KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

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COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

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DEPARTMENT OF HORTICULTURE

A SURVEY AND LABORATORY STUDIES ON THE EFFECTS OF THE SOURCES OF IRRIGATION WATER AND PESTICIDES ON POSTHARVEST QUALITY OF THREE VEGETABLES IN THE WA MUNICIPALITY OF THE UPPER WEST REGION OF GHANA

BY

IDDRISU HARISU

JUNE, 2012

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A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF SCIENCE (MSC. POSTHARVEST TECHNOLOGY) DEGREE.

BY

IDDRISU HARISU

JUNE, 2012

DECLARATION

I hereby declare that this submission is the result of my own work towards the award of an MSc. Postharvest Technology programme. This submission to the best of my knowledge contains no previously published materials except where acknowledgements have been cited at the reference site. Any omissions or flaws that may be detected in this work are solely my responsibility.

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DEDICATION

I dedicate this research to the Almighty Allah for his mercy and blessing throughout my educational carrier. I cannot forget of the support and encouragement of my lovely wife Ubaida .B. Hamidu and my children Haazik Sungmaana and Hilmi Junoo.

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ABSTRACT

A study was carried out in the Wa Municipality of the Upper West Region of Ghana to investigate the effects of sources of irrigation water and pesticides on postharvest quality of three vegetables. The objectives of the study were to document the sources of water for irrigation, coliform load in the water sources and the vegetables, The pesticides used and pesticides residue as well as the postharvest treatment methods in the study area using a survey and laboratory experiments were also investigated. One hundred (100) respondents were interviewed comprising 50 farmers and 50 consumers and the survey data analyzed using SPSS version 19. Laboratory assessment of microbial quality and pesticides residue were analyzed using Statistix 9. From the results, the major source of irrigation water used in vegetable productions was dug out wells (88%). The use of watering can and bucket was the commonest irrigation method (82%) used for dry season vegetable farming. Apart from farming, sixty eight percent (68%) of the respondents also used the available water for domestic purposes and another 26% for livestock rearing. Organic fertilizer was the major source of soil amendment applied by the farmers (52%). Cypermethrine, DDT, Lambda and Actelic 25 EC were the most common pesticides used in controlling pests and diseases on the farm in the study area. The major postharvest treatment given to the vegetables was the washing of vegetables in water (45%). It was also observed that 79.5% of the consumers normally obtained their vegetables from the retail market. Some complications associated with the consumption of vegetables included stomach ache (77.5%) and diarrhea (22.5%).

The microbial presence in the irrigation water used and vegetables produced were poor as total coliforms, faecal coliforms, E. coli and Salmonella were recordedx. Heptachlor, Alpha Endosulfan, Endrin, 1, 1-dichloro-2, 2-bis

(4-chlorophenyl) ethylene (PP-DDE), 1, 1, 1-dichlo-2, 2-bis (4-chlorophenyl) ethane (PP-DDT) and Permethrin were pesticides found to be above the International MRL in the vegetable samples.

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CHAPTER ONE

1.0. INTRODUCTION

A vegetable is defined as the edible portion of a herbaceous plant. It can also be said to be the succulent edible plant part that may be eaten as supplementary food or as a side dish in the raw state or cooked form, alone or with meat or fish, in stews, soups and various preparation (Norman, 1992).

Nutritionally, vegetables are important sources of minerals, vitamins, dietary fiber, carbohydrate, proteins and they also add colour, flavor and aroma to consumers' diet (Swaider *et al.*, 1992). Vegetables and their products are usually valued for their nutrients content but they are now regarded as rich source of non-glycerin carbohydrate, collectively referred to as dietary fiber (Rezuanul *et al.*, 2004).

Leafy vegetables which are rich sources of dietary fiber have demonstrated benefits for health maintenance, disease prevention and as components of medicinal nutrition therapy (Rezuanul *et al.*, 2004). Many studies have reported that dietary fiber of leafy vegetables was effective for counteracting obesity, diabetes, hyperlipidemia, colon diseases and constipation (Rezuanul *et al.*, 2004).

Peri-urban and urban vegetable cultivation is increasing in major towns and cities in Africa and Sub- Saharan Africa. With the sharp rise in population, demand for vegetables and other food items are high. In order to meet the increasing demand of vegetable throughout the year it is essential to expand the scope of dry season vegetable farming (Ojo *et al*., 2010).

According to Van Leeuwen (2001), water resources are limited and irrigation is very much labour demanding because in many urban and peri-urban farming, irrigation water is carried by hand from the well, reservoir or river to the field. The adoption of small scale low-cost irrigation technologies by small-holder farmers in Africa has great potential and could be one of the solutions for increasing food production of farmers, income and improving food security.

The use of chemicals in the cultivation of leafy vegetables is high. Most farmers use these chemicals (fertilizers and pesticides) without knowing their harmful effect to human life since they are mostly consumed in the raw state. (Wa Municipal Assembly, 2006).

Quality is the combination of attributes, properties or characteristics that give each commodity value in terms of its intended use. Some of the quality factors include appearance, flavor, texture, nutritional and safety. A number of factors threaten the safety of fruits and vegetables. These include naturally occurring toxicants such as glycol alkaloids, fungal and bacteria toxins, heavy metals, environmental pollutants such as pesticide residue and microbial contamination. While health authorities and scientists regard microbial contamination as the number one safety concern, many consumers rank pesticide residue as their most concern (Kader and Rosa, 2004).

Food borne diseases originating from vegetables and fruits are being reported from many countries. These viruses, bacteria and parasitic diseases affect various numbers of populations, either a few or thousand. It is also reported that vegetables may be exposed to microbial contamination before, during or following harvest. Enteric pathogen may be found in the soil, manure, urban waste and irrigation water (Anon, 2002).

Potable water is limited in the municipality; irrigation dams are few yet dry season vegetable cultivation is high because of the role it plays in the socio- economic life of the people. In the study area people compete with animals for water and the same source of water is also used in the cultivation of vegetables.

It is an undeniable fact that dry season vegetables production plays a major role in the socio economic development of people in Ghana and Wa municipality in particular. It is a source of livelihood for majority of people and also a means to poverty alleviation and household food security. The nutritional value of leafy vegetables cannot be over looked. The consumption of leafy vegetables could affect our health most especially when the source of water is not safe and production practices are in- appropriate. Little or no studies have been carried out on the quality of vegetable crops production (cabbage, lettuce and green pepper) and their effect on health in the study area.

The main objective of the study was to determine the effects of the sources of irrigation water and pesticides on postharvest quality of three vegetables in Wa Municipality.

The Specific objectives for the study therefore were to:

1. Identify the sources of water for dry season vegetable farming
2. Determine the microbial quality of water and that of the vegetables (cabbage, lettuce and green pepper).
3. Identify the available pesticides residue in these vegetables.
4. Identify the common postharvest -treatments of these vegetables.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. Definition of vegetable

A vegetable is defined as the edible portion of a herbaceous plant. It can also be said to be the succulent edible plant part that may be eaten as supplementary food or as a side dish in the raw state or in a cooked form alone or with meat or fish, in stews, soup and various preparation (Norman, 1992).

Vegetables are living tissue of plants that are subjected to continuous changes after harvest because of their characteristics of high moisture, large size, rapid rate of metabolism etc. They can deteriorate rapidly after removal from the plant (Swaider *et al.*, 1992)

2.2. Classification of vegetables

There are various criteria for classifying vegetables, but the use of plant parts in the classification is the most important. This is due to the fact that commodities within the same group (class) usually have the same production practices. Based on this, vegetables can be grouped into three namely: Leafy and succulent vegetables, underground vegetables and fruit vegetables,(Swaider *et al.*, 1992).

2.2.1. Leafy and Succulent Vegetables

Leafy and succulent have relatively low monetary value per unit weight. Within the group are the Amaranthus, lettuce, lettuce, beans, pumpkin, cassava, and corchorous. With the exception of cabbage, leafy and succulent vegetables are traditionally marketed immediately after harvest. They have high water content and large surface to volume to volume ratio that contribute to their susceptibility to water loss and physical damage, (Swaider *et al*., 1992).

2.2.2. Underground Vegetables

This group of vegetables have their edible portion covered in the soil during their growth and development and are exposed to soil borne micro-organism (contamination) during harvesting and handling. They are prone to fungal and bacteria diseases. Onions, shallots, garlic, potatoes and carrots are some of the vegetables in this class (Swaider *et al*., 1992).

2.2.3. Fruit Vegetables

Botanically, fruit vegetables are produce from ripening ovaries and their associate tissue. They include Tomato, Pepper, Okro, Garden eggs and water melon.(Swaider *et al.*, 1992).

2.3. The nutritional value of vegetables

The nutritional value of vegetables as an important source of minerals, vitamins, and dietary fiber has been recognized. In addition these two important aspects, vegetables also supply some amount of carbohydrate, protein and also add colour, flavor and aroma to consumer's diets (Swaider *et al., 1992*). Vitamins such as C, E and K from vegetables help in the maintenance of reproductive system and intercellular materials in tissue and bones as well as blood clotting. They are also a major source of minerals such as iron, calcium and phosphorous (William *et al*., 1991*)*.

2.4. Sources of water for irrigation in the Wa municipality

According to Abdul- Ganiyu *et al.,* (2002) in his studies on the sources of water for urban vegetable production, one third of the population of Tamale is served with portable water while the rest depends on dam and dug out that retains run off from the previous rainy season. He added that ground water availability is limited with a depth ranging from 18-122m, depending on the rock material present beneath the soil horizon. This situation makes vegetable farmers use almost any water that they can lay their hands on regardless of its source especially during the dry season.

A research conducted by Drechsel *et al*., (2006) on sources of water in the three cities of Accra, Kumasi and Tamale revealed that the main source of water for dry season vegetable farming is urban drains. However few of the farmers use pipe born water and treated waste water. The report stated that in Kumasi, water for vegetable cultivation is obtained from polluted rivers and streams. In Tamale the main source of water for growing vegetables is from drains.

Vegetable production using polluted water is a regular practice in Tamale metropolis and large quantities of local leafy vegetables; cabbage, carrots, tomatoes and other crops are being produced using these same resources especially during the long dry season. This is however driven by the demand for water more than the nutrients in the polluted water. (Abdul-Ganiyu *et al*., 2002).

To protect farmers and consumers, the world health organization (WHO) published guidelines for safe use of waste water in agriculture which are currently under revision. The purpose of the (1998) guidelines was to guide design engineers and planners in the choice of waste treatment technology and water management options.

Water, sanitation and hygiene have important impact on health and diseases. Water related diseases include those that are caused by micro-organisms and chemicals in the water people drink. For instance diseases such as schistosomiasis which have part of their life cycle in water (WHO, 1998).

2.4.1. Irrigation Method

Irrigation is the artificial supply of water to the plant. Irrigation method could be formal or informal. Cornish et *al*., (1999) defined formal irrigation as one that is reliant on some form of fixed irrigation structure that was designed and may be operated by the government or a donor which is more than one farm household. On the contrary informal irrigation is one that is practiced by an individual or groups of farmers without reliance on government or a donor.

According to study conducted by Drechsel *et al*. (2006) in the three major cities (Accra, Kumasi and Tamale) on irrigated urban vegetable farming in Ghana, the common irrigation methods include the use of watering can, bucket, sprinkler, motorized and surface irrigation methods.

A research conducted by Kariata *et al.* (2002b; 2003a) also reveal that most of the farmers use watering cans to draw water from dug out wells and streams to the field . Drechsel *et al.* (2002) writing on irrigation stated that bowls and bucket are used to draw water from rivers, streams or dug out as method of irrigation. These farmers come into contact with water by stepping in it while fetching. He added that few farmers however use motorized, sprinkler and overhead irrigation because of the cost involved.

2.5. Quality of water in vegetable production

According to dictionary quality can be define as any of the features that makes a commodity or something what it is: characteristic element and attribute or the degree of excellence a thing possesses. Quality can also be defined as the degree of excellence or superiority or it is the combination of attribute, properties or characteristics that give each commodity value in terms of its intended use (Kader and Rossa, 2004). He added that certain factors such as visual, nutritional, flavor and textural quality are used to determine quality of substances.

2.5.1. Effects of water quality on human health

A report by Drechsel *et al.* (2006) stated that it is possible to introduce restriction to ensure that wastewater is not used to irrigate high risk crops such as leafy vegetables that are eaten raw. Public awareness campaign e.g. through media might steer consumers demand for safer and influence farmers decision making. The author added that political recognition and sustainability of irrigated urban and peri- urban vegetable farming is mostly constrained by the use of waste water. This notwithstanding the best approach to reduce this health risk was to follow World Health Organization guidelines for use of wastewater in Agriculture.

The use of watering cans increases crop contamination more especially on leafy vegetables through spraying with droplets on the leafs of vegetables. Writing on water quality, Drechsel and Varma (2007) indicated that, the recognition of informal irrigated urban farming requires the institutionalization of risk reducing interventions. This has to consider the risk perception of all the actors along the contamination pathway from farmers to the traders and consumers. Irrigation practices that reduce exposure to polluted water and effective vegetable washing before consumption are some of the ways to reduce the health risk.

Farmers who pull water from ponds, streams, canals and ditches must consider the quality of water. Regardless of the irrigation source, it is important to test your water regularly. This will provide a snapshot of water quality at the time of testing and will allow growers to document changes over time. It may also pinpoint periods during the growing season when water quality may be a suspect (Allen, 2006). In addition, one important agricultural practice is to protect and maintain safe irrigation water sources. For example, maintenance of wells and ponds and the prevention of polluted run –off from entering water sources will help reduce the risk of contamination Allen (2006).

A research conducted by Watch *et al*.(2002) on quality of vegetables reported that postharvest quality is threatened by various factors including poor quality irrigation water, which could result in internal contamination of vegetables.

Steele and Odumeru (2004) stated that pipe water, ground water, surface water and waste water from drains are commonly used for irrigation. Pipe and ground water are generally of good quality unless it is being contaminated with surface run- off. Waste water from drains are usually of very poor microbial quality and requires extensive treatment before it can be used safely to irrigate crops. Surface water is of variable quality. Mensah *et al.* (2001) and Obeng *et al.* (2007) said that most farmers use water from wells and streams due to high cost of pipe water but stream or well water are subjected to high rate of environmental pollution in Ghana. Studies on various vegetables had shown association of the commodity with high microbial risk. Donkor *et al.* (2009) also reported that green pepper sold in Accra had high microbial quality than lettuce and cabbage. The study revealed that wide variations were observed in the microbial quality of the three types of water.

Similarly, Eric *et al*., (2010) stated that pipe born water has the better quality than stream and well water. A study by Mensah *et al*., (2001) and Karaita *et al*. (2003a) reported that low quality water is being used for urban vegetables production in most Ghanaian cities. Bacteria can be present as a result of the uptake of water through certain irrigation or washing procedure and if these waters are contaminated with human pathogens, they may also be introduced (EC, 2002). A similar statement have been made by Beuchat (1996) that several factors such as manure, dust, wild and domestic animals, insects and human handling can cause contamination of irrigation water. Eric *et al*. (2010) reported that feacal content of manure based soil (4.7x 10^7 cfu/g/1.8x10^6 cfu/g were similar to that of stream water(5.8x10^7 cfu/ml / 1.6x10^7cfu/ml) and well water (1.6x 10^6 cfu/ml / 2.3x10^5 cfu/ml) and is likely that both may have exerted similarly contamination rates on the vegetables.

2.6. Effects of production practices on quality of vegetables.

According to Allen (2006) recent outbreak of *E. coli*: 0157:H7 on spinach grown in California has put the spotlight on leafy green production and emphasized the need for good agricultural practices. Unfortunately this is not the first time that leafy greens have been implicated in a food borne outbreaks. In the US, there have been 20 outbreaks associated with lettuce or spinach since 1995.

In Ontario, more than 870 hectares green are grown including celery, head and leaf lettuce and spinach. All three crops are grown throughout the season, late into the fall months. Growers of leafy greens take the time to pick the right variety, planting date and field, but it does not stop there. Producers of these crops must ensure good agricultural practices are adhered to, from the time the seed arrives until the product is shipped to the consumer. Obviously it is not possible to negate every possible risk. However there are principles and practices that will help minimize contamination, reduce survival of pathogen and prevent cross contamination (Allen, 2006).

Manure and improperly managed compost may act as reservoir for pathogenic bacteria like *E. coli*. Good agricultural practices require that untreated or partially treated manure are not used in leafy vegetable production because the interval between planting, application and harvest is not long enough to reduce the risk of contamination (approximately 120 days are needed between nutrient application and harvest). According to Allen (2006) farmers using manure as source of plant nutrients must apply the nutrient to the field after final harvest to maximize the interval .The author re-iterated that when purchasing compost farmers should ask of compost documentation to ensure that, the composting process was completed. If you are composting on-farm keep good records –record the treatment procedure and the date treated.

2.7. Quality of vegetables in urban market

According Drechsel et *al* (2006), the use of polluted water is common in Ghana. Consumers of irrigated vegetables are at risk especially those that are consumed in their fresh or uncooked state. The author re iterated that faecal coliform level of lettuce at different entry points starting from the farm to the market. Irrespective of the water source faecal coliform level exceeded the recommended level in the study area. However , a report by Drechsel *et al.* (2006) reveals that on farm crop contamination also takes place under irrigation with pipe born and the source of contamination include soil and frequent application of improperly composted poultry manure. An observation by Mensah *et al*. (2001) indicated that on a small "white" market where (expatriate) consumers ask frequently about produce quality, the sellers change the water to wash their vegetables more often than on other market and reduce indeed the pathogen level.

A research conducted by Drechsel *et al.*, (2006) pointed to the fact that faecal coliform level of vegetables in Tamale ranged from 4.0 x 10^5 to 7.5 x 10^8 for the three vegetables (cabbage, lettuce and spring onions). The authors indicated that total coliform and faecal coliform levels are lower in Kumasi as compared to Accra and Tamale. The reason for the variation in quality of vegetables in the three major cities as observed by Drechsel *et al*. (2006) could be both on farm and postharvest handling of vegetables. Drechsel *et al*,,(2006) and Cornish *et al*. ,(1999) found out that many farmers used shallow wells along the stream with better water quality in Kumasi than in Accra and Tamale. These authors re iterated that, majority of the farmers in Accra and Tamale draw water from drains which are of poor quality.

Riser *et al*. (1984) revealed that, total count on hydroponic grown lettuce of $1.7x10^6$ cfu/g. These counts may be due to the different cultivation practices including irrigation and handling of crops. Eric *et al*., (2010) writing on internalization of vegetables in Ghana recorded an overall mean count of vegetables of $4.0x10^3$ cfu/g; $8.1x10^2$ cfu; 2.0×10^2 cfu/g; 3.5×10^2 cfu for total bacteria, total coliform counts, faecal coliform counts and yeast count respectively.

The author emphasized that, the rate of internalization of coliform in vegetables irrigated with stream/well water was 2.7 times higher than those irrigated with pipe born water. The mean coliform count of 4.7×10^7 and feacal coliform count of 1.8×10^6 cfu/g of soil sample were similar to those of stream water suggesting that both sources exerted similar contamination rate on the vegetables. The study found out that microbial contamination of vegetables in Ghana is not limited to the external surface but the internal part could also harbor microbial load and pose risk to consumers. Thus safety practices associated with commodity should therefore not be limited to the external washing only. There is the additional need of heating vegetables to eliminate microbes both externally and internally before consumption. Penteado (2007) observed that 27.5% of vegetables sampled were sterile as judge by the absence of bacteria and fungi. However internalization have been reported by several other writers. The same author reported that exposing mangoes to10^7 cfu/ml salmonella enteritis resulted salmonella internalization at frequency of 80% and 87% for matured and ripe mango. Eric *et al.*, (2010) noticed that the level of coliform counts of a higher proportion of the samples (42.0%) were high.

Writing on the quality of vegetables on the market by Drechsel *et al*., (2006) point to the fact that farmers in their quest to control pest and diseases use band chemicals such as DDT, Endosulfan, Lindane and Chlorphyrifos. Most of these chemicals are highly toxic and persist in the environment causing serious threat to the health of producers and consumers. They added that majority of farmers do not perceived the health risk as compared to the yield.

Another report on pesticides residue by Okorley and Kwarteng, (2002) stated that Dursban is the major pesticide use in the central region and endosulfan and lindane are among the band/restricted chemicals.

2.8. Postharvest handling of vegetables

2.8.1. Harvesting and Packing

Many leafy vegetables are harvested and packed in the .However; some do received further processing including washing and individual packaging. It is important that all equipment that comes into contact with leafy vegetables, whether in the field or packing shed, is cleaned on a regular basis, knives, containers and baskets should be sanitized between users. All processing water should be sampled on regular basis. If your operation uses recalculated water, ensure that practices are in place to reduce the risk contamination though the use of sanitizers or frequent changes of water (Allen, 2006).

2.8.2. Transportation

Unfortunately, the risk of contamination does not end when the produce leaves the growers premises. The risk of microbial pathogens and reduce quality can increase during transportation if proper temperature are not maintained. In fact temperature abuse anywhere along the food chain can turn a small problem into a large problem due to rapid growth of bacteria.

2.8.3. Worker sanitation

Washing of hands is an effective way to minimize worker based contamination. If running water is not available, supply workers with water free from contaminants and sanitizers, ensure field workers have access to washroom facilities that maintained and serviced (Allen, 2006).

It is reported that postharvest contamination might occur during transportation or in the market. This is due to poor sanitation facilities and lack of water supply for personal hygiene as well as washing and refreshing of vegetable. Display of vegetables on the ground instead of table is an additional source of contamination. It is important that authorities not to ignore informal vegetable markets in their efforts to improve cleanliness in the markets. The authors added that an important option for complementary risk reduction is washing and disinfection of vegetables at home and at food outlet. This is a common practice in develop and developing countries (htt:p//www.cityfarmers.vegis.org /Ghana irrigated vegis).

2.8.4. Market Handling

In Ghana, market women employ different handling techniques to various products depending on their kind. Produce are heaped on the ground, or into bigger basins or baskets, subjecting them to impact and static loading. Some of them are squashed as a result of compression (loading). The squashed ones are scarcely removed or sorted out of the lot, with consequence of being infected by bacteria and fungi at the points of injury. Thus, inappropriate sorting of the produce at the market can cause deterioration before the produce gets to the final consumer. In the market, for example, tomatoes are usually handled in crates or boxes that can be lifted and emptied readily (Ware *et al*, 1975). As a result of the perishable nature of tomato fruits, there is the need to handle them with care at the market. Inappropriate handling of produce brings about losses, both in quantity and quality. The losses incurred after harvest is due to high temperatures, unsatisfactory handling, storage and transportation (Norman, 1992).

2.9. Health issues

Microbial infections of food borne origin are a major public-health problem internationally and are significant cause of death in developing countries (WHO, 2006).

Thus the 2006 WHO guidelines for safe waste water irrigation presented on one of several concepts. However, although, different terminologies are used, there is considerable agreement on the best way forward. The best known initiative according to the author is Codex Alimentarius which calls upon countries to work towards international food safety and quality standard.

2.10. Pesticides residue and the effect on vegetables

A study conducted by the consumers union, the publisher report magazine examines and rates the residual level on many vegetables and fruits. The report by the environmental working group using data from the US food and drug board administration has found that much of the health risks associated with pesticide residue are concentrated in a relatively small number of fruits and vegetables.

The US food and drug administration maintains that consuming pesticides in low amount is harmless but some studies reported an association between pesticides and health problems such as cancer, attention deficit disorder (hyperactivity) and nervous system disorder. The report indicated that exposure to pesticides could lead weak immune system (http:www.eartheasy.com).

According to a study by Sharada (1998) on pesticides residue on vegetables in Mysore indicated that vegetables sold in the area are harvested and sold fresh. The author pointed out that as many as 514 samples collected over four different seasons were checked for pesticide residue level.

A similar survey conducted by Seth *et al*. (1998) in different state of the country on pesticide residue level produce varying result of minimum residue level. Karanth (2000), writing on notorious chemicals is of the view that DDT and BHC (HCH, gammaxane and lindane) are particularly important .In India DDT and BHC were the two major chemicals in Agriculture and public health programs. DDT persist with a half-life of about ten years; with a minor conversion to PP, DDE and DDT. The uptake and accumulation of DDT and metabolites in different plants and animal species Varies considerably.

According to a new report from the environmental working group. The group, a nonprofit organization focused on public health, scoured nearly 100,000 produce pesticide reports from the US Food and Drug Administration to determine what fruits and vegetables we eat have the highest and lowest amount of chemical residue. The most alarming are the fruits and vegetables dubbed the "Dirty Dozen" which contain 47 to 67 pesticides per serving. These foods are believed to be most susceptible because they have soft skin that tends to absorb more pesticides.(http://article.CNN.com/2010/-06-01/dirty dozen produce)

"Its critical for people to know what type of vegetables they are consuming". The environmental working groups Army Rosenthal said "the list is based on pesticide test conducted after the produce was washed with USDA high power pressure water system. The numbers reflect the closest thing to what consumers are buying at the source". The group suggests limiting the consumption of pesticides by purchasing organic for the 12 fruits and vegetables. The author indicated that "you can reduce your exposure to pesticide by up to 80 percent by buying the organic version of the "Dirty Dozen". Rosenthal added that the "The Dirty Dozen" vegetables include lettuce and sweet pepper of the non-organic clean vegetables which includes: onion, and cabbage. .(http://article.CNN.com/2010/-06-01/dirty dozen produce)

Another report by Clarke *et al.*,(1997) indicated that pesticides are used to decrease crop loss both before and after harvest. That pesticide is a direct result of the application of pesticides to crop growing in the field, and to a lesser extent from pesticide residue remaining in the soil (Businelli *et al.*, 1992).

Writing on pesticide residue, Freidberg (2003) and Pretty and Hine (2005) revealed that many pesticides are toxic substances and persistent in character. There is a growing social desire to reduce the use of pesticides in Agriculture and Horticulture.

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1. Background of the study area

The study was conducted in five vegetable-producing communities (Sing, Busa, Zingu, Charia, and Wa) in the Wa Municipality of the Upper West Region.

3.1.1. Location

The Upper West Region is located in the north-western corner of Ghana. It stretches from latitude $9^{o}35^{l}$N to 11^{o}N and from longitude 1^{o} 25^{l} W to 2^{o} 50^{l}W. The area falls under the Guinea savanna ecological zone. In the Guinea savanna the vegetation is characterized by pro-climax tree species. The vegetation is the savanna woodland comprising of scattered trees and sparse ground cover of grasses. The predominant trees also include *Parkia biglobosa* and *Vitellaria paradoxa* and other species like *Diospyros mespuliformis Daniella species* and *Balanitis aegyptiaca. Vitellaria paradoxa* and *Parkia biglobosa* are very common as they are protected for their economic value

The vegetation in the area has been degraded as a result of annual fires and human population pressure.

The climate of Upper West Region is characterized by short term single- peak rainfall regime and a long dry season from October to the end of April with temperature rising to between 36^{o}Cto 42^{o}C. The rainfall pattern is a result of the region's location in the sub-equatorial zone with changing wind regimes in the course of the year. During the dry season, the area is under the influence of the dry north-eastern trade wind (Harmattan). The relative humidity of the area during the dry season is normally low, less than 50% but rises steadily to about 80% in the wet season. The mean annual rainfall is about 1111mm and the rainfall distribution varies considerably from year to year. In some years, the first rains start in April and May. This is followed by a short dry spell of about three to five weeks resulting in serious crop damage. (Wa Municipal Assembly, 2006).

The geology of the area is dominated by sandstone, and the soils are the savanna ochrosols, which get eroded by wind or water. The area is generally undulating with few hills and has an altitude of about 180m to 450m above sea level. (Wa Municipal Assembly, 2006).

3.2. SAMPLING PROCEDURE AND SAMPLE SIZE

3.2.1. Source of data

A base line survey was conducted through the administration of questionnaire. Both primary and secondary data were collected from farmers, consumers, Ministry Of Food and Agriculture (MOFA), Savannah Agricultural Research Institute (SARI), Non Governmental Organization (NGO's) and the Internet. The information was obtained on the sources of water use in vegetable production and how it affects produce quality.

3.2.2. Field survey

The purpose of the study was to seek the views of farmers and consumers on the extent to which production practices can negatively affect the quality of leafy vegetables produced in the study area. A total of one hundred and (100) respondents were selected for the administration of questionnaire. Fifty (50) farmers and fifty (50) consumers. A multi-stage sampling technique was adopted to select the respondents. Purposive sampling was use to select five (5) communities out of a total of fifteen (15) vegetable farming communities in the municipality. Ten (10) farmers were selected purposely from each community for the interview. However, random sampling technique was use to select (50) consumers from Wa municipality for the administration of questionnaire. Data were collected on the demographic characteristic of respondents, sources of water, methods of irrigation, application of plant nutrients, types of pesticides, sources of vegetables for consumption and postharvest treatment of vegetables before consumption in the Wa Municipality.

3.2.3. Data Analysis for the Survey

The survey data collected were analyzed using the Statistical Package for Social Scientist (SPSS) version 19. The results obtained were presented in tables and graphs (pie and bar charts). One sample t-test analysis was performed on the individual questions asked to assess whether there are differences in the responses given.

3.3. laboratory work

The purpose of the laboratory analysis was to determine the microbial contamination and the presence of chemicals (pesticides) in the irrigation water and vegetables.

3.3.1. Microbial contamination of Irrigation Water used in Vegetable Production

3.3.1.1.Sampling procedure

Stratified sampling technique was used .In this circumstance each of the sources of water identified was considered as a stratum. Samples were taken at random from each stratum in bottles and placed in an ice chest containing the samples of the vegetables with ice blocks placed on top before it was transported to the Micro biology laboratory of the Kwame Nkrumah University of Science and Technology, Kumasi for the microbial analysis.

The municipality was put into two clusters, samples of each of the three vegetables (cabbage, lettuce and green pepper) were put together and samples from each of the cluster was taken for microbial and chemical residue test. The vegetables samples were kept in black polythene bags. The black polythene bags containing the vegetables were kept in an ice chest. Ice blocks were placed on top of the samples before transporting them together with the bottles containing the water samples. The samples were conveyed to the Microbiology laboratories at the Kwame Nkrumah University of Science and Technology, Kumasi. The microbial test of both the water and vegetables were done at the Microbiology Laboratory whiles the pesticides residue test was conducted at the National laboratory of Ghana Standard Board in Accra.

Table 3.1: **Water sampling for laboratory analysis**

Cluster/Water Source	Wa East	Wa West
Dug Out	One Sample	One Sample
Dam	One Sample	One Sample

Table 3.2: Sampling vegetables for laboratory analysis

Sample/Vegetables	Wa East	Wa West
Cabbage	One Sample	One Sample
Lettuce	One Sample	One Sample
Green Pepper	One Sample	One Sample

3.3.2.1. Determination of total and faecal coliform

The most probable numbers (MPN) was used to determine the total and feacal coliform in the samples. Serial dilution of 10^{-11} were made by picking 1ml of the samples into 9ml sterile distilled water. One millimeter aliquots from each of the dilution was inoculated into 5ml of Mackonkey Broth with inverted Durham tubes and incubated at 35^{o}c for the total coli forms and 44^{o}C feacal coli forms for 18-24hours.Tubes showing colour change from purple to yellow and gas collected in the Durham tubes after hours were identified as positive for both total and faecal coliforms. Counts per 100ml were calculated from Most Probable Numbers (MPN) tables.

3.3.2.2. Determination of *E .coli* (Thermo tolerant coliform)

From each of the positive tubes identified a drop of dilution was transferred into a 5ml test tube of trypton water and incubated at 44^{o}C for 24hours. A drop of kovacs reagent was then added to the tube of trypton water. All tubes showing a red ring colour development after gentle agitation denoted the presence of indole and recorded as presumptive for thermo tolerant coliform (*E.coli*). Counts per 100ml were calculated from the Most Probable Numbers (MPN) tables.

3.3.2.3. Determination of Salmonella

Prepared 10ml of manufactured formulae of Buffered Peptone Water (BPW) was kept in a universal bottle and serial dilution of samples added to it. It was incubated at 37^0C for 24hours, and then 0.1ml of the sample from the BPW was placed in a 10ml of selenite broth in universal bottle and incubated at 44^0C for 48hrs. Swaps from the bottle were dropped onto SS agar and incubated at 48hrs at 37^0C. Black colonies on the SS agar indicated the presence of salmonella.

3.3.2.4. Determination of multi pesticide residues on the three vegetables (cabbage, lettuce and green pepper)

The Quick, Easy, Cheap, Effective, Rugged and Safe (QuEChERS) mini multi-residue method for the analysis of pesticide residues was used. In this method a representative sample of the three vegetables (cabbage, lettuce and green pepper) was cut coarsely into 3×3cm with a knife and blended using a Warren blender. Ten grammes (10g) each of the vegetables homogenate was placed in a 50ml centrifuge tube with screw cap. Ten (10ml) of acetonitrile was added to each sample and shaken vigorously for 1min. A mixture of 4g of Magnesium sulphate anhydrous, 1g of Sodium chloride, 1g of Trisodium citrate dehydrate and 0.5g disodium hydrogen citrate sesquuihydrate was added to each of the samples and shaken vigorously for another 1 min. The samples were centrifuged at 3000rpm for 5min each.

After centrifuging, a 6mL aliquot of the extract was transferred into a polypropylene-single use centrifugation tube containing 150mg Primary Secondary Amine and 900mg magnesium sulphate. The tube was shaken vigorously for 30 seconds and centrifuged at 3000 rpm for 5 min. 4ml aliquot of the extract was again transferred into a round bottom flask and acidified with 40ml of 5% formic acid in acetonitrile and concentrated to dryness using a rotary evaporator. The cleaned and acidified extract was reconstituted in ethyl acetate and transferred into auto sampler vials. The determination of analyte was done with the gas chromatography technique.

3.3.3. Laboratory Data Analysis

The data collected were subjected to Analysis of Variance (ANOVA) and mean separation was done using the least significant differences (Lsd) at P=0.05. Two sampled T-test was also performed to test the hypotheses set for the water quality, microbial load on the vegetables and pesticide residue from the two locations. The statistical packaged used was Statistix version 9 software.

The following were the hypotheses tested:

1. H_o – The microbial quality of water from the two locations are the same.

   H_1 - The microbial quality of water from the two locations are not the same.

2. H_o – The microbial load on the vegetables (lettuce, cabbage and green pepper) sampled from the two locations are the same.

   H_1 - The microbial load on the vegetables (lettuce, cabbage and green pepper) sampled from the two locations are not the same.

3. H_o – The pesticide residue levels in the vegetable crops from the two locations are the same.

   H_1 - The pesticide residue levels in the vegetable crops from the two locations are not the same.

CHAPTER FOUR

4.0. RESULTS

4.1. FIELD SURVEY

4.1.1. Demographic characteristics of farmers engaged in vegetable production

4.1.1.1 Gender of Farmers.

Table 4.1 shows the gender of farmers. There were significant differences in the gender of the respondents at P>0.05 (Appendix 1a).

Majority of the farmers were males representing 78.0% of the population while 22.0% were females

Table 4.1: Gender of farmers engaged in vegetable production

Gender	Frequency	Percentage (%)
Male	39	78
Females	11	22
Total	50	100

4.1.1.2 .Age Distribution of farmers engaged in vegetable production

It could be inferred from Table 4.2 that, majority of the respondents fall within the age group of 20-29 years which represents 40% of the respondents. The age group of 30-39 years was the second largest which represents 30% while 40-49 years age group recorded only 16%. Ten percent 10% of the respondents were between 50-59 years. The lowest age group size was that of less than 20 years and above 60 years. These accounted for 2% each. There were significant differences between the ages of the respondents at P>0.05 (Appendix 1a).

Table 4.2: Age distribution of farmers engaged in vegetable production

Age	Frequency	Percentage (%)
Less than20 years	1	2.0
20-29 years	20	40.0
30-39 years	15	30.0
40-49 years	8	16.0
50-59 years	5	10.0
60years above	1	2.0
Total	50	100.0

4.1.1.3. Educational background of farmers engaged in vegetable production

From Table 4.3, it could be inferred that majority of the farmers had no formal education which represented 64% of the respondents. Few of the total respondents that took part in the research had some form of basic education and this accounted for 30.0% of the total. Only 6.0% of the total had secondary education. Significant differences were realized in the level of education of the respondents at P>0.05 (Appendix 1a).

Table 4.3: Educational level of farmers engaged in vegetable production

Education	Frequency	Percentage (%)
No education	32	64.0
Primary/basic	15	30.0
Secondary	3	6.0
Total	50	100.0

4.1.2. Sources of Irrigation Water for Dry Season Vegetable Farming

Table 4.4 indicates that majority of the farmers (88%) who took part in the research fetched water from dug-out wells to irrigate their farms. The least figure (2.0%) obtained their water from dams. There were significant differences between the number of farmers using dugout water and dam water for irrigation in the Wa Municipality at P>0.05 (Appendix 1a).

Table 4.4: Sources of irrigation water

Source	Frequency	Percentage (%)
Dug- out wells	44	88.0
Dam	6	12.0
Total	50	100.0

4.1.3. Methods of Irrigation for the Dry Season Vegetable Farming in the Wa Municipality.

Table 4.5, revealed that the use of bucket and perforated calabash (watering can) is the most common form of irrigation as reported by 82.0% of the respondents (table 4.5). The least number of respondents (12.0%) use canal irrigation. Appendix 1a revealed significant differences between the two methods of irrigation used by farmers in the Wa Municipality at p>0.05.

Table 4.5: Methods of irrigation for the dry season vegetable farming in the Wa Municipality.

Irrigation	Frequency	Percentage
Watering can and bucket	41	82.0
Canal irrigation	9	12.0
Total	50	100.0

4.1.4. Other Uses of Water Apart From Irrigation

From Table 4.6 majority of farmers, representing 68.0%, used the water for domestic purposes in addition to irrigation. Twenty six percent of the respondents for their livestock. While using water for construction is the least (30%). There were significant differences between the three other uses of the sources of water apart from irrigation at P>0.05 (Appendix 1a).

Table 4.6: Other uses of water aside irrigation

Other uses of water	Frequency	Percentage (%)
Domestic	34	68.0
Livestock	13	26.0
Construction	3	3.0
Total	50	100.0

4.1.5. Types of fertilizers used by farmers in the Wa Municipality

As indicated in Table 4.7, majority of the farmers (52%) used organic fertilizer. The second largest number of respondents (30%) used both organic and in-organic fertilizer. Those who use only in-organic fertilizer were in the least, representing 18.0% of the respondents. Appendix 1a reveals that significant differences exist between the types of fertilizers farmers used in the Wa Municipality at P>0.05.

Table 4.7: Types of fertilizers used by farmers in the Wa Municipality

Nutrient applied	Frequency	Percentage (%)
Organic fertilizer	26	52.0
In-organic Fertilizer	9	18.0
Organic and in-organic fertilizer	15	30.0
Total	50	100.0

4.1.6. Types of Pesticide Used To Control Pest.

From Table 4.8, it could be inferred that, Lambda cyhalothrine was the most widely used pesticides 40%, followed by cypermethrine (26%) . DDT was the third most widely used pesticides (14%), whilst Actelic 25EC was the least used pesticide (2%). Appendix 1a revealed significant differences between the types of pesticides used by farmers in the Wa Municipality at p>0.05.

Table 4.8: Types of pesticides used in vegetable production.

Type	Frequency	Percentage (%)
Cypermethrine	13	26.0
DDT	7	14.0
Lambda cyhalothrine	20	40.0
Actelic 25 EC	10	2.0
Total	50	100

4.1.7. Demographic characteristics of consumers.

4.1.7.1. Age and occupation of consumers in the Wa municipality.

Table 4.9, shows that majority of the respondents were within the age range of 20-29 years which represents 36.4%. The age range of 30-39 years was the second largest with only 27.3%, followed by those in the 40-49 years (22.7%) and the 0-20 years, with only 6 respondents, representing 13.6% of the respondents. The age distribution of respondent were significantly different at p>0.05. (Appendix 3b).

From table 4.9, 56.8% of the respondents were unemployed. Teaching as an occupation accounts for 27.3% of the respondents. Trading and nurse profession were also indentified which accounted for 4.5% each. While farming, administration and tailoring accounted for 2.3% each. There were significant differences between the occupational distribution of respondent at p>0.05. (Appendix 3b).

Table 4.9: Age and occupation of consumers

Age(years)	Frequency	Percentage	Occupation	Frequency	Percentage
Less than 20	5	11.4	Unemployed	25	56.8
20-29	14	31.8	Teaching	12	27.3
30-39	12	27.3	Farming	1	2.3
40-49	10	22.7	Nurse professional	2	4.5
50-59	2	4.5	Trading	2	4.5
60 and above	1	2.3	Tailoring	1	2.3
			Administrator	1	2.3
Total	44	100	Total	44	100

4.1.7.2. Educational level of consumers in the Wa Municipality

Table 4.10 shows that 49% of the respondents had no formal education while 11% each had University and secondary education. Only 9.1% of the respondents had primary /basic education.The educational level of respondents were statistically significant at p>0.05 (Appendix

3b).Table 4.10. Educational level of consumers

Educational level	Frequency	Percentage
No education	18	40.9
Primary/basic	4	9.1
Secondary/Post-secondary	11	25.0
University	11	25.0
Total	44	100

4.1.8. Postharvest treatment of vegetables by consumers in the Wa Municipality

The results in Table 4.11 indicated that 45% of the respondents used water to wash the vegetables. Thirty two percent (32%) washed the vegetables in salt solution, while 23% used vinegar to disinfect the vegetables. Analysis of variance in Appendix 1a indicated significant differences among the various postharvest treatments by consumers in the Wa Municipality at $P>0.05$.

Table 4.11: Postharvest treatment of vegetable by consumers in the Wa Municipality

Treatment	Frequency	Percentage (%)
Wash with water	20.0	45.0
Salt solution	14.0	32.0
Vinegar	10.0	23.0
Total	44.0	100

4.1.9. Sources of vegetables for consumption

As shown in Figure 4.1, majority (79.5%) obtained vegetables from market retailers. Thirteen percent (13%) obtained their vegetables from farmers, whiles 6.8% buy from food vendors. Significant differences exists between the three sources of vegetables used by consumers in the Wa Municipality at $p>0.05$. (Appendix, 1b).

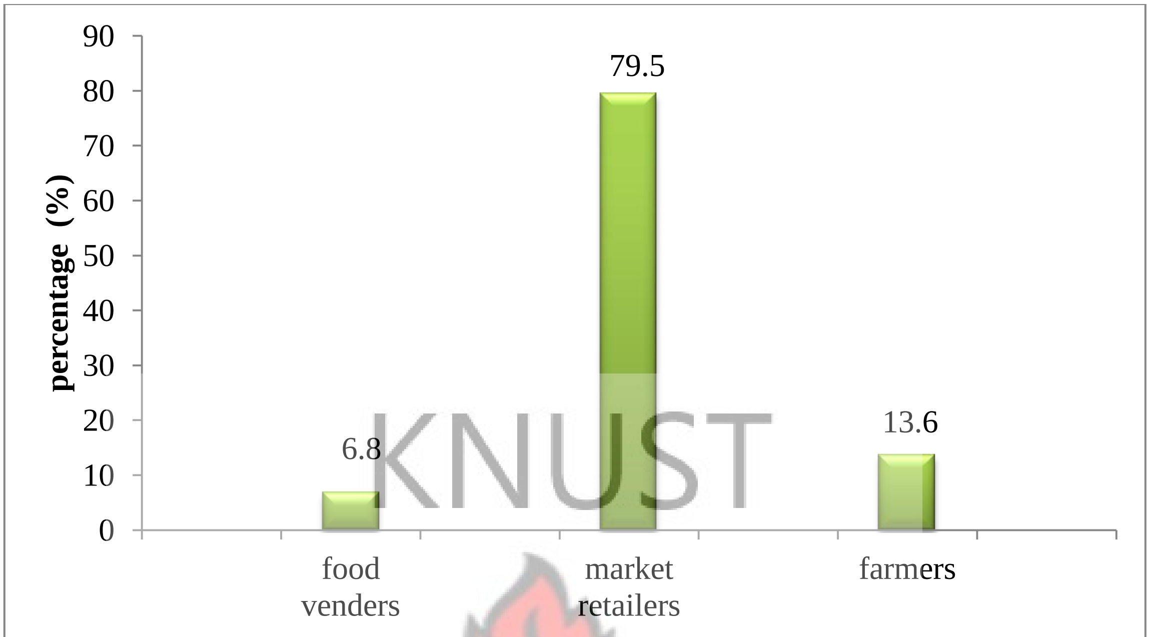

Figure 4.1: Sources of vegetables for consumption in the Wa Municipality

4.1.10. Reasons why vegetables were not safe for consumption in the Wa Municipality

Majority, (52.3%) of the farmers are of the view that contaminated water is used to irrigate the vegetables (Figure 4.2). The second highest reason (27.3%) for unsafe consumption is the poor handling of vegetables at the market. Only 20.4% of the respondents were of the view that vegetables are not safe for consumption because chemicals are used. Appendix 1b revealed significant differences existed between the reasons given for unsafe for consumption in the Wa Municipality at $p>0.05$.

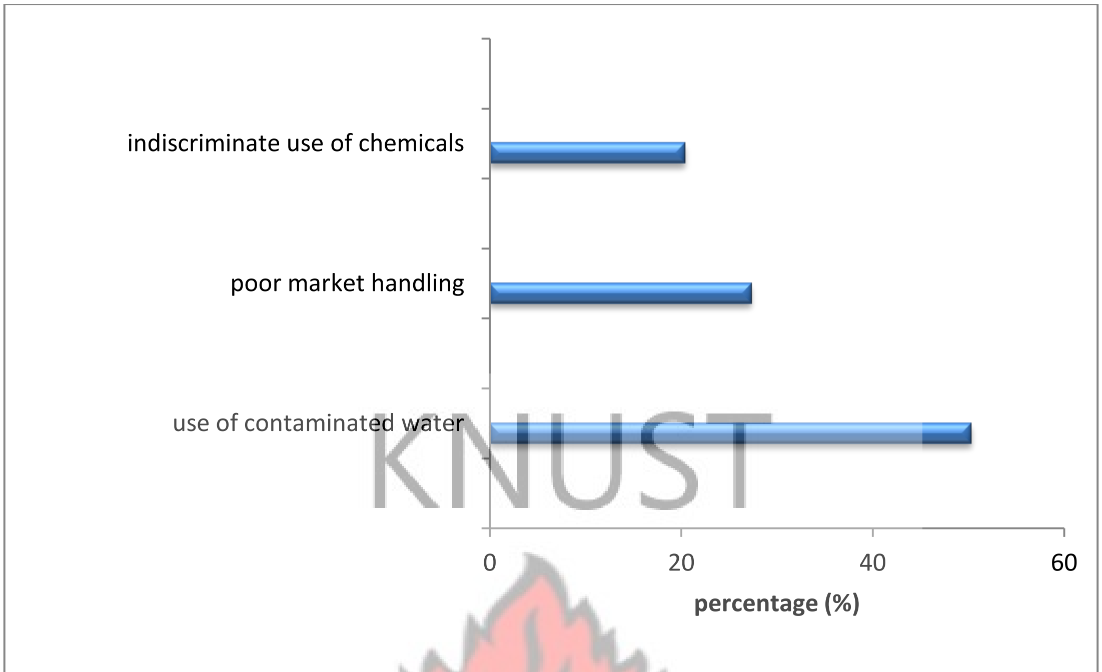

Figure 4.2: Reasons why vegetables were not safe for consumption in the Wa Municipality

4.1.11.Problems associated with consuming fresh vegetables in the Wa Municipality

As shown in Figure 4.3, there were significant differences recorded with diarrhea and stomach ache attributed to consumption of vegetables. Diarrhoea was given as the major problem associated with consuming fresh vegetables (77.5%). Only 22.5% indicated stomach ache as a problem associated with consuming fresh vegetables.

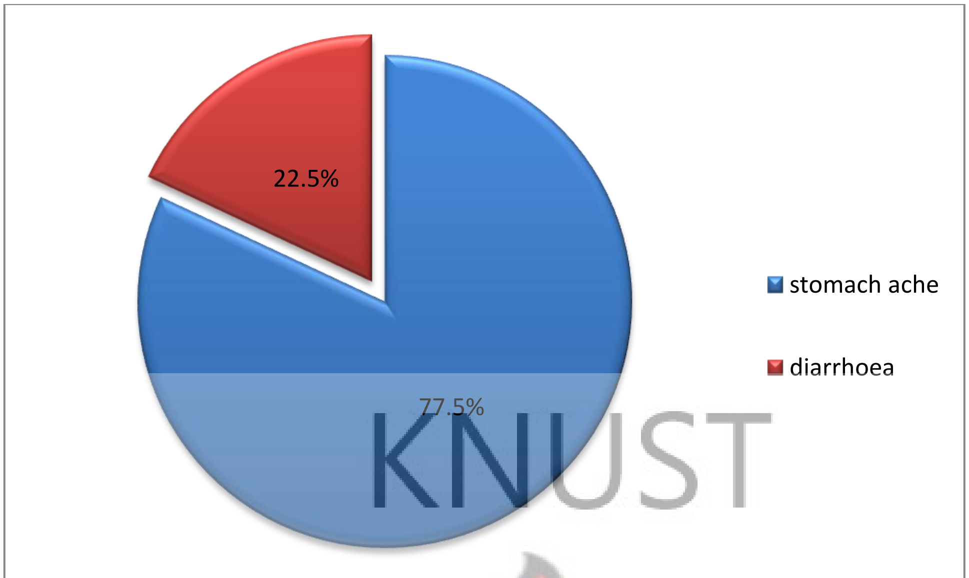

Figure 4.3: Problems associated with consuming fresh vegetables in the Wa Municipality

4.2. Microbial content of irrigation water used in the Wa Municipality

4.2.1. Microbial content of water from two different locations

The results from the microbial quality analysis conducted on irrigation water at the two different locations in the Wa Municipality are represented in Table 4.12. Total coliform and faecal coliform count were higher at Wa East than at Wa West but *E.coli* count was higher at Wa West than at Wa East. Significant differences were observed in total coliform count and faecal coliform count in the two locations ($P<0.05$). However, E. coli counts were not significantly different at the two location ($P>0.05$).

Table 4.12: Microbial content of the water from two different locations

Microbial count	Location	Means	df	t-value	p-value
Total coliform (log cfu)	Wa East	3.24	10	5.32	0.0003
	Wa West	2.55			
Faecal coliform	Wa East	2.14	10	2.58	0.0273
	Wa West	1.45			
E. coli (log cfu)	Wa East	1.55	10	-0.44	0.6726
	Wa West	1.70			

4.2.2. Microbial content in the different irrigation water sources

Results of the analysis conducted on the microbial quality of different irrigation water used in the Wa Municipality are presented in Table 4.13. Total coliform and faecal coliform count were higher in water from the dugout wells than water from the dam but *E.coli* count was higher in water from the dam than water from the dugout well. However, no significant differences in total coliforms, faecal coliforms and *E. coli* counts were observed among water from the dam or dugout wells used in the Wa Municipality (P>0.05).

Table 4.13: Microbial content of irrigation water sources

Microbial count	Location	Means	df	t-value	p-value
Total coliforms (log cfu)	Dam	2.78	10	-0.97	0.3534
	Dug out	3.01			
Faecal coliforms (log cfu)	Dam	1.59	10	-1.27	0.2320
	Dug out	2.00			
E. coli (log cfu)	Dam	1.70	10	0.47	0.6505
	Dug out	1.55			

4.3. Microbial content in the three vegetables sampled from two locations in the Wa Municipality

4.3.1 Total coliform count.

4.3.1.1Total coliform in vegetables from the two sites

Table 4.14 shows the total coliform count on the vegetables obtained from the two locations. Wa West recorded significantly the highest total coliform count of 4.14 cfu than Wa East which recorded a total coliform count of 3.82 cfu ($P<0.05$)

Table 4.14: Total coliforms in vegetables from two locations

Location	TC (log cfu)
Wa East	3.82 a
Wa West	4.14 b

4.3.1.2. Total coliforms on the three different vegetables

Table 4.15 also shows the total coliform count on the three vegetables sampled. Lettuce recorded the highest total coliform count of 4.44 cfu followed by cabbage (4.28 cfu). The least total coliform count of 3.22 cfu was recorded on green pepper. Significant differences were observed in total coliforms between lettuce and green pepper as well as between cabbage and green pepper (P<0.05).

Table 4.15: Total coliforms on the different vegetables sampled

Vegetable Crops	TC (log cfu)
Lettuce	4.44 a
Cabbage	4.28 a
Green pepper	3.22 b

4.3.2. Faecal coliforms (FC) on vegetable Crops

4.3.2.1. Faecal coliform (FC) on vegetables from sampled from two different locations

Table 4.16 shows the faecal coliform count on vegetables obtained from the two locations. Faecal coliform count in Wa West was higher (2.68 cfu) than in Wa East (2.41 cfu). Significant difference were observed in faecal coliform counts on vegetables from Wa East and Wa West (P<0.05).

Table 4.16: Faecal coliforms on vegetables sampled from two different locations

Location	FC (log cfu)
Wa East	2.41 b
Wa West	2.68b

4.3.2.2. Feacal coliform on different vegetables

Table 4.17 depicts faecal coliform count on three vegetables sampled. Lettuce and cabbage recorded the highest faecal coliform count was recorded 2.69 cfu each, whiles green pepper recorded the least faecal coliform count of 2.25 cfu. Significant differences were observed between total coliforms on lettuce and green pepper as well as between cabbage and green pepper (P<0.05).

Table 4.17: Faecal coliforms on the three different vegetables

Location	FC (log cfu)
Lettuce	2.69 a
Cabbage	2.69 a
Green pepper	2.25 b

4.3.2.3. Faecal coliform count on the different vegetables from different location

Table 4.18 shows faecal coliform count on the vegetables sampled at different locations. Lettuce sampled from Wa West and cabbage sampled from Wa East had similarly the highest faecal coliform count of 2.85 cfu. Green pepper sampled from Wa West recorded the second highest faecal coliform count of 2.65 cfu, while, green pepper sampled from Wa East had the least faecal coliform count of 1.85 cfu. Significant differences were observed in feacal coliform count among the vegetable crops sampled from the two sites ($P<0.05$).

Table 4.18: Faecal coliform count on the vegetable crops sampled from two different locations

Vegetable crop	Location		Mean
	Wa East	Wa West	
Lettuce	2.54 b	2.85 a	2.69
Cabbage	2.85 a	2.54 b	2.69
Green pepper	1.85 c	2.65 ab	2.25
Mean	2.41	2.68	

Lsd $_{variety}$	=0.14	P=0.0018
Lsd $_{package}$	=0.17	P=0.0003
Lsd $_{variety\ x\ package}$	=0.25	P=0.0001

4.3.3 *E. coli* count.

4.3.3.1. *E.coli* count on vegetables from two different locations

Table 4.19 shows *E. coli* count on vegetables obtained from the two locations. Wa West recorded high E. *coli* count of 1.76 cfu than Wa East which recorded a total coliform count of 1.72 cfu. Even though Wa west recorded a higher *E. coli* there were no significant differences between them at (P>0.05).

4.3.3. *E. coli* Count on Vegetable Crops

Table 4.19: *E. coli* count on vegetables crops from two locations

LOCATION	Count (log cfu)
Wa East	1.72 a
Wa West	1.76 a

4.3.3.2. *E.coli* count on the different vegetables

Table 4.20 depicts the *E. coli* count on the three vegetables sampled. Green pepper recorded the highest *E. coli* count of 1.81 cfu followed by lettuce which recorded the second highest *E. coli* count of 1.72 cfu. Cabbage however, had the least *E. coli* count of 1.69 cfu. There were no significant differences in *E. coli* count observed among the three vegetables (P>0.05).

Table 4.20: *E. coli* count on three vegetable crops

vegetable	E. coli count (log cfu)
Lettuce	1.72 a
Cabbage	1.69 a
Green pepper	1.81 a

4.3.4. Salmonella count

4.3.4 .1. Salmonella count on vegetable crops from the different locations

Table 4.21: shows Salmonella count on vegetables obtained from the two locations. Vegetables from Wa West recorded a high Salmonella count of 1.85 cfu while those from Wa East had a count of 1.45 cfu. No significant differences were observed in salmonella count on vegetables from Wa East and Wa West (P>0.05).

Table 4.21: Salmonella count on vegetables crops from two locations

LOCATION	Count (log cfu)
Wa East	1.45 a
Wa West	1.85 a

4.3.4.2. Salmonella count on the vegetables

Table 4.22 shows the Salmonella count on the different vegetables sampled. Cabbage recorded the highest Salmonella count of 2.66 cfu, followed by lettuce (2.29 cfu) but green pepper had no Salmonella on it. The differences observed between Salmonella count on lettuce and green pepper as well as cabbage and green pepper were significant (P<0.05).

Table 4.22: Salmonella count on three vegetable crops

LOCATION	Salmonella count (log cfu)
Lettuce	2.29 a
Cabbage	2.66 a
Green pepper	0.00 b

4.4. Pesticides residue of vegetables sample from two different sites

Significant levels of pesticides were detected in lettuce grown in East and West of Wa. Table 4.23 shows that, among the different pesticides detected in the vegetables P, P' DDE with the highest concentration of 21.1mg/kg was detected in lettuce from Wa East. The second highest pesticide residue was P, P'DDE with concentration of 12.2mg/kg in lettuce from Wa West. Both levels exceeded the MRL in lettuce. The third highest pesticides residue was Alpha-endosulfan with concentration of 0.7mg/kg in cabbage from Wa East. The concentrations of heptachlor (0.02mg/kg),P,P'DDT (0.06mg/kg) and Permethrin (0.1mg/kg) in cabbage from Wa East were significantly higher compared with the international MRL. Seven (7) different pesticides were detected in green pepper from Wa East and only two (Alpha-endosulfan and P,P' DDE) were higher than their international MRL. Alpha- Endosulfan was the only pesticide residue with the highest significant values. Alpha -endosulfan and P.P'DDT detected in lettuce from Wa West were also significant. The levels of (0.3mg/kg) and Alpha- endosulfan (0.06mg/kg) detected in green pepper from Wa West were significant.

Results from the two-sample t-test for lettuce and cabbage revealed that no significant differences were observed between the two locations for the pesticides detected except for PP-DDT which was significantly different in the two locations for lettuce and cabbage. However, for the green pepper, there was no difference observed between the two locations (Appendix 3a).

Table 4.23: Pesticide residue levels (mg/kg) in the three vegetable samples from the two different sites

Pesticides/ Vegetables Mg/Kg	Heptachlor	Alpha Endosulfan	Endrin	P,P'DDE	P,P'DDT	Lambda	Permethrin	Cypermethrine
Lettuce (Wa East)	0.0007	0.4*	Not Detected	21.1*	Not Detected	0.02	0.04	0.02
Cabbage(Wa East)	0.02*	0.7*	0.05	Not Detected	0.06*	0.003	0.1*	0.1
G.Pepper(Wa East)	0.01	0.2*	0.05	0.07*	Not Detected	0.01	0.04	0.04
Lettuce(Wa West)	0.002	0.2*	Not Detected	12.2*	0.3*	0.004	0.03	0.1
Cabbage(Wa West)	0.003	0.2*	0.02	Not Detected	0.001	0.006	0.04	0.03
G.Pepper (Wa West)	Not Detected	0.3*	0.06*	Not Detected	0.01	0.009	0.04	0.04
Mrl Level Mg/Kg(Max)	0.01	0.05	0.05	0.01	0.01	0.05	0.05	0.2

Each value is the mean of one sample with three replications,

*= Significant higher as compared with the International MRL for each chemical

CHAPTER FIVE

5.0. DISCUSSION

5.1 Field survey

5.1.1. Demographic Characteristics of Farmers.

5.1.1.1. Gender of Farmers

Gender plays a major role in vegetable production among the people in Ghana and the Upper West Region is not an exception. Men are engaged in the cultivation of crops and women undertake activities such as harvesting and processing of products. This could be the reason why majority of the farmers were males representing 78.0% of the respondents in the study area whilst 22.0% are females. It could be deduced from the results that there were significant differences in the gender of the respondents. The reason probably is that farming is a vigorous and energetic activity and that is why men are mostly in it while women do harvesting and processing.

5.1.1.2. Age of Farmers

Age also plays a vital role in determining agricultural productivity. Both the youth and the elderly engage in farming. The findings brought to light that majority of the respondents are in the age range of 30-39 years. This represents 46.0% of the population. There were significant differences among the ages of respondents. This implies that the active age group is mostly engaged in farming in the Wa municipality.

5.1.1.3. Educational Level Farmers

The results indicated significant numbers of the respondents were illiterates with no formal education. This could be attributed to high illiteracy in the north and may account for the indiscriminate use of pesticides in the study areas as they could not read basic descriptions on the pesticides. It could also be inferred from the results that t the level of education reduce from no education to secondary education, thus as one progresses in the educational ladder the interest for farming reduces.

5.1.2. Sources of Water for Dry Season Vegetable Farming

Dry season vegetable farming largely depends on irrigation. However there are few irrigation facilities in the municipality for this lucrative venture. Farmers therefore draw water from hand dug wells and dams. Significantly more farmers draw water from dug out wells than from dams. This could be attributed to the fact that irrigation facilities are inadequate and the few existing ones are being abandoned. This confirms a statement made by Kariata *et al. (*2002b, 2003a) that farmers draw water from dug out wells and streams. This however contradicts a study by Abdul-Ganiyu *et al. (* 2002), that vegetable production using polluted water is a regular practice in Tamale metropolis and large quantities of leafy vegetables are produced using polluted water. It also contradicts a statement by Drechsel *et al. (2006*) that farmers in three major cities of Accra, Kumasi and Tamale draw water from drains and sometimes treated waste water.

5.1.3. Methods of irrigation for dry season farming in the Wa municipality

The common method of irrigation was the use of watering can, bucket and perforated calabash. The reason for the choice could be due to in- adequate capital to procure sophisticated irrigation facilities. This practice of using buckets and watering could cause crop contamination. This Drechsel and Varma *(2007*), reported that the use of watering cans to draw water could increase crop contamination. Similarly it has been reported by Drechsel *et al.(2002)*, that farmers use bowls and bucket to draw water from dug out and wells which increases contamination as they step in it while fetching the water.

5.1.4. Other uses of water apart from irrigation

The findings also indicated that, these sources of water are not only for vegetable production; but also used for domestic activities, construction and livestock drinking. This could be the reason why coliform was detected in both the water and the vegetables.

5.1.5. Types of fertilizers used by farmers in the Wa Municipality

Application of plant nutrient is a practice that helps farmers to maximize yield. However, there are certain basic factors that one must consider when applying fertilizer. The results of this study revealed that organic manure is the most widely used fertilizer for the cultivation of vegetables. This might be due to abundance of organic fertilizer in the study area and could account for it could account for the presence of feacal coliform in both the water and vegetables, since organic manure is the main source of feacal contamination.

This could also explain why *E. coli* was found in both the water and vegetables confirming a statement by Allen (2006) that manure and improperly managed compost may act as reservoir for pathogenic bacteria like E.coli.

5.1.6. Types of pesticides used by farmers in the Wa Municipality

Pest attack is probably one of the major problems confronting farmers in the municipality since they use lots of pesticides to control pests. Lambda cyhalothrine was the most widely used pesticide; however, pesticides such as DDT, Cypermethrine, and Actelic 25EC were also mentioned by farmers. Most of the chemicals mentioned were detected in the vegetables. This could be attributed to high illiteracy rate as most of them could not read labels on the container; as such they use these pesticides without expert advice. Pesticides are applied frequently until the crops are harvested. The implication is that farmers do not observe the correct harvest interval when no pesticides application is recommended therefore exposing consumers to the adverse effects of pesticides residue.

5.1.7. Demographic characteristics of consumers in the Wa Municipality

5.1.7.1. Age and Occupation of consumers in the Wa Municipality

It could be inferred from the results that majority of the consumer's falls within the range of 20-29 years, which is the active working group. Therefore the health of these people could be a determining factor on the Gross Domestic Products of the nation. Significant differences exist between the different age groups and could be attributed to the important role vegetables play on the health of the people in the Wa municipality.

It is also clear that significant number of the consumers had no form of employment but were mainly house wives and this could be due to the significantly higher illiteracy rate among females in the Wa municipality.

5.1.7.2. Educational level of the consumers in the Wa municipality

With regards to the educational level it is obvious that illiteracy among the consumers is significantly high which may be attributed to significant number of illiterates in the north. Though some of the consumers had some form of formal education, majority were illiterates and that might have determined the level of postharvest treatment used as majority of the consumers used only water to wash their vegetables. Few consumers from the literate group who took part in the research used vinegar and salt solution to disinfect their vegetables.

5.1.8. Postharvest treatment of vegetables by consumers in the Wa Municipality

Improper handling of vegetables create conducive environment for pathogenic bacteria to attack vegetables. It is therefore expedient for farmers and consumers to adopt proper postharvest handling methods that aim at minimizing post harvest losses. The studies revealed that the common and significant method of treatment in the study area is washing of vegetables with water. This might be due to the high illiteracy rate among the consumers and the water used in washing these vegetables could be the main source of contamination. This was confirmed in the laboratory results where total coliform, feacal coliform and *E. coli* were found in the two major sources of water used by farmers and suggests that the vegetables are of poor quality in terms of microbial contamination. This Norman (1992) reported that in appropriate handling of vegetables brings about losses in both quantity and quality.

5.2. Microbial content in the irrigation water and vegetables sampled from two different locations in Wa municipality

5.2.1. Microbial content in the water from two different locations

5.2.1.1.Total Coliform Count

Total coliform count was significantly higher at Wa East than Wa West. The differences observed could be due to differences in farming activities and other uses of water sources. Beuchat (1996) reported that several factors such as manure, dust, wild and domestic animals, insects and human handling can cause contamination of irrigation water.

Total coliform in Wa East were significantly higher than total coliform count in Wa West. This could be attributed to the differences in the levels of organic manure used and also environmental condition such as pollution. The presence of total coliform in the main water source for irrigation may account for the presence of total coliform on the vegetables. Drechsel *et al*. (2002) reported that watering can to draw water from wells could increase contamination as growers step in the water while fetching.

Lettuce and cabbage had significantly higher total coliform count than green pepper. The reason could be that lettuce and cabbage by their characteristics as broad leafy vegetable with soft skin may possibly harbor more pathogens than green pepper. The similarity in total coliform count on lettuce and cabbage may be due to the fact that these vegetables belong to the same class (leafy vegetables).

5.2.2. Faecal Coliform Count

Feacal contaminations between the two sites were significantly different and this might be attributed to the presence of feacal contamination of both water sources from the two locations which might have been transferred to crops during watering. Thus feacal contamination was probably not only transferred from water but also from the manure used.

Lettuce from Wa East and cabbage from Wa West similarly recorded the highest feacal coliform count. This could be attributed to the similarities in the two vegetables. The location also differed significantly in terms of feacal coliform load in the vegetables. The possible reason is that poultry manure and compost which are the main sources of feacal contamination differed in the two locations. No significant differences were observed between the two leafy vegetables; possibly because they have similar characteristics that make them easy for pathogenic infection.

5.2.3. *E. Coli* Count

E. coli count in the three vegetable samples was not significantly different at the two locations. Similarities in farming practices such as the use of manure and irrigation may be the reason. Allen (2006) reported the presence of *E. coli* on spinach and recommended the need to adopt good agricultural practices. The higher Feacal contamination in lettuce might be due to its broader leaves which make it easier to habour the pathogens

5.2.4. Salmonella count

Salmonella was not detected in any of the water sources. On the contrary Salmonella was found in the vegetable samples from the two different locations. The presence of Salmonella on vegetables indicates a high feacal contamination which is the main source of Salmonella. It could also be that the succulent and sweet nature of the vegetables creates an enabling environment for easy migration of the pathogen from soil to the vegetable. Salmonella contamination could also arise from the manure used.

5.3. Pesticides residue of the vegetables sample from the different location

Eight (8) pesticides were detected from the three different vegetable samples from two different locations in the Wa municipality and this confirms the results from the baseline survey that pesticides are used in vegetable production at these locations. Residue of PP- DDE at the rate of 21.2 mg/kg and 12.2 mg/kg recorded in lettuce from Wa East and Wa were significantly higher when compared to the international MRL of lettuce ($p>0.01$mg/kg). Osman *et al.* (2010) reported that lettuce contained the highest pesticides residue among a number of vegetables and concluded that the pesticides might have been transferred from the soil into the vegetables. It could also be the persistent nature of the pesticide in the soil.

Green pepper fruits had the least pesticide concentration detected which could be attributed to the fact that the green pepper fruits have smaller surface area and has thicker skin than the leafy vegetables.

Vegetables obtained from Wa East had the highest number of pesticide residue detected than vegetables from Wa West probably because of the differences in production practices observed in the two locations.

Cabbage heads, lettuce and green pepper obtained from the two locations were not significantly different for pesticides residue except for PP-DDT (Appendix 3a, 3b, 3c). This may be attributed to the fact that farmers use similar chemicals at similar rates. Farmers probably use banned persistent pesticides such as PP-DDE and DDT chemicals in pest and disease control resulting in the high levels detected. Karanth (2000) reported that DDT persists with a half-life of about ten years; with a minor conversion to PP-DDE and PP-DDT.

CHAPTER SIX

6.0. SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1. Summary

From the survey conducted, majority of the farmers were males and the difference was statistically significant. Though most of the respondents fall within the working class of 20-39 years, illiteracy rate was high among the respondents.

Due to in-adequate formal irrigation facilities the common source of water was dugout wells and farmers irrigate their fields by the use of watering cans.

Majority of the farmers used organic manure as source of plant nutrient and Lambda cyhalothrine is the most widely used pesticides in the Wa Municipality.

The use of water to wash the vegetables was the common postharvest treatment in the study area and most of the vegetables for consumption were obtained from market retailers who do not apply any treatment, hence majority of the consumers complained of stomach ache after taken the vegetables.

Vegetables in Wa west had more microbial contamination. It was found that microbial contamination was high in dug out water at Wa West than Wa East.
Lettuce and cabbage had more coliform load in Wa West. Similar trend was observed for the pesticides.

Residue of P,P' DDT and P,P'DDE in lettuce were above the international MRL.

The levels were statistically different between the two locations and Wa East had significantly higher residue.

6.2. Conclusion

It can be concluded from the findings of this study that the major source of irrigation water for dry season vegetable cultivation in the Wa Municipality is water from dug out wells. However, total faecal coliform as well as E .coli counts were found in the water sources. There is the need to purify the water sources for irrigation and to adopt good agricultural practices. Likewise, coliform loads in the vegetables were high in both locations hence the need to adapt postharvest treatment to eliminate these microbes in the vegetables before consumption.

Pesticides residue (PP-DDE, PP-DDT, Cypermethrine, Lambda cyhalothrine) were found in the vegetables that were above the International standards, posing health threat to consumers of these vegetables.

The main postharvest treatment is the use of water to wash the vegetables which might not be effective enough to eliminate the pathogens.

6.3. Recommendation

Based on the findings of this study the following recommendations were made:

1. In future laboratory analysis should be carried out on the presence of heavy metals in both the water source and that of the vegetables.

2. Subsequent research on postharvest quality of vegetables should focus on the other districts in the Upper West Region.
3. Consumers should be educated and encouraged on the need to apply postharvest - treatments to reduce microbial load in the vegetables before consumption.
4. Further research should be carried on the effects of postharvest treatments on the vegetables (cabbage, lettuce and green pepper).
5. There is the need to encourage farmers to consult technical officers for advice on safer ways of controlling pests and diseases on their crops.

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APPENDICES

APPENDIX 1: ANALYSIS OF SURVEY DATA

APPENDIX 1A: ONE-SAMPLE TEST FOR FARMERS

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Gender	20.616	49	.000	1.22000	1.1011	1.3389
Age group	21.266	49	.000	2.72000	2.4630	2.9770
Level of education	16.484	49	.000	1.42000	1.2469	1.5931
Sources of water for dry season vegetable production	24.126	49	.000	1.12000	1.0267	1.2133
Method of irrigating farm	12.713	49	.000	1.34000	1.1282	1.5518
Other uses of water source	12.657	49	.000	1.58000	1.3291	1.8309
Method of fertilizer application	15.825	49	.000	1.74000	1.5190	1.9610
State the method of pesticide/ insecticide application	16.083	49	.000	1.36000	1.1901	1.5299
Sources of water to wash vegetables	15.815	49	.000	1.22000	1.0650	1.3750

APPENDIX 1B: ONE-SAMPLE TEST FOR CONSUMER

	Test Value = 0					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
age	35.611	43	.000	1.863634	1.7581	1.9692
0ccupation	9.09943	43	.000	2.409	1.88	2.94
Educational level	15.161	43	.000	3.22727	2.97980	3.6566
Where do you normally obtain some of the vegetables?	30.333	43	.000	2.06818	1.9307	2.2057
List the methods/form of treatment you normally apply to leafy vegetables before consumption?	17.115	43	.000	1.52273	1.3433	1.7022
After treatment what is the level of safety before consumption	12.153	43	.000	2.06818	1.7250	2.4114
Which of this sickness do you normally experience after taking green leafy vegetables? tic as many as answers as possible	22.184	43	.000	2.54545	2.3141	2.7769

APPENDIX 2: ANOVA TABLES FOR VEGETABLE CROPS SAMPLED

Analysis of Variance Table for Total Coliform Count

Source	DF	SS	MS	F	P
rep	2	0.06013	0.03007		
location	1	0.46544	0.46544	5.25	0.0449
crop	2	5.29535	2.64767	29.85	0.0001
location*crop	2	0.13128	0.06564	0.74	0.5015
Error	10	0.88688	0.08869		
Total	17	6.83909			

Grand Mean 3.9793 CV 7.48

Analysis of Variance Table for Faecal Coliform Count

Source	DF	SS	MS	F	P
rep	2	0.30442	0.15221		
location	1	0.32503	0.32503	17.71	0.0018
crop	2	0.77880	0.38940	21.22	0.0003
location*crop	2	0.94068	0.47034	25.63	0.0001
Error	10	0.18348	0.01835		
Total	17	2.53240			

Grand Mean 2.5443 CV 5.32

Analysis of Variance Table for E COLI count

Source	DF	SS	MS	F	P
rep	2	0.40887	0.20443		
location	1	0.00720	0.00720	0.03	0.8565
crop	2	0.05034	0.02517	0.12	0.8877
location*crop	2	0.33328	0.16664	0.80	0.4770
Error	10	2.08860	0.20886		
Total	17	2.88828			

Grand Mean 1.7392 CV 26.28

Analysis of Variance Table for Salmonella count

Source	DF	SS	MS	F	P
rep	2	1.0991	0.5496		
location	1	0.7436	0.7436	2.08	0.1801
crop	2	24.8900	12.4450	34.76	0.0000
location*crop	2	1.0991	0.5496	1.54	0.2622
Error	10	3.5801	0.3580		
Total	17	31.4120			

Grand Mean 1.6488 CV 36.29

APPENDIX 3: ANALYSIS ON LABORATORY DATA

APPENDIX 3A: TWO-SAMPLE T-TEST FOR CABBAGE

Pesticides	Location	Location	Df	T-Value	P-Value	Remarks
Heptachlor	A	B	4	1.12	0.3244	Accept H_0
Endosulfan	A	B	4	-	-	-
Endrin	A	B	4	4.00	0.1061	Accept H_0
PP- DDE	A	B	4	-	-	-
PP-DDT	A	B	4	2.98	0.0407*	Accept H_1
Lambda	A	B	4	-	-	-
Permethrin	A	B	4	-0.88	0.4303	Accept H_0
Cypermethrine	A	B	4	-	-	-

*= Significant at 5% ($P<0.05$)

If $P<0.05$ - then reject H_0 and accept H_a.

If $P>0.05$ - then accept H_0 and accept H_a

APPENDIX 3B: TWO-SAMPLE T-TEST FOR LETTUCE

Pesticides	Location	Location	Df	T-Value	P-Value	Remarks
Heptachlor	A	B	4	-1.58	0.1890	Accept H_0
Endosulfan	A	B	4	-	-	-
Endrin	A	B	4	-	-	-
PP- DDE	A	B	4	19.60	0.000*	Accept H_1
PP-DDT	A	B	4	-	-	-
Lambda	A	B	4	2.09	0.1045	Accept H_0
Permethrin	A	B	4	0.35	0.7415	Accept H_0
Cypermethrine	A	B	4	-	-	-

*= Significant at 5% ($P<0.05$)

If $P<0.05$ - then reject H_0 and accept H_1.

If $P>0.05$ - then accept H_0 and accept H_1

APPENDIX 3C: TWO-SAMPLE T-TEST FOR GREEN PEPPER

Pesticides	Location	Location	Df	T-Value	P-Value	Remarks
Heptaclor	A	B	4	-	-	-
Endosulfan	A	B	4	-1.29	0.2658	Accept H_0
Endrin	A	B	4	-0.52	0.629	Accept H_0
PP- DDE	A	B	4	-	-	-
PP-DDT	A	B	4	1.00	0.3753	Accept H_0
Lambda	A	B	4	-1.63	0.1788	Accept H_0
Permethrin	A	B	4	0.50	0.6495	Accept H_0
Cypermethrine	A	B	4	0.50	0.6433	Accept H_0

*= Significant at 5% ($P<0.05$)

If $P<0.05$ - then reject H_0 and accept H_1

If $P>0.05$ - then accept H_0 and accept H_1

APPENDIX 4: QUESTIONAIRES

APPENDIX 4A: QUESTIONAIRE FOR FARMERS

I am an MSc Postharvest student of Kwame Nkrumah University of Science and Technology who is conducting a research for an academic purpose. The study is focus on five communities in the municipality (farmers, and consumers) to seek the views of farmers and consumers on the effects of sources of irrigation water and pesticides on postharvest quality of three vegetables in the Wa Municipality. It is my hope that, the findings will benefit policy makers, (NGO'S and governmental Agencies as well as the general public who in diverse ways make strenuous efforts to improve on the living standards as well as Agricultural Development in the Area. All the information provided will be treated with utmost confidentiality.

Please choose the answer that corresponded to your choice in the alternative provided

Tick the box provided.

1. Gender

[ ] MALE [ ] FEMALE

2. Age level

[ ] Less than 20 years [ ] 20 - 29 years [ ] 30 - 39 years

[ ] 40 - 49 years [ ] 50 - 59 years [ ] 60 and above

3. Level of education

[ ] No Education [ ] primary /Basic [ ] Secondary

[ ] Post /secondary [ ] specify...

Provide the answer or thick where appropriate

1. which of the following source of water do you rely on to irrigate your farm during the dry season.

[ ] well [ ] stream [ ] Dug –out [ ] Dam

[ ] others specify…………………

4. State the method of irrigation

....

....

....

5. What other used does the source of water served aside irrigation

....

....

6. What type of fertilizer Do you applied in order to improve on the fertility of the soil.

[ ] organic fertilizer [ ] in-organic fertilizers [ ] both organic and in-organic fertilizer others specify...

7. List the pesticides you normally used?

…………………………………………………………………………………………

………………………………………………………………………………...................

APPENDIX 4B: QUESTIONAIRE FOR CONSUMERS

DEMOGRAPHIC CHARACTERISTICS OF CONSUMERS

1. Age level

[ ] Less than 20 years [ ] 20 - 29 years [ ] 30 - 39 years

[ ] 40 - 49 years [ ] 50 - 59 years [ ] 60 and above

2. Occupation:..

3. Level of education

[ ] No Education [ ] primary /Basic [ ] Secondary

[ ] Post /secondary [ ] specify...

4. Where do you normally obtain our vegetables?

[ ] Food vendors [ ] market retailers

[ ] farmers [ ] others

5. Reasons why vegetables are safe for consumption?

....

....

....

6. List the methods /form of treatment you normally apply to leafy vegetables before consumption

....

....

....

7. Which of this sickness do you normally experience after taking green leafy vegetables?

[ ] Diarrhoea [ ] stomach ache [ ] Headache [ ] Body itch

[ ] Others specify..

THANK YOU!

PLATES

Plate 1.Dam water at Charia

Plate 2: Dam water at Sing

Plate2; Dugout at zingu

Plate 3. Dug out at sing

Plate 4: Farmer mixing pesticides at Charia

Plate 5: Method of irrigation at Charia

Plate 6. Water for postharvest treatment at the farm. At kambali bau

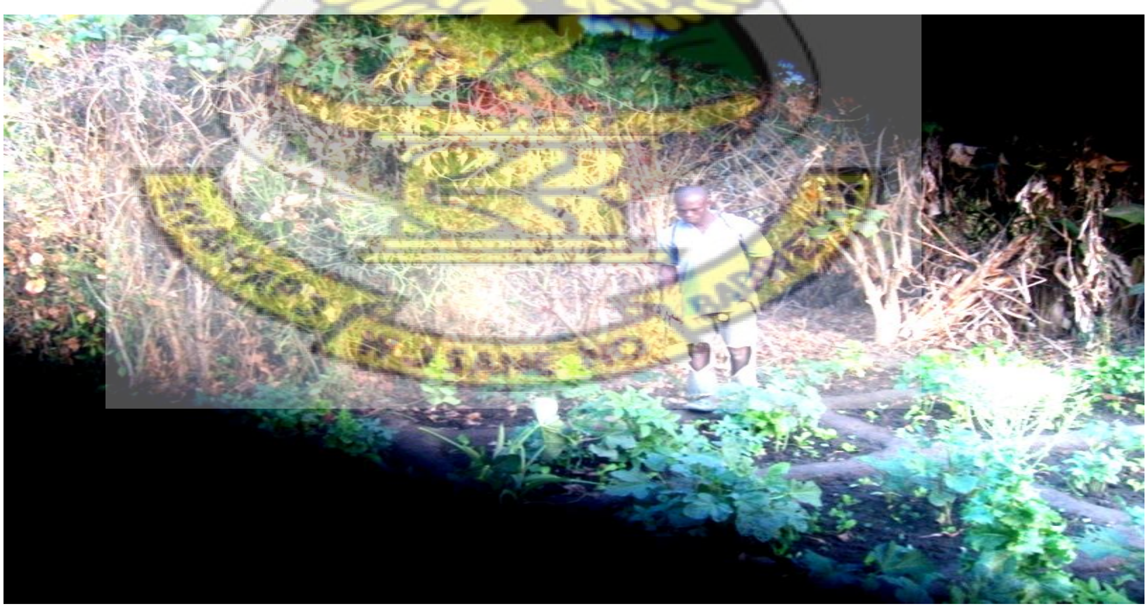

Plate 7 ; Farmer spraying lettuce at kambali bau

Plate7:Woman carrying vegetables at Busa

Plate 9:Woman transporting vegetables