century, but their effects on insects, which are similar to their effects on humans, were discovered in 1932. Some are very poisonous (they were used in World War II as nerve agents). However, they are usually non persistent in the environment (http://www.epa.gov/pesticides/about/ types.htm). About 70,000 species of insects and mites attack all parts of agricultural plants in their growth phase or in storage and about ten thousand species of them cause substantial economic harm (Gruzdyer, *et al.* 1983).

Small-scale farmers in Northern Tanzania grow vegetables that include tomatoes, cabbages and onions and use many types of pesticides to control pests and diseases that attack these crops (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2410092/). The farmers use about 41 different insecticides. Organophosphorus insecticides such as pirimiphos-methyl, profenofos, chlorpyrifos, and fenitrothion were among the insecticides used by these farmers.

There are many organophosphorus insecticides in common use in agricultural and domestic pest control. They vary considerably in their toxicity (http://www.deir .qld.gov.au/workplace/resources/pdfs/ddp-organoguide.pdf). Organophosphorus insecticides are widely used on a large variety of crops and are dispersed as an aerosol consisting of the pesticide adsorbed on an inert fine particle dissolved in a hydrocarbon solvent. They have also found widespread use around the home and garden to control insects.

They have replaced the more persistent organochlorine insecticides such as DDT and Aldrin. Organophosphorous are less persistent and are more readily broken down by environmental conditions and by metabolism than those insecticides they replaced. However, the acute toxicity of organophosphates is higher. Less toxic pyrethrum and synthetic pyrethroids are replacing many of the currently used organophosphates. Commonly used organophosphorous insecticides in Ghana include dichlorvous, fenitrothion, diazinon, chlorpyrifos, malathion, azinphos – methyl, parathion, phosmet, profenofos and dimethoate.

2.6.1 Dichlorvos

Dichlorvos or 2,2-dichlorovinyl dimethyl phosphate (Trade Names: DDVP, Vapona, etc.) is a highly volatile organophosphate, widely used as an organophosphorus insecticide to control household pests, in public health, and protecting stored product from insects (Espeland *et al.*, 2010). It is effective against mushroom flies, aphids, spider mites, caterpillars, thrips, and whiteflies in greenhouse, outdoor fruit, and vegetable crops. It is also used in the milling and grain handling industries and to treat a variety of parasitic worm infections in dogs, livestock, and humans. It is fed to livestock to control bot fly larvae in the manure. It acts against insects as both a contact and a stomach poison. It is available as an aerosol and soluble concentrate. It is also used in pet collars and "no-pest strips" as pesticide-impregnated plastic. In this form it has recently been labeled for use against bed bugs. The United States Environmental Protection Agency first considered a ban on DDVP in 1981. Since then it has been close to being banned on several occasions, but continues to be available. Major concerns are over acute and chronic toxicity. There is no conclusive evidence of carcinogenicity to date, however a 2010 study found that each 10-fold increase in urinary concentration of organophosphate metabolites was associated with a 55% to 72% increase in the odds of Attention Deficit Hyperactivity Disorder (ADHD) in children. Dichlorvos is absorbed through all routes of exposure. Since it is an acetylcholinesterase inhibitor, its overdose symptoms are weakness, headache, and tightness in chest, blurred vision, salivation, sweating, nausea, vomiting, diarrhea, and abdominal cramps (Espeland *et al*., 2010).

2.6.2 Fenitrothion

Fenitrothion (IUPAC name: *O*, *O*-Dimethyl *O*-(3-methyl-4-nitrophenyl) phosphorothioate) is a phosphorothioate (organophosphate) insecticide; cheap and widely used worldwide.

According to Ferrando, *et al*. (1996), sublethal fenitrothion doses affected the motor movement of marsupials, and at acute dose levels it reduced the energy of birds. In chronic (low) dose tests, unexpectedly only the lowest concentration (0.011 microgram/liter) of fenitrothion depressed the growth of an algae, though all of the chronic dose levels used were toxic in other ways to the algae.

Just half of fenitrothion's minimally effective dose altered the thyroid structure of a freshwater murrel (the snakehead fish). In an unusual demonstration of resistance to pesticides, 8% of insects in farm fields were found to carry a symbiotic gut microbe that can metabolize and detoxify fenitrothion; after in-vitro tests showed that the microbe significantly increased the survival of fenitrothion-treated insects (Ferrando *et al*., 1996).

2.6.3 Diazinon

Diazinon was developed in 1952 by the Swiss company, Ciba-Geigy as a replacement for the insecticide DDT. Diazinon became available for mass use in 1955, as DDT production tapered. Prior to 1970 diazinon had issues with contaminants in the solution. However, by the 1970s, alternative purification methods were utilized to reduce residual materials. After this, diazinon became an all-purpose indoor and outdoor commercial pest control product. In 2004, domestic use of diazinon was outlawed in the US, except for agricultural purposes and cattle ear tags. (http://www.apvma.gov.au/products/review/docs/diazinon_hh_tox_part_2.pdf)

Diazinon functions as an acetylcholinesterase (AChE) inhibitor. This enzyme breaks down the neurotransmitter acetylcholine (ACh) into choline and an acetate group. The inhibition of the AChE causes an abnormal accumulation of ACh in the synaptic cleft. When Diazinon enters the body, it is oxidatively degraded to diaxozon, an organophosphate compound that is much more poisonous than diazinon and causes mainly the inhibition of AChE (Geller *et al*., 2003). The activation of diazinon is located in the liver microsomal enzyme system and requires O_2 and NADPH. Additionally it can also be degraded via oxidation in the microsomal enzyme system. Both reactions are possible, and likely are catalyzed nonspecifically by the same mixed function oxidase; once formed, diazoxon is biotransformed again as it is degraded. Diazoxon is degraded due to the very effective hydrolyases in the microsomal and other sub cellular fractions within the liver (Hansch *et al*., 1995). Mammalian species degrade diazoxon at a much slower rate though. Insects lack this hydrolysis step which allows for the toxic insecticides to accumulate rapidly. The detoxification of diazoxon is processed through the mircosomal mixed function oxidase system. Although not fully understood, it is believed that this is the cause for the selectivity of diazonon against insects (Budavari 1996). After the hydrolysis or oxidation diazonon is further degraded.

Diazinon is a contact insecticide which kills insects by altering normal neurotransmission within the nervous system of the insect. As mentioned above, diazinon inhibits the enzyme acetylcholinesterase (AChE), which hydrolyzes the neurotransmitter acetylcholine (ACh) in cholinergic synapses and neuromuscular junctions. This results in abnormal accumulation of ACh within the nervous system. Diazinon, although a thiophosphoric ester, shares a common mechanism of toxicity with other organophosphate insecticides such as chlorpyrifos, malathion and parathion, and is not very effective against the organophosphate-resistant insect populations.

Symptoms of acute diazinon exposure develop in minutes to hours following exposure, depending on the exposure pathway. The initial symptoms of humans are nausea, dizziness, salivation, headache, sweating, lacrimation, and rhinorrhea. The symptoms can progress to vomiting, abdominal cramps, diarrhea, muscle twitching, weakness, tremor, a lack of coordination and meiosis. Furthermore, some studies have even reported some psychiatric side effects as well including memory loss, confusion, and depression (Berger, 1988).

Because diazinon is fat soluble, there is potential for delayed toxicity if significant amounts of diazinon are stored in fatty tissues. Intermediate syndrome generally occurs within 24 – 96 hours after exposure. Intermediate syndrome in humans is characterized by difficulty in breathing and muscular weakness, often in the face, neck and proximal limb muscles. Cranial nerve palsies and depressed tendon reflexes have also been reported (Berger, 1988).

2.6.4 Chlorpyrifos.

Chlorpyrifos (IUPAC name: *O*, *O*-diethyl *O*-3,5,6-trichloropyridin-2-yl phosphorothioate) is a crystalline organophosphate insecticide. It was introduced in 1965 by Dow Chemical Company, Midland United State, and is known by many trade names, including Dursban and Lorsban. It acts on the nervous system of insects by inhibiting acetylcholinesterase.

Chlorpyrifos is moderately toxic to humans and chronic exposure has been linked to neurological effects, developmental disorders, and autoimmune disorders. Exposure during pregnancy retards the mental development of children, and most use in homes has been banned since 2001 in the U.S. (http://www.scientificamerican.com/article.cfm?id=common-insecticide-may-harm-boys-brains-more-than-girls). In agriculture, it remains "one of the most widely used organophosphate insecticides", according to the United States Environmental Protection Agency (2012).

Chlorpyrifos is an organophosphate, with potential for both acute toxicity at larger amounts and neurological effects in fetuses and children even at very small amounts. For acute effects, the US EPA classifies chlorpyrifos as Class II: moderately toxic. The oral LD_{50} for chlorpyrifos in experimental animals is 32 to 1000 mg/kg. The dermal LD_{50} in rats is greater than 2000 mg/kg and 1000 to 2000 mg/kg in rabbits. The 4-hour inhalation LC_{50} for chlorpyrifos in rats is greater than 200 mg/m^3. Research by Rauh in 2006, indicated that children exposed to chlorpyrifos while in the womb have an increased risk of delays in mental and motor development at age 3 and an increased occurrence of pervasive developmental disorders such as ADHD . (http://www.scientificamerican.com/article.cfm?id=common-insecticide-may-harmboys-brains-more-than-girls). An earlier study had demonstrated a correlation between prenatal chlorpyrifos exposure and lower weight and smaller head

circumference at birth.

Studies have shown evidence of "deficits in Working Memory Index and Full-Scale IQ as a function of prenatal chlorpyrifos exposure as measured when the children reach 7 years of age. A 2012 study showed that the insecticide is more harmful to the mental development of boys than to that of girls (http://www.scientificamerican. com/article.cfm?id=common-insecticide-may-harm-boys-brains-more-than-girls). A 2011 study on the neurotoxic effects of chlorpyrifos showed that chlorpyrifos and its more toxic metabolite, chlorpyrifos oxon, altered firing rates in the locus coeruleus. These results indicate that the pesticide may be involved in Gulf War Syndrome and other neurodegenerative disorders (http://en.wikipedia.org/wiki/ Chlorpyrifos).

2.6.5 Malathion

According to Bonner *et al*. (2007) malathion is an organophosphorus parasympathomimetic which binds irreversibly to cholinesterase. It is an insecticide of relatively low human toxicity. In the former USSR, it was known as Carbophos, in New Zealand and Australia as Maldison and in South Africa as Mercaptothion

Malathion is an insecticide that is widely used in agriculture, residential landscaping, and public recreational areas for insect control and in public health pest control programmes such as mosquito eradication. In the US, it is the most commonly used organophosphate insecticide (Hansch *et al*, 1995).

Malathion was used in the 1980s in California to combat the Mediterranean fruit fly. This was accomplished on a wide scale by the near weekly aerial spraying of suburban communities for a period of several months. Formations of three or four agricultural helicopters would overfly suburban portions of Alameda County, San

Bernardino County, San Mateo County, Santa Clara County, San Joaquin County, Stanislaus County, and Merced County releasing a mixture of malathion and corn syrup, the corn syrup being a bait for the fruit flies. Malathion has also been used to combat the Mediterranean fruit fly *(Drosophila spp)* in Australia.

Manitoba ordered the city of Winnipeg, Manitoba to be sprayed in July 2005 as part of the West Nile virus campaign. Prior to this, malathion was used over the last couple of decades on a regular basis during summer months to kill nuisance mosquitoes, but home owners were allowed to exempt their properties if they chose. Today, Winnipeg is the only major city in Canada with an ongoing Malathion nuisance-adult-mosquito-control program.

Malathion itself is of low toxicity; however, absorption or ingestion into the human body readily results in its metabolism to malaoxon, which is substantially more toxic. In studies of the effects of long-term exposure to oral ingestion of malaoxon in rats, malaoxon was shown to be 61 times more toxic than malathion. It was cleared from the body quickly, in three to five days. According to the United States Environmental Protection Agency there has been no reliable information on adverse health effects of chronic exposure to malathion. Acute exposure to extremely high levels of malathion will cause body-wide symptoms whose intensity will be dependent on the severity of exposure. Possible symptoms include skin and eye irritation, cramps, nausea, diarrhea, excessive sweating, seizures and even death. Most symptoms tend to resolve within several weeks. Malathion present in untreated water is converted to malaoxon during the chlorination phase of water treatment, so malathion should not be used in waters that may be used as a source for drinking water, or any upstream waters.

If malathion is used in an indoor, or other poorly ventilated environment, it can seriously poison the occupants living or working in this environment. A possible concern is that malathion being used in an outdoor environment, could enter a house or other building; however, studies by the EPA have conservatively estimated that possible exposure by this route is well below the toxic dose of malathion. Regardless of this fact, in jurisdictions which spray malathion for pest control, it is often recommended to keep windows closed and air conditioners turned off while spraying is taking place, in an attempt to minimize entry of malathion into the closed environment of residential homes (http://en.wikipedia .org/ wiki / Malathion)

2.6.6 Azinphos-methyl

According to Scott (2008), azinphos-methyl (Guthion) (also spelled azinophosmethyl) is a broad spectrum organophosphorus insecticide. Like other insecticides in this class, it owes its insecticidal properties (and human toxicity) to its inhibition of acetylcholinesterase.

Azinphos-methyl is a neurotoxin derived from nerve agents developed during World War II. In the US, it is registered for use on select nut trees, vegetable crops, and fruit trees. It is not registered for consumer or residential use. It has been linked to health problems of farmers who apply it, and the U.S. Environmental Protection Agency (EPA) considered a denial of reregistration due to health concern to farm workers, insecticide applicators, and aquatic ecosystems. After settling a 2004 lawsuit brought by the United Farm Workers of America and other groups, the EPA announced it would begin phasing out the remaining uses of the pesticide in 2007 with all uses ending in 2012. In January 2007, the suit was reopened, with the plaintiffs seeking a quicker phase out.

2.6.7 Parathion

Parathion, also called parathion-ethyl or diethyl parathion is an organophosphorus compound. It is a potent insecticide and acaricide. It was originally developed by IG Farben in the 1940s. It is highly toxic to non-target organisms, including humans. Its use is banned or restricted in many countries, and there are proposals to ban it from all use. Closely related is "methyl parathion"

Parathion is synthesized from diethyl dithiophosphoric acid $(C_2H_5O)_2PS_2H$, which is obtained by treatment of P_2S_5 with ethanol (methanol is used to prepare methyl parathion). Diethyl dithiophosphoric acid is chlorinated to generate diethylthiophosphoryl chloride, which is then treated with sodium 4-nitrophenolate (the sodium salt of 4-nitrophenol).

As an insecticide, parathion is generally applied by spraying. It is often applied to cotton, rice and fruit trees. The usual concentrations of ready-to-use solutions are 0.05 to 0.1%. The chemical is banned for use on many food crops.

Degradation of parathion leads to more water soluble products. Hydrolysis, which deactivates the molecule, occurs at the aryl ester bond resulting in diethyl thiophosphate and 4-nitrophenol.

Parathion is a cholinesterase inhibitor. It generally disrupts the nervous system by inhibiting acetylcholinesterase. It is absorbed via skin, mucous membranes, and orally. Absorbed parathion is rapidly metabolized to paraoxon, as described above. Paraoxon exposure can result in headaches, convulsions, poor vision, vomiting, abdominal pain, severe diarrhea, unconsciousness, tremor, dyspnea, and finally lungedema as well as respiratory arrest. Symptoms of poisoning are known to last for extended periods of time, sometimes months. The most common and very specific antidote is atropine, in doses of up to 100 mg daily. Because atropine may also be toxic, it is recommended

that small frequently repeated doses be used in treatment. If human poisoning is detected early and the treatment is prompt (atropine and artificial respiration), fatalities are infrequent. Insufficient oxygen will lead to cerebral hypoxia and permanent brain damage. Peripheral neuropathy including paralysis is noticed as late sequelae after recovery from acute intoxication. Parathion has been used for committing suicide and deliberately poisoning other persons. It is known as "Schwiegermuttergift" (mother-in-law poison) in Germany. For this reason, most formulations contain a blue dye providing warning (http://en.wikipedia.org/wiki/
Malathion).

2.6.8 Phosmet

Phosmet is a phthalimide-derived, non-systemic, organophosphorus insecticide used on plants and animals. It is mainly used on apple trees for control of codling moth, though it is also used on a wide range of fruit crops, ornamentals, and vines for the control of aphids, suckers, mites, and fruit flies (Purdey , 1998).

2.6.9 Profenofos

Profenofos is used for the control of important cotton and vegetable pests including chewing and sucking insects and mice, cotton borers, aphids, cabbage looper and thrips. The health effects of profenofos is cholinesterase inhibition and the associated neurological and neuromuscular effects (Kumar 2007).

2.6.10 Dimethoate

According to Kumar (2007), dimethoate is a systemic and contact insecticide and acaride, effective against red spider mites and thrips on most agricultural and horticultural crops. Dimethoate might have carcinogenicity, birth defects, reproductive toxicity and mutagenic effects.

2.7 Residues of Pesticides in Food Crops

When a insecticide is applied directly to a target pest (plant or animal) the whole site is affected including crop plants, soil organisms and, potentially, humans and wildlife in the immediate area (http://www.news-medical.net/health/Toxicology-what-isToxicology.aspx).

‗‗Beware of the vegetables you eat, some are contaminated with dangerous chemicals‘‘ (The Ghanaian Times, November 27, 2012). According to the paper, vegetables sold in the markets have been found to contain up to 5000 times the permissible levels of chemical residues. Most of these vegetables are from Weija,

Ada and Kawukudi in the Greater- Accra region, Keta in the Volta region and Akomadan in the Ashanti region.

Organophosphorus insecticides (Ops) are regularly detected at low levels in a range of food items. OP residues found in UK carrots have proved a recent exception. Ministry of Agriculture, Fisheries and Food figures for 1995 showed that 1-2% of carrots contain OP residues up to 25 times higher than expected (Pesticides News No.31, March 1996,). Eating fruit or vegetables can mean ingesting on average residues from 20 different endocrine disrupting pesticides. Around 40 pesticides in use in Europe show endocrine disrupting properties and 30 of them can be analysed in food as residues (.http://www.disruptingfood.info/files/PANE_-_2012_ _Consumer_guide_EDC_-_EN.pdf)

The problem is that, as they add up, the effects of Endocrine Disrupting Chemicals

(EDC) can ―accumulate‖, leading to even more dangerous mixtures – the ―cocktail effects‖. Averagely pesticides used in the Third World is nearly 100 grams per annum for every person (http://www.cabdirect.org/abstracts/19826745014.html; jsessionid= 7A 192D CD 03 AD46E64D08472A2A8D8378).

In the Eastern Romania area, between 1996 and 1997, organochlorine insecticide residues were analyzed using gas-chromatographic method. DDT-total and HCH-total were determined in _food‘ (milk, bread, coffee) sampled in the Eastern Romania area; _maternal body‘ (placenta, milk, urine) and _young body‘ (serum, urine) from the Iassy district (http://www. Sciencedirect.com/science/article/pii/S0378427499000375)

In late 2010, 15 farmers died from suspected insecticide poisoning in Upper East region of Ghana. Most of these deaths resulted from poor storage of pesticides, which seeped into food stocks (http://www.christianaid.org.uk/images/ghanas-pesticidecrisis.pdf). These deaths may well be the tip of the iceberg: Senior health officials believe that some _natural‘ deaths among Ghanaian farmers might be related to insecticide use, partly since poisonings are hard to diagnose.

2.8 Pesticide Use and Residues in Food in Ghana

According to Essumang *et al.* (2008), insecticide residues, both natural and synthetic, can be found in most of the foods that we eat, for example, fruits, vegetables, bread, meat, poultry, fish, and the processed foods made from them. Some amount of insecticide contamination is allowed, but does not mean it is safe. Much of it is illegal, with residues found in excess of regulatory safe levels. Identifying and determining the level of trace contaminants in our food and environment is critical in protecting and improving human health and the environment. A study to evaluate the residue levels of selected pesticides used on tomato crops in Ghana that are likely to have accumulated in the tomatoes during application confirmed that pesticide residues were indeed present in the tomatoes and further analysis quantified the amount present. According to Essumang *et al.* (2008), analysis of some organochlorine and organophosphorus residue levels in the tomato fruits indicated that chlorpyrifos, which is an active ingredient of pesticides registered in Ghana under the trade name‖ Dursban 4E‘ or Terminus 480 EC‘ for use on vegetables, has the greatest residue level of 10.76 mg/kg. The lowest residue level observed was that of Pirimiphos-methyl with 0.03 mg/kg. According to Essumang *et al.* (2008), Human health risk assessment was performed on the results obtained from the analysis using Human Health Evaluation computerized software-RISC 4.02. The risk assessment showed cancer risk for adults and children due to the presence of Endosulfan and Chlorpyrifos. Endosulfan is not registered in Ghana as a pesticide for use on vegetables; therefore, the detection of endosulfan in several samples indicates misuse of agrochemicals among Ghanaian farmers (Essumang *et al.*, 2008).

As part of a programme aimed at promoting safe and sound agricultural practices in Ghana, a study was undertaken on farmers‘ perception of pesticides for use and application in vegetable production, using a small survey of 137 farmers who applied pesticides. The survey showed that knapsack sprayers were the most widely used type of equipment for spraying insecticides. However, on large scale vegetable farms of 610 acres, motorized sprayers were also used. Various inappropriate practices in the handling and use of insecticides caused possible poisoning symptoms among those farmers who generally did not wear protective clothing. Younger farmers (< 45 years of age) were the most vulnerable group, probably because they did more spraying than older farmers (> 45 years of age). Farmers did not necessarily associate hazardous pesticides with better pest control. The introduction of well-targeted training programmes for farmers on the need for and safe use of pesticide was thus advocated (Ntow *et al*., 2006).

Amoah *et al*. (2006) carried out a study to determine and compare the current level of exposure of the Ghanaian population to hazardous pesticides and faecal coliform contamin-ation through the consumption of fresh vegetables produced in intensive urban and peri-urban smallholder agriculture with informal waste water irrigation. In that study a total of 180 vegetable samples (lettuce, cabbage and spring onion) were randomly collected under 15 normal purchase conditions from 9 major markets and 12 specialized selling points in 3 major Ghanaian cities: Accra, Kumasi and Tamale. The samples were analyzed for pesticide residue on lettuce leaves; a total number of faecal coliforms and helminth egg counts on all the three vegetable were found. Chlopyrifos (Dursban) was detected on 78% of the lettuce, lindane (Gammalin 20) on 31%, endosulfan (thiodan) on 36%, Lambda Cyhalothrin (Karate) on 11% and dichlorodiphenyl- trichloroethane (DDT) on 33%. Most of the residues recorded exceeded the maximum residue limit for consumption. Vegetables from all three cities were faecally contaminated and carried faecal coliform population with geometric mean values ranging from 4.0 X 10^3 to 9.3 X 10^8 g (-1) wet weight and exceeded recommended standards. Lettuce, cabbage and spring onion also carried an average of 1.1, 0.4 and 2.7 g (-1) helminth eggs respectively. The eggs were identified as those of *Ascaris lumbricoides, Ancylostoma duodenal*, *Schistosoma heamatobium* and *Tricchuris trichiura*. Because many vegetables are consumed fresh or only slightly cooked, the study showed that intensive vegetable production, common in Ghana and its neighboring countries, threatens public health from the microbiologic and pesticide dimensions. Standard recommendations to address this situation (better legislation, law enforcement or integrated pest management) often do not match the capabilities of farmers and authorities. Amoah *et al*. (2006) indicated that the most appropriate entry point for risk decrease that also addresses postharvest contamination is washing vegetables before food preparation at the household or ―chop‖ bars.

Organochlorine insecticides are widely used by farmers because of their effectiveness and their broad spectrum activity. Lindane is a widely used chemical in Ghana on Cocoa plantations, on vegetable farms and for the control of stem borers in maize. Endosulfan, marketed as Thiodan, is widely used in cotton growing areas on vegetable farms and on coffee plantations (Gerken *et al.,* 2001).

Through their persistence and lipophilicity, the pesticides and their residues may concentrate in the adipose tissues and in the blood stream of animals leading to environmental persistence, bioconcentration and biomagnification through the food chain. Although the organochlorines are banned from importation, sales and use in Ghana, there is evidence of their continued usage and presence in the ecosystem. Work already done in some farming communities in the Ashanti region of Ghana and some other countries indicate the presence of Organochlorine pesticide residues in fish (Osafo and Frempong, 1998).

Meat may contain high levels of pesticide residues as a result of concentration of residues in the tissues following cattle dipping or vector control or when they feed on foodstuffs contaminated with these chemicals. Because these chemicals are toxic to living organism, increased accumulation in the food chain may pose serious health hazards to the general populace (Jayashree and Vasudevan, 2007).

2.9 Effects of Pesticides on Health

According to Richter *et al* (1992), there are many organophosphorus insecticides commonly used in agricultural and domestic pest control. They vary considerably in their toxicity. Organophosphorus is less persistent and more readily broken down by environmental conditions and by metabolism than those organochlorine insecticides they replaced. However, the acute toxicity of organophosphorus is higher.

Insecticide use raises a number of environmental concerns. Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, including nontarget species, air, water, and food (Miller, 2004). According to Miller (2004), the World Health Organization and the United Nations Environmental Program estimate that each year, three million workers in Agriculture in the developing countries experience severe poisoning from pesticides of which about eighteen thousands of them die.

2.10 Poisoning statistics of organophosphorus pesticides.

An accurate assessment of the numbers of people affected by OP use and misuse is impossible (Osman *et al.*, 2010). The World Health Organisation estimates that there are, in total, three million acute severe cases of insecticide poisonings and 20,000 unintentional deaths each year, mostly in developing countries. Of these poisonings a large (but unknown) proportion involves OPs. Poisoning data on OPs is difficult to come by in developing countries. An assessment by the Insecticides Trust revealed azinphos methyl, chlorpyrifos, methamid-ophos, methomyl, monocrotophos, parathion and phosphamidon have caused a number of health concerns in a range of developing countries. In 1995, there were 15,300 insecticide poisoning cases in China, 91% of which were caused by OPs (67% were caused by just three OPs, parathion, methamidophos and omethoate (http://www.cnn.com/2010/ HEALTH/05/17/ pesticides.adhd/).

In 1995, Ciba- Geigy (Swiss company) withdrew its product Miral 500 CS product (isazofos) from 16 countries following three serious accidents in Africa and Latin America linked with its use.

Kyle Steenland at the US National Institute for Occupational Safety and Health maintains that acute poisoning from OPs remains a problem in industrialised countries. Estimated 3,000-5,000 cases of accidental poisoning occur annually in the US, according to the Environmental Protection Agency (EPA, 1995).

An FAO study in Indonesia found that most symptoms associated with pesticide toxicity were significantly greater in the time of year when spraying occurred.

Farmers sprayed often using mixtures of hazardous pesticides, and over 50% were OPs. This study was typical of OP poisoning in developing countries where it is impossible to match specific pesticides with symptoms.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

Nkawkaw (meaning "the red, red" in the Akan language) is the capital town of Kwahu West District in the Eastern Region of Ghana, with an estimated population in 2012 at

60,427 people (http://en.wikipedia.org/wiki/File:Nkawkaw_Eastern_Region_Ghana.jpg). Nkawkaw is situated along the road and former railway between Accra and Kumasi, thus, 127 km from Accra and 95 km from Kumasi. It is also connected by road to Koforidua and Konongo. It is one of the major towns in the low lying area at the foot of the Kwahu Mountain range. It forms the western part of the Kwahu portion of the Eastern Region (6°33′N 0°46′W6.55°N 0.767°W). The main occupation for the people are trading and farming with few government workers. The other districts in Kwahu are all linked to Nkawkaw (fig 1 (a) and (b).

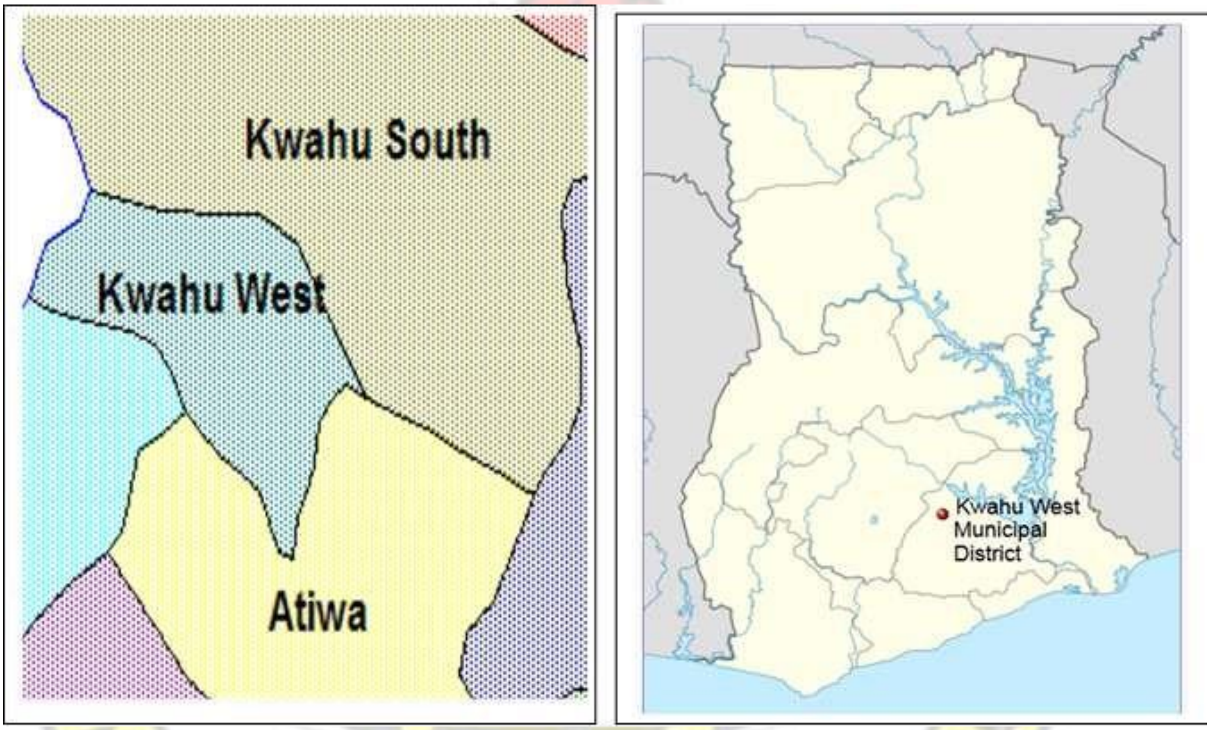


Fig. i Map of study area (a) Kwahu West Municipality with its adjoining districts.

Nkawkaw market serves most of the people in Kwahu. Among the produce sold in this market are tomatoes, cabbages, garden eggs, water melon, onion, maize, yam etc.

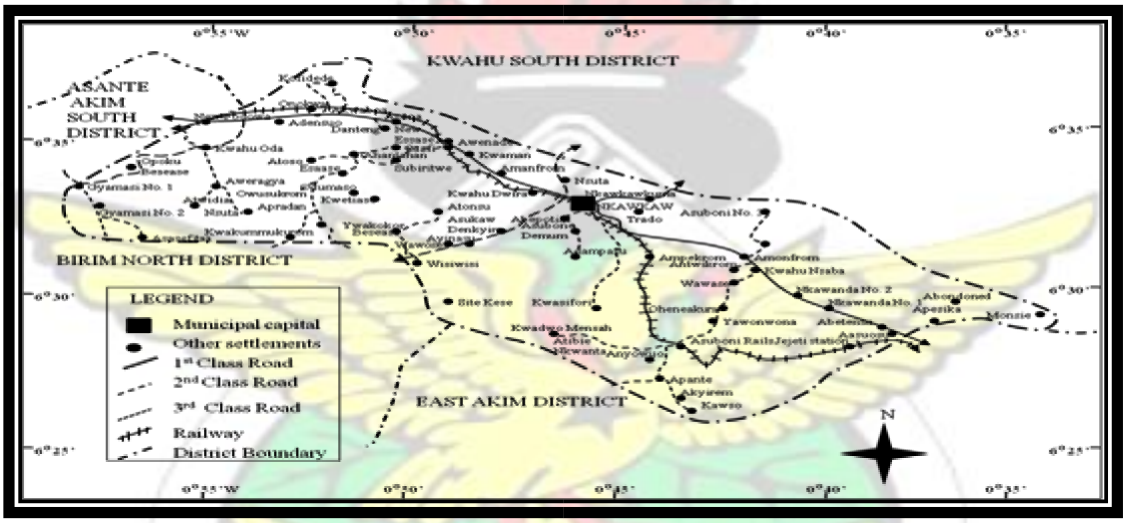
3.2 Scope of the Study

The study was carried out in four stages. The first stage was a questionnaire administration to the sellers in Nkawkaw market to find out where they took their vegetable supply from.

The second stage was an interview of agrochemical sellers in Nkawkaw to determine the types of pesticides they sold to (cabbage and tomatoes) farmers.

The third stage was a questionnaire administration to the farmers who supply vegetables to the Nkawkaw market to find out what organophosphorus insecticides they used in controlling pests that affect their vegetables.

The fourth stage involved the collection of samples of harvested tomato and cabbage from selected vegetable sellers for laboratory analysis for organophosphorous compounds or pesticide residual levels in them.



(b) Kwahu West Municipality with Nkawkaw as the municipal capital

3.3 Sampling

Fifty (50) vegetable sellers in the Nkawkaw market were randomly selected and questionnaires were administrated to them. In addition a total of twenty (20) vegetable farmers from around Nkawkaw and Konongo were given questionnaires to respond to. The questionnaires were translated in the local language (Asante Twi) to both the market sellers and the farmers.

A total of 300 tomato fruits were collected from 50 tomato sellers selected from the Nkawkaw market and put into 10 groups each of samples to assess the level of organophosphorus insecticides in them. They were wrapped, 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 Ghana Standard Authority Pesticides Residue Laboratory and kept refrigerated at 5ºC. They were analysed within 7 days from the time of their collection from the market.

Also a total of ten heads of cabbage were collected from ten cabbage sellers in the same market and grouped as 10 samples each of one cabbage head and transported under the same condition as that of the tomato to the same laboratory in order to assess the accumulation of organophosphorus insecticides in them.

3.4 Extraction of organophosphorous insecticide from cabbage and tomato

The cabbage and tomato were both chopped into small pieces into separate blenders and blended. No washing was done to any of the vegetables to prevent tempering with the insecticides deposition on the outside. Ten grams (10g) of each of the blended sample was accurately weighed into a sample bottle. Ethyl acetate (40 ml) was added and macerated for 30 seconds. Anhydrous sodium sulphate (20g) and sodium hydrogen carbonate (5g) were added to the mixture and macerated for further 90 seconds. The content was centrifuged at 3000 rpm for 5 minutes. Ten millilitres

(10 ml) ≡ 5.0g of the aliquot was pipetted into a round bottomed flask (50ml). It was evaporated to about 2ml below 40°C on a rotary evaporator.

The ENVI-Carb/LC-NH_2 (500 mg / 500 mg, 6 ml) cartridge was conditioned with 10 ml of ethyl acetate and loaded the extract from (2 ml) onto the cartridge and the eluate collected into 100 ml round bottom flask.

The cartridge was eluted with 10ml of ethyl acetate and the filtrate concentrated below 40°C to approximately 1ml on the rotary evaporator to dry it.

The eluate was re-dissolved in 1ml ethyl acetate and transferred into a GC vial for quantitation by Gas Chromatography Pulse Flame Photoelectric Detector (GC-PFPD). With the Gas Chromatography (GC), the carrier gas (nitrogen) was the mobile phase and the stationary phase was the column. Temperature programming was used to run the samples.

Pesticides Mixture was the standard used for peak identification and the calibration curve used for quantification. The concentrations of the various residues in each sample were expressed in mg/kg, and the mean concentration of each pesticide was compared to the EU Maximum Residual Levels (MRLs) 1996 Guideline Value in mg/kg.

Table 1: Retention Times for Organophosphorus insecticides

STANDARDS	RETENTION TIME (min)
Methamidophos	7.021
Ethoprophos	8.450
Phorate	8.708
Diazinon	8.962
Fonofos	9.156
Dimethoate	9.572
Pirimiphos-methyl	9.713
Chlorpyrifos	9.895
Malathion	10.110
Fenitrothion	10.251
Parathion	10.481

Chlorfenvinphos	10.626
Profenofos	11.319

3.6 Data Analysis

Data from the questionnaire were statistically analysed using the Statistical Package for the Social Sciences (SPSS). The results were presented in Tables and Bar charts with respect to the sellers; the results on the farmers were presented in Tables and Pie charts.

CHAPTER FOUR

RESULTS

4.1 Market Survey

Results of the questionnaire administered to the vegetable sellers are shown in Bar Charts covering Age, gender, education, duration of trading, commodities trade in, supplier‘s location, washing of produce.

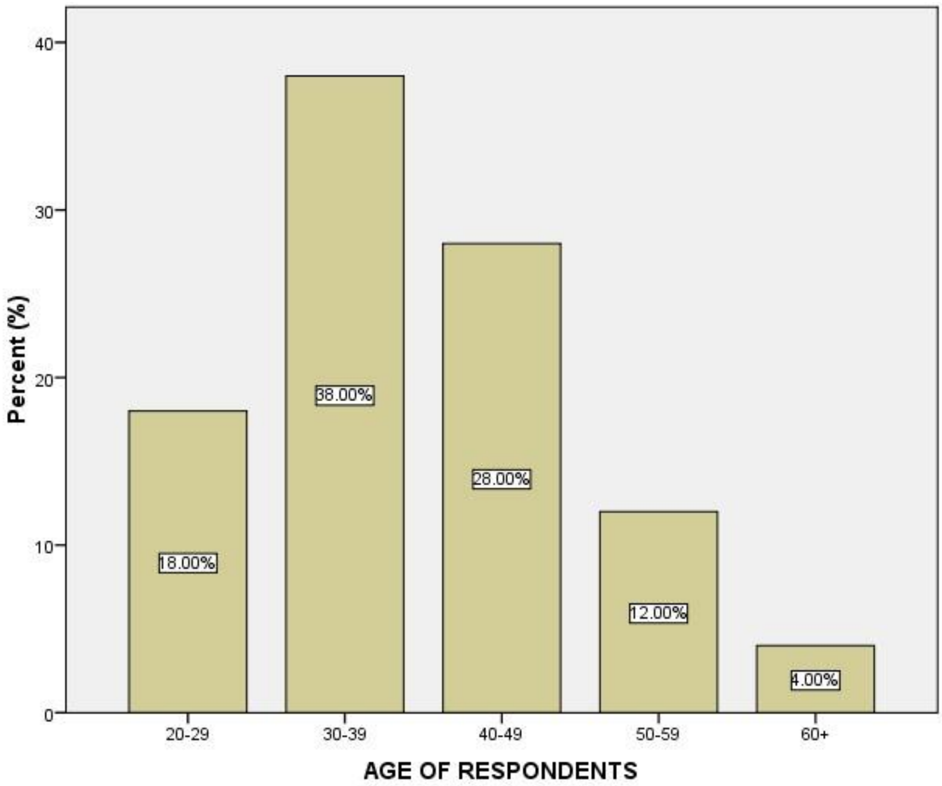


Fig. 1 Age of Cabbage and Tomato sellers at Nkawkaw market

4.1.1 Age of the Sellers

Fig. 1 indicates that of the fifty sellers who responded to questionnaires administered, nine (18%) were between 20-29 years of age. 19 representing 38% were between 3039 years. Fourteen (14) sellers representing 28% were between 40- 49. Six (6) of them representing 12% were between 50-59 and only 2 of the sellers representing 4% were 60 years and above. For details refer to Appendix1

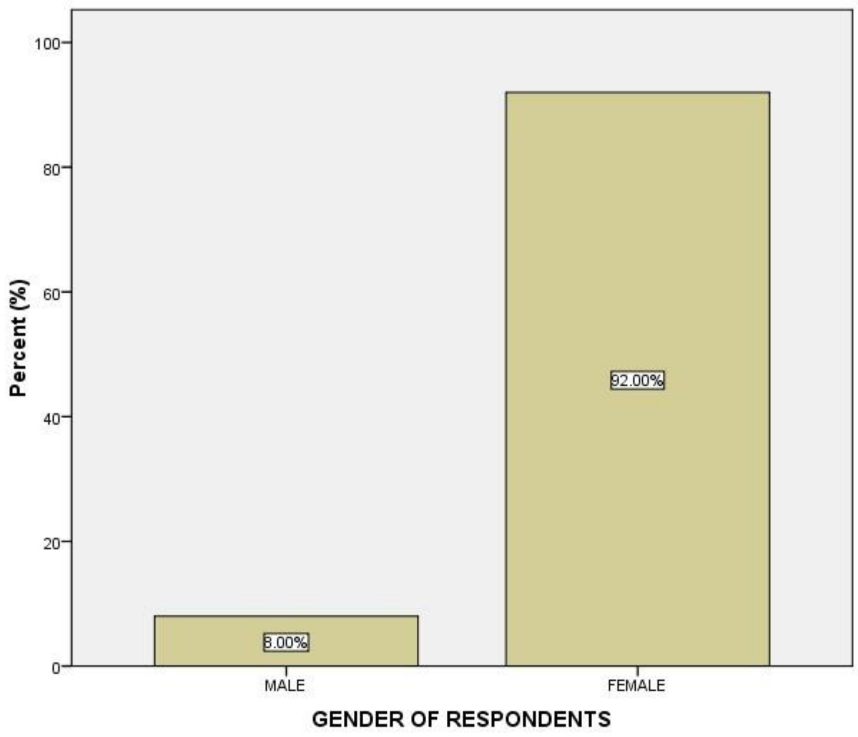


Fig. 2 Gender of Cabbage and Tomato sellers at Nkawkaw market

4.1.2 Gender of the Sellers

Fig. 2 shows that, out of the 50 sellers that the questionares were administered to, 46 representing 92% were females while 4 of them reprenting 8% were male.

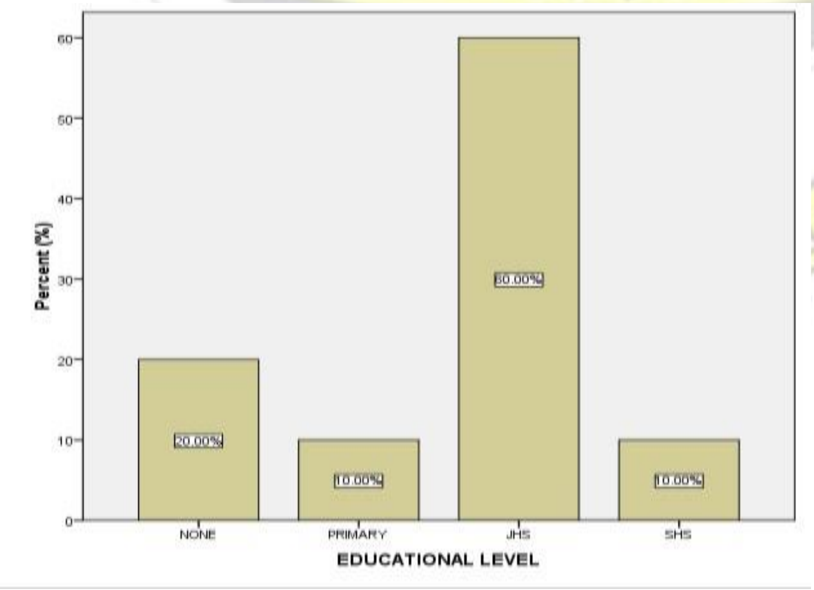


Fig. 3 Educational levels of Cabbage and Tomato sellers at the Nkawkaw market

4.1.3 Educational Level of the Sellers

Results of questionnaire administered on educational level of sellers are presented in Fig. 3. Ten (10) of the 50 sellers representing 20% have never been to school before. 5 representing 10% stopped school at the primary level. Thirty (30) of them representing 60% have completed JHS while 5 of them representing 10% have completed SHS. (Appendix 3)

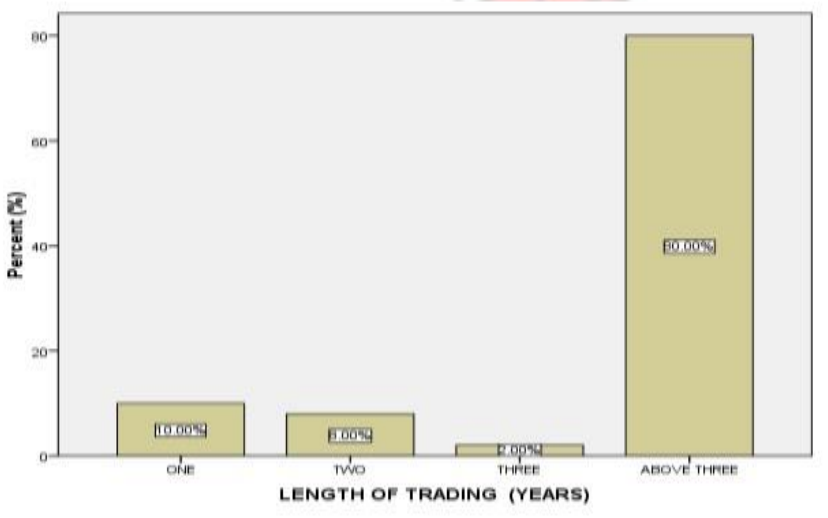


Fig. 4 Length of trading by Cabbage and Tomato sellers at Nkawkaw market

4.1.4 Length of Trading at the Nkawkaw market

Fig. 4 indicates that out of the 50 sellers at Nkawkaw market, 5 of them (representing 10%) have sold in the market for only one year. Four (4) of them representing 8% have sold for 2 years. Only one of them, representing 2% had sold in the market for 3 years, 40 of the sellers representing 80% have sold for more than 3 years.

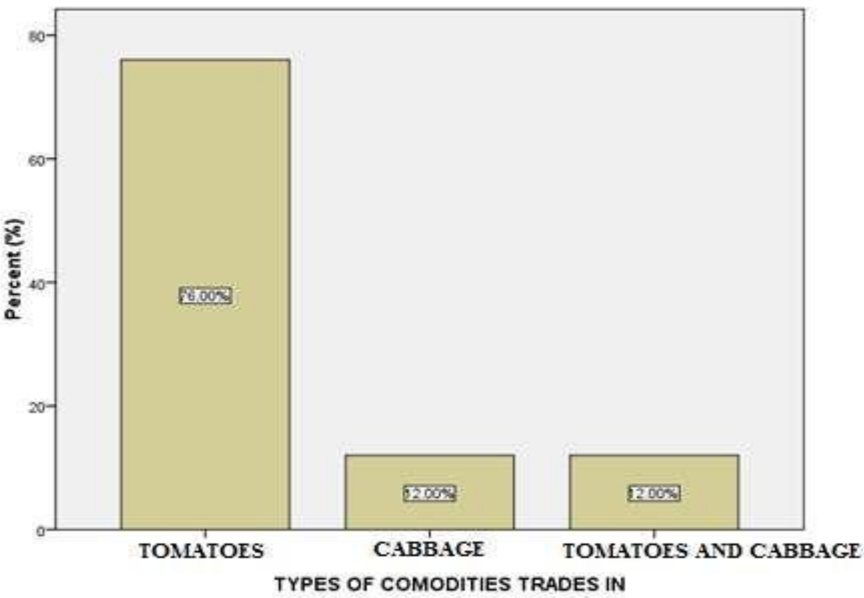


Fig 5 Type of commodity sold by Cabbage and Tomato sellers at Nkawkaw market.

4.1.5 Types of Commodities Sold

Fig 5 shows that 38 (76%) of the seller‘s trade in tomato, 6 (12%) trade in cabbage, while 6 (12%) of them trade in both tomato and cabbage.

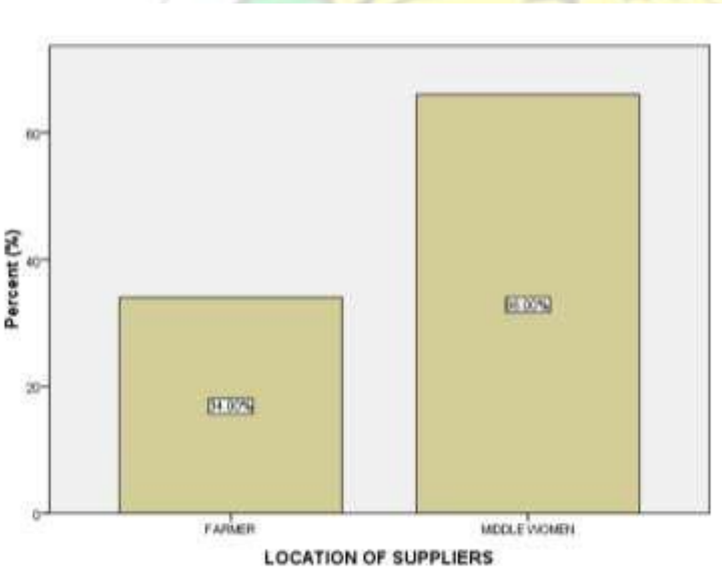


Fig 6 Source of the Supply of Cabbage and Tomato to Sellers at the Nkawkaw market

4.1.6 Source of Supply

Fig 6 indicates that, 17 (34%) take their supplies from the farmers, while 33 (66%) of the sellers take their supplies from middle women. (Appendix 6)

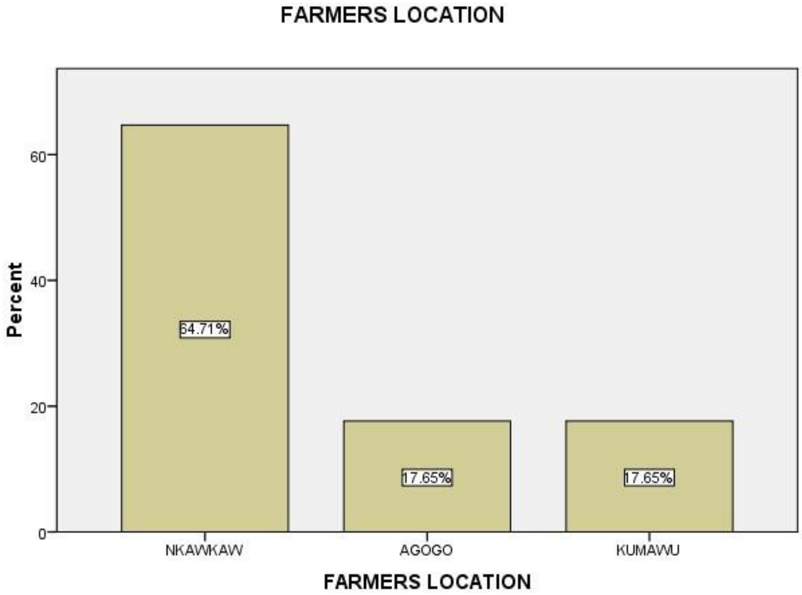


Fig 7 Location of Farms

4.1.7 Location of Farmers

Fig. 7 shows that, out of the 17 farmers who supplied their commodities (Cabbage and Tomato) directly to the sellers 11 (65%) of them have their farms located in Nkawkaw and its environ, 3 (18%) of the 17 farmers have their farms at Asante Akim Agogo, whilst the remaining 3 (18%) have their farms at Kumawu in the Ashanti region.

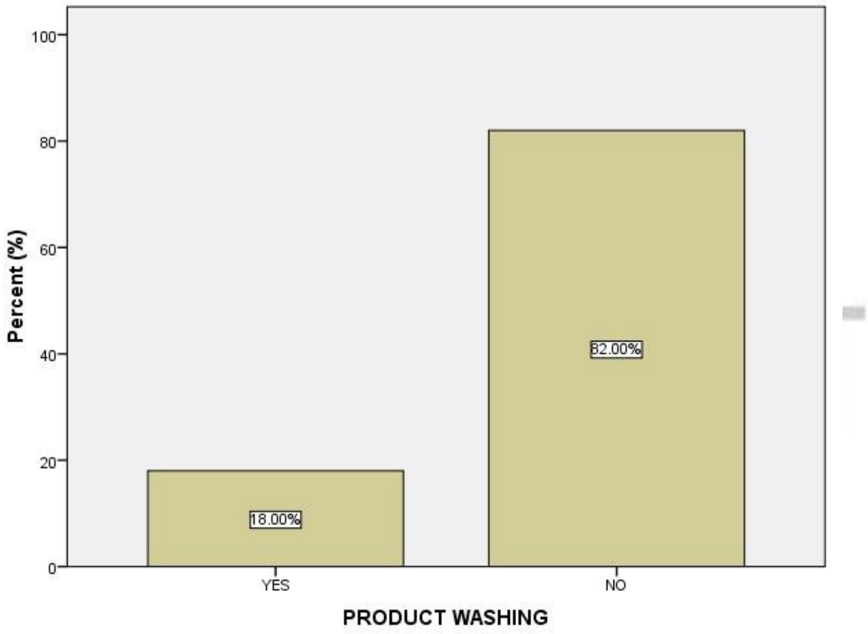


Fig 8 Washing of vegetables by the sellers before sale

4.1.8 Product Washing

Fig 8 shows that, out of the 50 respondents to find out whether they washed their vegetables before selling them or not 9 of the sellers (representing 18%) admitted washing the vegetable before selling; 41(representing 82%)do not wash them before selling.

4.2 Field Survey

Results of the questionnaires interviews with the vegetable farmers are shown in Pie Charts covering Age, gender, educational level, type of crop produced, number of buyers, and location of buyers, type of pesticides used, spraying times and period of pesticide application.

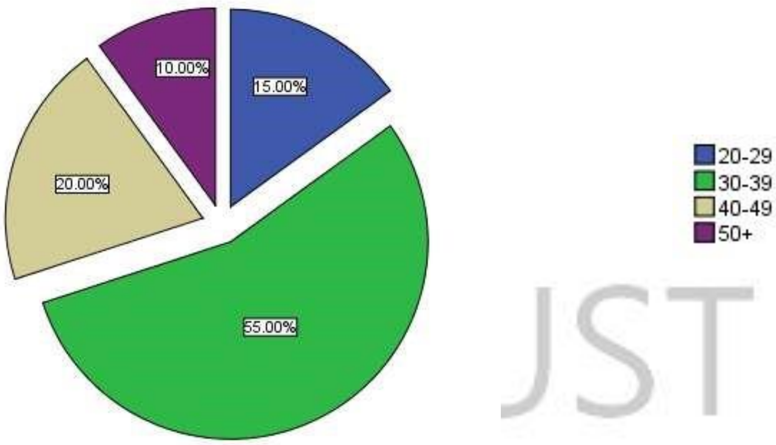


Fig 9 Age of Cabbage and Tomato farmers

4.2.1 Age of the Farmers

Fig 9 indicates that of the 20 farmers, 3 (15%) were between the ages 20-29; 11, representing 55%, were between 30-39; 4 representing 20% were between 40-49, and only 2 of them representing 10% were 50 yrs.‘ and above. Refer to appendix 9 for details.

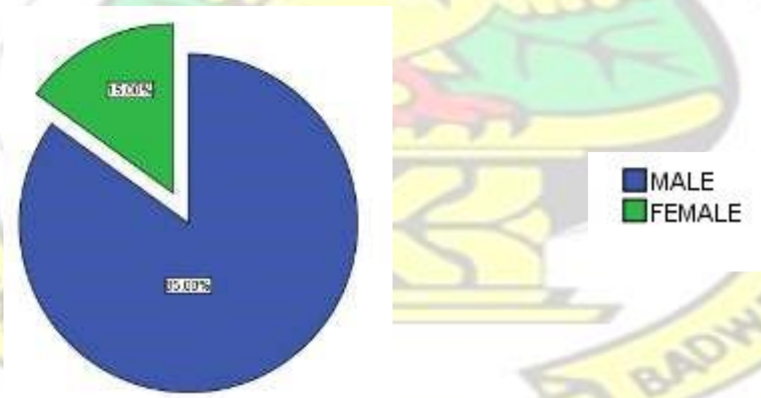


Fig 10 Gender of the farmers

4.2.2 Gender of the Farmers

Fig 10 indicates that out of the 20 farmers that the questionnaires were administered to 17 of them (representing 85%) were male, with only 3 of them (representing 15%) being female.

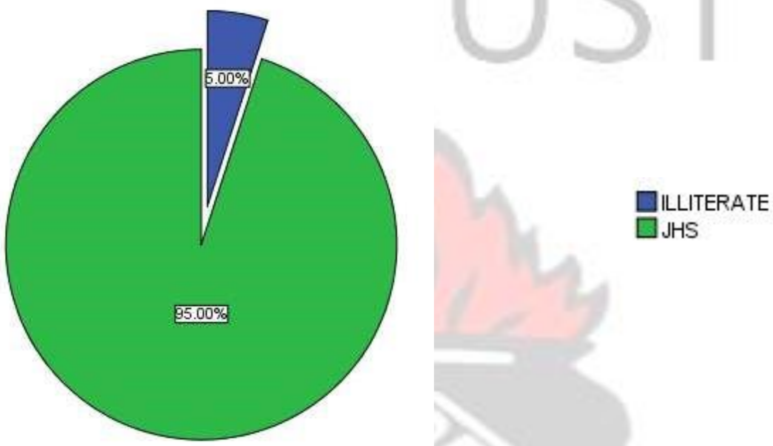


Fig. 11 Educational levels of the farmers

4.2.3 Educational Level of the Farmers

Fig. 11 shows that, out of the 20 farmers that the questionnaires were administered to 19 of them (representing 95%) have had basic education and only 1 (5%) was illiterate.

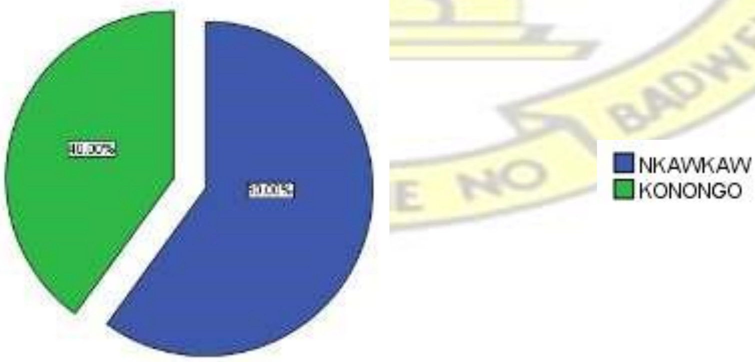


Fig. 12 Location of the farms

4.2.4 Location of Cabbage and Tomato Farms

Fig. 12 indicates that, of the 20 farmers that the questionnaires were administered to 12 of them (representing 60%) have their farms located around Nkawkaw (Kwahu West District) and 8 of them (representing 40%) have their farms located around Konongo (Asante Akim District)

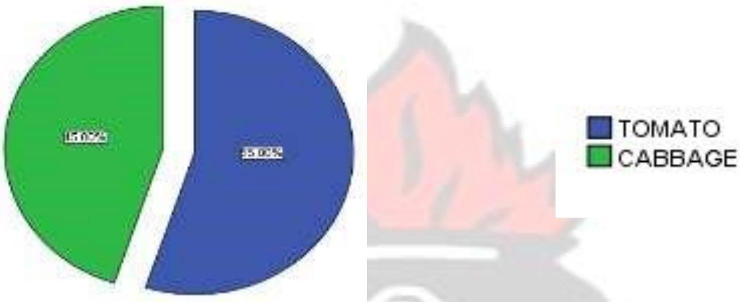


Fig. 13 Produce of farmers

4.2.5 Produce of Farmers

Fig. 13 shows that, out of the 20 farmers that the questionnaires were administered to11 (representing 55%) were tomato farmers, and 9 (representing 45%) were cabbage farmers.

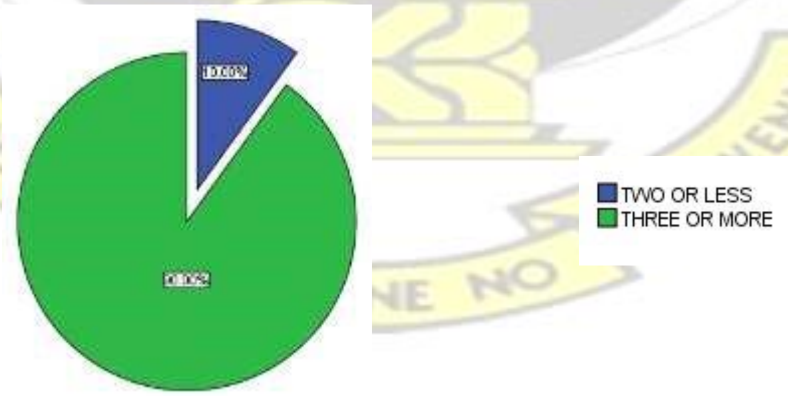


Fig. 14 Number of buyers of produce

4.2.6 Number of Buyers of Produce

Fig. 14 indicates that, of the 20 farmers that the questionnaires were administered to 18 (representing 90%) supplied their produce to more than two market sellers, with only 2 of them (representing 10%) supplying them produce to only one or two market sellers.

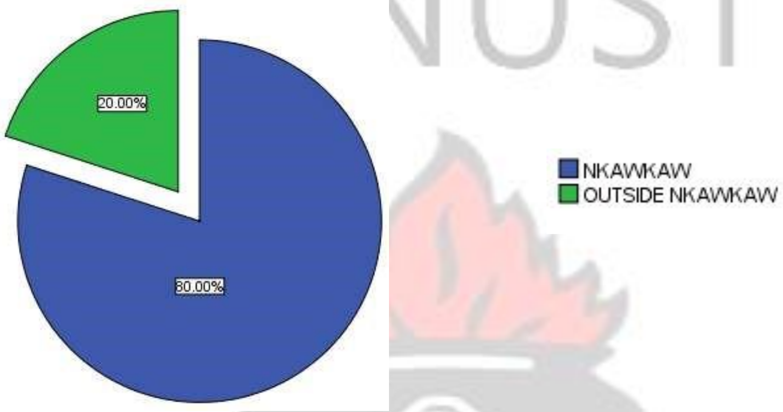


Fig. 15 Location of buyers

4.2.7 Location of Buyers

Fig. 15 shows that, of the 20 farmers that the questionnaires were administered to 16 of them (representing 80%) sold their produce to only Nkawkaw market sellers whereas 4 of them (representing 20%) sold their produce to buyers from Nkawkaw and outside Nkawkaw.

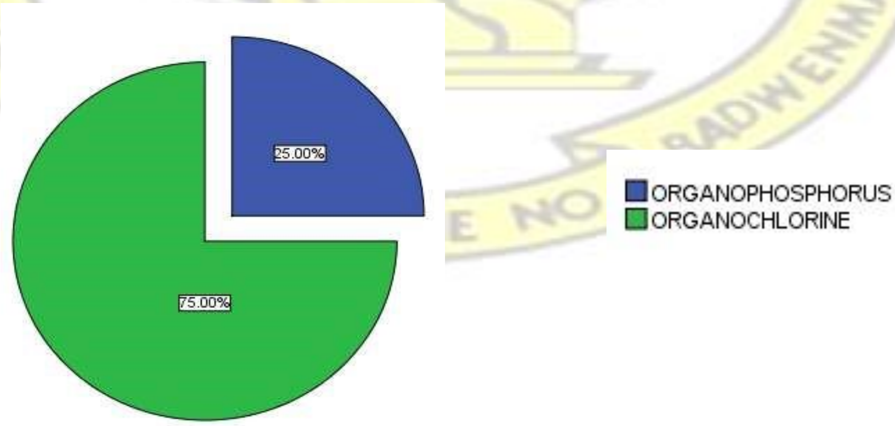


Fig. 16 Types of pesticides used by farmers

4.2.8 Types of Pesticides Used By Farmers

Fig. 16 indicates that, of the 20 farmers that the questionnaires were administered to only 5 of them (representing 25%) used organophosphorus insecticides whereas the remaining 15 (representing 75%) used organochlorine insecticides.

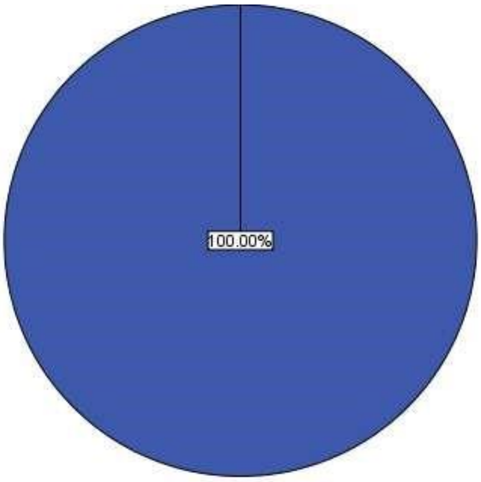


Fig. 17 Spraying times by farmers

4.2.9 Spraying Times by Farmers

Fig. 17 indicates that, all the 20 farmers that the questionnaires were administered to spray their crops more than four times by the time of harvesting the crops.

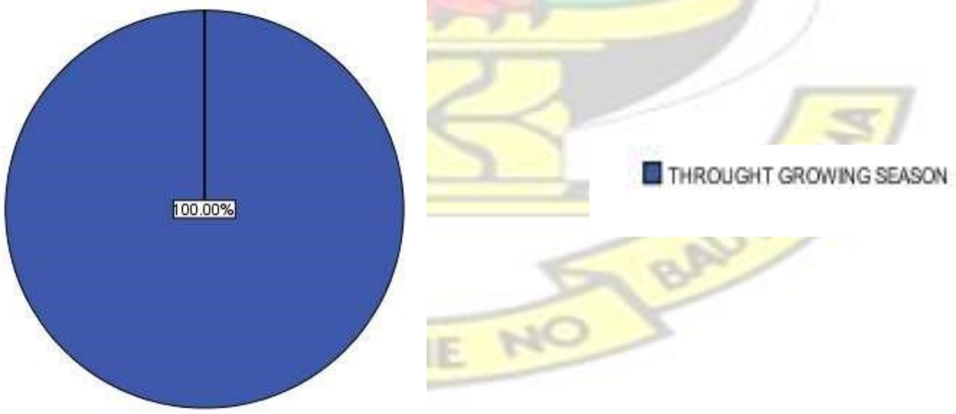


Fig. 18 Time of pesticides application

4.2.10 Time of insecticides Application

Fig. 18 shows that, all the 20 farmers that the questionnaires were administered to sprayed their crops from planting till harvesting. The spraying is done few weeks after germination, then before flowering in the case of tomato, then again, non-poison at flowering. Finally an insecticide is sprayed during fruiting and harvesting.

In the case of cabbage, insecticide is sprayed anytime insects are found on them.

4.4 Organophosphorus insecticide Residual Analysis

Cabbage and tomato samples from Nkawkaw market were analyzed for organophosphorus insecticide residues.

The results of analysis of cabbage and tomato samples for insecticide residues are given in Tables 2 and 3 respectively. The results indicated that Phorate and Ethoprophos were present in the cabbage samples analysed, whilst Profenofos, Chlorpyrifos and Malathion were detected in the tomato samples analysed. The mean concentrations of Ethoprophos were <0.01mg/kg and that of Phorate was 0.02mg/kg in the cabbage samples (Table 2).

The mean concentration of Malathion was <0.01mg/kg that of Chlorpyrifos was <0.01mg/kg and that of Profenofos was 0.47mg/kg (Table 3.

Table 2: Mean Concentration of Organophsphorus insecticide Residue Levels in cabbage.

	Mean concentration (mg/kg)	EU MRLs for cabbage (mg/kg)
Ethoprophos	< 0.01	0.02 (Max)
Phorate	0.02	0.05 (Max)

Table 3: Mean Concentration of Organophsphorus insecticide Residue Levels in tomatoes.

	Mean concentration (mg/kg)	EU MRLs for tomato (mg/kg)
Malathion	< **0.01**	**0.02 (Max)**
Chlorpyrifos	< **0.01**	**0.5 (Max)**
Profenofos	**0.47**	**10 (Max)**

4.3 insecticides sold to Farmers

The results of the interview of agrochemical sellers in Nkawkaw to cabbage and tomato farmers in Nkawkaw and its environs are presented in Table 4.

Table 4: Pesticides sold by Agrochemical sellers to cabbage and tomato farmers in Nkawkaw and its environs to control insect pests

	Common Name (Trade Name)	**Active Ingredients**
1	K Lambda	Cyhalothrin
2	Bossmate 2.5EC	Cyhalothrin
3	Polytrine	Cypermethrin
4	M – Fos	Chlorpyrifos
5	Kombat 25g	Lambda
6	Golan	Acetamiprid
7	Akape	Imidacloprid
8	Attack	Emamectin benzoate
9	Aceta 46EC	Acetamiprid Bifenthrin
10	Protect 1.9EC	Emamectin Benzoate
11	Victory 72WP	Metalaxyl Mancozeb
12	Power 76WP	Cymoxanil Dithiocarbamate
13	Focus Ultra	Cycloxidime
14	Shavit F 71.5WP	Triadimenol Folpet
15	Topsin- M 70%WP	Thiophanate-methyl
16	Mektin 1.8EC	Abamectin
17	Agro Blaster	Pyrethrin
18	Dursban 4E	Chlorpyrifos
19	Sumitex 40EC	Dimethoate
20	Akate suro	Diazinon

CHAPTER FIVE

5.0 DISCUSSION

The market survey revealed that 17 (34%) of the 50 sellers take their supplies from the farmers directly, while 33 (66%) of the 50 sellers take their supplies from middle women. This implies that most of the sellers do not go to the farm to see the kind of chemicals used by the farmers. This is probably the reason why most of them, 41 (82%), do not find it necessary to wash the vegetables before selling them.

Interactions during the interview with the agrochemical sellers in Nkawkaw revealed that over twenty different insecticides most of which are the organochlorines were sold to cabbage and tomato farmers in the area. Even though some of them have different trade names, they contain the same active ingredient. For example K Lambda and Bossmate 2.5EC both contain Cyhalothrin.

Most of the farmers (82%) have had some form of education 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). Questionnaire interviews revealed that, 3 (15%) out of the 20 farmers were between the ages of 20-29, with 11 (55%) of them being between 30-39, 4 (20%) out of 20 farmers were between 40-49, and only 2 (10%) of them were in the 50 years and- above age bracket. The above information suggests that vegetables and for that matter, tomatoes and cabbage farming, is mostly done by strong individuals. That is most of the farmers are in their youthful age. This was revealed in the questionnaire when all the twenty farmers responded that they spray their crops throughout the growing season of the plant. How tedious this work is, is the reason why there are more males than females. Thus, 17 (85%) of them were male, with only 3 (15%) of them being females. With regard to the type of pesticides used on the crops, the farmers mentioned insecticides such as Bossmate 2.5 EC, Golan S L,

Karate 5EC, Dursban 4E, Akate suro etc . Out of 20 farmers that the questionnaires were administered to only 5 (25%) of them, used insecticides that are mostly organophosphorus with the remaining 15 representing 75% using organochlorine insecticides. This could account for the result from the analysis which indicated that only Ethoprophos and Phorate were found in the cabbage samples with mean concentration of <0.01mg/kg and 0.02mg/kg respectively. Then Malathion, Chlorpyrifos and Profenofos were in the tomato samples with mean concentrations of <0.01mg/kg, <0.01mg/kg, and 0.47mg/kg
respectively.

The occurrence of selected organophosphorus insecticides was studied in the cabbage and tomato sold in Nkawkaw market in the Eastern region of Ghana. The pesticides detected were Ethoprophos and Phorate in the cabbage, Malathion, Chlorpyrifos and Profenofos in the tomatoes. However, their concentrations were below the EU maximum residue levels (MRLs) 1996 Guideline Value in mg/kg. This might be due to the less persistence and ability to degrade more rapidly in the environment than organochlorine pesticides. Similar results were obtained by Abou-Arab and Abou Donia (2001) who found that samples of cabbage collected from Egypt contained organophosphorus insecticides particularly, malathion, dimethoate and profenofos at levels ranging from 0.061 to 1.756mg/kg. In 2006, Bai *et al*. (2006) concluded that the OP pesticide residues were present in fruits and vegetables in Shaanxi area of China. According to Anonymous (1996), the maximum residue level (MRL) for chlorpyrifos is 0.5 mg/kg and acceptable daily intake is 0.01 mg per kg body weight in humans, which are below the maximum residue level (MRL).

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

The use of pesticides in controlling different types of pests is one of the essential measures of modern food crops production. However, the residue resulting from misapplication of pesticides on vegetables is of crucial concern not only to the people of Ghana but the international community at large. The aim of the present study was to determine the usage and types of organophosphorous insecticides and their residue levels in the tomato and cabbage sold in the Nkawkaw market. The objectives were to determine: the sources of production of Cabbage and Tomato sold in the Nkawkaw market, the types of Organophosphate insecticides sold to tomato and cabbage farmers by the agrochemical sellers, the frequency and times of administration by the farmers and the concentrations of Organophosphorous insecticides identified in the Cabbage and Tomato sold in the above mentioned market.

Of the fifty sellers, only17 (34%) of them dealt with the farmers directly, while 33 (66%) of the sellers took their supply from middle women. Out of the seventeen (17) farmers who sold their produce directly to the sellers, eleven (65%) of them have their farms located in Nkawkaw and neighbouring areas, three (18%) of the 17 farmers have their farms at Asante Akim Agogo, whilst 3 (18%) of the farmers have their farms at Kumawu in the Ashanti region. It was also realized that, farmers sprayed their vegetables throughout the growing season of the crop. Thus, from planting till harvesting or the crop die out the farmers sprayed the vegetable in order to control pests. Most of the pesticides used by the farmers however, were organochlorine.

From the results of the laboratory analysis, only Ethoprophos and Phorate with mean concentrations of <0.01 and 0.02mg/kg respectively were the only organophosphorous insecticides detected in the cabbage samples.

Malathion, Chlorpyrifos and Profenofos, with their mean concentrations of <0.01, <0.01 and 0.47mg/kg were detected in the tomato samples.

6.2 Conclusion

In conclusion, the results of the chemical analysis showed that, cabbage and tomato sold in Nkawkaw market in the Kwahu West District of the Eastern region may not pose any health risk to the consumers as far as organophosphorous insecticide residues are concerned. Although Malathion, Chlorpyrifos, Profenofos, Ethoprophos and Phorate were detected, their concentrations were far below the maximum residue levels.

Organophosphorous insecticides are less persistent in the environment than organochlorine; this could be the reasons why only a few of the organophosphorous pesticides were detected in the samples analysed in the laboratory.

6.3 Recommendations

It is therefore recommended that:

- Future research should cover organochlorine pesticides as well. Most of the farmers made mention of many pesticides which are organochlorine. The samples analysed attest to the fact that organophosphorous pesticides were not mostly used in the area under investigation.

- Future research should also aim at comparing the mean concentrations of the residue in freshly harvested vegetables from the farm with those sold at the market.

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APPENDICES

APPENDIX 1

AGE OF RESPONDENTS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-29	9	17.6	18.0	18.0
	30-39	19	37.3	38.0	56.0
	40-49	14	27.5	28.0	84.0
	50-59	6	11.8	12.0	96.0
	60+	2	3.9	4.0	100.0
	Total				

Missing System	50	98.0	100.0	
Total	1	2.0		
	51	100.0		

APPENDIX 2

GENDER OF RESPONDENTS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MALE	4	7.8	8.0	8.0
	FEMALE	46	90.2	92.0	100.0
	Total	50	98.0	100.0	
Missing System		1	2.0		
Total		51	100.0		

APPENDIX 3

EDUCATIONAL LEVEL OF SELLERS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NONE	10	19.6	20.0	20.0
	PRIMARY	5	9.8	10.0	30.0
	JHS	30	58.8	60.0	90.0

	SHS	5	9.8	10.0	100.0
	Total	50	98.0	100.0	
Missing	System	1	2.0		
Total		51	100.0		

APPENDIX 4

LENGTH OF TRADING

	YEARS	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A YEAR	5	9.8	10.0	10.0
	TWO YEARS	4	7.8	8.0	18.0
	THREE YEARS	1	2.0	2.0	20.0
	ABOVE THREE YEARS	40	78.4	80.0	100.0
	Total	50	98.0	100.0	
Missing	System	1	2.0		
Total		51	100.0		

APPENDIX 5

TYPES OF COMODITIES

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TOMATO	38	74.5	76.0	76.0
	CABBAGE	6	11.8	12.0	88.0
	BOTH	6	11.8	12.0	100.0

Total	50	98.0	100.0	
Missing System	1	2.0		
Total	51	100.0		

APPENDIX 6

LOCATION OF SUPPLIERS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	FARMER	17	33.3	34.0	34.0
	MIDDLE WOMEN	33	64.7	66.0	100.0
	Total	50	98.0	100.0	
Missing System		1	2.0		
Total		51	100.0		

APPENDIX 7

SOURCE OF PRODUCE

SOURCE	Frequency	Percent	Valid Percent	Cumulative Percent

Valid	NKAWKAW	11	21.6	22.0	22.0
	AGOGO	3	5.9	6.0	28.0
	KUMAWU	3	5.9	6.0	34.0
	MISCELLANOUS	33	64.7	65.0	100.0
	Total	50	98.0	100.0	
Missing	System	1	2.0		
Total		51	100.0		

APPENDIX 8

WASHING OF PRODUCE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	9	17.6	18.0	18.0
	NO	41	80.4	82.0	100.0
	Total	50	98.0	100.0	
Missing	System	1	2.0		
Total		51	100.0		

APPENDIX 9

FARMERS LOCATION

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NKAWKAW	11	64.7	64.7	64.7
	AGOGO	3	17.6	17.6	82.4
	KUMAWU	3	17.6	17.6	100.0
	Total				

		17	100.0	100.0	

APPENDIX 10

AGE OF FARMERS

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 20-29	3	15.0	15.0	15.0
30-39	11	55.0	55.0	70.0
40-49	4	20.0	20.0	90.0
50+	2	10.0	10.0	100.0
Total	20	100.0	100.0	

APPENDIX 11

GENDER OF FARMERS

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid MALE	17	85.0	85.0	85.0
FEMALE	3	15.0	15.0	100.0
Total	20	100.0	100.0	

APPENDIX 12

EDUCATIONAL LEVEL OF FARMERS

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid NONE	1	5.0	5.0	5.0
JHS	19	95.0	95.0	100.0
Total	20	100.0	100.0	

APPENDIX 1
3

LOCATION OF FARMS

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid NKAWKAW	12	60.0	60.0	60.0
KONONGO	8	40.0	40.0	100.0
Total	20	100.0	100.0	

APPENDIX 14

PRODUCE OF FARMERS

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid TOMATO	11	55.0	55.0	55.0
CABBAGE	9	45.0	45.0	100.0
Total	20	100.0	100.0	

APPENDIX 15

PRODUCE SALE OUTLETS

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid TWO OR LESS	2	10.0	10.0	10.0
THREE OR MORE	18	90.0	90.0	100.0
Total	20	100.0	100.0	

APPENDIX 1

6

LOCATION OF BUYERS

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid NKAWKAW	16	80.0	80.0	80.0
OUTSIDE NKAWKAW	4	20.0	20.0	100.0
Total	20	100.0	100.0	

APPENDIX 17

TYPES OF PESTICIDE USED

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid ORGANOPHOSPHORUS	5	25.0	25.0	25.0
ORGANOCHLORINE	15	75.0	75.0	100.0
Total	20	100.0	100.0	

APPENDIX 18

FREQUENCY OF SPRAYING

	Frequency	Percent	Valid Percent	Cumulative Percent

APPENDIX 1

Valid MORE THAN FOUR TIMES	20	100.0	100.0	100.0

9

TIME OF APPLICATION

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid THROUGHT GROWING SEASON	20	100.0	100.0	100.0

APPENDIX 1

APPENDIX 20

PARAMETERS STUDIED IN THE MARKET.

QUESTIONNAIRE TO THE SELLERS IN NKAWKAW MARKET TO FIND OUT THE SOURCES OF THEIR VEGETABLE SUPPLY.

Tick ☑ **where appropriate.**

1. **Profile of the seller:**

(a) .Age: [ ]

(b) .Gender: male [ ] female [ ]

(c)). Education:...

2. How long have you been selling in this market? One yr. ☐ Two yrs.

Three yrs. ☐ Above three yrs. ☐

3. Which of the following commodities do you sell? Tomatoes. ☐ Cabbages.

Both ☐

4. Where do you take your supply? A. From a farmer. ☐ B. from a middle

woman. ☐ C. other ☐

Specify …………………………………………………………………

5. If your supply is from a farmer, where does he/she farm?

....

6. Do you wash your produce before you sell them? Yes. ☐ No. ☐

APPENDIX 21

PARAMETERS STUDIED FROM THE CABBAGE AND TOMATO FARMERS.

QUESTIONNAIRE ADMINISTERED TO FARMERS WHO SUPPLY VEGETABLES TO MARKET WOMEN IN NKAWKAW MARKET TO DETERMINE THE TYPES OF ORGANOPHOSPHATE INSECTICIDES USED, THE FREQUENCY AND TIMES OF ADMINISTRATION.

Tick ☑ **where appropriate.**

(A) PROFILE OF THE FARMER:

(a) Age: [ ]

(b) Gender: male [ ] female [ ]

(c) Education:...

1. Where is your farm located? ....

2. What commodities do you produce? Tomatoes. ☐ Cabbages.

Other ☐

3. (A) How many sellers do you supply your produce to? Two or less.

Three or more ☐

(B) Where do you sell your vegetables? Nkawkaw. ☐ Elsewhere / outside Nkawkaw ☐

Place………………………………………………………………………………

4. Which type of pesticides do you apply on your vegetables?

……………………………………………………………………………………

5. How often do you apply the pesticides on your vegetables? Once.

Twice. ☐ Thrice. ☐ Four times or more ☐

6. What period do you apply the pesticides on the vegetables? Planting. ☐

Growing. ☐ Flowering. ☐ Harvesting. ☐ Throughout the growing season ☐