ASSESSMENT OF ORGANOCHLORINE PESTICIDE RESIDUES IN COW MILK, SEDIMENTS AND WATER FROM NAIROBI WEST REGION.

By

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DECLARATION

This thesis is my original work and has not been presented for a degree in any university

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DEDICATION

This thesis is dedicated to my dear wife Peninah, our two children Kimathi and Kinya, my parents Mr and Mrs Kinoti, my brothers Kithinji, Gitonga and Guantai, my sister Nkirote and friends for their moral support.

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Lastly, I acknowledge my God for granting me favour and good health to pursue this study.

ABSTRACT

The aim of this study was to investigate the levels of 17 organochlorine pesticide residues in cow milk, water and sediments from Karen and Langata areas of Nairobi West region. Water, sediment and milk were sampled using the standard operating procedures. The methods used for extraction of the pesticide residues were; Soxhlet extraction for sediments and liquid-liquid partitioning for water and milk sample. The extracts were then cleaned up using a column packed with alumina. The samples were analysed using Varian CP-3800 Gas Chromatograph equipped with electron capture detector for detection of organochlorines pesticides and statistical data was analysed using microsoft excel and Statistical Programme for Social Sciences tools (SPSS).

The pesticides residues in milk varied from below detection limits to 3309 ng/kg. Milk from Karinde had the highest $\sum 17$ organochlorine pesticide at 2225.74 ng /kg while the other four sites had lower concentrations which were: 1834.40 ng/kg for Maasai Plains, 1826.26 ng/kg for Olepolos, 1748.09 ng/kg for Fare Acres and 1738.32 ng/kg for Bogani. The highest $\sum 17$ organochlorine pesticides concentrations were recorded at and Bogani, they had 5639.29 ng /kg and 5024 ng /kg respectively.

The average levels of pesticides in sediments ranged from below detection limit to 4238.71 ng /kg. The highest concentration in sediments was that of heptachlor epoxide at 2387.10 ng /kg which was detected at the Co-operative College Bridge. The month of February had the highest sum of OC pesticides detected in sediments samples collected from Co-operative College Bridge site at 5064.55 ng /kg. The same site had the highest mean concentration detected at 1587.77 ng/kg levels. Sediment samples from Ngong Bridge and Ongata Rongai Bridge had low mean concentration values recorded at 536.26 ng/kg and 522.8 ng/kg levels respectively.

Water samples had pesticide residue levels ranging from below detection limits to 141.51 ng/l for *p, p'*- DDT from Co-operative College Bridge. Water samples from this site had the highest mean organochlorine pesticides residue levels in February at 417.04 ng/l levels. The highest mean of organochlorine pesticides residues in water was 272.38 ng/l at Ngong Bridge. On average the detection frequency of the pesticides varied from 36% for methoxychlor to 100% for Aldrin.

The Pearson's correlation coefficients as determined for the OCPs present between water and sediment were positive at all the sites. The strongest and most significant intermatrix correlation was observed at Cooperative bridge ($r=0.696$) followed by Ongata Rongai bridge ($r=0.448$) while that for Ngong bridge area was weak ($r=0.215$), for all the sites $p> 0.005$. Seasonal variation pattern was reflected in the three matrices, but higher values of residues were recorded mostly during the short rain season than the dry and long rain seasons.

In general, from the three matrices studied, milk samples had exceeded the FAO/ WHO allowed levels of pesticides in November and December at Karinde and Bogani. High values were also recorded in sediments from Co-operative College Bridge site during February as compared to water at the same time.

This study shows the OCPs residues in the environmental media studied and milk which is human food. Presence of OCPs residues in milk implies that the consumers of milk and it products are exposed to dangers coursed by these residues which include cancers. This study reveals to the public health and other health stakeholder the residues status in Nairobi West region. Farmers who participated in the study will be advised on the methods to spraying their animals in order to protect themselves from the pesticide contamination. The data from this study is added to the scientific data and knowledge on pesticide residue levels in cow milk which was not available for any of the Nairobi regions.

LIST OF ABBREVIATIONS

BDL	Below Detection Limits
DCM	Dichloromethane
DDD	Dichlorodiphenyldichloroethane
DDE	1,1-dichloro-2,2-bis(p-chlorophenyl)-; p.p''- (**Dichlorodiphenyl**)dichloroethylene
DDT	Dichloro Diphenyl Trichloroethane
CP	ChromPack
ECD	Election Capture Detector
FAO	Food and Agriculture Organisation
GC	Gas Chromatography
HCH	Hexachlorocyclohexane
IDEA	Investment in Development of Agriculture
KEPHIS	Kenya Plants Health Inspectorat Services
LOD	Limit of Detection
LSC	Liquid Scintillation Counter
NRBP	Nairobi River Basin Programme
OCPs	Organochlorine pesticides
OPs	Organophosphorus pesticides
PCPB	Pesticides Control and Protection Board
PCB	Polychlorinated Biphenyls.
POPs	Persistent Organic Pollutants
SPSS	Statistical Programme for Social Scientists

TSD	Thermal Selective Detector
USEPA	United States Environmental Protection Agency.
UNEP	United Nations Environment Programme
WHO	World Health Organisation

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CHAPTER ONE

1.0 INTRODUCTION

Agriculture is the backbone of Kenya's economy, and supports over 23 % of the country's GDP every year. However, the sector suffers from field and post-harvest loses of produce due to a myriad of pests and disease vectors which are promoted by the hot and humid climatic conditions. Furthermore, the rapidly increasing population also poses an additional stress on the limited arable land due to high demand for food production. As a result, Kenyan farmers strongly depend on the use of chemical pesticides for economic management of crops and livestock to aid in the control of pests in order to boost on farm yields.

The major problem associated with the use of pesticides is in their ability to cause detrimental effects to non-target organisms. Organochlorine pesticides, for instance, have been used in Kenya for the last 9 decades, but due to their adverse health effects, the use of most of them has been discontinued or restricted under the Stockholm Convention, along with other persistent organic compounds such as PCBs, dioxins and furans. These chemicals are lipophilic and resist photolytic, biological and chemical degradation. Therefore, they have potential to bioaccumulate and biomagnify in the food chain causing adverse health effects in human beings and animals.

1.1 Advantages of Using Pesticides

Pests are an ecological problem and therefore our control strategies must be ecologically sound.Basically, there are two approaches to pest control: prevention, cure or removal of the cause.

Modern agriculture is a combination of both and human intervention is necessary, whether it be pulling out weeds by hand, use of pesticides or genetic engineering. Control methods evolve over time as knowledge and techniques improve. This include the development of chemical means of control which become very important because of a number of advantages. For example:

Cost effectiveness. Pesticides are an economical way of controlling pests. They require low labour input and allow large areas to be treated quickly and efficiently. It has been conservatively estimated that for every dollar a farmer spends on Pesticides he/she receives $4 return (Anon, 1990a). Production per labour unit has increased while production costs and energy inputs are lower.

Timeliness and flexibility. A suitable Pesticide is available for most pest problems with variations in activity, selectivity and persistence. The best product can be chosen for the situation. This allows more flexibility in management options and better timeliness of pest control.

Quality, quantity and price of produce. Pesticides ensure a plentiful supply and variety of high quality, wholesome food at a reasonable price. Modern society demands nutritious food free from harmful organisms and blemishes. Ornamental horticulture also requires unblemished and pest-free plants and flowers. This would be very difficult without farm chemicals.

Prevention of problems. Pesticides are frequently used to prevent pest problems from occurring, for example preventing weeds in gardens and lawns; treatment of export and import produce to prevent the spread of pests; treatment of stored products to prevent pest attack and destruction during storage period.

Protection of farm animals, pets and humans. Pesticides are used in the treatment of pests like spiders, cockroaches, fleas and ticks.

Protection of the environment. Pesticides have been used to control environmental pests like noxious weeds, feral animals this has improved the environment. Herbicides have been used to control crop weeds which reduces the need for cultivation, thus preventing land degradation.

1.2 Potential adverse effects of pesticides

Despite their many advantages, there are some potential hazards or risks when using farm chemicals. These risks may be associated with all chemicals whether they are industrial chemicals, pesticides, household products or even natural chemicals found in the environment. Undesirable side effects of farm chemical use usually stem from a lack of understanding of the impact of the chemical on the environment, compounded by indiscriminate and overuse of the product. These side effects do not always occur when farm chemicals are used. Some of these effects may be:

1. **Reduction of beneficial species.** Non-target organisms, including predators and parasites of pests, can also be affected by chemical application. The reduction of these beneficial organisms can result in changes in the natural biological balances for example losses of honeybees and other pollinating insects.

2. **Drift of sprays and vapour** during application can cause severe damage and residue problems in crops, livestock, waterways and the general environment. Care in the methods of application and the weather conditions under which it is carried out can reduce drift. Environmental pollution from careless application and runoff can result in wildlife and fish losses.

3. **Residues in food** for humans and feed for livestock can be a consequence of direct application of a chemical to the food source, by the presence of pollutants in the environment or by transfer and biomagnification of the chemical along a food chain. Not all residues are undesirable although good agricultural practice must be observed to prevent unnecessary and excessive levels of residues.

4. **Ground water contamination** by leached chemicals can occur in high use areas if persistent products are used.

5. **Resistance** to the pesticide used can develop in target pests due to overuse and incorrect use of the chemical.

6. **Poisoning hazards** and other health effects to operators can occur through excessive exposure if safe handling procedures are not followed that include not wearing protective

clothing and eating or smoking when spraying. Poisoning risks however, depend on dose, toxicity, duration of exposure and sensitivity.

7. **Other possible health effects** due to indiscriminate use of farm chemicals also concern many people in the community.

The problems listed above result from misuse, abuse and overuse. Farm chemicals can be used safely and effectively without these undesirable effects although there is always a risk associated with any activity. Many commonly used substances like aspirin or common salt are more toxic than many pesticides. Despite the relative risks being low, all users of farm chemicals, whether on a large scale or in the home, have a responsibility to use them correctly.

In both developed and developing countries, milk remains the best sole nutrient source for infants, even though it could contain pollutants, such as PCBs and DDT (Sonawane, 1995;Pronczuk et al., 2004). The presence of DDT and other organochlorine compounds in human breast milk has been known for quite some time from malaria and non-malaria areas (Bouwman et al., 1992, Savage et al., 1981). The restriction on or banning of many of these compounds for agriculture use in most parts of the world has led to gradual reduction in residue levels of organochlorine compounds in breast milk, especially in developed countries such as Canada and Sweden (Van Hove Holdrinet et al., 1977; Bernes, 1998; Shutz et al., 1998). In Africa where malaria still kills more than a million people each year, the use of pesticides to interrupt the parasite transmission has continued to rely on insecticide treatment of dwellings, and insecticide treated bed nets (Kapp, 2004). The intention of international initiatives such as the Stockholm Convention and the

Roll Back Malaria campaign is to reduce the reliance on DDT per se, and to use alternative methods, products and strategies. Much of the effort has concentrated on using synthetic pyrethroids as one such alternative, and some countries have successfully done so. In accordance with the Stockholm convention, the use of most of the organochlorine pesticides has been banned in Kenya, except DDT which has has been restricted to use in malaria control through indoor spraying (PCPB, 2005). At the momment, most OCPs have been replaced by less persistent groups of pesticides such as organophosphates, pyrethroids and carbarmates. However, there are concerns about the use of these compounds due to their acute toxicity on nontarget organisms.

The extent of pesticide use in Kenya is highly diversified and difficult to track due to weak regulatory framework. However, a number of research activities in the country have reported pesticide residues in Kenyan rivers, lakes and soils. But at the moment, there is no data on pesticide residues in Nairobi West area, although the residents heavily depend on the use of pesticides for horticultural crops and livestock disease vector control. In this regard, this study was undertaken to provide baseline data on pesticide residues in Karen and Langata surburbs of Nairobi West Region.

CHAPTER TWO

LITERATURE REVIEW

2.1 Pesticides

Pesticides are chemical agents used to control, destroy, attract, or repel pests in order to minimize their detrimental effects [Ware, 1983; Oudejans, 1991]. They help to reduce, and in some cases eliminate, the negative impacts of insects, bacteria, weeds, viruses, parasites fungi, and animals, thereby improving the quantity and quality of agricultural produce as well as human health. Pests can reduce the quality and quantity of food produced by lowering production and destroying stored produce; they can harm our animals (like fleas, worms and diseases); they compete with humans for food and affect their health, welfare and way of life; they can destroy buildings (termites) and are a major cause of land degradation (noxious weeds, rabbits, feral pigs, etc). Pests are also a major nuisance around our homes (prickles in the lawn, flies, etc) and they greatly increase the costs of farming.

Pesticides therefore are used in many situations such as livestock farming, cropping, horticulture, forestry, home gardening, homes, hospitals, kitchens, and roadsides, recreational and industrial areas.

2.2 Classification of Pesticides

Pesticides can be categorised into two main groups: organic or inorganic pesticides. Inorganic pesticides are derived from naturally occurring elements. They are generally stable, non volatile and soluble in water. Most of the inorganic pesticides contain arsenic, cyanide, sulfur, mercury, copper and thallium, and the presence of such metals make pesticides persistent and bioaccumulative (Hassall, 1990). On the other hand, natural organic sources (plants) or be organic compounds synthesized in a laboratory. Many of these synthesized products mimic the activity of natural organic compounds.

Synthetic compounds mainly containing either aliphatic or aromatic hydrocarbon chains. They consists of organochlorines, organophosphorus, organosulfurs, carbamates and pyrethroids depending on the element(s) bonded to the hydrocarbon system (Wasswa, 2008).

2.2.1 Organochlorine Pesticides (OCPs)

Organochlorine pesticides contain carbon, chlorine, hydrogen and sometimes oxygen in their chemical structure (Briggs, 1992). They are very toxic organic compounds, persist in the environment and have the potential for long range transpot, posing a serious threat to the environment and its habitats at remote places (Vesna *et al.*,2001). OCPs include dieldrin, heptachlor, chlordane, aldrin, endrin, dichlorodiphenyltrichloroethane (DDT and its metabolites DDD and DDE), hexachlorocyclo hexane, methoxychlor, heptachlor, Endosulphan sulfate, β-and α-Endosulphans (Appendix I Figure a)

OCPs were used widely to protect crops, livestock, buildings and households against a variety of pests such as ticks, locust, termites and mosquitoes. Currently, most of these pesticides have been banned, except a few which are under restriction. Following the ban, large stocks of obsolete OCPs are still in the environment especially with individual farmers, households and government agencies. The probability of these chemicals being released into the environment is very high posing a high risk to animals and human health.

2.2.3 Organophosphorus Pesticides (OPs)

Organophosphorus pesticides are phosphate esters amides, or thiol derivatives of phosphoric, phosphonic, phosphorothioic, or phosphonothioic acids. They comprise of a central phosphate atom and three organic side chains (R^1,R^2,R^3), two of which are usually ethyl or methyl, whereas one is more specific for a given pesticide (Figure 2.1). Equations 1 to 3 show the esterification of organic groups to phosphorus through oxygen linkers

1. $OP(OH)_3 + R^1OH \rightarrow OP(OH)_2(OR^1) + H_2O$

2. $OP(OH)_2(OR^1) + R^2OH \rightarrow OP(OH)(OR^1)(OR^2) + H_2O$

3. $OP(OH)(OR^1)(OR^2) + R^3OH \rightarrow OP(OR^1)(OR^2)(OR^3) + H_2O$

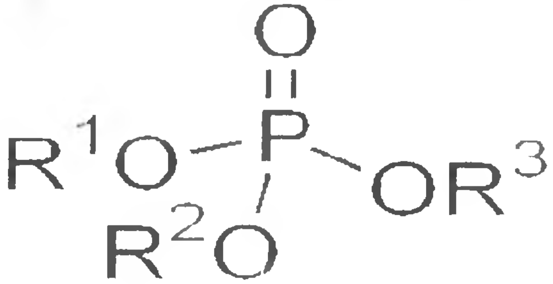


Figure 2.1: General structure for organophosphorus compound

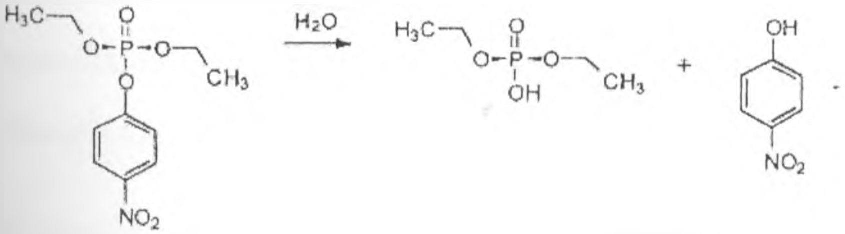
Examples of OPs include; acephate, dichlorvos, dimethoate, ethion, mevinphos, chlorfenvinphos, parathion. chlorpyrifos and diazinon. (Appendix I Figure b)

OPs are chemically unstable and less-persistent than OCPs but less toxic to man and vertebrate animals. This group of pesticides has virtually replaced the persistent organochlorine compounds (Briggs, 1992). The major disadvantage of organophosphates is the lack of selectivity to non target organisms. These compounds irreversibly inactivate the acetylcholinesterase (AchE) enzyme; an enzyme essential for neurotransmission and central nervous system of organisms (Moretto, 1998). This results in the accumulation of acetylcholine (Ach) which interferes with the neuromuscular function thereby producing rapid twitching of voluntary muscles and finally paralysis (Byoung, 2003).

OPs are neurotoxic even at very low levels of exposure (Bachmann *et.al.*, 2000). Short-term exposure to these chemicals has been shown to produce muscle twitching, headache, nausea, dizziness, loss of memory, weakness, tremor, diarrhea, sweating, salivation, tearing, constriction of pupils, and slowed heartbeat. Long-term exposure can produce delayed neurotoxicity, such as tingling and burning in the extremities. This delayed neurotoxicity can progress to paralysis and is seldom reversible. Damage may also occur to the liver, kidney, immune system and bone marrow. Most are only slightly soluble in water and have a high oil-to-water partition coefficient and low vapor pressure.

Organophosphate pesticides degrade rapidly by hydrolysis (equation 4) on exposure to sunlight, air, and soil, although small amounts can be detected in food and drinking water. Their ability to degrade makes them an attractive alternative to the persistent organochlorine pesticides such as DDT, aldrin and dieldrin.

Equation 4



2.2.4 Organosulfurs

Organosulfurs have sulfur in their structure as the central atom (Kenneth, 1972). Their mode of action is by disrupting the target organism's metabolism (Stenersen, J., 2004). They have low toxicity to insects and mammals and as a result are used for selective purposes. They are characterized by their toxicity to young and adult insects which is a valuable property. They also cause irritation to the eyes, ears and nose.

The common examples of this subclass are aramite, propargite, tetradifon and tetrasul (Appendix I Figure c)

2.2.5 Carbamates

Carbamates are esters of N-methyl carbamic acid. $R_2O\text{-}CO\text{-}NHR_1$.

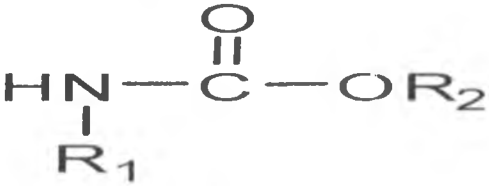


Figure 2.2: General Structure for Carbamates

Carbamates have groups attached to the central carbonyl carbon. R_2 is always an aromatic or aliphatic moiety. The major difference among the carbamate pesticides is in the functional group attached at R_1. For instance, carbamate insecticides have R_1 as an ethyl group, herbicides have R_1 as an aromatic group, whereas fungicides have R_1as a benzimidazole moiety. Some of the known carbamates are carbaryl, carbofuran and aldicarb (Appendix I Figure d).

Biologically, carbamates resemble the organophosphates in their activity. They inhibit the cholinesterase enzyme required for nerve function in animals. Some carbamates are also suspected carcinogens (USEPA, 2009). Carbamates are hydrolyzed slowly in neutral and mildly acidic aqueous surroundings, but in the presence of alkali, they decompose rapidly. The half- life of carbaryl, for example, is about 10 days in neutral aqueous suspension (pH 7) but only a few minutes at pH 11 (Briggs, 1992).

2.2.6 Synthetic pyrethroids

Pyrethrin is a natural insecticide extracted from *Chrysanthemum cineraria folium* (pyrethrum) -the crude flower dust. The synthetic pesticide pyrethroids are derivatives of pyrethrins which was designed to improve the biological activity of the active principal of the natural pesticide (Kegley, 2007). Pyrethroids synthesized before 1970 were very sensitive to sunlight, as their molecules split under UV light making them unsuitable for agricultural use but effective for indoor insect pest control.

Since 1970s, synthetic pyrethroids with better photo-stability and low volatility have been produced to suit both agricultural and indoor uses (Soderlund et, al., 2002). This class of pesticides poisons the target by contact and causing paralysis. These compounds have low mammalian toxicity, but are highly toxic to insects and aquatic organisms. The common pyrethroids are permethrin, deltmethrin, fenvalerate and tetramethrin (Appendix I Figure e).

2.3 Fate of pesticides

The purpose of pesticide use is that the applied chemical will remain in the target organism long enough to control the specific pest(s) and then degrade into harmless compounds without contaminating the environment. However, in practice the applied pesticide undergoes one or more of the several major processes which include:

volatilization, sorption, solubility, transpotation and persistence, depending on the environmental conditions and its physicochemical properties.

Water and wind can transpot pesticides and their residues for long distances. In the process, the pesticides could be altered physically, chemically, photochemically and/or biologically. Pesticides carried by wind can be deposited onto terrestrial or aquatic ecosystems.

Water-transpoted pesticides may enter plants through the roots and then be carried upward in the transpiration stream by the plant. Volatile pesticides may then enter the atmosphere from the plants through the openings in the leaves and stems (Boersma *et al.*, 1988). Pesticides fate in water depends on its solubility, vapour pressure and water physico-chemical properties including pH, temperature, conductivity and turbidity.

Water solubility is perhaps the most important factor in estimating the fate of pesticides in aquatic environment. The solubility depends on temperature, pH and the nature of the chemical. Compounds with higher water solubility tend to desorb from the soils and sediments due to lower soil adsorption coefficients (K_{OD}) values and are less likely to volatilize from water. This coefficient measures the amount of chemicals adsorbed onto soil per amount of water and also considers the organic content of the soil. As a result, high water solubility makes them more susceptible to biodegradation (Montgomery, 2000).

Environmental factors such as wind, rainfall, solar radiation intensity, and soil characteristics including pH, percentage of organic carbon matter, texture and microbial activity also play a significant role in determining the fate of pesticides (Lalah *et al.*, 2001).

2.4 History of pesticides use in Kenya

While the first recorded use of chemicals to control pests, dates back to 2500 BC, it is really only in the last 50 years that chemical control has been widely used (Hock *et al.*, 1991). Many of the earliest pesticides were either inorganic products or derived from plants, for example burning sulphur to control insects and mites. Other early insecticides included hellebore to control body lice, nicotine to control aphids, and pyrithrin to control a wide variety of insects. Lead arsenate was first used in 1892 as an orchard spray while about the same time it was accidentally discovered that a mixture of lime and copper sulphate (Bordeaux mixture) controlled downy mildew, a serious fungal disease of grapes. It is still one of the most widely used fungicides (Hock *et al.*, 1991). Many of these early chemicals had disadvantages. They were often highly toxic, were very persistent, posing a threat to the environment, or they damaged the crops they were meant to protect.

The modern era of chemical pest control commenced during World War II: For example, the much maligned DDT played a major role in the health and welfare of soldiers who used it to control body lice and mosquitoes which transmitted major illnesses. Further developments of insecticides and herbicides followed. With their relatively low cost, ease of use and effectiveness, they became the primary means of pest control. Protection of crops, produce, animals and humans over extended periods became possible with corresponding increases in food production and improved standards of living (Hock *et al.*, 1991).

Modern pesticides are sophisticated compounds which are very carefully researched to ensure they are effective against target organisms, are safe to the environment and can be used without undue hazards to the operators or consumers. Many of these have been developed to target specific biochemical reactions within the target organism, e.g. an enzyme necessary for photosynthesis within a plant or a hormone required for normal development in an insect. Modern chemicals are much safer, more specific and friendlier to the environment than the older products they have replaced.

The use of pesticides in Kenya dates way back to the early 1900s. Acaricides, especially sodium arsenites were the first to be introduced between 1912 and 1949 for vector control of livestock diseases such as East Coast Fever (Keating, 1983). Benzene hexachloride (BHC) and Hexachlorohexane (HCH) were introduced in 1949 for the control of the vector (Keating, 1983), but due to the development of resistance by strains of the ticks, toxaphene was introduced in 1950. Toxaphene, a chlorinated camphene and was banned by National Environmental Action Plan (NEAP) which was more stable in dip washes and residual effect (Keating, 1983).

DDT and dieldrin were introduced in 1956 and 1961, respectively. Other compounds that were used as acaricides in the same period include dinitrocresol (DNC), organophosphorus compounds, Tetraethylpyrophosphate (TEPP), dioxathion, coumaphos and schradan. In 1986, the organochlorines were banned from use in tick control due to the development of resistant strains of ticks (Keating, 1983).

Currently, approximately 80-90% of households use pesticides which translates to approximately 7,000 metric tones of synthetic pesticides imported annually and valued at

KShs. 4 billion (US $ 50 million) (Birech *et al*, 2006; PCPB, 2005). The most common pesticides imported for the control of pests include glyphosate, mancozeb, amitraz, copper oxychloride, 1, 3-dichloropropene, 2, 4-d, amine, sulphur, dimethoate, methyl bromide, carbaryl, quintiofos, chlorfenviphos, coumaphos, fromamidines, chlorpyrifos, malathion, diazinon, the pyrethroids *cis*-permethrin and *trans*-permethrin, the carbamates propoxur, benthiocarb, and the fungicide/disinfectant *ortho*-phenylphenol. Some of these pesticides have replaced the older organochlorines.

Pesticides are basically toxics and persistence; they can enter in food chain and causes injury to human health. they also destroys the diversity and food web and causes ecological imBDLance. Pest control therefore needs regulation on the interest of the human health and environment.

2.5 Health Effects of Pesticides

Humans are exposed to pesticides by direct inhalation of contaminated air or ingestion of contaminated food and water or dermal absorption. Pesticides have been detected in human blood, urine, breast milk, semen, adipose tissues, amniotic fluids, infant meconium and umbilical cord blood (Bouwman *et al.,* 2006). In the body, pesticides are either metabolized, secreted or stored in the fatty tissues. Farm and industrial workers are at a higher risk of occupational exposure.

Exposure to pesticides has been shown to have adverse health effects (Landrigan *et al.,* 1999). For example exposure to aldrin, dieldrin, HCH and chlordane are associated with illness and death depending on the level of exposure. The dangerous acute dose of the technical mixture has been estimated at about 30 g (Lewis, 1999). The mean lethal dose of technical HCH may be about 400 mg/kg when ingested by man and inhalation of more than 400 µg/kg within 3 days may cause toxic effects (Gosselin, 1984). Some acute effects include the development of photosensitive skin lesions, hyperpigmentation, hirsute, colic, severe weakness, porphyrinuria and debilitation. Nursing mothers who ingested these seeds passed the HCH to their breast feeding children. Children born by the pregnant women who consumed the HCH-treated seeds developed a condition called pink sore (Pembe Yara) and had a mortality rate of approximately 95% (Stober, 2000).

Exposure to p, p' -DDE is associated with testicular germ cell tumours whereas exposure to chlordane compounds and its metabolites have been associated with the risk of seminoma (Peters J.A et al., 2006). Research suggests that the development of testicular germ cell tumours in the early stages of life could be associated with the exposure to persistent organic pollutants either during pregnancy or via breast feeding (Katherine *et al., 2008*).

Pesticides are important because they enable farmers to produce sufficient high quality, wholesome food for the world growing population. They also allow efficient and economic pest control and often there is no alternative control option.

People who enjoy a healthy lifestyle because they have unrestricted access to an abundance of good, inexpensive food easily overlook the fact that historically starvation has been a major health hazard. Civilization has been combating weeds, insects, diseases and other pests throughout history and there are many examples of how these pests have had a major impact on humans. One of the worst examples is the Black Plaque of Europe in the fourteenth century when millions died from a bacterial disease spread by fleas from rats

(Hock *et al.*, 1991). Another example is the infamous Irish potato famine of the nineteenth century in which millions died and many more were forced to emigrate. A fungus also destroyed the entire German potato crop in the early twentieth century resulting in 700,000 deaths from starvation (Anon, 1992a). In many countries similar situations continue. Economically advanced countries have plenty of good wholesome food due to a scientific approach to agriculture that includes the use of pesticides.

Without the use of pesticides, the production of quality food would be severely jeopardized; the supply of food production would immediately fall by about 30 to 40% due to the ravages of pests (Anon, 1990b; Anon, 1992a).

2.6 Pesticides in the Environment

Studies on pesticide residues in the environment have been limited to organochlorine pesticides. Following the banning of most organochlorine pesticides, less persistent but more toxic compounds have been introduced. These include organophosphates, pyrethroids and carbamates.

Pesticide residues have been reported in cow and human milk, eggs, beef, fish, flowers, vegetables and fruits from different parts of Kenya. Kituyi *et al.*, (1997) reported chlorfenviphos residues in cow milk ranging from 0.52 to 3.90 mg/kg in dry season and 1.58 to 10.69 mg/kg during the wet season. Milk from cows that were regularly plunged into cattle dip for tick control had the highest pesticides residue levels. Kahunyo *et al.* (1986) reported high residue levels of p.p'-DDT and dieldrin in eggs collected from free range rearing of poultry in Embu.

Wandiga et al., (1988) reported residue levels of γ-HCH in human milk from a Nairobi Hospital in the concentration range from 9×10^{-6} to 1.0 mg/kg. Kanja (1988) had earlier reported thirteen organochlorine pesticides in human milk collected from eight different areas in Kenya. The study revealed that mothers living in urban areas had low levels of organochlorines in their breast milk than those living in rural area. Kanja *et al.* (1992) in studied 41 samples of maternal blood, milk subcutaneous fat and umbilical cord blood from women giving birth by caesarean operation at a National Hospital in Nairobi. They reported the presence of p.p'-DDT, p.p'-DDE, o, p'- DDT, dieldrin, transnonachlor, ß -HCH and lindane with the mean levels of total DDT to be 5.9 mg/kg fat in subcutaneous fat, 4.86 mg/kg in mother's milk, 2.75 mg/kg in maternal serum and 1.9 mg/kg in umbilical cord serum. The mean levels of beta hexachlorocyclohexane (ß -HCH) in subcutaneous fat and milk fat were 0.034 and 0.26 mg/kg fat, respectively.

Getenga *et al.*, (2004) in their study, reported levels of α-BHC, β-BHC, lindane, endosulphan, heptacholar, aldrin heptachlor epoxide, dieldrin, endrin and methoxychlor pesticides contamination in a river draining the sugarcane fields and also soils from the same fields. The reported residue levels ranged from 0 .219 mg/l to 0.691mg/l. Wandiga *et al.* (2002) also reported similar pesticides residue in sea water, sediments, seaweeds and fish which included DDT, DDD, DDE, lindane, α-endosulphan, dieldrin, aldrin and endrin. The levels ranged from 0.503 to 9.025 ng/g in sea water, 0.584 to 59.00ng/g in sediments and concentration of 1011 ng/g and 418 ng/g of p.p'-DDT and p.p'- DDD in fish, respectively.

2.7: Statement of the Problem

In the last two decades, concerns have been raised about the negative impact of chemicals on human health and environment. In this regard, the Stockholm Convention came into force in 2004 as a legally binding international instrument with the aim of protecting humans and the environment from the harmful effects of persistent organic pollutants (POPs). Nine out of the initial twelve chemicals under the convention are pesticides (UNEP, 2008).

Due to rapid population growth worldwide, there is increasing pressure to enhance agricultural production for subsistence purposes and income generation. This situation has resulted in increased use of pesticides in the country to protect crops and livestock from pests and disease vectors. However, lack of awareness on the hazardous effects of these chemicals among the majority of farmers, has resulted into misuse and mishandling leading to environmental contamination. For instance, contamination of fish by endosulfan resulted into a fish ban by the EU in 1999 (EU, 1999).

The past studies on pesticides residue in the country have dwelt on marine and selected riverine ecosytems (Getenga *et al.*, 2004;Wandiga *et al.*, 2006 and Wandiga *et al.*, 2002). Despite the fact that Nairobi West Region has attracted many farming activities due to a ready market for the produce in the City population, data is missing for the levels of pesticide residues in both environment and products such as cow milk. This study was conducted to address this gap.

2.8 Objectives

Overall Objective

To assess the impact and effects of organochlorine pesticides used in agriculture on human health and the environment.

Specific Objectives

1. To conduct a survey to determine the nature of pesticides used in the Nairobi West Region.
2. To determine temporal and seasonal variation in the levels of pesticides in cow milk from selected farms within Nairobi West.
3. To determine the levels of pesticide residues in water and sediments from Mbagathi River that drains the Nairobi West Region and their seasonal variation.
4. To determine the correlation between physicochemical parameters and levels of pesticides in water, sediments and low milk from Nairobi West region.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

Nairobi is the capital city of Kenya, previously known as *'the city in the sun'* because of its appealing environment. It is the most populous city in East Africa, with a current population of 3.1 million according to the national census report (KNBS, 2009). It is located at the south-eastern end of Kenya's agricultural heartland, at approximately 1° 9'S, 1° 28'S and 36° 4'E, 37° 10'E. It occupies an area of about 696 km^2 (CBS ,2001) and the altitude varies between 1,600 and 1,850 metres above sea level (Mitullah, 2003).

The western part of Nairobi is on high ground (approximately 1700–1800 m) with rugged topography, the eastern side is generally low (approximately 1600 m) and flat (Saggerson, 1991). Key physical features include the Mbagathi, Nairobi, Ngong and Mathare rivers and the indigenous Karura forest in northern Nairobi. The Ngong hills stand towards the west, Mount Kenya towards the north and Mount Kilimanjaro towards the south-east of Nairobi.

The capital Nairobi has a temperate climate moderated by the altitude, the hot seasons are sunny and warm while cold seasons are cool. The average maximum temperature in Nairobi varies between 25 °C in February and March and 20°C in July, the average minimum temperatures vary between 10 °C in July and 14°C in April (CBS, 2003) . The rainy months are between April and May and between November and December the average annual rainfall is 1000 mm. The dry months are those between June and September, and January and March.

Five sites located in Karen and Lang'ata suburbs were studied. The areas lie between 1^0, 18'48"S, 36^0, 44'01" E and 1^0, 19'47"S ,36^0.40'48"E; with altitude ranging between 1800 metres and 1854 metres respectively was studied. The area lies about 15 km South-West of Nairobi Central Business District.The main economic activities in Karen and Lang'ata are horticulture and dairy farming.

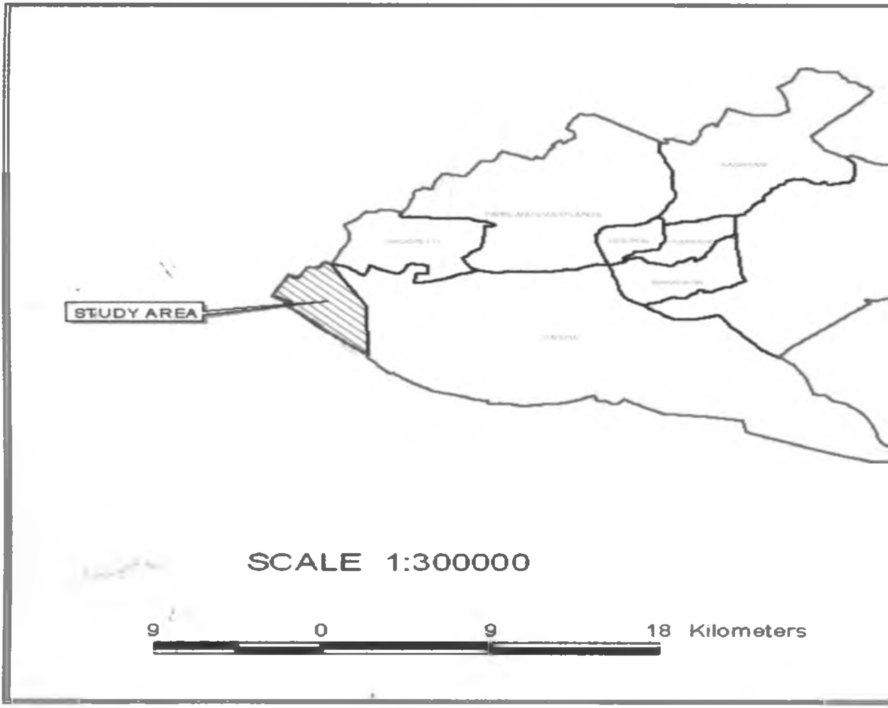
Mbagathi river is from the slopes of Ngong Hills and Kikuyu hills and runs long the boarders of Nairobi and Kijiado Districts.It drains Kiraponi and Gikabura swamps, Ngong area, Karen, Langata as grows to Athi River and all the Rivers in Nairobi becomes it's tributaries. The river is between 4.0 and 5.5metres wide at all the three sites, the depth and water speed varied from one sampling site to another and from one season to the other. The river data was taken during the dry season in the month of February thus the depth and speed were; at Ngong bridge 50cm and 2m/s, Co-operative bridge 80cm and 1.5m/s and Rongai 120cm and 0.8m/s. Mbagathi River changes after the Nairobi National park in wideth, depth and colour because two other tributaries join it thus River Morkoiyot from Langat and Kalai river from Ngong. The river is very usefull for sustaining the wildlife in the park.

3.2 Study Design

Milk samples were collected from the following livestock farms spread randomly within the study area. They are Fare Acres, Karinde Farm, Bogani, Olepolos and Maasai Plains.These site are coded as 3.1.1, 3.1.2, 3.1.3, 3.1.4 and 3.1.5 on the area map (Figure 3). Sediments and Water were collected from the Ngong Road Bridge, the Co-operative College bridge and at the Rongai Bridge on Mbagathi River, which are represented on the area map as 3.1.6, 3.1.7 and 3.1.8 in that order (Figure 3).

The criteria for selection of milk sampling sites 3.1.1, 3.1.2 3.1.3, 3.1.4 and 3.1.5 was based on their vicinity to flower farms where pesticides are used. Mbagathi River was chosen because it acts as a recipatory for wastes and storm water from homes and farms. The maps of the study area is shown in Figure 3 and 4 below.

Figure 3: Map of Nairobi Province



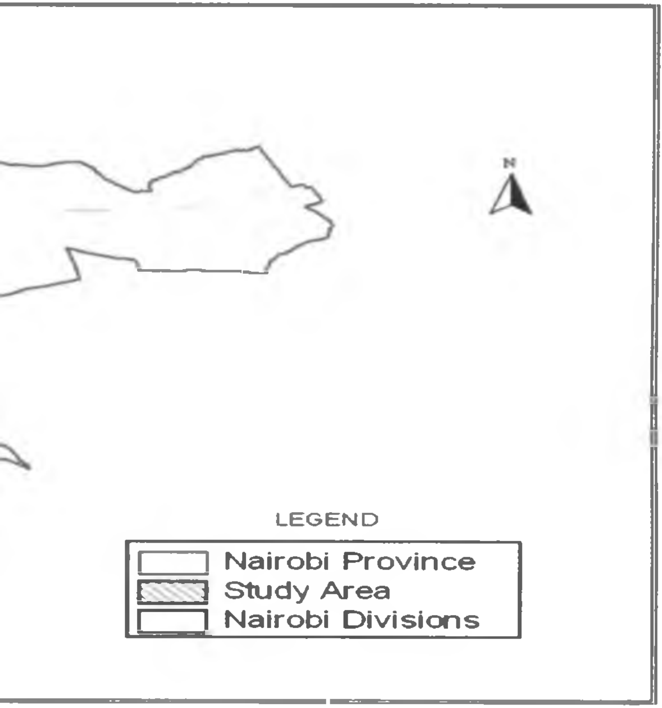
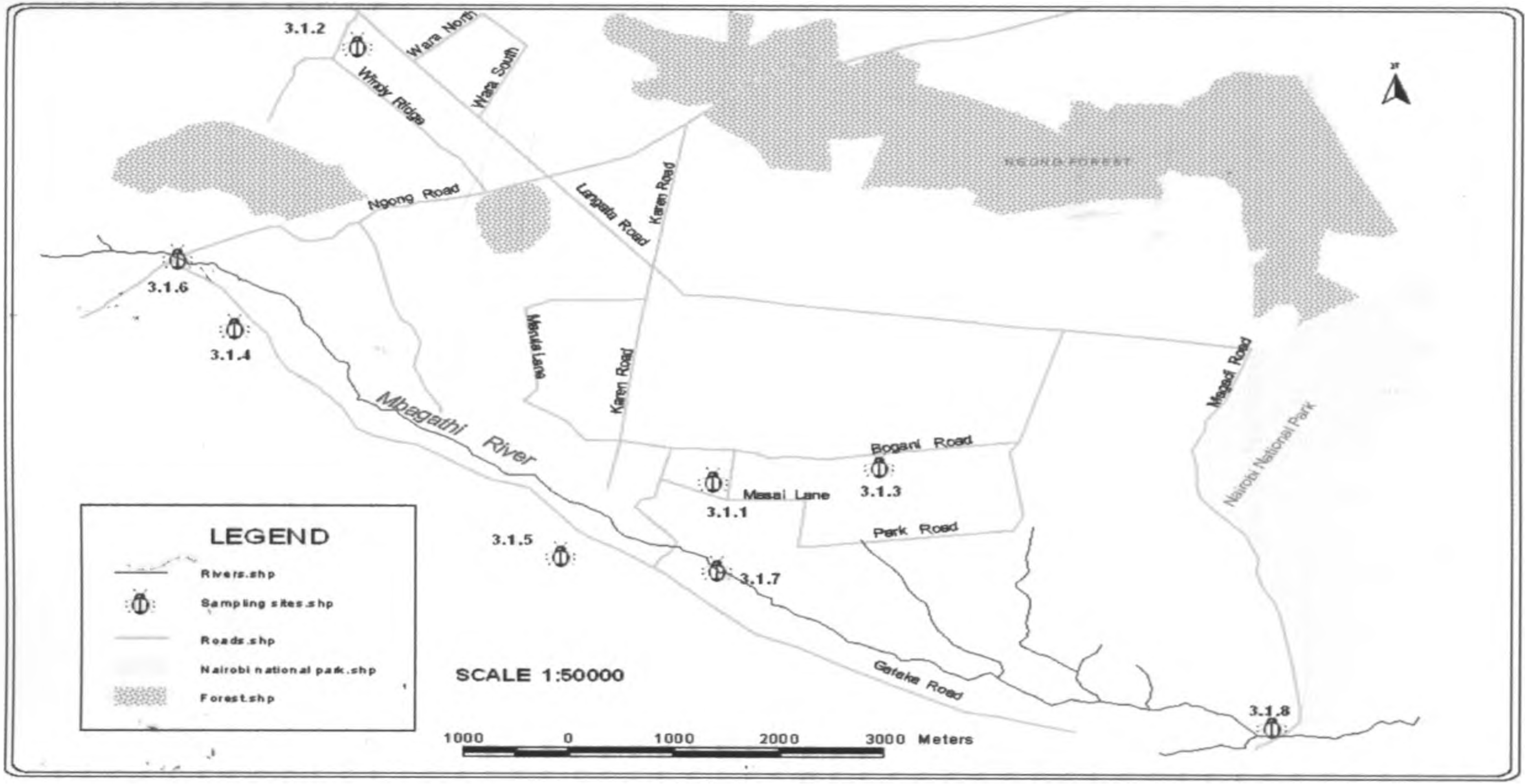

N
LEGEND
Nairobi Province
▨ Study Area
Nairobi Divisions

Figure 4: Map of the study Area



3.3 Chemicals

General Purpose Grade n-hexane, methylene chloride, acetone, HPLC grade iso-octane and toluene were acquired from SCIELAB LTD, Nairobi. In the laboratory, General Purpose Grade solvents were triple distilled before use. Aluminium oxide, anhydrous sodium sulphate, analytical grade sodium chloride, mercuric chloride, dipotassium hydrogen phosphate, analytical grade hydrochloric acid and sodium hydroxide were bought from SCIELAB LTD, Nairobi.

White spot nitrogen used for gas chromatography was purchased from BOC Kenya LTD, Nairobi.

High purity pesticide standard mixture was obtained from ULTRA Scientific, North Kingstown, USA.

3.4. Methodology

3.4.1 Field Survey

A structured field questionnaire was designed and distributed to a total of 105 farmers, 25 Agro- chemical suppliers and 10 extension workers selected randomly (Annex Table II). The respondents were asked questions on awareness status regarding safety information, training on the use and formulation, pesticide- related accidents and their frequency, any known effects of pesticides to the users and the details of the pesticide claimed to have any effect by name. They were also asked questions regarding the technical assistances from agricultural extension workers. Additional questions were designed to gather more information from the agro- veterinary dealers and the extension workers. Their questions touched on educating the farmers on the use of the chemicals, the stock of pesticides in the area and how they deal with emerging issues.

3.4.2 Sampling

3.4.2.1 Sampling of Cow Milk

Fresh milk samples were collected once a month for a period of six months from five different farms. At each sampling site, all lactating cows were milked, the milk thoroughly mixed and a 500 ml representative sample drawn using a glass cup. The sample was put into a hexane- rinsed 500 ml amber bottle, stored in a cooler box at 4°C in the field a waiting to be transpoted to Laboratory where they were refrigerated at -4 °C awaiting extraction.

3.4.2.2 Sampling of water

Water was collected by grab method into 2.5 L amber bottles from three sites along Mbagathi River namely: Ngong Bridge, Co-operative College Bridge and Rongai Bridge. Each sample was treated with mercuric chloride solution to achieve 10 ppm concentration for preservation. The samples were kept in ice box containing wet ice and transpoted to the labaratory where they were refrigerated at 4°C because water solidify at this point.

3.4.2.3 Sampling of Sediments

Both sediments and water samples were collected from the same points. A pre-cleaned stainless steel shovel was used to sample surface sediments from the shallow river beds Wandiga S.O. (2001). Three composite samples, were mixed on clean piece of aluminum foil, and a 500g representative sample weighed and wrapped in another clean piece of aluminum foil, packed in black polythene bag, labeled, then placed into a self-sealing bag. They were then packed in a cooling box and transpoted to the laboratory, where they were stored in a deep freezer at -20 °C prior to analysis (UNEP, 2007).

3.4.3 Preparation of Reagents

Aluminum oxide (Al_2O_3) was activated by putting in an oven for 12 hours at 200°C. This was followed by deactivation with 8 % by weigt distilled water. Sodium sulphate (Na_2SO_4) was prepared by baking out for 16 hours at 200 °C. The copper powder was activated by shaking with 9 ml of dilute hydrochloric acid solution (3:1 ratio for H_2O:HCl). The mixture was centrifuged for 1 minute at 300 rpm and acid solution discarded. The powder was rinsed three times with methanol to eliminate all the hydrochloric acid, and the supernatant discarded. The remaining powder was dried under a gentle stream of white spot nitrogen before use.

3.4.4 Extraction

3.4.4.1 Extraction of Milk

Milk sample (25 ml) was put in a conical flask. A 100 ml mixture of hexane:acetone (3:2 v/v) ratio was added, put in a blender and then homogenized at 1500 rpm for 15 minutes. The hexane layer was drained through a column of sodium sulphate and concentrated to 1 ml using a rotary evaporator. The lipid content was determined gravimetrically before taking an aliquote sample with maximum fat content of 250 mg for alumina column clean up.

3.4.4.2 Extraction of sediment samples

USEPA method 3540 Soxhlet extraction was used (Keith, 1996) for sediments. Approximately 20 g of a wet sample was transferred into a beaker mixed with 60 g anhydrous Na_2SO_4 The sample was ground and allowed to stand for at least four hours to dry before being transferred into a Soxhlet thimble. PCB 155 (100μl) of concentration 1 ppm was added to the sample as an internal standard and extraction was done for 16 hours using 130 ml n-hexane:acetone (3:1 v/v). The extract was concentrated to 1 ml using a rotary evaporator before alumina clean up.

3.4.4.3 Extraction of Water samples

The water samples were extracted by solvent –solvent extraction method (Keith, 1996). A liter of water was transferred into a two liter separatory funnel and pH adjusted to 7 by adding 50 ml of 0.2 M dipotassium hydrogen phosphate buffer. The sample was treated with 100 g of sodium chloride to salt out pesticides from the aqueous layer before adding 60 ml of DCM for extraction. Extraction was repeated thrice using 60 ml portions of DCM and the extracts combined, 2 ml of isooctane was added to the extract and concentrated to 1 ml using a rotary evaporator.

3.4.5 Fat content determination

Milk extract (0.5 ml) was transferred into a preweighed clean glass vial. The fat content was determined by evaporating off the moisture at 105 ^{0}C for two hours until a constant weight was achieved. The difference in weight between the empty vial and the vial with dry content constituted the weight of fat in the sample (UNEP,1982).

3.4.6 Sample cleanup

Sample clean up was done using USEPA Method 3620B (Keith, 1996). A chromatographic column 25 cm x 1.5 cm diameter was packed with 1 cm of freshly baked anhydrous sodium sulphate, followed by 15 g of deactivated alumina and finally another 1cm layer of anhydrous sodium sulphate. The column was pre-conditioned with 15 ml hexane and discarding filtrate.

The sample extract was introduced into the column, the sample vial was rinsed four times with 1ml portions of n-hexane then eluted with 165 ml of the same. 2 ml of iso-octane was added to each cleaned sample and concentrated to 1ml using a rotary evaporator. The extract was transferred into a clean pre-weighed vial and concentrated to 0.5 ml under a gentle stream of white spot nitrogen.

3. 4.7 Sulphur Removal

Sulphur was removed from all sediment extracts by adding gentlely a gram at time of freshly activated copper powder until no more fromation of black coloration of copper sulphide is observed. The extract was then filtered into a clean vial and concentrated to 0.5 ml under a gentle stream of nitrogen.

3.4.8 GC Analysis and Quantification of pesticides in samples.

Pesticide residues were identified and quantified using Varian CP 3800 gas chromatograph equipped with Electron capture detector (ECD), at the Department of Chemistry, University of Nairobi. Capillary column BPX 5 30 m x 0.25 mm x 0.25μm was used for separation of analytes. Helium (99.9995%) was used as the carrier gas, whereas white spot Nitrogen (N_2) was used as a make-up gas. A temperature programme starting at 90 °C with hold time of 3 minutes, ramped at 8 °C /minute to 190°C with a hold time of 10 minutes, then ramped to 220°C at 4 °C /minute with a hold time of 10 minutes and finally ramped to 275 °C at 5 °C/min and maintained for 16 minutes was done.

The injector and detector temperatures were set at 250°C and 300°C, respectively, whereas the injection volume was fixed at 1 μl. The GC was calibrated using 8 multilevel concentrations standards consisting of 17 organochlorine pesticides. A calibration curve was developed for each analyte and used in the quantification of the pesticides. Data processing was done using Microsoft Excel.

3.5 Moisture content determination

Moisture content in each sediment sample was determined by heating 5 g of the sample in pre-cleaned and pre-weighed glass vials in an oven (model E 28# 04- 71528) at 105°C for 24 hours. The difference in weight between wet and dry sediments was used to calculate the moisture content of the sediment sample.

3.6 Determination cf pH of Sediment, Milk and Water Samples

The pH of the sediment and water samples was determined using pre-calibrated Fishers Scientific Accumet pH meter model 910 at room temperature. A buffer solution of pH 7.0 was used to standardise the instrument before taking the readings.

The pH of the sediment was measured by taking 10 g of the sample and adding 25 ml of the distilled water in a 2:5 ratio of a sediment:water suspension. The mixture was manually shaken for about 30 minutes before the electrode was dipped into the suspension to measure the pH.

The pH of the water and milk samples was determined by transfering 50 ml of each into a beaker and taking the reading directly.

3.7 Quality Control

Recovery tests were conducted to determine the extraction efficiency of the method. This was achieved by spiking blank with organochlorine pesticides standards. One litre of distilled water, 25 ml of milk and 5 g of sodium sulphate were spiked with 100 µl of standard pesticide mixture of aldrin, dieldrin, p.p'-DDT, p.p'-DDE, p.p'-DDD, α-endosulphan, β-endosulphan, endosulfansulfate, endrin, endrin aldehyde, α-HCH, β-HCH, γ-HCH, δ-HCH, heptachlor, heptachlor epoxide and methoxychlor, which was then allowed to stand for 15 minutes. The spiked samples and blanks were extracted, cleaned and analysed following the same method used for field samples. Recoveries were calculated to determine the method performance.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Inventory of Pesticides Used in the Nairobi West Region

The interview questionaires were administered to 140 adults, where 57% were women and 43% men. From the number interviewed, 51% were farmers, 17.8% were agro- chemical dealers while the rest were involved in other occupations. Analysis of the data gathered from the questionnaires also revealed that over 61.3% of people in Langata and Karen area use pesticides to control crops and livestock pests and disease vectors. The study also reviewed that all the people interviewed had some primary education, however only 43% read the instruction manual attached on the pesticide packageing containers. The study further revealed that only 25% of the farmers have basic training on safety and control measures when handling farm chemicals. (Table 4.9 in Appendix III).

This region of Nairobi has many livestock kept mainly as pets, for sports, for meat, milk and eggs. More than 91% of men who responded to my questionaires were below the age of 35 years and many worked in the farmers as gardners, cooks and livestock managers. They spray crops, livestock and houses regularly hence high usage of pesticide leading to 17.8% agro-chemical based business. On the other hand only 87.5% of the women respondants were below 35 years were involved in household chores, and in flower farms to grade to flowers this explain difference imbalances. Low percentages depicted in the area of reading instruction manuls and training is because of ignorance on the side of the farmer owners and employees. There are no regulations and guideline on public health safety.

Most farm manager were unwilling to answer questions related to health and safety of their farm employees, this was because they feared to be victimised or reported to Human rights authorities.

4.2 Milk analyses

4.2.1 Fat content in milk

The average fat content in milk varied from one type of breed to the other with a mean value of 3.7% , 3.6%. 4.7%, 5.0% and 6.5% for breeds: Fresian, Jersey, Zebu and Mixed, respectively. Table 4.1 below shows the summary of fat content over the entire sampling period.

Breed	Site	Nov	Dec	Jan	Feb	March	April
Mixed	Bogani	3.9±0.2	4.3±0.5	4.9±0.2	6.3±0.6	4.7±0.5	5.9±0.6
Fresian	Fare Acres	3.6±0.3	3.7±0.3	3.6±0.4	3.6±0.4	3.7±0.3	3.9±0.4
Fresian and Jersey	Karinde	3.6±0.1	3.8±0.2	3.5±0.1	3.9±0.5	3.7±0.4	3.5±0.3
Zebu	Olepolos	4.5±0.5	4.7±0.1	4.8±0.6	4.9±0.3	4.4±0.5	4.9±0.2
Mixed	Maasai plains	5.2±0.4	5.8±0.3	7.0±0.5	7.2±0.1	6.6±0.4	6.9±0.3

Table 4. 1: The percentage fat content in milk samples from the five sites

Milk from the Fare Acres and Karinde sites had fat content within the expected range of 3.0 to 4.5 percent, but milk from Bogani, Olepolos and Maasai Plains sites recorded significantly higher values in , which were above the recommended range of 3.0 to 4.5 (Kirk *at el.*, (1991)). Milk composition varies considerably among breeds of dairy cattle: Jersey and Guernsey give milk of higher fat and protein content than Shorthorns and Friesians. Zebu cows can give milk containing up to 7% fat (Coulibaly et.al., 1998). The three sites had milk fat content above the recommended range, they also had mixed breed and zebu all theses have a higher fat content.

The potential fat content of milk from an individual cow is determined genetically, as well as protein and lactose levels. Heredity also determines the potential milk production of the animal. However, environment and various physiological factors greatly influence the amount and composition of milk that is actually produced. The fat content of milk varies considerably between the interval between milkings (Dang A.K et.al (2007). If cows were milked at 12-hour intervals the variation in fat content between milkings would be negligible, but this is not practicable on most farms. The fat, lactose and protein contents of milk also vary according to stage of lactation. Solids-not-fat content is usually highest during the first 2 to 3 weeks, after which it decreases slightly. Fat content is high immediately after calving but soon begins to fall, and continues to do so for 10 to 12 weeks, after which it tends to rise again until the end of the lactation (Jöchle, W., (1972), Lescourret F, et.al (1994). Juozaitiene V et. al., (2006)).

4.2.2 pH of cow milk.

The pH of milk ranged between 6.3 to 6.9 Samples collected in November and December from Fare Acres (7.3 and 8.2) and Maasai Plains (7.5 and 7.1) had the highest pH recorded compared to the rest of the months. The difference could be attributed to different sources of cow feeds, however the pH measured is within the range expect for Fare Acres and Maasai plains during November and December months. Table 4.2 below shows the results of milk pH.

Table 4.2: The pH of milk samples

Months	Nov.	Dec.	Jan.	Feb.	March	April
Bogani	6.7±1.2	6.5±1.4	6.5±1.2	6.5±1.1	6.4±1.1	6.5±1.0
Fare Acres	7.3±0.8	8.2±0.6	6.3±1.2	6.8±0.2	6.5±1.2	6.7±1.2
Karinde	6.6±1.2	6.6±1.0	6.5±0.6	6.7±0.9	6.4±1.2	6.5±0.7
Olepolos	6.9±0.2	6.3±1.2	6.6±0.9	6.5±0.6	6.9±1.2	6.5±1.0
Maasai plains	7.5±0.4	7.1±0.5	6.7±0.9	6.7±1.0	6.8±0.8	6.6±1.2

4.2.3 OCPs recoveries

The mean recoveries for all pesticides ranged between 70-115%. This is within the acceptable range hence the results were not corrected. Table 4..3 shows the recovery of each pesticide.

Table 4.3: Percentage recovery values for selected pesticides

Organo chlorine Pesticides	**Average % ± S.D**
alpha BHC	77.42±11.92
Aldrin	81.80±41.59
Dieldrin	114.83±18.39
Endrin	70.00±10.77
endosulfan II	88.00±30.86
4,4'-DDD	71.93±7.87
endrin aldehyde	114.50±9.19
4,4'- DDT	79.50±13.43

4.3.1 Calibration plots

Calibration of the gas chromatograph (Varian CP 3800) consisted of the analysis of nine calibration solutions of OCP mixed standards each at diffirent concentrations that spanned the concentration range of the samples. The standard solutions were prepared in iso-octane, an internal standard PCB 198 added into each OCP standard mixture and determined by GC-ECD with conditions described in section 3.4.8 above. Standard curves for the pesticides were constructed by plotting the ratio of the OCP peak to that of PCB 198 peak are against the concentrations and a line fitted using linear regression.

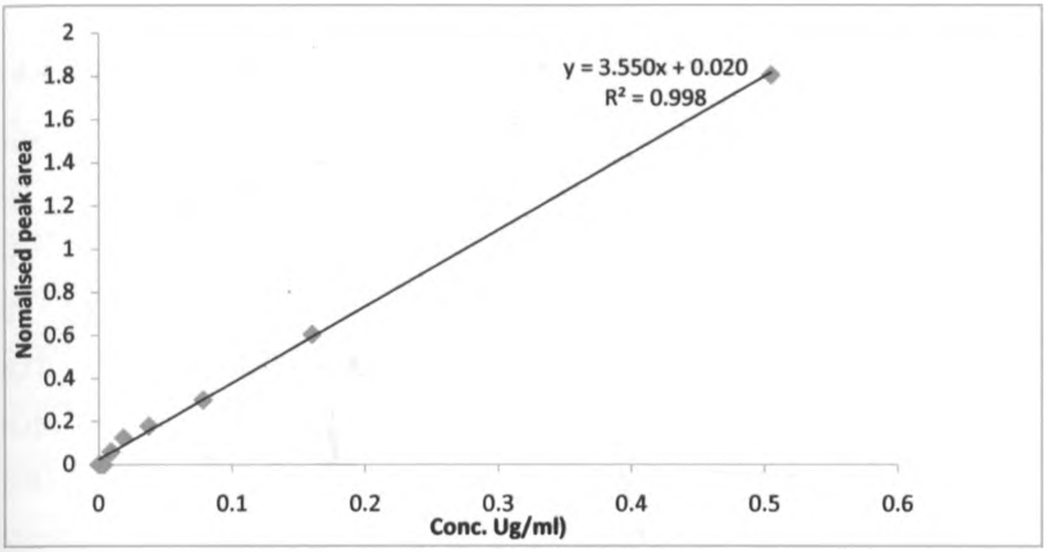


Figure 4.5: Sample Multilevel Calibration Curve for OCP mixed standards.

4.2.4 Limits of detection

Table 4.4 below shows the Limit of Detection (LOD) of various pesticides. The LOD of a compound is the lowest concentration of the analytes that the analytical process can reliably detect.

The LOD of each of the OC Pesticides was calculated based on the lowest concentration of the calibration standards injected and the corresponding noise signals using the following relationship:

LOD = <u>3 x Noise Signal x Mass of Analyte</u> (Miller and Miller, 1993).

Analyte response

The limits of detection for OC Pesticides ranged from 0.0011µg for α HCH to 0.0036µg for Aldrin. Any other values detected below these values were considered as noise and hence reported as below detection limit (BDL).

Table 4.4; Limit of Detection Values for various pesticides.

Pesticides	LOD (µg)	Pesticides	LOD (µg)
α HCH	0.0011	Endosulfan sulfate	0.0021
β HCH	0.0016	Aldrin	0.0036
γ HCH	0.0016	Dieldrin	0.0031
p.p' DDT	0.0017	Endrin	0.0022
p.p' DDE	0.0018	Heptachlor	0.0011
p.p' DDD	0.0016	Heptachlor epoxide	0.0011
α- endosulfan	0.0011	Methoxychlor.	0.0016
β endosulfan	0.0015		

4.2.5 Levels of OC Pesticides in Cow Milk

A total of 17 pesticide residues were measured in cow milk collected from the five sampling sites. The mean concentration ranged between below dectection limits (BDL) to 4861 ng/kg. The highest concentration was recorded in milk from Karinde in November. Farmers in Bogani, Fare Acres and Karinde practice zero grazing while the farmer in Olepolos practiced semi- zero grazing. The farmer from Maasai plains grazed his cows from one point to another. The results of pesticides residues analysed in milk are summarised in Tables 4.6 (a) to (e).

The concentration of heptachlor epoxide in milk from Bogani was below the detection limits during the months of February and April while p.p'- DDD was the highest recorded pesticide level with a concentration of 1178.ng/kg as seen in table 4.6 a below

***Table 4.6a Levels of OC Pesticides in Bogani milk* (ng/kg ± s.d). Mean ±s.d N=3, BDL= Below Detection Limit**

OCPS	November	December	January	February	March	April	Average
p, p DDT	88.6±16.80	283.23 ±28.20	285.00±106.09	12.60±5.26	158.20±52.60	65.81±9.40	148.87±105.67
Methoxychlor	69.40±7.40	1154.80±151.20	104.40±73.80	216.00±0.45	26.36±12.20	91.40±21.60	277.70±23.03
Endrin	18.20±10.40	189.40±119.31	68.43±8.09	62.40±39.20	69.80±0.67	66.56±11.60	78.97±38.03
Endrin aldehyde	15.30±1.20	341.40±61.40	54.87±5.60	14.80±0.35	88.40±14.60	26.80±33.20	90.12±9.03
Endosulfan sulphate	41.20±0.39	68.20±7.60	223.40±161.20	35.40±25.20	61.40±5.80	61.40±5.80	81.83±6.10
Dieldrin	47.60±17.34	79.60±41.20	86.80±58.40	186.32±21.20	15.20±8.60	1.60±0.21	69.47±57.73
Heptachlor	14.49±10.40	38.60±14.40	33.80±7.14	22.80±19.20	4.60±2.80	38.80±4.80	25.43±15.77
Endosulphan	30.12±12.23	126.20±58.80	173.41±93.20	50.80±14.40	8.80±3.60	25.60±0.50	69.07±41.97
A-endosulphan I	103.60±73.20	751.40±114.56	218.11±128.60	41.71±26.20	3.60±0.89	63.20±0.23	196.73±24.23
p.p' DDE	3.60±0.20	10.20±1.20	3.11±2.20	8.40±11.20	4.20±0.20	2.60±0.40	5.33±4.07
Aldrin	69.60±17.60	433.40±53.12	109.20±15.20	69.60±10.20	23.00±17.15	250.60±38.20	159.23±124.87
α-HCH	30.40±19.80	36.80±0.13	101.40±68.15	11.60±9.13	79.20±0.11	42.11±4.80	50.23±16.93
γ-HCH	21.80±7.40	103.23±84.23	79.40±55.80	31.80±24.60	38.80±11.80	29.40±2.20	50.70±4.63
β-HCH	32.40±19.80	82.80±35.60	115.20±47.20	34.80±25.20	33.60±26.20	33.2±12.40	55.33±27.73
δ-HCH	18.60±11.80	72.60±53.80	48.60±29.40	27.80±15.40	26.40±16.11	49.40±32.80	40.57±26.53
Heptachlor epoxide	39.33±3.07	74.16±7.22	78.02±6.63	BDL	22.29±0.76	BDL	53.45±28.15
p.p' DDD	161.03±114.68	1178.84±181.29	106.36±77.70	34.61±5.22	93.24±23.43	141.85±15.29	285.99±37.27
∑17 OCPs	804.65±39.24	5024.00±478.33	1887.6±64.62	860.41±57.04	756.73±38.58	989.66±72.22	1738.32±94.02

In Table 4.6b it is envidence that endosulphan sulfate and heptachlor epoxide had the lowest concentrations recorded while aldrin was the highest at Fare Acres at a concentration of 1117.84 ng/kg in April.

Table 4.5b Levels of OC Pesticides in Fare Acres milk (ng/kg ± s. Mean **±s.d N=3, BDL= Below Detection Limit d).**

OCPS	November	December	January	February	March	April	Average
P, P DDT	17.38±7.92	55.93±7.14	319.85±64.03	118.11±85.80	28.78±8.73	95.03±35.57	105.85±56.53
Methoxychlor	44.80±9.46	53.22±13.58	62.45±6.82	132.77±65.63	198.48±16.85	188.70±12.18	113.40±13.09
Endrin	80.37±0.27	15.48±10.59	26.61±8.42	999.19±158.60	163.99±14.93	73.04±7.14	226.45±27.66
Endrin aldehyde	26.88±36.11	22.81±20.09	100.19±89.60	94.76±29.79	171.60±16.18	883.52±123.46	216.63±27.04
Endosulfansulfate	bdl	115.67±0.34	9.50±3.77	36.38±19.55	59.73±6.54	59.73±6.54	46.84±26.07
Dieldrin	138.75±57.02	146.35±65.16	42.90±2.72	112.95±14.66	34.07±3.40	51.58±38.83	82.77±35.30
Heptacholor	41.54±31.22	23.89±2.17	19.55±5.70	22.81±21.99	20.09±14.99	15.75±13.85	23.94±14.98
Endosulphan	19.01±6.07	43.71±4.71	31.22±21.99	317.13±27.95	91.77±14.90	31.50±3.67	89.06±9.05
A-endosulphan I	39.64±6.44	26.34±19.28	154.50±20.72	76.30±8.37	46.43±8.69	49.96±0.45	65.53±63.08
P.P' DDE	3.26±0.99	4.34±0.80	1.90±0.17	55.39±5.02	8.96±1.59	14.39±7.33	14.71±3.98
Aldrin	17.38±1.82	47.52±9.51	39.37±5.03	8.42±0.34	108.61±0.67	1117.84±119.90	223.19±43.88
α-HCH	47.79±9.40	292.70±33.24	15.75±11.13	306.00±48.73	52.95±16.56	36.24±4.09	120.24±18.65
γ-HCH	31.50±3.38	89.06±7.22	34.75±9.77	36.38±22.81	33.13±9.37	935.92±124.92	193.46±27.08
β-HCH	31.50±3.30	81.73±34.75	45.07±25.52	95.85±8.38	158.02±12.28	29.60±8.96	73.63±47.20
δ-HCH	26.34±2.79	58.65±22.56	30.41±21.99	38.28±19.28	42.90±29.87	27.69±21.18	37.38±23.45
Heptchlor Epoxide	BDL	18.96±0.24	29.31±3.72	41.81±37.28	98.08±64.88	43.80±8.86	38.66±24.13
P.P' DDD	56.33±12.65	34.75±30.38	75.88±52.54	101.66±45.45	177.96±26.89	11.77±5.94	76.39±8.64
∑17 OCPs	622.44±31.83	1131.09±55.32	1039.21±120.87	2594.19±303.43	1465.56±67.41	3636.08±479.34	76.39±3.65

At the Karinde site, p. p' DDE had the highest concentration of 4861.19 ng/kg while methoxychlor, aldrin, α-HCH, endosulfan sulfate and heptachlor epoxide were below detection limits during the months of February and March, Table 4.6c below

Table 4.6c Levels of OC pesticides in Karinde milk (ng/kg ± sd). Mean **±s.d N=3, BDL= Below Detection Limit**

OCPS	November	December	January	February	March	April	Average
p, p DDT	92.17±44.26	BDL	468.23±66.94	38.72±3.63	128.44±116.17	50.49±43.63	129.68±16.94
Methoxychlor	4.64±2.45	34.36±3.39	62.45±9.08	26.99±17.73	455.41±25..34	137.17±18.8	120.18±105.13
Endrin	16.91±7.93	32.72±3.03	33.82±38.45	173.44±142.62	295.61±73.88	29.72±20.09	97.04±10.99
Endrin aldehyde	6.54±1.42	41.99±4.23	101.45±12.26	94.08±64.36	356.15±209.16	32.45±12.00	105.44±74.87
Endosulph.Sulphate	1.91±0.45	111.26±21.20	120.81±0.34	22.09±0.34	BDL	BDL	42.68±18.14
Dieldrin	47.18±35.45	59.45±59.45	32.18±21.23	184.89±19.09	217.34±12.21	19.63±2.27	93.45±30.04
Heptachlor	15.54±8.54	10.64±1.44	24.82±2.095	46.63±15.27	79.90±28.01	6.27±3.32	30.63±16.25
Endosulphan	26.18±2.36	43.91±7.63	22.09±7.90	278.16±68.72	144.53±46.09	33.82±28.25	91.45±8.99
A-endosulphan I	79.90±7.63	93.54±9.84	85.08±0.25	44.18±6.45	164.99±76.36	36.11±0.35	83.95±49.50
P.p' DDE	4861.19±2.37	5.73±5.73	6.23±0.27	10.09±1.64	16.91±7.18	1.91±0.55	816.97±6.12
Aldrin	105.81±163.51	71.99±21.57	98.17±61.63	110.99±15.99	BDL	62.18±17.63	74.86±27.87
α-HCH	35.45±3.36	139.08±19.08	277.07±0.34	BDL	117.81±9.63	48.81±6.99	103.04±41.91
γ-HCH	118.08±9.54	23.73±2.73	34.91±3.82	102.81±81.81	112.63±12.99	20.73±2.73	68.81±6.77
β-HCH	27. 80±2.91	42.54±4.63	21.82±9.82	104.99±91.08	168.26±72.81	205.34±39.52	94.99±9.63
δ-HCH	20.45±6.36	22.69±2.53	25.63±8.18	71.18±44.18	119.99±49.63	68.18±99.26	54.68±40.04
Heptchlor Epoxide	57.19±0.14	9.98±0.98	11.81±3.47	BDL	52.07±13.22	33.07±4.77	27.35±13.26
P.P' DDD	123.14±109.76	147.97±44.31	184.16±87.05	364.97±0.34	247.79±121.19	75.36±15.69	190.57±95.10
∑17 OCPs	5639.29±851.2	891.52±45.14	1610.48±136.8	1674.22±82.6	2677.82±120.	861.13±73.45	2225.74±142.2

Milk from Olepolos had Methoxychlor as the highest with a concentration of 949.47 ng/kg in November milk while least concentrations recorded were those of p.p' DDT, methoxychlor, endosulfan sulfate, Aldrin, γ-HCH, α-HCH and heptachlor epoxide recorded at below detection limits, shown in Table 4.6d.

Table 4.6d:Levels of OC Pesticides in Olepolos milk (ng/kg ± s .d). Mean **±s.d N=3, BDL= Below Detection Limit**

OCPS	November	December	January	February	March	April	Average
p, p DDT	476.17±61.49	BDL	62.77±2.45	35.74±5.51	45.74±27.87	22.98±2.19	107.23±15
Methoxychlor	949.47±2.25	165.64±15.46	196.17±23.64	BDL	864.32±219.38	548.92±10.02	454.08±20.16
Endrin	45.74±13.19	8.72±1.21	27.87±8.87	179.36±17.24	97.87±52.34	152.99±15.18	85.43±7.16
Endrin aldehyde	510.12±78.51	156.60±28.72	191.28±11.48	266.17±26. 71	131.70±60.21	103.62±13.12	226.56±21.42
Endsulfan sulfate	95.32±12.13	82.34±61.49	6.20±3.19	18.30±1.30	BDL	BDL	33.19±24.18
Dieldrin	289.79±21.49	50.85±11.28	25.53±5.50	177.66±17.06	132.99±7.02	26.17±2.96	117.16±81.49
Heptachlor	12.34±5.74	16.60±5.32	7.87±2.87	32.98±2.98	42.98±4.68	7.45±1.45	20.04±10.67
Endosulphan	72.1±55.74	10.85±1.49	20.13±4.35	18.72±3.12	72.34±2.34	87.45±7.02	46.91±39.43
A-endosulphan I	164.26±12.98	7.02±2.87	65.11±5.11	54.26±4.26	8.94±2.66	133.19±13.19	72.13±8.51
P.P' DDE	7.66±3.40	6.17±6.81	3.4±3.40	7.87±1.87	1.28±0.74	4.89±1.89	5.21±1.40
Aldrin	413.19±27.45	59.57±7.23	33.83±3.83	84.89±8.89	BDL	198.30±24.68	131.63±18.01
α-HCH	20.43±18.30	56.17±0.45	7.87±1.87	7.23±0.23	116.17±7.21	BDL	34.65±5.57
γ-HCH	404.89±51.70	31.49±18.30	50.64±26.38	72.34±7.34	43.40±29.36	BDL	100.46±23.01
β-HCH	32.98±24.89	38.72±20.21	33.19±33.19	31.28±3.28	12.55±8.51	93.19±9.13	40.32±5.04
δ-HCH	155.55±65.04	32.97±15.74	18.08±1.08	23.19±2.19	867.05±194..91	62.77±7.40	193.27±35.06
Heptchlor epoxide	50.54±31.67	31.24±16.74	1.68±0.68	BDL	74.89±6.92	42.58±4.58	33.49±25.76
P.P' DDD	255.51±25.35	14.82±0.01	45.87±5.87	72.07±7.37	101.55±13.52	257.37±26.46	124.53±12.88
∑17 OCPs	3955.96±676.80	769.78±132.46	794.36±139.63	1082.07±187.27	2613.76±519.59	1741.83±315.05	1826.29±117.53

Milk from Maasai Plains site, heptachlor as the highest during the month of April with a concentration of 1851 ng/kg,while that of Heptachlor epoxide was below detection limit during the month of February, Table 4.6e

Table 4.6e Levels of OCPs pesticides in Maasai Plains milk (ng/kg ± s.d) Mean ±s.d **N=3, BDL= Below Detection Limit**

OCPS	**November**	**December**	**January**	**February**	**March**	**April**	**Average**
p.p' DDT	639.38±52.71	89.92±7.66	71.32±0.57	44.51±10.23	57.05±0.43	19.93±0.35	153.68±23.10
Methoxychlor	31.01±3.39	111.78±1.24	1350.54±213.81	55.19±8.29	7.75±1.70	28.53±2.17	264.13±72.89
Endrin	62.33±53.49	41.24±5.59	178.45±21.39	56.59±30.39	55.35±41.55	5.12±6.67	66.53±6.51
Endrin aldehyde	222.95±38.60	9.46±5.46	499.69±55.88	73.18±0.23	552.25±211.63	144.19±13.64	250.28±28.04
Endosulfan sulphate	38.45±0.29	17.98±12.84	60.93±23.72	67.60±6.37	44.81±12.40	44.81±12.40	45.76±22.79
Dieldrin	55.81±8.45	27.60±20.78	97.83±36.74	52.25±46.36	49.15±31.78	49.47±4.88	55.35±9.66
Heptachlor	86. 20 ±6.24	209.30±28.68	228.84±65.74	87.13±12.93	74.73±17.21	1851.94±5.48	423.02±92.30
Endosulphan	6.36±3.12	4.81±2.50	9.92±2.33	6.34±3.26	1.71±0.39	2.48±1.17	5.27±2.89
A-endosulphan I	94.26±14.57	4.65±0.93	18.45±12.56	45.27±4.27	41.24±5.70	24.96±9.69	38.14±23.95
P.P' DDE	6.36±5.12	4.81±2.50	9.92±2.33	6.36±3.26	1.71±0.78	2.48±1.17	5.27±2.89
Aldrin	94.26±14.57	4.65±0.93	18.45±12.56	45.27±4.24	41.24±5.70	24.96±19.31	38.14±2.95
α-HCH	77.98±36.12	4.81±1.88	24.03±1.21	22.48±3.70	49.77±3.72	33.33±0.56	35.40±12,40
γ-HCH	47.29±6.52	22.02±17.98	229.61±15.81	46.98±3.19	186.20±28.06	139.07±18.91	111.86±75.25
β-HCH	36.12±21.71	33.49±28.53	81.71±8.47	29.92±2.78	73.95±9.16	71.94±13.26	54.52±5.65
δ-HCH	13.33±9.30	3.72±0.62	35.04±31.78	19.07±2.64	61.09±7.74	48.37±5.71	30.10±2.97
Heptachlor epoxide	11.32±0.32	18.79±23.97	1027.44±190.85	BDL	39.88±4.94	17.92±11.76	185.89±43.64
P.P' DDD	130.63±95.92	22.15±3.69	102.29±13.86	65.84±47.48	34.69±3.15	70.70±7.22	71.05±58.55
∑17 OCPs	1654.04±292.70	631.17±117.10	4044.46±780.74	723.98±119..29	1372.55±241..94	2580.17±522.09	1834.40± 1293.61

4.3.1 Temporal Variation

Figure 4.6 below shows the monthly sum of 17 OC Pesticides in Milk for all the sites.

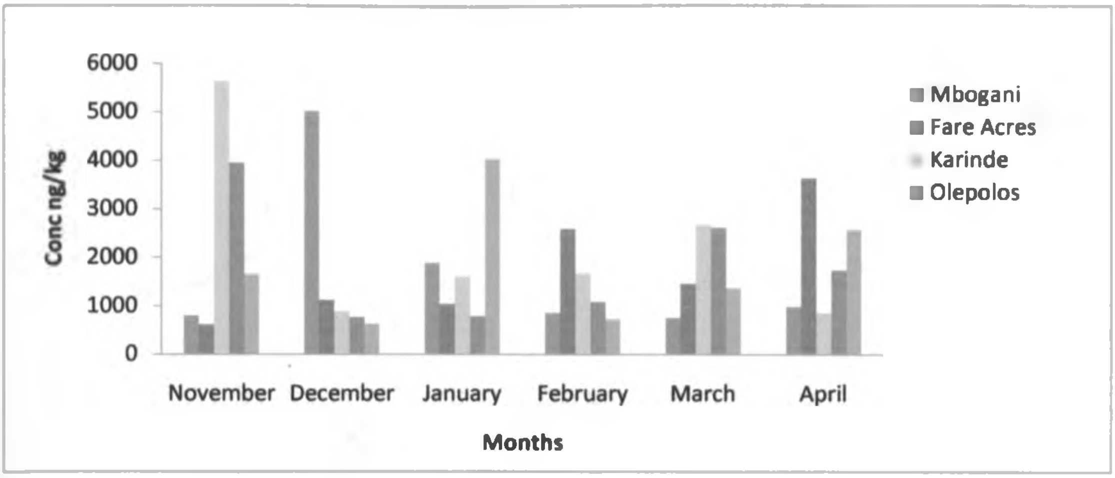


Figure 4. 6: The Sum (∑) of 17 OCPs in milk per month.

From the results, it was notable that the ∑17 OC pesticides levels found in milk from Karinde were the highest during the month of November. This was during the short rains season when farmers sprayed their crops and flowers. The cows might have been fed on pesticide contaminated fodder or inhaled contaminated air. In general, November, December and January had high pesticide levels in milk from two of the three zero grazing sites and one field grazing site. Milk from the zero grazing sites had higher levels of pesticide residues than that from open field grazing, probably because the animals were enclosed and fed with commercial dairy meals and locally available feeds gathered from within the area.

Figure 4.7 below shows the seasonal variation of OC Pesticide Residues in milk from Bogani site.

It was clear that Methoxychlor and p.p'- DDD (a DDT metabolite) were the highest during the short rains season that fall in November to December. This coincides with the wet seasons, when farmers carry out widespread spraying of pesticides to protect crop pests and disease vectors. Hence, high pesticide concentrations in the milk samples could be associated with these activities.

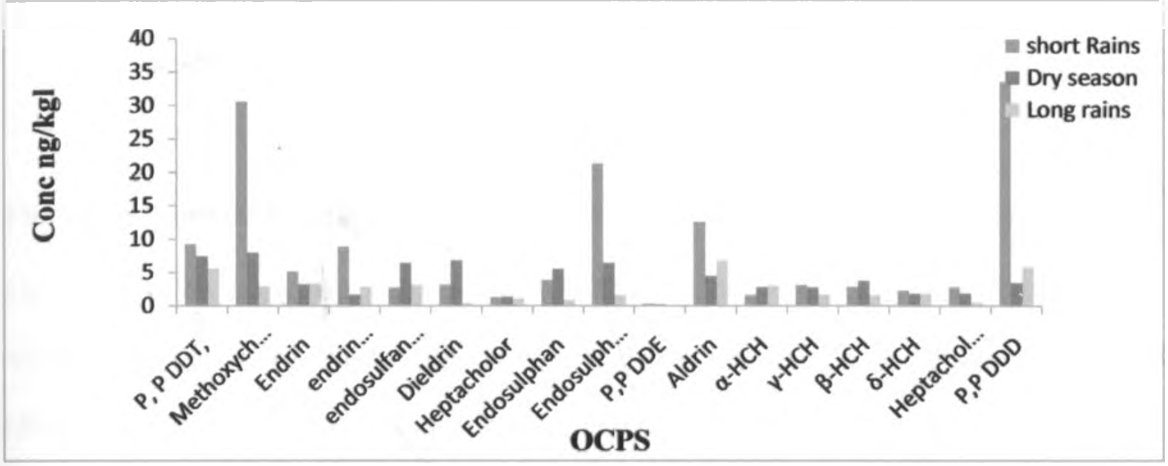


Figure 4.7: Seasonal Variation of OC Pesticides Residues in milk from Bogani

P.p'' DDT,Aldrin and δ-HCH were relatively the highest OC pesticide residue determined in milk from Fare Acres during the long rains of March to April. The residues were very low compared to the other four sites. This farm is located 5kms to the north of the nearest flower farm. This farmer did not depend on any water from Mbagathi River nor any pesticide in his farm. Here the livestock were always enclosed and fed with commercial hay and dairy meals. The OC pesticides contamination detected in the milk samples therefore resulted probably from the fodder or air. Figure 4.8 below shows the seasonal variation of OC pesticide residues in milk from Fare Acres.

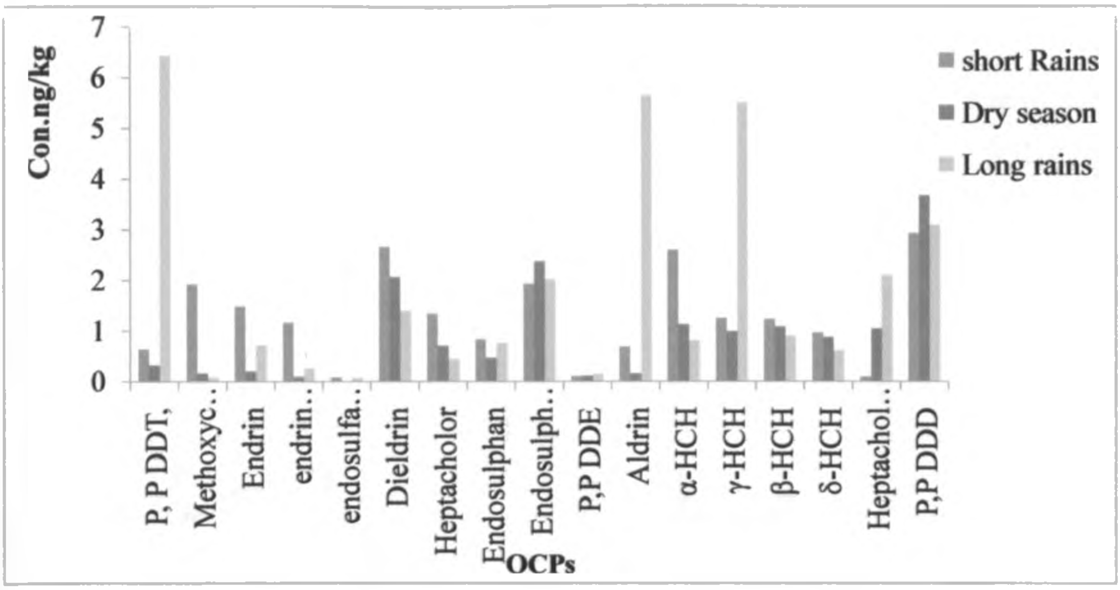


Figure 4.8 Seasonal Variation OC Pesticides Residues in milk from Fare Acres

Figure 4.9 below show seasonal variation of OC pesticides residues in milk from Karinde which was 5 kms North West of the three main flower farms and near the source of River Mbagathi from where Karinde farmers draw or pump water for their livestock.

The Karinde farmer, had his livestock in zero grazing sheds all the time and were fed on commercial feeds and other locally available feeds from local horticultural farms and horticultural export rejects. He occasionally sprayed the cows with pesticides to control ticks. His fencing hedge was also sprayed with lindane semi annually to control termites. It was evidenced that δ-HCH was the highest determined residues in milk collected during the dry season during January to February from this farm.

During the dry season January to February, farmers rarely spray their crops or livestock with pesticides to protect them against pest. Therefore the determined residues probably resulted from other activities or from contaminated feeds, air or water.

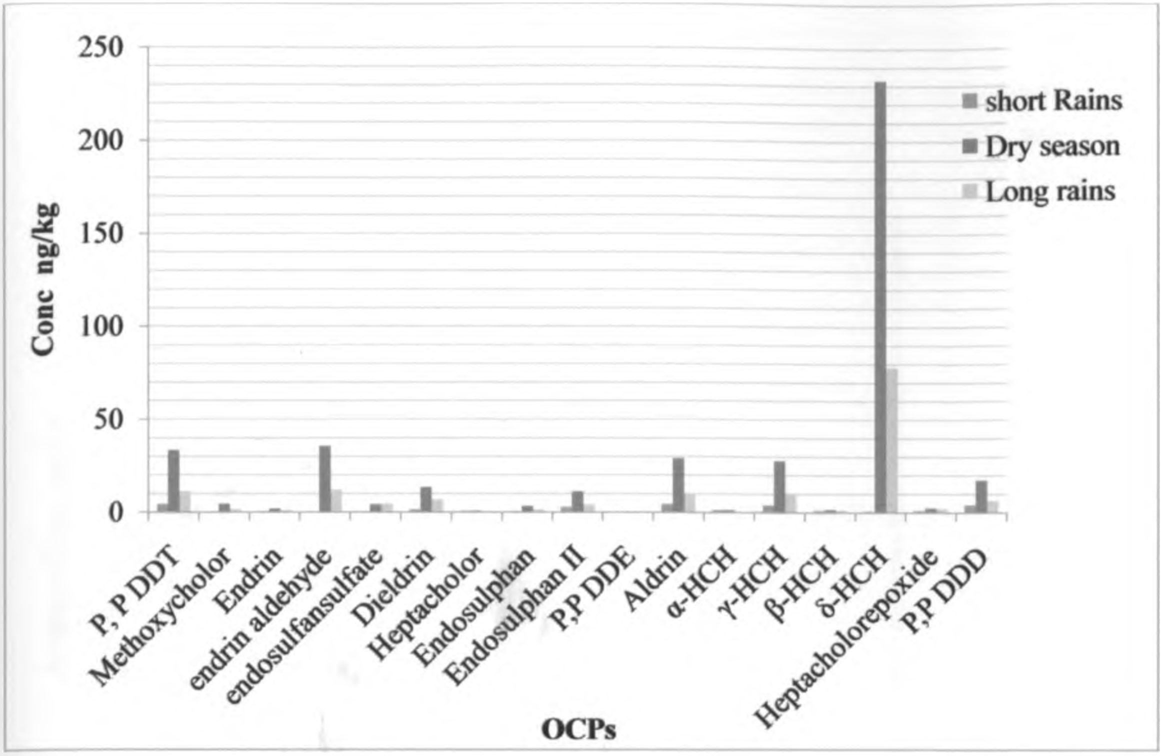


Figure 4. 9. Seasonal Variation of OC Pesticides Residues in milk from Karinde

The Olepolos farmer had his cows in semi zero grazing and in open fields where he had no control over what the cows fed on or drunk. This category of farmers had the quality of livestock feeds and water varying daily with the activities at the time.

It was noted that lindane metabolite, δ-HCH, was the highest determined pesticide residue during the short rains season that is November to December. Figure 4. 10. below show the seasonal variation of OC pesticides residues in milk from Olepolos.

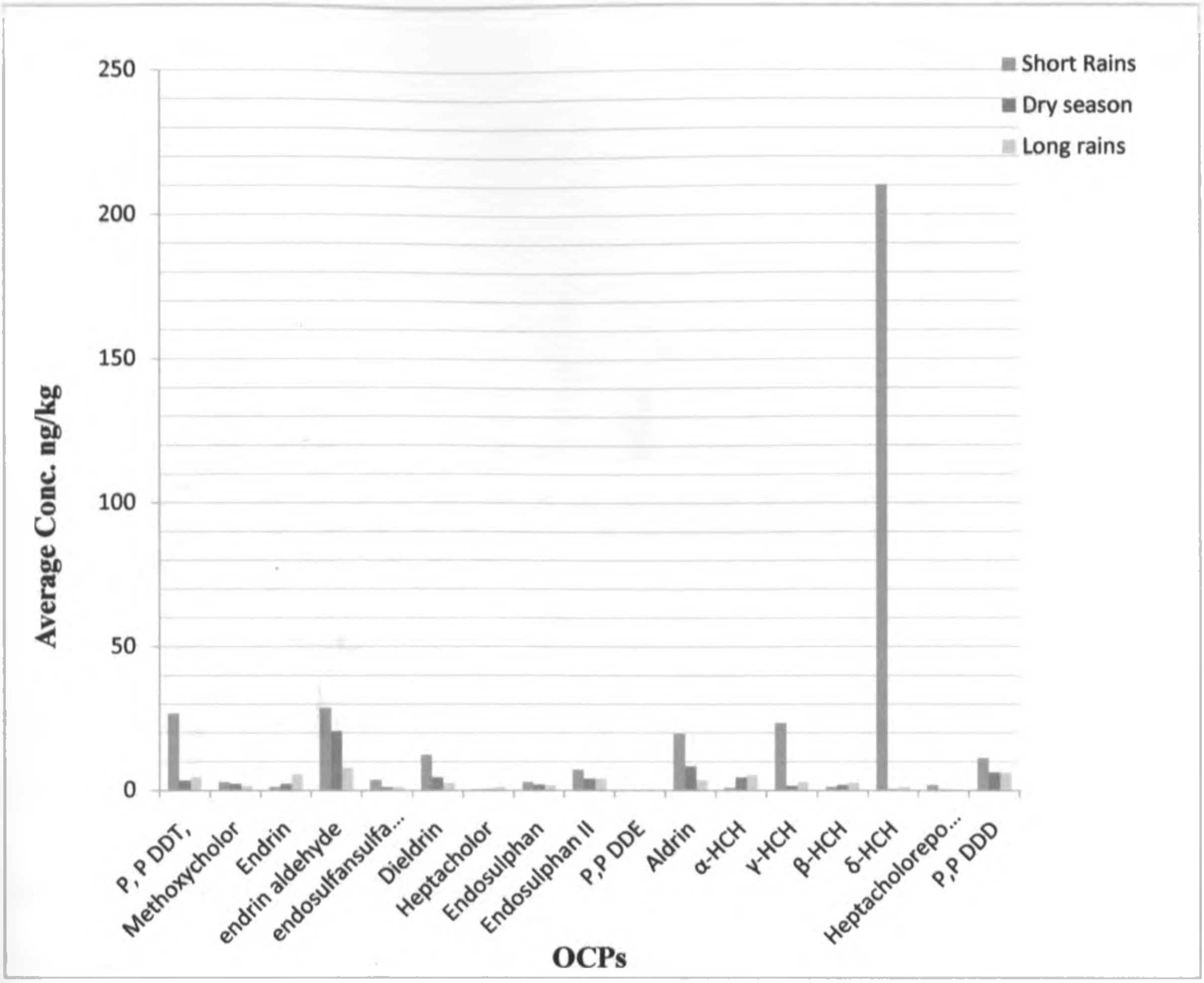


Figure 4.10: Seasonal Variation of OC Pesticides Residues in milk from Olepolos

Figure 4.11 below shows the seasonal variation of OC pesticides residues in milk from Maasai Plains site. It was noted that in this site p.p'' DDD was the highest determined pesticides during the long rains season while the highest for dry season for same site was methoxychlor.

Cows in Maasai Plains site were grazed from one grazing area to another. Pesticide contamination in these milk samples therefore may have resulted from diverse sources which include air, water and grass.

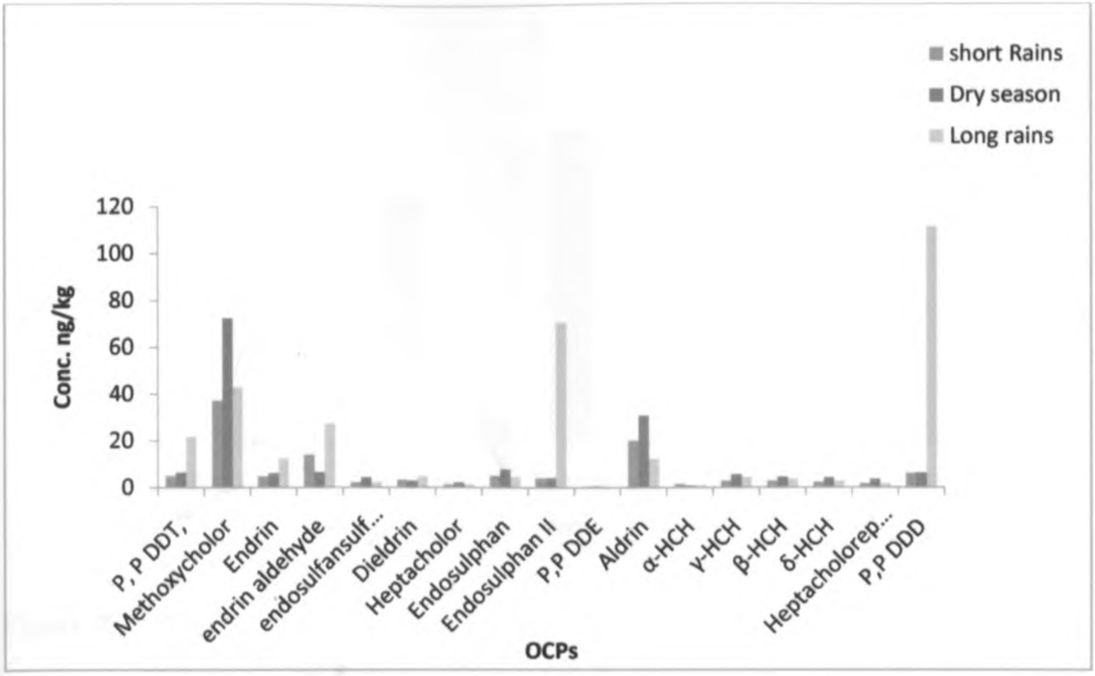


Figure 4.11 Seasonal Variation of OC Pesticides Residues in milk sample from Maasai Plains.

4.3.2: Spatial Variation in OC Pesticides Residues in Milk

Figure 4.12 below show the $\sum 17$ OC pesticide levels per site. Milk samples from Karinde recorded the highest sum of 17 OC. It was notable that four sites out of the five sites had very close value of $\sum 17$ OC pesticide levels measured compared to the fifth. This implied that the milk samples from the five sites had levels of OC contamination that was above 1500 ng/kg they were; Karinde 2225 ng/kg; Maasai Plains 1834 ng/kg; Olepolos 1826 ng/kg; Fare Acres 1748 ng/kg and Bogani 1738 ng/kg. However the values recorded were below the FAO/WHO recommended level of 5000 ng/kg limit. Nevertheless, the levels are of concern when bioaccumulation through the food chain is taken into account.

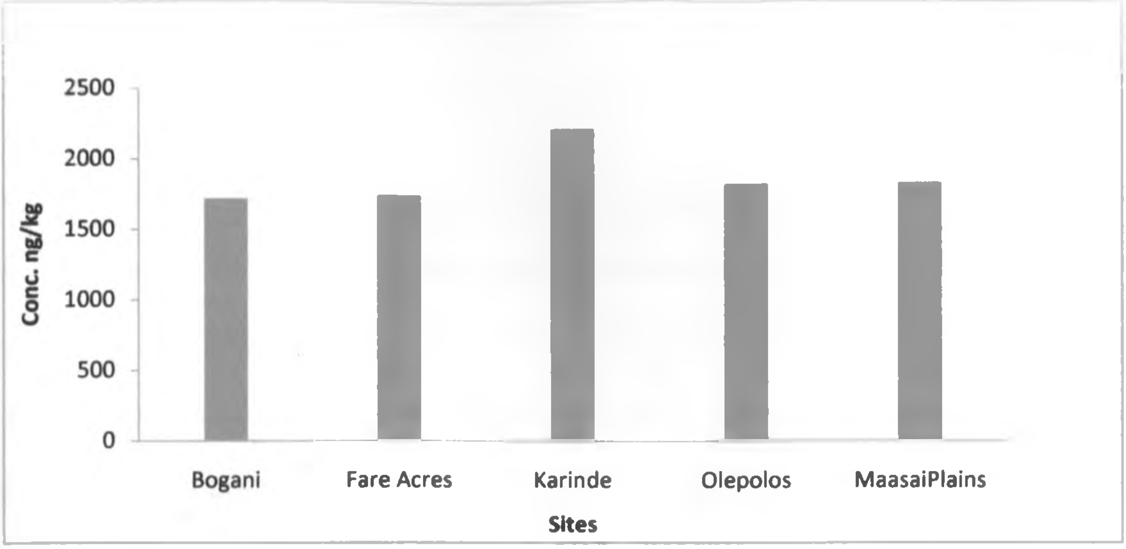


Figure 4.12: The ∑17 OC pesticides levels

In general, the methoxychlor, endosulphan sulphate, endrin, aldrin and the metabolites of DDT (p.p'' DDD) and lindane (δ- HCH) were the major residues detected in high concentrations in all the milk samples during this study.

Cow milk is a highly nutritious food, which is rich in several nutrients like calcium, potassium, vitamins and protein, it is one of the healthiest foods. Milk meets the basic requirements of the body. It is highly beneficial in the growth and development of bones. It is also helpful to the body in fighting against diseases which include gout, kidney stones, breast cancer, rheumatoid arthritis, and migraine headaches.

Milk is also a source of excretion of lipid soluble, toxic organochlorine pesticides which are excreted by diffusion due to the chemical nature of milk. Basic substances can be concentrated in milk since it is more acidic with a pH range of between 6.3 to 6.5 which is lower than that of blood plasma which ranges between 7.3 to 7.5 (Ebbing *et al.*, 1987). Milk contains about 3 to 4% lipids depending on the breed of the cow. Lipid-soluble toxicants such as pesticides can diffuse into the mammary glands and thus can be present in milk (Klaassen et. al., 1996 and Ahmed *et. al.*, 2002)

Assuming that a person weighing 60 kg consumes two glasses of milk per day (350 ml), the average values of $\sum 17$ OC pesticides taken by the person daily per site were: Karinde 1558.02 ng, Maasai Plains 1284.08 ng; Olepolos 1278.38 ng; Fare Acres 1223.66 ng and Bogani 1216.82 ng. When these values were compared with (Average Daily Intake) data, it was found that none of the studied sites exceeded the Food and Agriculture Organization/World Health Organization recommended limits (FAO/WHO, 1993).

Donia *et. al*, (2010), reported higher pesticides residues levels from 260 samples of cow milk from Kalubi, Egypt compared to what was found in the Nairobi West Region. The pesticides values reported were lindane (46000ng/kg), aldrin (72000ng/kg), heptachlor (30000ng/kg), heptachlor epoxide (82000 ng/kg), eldrin (16000 ng/kg), p.p' DDT (48000ng/kg), p.p' DDE (6000ng/kg) and p,p′ DDD (96000ng/kg). All the cow milk studied by Donia was collected from zero grazing cows which compares with Karinde, Fare Acres and Bogani.

It is possible therefore to suggest that cows get the pesticides contamination from the air and water. The contamination levels are increased further from the feeds which include maize, cotton seeds and wheat that are used to manufacture dairy meals. These cereals used to manufature dairy meals are usually sprayed, dressed or preserved with methoxychlor, endosulphan sulphate, endrin, aldrin and lindane pesticides. DDT is also used indoors to contol mosquito vectors and other indoor insects and could probably have contaminated the stored animals feeds and cereals.

Nappier grass and other vegetations used to feed cows, grow in the same area with potatoes, coffee, beans, cabbages, banana, citrus fruits, tomatoes and flowers. Although the nappier grass is never sprayed, the crops in the same farm are sprayed with these pesticides and in turn the sprayed chemical contaminate the nappier grass, which is later fed to the livestock. These pesticides residues bioaccumulate in the animal tissues and are later transferred to man and other higher animals in the food chain who feed on these livestock or use their products.

4.4: Physicochemical parameters of Water.

Table 4.7 below represents the physicochemical parameters measured in water samples collected at the various sites along Mbagathi River. The temperature of water ranged from 19.7 to 21.5 °C for the Ngong Bridge site with the highest value recorded during the dry month of February. At the Co-operative College Bridge site, the temperature for water samples ranged between 20.2 to 22.0 °C, while similar readings were recorded in the water samples collected from the Ongata Rongai Bridge site, it ranged between 20.5 to 22.9 °C. The trend was that the temperatures decreased from Ongata Rongai site to Co-operative College Bridge site by 0.3°C to 0.9 °C and 0.8°C to 1.4 at Ngong Bridge whose temperatures were measured at midday since it was always the last in order of collection for both water and sediment samples. These values showed a gradual increase in measured water temperatures down the river profile. This observed phenomenon may have been influenced by the following factors: seasons, increased distances from Ngong Hills and Kikuyu Highlands, increased damping of organic matter into the river, removal of the vegetation cover by contaminated farmers along the banks of the river and time of the day when the temperature readings were taken.

The pH was within the World Health Organization's allowed limit of 6.5 to 8.5 for drinking water (WHO, 1987). There was no clear trend in the monthly variation of pH along the river at the three study sites. For the electrical conductivity and the total dissolved solids, the study revealed that the levels increased downstream. This trend implied that dissolved ions were washed into the river through surface run offs Domestic waste water, numerous illegal and unregulated raw sewers were discharged directly into the river and this may have contributed to this trend. The colour of water was brown throughout the study period but it intensified during the wet seasons due to effect of soil erosion from the highlands.

The Ngong Bridge site, showed the least TDS values (between 151.33mg/l and 169 mg/l) compared to the other two sites. The measured TDS values in the three sites would be interpreted that there were few activities upstream that could have contributed soluble substances to the river. The maximum WHO acceptable concentration for TDS for irrigation water is 600 mg/l and all the measured values were below this level.

Table 4.7:Physicochemical Paramaters for water samples

Sites	Ngong Bridge				Co-op College Bridge				Rongai Bridge			
paramater	TDS mg/l	pH	Temp °C	E.C. µS/cm	TDS mg/l	pH	Temp °C	E.C. µS/cm	TDS mg/l	pH	Temp °C	E.C. µS/cm
Nov.	169.0	6.5	19.7	340.0	176.3	6.7	21.3	354.4	204.3	6.8	22.3	443.0
Dec.	166.0	6.6	20.3	351.6	172.0	6.5	21.4	333.0	175.7	6.7	22.5	354.4
Jan.	168.3	6.8	21.2	335.1	174.3	6.7	21.7	351.0	197.2	6.8	22.4	394.3
Feb.	167.0	6.9	21.5	333.7	193.3	6.8	22.3	386.3	210.0	7.0	22.9	419.0
Mar	151.3	6.5	19.7	305.3	181.0	6.6	20.5	362.0	222.0	6.7	21.2	442.60
Apr	168.3	6.8	19.8	337.2	186.0	6.7	20.2	371.4	216.3	7.1	20.8	431.60

4.5.0: Sediment Analyses

The analyses of sediment samples from the three sites on Mbagathi River namely Ngong Bridge; Co-operative College Bridge and Rongai Bridge, showed existence of sixteen (16) pesticide residues at varying concentrations. The average pesticides levels ranged from below dectection limits (BDL) to 4238.ng/kg. The highest concentration was recorded in the sediments collected in the month of February from Co-operative College Bridge site while the lowest values were recorded in sediments from the other two sites. The results for the pesticides levels in sediments are shown in Tables 4.8(a) to (c) below.

In table 4.8a below, it was noted that concentration of the heptachlor epoxide was the highest at Ngong Bridge Site, with a recorded value of 903.3 ng/kg while α-endosulphan and β-endosulphan, p.p' DDE and Aldrin were below detection limit in November, December, January and February.

Table 4.8a Levels of OC Pesticides in sediments samples from Ngong Bridge (ng/kg ± s.d). Mean ±s.d **N=3, BDL= Below Detection *Limit***

OCPS	**November**	**December**	**January**	**February**	**March**	**April**	**Average**
p, p DDT	35.71±26.31	60.45±48.90	47.66±31.84	6.57±5.64	20.63±15.92	23.81±9.86	29.14±16.51
Methoxychlor	25.49±18.81	41.15±31.05	5.35±3.76	39.59±29.97	13.30±6.36	22.53±8.83	21.90±12.22
Endrin	10.50±2.64	12.50±5.73	7.80±4.53	36.39±14.02	32.92±13.87	23.21±9.61	19.39±12.20
Endrin Aldehyde	19.49±14.70	57.65±30.94	17.44±5.35	10.34±8.55	50.94±10.71	23.06±9.40	23.32±13.84
Endosulfan Sulfate	24.60±9.47	48.21±17.38	34.35±19.32	16.06±4.68	26.43±5.70	23.53±10.28	28.86±10.17
Dieldrin	45.14±4.26	12.52±1.25	55.18±42.92	16.78±8.90	182.17±1.45	16.10±7.27	82.98±60.40
Endosulphan	8.14±4.96	9.83±6.62	44.36±24.92	BDL	7.94±1.22	6.91±2.82	12.57±4.41
A-endosulphan I	BDL	6.09±2.76	5.70±2.06	6.68±3.17	13.26±1.50	10.45±1.37	7.21±3.84
p.p' DDE	38.56±4.22	38.71±5.24	16.67±1.60	BDL	13.25±5.10	16.88±7.65	20.85±13.64
Aldrin	4.72±3.20	BDL	BDL	6.09±0.23	3.61±1.43	17.40±7.79	5.88±5.39
α-HCH	43.18±11.38	11.94±1.83	21.74±10.34	26.75±17.03	26.70±11.71	17.15±7.36	24.58±9.82
γ-HCH	29.34±7.57	39.36±4.75	7.85±5.15	8.10±3.51	12.43±9.53	17.38±7.26	19.08±11.62
β-HCH	11.18±7.73	20.60±14.77	23.29±20.85	4.99±0.81	14.65±5.34	10.30±3.63	14.17±6.23
δ-HCH	124.06±8.37	16.06±18.45	22.53±0.85	4.85±2.09	10.14±4.27	16.66±7.33	52.3±41.37
Heptachlor Epoxide	903.53±171.81	8.94±5.52	74.66±18.57	129.40±12.51	10.92±1.80	25.54±12.13	192.17±30.93
p.p' DDD	9.19±3.96	91.88±23.87	26.06±0.14	16.69±7.83	32.68±1.59	14.18±6.25	31.78±20.97
∑16 OCPS	1314.93±322.47	437.14±29.08	392.87±38.60	315.55±51.62	471.97±30.46	285.10±30.66	536.26±83.81

In table 4.8b below show the concentrations of α-endosulphan and β-endosulphan, were below detection limit in November, December and January at this site while that of Heptachlor epoxide was the highest with 4238.71 ng/kg level in February.

Table 4.8b Levels of OC Pesticides (ng/ kg ± s.d) in sediment samples from Co-operative College Bridge

OCPs	November	December	January	February	March	April	Average
p, p DDT	31.01±6.64	11.21±9.62	3.46±2.59	141.51±28.47	14.90±6.07	25.13±7.04	37.87±7.21
Methoxychlor	17.15±2.35	12.29±3.79	2.70±0.01	5.20±1.06	13.70±1.34	23.61±6.32	12.44±0.02
Endrin	6.57±5.56	10.63±0.71	19.51±2.16	111.93±13.13	36.08±11.85	24.50±6.86	34.87±3.76
Endrin Aldehyde	12.60±2.98	8.96±9.49	8.72±8.39	55.07±11.81	24.93±21.35	24.29±6.71	22.43±16.02
Endosulfan Sulfate	17.04±10.70	12.33±4.36	21.53±12.70	29.55±16.94	46.73±11.23	25.03±7.32	25.37±11.02
Dieldrin	46.70±2.20	25.35±4.45	28.57±3.87	58.87±4.94	32.43±7.94	17.21±10.65	34.85±13.93
Endosulphan	6.55±2.25	BDL	35.18±3.61	104.87±17.92	4.36±4.59	2.62±2.01	25.83±7.20
A-endosulphan I	BDL	7.60±7.56	BDL	17.08±0.02	9.54±1.27	16.76±4.90	8.89±6.42
P.P' DDE	36.39±3.07	20.67±9.01	0.95±0.15	15.06±4.32	26.62±2.47	18.05±5.44	19.62±10.82
Aldrin	3.96±1.07	5.83±4.80	35.94±5.24	8.55±2.04	7.13±5.83	18.57±5.54	12.64±9.81
α-HCH	42.28±1.28	14.25±1.28	9.75±2.66	34.12±19.43	37.74±9.68	8.05±2.35	22.03±13.38
γ-HCH	33.45±5.82	7.90±1.64	46.03±0.71	13.30±9.76	18.54±10.23	15.10±4.45	20.72±10.15
β-HCH	9.45±2.44	6.31±4.81	33.79±2.15	82.07±28.83	76.92±54.77	18.19±5.24	37.79±20.79
δ-HCH	66.22±11.80	7.66±3.41	4.68±0.89	5.29±1.42	35.73±21.48	18.36±5.18	22.99±2.12
Heptachlor Epoxide	1087.67±260.42	18.16±9.98	1738.41±377.43	4238.71±1002.26	16.04±11.99	17.73±5.21	1585.12±213.58
p.p' DDD	11.58±3.37	19.31±8.90	169.30±0.23	173.45±17.10	19.61±12.98	27.50±8.60	64.29±6.72
∑16 OCPs	1429.48±63.90	185.87±5.23	2156.15±95.18	5064.55±237.78	389.89±12.87	300.69±5.64	1587.77±64.10

At Rongai Bridge, α-HCH had the highest concentration at 364.99 ng/kg in March while those of aldrin, α-endosulphan, γ- HCH, β-HCH, p.p' DDD and Heptachlor epoxide were below detection limit in November, December, January, February and March as depicted in table 4.7*c*.below

Table 4.8c Levels of OC Pesticides (ng/ kg ± s.d) in sediments samples from Ongata Rongai Bridge

OCPS	November	December	January	February	March	April	Average
P, P DDT	5.05±3.68	6.11±0.11	3.63±1.77	30.15±23.28	12.09±1.39	53.11±38.22	18.36±11.93
Methoxycholor	11.19±3.28	10.05±7.85	7.42±5.35	21.31±16.41	16.28±4.83	48.98±34.45	19.21±14.06
Endrin	9.79±8.88	82.79±41.08	19.19±3.42	32.73±3.13	17.58±5.89	51.77±37.25	35.64±25.03
Endrin aldehyde	12.21±9.45	34.66±29.36	40.67±5.05	4.88±2.78	25.50±21.12	51.05±36.49	28.16±15.95
Endosulfan sulphate	107.64±15.65	87.85±0.71	31.54±7.53	20.98±11.76	4.35±2.07	53.86±9.62	51.04±36.58
Dieldrin	17.62±0.63	19.65±3.73	93.69±13.99	40.78±27.68	19.54±6.75	37.45±27.90	38.12±26.46
α-endosulphan	5.77±3.60	BDL	56.19±6.68	BDL	4.71±3.65	20.13±7.61	15.04±9.44
β-endosulphan	9.32±15.07	8.08±0.76	53.42±0.45	3.06±1.02	10.38±8.84	36.06±26.53	20.05±8.31
P.P' DDE	168.60±26.44	21.39±0.87	4.58±1.93	7.97±2.50	9.94±2.81	39.34±29.36	41.97±7.80
Aldrin	BDL	7.12±0.21	4.14±2.44	48.14±8.73	BDL	40.30±29.92	17.24±9.29
α-HCH	10.97±2.63	29.31±8.08	31.99±3.65	11.62±2.05	364.99±43.31	17.31±12.72	77.70±18.73
γ-HCH	4.66±2.99	BDL	60.39±4.94	BDL	9.30±4.02	32.59±4.05	18.43±2.56
β-HCH	15.41±3.18	20.52±0.67	39.07±23.23	BDL	80.39±63.18	38.90±28.40	32.84±2.83
δ-HCH	28.16±6.67	3.48±2.61	20.67±2.23	9.61±4.05	34.62±23.22	38.93±28.13	22.58±12.78
Heptachlor epoxide	10.12±8.82	BDL	23.43±10.14	7.66±5.73	5.27±5.09	21.35±14.35	11.69±7.94
P.P' DDD	11.24±2.99	38.77±30.56	BDL	5.42±1.71	7.98±3.38	60.93±4.32	21.11±2.48
∑16 OCPs	486.37±56.52	431.22±56.53	549.73±57.40	302.13±50.59	679.01±54.47	684.12±42.05	522.08±52.91

4.5.1 Temporal Variations of OC Pesticides in sediment samples from selected sites along Mbagathi River

Figure 4.13 show the seasonal variation of OC Pesticide Residues in Sediment samples from Ngong bridge. It is notable that the highest recorded OC pesticide residue was heptachlor epoxide (903.5 ng/kg) during the short rains seasons of November to December. These levels suggested fresh use of the pesticide to spray crops in the catchment area .

Ngong bridge boarders with a large dairy farm and two flower farms, they heavily use pesticides to control crop pests, ticks and termites. During the rain season these chemicals from the farms, together with other domestic refuse are washed by storm water and surface runoff into the river.

These activities contributed to the observed levels of OC pesticide residues in the sediments.

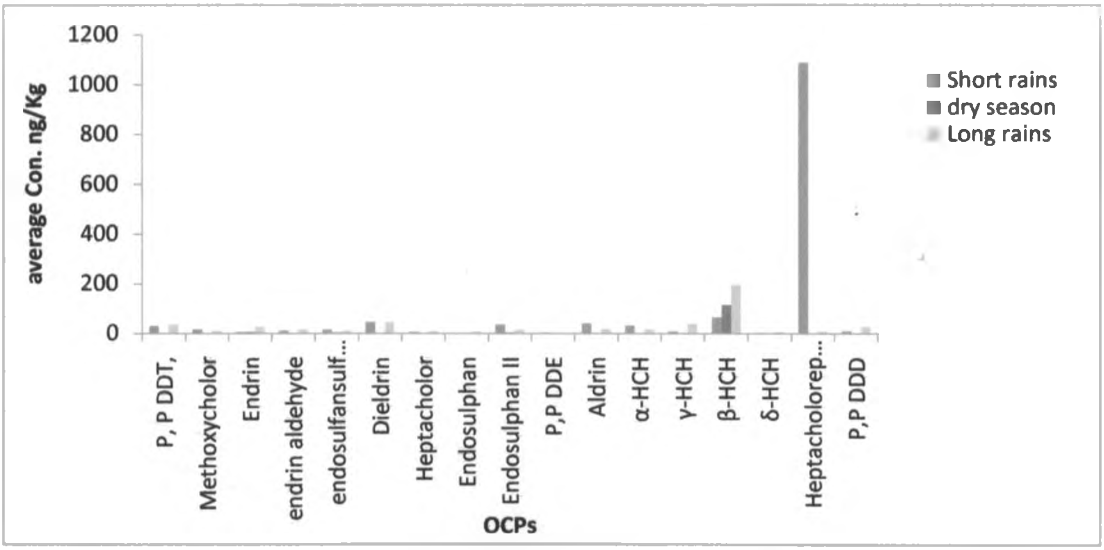


Figure 4.13 Seasonal Variation of OC Pesticides Residues in Sediment samples from Ngong bridge

The sediments collected from the Co-operative College Bridge site, portrayed a different picture in that high residue concentrations were noted during the dry season. β-endosulphan was the the highest recorded residue during the dry season that is January to February when few farming activities take place.

Horticultural activities and flower production are at their peak due to the warm conditions that were conducive. This therefore suggest that the observed trend could have resulted due to these activities since Co-operative College Bridge boarders four large flower farms. Figure 4.14 shows the Seasonal Variation of OC Pesticide Residues in Sediments from this site.

Co-operative College Bridge site is located mid- way between Ngong and Ongata Rongai sites. Besides, there were many dairy farms with zero grazing units holding 5 to 15 cows. The area also practised other types of horticultural farming either in green houses or on irrigation. The determined levels of OC pesticides in this area therefore implied farmers used some of these OC pesticides on their flowers, dairy cows and other crops grown here.

During the sampling trips it was noted that water from the Mbagathi River was pumped out and treated for domestic use despite the OC pesticide contamination observed in this study.

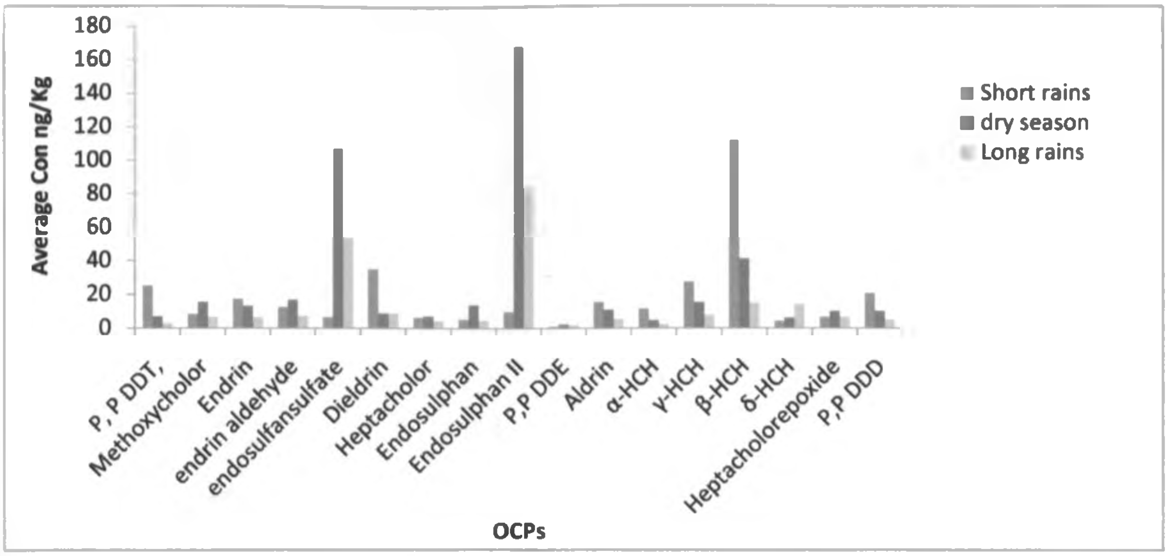


Figure 4.14: Seasonal Variation of OC Pesticide Residues in Sediments from Co-operative Bridge

The seasonal variation of OC pesticide residues detected in sediment samples at Ongata Rongai were lower than those recorded in the other two sites except for heptachlor epoxide which was the highest as evidenced in Figure 4.15 below. This was recorded during the long rain season in March to April

This site borders with the Ongata Rongai Town and the Nairobi National Park and there were little farming activities in the neighbouring residential area compared to the latter two study sites. The most notable activities were Maasai herders grazing in the fields and road reservese, dairy farming and zero grazing in a few farms and also in institutions of learning. The observed results could have come from other activities upstream since few farmers use pesticides on their livestock.

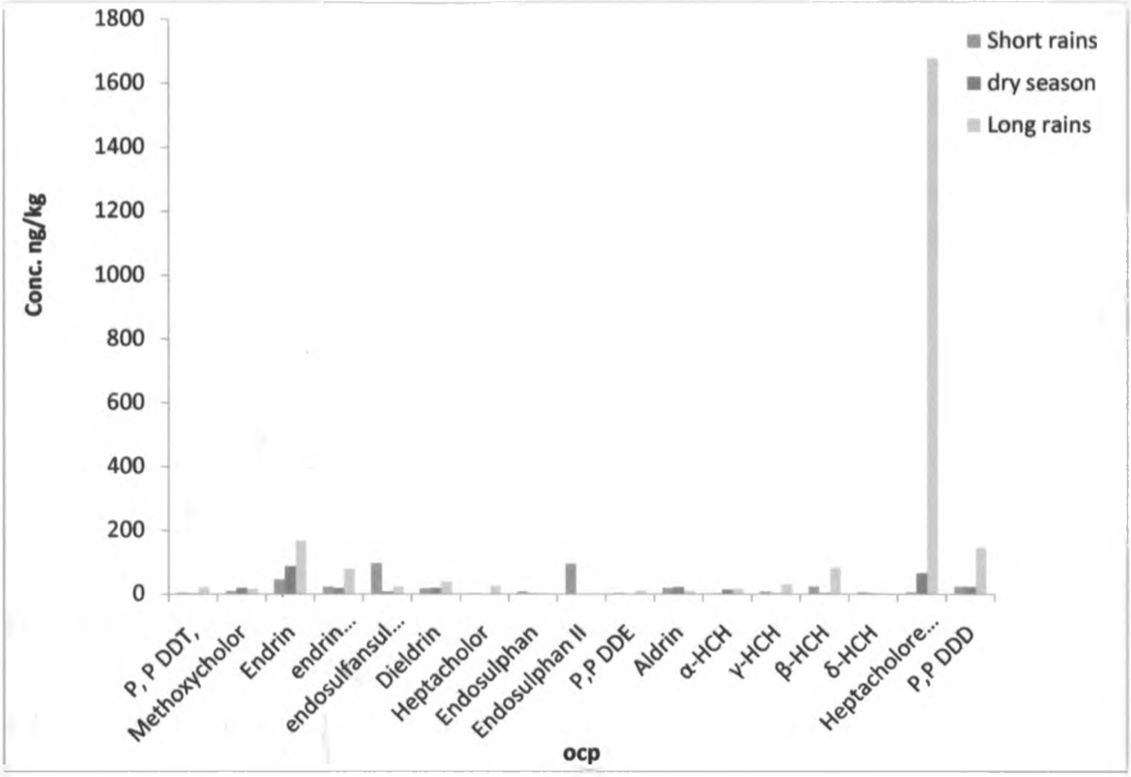


Figure 4.15: Seasonal Variation of OC Pesticide Residues in Sediment from Ongata Rongai Bridge.

Figure 15 below shows the sum of 16 OC Pesticides in the sediment samples from three sites, the highest sum of 16 OC pesticides concentration was recorded in the month of February as evidenced in the Figure 4.16. The month of February is usually dry and the water volumes are normally low. This meant that all the contaminants that were washed into the river from the farms, towns and fields by storm water and runoffs had been deposited in the sediments. The pesticide levels also increased with decrease in water volumes as a consequences of pre-concentration.

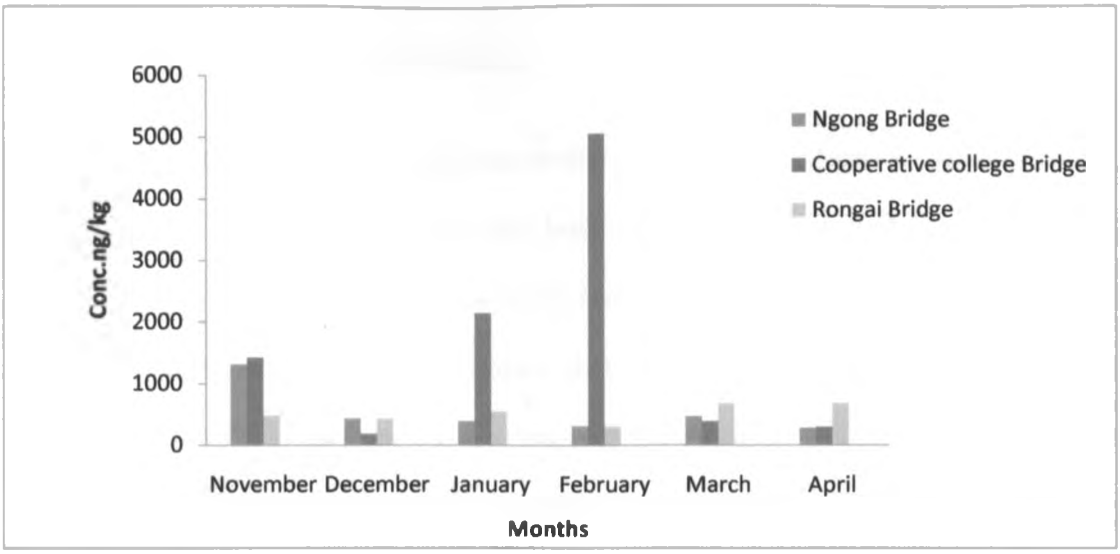


Figure 4.16: ∑16 OC Pesticides in the sediment samples from the three sites.

4.5.2 Spatial Variation in OC Pesticides Residues in Sediment Samples

All the residents in this area used different pesticides to control livestock pests and also flowers and other horticultural crops pests. The residues of these pesticides together with other domestic waste from farms, towns and homes were washed by storm water and surface runoff to Mbagathi River and its tributaries. The residues and other contaminants end up in water and eventually get deposited into the sediments. The sediment therefore had a higher level of OC Pesticide residues in than in water.

The sediments were found to be richer in organic matter than water this attracted the more hydrophobic pesticides to bind on the organic matter surfaces.

The Co-operative College Bridge site had the highest overall sum of 16 OC Pesticides residues as evident in Figure 4.17 below.

In general, the concentration of OC pesticide residues increased from Ngong Bridge to Co-operative College Bridge and decreased with the same rate at Ongata Rongai. This suggests that farmers in the area between the two sites used OC pesticide chemicals to control pests and diseases vectors in crops and livestock.

Increase in concentration of OC pesticides at the Co-operative College Bridge site also meant that waste water from the flower and other hoticultural farms were discharged or washed by storm water into the river. The decrease in the sum of 16 OC Pesticides detected in Sediment samples from Ongata Rongai Bridge meant that there were lower levels of OC Pesticides contamination to the river from the area between Co-operative College Bridge and Ongata Rongai Bridge. The river might also have undergone self purification in the cause of its flow.

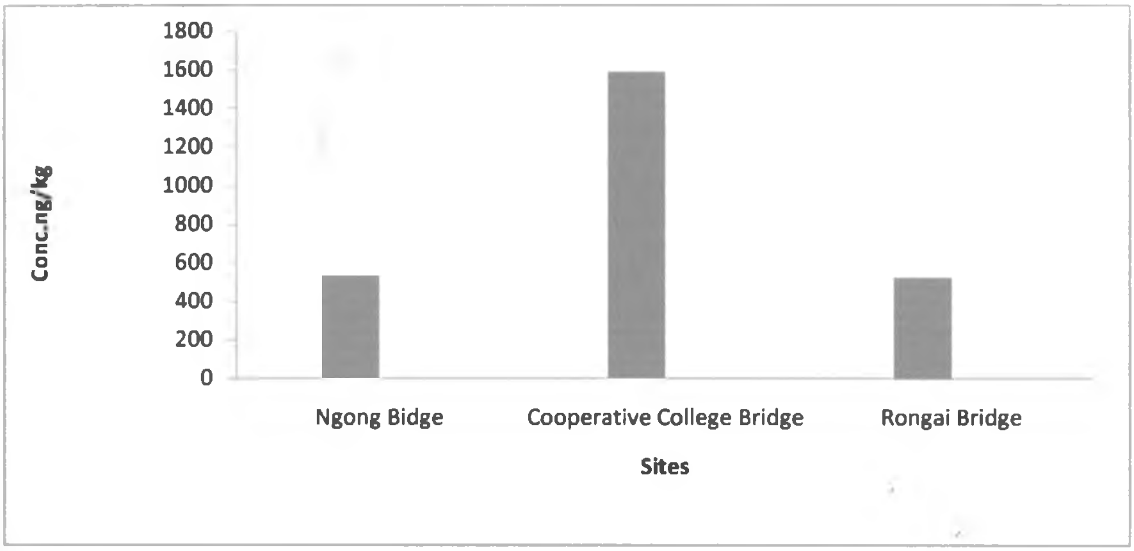


Figure 4.17: The ∑ 16 OC Pesticide levels in Sediments per Site.

4.6.0 Water Analyses

Water samples were collected from the three sampling sites; Ngong Bridge, Co-operative College Bridge and Rongai Bridge all on Mbagathi River are shown in figure 3 below. The samples were analysed for OC pesticides residue levels and that of their metabolites.

Seventeen OCPs were detected in water with levels that ranged from below detection limit to 141.51 ng/l with the highest concentration recorded at Co-operative College Bridge.

It was noted that the water samples collected at Ngong Bridge had α -HCH determined as the highest at 78.54ng/l during the month of January, while p, p DDE, δ –HCH, p.p' DDD, endosulphan, endosulphan sulfate and heptachlor were found to be below detection limit in November, December, January, February and March as evidenced in Table 4.9a below

***Table 4.9 a*:Residues levels of OC Pesticide in Water from Ngong Bridge (ng/ l ± s.d, Mean ±s d, N =3, BDL below detection limit)**

OCPs	November	December	January	February	March	April	Average
p, p DDT	18.74±31.80	60.45±48.90	27.66±31.84	6.57±5.64	20.63±15.91	23.81±9.9	26.31±18.18
Methoxycholor	15.49±18.80	41.15±31.05	5.35±3.76	33.59±29.97	13.30±6.36	22.53±8.83	21.90±13.39
Endrin	10.5±2.64	5.50±12.73	7.8±7.53	36.39±14.02	32.92±13.87	23.21±9.61	19.32±13.36
Endrin Aldehyde	10.49±14.70	27.65±30.94	17.44±5.35	33.70±8.56	50.94±10.71	23.06±9.40	27.13±15.79
Endo. Sulfate	24.60±9.47	48.21±17.79	34.35±19.32	16.06±14.68	26.43±5.70	23.53±10.28	28.86±11.14
Dieldrin	18.11±4.26	43.26±6.24	4.023±2.16	5.10±3.24	11.42±3.55	8.41±4.52	15.05±14.72
Heptachlor	8.15±5.00	5.77±6. 60	BDL	3.62±1.2	3.11±1.42	6.83±1.48	4.85±2.47
Endosulphan	10.85±6.18	6.09±6.76	BDL	6.68±7.17	9.54±11.27	16.88±7.65	8.82±4.83
A-endosulphan I	38.56±34.22	38.71±50.24	16.67±16.60	BDL	13.25±15.10	16.88±7.65	24.81±12.70
P.P' DDE	4.72±3.20	BDL	BDL	BDL	3.61±1.43	17.40±7.79	5.04±6.22
Aldrin	43.18±41.38	11.94±17.83	21.74±1.03	6.09±0.00	26.71±31.71	8.05±2.35	19.62±14.04
α-HCH	29.34±37.56	39.37±42.75	78.54±5.15	6.75±17.03	12.43±9.53	14.18±6.25	30.10±26.62
γ-HCH	20.69±14.77	11.18±7.73	23.29±20.85	4.99±3.82	15.02±13.03	17.15±7.36	15.39±6.63
β-HCH	7.49±0.02	4.58±2.11	4.12±1.23	3.87±0.32	3.96±1.11	4.45± 1.83	4.75±1.37
δ-HCH	8.11±2.19	40.26± 9.01	BDL	BDL	1.42±0.80	8.71±2.33	11.79±16.35
Hept. Epoxide	8.14±5.12	5.39± 2.27	6.45± 3.24	3.49±1.93	3.46± 2.12	4.10± 2.16	5.17±1.87
p.p' DDD	BDL	9.25±2.11	4.56±1.23	BDL	BDL	3.47± 1.83	3.39±3.31
∑17 OCPs	277.17±11.89	372.36±20.09	259.20±19.30	168.89±12.56	250.27±13.33	242.65±7.54	272.38±9.52

Water from Co-operative College Bridge had p.p' DDT as the highest at 141.51 ng/l while aldrin, α-HCH, p.p' DDD, methoxychlor, α-endosulphan and β-endosulphan were below detection limit in November, December, January and February as shown in table 4.9b below

Table 4.9 b: Residues levels of OC Pesticides in Water from Co-operative College Bridge (ng/ l ± s.d, Mean ±s d, N =3, BDL below detection limit)

OCPs	November	December	January	February	March	April	Average
p, p DDT	5.65±2.33	11.21±9.62	3.46±2.59	141.51±20.47	14.90±6.07	25.13±7.04	33.64±5.40
Methoxychlor	7.12±9.64	12.29±3.79	BDL	5.19±10.58	13.70±1.34	23.61±6.32	10.77±7.55
Endrin	17.49±1.09	10.64±0.71	19.51±2.16	111.93±13.13	36.08±11.85	24.51±6.86	36.69±3.82
Endrin Aldehyde	10.32±1.42	8.96±6.49	8.72±4.39	55.07±21.81	24.94±11.35	24.29±6.71	22.05±17.83
Endosulfan Sulfate	12.05±0.91	12.33±14.36	21.53±12.70	29.55±16.94	46.73±11.23	25.03±7.20	24.54±12.90
Dieldrin	19.68± 8.21	31.16±2.43	6.80±3.42	7.23±4.29	9.73±4.90	5.43±4.31	13.30±10.16
Heptachlor	18.11±4.26	43.26±6.24	4.023±2.16	5.10±3.24	11.42±3.55	8.41±4.52	15.05±4.72
Endosulphan	4.65±5.73	7.60±3.56	BDL	17.32±0.40	10.38±2.84	16.88±7.63	11.30±5.53
A-endosulphan I	4.76±2.15	BDL	3.97±1.64	4.91±2.23	4.25±1.21	10.47±3.84	5.11±2.79
p.p' DDE	34.81±7.45	9.94±2.67	2.49±1.25	14.74±5.28	8.06±3.28	10.07±3.29	13.35±1.23
Aldrin	3.39±1.98	BDL	4.33±2.17	3.82±1.64	5.06±1.85	4.59±1.57	3.92±0.97
α-HCH	5.24±1.27	BDL	3.98±1.89	3.47±1.95	4.52±2.16	3.93±2.11	3.56±1.74
γ-HCH	8.62±3.41	3.86±1.77	3.18±0.76	3.69±1.87	4.56±2.32	5.82±1.07	4.96±2.01
β-HCH	8.622± 0.01	3.86 ±1.94	3.18±2.31	3.69±0.11	4.56±1.62	5.82±1.45	4.96±2.01
δ-HCH	9.24±2.89	7.92± 2.34	8. 80±2.79	7.11± 2.04	9.83±3.14	8.43± 2.72	8.51±1.07
Heptachlor Epoxide	45.94±6.34	4.24±3.14	3.44±2.62	3.12±2.11	3.61± 3.28	5.20±2.19	10.93±1.17
p.p' DDD	BDL	5.66 ±1.94	4.62±2.31	BDL	5.23±1.62	3.54±1.45	3.16±2.49
∑17 OCPS	215.70±11.88	177.81±10.94	95.93±5.97	417.04±41.06	217.33±12.19	211.15±8.64	222.49±15.11

Water from Ongata Rongai Bridge had α-endosulphan and α-HCH determined as the highest at 60.4 ng/l levels during the month of April. All the other OC Pesticides recorded low levels throughout the study period as evidenced in table 4.9c below.

Table 4.9 c: Residues levels of OC Pesticides in Water from Ongata Rongai Bridge (ng/ l ± s.d, Mean ±s d, N =3, BDL below detection limit)

OCPs	November	December	January	February	March	April	Average
P, P DDT	8.68±1.54	17.35±2.38	8.15±2.84	3.74±1.54	BDL	3.47±1.89	7.15±6.89
Methoxychlor	3.26±1.04	4.63±1.20	BDL	3.80±1.13	3.75±1.15	3.21±1.45	3.49±3.53
Endrin	5.06±0.87	9.04±2.48	4.83±2.32	5.40±1.45	5.92±2.49	2.79±1.28	5.51±5.58
Endrin Aldehyde	BDL	3.75±1.84	5.34±1.85	4.27±2.44	3.30±2.16	2.81±1.21	3.57±3.84
Endosulfan Sulfate	BDL	BDL	BDL	8.31±2.84	4.29±0.41	4.93±1.88	3.86±4.13
Dieldrin	7.45±4.35	4.18±1.98	5.48±4.23	9.60±5.34	5.67±4.17	5.22±2.36	6.27±6.07
Heptachlor	3.75±0.95	3.70±1.62	3.77±1.35	3.14±1.25	2.88±1.4	BDL	3.23±3.14
Endosulphan	3.26±1.14	2.75±1.52	3.76±1.49	4.28±1.22	2.98±0.7	60.41±7.84	12.91±4.51
A-endosulphan I	3.26±1.93	2.92±2.78	2.88±0.25	4.44±2.05	*3.04±1.23*	9.93±3.65	4.41±4.60
P.P' DDE	19.63±2.23	6.83±3.21	4.35±1.92	4.10±1.87	BDL	8.12±2.83	7.45±5.42
Aldrin	3.74±1.41	29.15±6.40	4.18±1.45	4.45±2.15	3.37±1.83	4.91±1.34	8.30±2.06
α-HCH	3.26±2.13	2.75±1.69	3.76±1.32	4.28±2.17	2.98±1.28	60.4± 10.27	12.91±1.5
γ-HCH	3.17±1.14	BDL	2.88±0.81	4.56±2.16	3.15±1.34	4.46±2.14	3.19±3.20
β-HCH	3.17±0.01	BDL	2.88±0.20	4.56±0.19	23.15± 1.46	4.46±1.26	6.53±2.08
δ-HCH	7.15±3.12	5.18± 1.74	5.98±2.93	9.68±2.77	5.97±3.16	7.82±3.45	6.96±1.93
Heptachlor epoxide	4.36±4.23	3.26± 2.79	3.05±2.34	3.35±2.25	3.30± 2.13	5.10±2.12	3.74±3.63
p.p' DDD	BDL	BDL	BDL	BDL	2.86± 1.46	2.96±1.26	1.16±1.35
∑17 OCPs	83.39±4.35	99.75±7.19	65.35±1.83	82.31±2.34	79.78±4.93	193.14±18.58	100.62±6.54

4 6.1 Temporal Variations of OCPs in water samples from selected sites along Mbagathi River

Figure 4.18 below shows the seasonal variation of OC pesticides in water samples collected at the Ngong Bridge site. It was notable that the highest detected OC pesticide residue in water samples collected from this site was dieldrin during the short rain season. During the same season p.p' DDE and. α-HCH were detected but in slightly lower concentration levels.

The high values suggest a recent use of OCPs by farmers in the area. The presence of α-HCH which is an isomer of lindane, indicates it is a pesticide commonly used to control termites that destroy building materials and fencing materials like wood in the area. The application of lindane is done throughout the year but during the wet seasons, the residues are higher in the water, due to stormwater and surface runoff washing the sprayed chemical residues and other materials into the rivers.

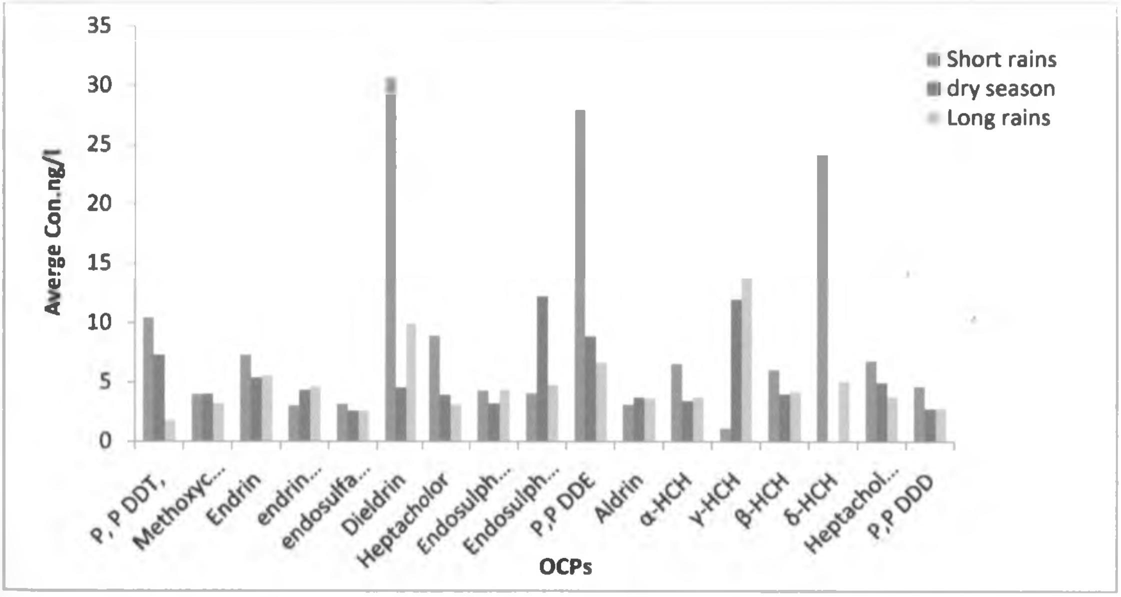


Figure 4.18: Seasonal variation of OCPs in Water samples collected at the Ngong Bridge site

The Co-operative College Bridge site is mid- way between the Ngong Bridge and the Rongai Bridge sites. At this site, the seasonal variation of α-endosulphan was the highest recorded during the long rain season. The results showed that these residues probably were introduced from the farms by storm water during the wet season or deposited from the air. During this time farmers do widespread spraying of crops with pesticides. The observed trend may have come from the activities within Nairobi West Region or from other far places.

Figures 4.19 below shows the seasonal variation of OC Pesticides in water samples collected at the Co-operative College site

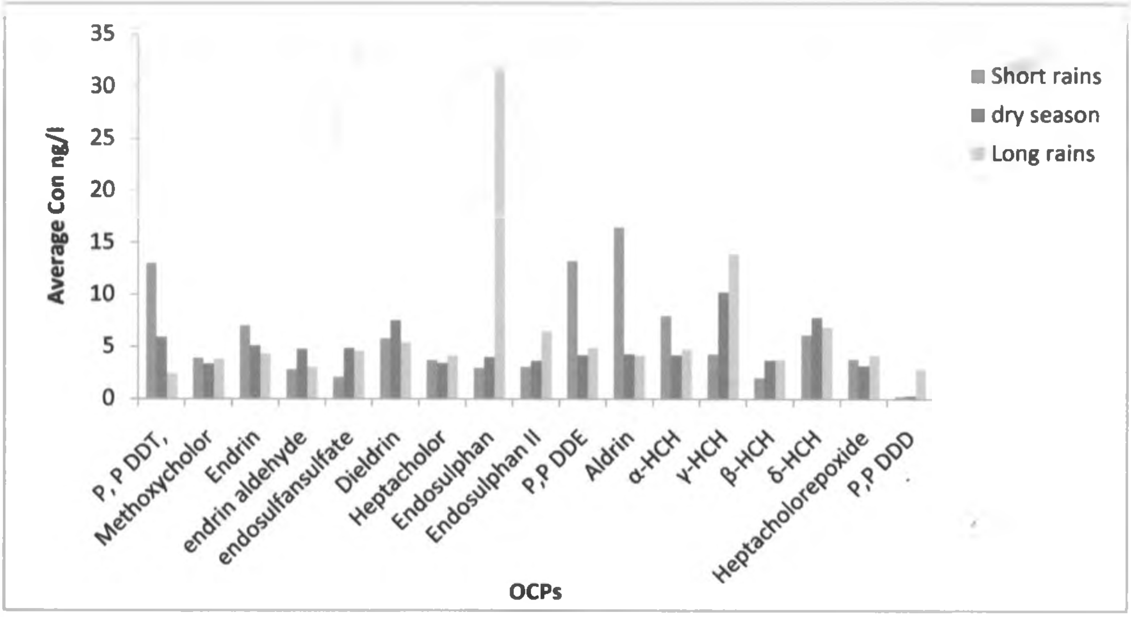


Figure 4.19: Seasonal Variation of OCPs in Water samples collected at the Co-operative College Bridge site

At the Rongai bridge site which was the last site on Mbagathi River before it enters into the Nairobi National park, endosulfsan I was noted to have the highest concentration of OC pesticide residues determined as seen in Figure 4. 20 below.

The tests showed decrease in all the OC pesticide residues compared to those recorded in water samples collected from the Ngong bridge and the Co-operative College Bridge sites. Farming activities in the bordering areas were fewer compared to the other two sites this, might have led to the observed trend. The river undergoes self purification and the pesticides binding on the organic matter in the river might have contributed to the decrease in OC Pesticides residues in the water. The low levels recorded could also have resulted from dilution of the pesticides residues caused by increased volumes of water in the river.

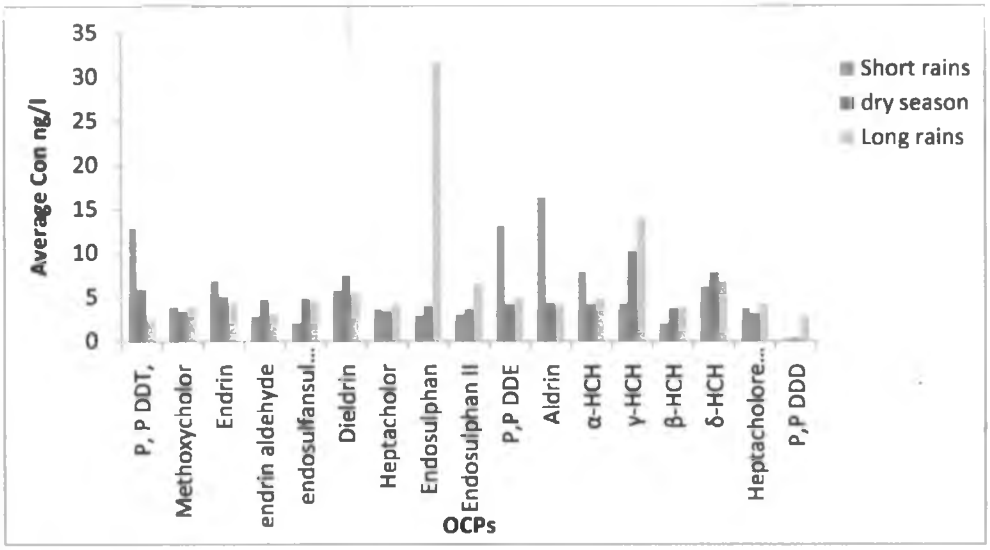


Figure 4.20: Seasonal Variation of OCPs in Water samples collected from the Rongai Bridge site

The highest sum of ∑17 OC Pesticides was detected during the month of February for the water samples collected from the Co-operative College Bridge site as evident in Figure 4.21 below. The water samples collected from Ngong Bridge site during the month of December had the highest sum of ∑17 OC Pesticides recorded. Samples collected from Ongata Rongai site had a notable a lower sum of 17 OC pesticides analysed through out the study period.

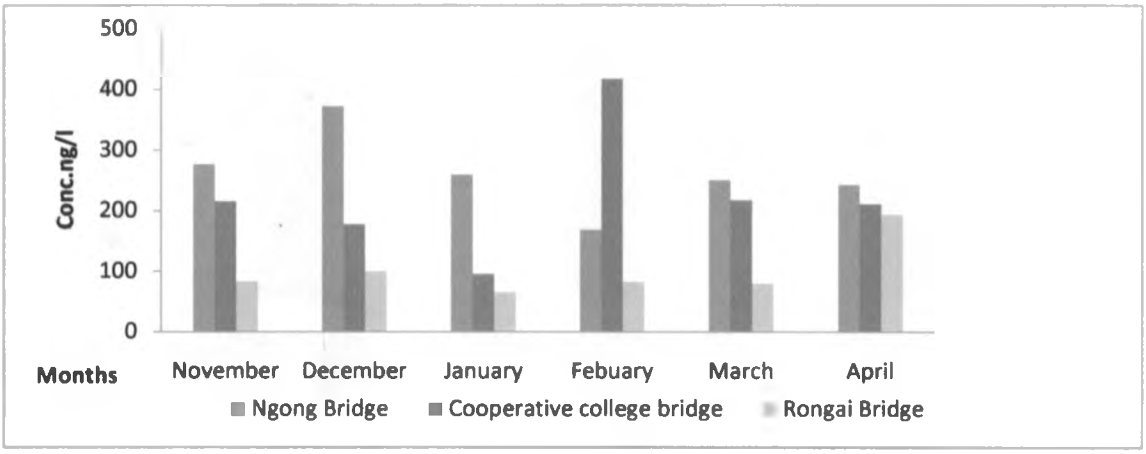


Figure 4.21; The monthly ∑17 OCPs Pesticides in Water Samples collected from the three sites

4.6.2 Spatial Variation in OC Pesticides Residues in Water Samples

Figure 4. 22 below shows the sum of 17 OC pesticides levels in water samples from all the three sites. From the Figure, it was clear that Ngong Bridge site had the highest OC pesticide levels overall. There was a general decrease in the observed trend down the river profile. The water samples from the Co-operative College Bridge site had lower OCPs Levels compared to those from the Ngong bridge while the Ongata Rongai bridge had the least. This can be attributed to the following factors: intensive farming activities in the Ngong and Kikuyu highlands which are the catchment areas of Mbagathi river, the OC pesticides tend to bind more on organic matter in sediments than in water column. Volume of water increased down

the river profile and this also diluted the OC pesticides that could have been deposited by storm water.

Organochlorine pesticides are mostly hydrophobic, therefore their solubilty in water was low.

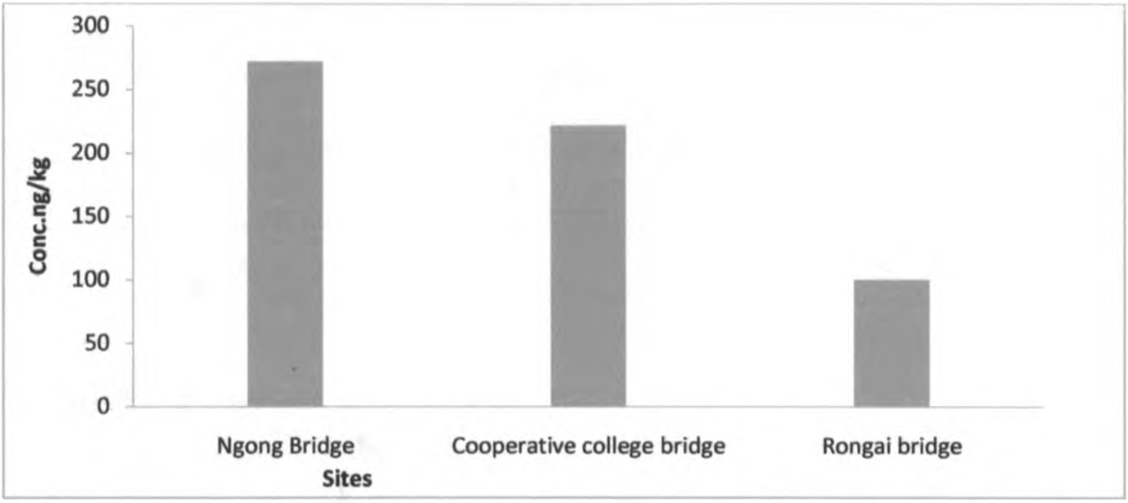


Figure 4.22: The ∑ 17 OC Pesticide levels in water per Sites

4.7. Correlations of levels of Organochlorine Pesticides in Milk,Water and Sediments

Correlation was done using Pearson's Correlations from SPSS tool. Correlation coeffients have numerical values (r) ranging from – 1.000 to 1.000 which represents the linear relationships between two data sets. Positive value indicates that the changes in the same direction while negative values indicate inverse variation relationships. The strength of linear correlation of the variables is determinrd by numerical value of r. A correlation coefficient of zero implies that there is no correlation between the data set. Correlation coeffivient below 0.5 are considered to be weak, while those above 0.5 are strong. The significance of the correlation is indicated by the p value. Correlation are significant if $p< 0.05$ and are not significant if $p > 0.05$ (APA, 2001). For comarability of data, only OCPs which were quantified in the three matrices for the entire study were considered.

The first set of correlations, discussed in section 4.7.1 was done to establish possible relationship between the variation in the levels of ∑17 OCPs in milk as well as water, milk as well as sediments, sediment as well as water as a function of time; both temporal and seasons. This was done by assigning numerical values to the six months and the three seasons covered by the study, Correlation between the levels of OCPs on a monthly time scal are discussed in section 4.7.2 while those on a seasonal scale discussed in section 4.7.3.

4.7.1 Correlation of intermatrix levels of OCPs

The correlation between the monthly levels of ∑17 ocps in water versus those in sediment were postive at each sites, although they all weak, the weakest being Ngong bridge (Appindix tables 4.13-15). the perason's correlation of the temporal levels of ∑17 OCPs in water and sediments (N=6) were 0.696, 0.448 and 0.215 at Cooperative bridge,Oganta Rongai Bridge and Ngong Bridge.

The ∑17 OC pesticides residue levels in water showed postive Pearson's correlation with TDS in water, the strongest was cooperative bridge while the weakest was Ngong bridge that is Cooperative bridge 0.876, Ongata Rongai 0.237 and Ngong bridge 0.032.

The Pearson's correlation between milk and water or milk and sediments does is postive but the cow did not only depend on water from the three sites measured so the correlation may not be valid.

4.8 Implications to Human Health and the Environment

In general, this study revealed a total of seventeen organochlorines pesticide residues and their metabolites in samples of cow milk from all the five sites. A similar number was detected in water and a total of sixteen OCPs in the sediments. Levels detected in cow milk were by far higher than those detected in sediments and water due to the physical and chemical properties of OC pesticides which include being more soluble in fats than in water. The continous exposure of livestock to pesticides through water, feeds and air also contributed to high levels in milk (Armendariz *et al.*, 2004).

The levels of pesticide residues and their metabolites detected, suggests that there are both previous and present use of banned and restricted pesticides by farmers to control pests and disease vector this was also established by the survey results,. The pesticide contamination detected in milk may be from the study area or other areas where dairy farmers purchase their feeds for the livestock or graze them. The levels recorded in this study were similar to those obtained by Jørgenson in their study in the USA (Jørgenson *et al.*, 2001).

Cow milk is a basic ingredient in every household in Kenya for tea, as well as basic diet for children and adults in some communities. The detected levels of pesticides in the milk mean that every body is at risk of pesticide contamination. Consumption of such milk over a lifetime of an individual may lead to high accumulation of these pesticides in the body fat and tissures. Some of these pesticides have been indicated as possible endocrine disrupters, carcinogens or mutagens. their effect on human and the environment may result from their bioacculation through food chain. it is essential that longerterm study on their effects on human and the environment be instituted. Furthermore, stricter content of their use should be instituted.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Organochlorine pesticide residues comprising of p.p''- DDT, p.p'-DDE, p.p''-DDD, aldrin, dieldrin, α-endosulphan, β-endosulphan, endosulfan sulfate, α-HCH, β-HCH, γ-HCH, δ-HCH, heptachlor, heptachlor epoxide, methoxychlor and endrin were detected at varying concentrations in water, sediment and milk samples. The disparities were attributed to the differences in environmental factors, the locations of the site, sample type, season, , previous and current use of the organochlorine pesticides as well as physical chemical properties of the pesticides. The levels of the OC pesticide residues detected were within the World Health Organisation allowed limits for drinking water and milk attached in the Appendix III,Table 4.11.

In this study, heptachlor epoxide, p.p''DDD, aldrin, δ-HCH, p.p' DDE and heptachlor were detected in high levels in milk samples. The study also revealed heptachlor epoxide, p.p' DDT, α-HCH and α endosulphan OC pesticide residues to be high in water samples. From the sediment samples, heptachlor epoxide, p.p'' DDT,α-HCH and α endosulphan OC pesticide residues were found to be in a higher concentration than in water samples.

In general, higher levels of OC pesticides were detected in milk samples compared to those found in sediments or water and this could be attributed to presence of lipids in milk in which OC pesticides were more soluble.

The milk fat content also influenced the levels of residues recorded. This means that a higher pesticide residue level was determined in milk samples with higher fat content. High pesticide levels were also detected in milk samples from sites where dairy meals and other supplements were used for cows. This implies that the feeds manufactured from maize stocks, maize seeds, cotton seeds and wheat which were preserved or sprayed with OC pesticides at some stage during their storage or production, might have contributed to the measured OC pesticide residues in milk. Another possible source of OC pesticide might have been from water, air, or livestock spraying.

The pesticide residues in water decreased down the river profile. The areas around the river catchment had more agricultural activities than those near the Nairobi National park lower downstream. However, the intense flower farming and horticultural activities in Karen altered the pattern such that high residue levels were detected in water and sediment collected from the Co-operative Bridge site. High pesticide residues were recorded in sediments; this was attributed to deposition of organic matter at the river bed where pesticides were adsorbed onto them.

These high concentrations of pesticides recorded were most likely due to the past use of these compounds in the Karen, Langata and Mbagathi River Catchment areas.

Steps should therefore be taken to educate people in the area and in other regions in Kenya, on the safe way of applying pesticides in order to reduce environmental contamination.

More studies should be carried out, especially in the rural areas where high levels of OCPs were previously detected in human milk.

In addition, there should be a follow up on the compounds banned or restricted to ensure that they are not illegally being used.

5.2 Recommendations

5.2.1 Policy recommendations

- The presence of some pesticide residues in cow milk samples from Karen and Langata areas at levels above the World Health Organisation's recommendation (attached in Appendix III, Table 4.11) may have adverse effects on human health and wildlife. There is therefore a need for the relevant policy makers to fromulate policies that will guide urban agricultural practices.
- The City Council of Nairobi and the Public Health Officers should conduct regular and frequent inspections on milk that are sold to the city residents from areas with similar activities as in Nairobi West Region. This will protect the residents from consuming contaminated milk and other foods.
- Strict controls on pesticide use in the river catchment areas, horticultural and flower farms are urgently required to protect aquifers from pesticides contamination.

5.2.2 Research Recommendations

- Further studies need to be carried out on the use of other pesticides such as edifenphos, chlorpyrifos, diazinon, ametryn, carbofuran and ethoprofos that have replaced organochlorines, to determine their levels and effects on the environment.
- Horticultural and other animal products from the region need to be studied to give a comparative contamination levels in these products.

- Animal feeds that are grown and those that are commercially availed to the region need to be studied to determine the pesticides residue levels in each category.
- People who work and live in this region may have high levels of pesticides contamination in their bodies resulting from the use of pesticide chemicals. A study needs to be conducted on these people to determine the extent of pesticide contamination on their bodies.
- Remediation models for recycling and cleaning of waste waters and surface runoff from agricultural fields should be developed before the water is discharged to the rivers. Natural or constructed wetlands around agricultural fields should be encouraged to purify water from the pesticide residues
- Resdue levels in processed milk samples such as those sold in supermarkets need to be determined.

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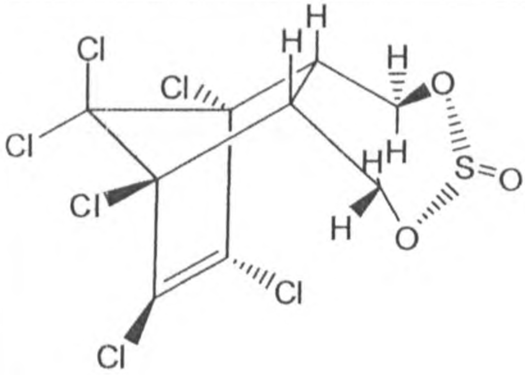
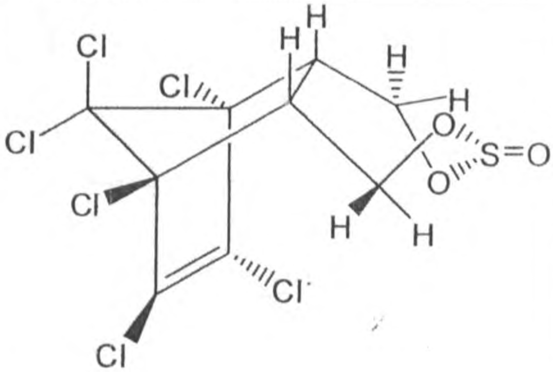
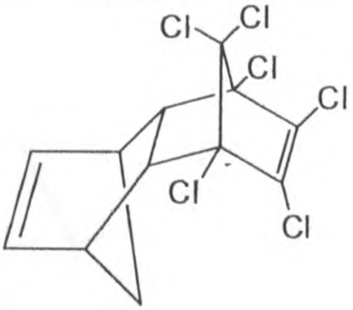
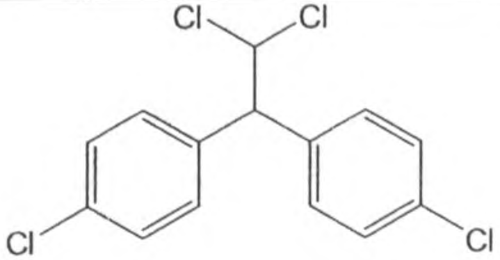
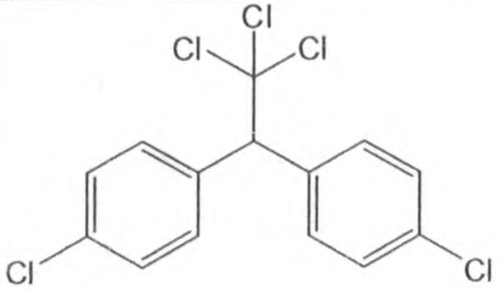
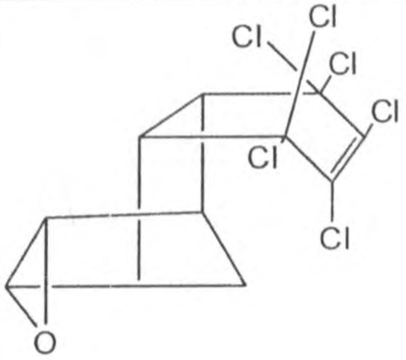
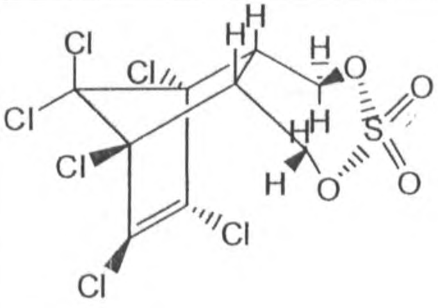
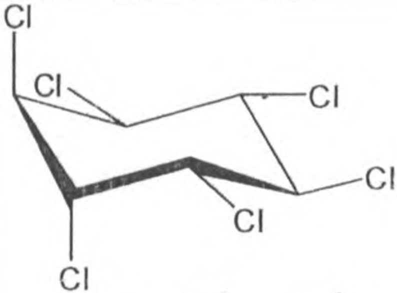
Structures APPENDICES

Appendix I

Figure a: Chemical of organochlorine Pesticides

SN	Name	Structures
1.	α–Endosulphan	
2.	β–Endosulphan	
3.	Aldrin	

4.	(1,1-dichloro-2,2-bis (4-chlorophenyl) ethane) p.p' DDD	
5.	dichloro-diphenyl-trichloro-ethane (DDT)	
6.	Dieldrin	
7.	EndosulphanSulfate	
8.	hexachlorocyclohexane (HCH),	

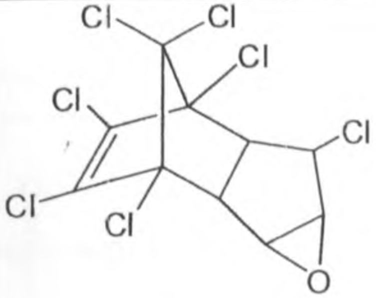
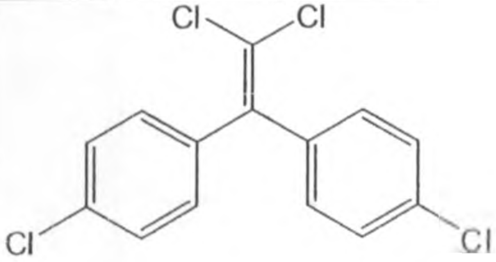
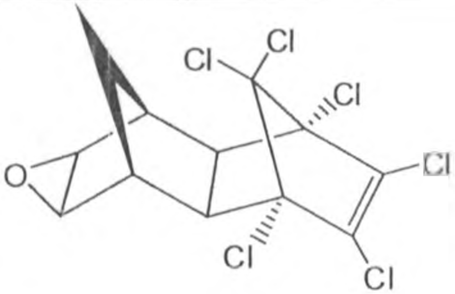
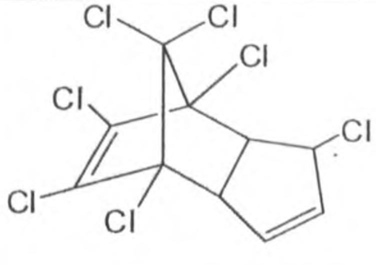
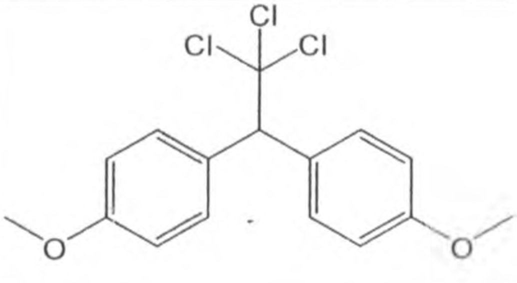
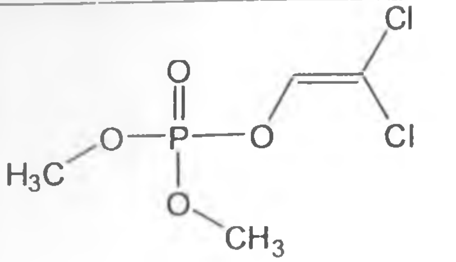
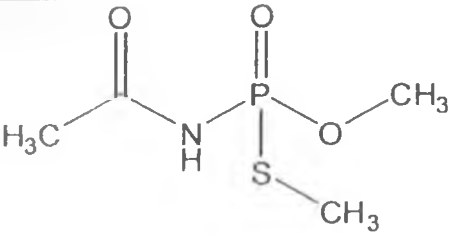
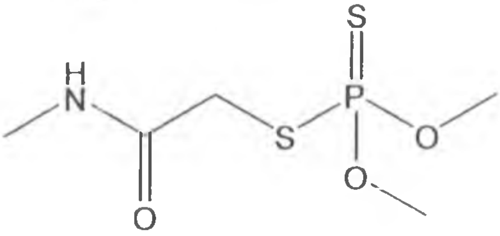
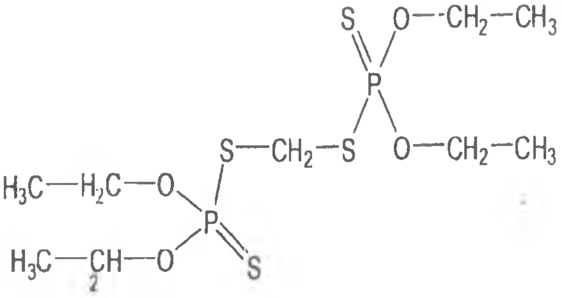
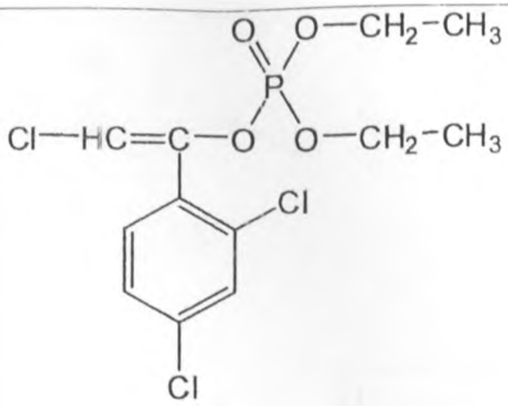
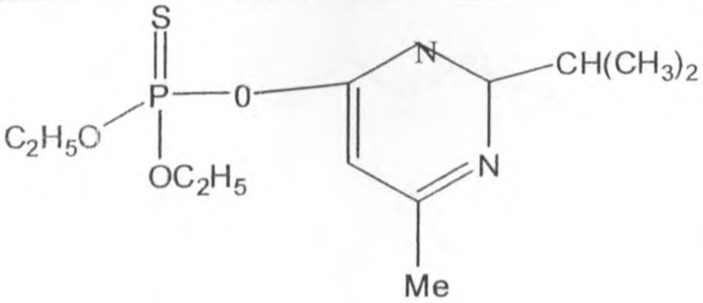
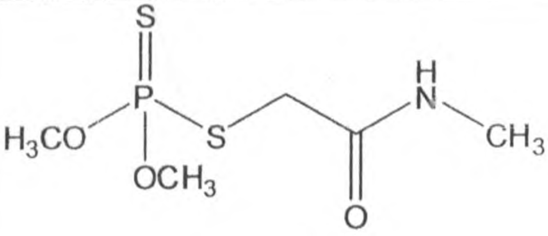
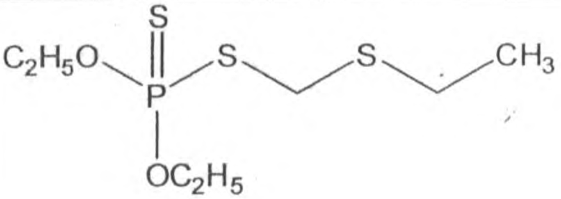
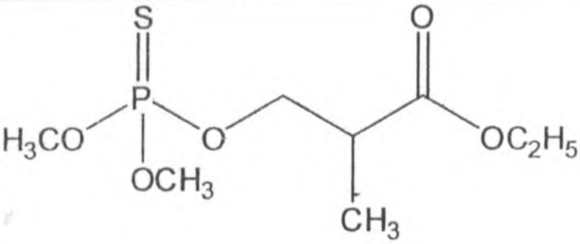
9.	Heptachlor epoxide	
10.	2,2-bis p-chlorophenyl1, 1-dichloroethylene- p.p''-DDE	
11.	Endrin	
12.	Heptachlor	
13.	Methoxychlor	

Figure b :**Some of Organophosphorus pesticides**

SN	Name	Structures
1.	Dichloros	
2.	Acephate	
3.	Dimethoate	
4.	Ethion	

5.	Chlorfenvinphos	
6.	Diazinon	
7.	Dimethoate	
8.	Disulfoton	
9.	Mevinphos	

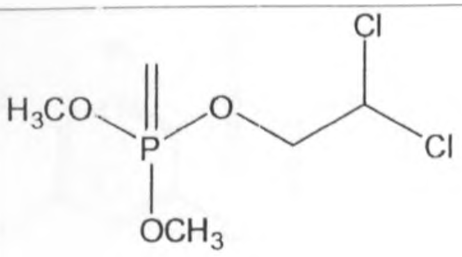
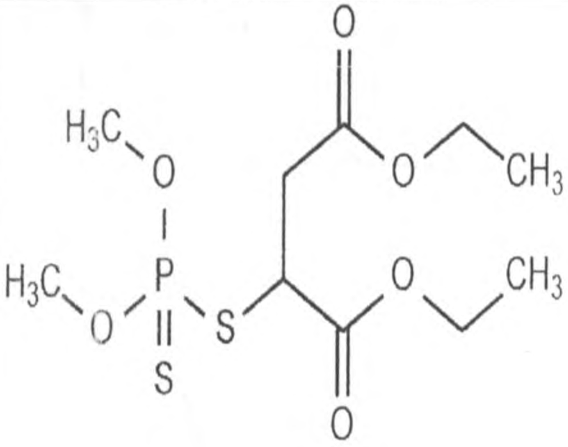
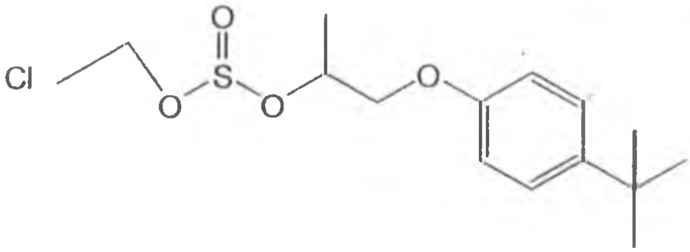
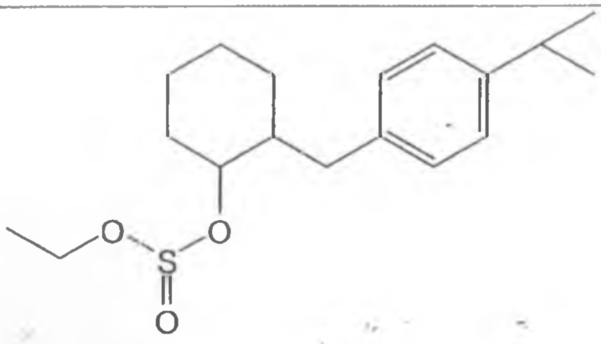
10.	Dichlorves	
11.	Malathion	

Figure c: Some of Organosulfur Pesticides

SN	Name	structures
1.	Aramite	
2.	Propargite	

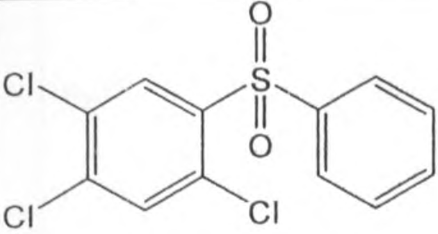
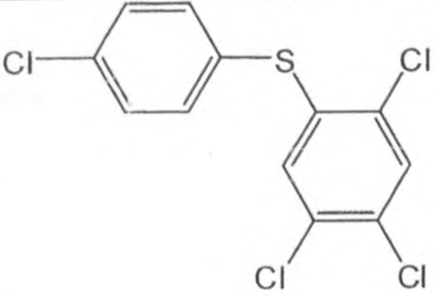
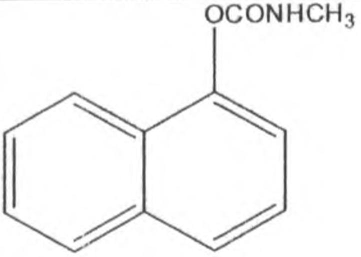
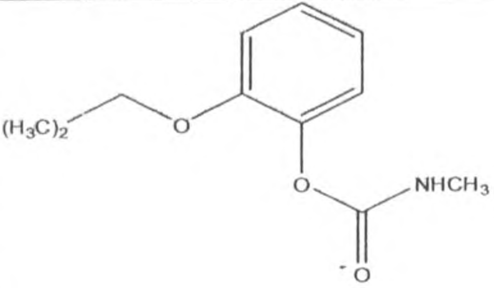
3.	Tetradifon	
4.	Tetrasulf	

Figure d :Some of Carbamate Pesticides

SN	Name	structures
1.	Carbryl	
2.	Carbofurans	

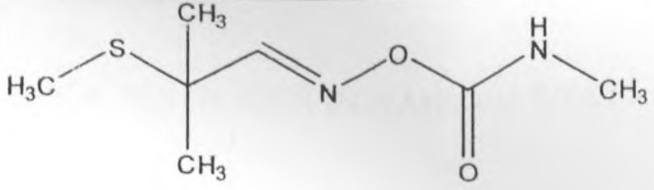
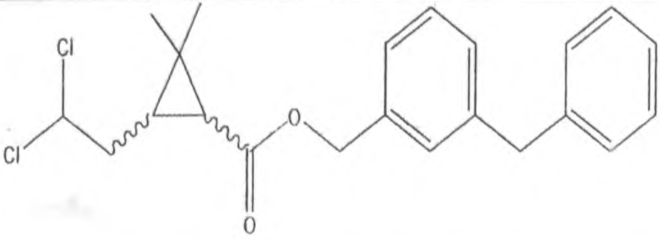
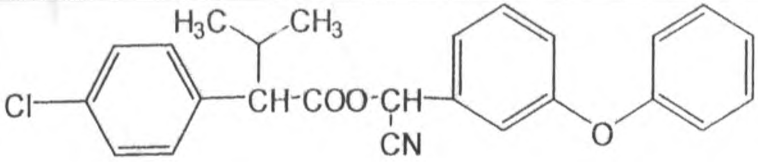
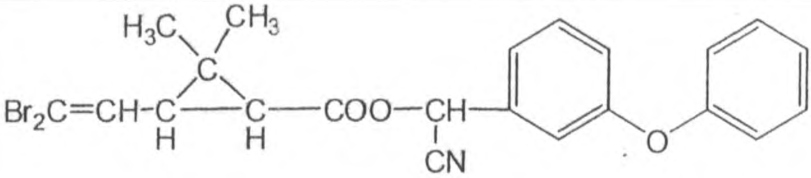
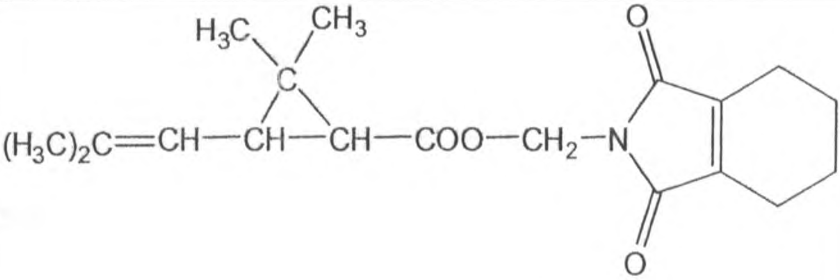
3.	Aldicarbs	

Figure e: Some pyrethroids Pesticides

SN	Name	Structures
1.	Permethrin	
2.	Fenvalerate	
3.	Deltmethrin	
4.	Tetramethrin	

Appendix II

QUESTIONAIRE ON THE USE OF PESTICIDES IN NAIROBI WEST REGION.

Introduction

This questionnaire seeks to gather infromation on knowledge concerning the types and use of pesticides in Nairobi West Region. Please note that this is not a test and there are no wrong and right answers. If you have no answer for a particular question, be free to write , "I don't know''. Your time and honest opinion are appreciated.

Section1. General Infromation (Kindly fill where Applicable.);

Questionnaire No----------date---------------

1.Address--

2.Gender Male---------------- Female--------------

3.Age-------------------- Occupation ----------------------------------

4 For how long have you lived in this area ?-----------------------------

5.The highest level of education reached please tick (Primary, Secondary and post secondary)

Section 2. Pesticides used in Nairobi West Region.

1.Do you have any infromation on the chemicals used in this area for spraying farm animals (cows, horses, dogs and cats), spraying crops (vegetables, potatoes, beans , fruits and coffee) and flowers.

2.Please list some of the chemicals you have mentioned in (1) above;

a.Animals -------------, ------------------;-------------------,-----------,--------------------------

b. Flowers--------------------.--------------------,-------------------,----------------------

c. Crops ------------------,-----------------------------, -------------------------,-----------------

3.Are there any guide lines given to you before buying any pesticide chemicals ?----------Who gives the guidelines -------------------------------

4.Have you ever had any training on pesticides managements and safety ?-----------

a.In which institution were you trained ? -----------------------------

b.How long did the training take ?------------ ----------------

c.What role did the government play in your training.-----------------------

5. Do you use any form of protection when handling pesticide chemicals?---if yes which one? --------- --------------------------- if no why?--------------

6.Where do you dispose used pesticide containers?-------------------------------------

7.Do you have infromation on the pesticide related pollution in this area ? ------------- if yes give some details.---

8. Do you know any national body that regulates the use of pesticides in Kenya ? ----------------------------if yes give name it --

Section 3. Chemical Dealers ;

1.Have you even been trained on how pesticides can be used in safe manner?------------------

2.List the chemicals that are commonly purchased by farmers--------------------------------------

3.Do you offer any after sale services or technical advice to your clients?-------

4.If yes in (3) above, indicate the kind of service or advice your offer (tick the one applicable) dosage, safety, disposal of used containers, others specify--------

5.Do you know any rule and regulations for pesticides handling in Kenya?---------------------

6.How are these rules enforced by the government?--------------------------

7.When do you have farmers seminars?------- ------------------Who comes to facilitate?--------

Appendix III

Tables

Table 4.9 Summary of Field Questionnaires Responses

Gender	**Males**				**Females**			
Age (years)	>18	>25	>35	> 45	>18	>25	>35	>45
Number	30	15	10	5	15	30	25	10
Purpose of using pesticides	To control pests that destroys crops, flowers, and vegetables. To controls ticks and flea in livestock, To controls termites flies, and mosquitoes.							
Occupation								
Farmers	3	7	8	9	8	10	12	15
Teachers	1	2	3	1	1	1	6	5
Agro- Vet dealers	2	4	3	2	2	3	3	6
Traders	0	6	2	8	0	2	3	2
Others	1	1	2	0	0	1	2	2
Training on pesticides handling								
With basic training	0	1	3	4	1	2	5	11
With no basic training	10	5	1	1	1	2	4	3
Advanced training	0	0	1	2	0	0	4	1
Safety and Control								
Always read instruction manual	1	2	14	1	6	4	2	2
Read instruction manual	0	0	5	1	0	9	9	4
Not aware of instruction manual	10	4	0	0	7	6	1	1
Do not read instruction manual	10	2	3	9	0	5	6	8
Education Level								
Primary	16	16	10	6	14	5	8	7
secondary	13	6	10	0	11	4	8	3
Post Secondary	4	9	1	1	13	2	4	5
Incidents and Accident reported	None							
Technical support	none							

Table 4.10: Pesticides Sold in Agro-veterinary Shops in Karen/Langata (Nairobi West Region)

Pesticides sold	Class	Users manual attached.
Carbofuran	Carbamates	Y
Ambush	Pyrethroids	Y
DDT	Organo chlorine	Y
Aldrin	Organo chlorine	Y
Dieldrin	Organo chlorine	Not-given and poor labels on the container
Decatrix	Pyrethroids	Y
Dursban	Organo phosphates	Y
Biatical	Pyrethroids	Y
Supona	organophosphates	Y
Triatick	Organo phosphate	Y
Diazion	Organo phosphate	Y
Dimethoate	Organophosphate	Y
Thelminutes	Organosulfur	Y
Sevin Dust	Organophosphate	Y
Tetrasul	Organosulfur	Y
Aramites	Organosulfur	Y
Alfatrim	Organosulfur	Y
Diazprim	Organophoshate	Y
Gentamycin	Carbamates	Y
Acephate	Organophosphate	Y
Malathion	Organophosphate	Y
Cooperthion	Organophosphates	Y
Lindane	Organo chlorines	Poor labels on the container
Chlorpyiphos	Organophosphate	Y
Chlofenvinphos	Organophosphate	Y
Mevinphos	Organophosphates	Y

Table 4.11: WHO Acceptable Limits Pesticides

Pesticides	Acceptable limits in ng/l
P, P- DDT,	1000
Methoxycholor	20000
Endrin	600
endrin aldehyde	20
Endosulfansulfate	
Dieldrin	30
Heptachlor	400
Endosulphan	
A-endosulphan I	
P.P' DDE	1000
Aldrin	30
α-HCH	2000
γ-HCH	2000
β-HCH	2000
δ-HCH	2000
Heptachlorepoxide	400
P.P'- DDD	1000

Table 4.12. The percentage frequency of pesticides

Pesticides	**Percentage Frequency**	**Pesticides**	**Percentage Frequency**
α HCH	95	Endosulfan sulfate	58
β HCH	67	Aldrin	100
γ HCH	69	Dieldrin	76
δ HCH	69	Endrin	59
p.p' DDT	72	Endrin aldehyde.	70
p.p' DDE	88	Heptachlor	61
p.p' DDD	86	Heptachlor epoxide	60
α- endosulfan	95	Methoxychlor.	36
β endosulfan	62		

Table 4.13 . Correlation coeffiecients for temperal varialiation of $\sum 17$ OCPs in water and sediments

		Ngongs	Coopers	Rongais	Ngongws	Cooperws	Rongaiws
Ngongs	Pearson Correlation	1	-.119	-.087	.215	-.109	-.289
	Sig. (2-tailed)		.822	.870	.682	.837	.579
	N	6	6	6	6	6	6
Coopers	Pearson Correlation	-.119	1	-.731	-.721	.696	-.399
	Sig. (2-tailed)	.822		.099	.106	.125	.434
	N	6	6	6	6	6	6
Rongais	Pearson Correlation	-.087	-.731	1	.100	-.570	.448
	Sig. (2-tailed)	.870	.099		.851	.238	.373
	N	6	6	6	6	6	6
Ngongws	Pearson Correlation	.215	-.721	.100	1	-.647	-.007
	Sig. (2-tailed)	.682	.106	.851		.165	.990
	N	6	6	6	6	6	6
Cooperws	Pearson Correlation	-.109	.696	-.570	-.647	1	.005
	Sig. (2-tailed)	.837	.125	.238	.165		.993
	N	6	6	6	6	6	6
Rongaiws	Pearson Correlation	-.289	-.399	.448	-.007	.005	1
	Sig. (2-tailed)	.579	.434	.373	.990	.993	
	N	6	6	6	6	6	6

Table 4.14 . Correlation coeffiecients for temperal varialiation of ∑17 OCPs in water and TDs

		Ngongws	Cooperws	Rongaiws	Ngongtds	coopertds	Rongaitds
Ngongws	Pearson Correlation	1	-.647	-.007	.032	-.824*	-.758
	Sig. (2-tailed)		.165	.990	.951	.044	.081
	N	6	6	6	6	6	6
Cooperws	Pearson Correlation	-.647	1	.005	-.019	.876*	.350
	Sig. (2-tailed)	.165		.993	.972	.022	.496
	N	6	6	6	6	6	6
Rongaiws	Pearson Correlation	-.007	.005	1	.233	.327	.237
	Sig. (2-tailed)	.990	.993		.658	.526	.651
	N	6	6	6	6	6	6
Ngongtds	Pearson Correlation	.032	-.019	.233	1	-.058	-.435
	Sig. (2-tailed)	.951	.972	.658		.914	.388
	N	6	6	6	6	6	6
coopertds	Pearson Correlation	-.824*	.876*	.327	-.058	1	.649
	Sig. (2-tailed)	.044	.022	.526	.914		.163
	N	6	6	6	6	6	6
Rongaitds	Pearson Correlation	-.758	.350	.237	-.435	.649	1
	Sig. (2-tailed)	.081	.496	.651	.388	.163	
	N	6	6	6	6	6	6

Table 4.15 . Correlation coeffiecients for temperal varialiation of ∑17 OCPs in water and milk.

		Ngongws	Cooperws	Rongaiws	Boganim	Fareacresm	Karindem
Ngongws	Pearson Correlation	1	-.647	-.007	.829*	-.521	-.036
	Sig. (2-tailed)		.165	.990	.041	.290	.946
	N	6	6	6	6	6	6
Cooperws	Pearson Correlation	-.647	1	.005	-.358	446	.021
	Sig. (2-tailed)	.165		.993	.486	.375	.968
	N	6	6	6	6	6	6
Rongaiws	Pearson Correlation	-.007	.005	1	-.064	.789	-.385
	Sig. (2-tailed)	.990	.993		.905	.062	.451
	N	6	6	6	6	6	6
Boganim	Pearson Correlation	.829*	-.358	-.064	1	-.310	-.439
	Sig. (2-tailed)	.041	.486	.905		.549	.384
	N	6	6	6	6	6	6
Fareacresm	Pearson Correlation	-.521	.446	.789	-.310	1	-.561
	Sig. (2-tailed)	.290	.375	.062	.549		.247
	N	6	6	6	6	6	6
Karindem	Pearson Correlation	-.036	.021	-.385	-.439	-.561	1
	Sig. (2-tailed)	.946	.968	.451	.384	.247	
	N	6	6	6	6	6	6

Appendix IV

Figures

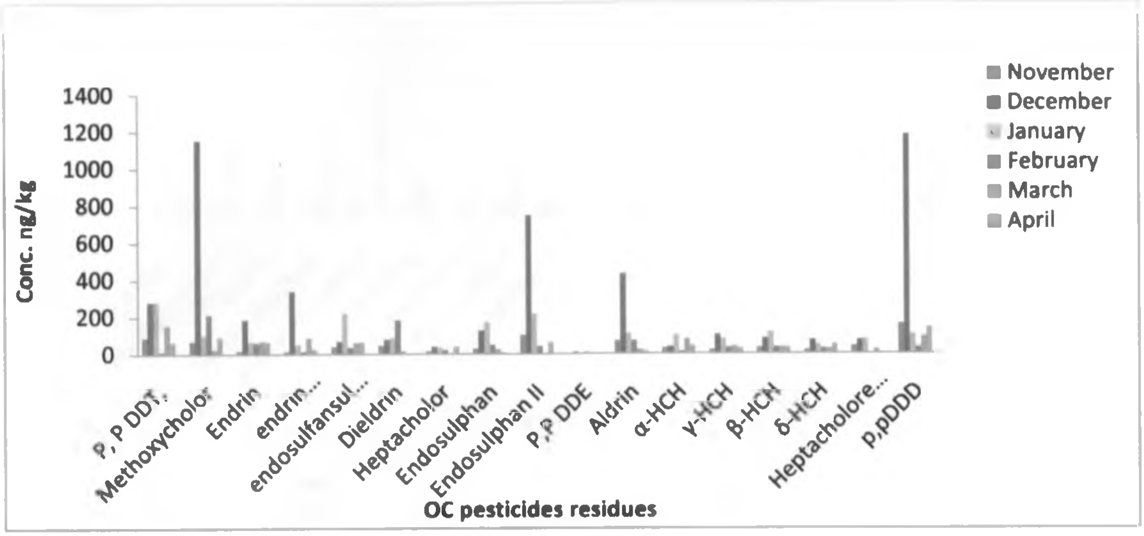
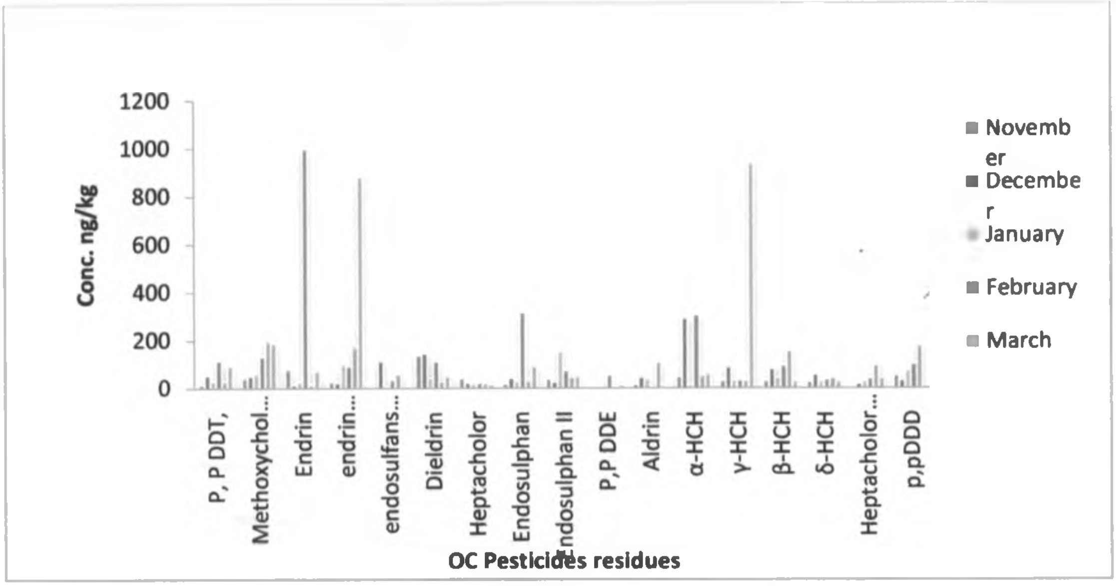


Figure 4.23:OC Pesticide Residues in Milk Samples collected from Bongani



Figures 4.24: Concentration of OC Pesticide Residues in Milk Samples collected from Fare Acres

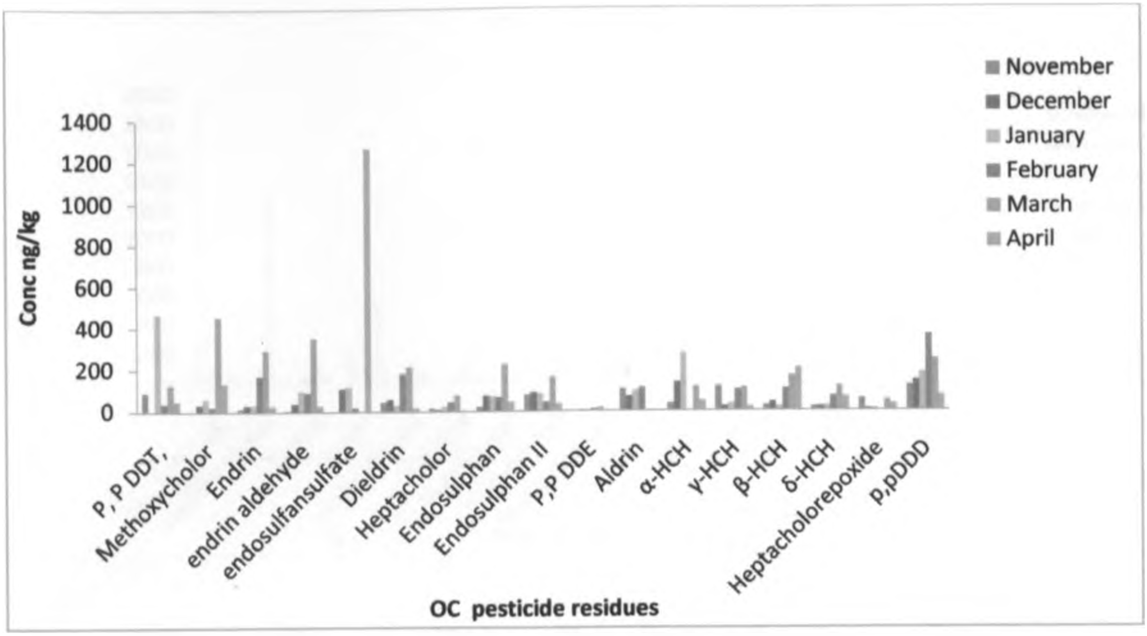


Figure 4.26: Concentration of OC Pesticide Residues in Milk Samples collected from Karinde

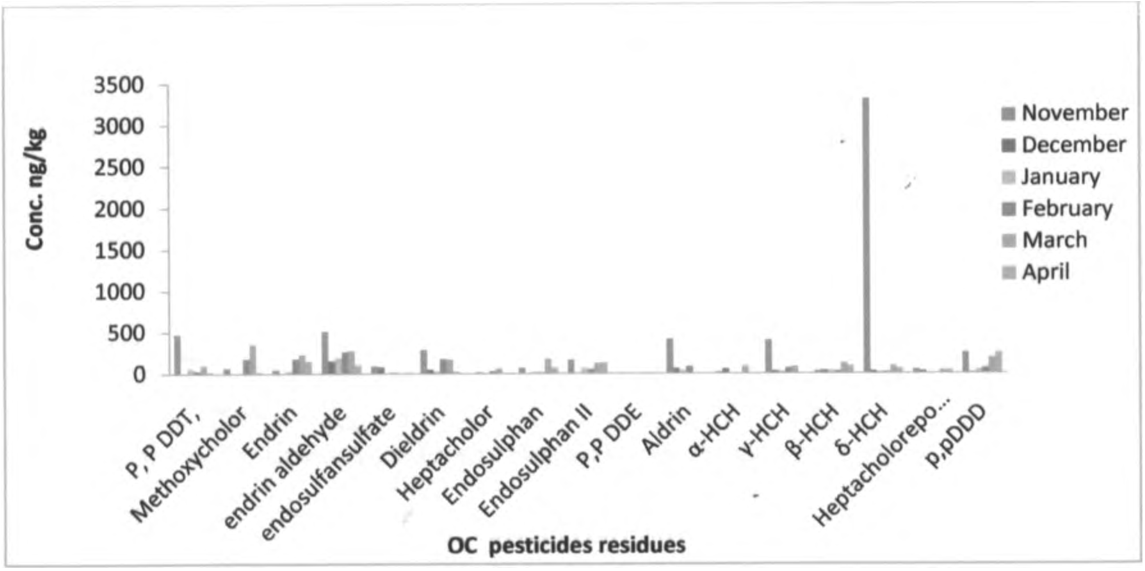


Figure 4.27:Concentration of OCPs in milk samples collected from Olepolos

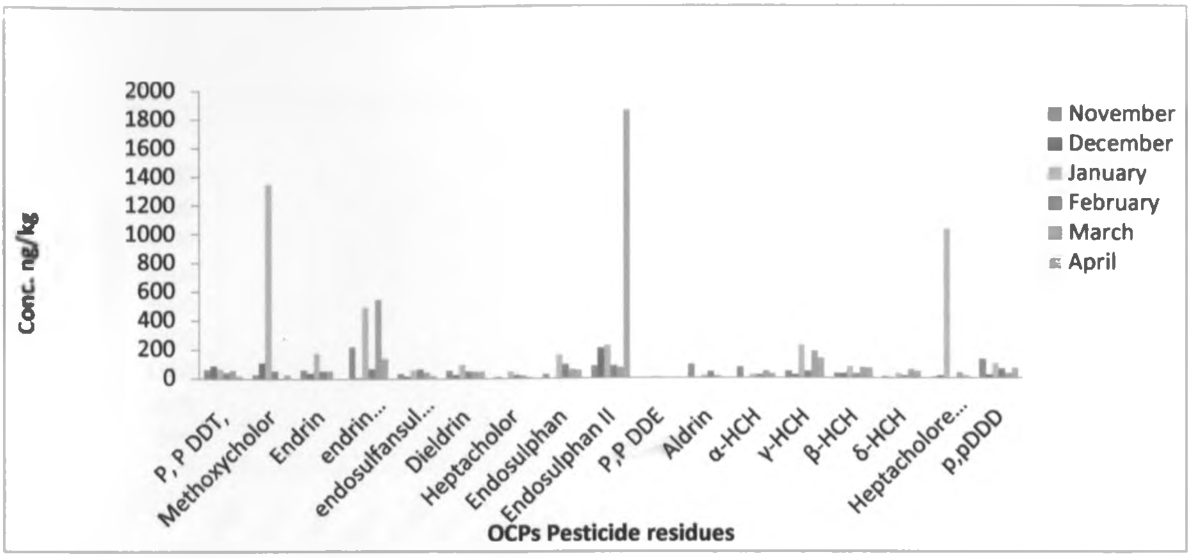


Figure 4.27:Concentration of OCPs in milk sample collected from Maasai Plains

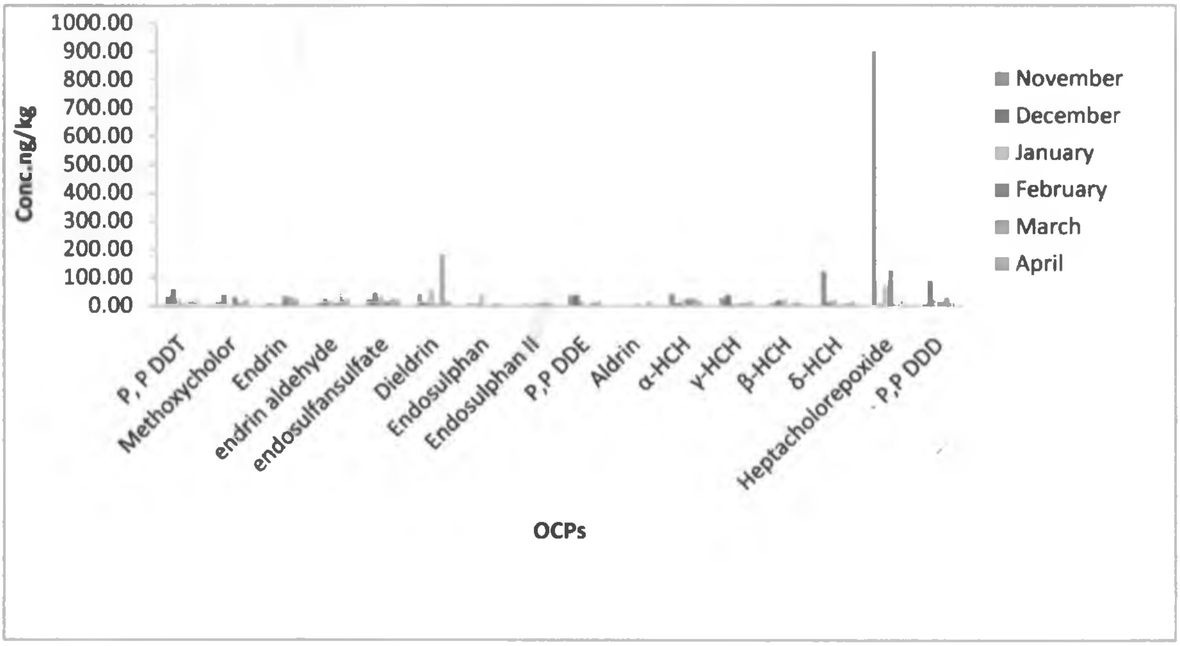


Figure 4.28: OC Pesticides Residues in Sediments from Ngong bridge

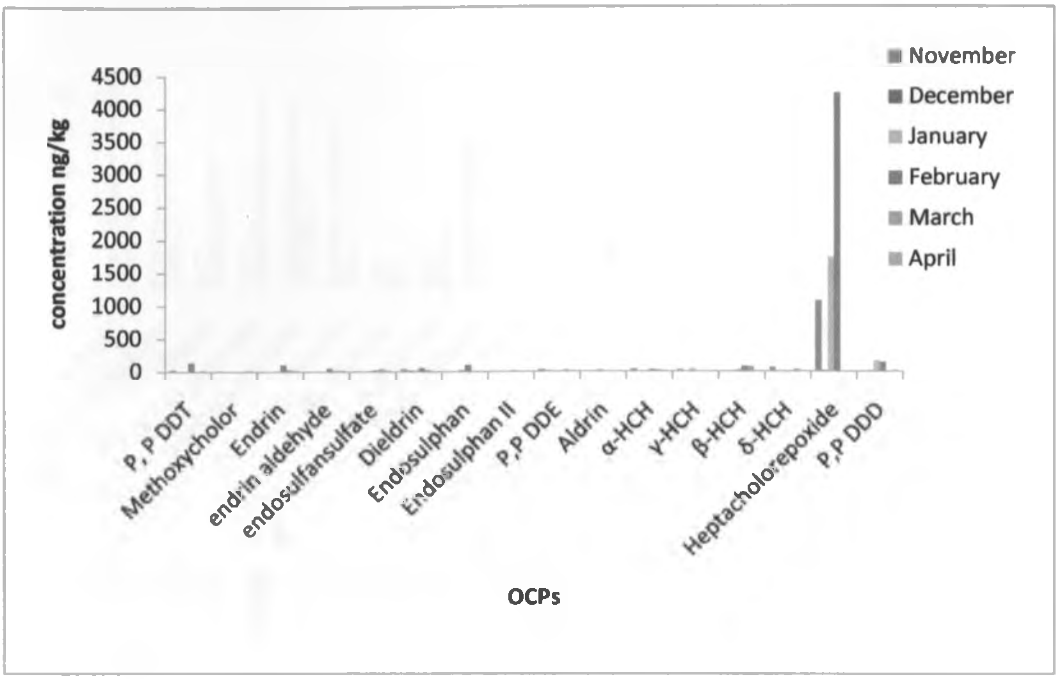


Figure 4.29: OC Pesticide Residues in Sediments from Co-operative Bridge

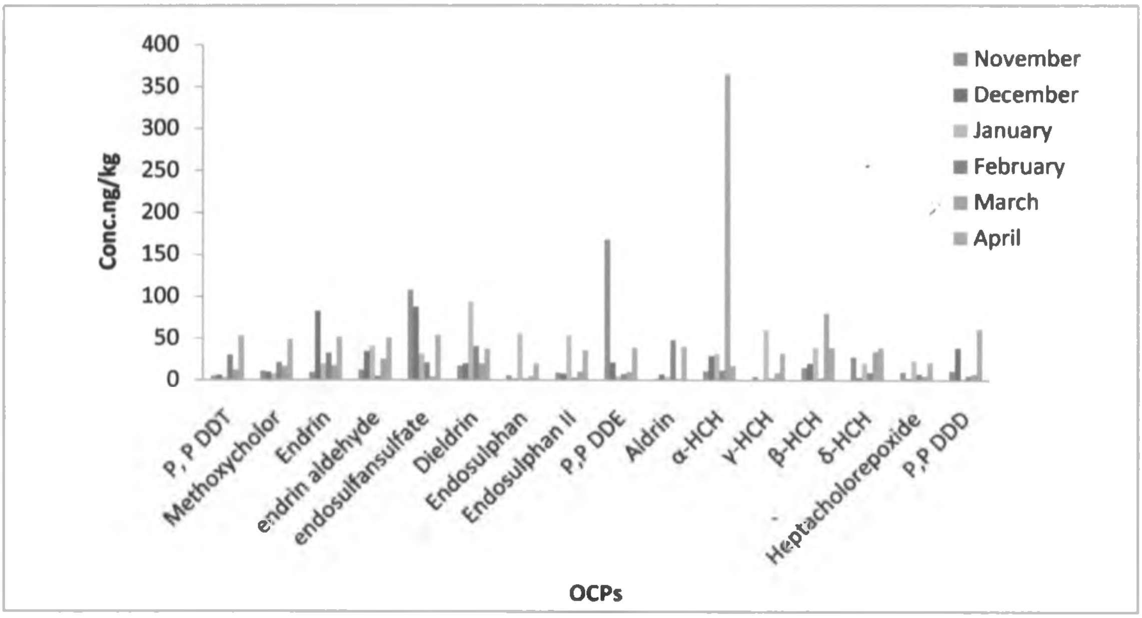


Figure 4.30: OC Pesticide Residues in Sediments from Rongai Bridge.

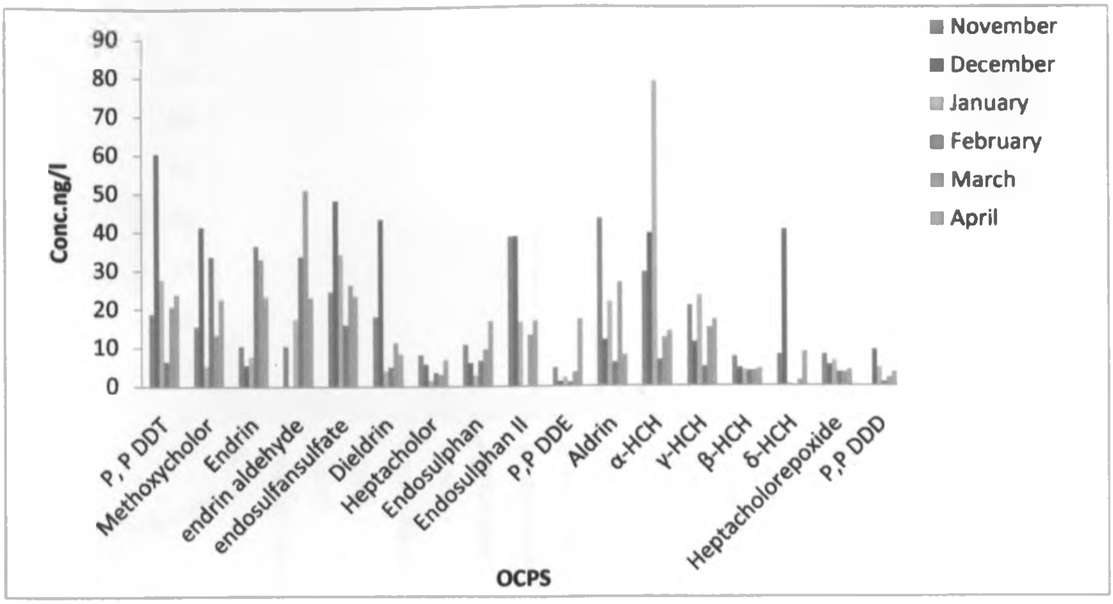


Figure 4.31: OCPs in Water samples per month at Ngong Bridge.

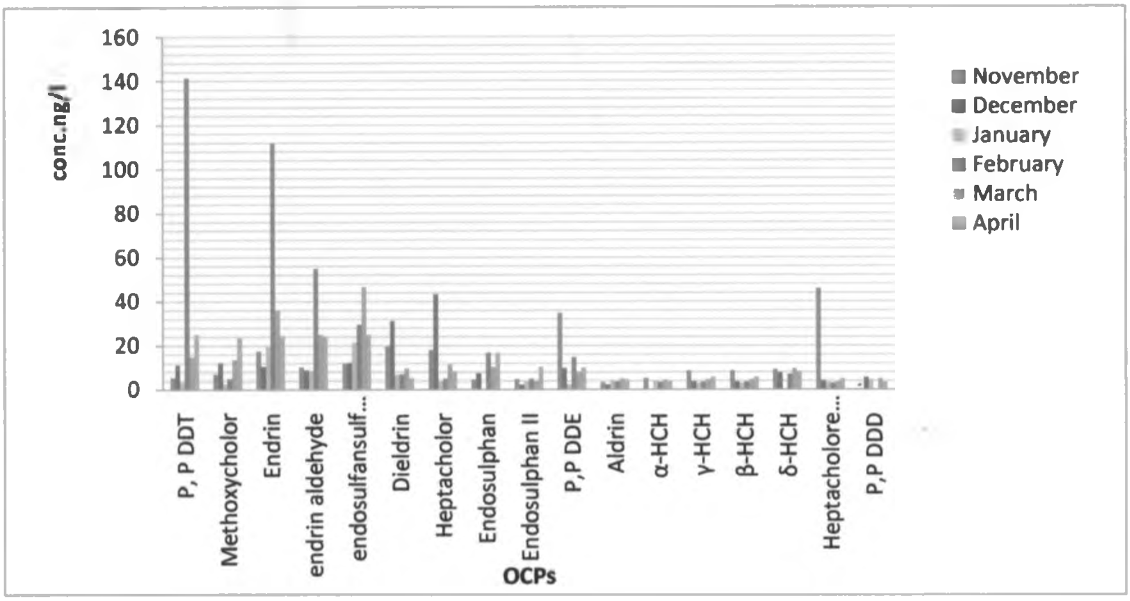


Figure 4.32: OCPs in Water samples per month at Co-operative College Bridge

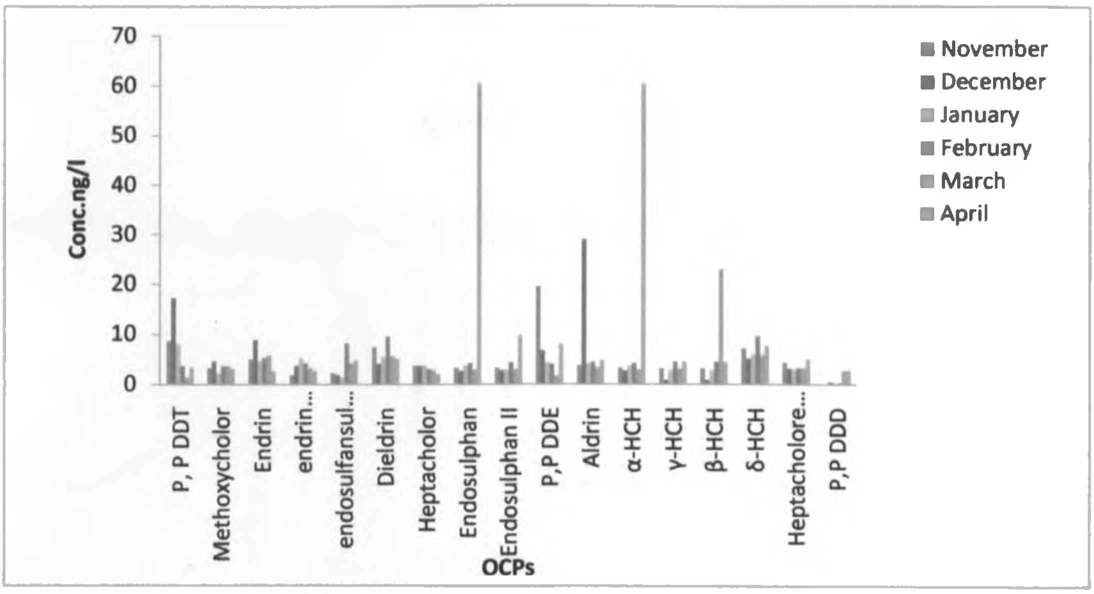
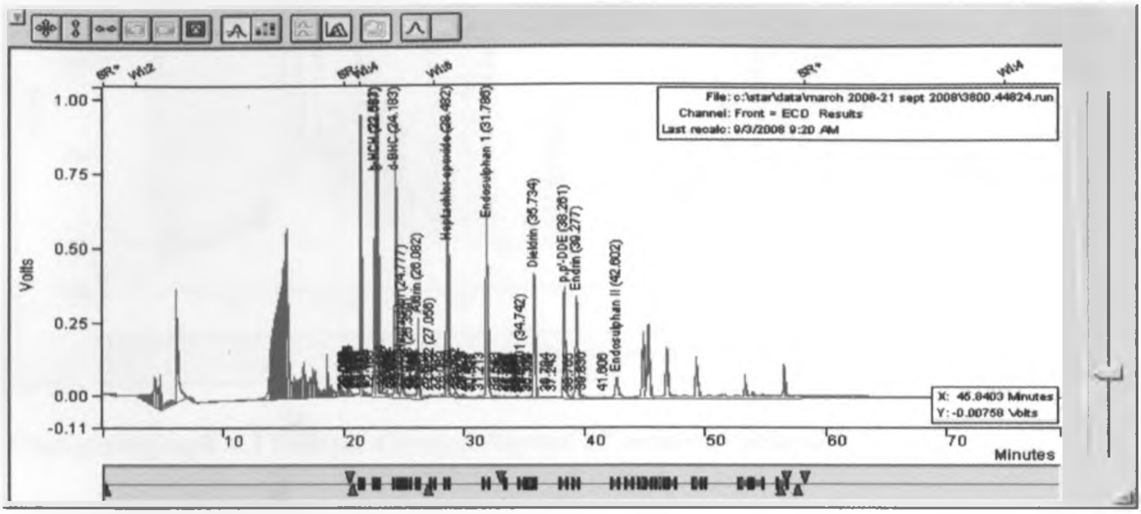


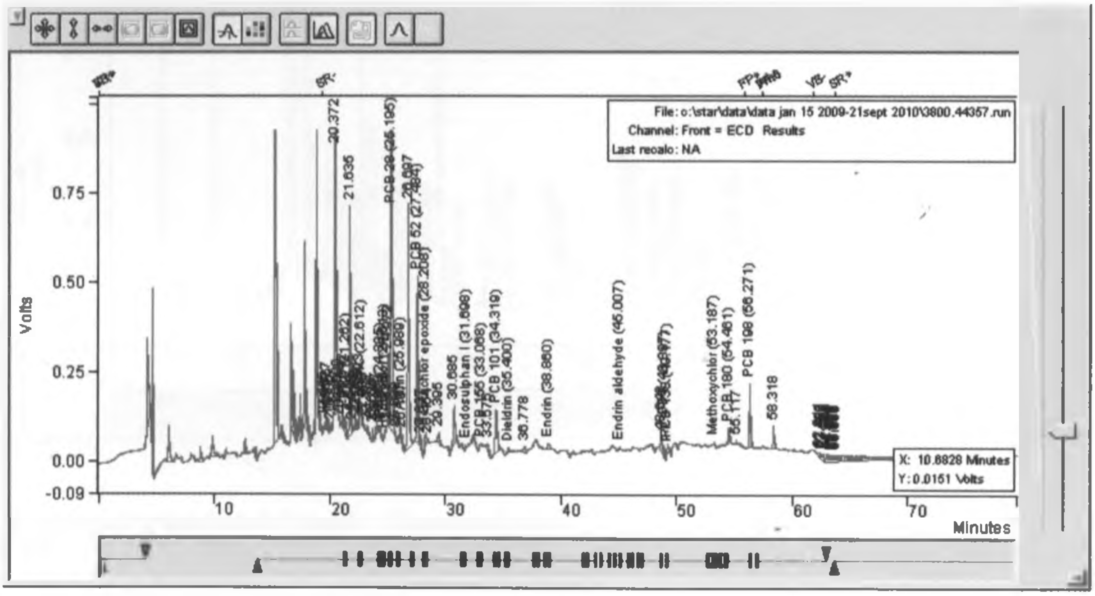
Figure 4.33: OCPs in Water samples per month at Rongai Bridge

Appendix V

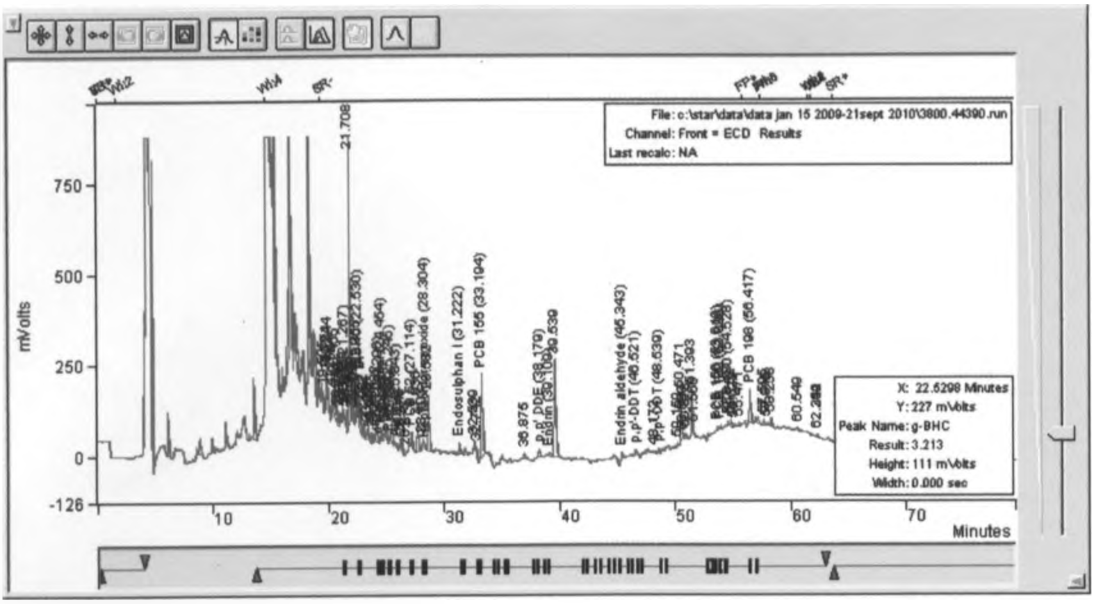
Chromatograms



Chromatograph 4.1 Sample Chromatogram of Pesticides Standards



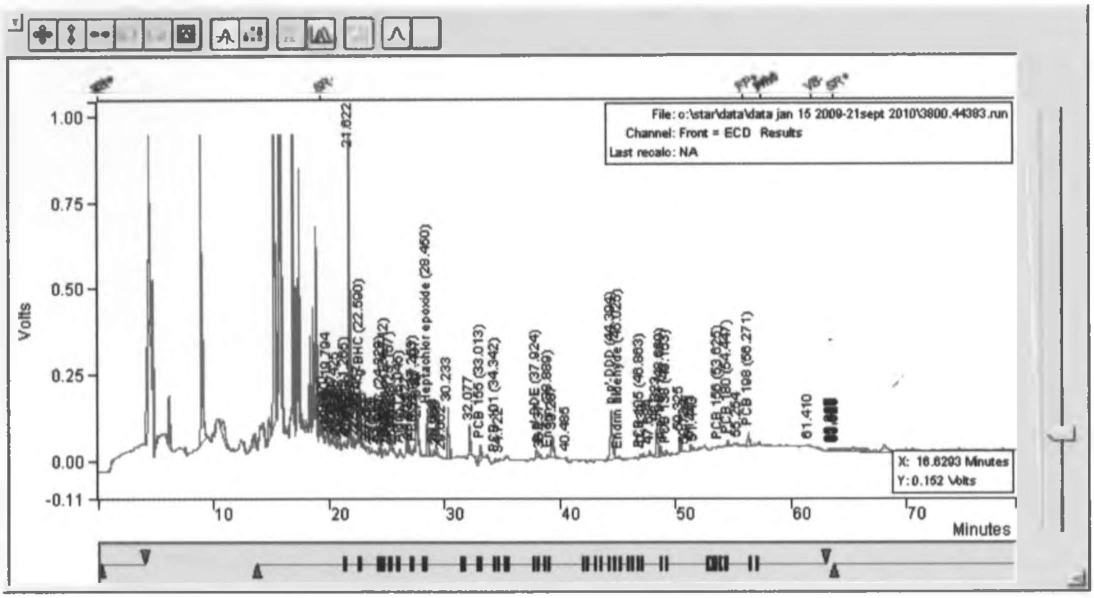
Chromatograph 4.2 Sample Chromatogram of water sample



File: c:\star\data\data jan 15 2009-21sept 2010\3800.44390.run
Channel: Front = ECD Results
Last recalc: NA

X: 22.5298 Minutes
Y: 227 mVolts
Peak Name: g-BHC
Result: 3.213
Height: 111 mVolts
Width: 0.000 sec

Chromatograph 4.3 Sample Chromatogram of sediment sample



File: o:\star\data\data jan 15 2009-21sept 2010\3800.44383.run
Channel: Front = ECD Results
Last recalc: NA

X: 16.6293 Minutes
Y: 0.152 Volts

Chromatograph 4.4 Sample Chromatogram of Milk sample