UNIVERSITY OF NAIROBI

SURVEY AND ASSESSMENT OF ACARICIDE RESIDUE LEVELS IN HOME CATTLE SPRAYS, SOIL AND WATER FROM EWASO RIVER, KAJIADO COUNTY, KENYA

BY

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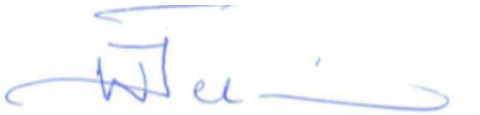
(I56/87425/2016)

A thesis Submitted for Examination in Partial Fulfilment of the Requirements for Award of the Degree of Master of Science in Environmental Chemistry of the University of Nairobi.

2021

DECLARATION

I declare that this thesis is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my own work has been used, this has been acknowledged and referenced in accordance with the University of Nairobi's requirements.

Signature:  .Date: 11th August, 2021

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DEDICATION

This Thesis is dedicated to my dear wife Ann Welimo, daughter Keya, and my two sons Ongera and Opete for allowing me to pursue this noble study.

ACKNOWLEDGEMENT

I am indebted to the ALMIGHTY GOD who gave me the spiritual strength and wisdom to accomplish this work through the grace of our Lord and Savior Jesus Christ.

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ABSTRACT

Tick borne diseases are a major global concern for livestock productivity. These ectoparasites control involve use of acaricides from which have reported tick treatment failures, increased environmental contamination and enhanced public health concerns. The study aimed at surveying and determining the residue levels of different types of amitraz (2, 4-dimethylaniline), deltamethrin (Br_2CA and PBA) and cypermethrin (3-phenoxybenzoic acid (PBA) pesticides used by farmers in Kajiado West Sub County. The parasites are responsible for economic losses that are either direct or indirect in cattle, goats and sheep. Some of the direct losses are as a result of discomfort and damage caused by parasites resulting to drop in milk production and damage to wool and hides. For proper understanding, researcher surveyed on information concerning pesticides usage, assessed levels of training on acaricides use, commonly experienced livestock diseases, control strategies, dilution modalities, preferred mode of application, health effects upon application and fate. Cross-sectional design using a structured questionnaire, face to face interviews and focus group discussions with 138 farmers in Magadi and Olkkeramatian locations, 38 willing farmers participated in questionnaire from which ten selected farmers' homesteads were used. Description statistic was carried for frequencies, percentages, variance and data subjected to confidence limits to T-test at 95 %. 1.0 L of freshly prepared homemade cattle sprays samples were collected by grab method into amber glass bottles. In addition, 100 g of soil samples were collected (0-30 cm) plough layers for pesticide residue level analysis. Soil samples for dissipation studies were also collected at the sites where the farmers sprayed their animals on day 0, 1, 2, 3, 4, 5, 7 and 10. Water samples were collected from the southern tributary of Ewaso Nyiro River in 2.5 L amber bottles by grab method. All the samples were collected during the dry and wet seasons. Soil samples were Soxhlet extracted with acetone: hexane (1:3) while Water samples and homemade cattle sprays were liquid-liquid extracted with dichloromethane as solvent, cleaned and analysed by gas chromatography mass spectroscopy at the University of Nairobi, Chemistry Department. Results from the interview revealed that farmers applied nine (9) acaricides under different trade names on their livestock. The major three acaricides used by the farmers were those with the following active ingredients (a.i) cypermethrin (76%), amitraz (72 %), and deltamethrin (46%). The acaricides were WHO class II (33.3 %) and WHO class III (67.7 %) respectively. Amitraz was found to be the most preferred acaricide compared to synthetic pyrethroids though some mixed the acaricides to improve efficacy. Farmers were too familiar with local names of different livestock diseases that are majorly controlled by hand spraying through use of privately owned knapsack sprayers within the cattle sheds. The concentration of the homemade cattle sprays ranged from 3,884±25.3 to 12,236 ± 145.4 µg/L for amitraz, 3,834±80.2 to 11,972 ± 74 µg/L for cypermethrin and 3,879±33.2 to 12,298 ± 82.1 µg/L for deltamethrin while the residue levels of these pesticides were below the detection limits (BDL) in all the river water samples. The half-life of amitraz range in soil was (0.44 - 1.60) days, cypermethrin (0.70 – 3.30 days) and deltamethrin (0.74 – 1.30 days). The analysis revealed that homemade cattle sprays in the sub-county had low concentrations of amitraz, cypermethrin and deltamethrin than those recommended by the manufacturers (50-400 mg/L) indicating that the acaricides were over diluted leading to the observed tick re-occurrence. Thus there is need for the agrochemicals and the county government of Kajiado to train the farmers on how to prepare the homemade cattle sprays to ensure efficient tick control. The observed disposal practices of unused acaricides and containers after use have great potential to cause environmental pollution and by extension affect human health.

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List of abbreviations

ASAHRP	Agricultural Sector Animal Health Rehabilitation Programme
CBOs	Community Based organizations
CVO	County Veterinary Office
ECD	Electron Capture Detector
EU	European Union
GC-MS	Gas Chromatography Mass Spectrometry
PCPB	Pest Control Products Board
POPs	Persistent Organic Pollutants
SIM	Selected ion Monitoring
SPE	Solid phase Extraction
SPME	Solid-Phase Micro extraction
SPs	Synthetic Pyrethroids
SPSS	Statistical Package for Social Sciences
TBDs	Tick Borne Diseases
USA	United States of America
MSDS	Material Safety Data Sheets

UNITS OF MEASUREMENT

µg	Microgram
µL	Microliter
µS	Micro Siemens
G	Grams
Kg	Kilograms
L	Litre
Ml	Milliliter
Ng	Nano gram
Nm	Nanometer
Ppb	Parts per billions
Ppm	Parts per millions
Ppt	Parts per trillions

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Livestock sector is a major player in the Kenyan economy offering support to many livelihoods in both the rural and urban communities. The livestock sector contributes an estimated Gross domestic product of 12 % locally (Warria *et al.,* 2019). The rural households directly depend on sale of livestock products for upkeep and are also directly employed in livestock related industries such as tanneries and meat processing.

In Arid and Semi-Arid lands (ASALs), the livestock sector contributes up to 90 % of the livelihoods of households and up to 95 % of family income (Kenya Ministry of Agriculture, 2008). However national and devolved government's development policies have not recognized the potential of the livestock sector especially in poverty reduction within the rural homesteads (Ermias, 2020). The study on livestock contribution to Kenyan economy sponsored by the livestock policy Initiative of Intergovernmental Authority on Development (IGAD-LPI) emphasizes that the livestock sector is underrepresented in the GDP estimates in Africa with respect to Kenya (Behnke *et al.,* 2011). Kenya vision 2030 aims at achieving greater heights within livestock production that ultimately meets the agricultural growth by purposing to attain 4-5 disease free zones. Its attainment will enhance industries dealing with livestock products and the related by-products to meet the requirements for foreign markets (GoK, 2008). The Ministry of livestock was established in April 2008 specifically for advancing, restructuring and enabling production of livestock for development of social and economic factors and growth of industries (MoLD, 2008). About 80 % of Kenya is inhabited by pastoralist communities in areas that are considered ASALs with 25% of the pastoralist communities earning their livelihood from rearing livestock (Amwata *et al.,* 2015).

The sector is observed to possess major potential in contributing towards achievement of the

global sustainable development goals (SDG 3) on healthy lives within the 2030 agenda. Basic emphasis being a shift from policy issues to enhancing the goals. This prompts nation's approaches for an integrated livestock sustainable development through translation of goals to specific and targeted national policies and actions that will prevent diseases thereby ensuring healthy lives through quality nutrition. Above 70 % of infectious diseases affecting humans since 1940s have animal origin, some of which include bovine spongiform and avian influenza. Therefore disease prevention in livestock will enhance food security through healthy diets. However, animal related products pose risks to human health through increasing peril from medicine residues, supplements and environmental contaminants (FAO, 2018)

The sector experiences some constraints which include inability of government to institute effective disease control measures, inadequate research and limited extension services to livestock farmers (Mugambi et al., 2012). Environmental contamination by pesticides has raised environmental concerns due to undesirable effects to non-target organisms. In addition illegal use of banned and obsolete stocks of pesticides continues to cause detrimental effects to human health and environment (Lamberth *et al.*, 2013). Early studies and analysis by Wandiga (1996) revealed pesticide pollution at the Kenyan coast in sediments and large invertebrates inhabiting the coastline. The government through the Pest Control Products Board has outlawed the import and use of some pesticides, but in spite of these some which have been banned still find their way on shelves (agro vets) and become accessible to farmers (Abong'o *et al*., 2014).

Acaricides are used in controlling tick transmission and associated diseases. Tick borne diseases and those caused by internal parasites limit livestock productivity due to weight loss and reduction in milk quantities (Jabbar *et al.,* 2015). The most common method of dealing with external parasites in livestock is by use of insecticides and acaricides. However, the use of acaricides has encountered resistance particularly from organochlorine, organophosphates and pyrethroids (Kunz *et al.,* 1994) by *Haematobia irritans, H. irritansexigua and Lucilia Cuprina*

tick population. Boophilus ticks have also reported resistance to organophosphates, synthetic pyrethroids, amidines and carbamates sparking discussions on new pest management strategies (Heath and Levot, 2015). Several methods have been used to assist minimize effects of tick borne diseases (TBDs) which include plunge dipping, spray races, showering and putting bands on tails in order to disrupt the vector life cycle (Young *et al.,* 1988). The control of livestock pests mainly employs the use of acaricides however these end up contaminating soil, air and water reservoirs and affecting non-target species (Gill *et al.,* 2014). Early studies by Kariuki, 1991 indicate need to review the frequency of acaricides application in any herd of cattle. He further states the start of an immunisation system called infection and treatment method that has enabled farmers control ectoparasites through dipping system at increased intervals rather than normal of twice per week. He further recommended more research in area of cost effective control so as to bring all other tick borne diseases on board that are a threat to cattle survival (Kariuki, 1991).

Mugambi (2012) reported widespread misuse of acaricides since government stopped controlling acaricides use by farmers. This was further complicated by lack of veterinary extension services who assist in acaricide application. He as well observed a combination of amitraz and other synthetic pyrethroids to improve their efficacy, an issue of concern and could compromise effectiveness of the two acaricides through development of resistance hence a window of insufficient technical knowledge amongst livestock owners.

Research by Kipngetich (2017) while investigating on whether application rates used in cattle dips met recommended guidelines and whether dissipation affected efficacy of pesticide in dip vat revealed lower amitraz concentrations in both dips compared to recommended dosage. The study revealed amitraz half-life's of 17 and 18 hours for dips 1 and 2 respectively and hence recommended dip solutions replenishment with acaricides for effective control of ticks. He observed a rapid decrease of amitraz from time of application to below detection ;limits for dip 1 at 6^{th} day and dip 2 by 5^{th} day respectively, a finding attributed to starting concentrations,

prevailing environmental factors and number of livestock dipped. He as well recommended need to control environmental contamination and human health due the toxicity of these compound. Acaricides categories depend on type of pest controlled and its nature (Arias- Este'vez et al., 2008). They are made up of amidines such as amitraz, Organophosphates as chlorpyrifos, pyrethroids such as cypermethrin and deltamethrin) and organochlorines such as DDT and Lindane. Amitraz a tickiticide is an essential requirement for livestock farmers in both tropical and sub-tropical regions. It has abroad acaricidal and insecticidal spectrum making it effective against lice, keds and mites on livestock.it has both a detachment and repellant effect on pests. In 1990s only a few brands were in existence such as tactic and Triatix. Currently dozens of brands are found prompting an increase in usage especially for dipping and spraying emanating from its reliability compared to synthetic pyrethroids and organophosphates (Del *et al.,* 2013). The active ingredient is a tertiary amino compound 1, 3, 5-triazapenta-1, 4-diene that acts as acaricide considered a potential contaminant to the environment. The United States environmental protection agency (EPA) classifies it as slightly toxic falling under class III.

In addition to amidines, pyrethroids have also found application as acaricides. The major ones being the synthetic pyrethroids found to be highly effective against ectoparasites. They include permethrin, decamethrin, deltamethrin, cyhalothrin, cyfluthrin and Flumethrin and show prolonged residual activity of at least seven (7) to ten (10) days with added advantage of being effective against biting flies. Cypermethrin is a pyrethroid that has found wider applications against different pests and cause soil contamination. The pyrethroids properties of hydrophobicity cause stronger sorption onto soil compounds leading to bound residues hence making them immobile. These is due to the high soil adsorption coefficient. However its environmental fate depends on factors as PH, humidity, Organic matter and intensity of light (Ostiz *et al.,* 1994, Fenoll et *al.,* 2011).

Deltamethrin a pyrethroid has wider application globally and is detected in many environments as soils and water where it poses greater toxicity to man and other organisms. It's a hydrophobic

compound with low movement in soils caused by its stronger sorption to organic matter in the soil (Oudou and Hansen, 2002). The acaricide undergoes dissipation and is broken through hydrolysis, photolysis and action by bacteria with half-life depending on soil type and oxygen availability (Elliot 1989; WHO 1990). Wider application of these acaricide and its high affinity to soil may lead to contamination.

The concept of relying on nature to heal nature is a worldwide practice. Natural products use was overtaken by synthetic chemicals due to their efficacy, reliability and quick action. However they become health hazards and environmental perils (Kekuda, *et al*., 2016) due to pollution. Hence emergency of biopesticides that are readily available, biodegrade easily, cheaper and less toxic. Examples are Neem, pyrethrum, cotton, tobacco, garlic, euphobia and citrus (Nefzi, *et al*., 2016) their action depends on type and mode of action; for instance microbial pesticides stop growth of pathogens, botanicals repel insects while predators kill prey(Vidyasagar, *et al*., 2013)

The major influencing factors affecting pesticide dissipation in the environment include pesticide environmental conditions, physicochemical characteristics, formulations, persistence, sorption, degradation and application rates (Young *et al*., 1988). The most widely used acaricides is amitraz (Mugambi *et al.,* 2012), although very few farmers know the active ingredients in the formulations. The ineffectiveness of amitraz in controlling ticks in some areas prompted some farmers to use a combination of both Pyrethroids and amitraz to improve efficacy of the acaricides (Mugambi *et al.,* 2012). Hence there is need to understand the degradation profile, efficacy and environmental residue levels of pesticides used in homemade cattle sprays.

1.2 Statement of the problem

There is growing concern about the efficacy of pesticides used in homemade sprays in Kajiado West sub-county due to regular re-occurrence of ticks shortly after spraying, leading to increased frequencies of spraying the livestock (Kagira *et al.,* 2013). Effective tick management requires adhering to specified amount of the pesticide application rate to achieve the specified efficacy and immediate tick control (Pfister and Armstrong, 2016). Tickborne diseases such as theileriosis and anaplasmosis lead to significant economic losses to farmers (Kivaria, 2006). In

addition, resistance of ticks to specific acaricides has forced farmers to increase frequency of spraying cattle per week and hence per month which raises the cost of livestock management (Wambua and Muhigiriwa, 2019). There is lack of data on the level of pesticide pollution caused by homemade cattle spraying in Kajiado West Sub-County. However, earlier research carried in Kajiado and neighboring counties showed that pesticides used by farming are likely to pollute areas where they are applied including soil (Abong'o *et al.*, 2015), surface waterways and underground water (Madadi, 2005; Osoro, 2015). This study aimed at establishing the extent of pesticide contamination from cattle home spraying in Kajiado West Sub Country.

1.3 Objectives

1.3.1 Main Objective

Survey and determine fate and concentration of acaricides used in homemade cattle sprays, soil and water from Southern Ewaso River in Kajiado West Sub County.

1.3.2 Specific objectives

1. Survey and identify types and classes of acaricides used in Kajiado West Sub-County and challenges experienced by farmers.
2. Determine Physico-chemical parameters and application rates of cattle homemade acaricides sprays in Kajiado West Sub-County
3. Determine the acaricides residue levels in homemade sprays, soil from selected farms where cattle's are sprayed and water from the Southern Ewaso Nyiro River
4. Determine the dissipation rates and half-lives of acaricides in soil from farms where cattle are sprayed in Kajiado West Sub-County.

1.4 Justification and Significance of the study

Pastoral communities in Kajiado West Sub-County suffer economic losses due to tickborne diseases but lack appropriate skills on safe handling and application of pesticides (Kagira *et al.*, 2013). In addition, there is no adequate data on methods of vector (tick) control especially

dipping and cattle spraying in Kajiado West Sub-County. Furthermore, there is no data on active ingredient efficacy, degradation, residue levels and use of obsolete pesticides in the area. Hence there is need for accurate information on the types and levels of the acaricides used in the area, residue levels in water and soil as well as their dissipation rates in soil.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Pesticides

Pesticides are ingredients or combinations of ingredients whose main purpose is stopping, killing, repelling or mitigating any pests (Oudejans, 1991). They help to reduce or eliminate the negative impacts of insects, bacteria, weeds, viruses, parasites and fungi, thereby improving the quantity and quality of agricultural produce as well as human health.

2.2 Classification of pesticides

Pesticides are divided into inorganic and organic. Inorganic pesticides are naturally occurring non-carbon elements, they are generally unchanging, stable in the environment and water soluble (Hassall, 1990). Organic pesticides are mostly artificial mixtures made up of hydrocarbon chains. They are categorized into carbamates, organochlorines, pyrethroids, organophosphorus and organosulfur (Wasswa, 2008).

2.2.1 Organochlorine Pesticides (OCs)

Organochlorine pesticides are a group of pesticides with chlorine attached to a hydrocarbon (Briggs, 1992). They are non-degradable in the atmosphere and bio accumulate in oily muscles of flora and fauna. Hence, they are available in the atmosphere and food web for long after use (Shokrzadeh *et al.,* 2009). One notable example of organochlorine pesticide is DDT currently restricted to indoor spraying for malaria control by the Stockholm Convention of Persistent organic pollutants because of its harm to environment and living systems. DDT was banned in 1986 for agriculture usage and is restricted for public health purposes (Biscoe *et al.,* 2005) despite its new use in Tana and Sabaki catchment areas that reveal higher concentrations in people, flora and fauna. Several organochlorine pesticides are endocrine disruptors (Moretto 1998; Vesna *et al.,* 2013).

Organochlorine Pesticides (OCPs) comprise of; perchlorobenzene, dieldrin, heptachlor, chlordane, aldrin, mirex, endrin, dichlorodiphenyltrichloroethane and toxaphene. They were extensively applied against diversity of pests to protect, defend crops, livestock and in areas of public health protection. Presently, a good number of these pesticides have been banned, except a few which are under restricted application.

2.2.2 Organophosphorus Pesticides (OPs)

Organophosphorus Pesticides (OPs) are esters resulting from phosphoric acid (H_3PO_4). They contain two single bonded and one double bonded side chain (R), two of which are usually ethyl or methyl attached to main phosphate atom (Figure 2.1).

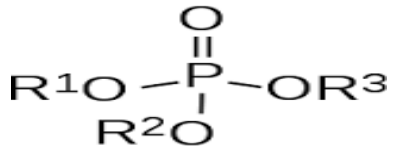

Figure 2. 1. General Chemical Structure of Organophosphorus Pesticides

Organophosphorus pesticides are chemically volatile and poisonous to people and vertebrate fauna. This set of pesticides has nearly substituted the chemically stable organochlorine pesticides (Briggs, 1992). The main drawback of organophosphates is the non-selective to target organism. These compounds permanently incapacitate the acetylcholinesterase (AchE) enzyme (Moretto, 1998). This results in the build-up of acetylcholine (Ach) that affects the neuromuscular functioning thus generating speedy jerking of controlled muscles and finally paralysis (Byoung, 2003).

Contact with organophosphorus pesticides even at low concentrations can cause destruction of the nervous tissue (Bachmann *et al*, 2000). Short-term exposure to these chemicals has been shown to result in muscle jerking, headache, vomiting, and faintness, lack of remembrance, lack of strength, shock, diarrhea, perspiring, salivation and ripping. Continuing contact can result to destruction of the nervous tissue. This hindered neurotoxicity may result to paralysis and is rarely

reversible. Injury may also occur to the immune system, liver, kidney and bone marrow (USEPA, 1992). Organophosphate pesticides degrade quickly by hydrolysis on contact to environment though lower concentrations can be identified in foodstuff and rivers. Their capability to degrade in the environment makes them an eye-catching substitute to the non-degrading organochlorines.

2.2.3 Organosulphur

Organosulfurs are types of pesticides with a central structure made of sulfur (Briggs, 1992). They work by disturbing the objective animal's digestion system. They are less poisonous to insects and animals and hence they are applied for selective uses. They are poisonous to young and mature insects through irritation to the eyes, ears and nostrils. Examples include alkyl benzene, propargite, tetradifon and tetrasul. The general structure of Organosulphur is shown in Figure 2.2.

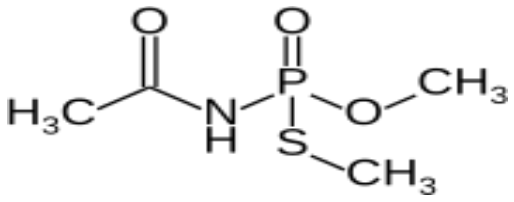

Figure 2. 2. General Chemical Structure of Organosulphur Pesticide

2.2.4 Pyrethroids

Pyrethroids are insect repellents taken from *Chrysanthemum cineraria folium* (pyrethrum) the unpolished flower powder. The artificial insecticide pyrethroids are synthetic derivatives of Pyrethrins (Kegley and Hills, 2007). Pyrethroids that were manufactured earlier than 1970 were highly sensitive to sunshine, as they degraded quickly under sunshine making them inappropriate for farming usage but good for controlling indoor pests. Pyrethroids manufactured after 1970s are stable in sunshine and less volatile hence can be used for farming and indoor activities. This group of insecticides kills by interaction and producing paralysis to the target organism. The pesticide is less poisonous to people while on the other hand are very poisonous

to insects and aquatic creatures. Examples are permethrin, deltamethrin, fenvalerate and tetramethrin. The general structure of permethrin is shown in Figure 2.3.

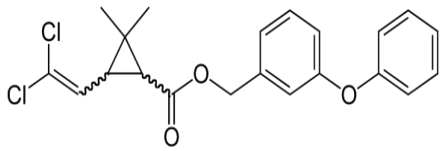

Figure 2. 3. General Structure of Permethrin

2.2.5 Synthetic Pyrethroids

They are non-systemic acaricides and insecticides that act by contact. Most were introduced in 1970s and still find greater applications in ectoparasites control in livestock. Their introduction replaced other pesticides due to their lesser toxicity to birds and mammals. Despite their disadvantages like environmental contamination, residues in food products and toxicity to farmers, they still are important in tick control worldwide (De Castro j. j, 1997). Intensive use of these acaricides lead to reduction of efficacy of the products due to increase in resistance by ticks hence the need for wise application (FAO, 2004). The structures of Cypermethrin and Deltamethrin are shown in Figure 2.4 and Figure 2.5 respectively.

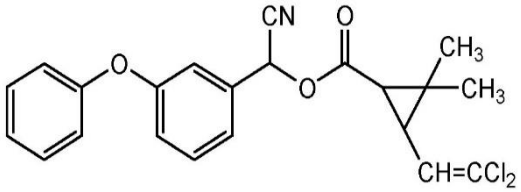

Figure 2. 4. General Structure of Cypermethrin

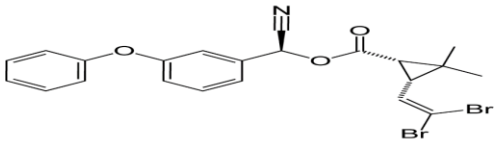

Figure 2. 5. General Structure of Deltamethrin

2.2.6 Formamidine

They are a class of insecticides including amitraz and chlordimeform that work by mimicking insect neurotransmitter octopamine. Amitraz is a non-systemic acaricide and insecticide with little harm to mammals and effective against acarids (Corta, 1999). It's available as spray or wash solution for ectoparasites prevention. Hydrolysis of amitraz strongly depends on environmental PH. At PH>6 it metabolizes to 2, 4-dimethylphenylformamide, at basic PH hydrolyses to 2, 4-dimethylaniline which predominates at acidic PH < 3 as a major product (Brown, 1977). The mode of action of amitraz is antagonistic effect on octopamine receptors in the brain and stoppage of monoamine oxidases and synthesis of prostaglandin. This is found to differ from that of synthetic pyrethroids and other ectoparasites (Fishel, 2008). The structures of Amitraz is shown in Figure 2.6

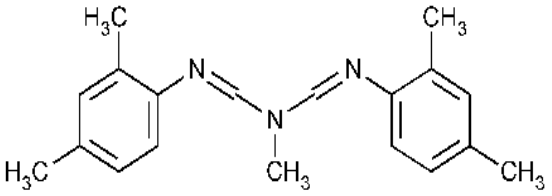

Figure 2. 6. General Structure of Amitraz

2.2.7 Carbamates

Carbamates are a class of organic pesticides resulting from carbamic acid (CH_3NO_2). The main functional groups are ethyl carbamate, carbamate group, carbamate ester and carbamic attached to the main carbonyl carbon. Examples of carbamates include carbofuran, carbaryl and aldicarb. They act by constraining the cholinesterase enzyme that is essential for nerve purposes in fauna. Certain carbamates are alleged to be cancer causing agents (USEPA, 1992). Carbamates are hydrolyzed gradually in neutral and slightly acid aqueous environments, however in the existence of base they undergo quick decomposition. Carbaryl half- life is around 240 hours in neutral environment and in acidic environment it is only a few minutes (Briggs, 1992). The general structure of carbamate is shown in Figure 2.7.

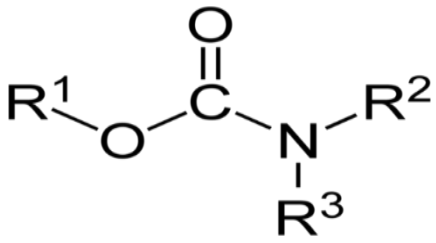

Figure 2. 7. General Chemical Structure of Carbamates

2.2.8 Bio pesticides

The control of ticks is mainly by use of chemical acaricides which exhibit several limitations such as non-selective elimination of non-target organisms, tick species resistance, environmental hazards and health risks to users. In addition acaricides are toxic, expensive and pose increased residue levels in animal products of milk and meat upon exposure. These limitations open a window to researchers to seek for alternatives hence use of bio pesticides that lack adverse effects on livestock and environment. An example is Metarhizium anisopliae sensu stricto (Metsch) a fungal found by the International Centre for insect physiology (ICIPE) to be effective for tick control that can be commercialized (Bailey *et al.,* 2010). Bio pesticides are biochemical, microbial and plant incorporated protectants for controlling pests. In Kenya these products have been registered by the pest control products board (PCPB) and are increasing in use. Although bio pesticides currently account for only 3 % of the world pesticides market, the rates of adoption are little (Olson, 2015) and it's estimated that bio pesticides markets will equalize synthetic pesticides in the period between 2040 and 2050 (Olson 2015, Dalmas and Koutroubas, 2018).

2.3 History of Acaricides use in Kenya

Kenya has been using acaricides since 1900 (Wycliffe, 2012). According to Zahid *et al.* (2006) sodium arsenite was the first acaricide to be used across the world. The acaricides were introduced in the year 1912 and 1949 to manage vectors that cause cattle sicknesses such as theileriosis. However, the sodium arsenite, had short residual effects on the livestock and ticks developed resistance to this category of acaricides (Zahid *et al.,* 2006). In the year 1949 Lindane

was manufactured for use in farming, after five years *B.decolaratus* developed resistance to lindane (Keating, 1983). Later in 1950 Toxaphene was manufactured and became an acaricide of choice due to the observed resistance of the tick strain to lindane and sodium arsenite (Keating, 1983).

DDT was produced in 1956 while dieldrin was manufactured by 1961 (Keating, 1983). DDT and dieldrin were banned in 1976 for use in livestock as acaricides because the ticks developed resistance, bio-accumulate in the oily tissues of the cattle and were detected in dairy products (Keating, 1983). Kenya experienced reduction of imports of pesticides in 1988 and 1990 due to the prohibition and control production of some organochlorine pesticides (Munga, 1985). The common acaricides that were available during 1950s‟ were tetraethyl pyrophosphate, dioxathion, coumaphos and schradan which are organophosphate (OP) compounds (Keating, 1983). The acaricides which are frequently sold to manage ticks are pyrethroids, trans-permethrin, amitraz, coumaphos, bendiocarb, phenylphenol and chlorpyrifos (Keating, 1983).

2.4 Resistance of Ticks to Acaricides

According to George *et al.* (2004), the ability of ticks to successfully develop resistance to acaricides explains the diversity observed in acaricides which have been developed. The progressive evolution of resistance to acaricides, attempts made by livestock farmers to control ticks and illness caused by tick have been unfulfilled (George *et al.*, 2004). Australia was the first to report resistance of *B. microplus* to arsenic in 1937 (Jonsson and Hope, 2007) then in 1939 South Africa reported resistance of *B. decoloratus* to arsenic (Mekonnen, 2005). Nari and coworkers suggested that the tick resistance to many acaricides like organophosphates, arsenic, organochlorines, pyrethroids and carbamates has stimulated much worry and pursuit for fresh acaricides (Nari and Hansen., 1999). In 1981, in some few widely spread regions in Australia; resistance to amitraz by „Ulam‟, an amitraz-resistant strain was first identified (Nolan *et al.*, 1981).

Livestock health within the sub-Saharan region is largely affected by tick-borne diseases (TBDs) and other related infections and hence slowing development in the sector, majorly known as an economic power base of Agriculture (Omore, 2003; Smith and Parker, 2010). Many roles are attached to the African livestock that is specifically a bedrock for easing food scarcity, uplifting the poverty levels, improvement of ways of life, creation of jobs that in the long run lead to better living standards (Smith and Parker, 2010). The sector is key particularly towards achieving millennium developmental goals (World Bank Group, 2011). It's paramount to note that in areas where acaricides are unavailable or too costly, problems of ticks may be fatal. Even though methods of tick control have been in use, the problem of ticks still persist giving a leeway to resistance to pesticides used, livestock poisoning and ecosystem impacts emerging from acaricides use, residual environmental pollution mainly propagated by unavailable trained personnel to manage the dipping processes (Dipeolu *et al.*, 1992; Norval *et al.*, 1992).

2.5 Pesticides use and practices

Pesticides are chemicals prepared with the aim of controlling pests as either fungal, animal or plants. The majority of them reach destinations that were not intended due to their mode of application as runoffs to water bodies or by winds that carry them over (George *et al.*, 2004). The practice of agriculture by man has reduced availability of native crops in favor of modern agricultural practices as greenhouses to cut down on food shortages required by the rapid population growth. This has prompted use of fertilizers and pesticides which have drastic impacts to the ecosystem in spite of the technological advancements in fields of agro chemistry that have reduced the footprint by the degradable species that were enhanced by poor practices (Lamberth *et al*., 2013).

2.6 Pesticides Contamination

Pesticides constitute majority of organic contaminants that are present in our environment basically originating from human activities majorly from the agricultural activities. These

contaminants are poisonous and can move and cause toxicity in the environment. It's due to their physical, chemical and biological nature that they exhibit strong persistence in the environment (Barth *et al*., 2007).

For a number of years, acaricides contamination in cattle dips and eradication has been viewed as essential in chemistry and will constantly grow due to great potential (Shewmon, 1998). Most studies that have been carried out have focused on the pesticides contamination in water, sediment and aquatic weeds (Abong'o *et al.,* 2018) and their effect in humans health and environment in the Nyando River catchment (Abong'o *et al*., *2014*). Pesticide studies have been enhanced through promotion and implementation of various plans that reveal its potentiality through case studies. Consequently a general theory on acaricides contamination must be firmly based. It should therefore not be surprising that monitoring of acaricides contamination effect in cattle dips and homemade cattle sprays will play major part in the eradication of ectoparasites (Nesom, 2007).

2.7 Pesticides Fate in Soil

Soil contains organic matter emanating from both plant and animal detritus at different stages of decomposition, tissues and cells of soil microbes. Higher organic matter helps the soil to retain more water which in turn leads to higher yields in drought periods. A lower organic matter content in the soil increases acaricides movement from point of application (Briceno *et al.,* 2007). This is because organic matter binds and assists in pesticide breakdown. Persistence of pesticides in soils is affected by degradation by microorganisms and sorption by bioaccumulation of pesticides that bind on organic matter. These processes influence transportation from soil, water, air and eventually to human food. Once sorbed, there is lesser access to microorganisms. The longer the pesticides stay in the soil, the more the pesticides residues resist breakdown and extraction as they lose their biological activity. Most of the contaminants in the soil are pesticides that persist for many years and affect the geological

nature of soils by lowering their biodiversity and soil quality.

Besides the process of acaricides contamination which is mostly considered important, practical problem has to do with process of analysis of acaricides in the respective cattle dips and predicting the most elaborate means of eradicating ectoparasites (Shewmon, 1998).

2.8 Effects of acaricides to Wildlife and Cattle

The African savannah region is inhabited by large mammals that are both wild and domestic that support a great population of tick ectoparasites (Keesing *et al*., 2013). Due to large number of ticks and their related pathogens, acaricides are used in treatment of cattle within East Africa. In spite of acaricides effectiveness in reducing tick abundance, their overall effects and composition are not well understood. Much concern is the influence of acaricides on livestock in areas with large mammals which are mainly wildlife as mega herbivores (giraffes and elephants) which revealed that different ticks prefer different host species in a given community (Keesing *et al*., 2013).

The study carried out in central Kenya showed a reduction in ticks in places with acaricide-treated cattle that is accompanied with health benefits for both man and wildlife habitation, though there is need to weigh benefits against potential costs, with special considerations on food chain of members like predators or preys. Furthermore there is observed positive interactions in habitats where both cattle and wildlife coexist and the attention shifts from cattle to wildlife as prey thus enhancing forage quality for domestic animals (Odadi *et al*., 2011).

2.9 Pesticides Contamination in Food Chain and Exposure in Kenya

A study carried out in Kiambu County within the precincts of Nairobi County on pesticides use show concern of harmful pesticides used in food and livestock production (Macharia, 2015). The intensive small scale farming is a major supplier of farm produce like vegetables and flowers to the Nairobi city residents. Most of these farmers tend to misuse the pesticides on the food products hence causing harm to consumers upon ingestion (Macharia, 2015).

Effects of pesticides use is a global public health concern particularly in developing nations where frequent exposure by both farmers is rampant (Garming *et al.,* 2009). Constant exposure leads to acute health complications such as headaches, stomach aches, skin rashes, eye irritations and coma while chronic illnesses are cancer and disruption of endocrine systems (S. Dasgupta *et al.,* 2005). Similarly fatalities are common resulting from direct pesticide exposure (Dasgupta *et al.,* 2005). In kenya , some empirical studies (Asfaw, 2008) have been done though based on snapshot cross sectional surveys and a proper trend of poisoning is not understood since only two studies researched into determinants' of acaricides related illnesses' and symptoms among farmers (Okello, 2005). A research done from seven major vegetable producing districts in Kenya indicate an increase in pesticide related illnesses at above 70 % showing a significant rise with number of acaricides products handled. These considerably are lowered with education level, use of personal protective equipment and record keeping that hinds at policy formulations aiming to reduce acaricides poisoning among vegetable farmers (Macharia, 2015).

2.10 Factors Affecting Pesticides Behaviour

2.10.1 Formulation of Pesticides

The formulation of pesticides is mainly based on a greater array of factors such as pest control needs, way of application, safety and mode of handling and means of storage (Rosell *et al.,* 2008). To minimize exposure to non-target subjects there is need to understand its chemical and physical characteristics. Pesticides contain active ingredients for controlling target pest and inactive ingredients for enhancing application and effectiveness of active ingredients. The formulation helps pesticides be applied either by spraying or dusting to give expected results (Rosell *et al.,* 2008).

Formulation of acaricides at industry gives preference to the mode of application of acaricide. For instance can be delivered as sprays by use of manual or motorized sprayers that provide

mists over the animal body. Other delivery modes are pour-ons or spot-ons that are topical formulations where acaricides are mixed with surfactants to spread spray over animals' hair. Similarly are acaricidal dusts applied as dusts where acaricide is mixed with talc and deposited directly on animals' body. Examples of such are flea powders for pets and dust bags for cattle. For durable efficacy, acaricides are incorporated into plastic matrices that enable slow release of toxicant over long periods. Plastic collars too containing Flumethrin have been used in regions with ricketsial endemic challenges (William, L.2019) At the farm the mostly used method is hand spraying where farmers do the preparation and use themselves the aqueous formulation of acaricides, considering chemical concentration that may be inadequate or quantity of acaricide being low in order to cut down on expenses (Minjauw *et al.*, 2003). At the field the number of ticks eradicated determines efficacy of acaricides. It's achieved by ensuring correct concentration of active ingredient shown as emulsifiable concentrate (EC) in the product, the mixing ratio of acaricide with water as per product label guidelines and appropriate application mode (Keating 1983, Vallero and Letcher, 2012).

2.10.2 Persistence of Pesticides

The stability of a pesticide under different conditions of light, moisture and temperature conditions with a residual time that result to persistence in pesticides (Abd-Rabo *et al.*, 1989). The quantity of active ingredients that can be detected which is lesser than the minimal quantity that can effectively control the parasites. The leftover of pesticides in the soil after control ends up affecting crops in the respective localities and is known as 'carryover'. The repeated application of pesticides has led to pollution of ecosystem components as water, soil and air. These compounds have as well entered the food chain and through bioaccumulation in these matrices have caused acute and chronic illnesses associated with pesticides exposure (Gill et *al.*, 2014).

2.10.3 Degradation of Pesticides

It involves the chemical breakdown where the pesticide is transformed into a benign substance

that is compatible with the environment and place applied. The breakdown of the pesticides in soil overtime is mainly temperature dependent where by the breakdown doubles for every 10 °C temperature increases. Temperature can be observed in two parts thus above soil surface and below soil surface. The temperature above soil surface is highly variable with many fluctuations. Generally it increases with height above the ground level such that for every 10 °C temperature rise the chemical reaction doubles. In reverse, below soil surface temperature is cooler slowing chemical breakdown reaction making it temperature dependant. (Donald, 2006). Similarly other physico-chemical properties affect pesticides differently leading to varying breakdown rates which in turn affect the period of the pesticide for controlling pests, quality of active ingredient upon the pests, non-target motion and ecosystem pollution (Donald, 2006).

2.10.4 Pest Resistance

Pests can evolve hence becoming resistant to pesticides. At first, pesticides will be effective in controlling pests but due to mutations in their genetics, pests will become resistant to pesticides. In some cases this problem is usually managed by pesticide rotation thus by use of different pesticide classes so as to delay resistance (Daly *et al*., 1998).

2.11 Acaricides Registered by Pest Control Products Board of Kenya

The Pest Control Products Board (PCPB) is a governmental body entitled with pesticides registration in Kenya. Some of the pesticides products registered for use in animal health include, those used as acaricides such as Amitraz (PCPB (CR) 1200) an emulsifiable concentrate for control of ticks, recommended mode of application is by hand spraying; Almatix (PCPB (CR) 0380) a veterinary acaricide applied by spray or through dips for pest control on cattle; Cypermethrin (PCPB (CR) 0977) an emulsifiable concentrate, a spray acaricide for cattle tick control and dipping; Bimatraz (PCPB (CR) 0392) an emulsifiable concentrate, a dip and spray acaricide to control cattle ectoparasites and Bovitraz (PCPB (CR) 0396) an emulsifiable concentrate, a spray and dip veterinary acaricide for tick control. It’s paramount to put into consideration that there are other modes of pesticide products application rather than dipping.

These are like alpha Cypermethrin (PCPB (CR) 0990) an acaricide used as a stock spray, Assiatix (PCPB (CR) 1175) whose mode of application is spraying, and Bayticol (PCPB (CR) 0778) whose mode of application is pour on. Registrants and agents of supply also vary from one product to the other depending on the geographical location (PCPB, 2015).

2.12 Gas Chromatograph-Mass Spectrometry

Gas Chromatography – Mass Spectrometry (GC-MS) is the leading technique that has been used for decades to analyses pesticides in environmental samples. The GC-MS has two main components the GC where the chemical mixture is separated and the MS components where identification of the chemical is done. GC-MS is mostly used for analysis of environmental samples because of its accuracy. The main working principle of GC is that a mixture will separate into different elements at higher temperatures (Maštovká and Lehotay, 2004). Volatiles are carried by the carrier gas through the stationary phase. The instrument purity gas is introduced to GC machine at first. The carrier gas comes in through the injection pot just at the liner and moves in to the stationary phase with the sample and finally into the detector. The injector is maintained at high temperatures (150-250 °C), this is to change the liquid sample to gaseous form. The volatile sample is carried to the stationary phase by the carrier gas (Karasek and Clement, 2008).

In the column the sample interacts with the stationary phase and is transported through the column whose particles are static; hence collision between the stationary and mobile phases (Steve *et al.,* 2005). All molecules that are associated to a particular chemical are carried through the stationary phase almost at the same speed and they are seen like a band of particles. The velocity at which the particles move on the stationary phase is determined by factors like; the chemical component of the stationary phase, structure of sample and the oven temperature (Steve *et al.,* 2005). The operating temperatures of the oven and dimension of the stationary phase influence the breadth of the particle group. Retention time is the duration a particle takes from the time of injection until it comes to the detector. The retention time usually is given to specific

particle peak (McCready *et al.*, 2000). Depending on the interaction of the sample with the column it leaves the column and enters the detector. Software is usually used to run the GC. The identification of a sample in the GC-MS is usually by comparing the retention time of known pure reference standard and retention times of the analytes. The pure standard is analysed using the GC-MS and its retention time is compared with the sample. If the retention time of the sample and standard match then the sample has the analyte of the standard (Fetzer, 2000). Equally identification of compounds can be by use of the compounds mass spectrum generated. Figure 2.8 shows the main components of a GC-MS. The equipment can be separated into two key components; first the Gas Chromatograph (GC) where separation occurs and a detector (mass spectrometer or Mass Selective Detector) where identification of the solutes occurs. The other components of the GC include injection port, carrier gas, oven and column. Most of the GC has automated injection.

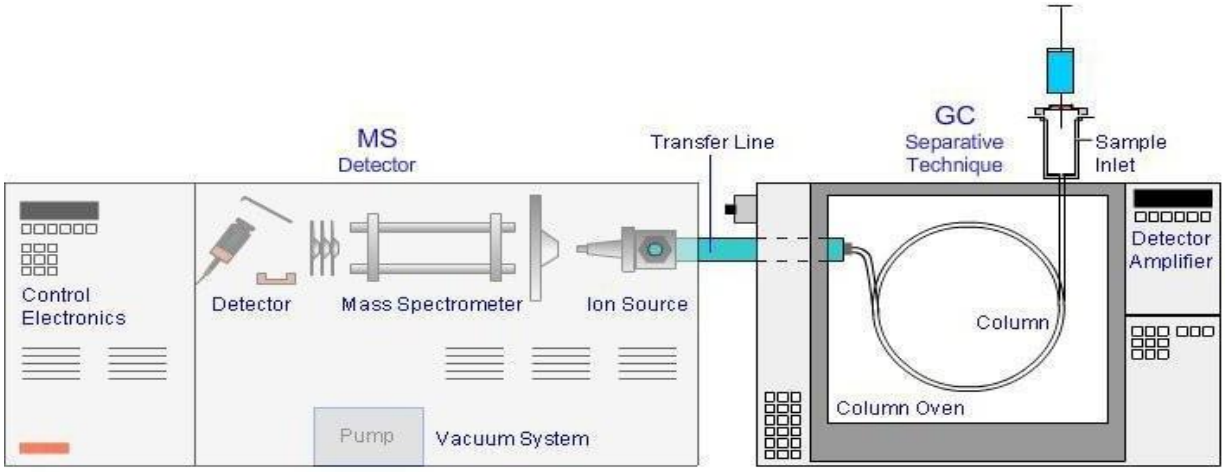

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Figure 2. 8. Components of GC –MS instrument

The carrier gas which sometimes is called mobile phase in GC is a crucial, but limiting, aspect in separation. The mobile phase is the means to transport components of a sample through the stationary phase. Selection of carrier gas is determined by aspects like the kind of solutes to be analysed and the cost (Clescerl *et al.*, 2007). The commonly used carrier gas is helium because it's inertness to most compounds.

When the sample is injected, mostly 1μL of sample is injected into the GC through the injection port with the temperature maintained at 300 °C so that all the samples injected are vaporized. The Common injection mode systems are split, pulsed split, split less and pulsed split less (Clescerl *et al.*, 2007).

The column is surrounded by the oven and the fan. The oven provides heat to the column to transport the molecules through the column while the fan is used to cool the column. The oven temperature is from 313 to 593 K. The stationary phase is mainly a thin pipe with a superior polymer covering on the inside. Analytes are separated according to their volatility and are transported by the carrier gas. Molecules that are very volatile move through the column faster than molecules that are less volatile (Fetzer, 2000).

Mass spectrometry instrument contains three main components. These include detector, ion source and filter. The molecules first pass through the ion source whose main function is to supply electrons to the molecules, and split them into small particles and turn into positively charged ions (h+). This is essential as the atoms must be positively charged to move through the filter (Fetzer, 2000).

The filter is sometimes named as an analyzer. Its chief purpose is to split the ions into their characteristics mass components in respect to their mass-to-charge ratio (Steve *et al.*, 2005). Finally the ions pass through the detector and its main function is to tally the quantity of ions with a particular weight. This data is transferred to the output which usually is a computer and a spectrum is drawn (Steve *et al.*, 2005). The computer components perform various functions like: control the instrument, acquire and manipulate data and compare spectra to spectra. The molecule elutes heating the hot detector, an electronic motion is produced depending on created contact of the analyte and the detector. We have different software used to record the motions produced by the detector and a chromatogram is produced (Karasek and Clement, 2008).

The produced peak areas are proportional to the corresponding compound quantity. The many peaks

produced for a compound in the gas chromatogram have unique mass spectrum that is used to identify it. By employing use of elaborate commercially available libraries of mass spectra, the unknown analytes are identified and further quantified (Steve *et al.*, 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Kajiado County was formed after implementation of the 2010 Constitution of Kenya and has a catchment area of 21,900.9 Km^2, consisting of five sub-counties; Kajiado Central, Isinya, Kajiado North, Loitoktok and Kajiado West (County Governments Act, 2012). It neighbours five other Counties; Kiambu, Machakos, Narok, Taita Taveta and Makueni Counties (County Governments Act, 2012). The county is mainly water stressed and inhabitants walk for long distances in search of the commodity due to the vastness and long dry spell in the county. Kajiado County is administered from the five Sub-counties. Kajiado West Sub-County was chosen for this study (Figure 3.1), due to it exhibiting dry and wet seasons and to compare what it holds in terms of livestock? The county lies between Longitudes 360 5' and 370 5' East and between Latitudes 10 0' and 30 0' South with the sub county having a population of 182,849 people (KNBS, 2019). The study area lies within the Agro ecological zone (AEZ) (GOK, 2002).

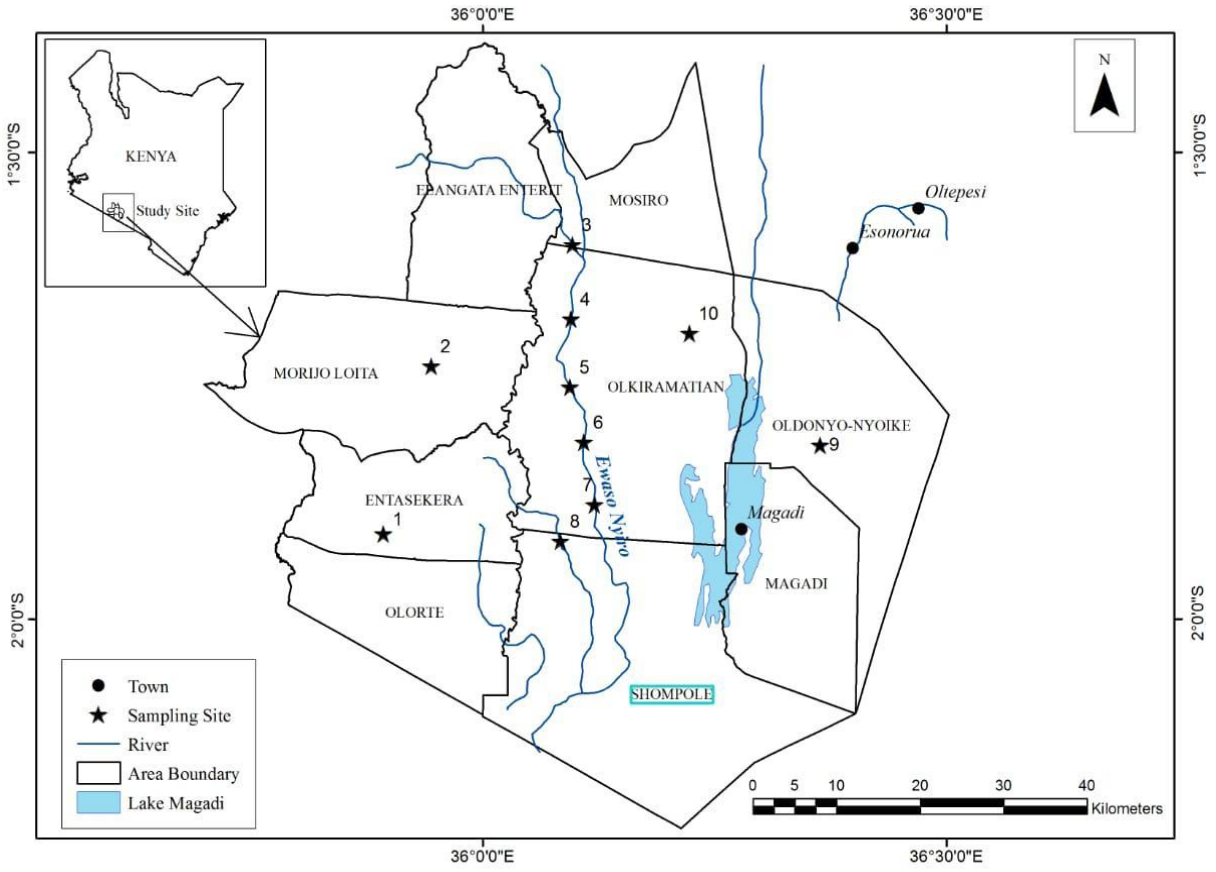

Figure 3. 1. **Map of Kajiado West Sub County Showing the Sampling Sites**

The chosen locations were geo-referenced, described and human events in the location are shown in Table 3.1

Table 3. 1. Description of the Sampling Sites in Kajiado West Sub County

Home Site	Given name	Longitude	Latitude	Altitude (m)	Human activities around the sampling location
1	Empaleki site 1	$35^0$87‟03.6E	$1^0$97.06‟49S	689	Cattle rearing, Subsistence farming
2	Empaleki site 2	$35^0$73‟04.5E	$1^0$84‟50.13S	699	Cattle rearing, Subsistence farming
3	Oldoraja site 1	$35^0$96‟55.4E	$1^0$86‟97.6S	703	Cattle rearing, Subsistence farming
4	Esaginy site 1	$35^0$84‟75.2E	$1^0$83,54.95S	711	Cattle rearing, Subsistence farming
5	Esaginy site 2	$35^0$89‟32.0E	$1^0$73‟65.1S	702	Cattle rearing, Subsistence farming
6	Esaginy site 3	$36^0$09‟97.4E	$1^0$88‟97.47S	706	Cattle rearing, Subsistence farming
7	Oldonyonyokie site 1	$36^0$46‟23.7E	$1^0$82‟02.67S	701	Cattle rearing, Subsistence farming
8	Oldonyonyokie site 2	$36^0$09‟97.4E	$1^0$65‟18.01S	703	Cattle rearing, Subsistence farming
9	Kamkuru site 1	$36^0$22‟91.8E	$1^0$78‟50.51S	698	Cattle rearing.
10	Kamkuru site 2	$36^0$33‟76.9E	$1^0$68‟89.2S	699	Cattle rearing.

The study area covers variety of acaricides used for spraying animals in Kajiado County, and the major local community, the Maasai in Kajiado was chosen for this study. Although other communities have inhabited the area, they are fewer in number leaving the Maasai as the main

livestock farmers. The region was chosen because it has people of all age groups, its accessibility and there are both livestock keeping and subsistence crop farming based on early studies (Mugambi *et al*., 2012). He reported the existence of tickborne diseases in Loitoktok and Kajiado sub counties as agro pastoral and pastoral areas respectively.

3.2 Land use in Kajiado West Sub-County

The sub-county economy and development activities are majorly based on strengths in sectors of livestock rearing, poultry farming, horticulture, food crop farming and other commercial exploits (Gitonga *et al.*, 2016). The inhabitants who are mainly Maasai are nomadic cattle herders and consider cattle a God given gift from their god Enkai, they treat cattle as a sign of prosperity and cattle are often used in dowry payment. The type of rainfall is 'bimodal' that is less than 500 millimeters per annum, insufficient to support agricultural activities that mainly rely on rainfall (GOK, 2002). The system of production in this region of pastoralists that is semi nomadic is taken as arid and semi-arid lands. The rainfall patterns are: long rains between months of March and May followed by short rains in October to December.

Water from the rivers, springs and manmade water points are used by both livestock and humans for consumption (GOK, 2002). The temperatures vary between 10 °C and 34 °C to the East and West with a cool spell from the months of July to August, hotter spell from November to April (GOK, 2002).The population of livestock in Kajiado County inclusive of cattle, goats and sheep is 286,191 cattle and 963,581 sheep and goats (Ogutu *et al*., 2016). Some impediments that have affected livestock production and water reservoirs for the animals include economic activities of sand harvesting, mineral mining, quarry work and charcoal burning.

3.3 Chemicals and Reagents

General Purpose Grade (GPR) hexane, dichloromethane, and acetone were procured from SCIELAB LTD, Kenya. General purpose grade solvents were triple distilled before use to

remove impurities. HPLC grade iso-octane, hexane and acetone were bought from Sigma Aldrich from their local supplier, Kobian Scientific Ltd. Analytical grade alluminium oxide, activated anhydrous Na_2SO_4, NaCl, K_2HPO_4, HCl, NaOH, and copper powder were bought from SCIELAB LTD, Kenya. Analytical grade pesticide standards (Amitraz, Cypermethrin and Deltamethrin) were purchased from Dr. Ehrenstorfer GmbH Company (Germany) from their local supplier Kobian Scientific Ltd in Nairobi. White sport nitrogen was bought from Gas labs LTD, Nairobi for the purpose of concentrating samples. 99.999% pure helium gas used for gas chromatography mass spectroscopy was obtained from BOC Kenya LTD. Distilled Water was obtained at the physical chemistry laboratory, University of Nairobi.

3.4 Equipment and Apparatus

Fractional distiller was used to distil all general purpose grade solvents. Soxhlet set up comprising of extractor, heating mantles, condensers, round bottomed flasks and fume chamber was used for extraction of soil samples. Homemade acaricide spray and water samples were extracted using solvent- solvent extraction method using 2.0 L separatory funnel. Sample extracts were concentrated using rotary evaporator. The concentrated samples were passed through Al_2O_3 chromatographic glass column with 1.5 centimeters internal diameter and 25 centimeter length were used for the sample clean up.

Total dissolved solids (TDS) and electrical conductivity was measured using Scientific Martin instruments maltiparameter meter model number MI 306. PH was measured using PH meter model IQ 150. Shimadzu analytical weighing balance model number ATX224 was used to weigh the samples and was calibrated using 1.0 g mass. Moisture content in soil was determined by gravimetric method using BINDER E28#04-71528 oven, whereas drying of glassware was carried out in Mammoth laboratory oven. A lab-line refrigerator was used for keeping the samples. HP Agilent GC system 6890N equipped with Agilent Mass selective detector was used for quality and quantifying of pesticides residues in the sample extracts. Other glassware used in the study included: measuring cylinders (1000 m to 100 mL), desiccators, Pasteur pipettes

and micro syringes (10, 25, 50, and 100 µL).

3.5 Socio - economic surveys of acaricides use in Kajiado West Sub-County

A survey was carried out in study area using field structured questionnaires (appendix 1) which helped in getting information about socio-demographic characterization of cattle farmers, acaricides used in Kajiado West Sub-County, Pest and diseases that affect cattle, their identification and control plus training of cattle farmers on the use of acaricides This was obtained by using the guided questionnaires arbitrarily to a total of 38 respondents randomly taken from initial 138 participating in focus group discussions. General information of the interviewees was also obtained which included gender, age, education level, occupation and challenges faced.

3.6 Study Design and Sampling Plan

The study was carried out in parts by survey using focus group discussions, administration of interview using guided questionnaires to the farmers (Appendix 1), to collect data on the types of acaricides used, types of pests and diseases controlled, Physicochemical parameters determination, analysis of concentration of acaricides in homemade cattle sprays, soil and in water samples from the southern tributary of Ewaso Nyiro River and finally the study of dissipation rates and half-life calculations of acaricides in soil from the sampled sites were done.

Collection of samples was carried out in the months of May (wet season) and November (dry season) in 2018, respectively; this was done after allowing the farmers to prepare the homemade acaricide sprays that they use in spraying their animals in ten selected farms. Soil samples for pesticide residue levels analysis and the degradation study were collected from the ten sites where the animals were sprayed. The spraying was conducted within the livestock sheds before releasing them into the grazing fields. While water samples were collected from southern tributary of the Ewaso Nyiro River from the sites adjacent to cattle spraying sites (Figure 3.1). Some of the homes were found to have common watering points for their livestock. The

homemade cattle sprays, soil and water samples were transported to the University of Nairobi pesticide analytical laboratory for analysis. River sampling was done one day after home spraying of the acaricides on the cattle. It was noted that there had been spatial rainfall within the two week period before the sampling period followed by sunny weather. The sampling points had varying distances from the major watering points ranging from five hundred (500) meters to one (1) kilometer. The homesteads were separate from each other as depicted by the global positioning coordinates indicated in Table 3.1 above. The water source was found to be covered by large trees that served as habitation to large herbivores as elephants and canines as lions, hyenas and leopards that are nocturnal.

3.7 Sample Collection

3.7.1 Homemade Cattle Spray Sampling

Ten farmers who were willing that their farms could be used in the study were randomly selected and all were requested to spray their animals on the same day. They were allowed to prepare cattle homemade sprays themselves following their normal procedures. Quadruplets of ready homemade cattle spray were sampled from each of the ten sampling farm sites into Labelled 1.0 L yellowish-brown glass amber bottle before the farmers were allowed to spray the animals. For recovery experiment, one of the quadruplet's samples was injected with 10mL of 100 mg/L of the acaricide standard, to be included in the sampling. 1.0 L glass amber bottles used were previously washed, rinsed using distilled deionized water and dichloromethane then dried in a Mermmert oven overnight. Each homemade spray sample was labelled and 100 grams activated sodium chloride further added to dehydrate bacteria which might degrade the acaricides. The samples were then packed in polythene cool-box prior to transportation to the University of Nairobi pesticide analytical laboratory for analysis. The homemade spray samples were kept in the freezer at - 4 ^{0} C awaiting, extractions, clean-up and analysis within two days.

3.7.2 River Water Sampling

Water from southern tributary of Ewaso Nyiro River was collected in quadruplets from six selected sampling sites adjacent to farms where cattle were sprayed. This was in a range of 500 meters to 1000 meters from the spray points. Sampling was done using cleaned 2.5 L yellowish-brown bottle by grab method. The 2.5 L sampling bottles were cleaned and dried as those for homemade spray (amber sampling bottles). For recovery experiment, a sample was injected with 10 mL of 100,000 µg/L of the acaricides standard. NaCl (100 g) was added to all the samples for conservancy. The samples were labelled and briefly packed in a polyurethane cooler boxes with dry ice and transported to laboratory as was done for homemade cattle spray. In the laboratory, the water samples were kept at - 4 ^{o}C in a freezer awaiting extraction, clean-up and analysis within a day.

3.7.3 Soil Sampling

Soil samples (0-30) cm plough layers were sampled from the selected ten farm sites, where the cattle had been sprayed. A soil core sample was dug with a hoe and taken at 25 cm depth using clean stainless steel shovel from five different points within the place where the cattle had been sprayed and approximately 200 g of each core scooped. The cores were carefully mixed in aluminum foil to make a compound sample. Quadruplet composite

Samples of 200 g from each site were collected in May and November, 2018 and on days 0, 1, 2, 3, 4, 5, 7 and 10 days after the spraying of animals. Day zero sampling was done two hours after spray and labeled as Batch A. Each triplicate soil sample was wrapped in an aluminum foil, labeled and packed in plastic container with lid and kept briefly in polythene cool-box prior to moving to the University of Nairobi pesticide analytical laboratory for analysis.

The other one of the quadruple samples labeled Batch B was collected and preserved for field recoveries samples. The samples were positioned in aluminum foil and injected with 4000 µL of 100 ppm of acaricide standard mixture from Dr. Ehrenstorfer GmbH Company (Germany). Lot B samples were wrapped the same as Lot a samples. At the workroom, portion of soil samples that was not injected with the standard were scooped for physico-chemical analysis the

remaining was kept at -16 ℃ in a freezer awaiting analysis, this was finished within two days. Similarly soil samples from separate (500 meters) from sampling points assumed non-contaminated were collected to check for recovery analysis. This were used as blanks.

3.8 Physico-chemical parameters determination

The physicochemical parameters analysed were total dissolved solids and conductivity of the cattle home spray and river water samples. Since the stability of a lot of acaricides is reliant on these parameters (BCPC, 1987). Soil organic carbon was also determined since it's a major parameter determining pesticides mobility in the soil. The more the organic matter in soil, the more the pesticides are held by soil and become immobile. Chemical parameters determined are pH of cattle homemade sprays and river water samples, measured using a pH meter after calibration using buffer solution 4 and 10 before taking the readings. 50 mL of homemade sprays and river water samples were taken in 75 mL beaker for pH measurements

3.8.1 Conductivity of homemade cattle sprays and water samples determination

The conductivity of cattle homemade sprays and river water samples was analysed by Scientific Martin instruments meter model MI 306. The meter was calibrated using conductivity solution before taking the measurement. 75 mL of homemade sprays and river water samples were taken in 100 mL beaker for conductivity measurements

3.8.2 Total dissolved solids of homemade cattle spray and water samples determination

The total dissolved solids of cattle homemade sprays and river water sample was analysed by Scientific Martin instruments model MI 306.-100 mL of homemade spray and river water. Samples were taken in 100 mL beaker for TDS measurements.

3.9 Sample Extraction

3.9.1 Homemade Cattle Sprays Extraction

Extraction of Homemade spray samples was achieved by solvent-solvent extraction following

EPA method 3510 C (USEPA 1996) a. Using a volumetric flask 500 mL of home cattle spray samples were moved into 1000 mL beaker then pH was noted and 0.05 L of 0.2 M K_2HPO_4 buffer was introduced and pH noted, and then attuned by addition of drops of 0.1 N HCl or 0.1 M NaOH to pH of 10 because amitraz is stable in a basic media. Each of the solutions was then moved to 2 L separatory funnel and 100 g of activated NaCl added to help in salting out pesticide from aqueous layer to carbon-based layer. The combination was extracted 3 times by trembling with 30 mL dichloromethane and permitted to relax for fifteen minutes to improve separation into two layers. The extraction of the samples was performed in quadruplicate including the field recovery sample. The organic layers extracts separated were transferred into 250 mL beaker dried using Na_2SO_4 then 2000 µL of isooctane introduced. The extracts were transferred into 250 mL round bottom bottle flask and reduced to around 2000 µL using rotatory evaporator. Reduced extracts were put into 10 mL glass vials with screw caps and stored in a freezer at - 4 °C awaiting clean- up.

3.9.2 River Water Extraction

Extraction of river water samples was achieved using liquid-liquid extraction process following EPA method 3510 C (USEPA 1996) a. Using a volumetric flask 500 mL of river water samples were moved into 1 L beaker then pH was noted and 0.05 L of 0.2 M K_2HPO_4 buffer was introduced into the blend stirred and pH noted, at that time attuned by addition of drops of 0.1 N HCl or 0.1 M NaOH to attain pH of 10 since most acaricides are stable in basic media. Each of the solutions was then moved to 2 L separatory funnel and 100 g of activated NaCl added to help in salting out pesticide from aqueous layer to carbon-based deposit. The combination was extracted 3 times by trembling with 30 mL dichloromethane and permitted to relax for 900 seconds to improve parting into two phases. Extraction of the samples was performed in quadruplicate including the field recovery sample. The organic layers extracts separated were transferred into 250 mL beaker dehydrated using Na_2SO_4 then 2 mL of isooctane introduced. Extracts were transferred into 250 mL round bottom bottle flask and reduced to 2 mL using

rotatory evaporator. The reduced extracts were put into 10 mL glass vials with screw caps and stored in a freezer at - 4 °C awaiting clean- up.

3.9.3 Soil Samples Extraction

The soil samples from the freezer were left to defrost for 12 hours in a desiccator. Soxhlet extraction of soil was done following EPA method 3540 (USEPA 1996) b. Triplicate 20 g of every sample was carefully mixed with 60 g of anhydrous Na_2SO_4. The dried samples were moved into Soxhlet cap, 50 mL of 0.1 ppm isodrin was introduced as internal standard before extraction. 200 mL of acetone: hexane combination in proportion of 1:3 was transferred into 0.25 L round bottomed flask and the Soxhlet apparatus set up, the extraction was done for 16 hours. The extracts were reduced using LABCONCO rotary evaporator to around 2 mL and transferred into 10 mL glass vials with screw caps and kept in a freezer at - 4 °C awaiting clean-up and Sulphur removal.

3.10 Homemade Cattle Sprays, River Water and Soil Samples Extracts Clean-Up

The concentrated 3 mL of homemade cattle sprays, river water and soil samples were cleaned by transitory through alumina chromatographic column 25 cm long x 1.5 cm internal diameter (ID) packed in sequence with 1 g of activated Na_2SO_4, 15 g of deactivated Al_2O_3 and 1 g of activated anhydrous $NaSO_4$. The contents were preconditioned with 0.015 L of hexane. Extracts were each eluted with 165 mL hexane into a pre-cleaned 250 mL round bottle flask. 2 mL of isooctane as keeper was introduced into the extracts and then the extracts reduced to around 1 mL using the rotary evaporator. The concentrates of home cattle spray and river water were then each moved into uncontaminated pre-weighed auto sampler vial and reduced more to 0.5 mL in a mild flow of nitrogen gas for GC-MS analysis. Soil sample extracts were put into 10 mL glass vials with screw caps and stored in a freezer at - 4 °C awaiting Sulphur removal.

3.11 Soil Sulphur Removal

Sulphur presence in solvent extracts meant for chromatographic analysis impairs and affects

proper interpretation of the chromatograms. These is because Sulphur peaks masks other compounds peaks that are present in the sample matrix. It further inconveniences the mass detector operations thereby leading to discrepancies in results causing erroneous interpretations and false assessments for environmental analysis. It's recommended that Sulphur should be removed and determined in a separate analytical procedure (Muir *et al*., 2006)

To eliminate Sulphur after extraction of soil samples, 1 g of stimulated copper powder was added. This was done so as to ensure that all extracts were free of Sulphur as may render the determination of some pesticides using gas chromatography impossible. Following the treatment, a black coloring was formed in all extracts that contained Sulphur indicating creation of copper (II) sulphide compound. Combinations were sieved by a crystal conduit crammed by glass wool and 2 g of Na_2SO_4. To condition glass funnel containing 2 g sodium sulphate, 5 mL of hexane was used and discarded and sample was introduced into the glass funnel where it was removed with 20 mL of hexane into 250 mL flask and 2 mL of iso- octane (keeper). The sample extracts were reduced to around 1 mL in a rotary evaporator and moved to a clean pre-weighed auto sample vials using Pasteur pipettes where it was further concentrated to 0.5 mL under a mild flow of white spot nitrogen and stored in fridge awaiting GC-MS analysis (UNEP, 2010).

3.12 Soil Characterization

This was done to get the base line information of the soil in question. Physical chemical analysis such as moisture retention was done while chemical parameters including total organic carbon was done at Kenya Agriculture Research and Livestock Research Organization (KARLO) in Nairobi using the method described by Avery and co-worker (Avery and Bascomb, 1982).

The amount of moisture in soils was analysed by drying 5 g of the samples in a watch glass that had been previously cleaned, dried and weighed in the binder kiln at 105 °C for 24 hours. The moisture content was determined by getting the variance in mass between dehydrated and hydrated sample.

The percentage of moisture in the samples were calculated using Equation below;

% moisture = $\frac{\text{(weight of wet sample – weight of dry sample)} \times 100}{\text{(Weight of wet sample).}}$ ……. Equation 1

Analysis of the amount of moisture in the soil samples was needed due to circumstances that amitraz dissipates quickly under moist situations.

3.13 Determination of Dissipation Rate in Soil Samples

The batch B of the soil samples was first taken to Kenya Agricultural and Livestock Research Organization (KALRO) for characterization. The collection of soil samples for the study on degradation of acaricides in the soil samples was carried out from day 0, 2, 4, 7 and 10. In day zero the soil samples was collected two hours after the spraying of the animals and this sample was analysed for pesticide residue levels of acaricides and degradation. The sample extraction method was as explained in soil extraction section.

3.14 Quality Control and Assurance

This was achieved by injecting the samples with internal standard (isodrin) before extraction. This was important in checking recovery and efficiency of the method. The samples were done in triplicates. Blank samples including anhydrous sodium sulphate and distilled water were taken for recovery purposes. The blanks were carried to and from the field during sampling to trace back any form of contamination if any. They were treated just like the samples.

3.15 Method Validation

3.15.1 Percent Recovery Analysis

Numerous steps were taken in analysis of percent recovery:

The preparation of 1,000 ppm standard stock solution of acaricides (amitraz, cypermethrin and deltamethrin) was done

1000 ppm = 1000 mg/L = 1 g/1000 cm^3 ..... Equation 2

This implies that 500 mg is contained in 0.5 L or 10 mg in 0.01 L. As such, 10 mg of amitraz, cypermethrin and deltamethrin standard were weighed using analytical weighing scale and dissolved in 2 mL acetone in a 10 mL volumetric flask and the flask filled to the mark using analytical grade iso- octane.

The working standard solutions of the acaricides was prepared from the standard stock solution using the formula: $C_1V_1 = C_2V_2$, Where C_1 is the initial concentration and V_1 is the initial volume. C_2 is final concentration and V_2 is the final volume respectively

Hence,

$1000\ mg/L \times V_2 = 100\ mg/L \times 10\ cm^3$ ..... Equation 3

$V_2 = 1\ cm^3$

Hence, 1 mL of standard stock solution was transferred to a 10 mL volumetric flask using a 1 mL micro-pipette and the volume made to the mark using analytical grade acetone.

3.15.2 Determination of Percent recovery of acaricides

Using volumetric flask, 500 mL of distilled water was measured then transferred to separatory funnel then it was injected with 0.5 mL of the 100 mg/L working standard of cypermethrin, deltamethrin and amitraz. The mixture was extracted thrice with 30 mL analytical grade dichloromethane and the extracts were mixed in a 250 mL round bottom flask. The extracts were reduced in a rotary evaporator to 2 mL and moved into vials and further concentrated to 0.5 mL then injected into GC-MS for analysis.

The recovery percent was obtained using Equation 4.

$$\% \text{ recovery} = \frac{(\text{Spiked sample} - \text{plain sample})\ mg/L \times 100}{\text{Amount spiked } (mg/L)} \quad \text{.....Equation 4}$$

3.15.3 Determination of Limit of Detection (LOD)

The limit of detection is the lowest amount of a substance that can be analysed and stated with 99 % sureness (Saadati, 2013). A standard solution of 100 ppm was made from 1,000 ppm stock solution of amitraz, cypermethrin. From 100 ppm reference standard range of 0.01-120 ppm were prepared for deltamethrin as outlined above, while those of 1, 2, 3, 4, 7, 16, 26, 40, 80 ppm were prepared using Equation 2 and the resulting were analysed using GC-MS.

3.15.4 Calibration Curves

Determination of the concentration of Amitraz, Cypermethrin and deltamethrin in the samples was done based on calibration curve of Amitraz, Cypermethrin and deltamethrin standards of concentrations (mg/L) 1.05, 2.56, 3.53, 4.15, 7.02, 16.79, 26.46, 40.14, 80.50 and 100.30 for deltamethrin, 1.123, 2.635, 5.316, 10.39, 25.37, 40.07, 60.06, 80.64 and 100.59 for amitraz and 1.22, 3.98, 5.31, 10.69, 25.21, 51.36, 60.37, 80.07 and 100.06 for cypermethrin were used to obtain calibration curves.

3.16 GC-MS Analysis of Homemade Sprays, Water, Soil Samples and Quantification

Analysis of acaricide from home cattle spray, river water and soil samples were carried out using the gas chromatography–mass spectrometry (GC–MS) on a 6890N GC instrument (Agilent, USA) equipped with a thermo scientific trace GOLD GC column (TG 5SILMS 30m X 0.25mm internal diameter X 0.25 µm coupled to an Agilent 5973 MS (USA). The mass spectrometer (MS) was operated in EI + mode in the resolution of >5000 in full scan mode. Injection was split less with volume of 1µL and temperature of 250 ºC, with helium (99.999% pure) as carrier gas at 1 mL $min^{-1.}$ Oven temperature was maintained initially at 90 ºC for 1min, increased at 35 ºC $min^{-1.}$ to 185 ºC, then at 5 ºC $min^{-1.}$ to 190 ºC hold time was 5 minutes, at 10 ºC $min^{-1.}$ to 220 ºC withhold time of 5minutes, 25 ºC $min^{-1.}$ to 250 ºC hold time is 5 minutes.

In quantification, reference standard of the acaricide obtained from Dr. Ehrenstorfer GmbH Company (Germany) were used in various steps in the analysis. Working reference standard

solutions curves for amitraz, cypermethrin and deltamethrin are shown in Figures 3a, 3b and 3c, appendix 3 in the range of 0.01-120 ppm, these were prepared individually. 1.0 µL of each reference standard solution was injected into GC–MS. The solution of the reference standard mixture was also injected to obtain the retention time.

3.17 Amitraz, Cypermethrin, Deltamethrin Calibration Curves

The calibration curves for standards of three different acaricides used in Kajiado West Sub-County under nine (9) different manufacture names shown in (appendix 3) were obtained by injecting known quantities of different acaricide standard solutions into GC-MS. The concentration of each sample was obtained by calculating the peak areas obtained and plotting the curves which had straight lines through the equation y= mx + c. where Y is the peak area or instrument response, X is the analyte concentration, M is gradient and C is a constant. Reference standards of the acaricides were used in various steps in the analysis. The calibration curves for the acaricides standards are shown in appendix 3, Figures 3a, 3b and 3c respectively.

The concentrations of acaricides residue levels in the samples were determined using a standard method involving use of reference standard calibration curve within laboratory reproducibility acceptability. The levels was gotten by interpolation from the graph which applies the straight line from Equation (5)

$y= mx + c,$ Equation 5

Where:

y= Peak area (Instrument response),

x = Analyte concentration,

m= Gradient and

c = Constant.

The dissipation of acaricide in soil was determined based on a first order kinetic model (FOCUS, 2006).

$k = -\ln(C/C_O)/t$ ……. Equation 6 (Focus, 2006).

Where,

k = Dissipation rate (day^{-1}),

C = Mean acaricides concentration at day t (mg/Kg)

C_O = Mean acaricides concentration at day 0 (mg/Kg)

The persistence of acaricides was estimated by the half-life time ($t_{1/2}$) according to equation:

$\ln (C_O/2C_O) = - kt_{1/2}$ ---------- Equation 7

$- kt_{1/2} = \ln 0.5$ or $t_{1/2} = - 0.693/k$ ---------- Equation 8

The dissipation rate, k was estimated by linear regression analysis (Tay *et al*., 2010))

3.18 Data Analysis

Data analysis of the questionnaire responses obtained was accomplished using Microsoft excel and Statistical Package for Social Scientists (SPSS version 20). The data was then presented in form of tables and graphs. On the other hand, data obtained on dissipation studies of the soil as well as on home spray and environmental residue levels of acaricides was analysed using Microsoft Excel software version 2010. The data was then presented as mean of triplicate analysis with standard deviation and represented in form of linear graphs and tables. Analysis of variance (ANOVA) was done at 95% Confidence Interval to compare the means of pesticide residue levels in homemade cattle spray, water and soil. Calculation of half-life of acaricides was done based on half-life time equation, $t_{1/2} = 0.693/k$ (FOCUS, 2006), where k is the dissipation rate constant. The standard calibration curve used was obtained within laboratory reproducibility acceptability.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Survey on the Farmers Using Acaricides on Cattle in Kajiado West Sub-County

The survey revealed that 100 % of the farmers participating were livestock keepers and control ectoparasites using acaricides by use of hand sprays through use of manual knapsack sprayers. The finding concurs with earlier study by Mugambi who confirmed use of both hand spray and chemotherapy to control ticks (Mugambi *et al.*, 2012). All the acaricides used by the farmers in the sub county were found to be registered by the Pest control products board of Kenya (PCPB, 2018). The sampling sites labelled numbers 1 and 2 (figure) are near Ngurumani where subsistence farming in addition to cattle keeping has great potential while sites 9 and 10 are areas of Kamkuru where only cattle rearing is experienced with water scarcity taking prevalence. In regions beyond Lake Magadi there is an additional pest, the tsetse fly, other than the tick. Focus group discussions revealed challenges of poor infrastructural establishment especially poor road networks and transport impediments to the nearby commercial centres where they purchase the acaricides with most of them purchased during market days.

During the interviews, it was noted that the number of livestock played a minimal concern when mixing or spraying the livestock a factor that could compromise disease vector control since each animal could not be sufficiently sprayed. Farmers beyond Magadi Township were found to coexist with wildlife inhabiting the Ewaso Nyiro river banks. These coexistence of livestock and wildlife could increase human-wildlife conflicts, otherwise there is need for collaboration to minimize risks (Valerie, 2012) by lowering negative attitudes pastoralists possess towards wildlife.

4.1.1 Academic Qualification and Training of Farmers Who Use Pesticides

The results in Figure 4.1 and from the questionnaire (Table 2a, appendix 2,) indicate 47 % of the cattle farmers had primary level of schooling, 32 % had not gone to school, and 18 % had secondary level while only 3 %

had tertiary education (Figure 4.1). Among the female respondents only one had attended school up to standard four while the rest had informal education.

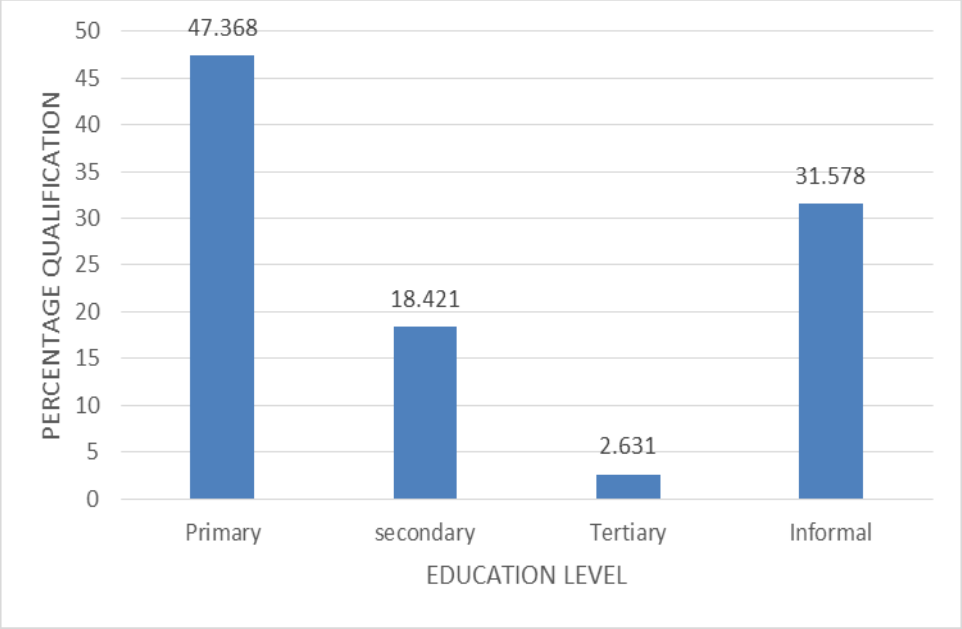

Figure 4. 1. Academic qualifications of farmers interviewed in Kajiado West Sub-County

In addition, 68 % of the farmers had advanced training and 32 % had received basic training on pesticides management and safe use (Table 4.1) indicates there is a need to urgently train the farmers. The results show that all the farmers interviewed had received either basic or advanced training. The responses on teachings on pesticide administration and care between farmers in the sub-county are as presented in Table 4.1**.**

Table 4. 1. Training of farmers on pesticides management and safe use

Farmers	Number	Percentage (%)
Basic Training	12	32
Advanced Training	26	68
Untrained	0	0
Total	38	100

4.1.2 Acaricides Used in Kajiado West Sub-County

The results from the survey indicated that farmers use nine different types of acaricides to spray their cattle at home. Most of these acaricides have different manufacturers' names but contain the same active ingredients (Table 4.2).

Table 4. 2. Acaricides Sprays used, application rates and WHO Toxicity Classifications

Acaricide	Active Ingredient	Quantities applied per 20 L	%Household use	WHO Toxicity Classification
Triatix	Amitraz	12.50%	36.7	III
Dominator	alpha-cypermethrin	100 EC:100 g/L alpha-cypermethrin	11.7	II
Sypertix	alpha-cypermethrin	100 EC: alpha-cypermethrin	11.7	II
Tixfix	Amitraz	12.50%	50	III
Norotraz	Amitraz	12.50%	50	III
Decis	Deltamethrin	25 g/L	8	III
Delete	Deltamethrin	50 g/L	46	III
Bye bye	Amitraz	12.50%	72	III
Ectopor	Cypermethrin	20 g/L	76	II

Source (PCPB, 2015; WHO, 2002)

The column four values are farmers' preference percentages for each of the acaricides indicated given that the acaricides are marketed under different trade names with varying active ingredients. The mixing instructions are indicated on the labels though the mixers have a standard volume of 15 mls per 20 mls water contrary to the instructions by manufacturer.

Ectopor (Cypermethrin) was the most commonly used by 76 % of the farmers, this was followed by Bye-Bye (Amitraz) at 72 % and Delete (Deltamethrin) at 46 % (Table 4.2). All the acaricides the farmers use in the sub-county are registered in Kenya by the Pest Control Products Board (PCPB, 2018). Questionnaire answers are shown in Appendix 2, Table 2a. In general, from the nine pesticides that are in use in the sub-county, 33.33 % are toxic, WHO II while 66.67 % are less toxic WHO III pesticides (Table 4.2).

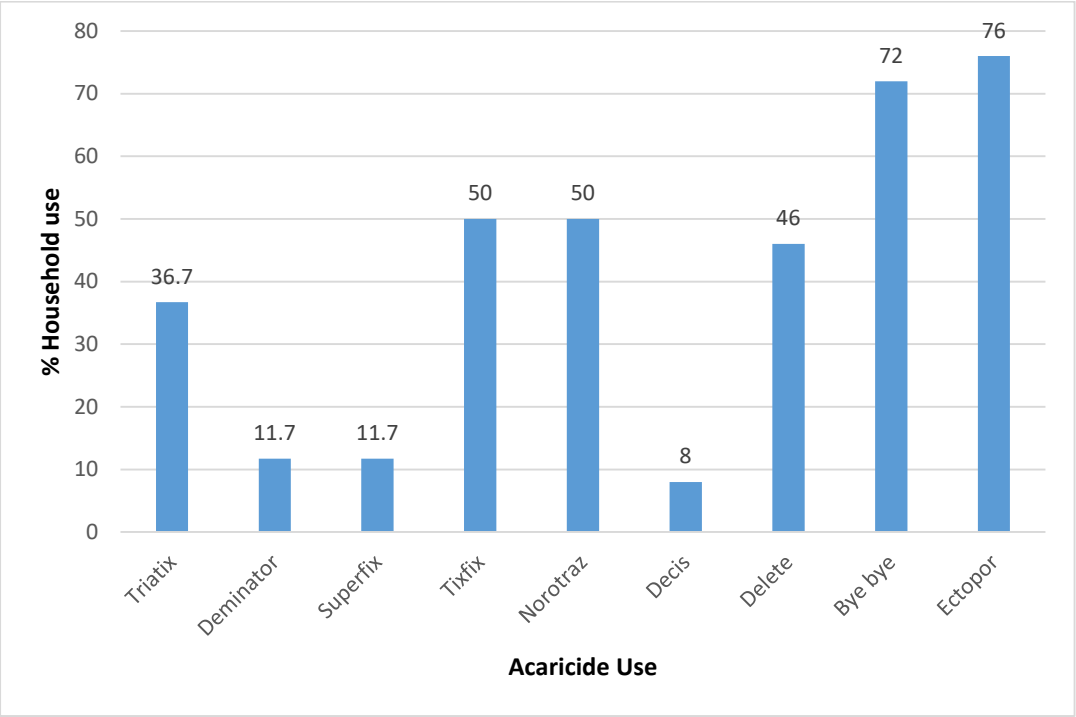

Figure 4. 2. Types of Acaricides and percentage Home Use in Kajiado West Sub-County

4.1.3 Diseases and pests which affect cattle

The farmers gave the diseases and pests that affect their cattle from the questionnaire (Table 2a, Appendix 2). The cattle lumpy skin disease, tick fever, anthrax, bovine anaplasmosis, East Coast fever, foot and mouth disease and black quarter these diseases are caused by ticks and other pests. Table 4.3 shows the diseases and their respective local names.

Table 4. 3. The local and scientific names of diseases affecting cattle

Local disease name	Disease Name	Scientific name	% Disease affects cattle
Entorobo	Trypanosomiasis	Trypanosoma Congolense	42
Lipis	East coast fever	theileriosis	48
Oloirobi	Foot and Mouth	Aphthae epizooticae (Gingiva)	61
Ollomoroos	Goat Pox	Variola caprina	38
Entemelua	Anthrax	Bacillus anthracis	52
Olmilo	Heart water	Ehrlichia ruminanium	12
Enpuruu	Black quarter		16
Olkipey	Contasiu bouvine pleuro pneumonia	Contagious bovine pleuropneumonia (CBPP)	24
Ngerebo	Lumpy Skin disease (LSD) cattle	Capri poxvirus	33
Echuka	Heiminthosis	Helminthiasis	12
Onkikana	Anaplasmosis	Bovine anaplasmosis	14
Oloodua	Rinderpest	Rinderpest (Cattle plague)	32

4.1.4 Occurrence and frequency of pests and diseases in cattle

Most of the farmers (58 %) indicated that there was reoccurrence of Tsetse flies, ticks and tick bone diseases. Thirty-one percent of cattle farmers indicated that their livestock sometimes encountered flies, ticks and tick bone diseases with a few (11 %) farmers indicating that their livestock rarely encountered flies (Figure 4.3).

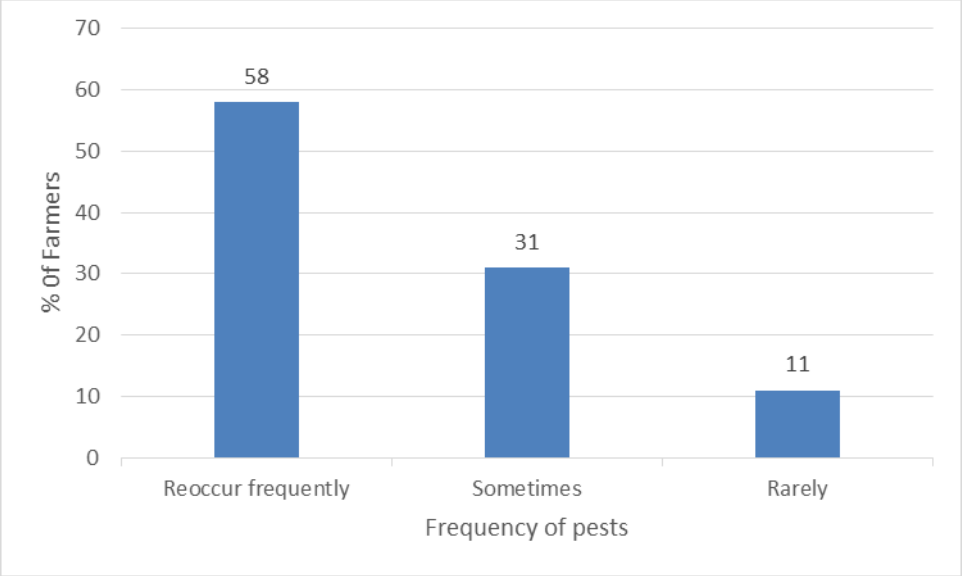

Figure 4. 3. Frequency of flies, ticks and tick borne diseases in Kajiado West Sub-County

4.1.5 Methods Use and Frequency for Controlling Ticks, Flies and Tick-Borne Diseases

In controlling the disease and pests, cattle farmers chose their preferred method of application of pesticides to control ticks, flies and tick- bone diseases on their animals. 82 % of farmers preferred spraying their cattle at home, 14 % of the farmers indicated manual removal of ticks and other pests as their preferred method while 2% used both manual removal and spraying while 5% did not have any preferred method (Figure 4.4).

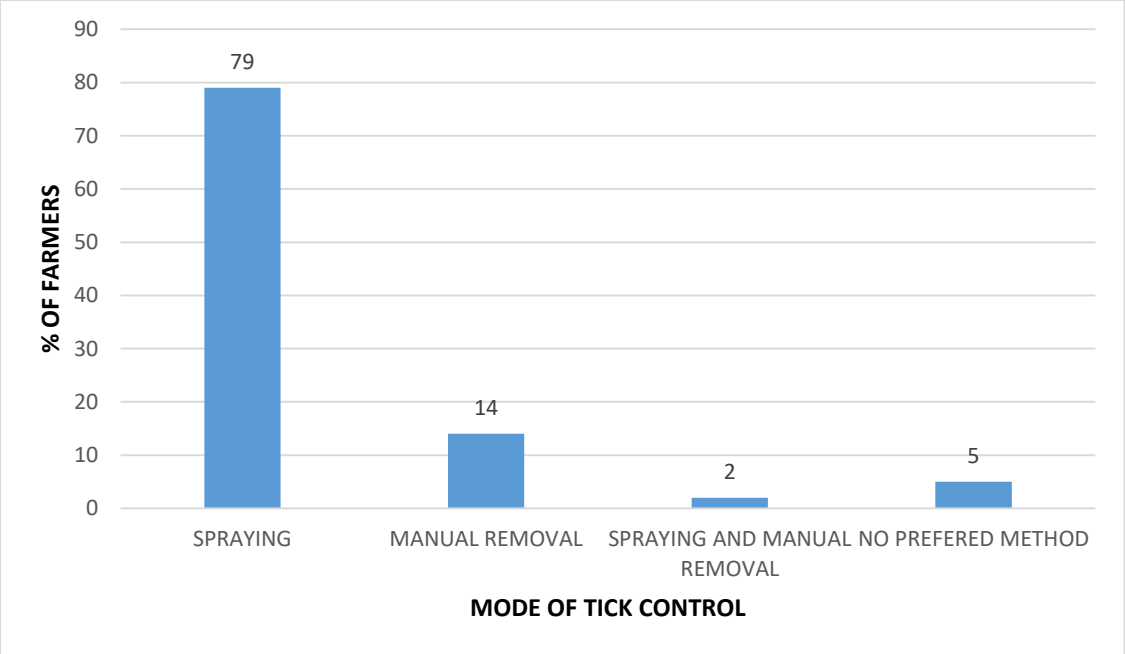

Figure 4. 4. Methods for pests and diseases control in cattle

The farmers gave different durations when they use acaricides on their cattle. Most farmers (48 %) preferred spraying their animals once a week, 23 % twice a week while 29 % after two weeks as shown in Figure 4.5.

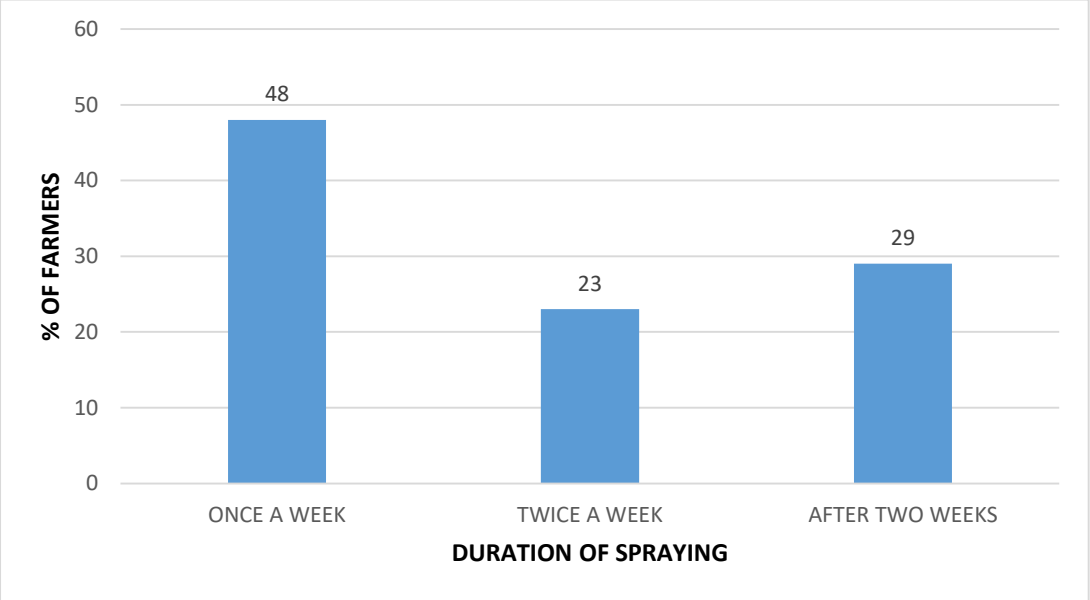

Figure 4. 5. Farmers' cattle spraying frequency in Kajiado West Sub-County

4.1.6 The disposal of unused acaricides and containers after use

43.3 % of the farmers discarded the bottle by burning, 21.7 % released the bottles to open pits while 11.7 % dug them under the ground as a mode of disposal. 23.3 % of the farmers used the bottles for other uses or retain them in warehouse for upcoming usage (Figure 4.6). The observed methods of discarding have great potential to cause environmental pollution. Pesticides in the environment have been connected to numerous adverse health effects like disruption of hormones and impairment of nervous system in man (IAEA, 1997).

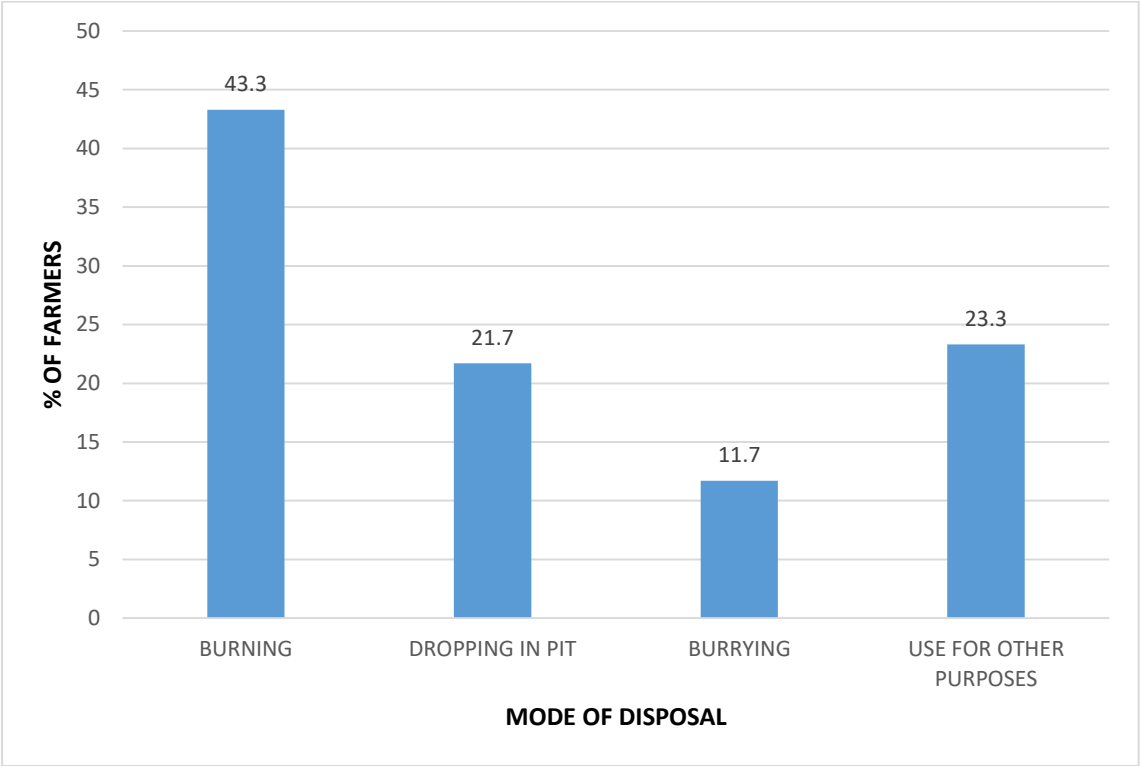

Figure 4. 6. Disposal practices of unused acaricides and containers after use

4.2 Physico-chemical parameters levels

4.2.1 Physico-chemical parameters of cattle homemade sprays and river water samples

The stability of acaricide is reliant on usual physico-chemical conditions. The degree of degradation of acaricides is reliant on a number of physico-chemical conditions (IAEA, 1997).

Table 4. 4. Physico-chemical parameters of homemade sprays and river water samples

Site	pH		Conductivity (µs/Cm)		Total Dissolved Solids	
	Homemade Spray	River Water	Homemade Spray	River Water	Homemade Spray	River Water
1	8.36±0.14	8.1±0.23	922±71.41	631±22.10	455±56.23	322±41.66
2	6.96±0.06	7.9±0.51	1098±22.32	688±19.30	562±28.14	345±35.81
3	7.54±0.33	7.8±0.01	1244±24.87	659±54.20	635±34.20	333. ±22.88
4	5.21±0.68	8.2±0.09	850±12.85	610±62.30	421±10.80	304±34.06
5	7.99±0.11	8.1±0.85	748±68.10	655±28.90	365±11.24	325±65.32
6	8.62±0.06	8.0±0.07	865±78.32	601±33.50	425±28.32	296±15.97
7	7.95±0.54	8.1±0.01	824±47.21	620±44.30	405±66.42	308±23.70
8	8.24±0.71	7.9±0.25	930±68.32	689±10.70	462±15.36	341±9.58
9	8.14±0.32	7.9±0.32	1654±95.32	625±11.60	833±62.45	319±10.32
10	9.36±0.05	8.1±0.59	1354±36.25	632±25.30	657±10.63	311±11.47

pH is the quantity of the proton ions associated to hydroxyl ions giving the basicity or acidity of a substance (Kalil *et al.,* 2000). Determination of pH was to ascertain whether the home spray pH was suitable for the stability of acaricides or may result to its early degradation. Study conducted found that Cypermethrin is stable at pH of 6.00 (Kalil *et al.,* 2000) while Amitraz is stable in basic media above pH 7. All the homemade sprays had basic pH of 7.54± 0.33 to 9.36 ± 0.05 except for homemade spray at Sites 2 and 4 which had 6.96 ± 0.06 and 5.21 ± 0.68, respectively (Table 4.4). While the pH for water ranged from 7.8 ± 0.51 to 8.2 ± 0.09. The conductivity of homemade cattle spray ranged from 748±68.1 µS/cm to 1,654±95.32 µS/cm while that for river water ranged from 296±15.97 µS/cm to 345±35.81 µS/cm. The high conductivity values observed in the homemade cattle spray suggests that the home spray water buffering agent applied was adequate to achieve the stability pH of acaricides observed (IAEA, 1997). TDS ranged from 365 ± 11.24 mg/L to 833 ± 62.45 mg/L in homemade cattle sprays.

The TDS levels for water ranged from 296 ± 15.97 mg/L to 345 ± 35.81 mg/L. The high TDS values observed suggests that the home spray water buffering agent applied was adequate to achieve the stability pH of acaricides observed. These TDs values were within the acceptable National Environment management Authority (NEMA) limits of 1200 mg/L and WHO permissible limits of 1000 mg/L. The water total dissolved solids value (TDs) value could be attributed to surface runoffs and animal watering. Similar studies on water from Lake Baringo show higher TDS values in the range of 245 ± 42.37 mg/L to 321 ± 78.98 mg/L at Permalock Island and Perkerra respectively occasioned by surface runoffs, weathering of rocks, agricultural runoff, discharge of domestic waste and animal watering (Ndiba *et al.,* 2018).

In the study, farmers were found not to add any buffers in the acaricide before spraying since was done by the manufacturer. The conductivity of the river water was to screen for the suitability to mix the acaricides. The water used for mixing the acaricides was obtained from Ewaso Nyiro, used for both domestic and watering livestock. Once the mixing is done, spraying

follows immediately to avoid acaricide degradation.

Table 4.5 shows the physico-chemical parameters, soil textures and other parameters of soil from the ten sites in Kajiado West Sub County. Soil pH ranged between 5.24 ± 0.00 to 7.21 ± 0.10. The highest pH was recorded in soil from Home Site 8 while the lowest was at site 2 (Table 4.5). The acidic pH at Site 2 can be attributed to the formation of carbonic acid as a result of dissolving carbonates with water.

Table 4. 5. Soil Physiochemical Parameters

Site/ Parameter	Soil PH	% Sand	% silt	% clay	%Moisture content	% Nitrogen	Total
1	5.89±0.0	36±2.5	16±0.6	48±4.5	33±0.3	0.14±0.0	1.62
2	5.24±0.0	34±1.6	17±0.9	49±5.1	28±4.5	1.36±0.2	1.42
3	5.98±0.1	35±0.9	18±2.1	47±0.9	31±5.6	0.16±0.0	0.22
4	6.22±0.4	34±3.4	14±0.3	52±2.1	30±1.4	0.32±0.0	0.53
5	5.55±0.1	33±2.4	17±0.5	50±5.8	29±1.3	0.24±0.0	0.91
6	6.28±0.2	33±2.4	17±0.5	52±2.1	30±1.4	0.31±0.00	0.21
7	6.23±0.3	31±1.0	15±0.1	54±2.8	36±2.4	0.57±0.04	0.31
8	7.21±0.1	28±2.1	18±0.8	54±3.6	44±2.7	0.27±0.1	0.18
9	5.56±0.0	35±6.2	12±1.6	53±3.8	32±1.9	0.69±0.04	0.31
10	5.81±0.2	34±1.3	15±0.9	51±1.2	29±1.2	0.21±0.0	0.69

The % organic carbon ranged 0.21 ± 0.0 - 1.62 ± 0.0 %, highest % organic carbon (1.62 ± 0.6 %) was recorded at Site 1 followed by 2 (1.41 ± 0.0 %) and 5 (0.91 ± 0.0 %), respectively. The low organic carbon levels for instance ranging from 0.21 ± 0.0 to 1.62 ± 0.0 %, (Table 4.5) makes the soil to have low ability to retain organic pollutants leading to higher losses through runoff. The percentage total nitrogen ranged from 0. 0.16 ± 0.0 -1.36 ± 0.0 %. The highest (%) total nitrogen (1.36%) was recorded at Site 2 followed by 9 (0.69 ± 0.0 %), then site 3 (0.16 ± 0.0). Phosphorous concentration ranged between 18.0 ± 1.6 to 39.6 ± 4.1 mg/kg. The highest concentration of phosphorous (39.6 ± 4.1 mg/kg) was recorded at Site 9 followed by site 6 at (33.6 ± 3.5 mg/kg), while site 5 recorded the lowest concentration at (18 ± 1.6 mg/kg).

Table 4. 6. Soil Metal ion content from various Sampling sites

	K (me %)	Ca (me %)	Mg (me %)	Mn (me %)	cu (ppm)	Fe (ppm)	Zn (ppm)	Na (me %)	Texture grade
1	3.36±0.1	15.43±0.6	2.46±0.0	1.96±0.0	1.75±0.0	601±25	3.63±0.6	1.90±0.0	SLC
2	0.11±0.0	8.54±0.2	1.66±0.0	1.05±0.0	9.15±0.3	336±22	7.8±0.0	0.81±0.0	SLC
3	0.96±0.0	6.21±0.0	3.06±0.3	1.41±0.1	9.62±0.0	275±16	7.6±0.3	0.23±0.0	SLC
4	0.96±0.0	6.35±0.3	1.98±0.1	1.96±0.0	11.72±0.1	402±12	9.63±1.1	1.29±0.1	SLC
5	0.64±0.0	11.85±1.1	3.99±0.0	2.45±0.2	11.8±0.2	398±25	6.7±0.9	1.22±0.2	SLC
6	0.98±0.0	12.32±0.9	4.21±0.0	1.85±0.0	11.7±0.3	324±13	8.19±0.4	0.91±0.0	SLC
7	0.77±0.0	7.95±0.3	2.02±0.1	1.96±0.1	9.01±0.1	334±12	7.08±0.6	0.66±0.0	SLC
8	0.79±0.0	8.52±0.4	2.67±0.0	1.45±0.0	7.25±0.5	487±36	8.44±0.1	1.06±0.2	SLC
9	0.56±0.04	8.97±0.1	2.31±0.3	2.88±0.0	9.11±0.0	365±21	6.6±0.2	0.21±0.0	SLC
10	0.56±0.00	8.84±0.0	2.01±0.0	2.63±0.2	8.22±0.3	389±32	7.1±0.1	1.08±0.1	SLC

S-Sand, L- Loam, C-Clay

4.3 Method Accuracy

The plot of the peak area against the concentration of specific standard gave the best line of fit that resulted to a correlation factor (R^2) of more than 0.99 showing that the relationship between the instrument response and analyte concentration was good. Calibration curve for amitraz, cypermethrin, deltamethrin standards are shown in appendix 3, Figures 3a, 3b and 3c

Which produced straight lines with correlation factors (R^2) of 0.9915, 0.9977 and 0.9956, respectively, showing a good association between instrument response and analyte concentration. The GC chromatogram obtained and chemical structure and ionic mass spectra for amitraz standard are shown in appendix 4, Figures 4a and 4b, respectively, for cypermethrin Figures 4c and 4d, while for deltamethrin Figures 4e and 4f, respectively. The GC chromatograms for acaricides standard mixture, water and homemade cattle spray samples are shown in Figures 4g, 4h 4i and 4j appendix 4, respectively.

4.4 Limits of Detection and Quantification of Acaricides

Amitraz had the highest limit of detection (LOD) at 0.034 ± 0.001 µg/L and limit of quantification (LOQ) of 0.340 ± 0.001 µg/L while Cypermethrin had the lowest limit of detection of 0.022 ± 0.001 µg/L. The limit of detection and quantification for the pesticides

standards are given in Table 4.7.

Table 4. 7. Retention Time, Limit of Detection, Limit of Quantification of Acaricide

Parameter	Amitraz	Cypermethrin	Deltamethrin
Retention Time (min)	13.96	15.04	16.72
Linearity (r^2)	0.995	0.9977	0.9956
LOD (ug/L)	0.034±0.001	0.022±0.001	0.026±0.001
LOQ (ug/L)	0.340±0.001	0.222±0.001	0.201±0.001
Accuracy (%)	98.14	102.86	105.06
Quantitative ion (m/z)	106	181	253
Qualifier ion (m/z)	121.0, 132.0, 162.0, 293.0	163.0, 209.0, 91.0	255.0, 181.0

4.5: Percentage Recoveries of Acaricides in Samples

The recoveries for homemade cattle spray, water and soil are given in Table 4.8. All the recoveries were within the recommended range of 70-120 % hence the concentrations of the pesticides were not corrected (Hill, 2000).

Table 4. 8. Percentage Recoveries of Acaricides

Acaricides	(%) Homemade cattle sprays (µg L^{-1})	(%) Water (µg L^{-1})	(%) soil (µg kg^{-1}, DW)
Amitraz	89.27±1.64	78.17±4.21	76.38±4.81
Cypermethrin	93.42±3.22	81.67±2.18	85.23±5.80
Deltamethrin	91.66±2.87	89.34±5.66	79.69±3.16

n = 6, mean ± standard deviation, DW = dry weight

4.6 Amitraz, Cypermethrin and Deltamethrin Levels in samples in dry and wet seasons

4.6.1 Amitraz, Cypermethrin and Deltamethrin Residue Levels in the samples in Dry Season

The study was conducted to determine the residue levels of amitraz, cypermethrin and deltamethrin

in homemade cattle spray that farmers use to spray their animals in the dry season. Table 4.9 shows that some farmers mixed the Amitraz, cypermethrin and deltamethrin because they believe mixing would increase the efficiency of the acaricides. The homemade spray in Site 1 was a mixture of amitraz (11,620±120.1 µg/L) and deltamethrin (6,285±35.05 µg/L), Site 2 cypermethrin (9,311±23.17 µg/L) and deltamethrin (7,226±41.3 µg/L), in Site 3 cypermethrin (11,972±74 µg/L) and deltamethrin (3,879±33.2 µg/L).

Amitraz was used by 72 % of the farmers, while cypermethrin was by 76 % and deltamethrin by 46 % (Table 4.2). Farmers at Sites 2, 3, 4 and 5 did not use amitraz. Its residue levels were below detection limits (BDL) of 0.034±0.001 µg/L at those four sites. Farmers at Sites 6, 7, 8, 9 and 10 did not use both cypermethrin and deltamethrin as their concentrations were below the detection limits (BDL) of 0.022±0.001 µg/ L and 0.026±0.001 µg/L respectively (Table 4.9)

Table 4. 9. Acaricides Residue Levels in Home Cattle Spray (µg/L) in dry season

Site/Acaricides	Amitraz (µg/L)	Cypermethrin (µg/L)	Deltamethrin (µg/L)
1	11,620±120.1	≤0.022	6,285±35.05
2	≤0.034	9,311±23.17	7,226±41.3
3	≤0.034	11,972±74	3,879±33.2
4	≤0.034	3,834±80.2	≤0.026
5	≤0.034	11,586±62.1	12,298±82.1
6	7,814±61.4	≤0.022	≤0.026
7	11,196±98.2	≤0.022	≤0.026
8	3,884±25.3	≤0.022	≤0.026
9	5,682±41.3	≤0.022	≤0.026
10	12,236±14.54	≤0.022	≤0.026

4.6.2 Acaricides residue levels in homemade cattle sprays in wet season

The concentration of the acaricides in homemade cattle spray during the wet season were high at Site 3 (10,315±318.1 (µg/L) for cypermethrin and 4,781±125.8 (µg/L) deltamethrin. The results of the concentration of acaricides during the wet season in homemade spray is shown in Table 4.10.

Table 4. 10. Acaricides residue levels in homemade cattle spray (µg/L) in wet season

Site/Acaricide	Amitraz (µg/L)	Cypermethrin (µg/L)	Deltamethrin (µg/L)
1	5,430±96.10	≤0.022	≤0.026
2	6,658±35.3	8,975±103.7	≤0.026
3	≤0.034	10,315±318.1	4,781±125.8
4	6,978±36.8	≤0.022	≤0.026
5	11,634±107.2	≤0.022	≤0.026
6	8,695±49.5	≤0.022	≤0.026
7	≤0.034	10,383±562	≤0.026
8	6,632±79.9	≤0.022	≤0.026
9	6,876±105.3	≤0.022	≤0.026
10	9,876±634.2	≤0.022	≤0.026

It can be deduced that in dry season (Table 4.9) and wet seasons (Table 4.10) farmers vary their concentrations probably due to the quantity of rainfall which is spatial and the overlap of seasons that tends to harbor similar pests (Mutavi et al.,2018).

4.7 Acaricide residue levels in river water in dry and wet seasons

Determination of the levels of pesticides in water in rivers is vital in order to safeguard their fate in the environment and evaluation of their potential toxicity (Hladik and Megan, 2012). Analysis of water samples from six (6) Ewaso Nyiro River sites which were adjacent to the spraying homes (Figure 3.1) were carried out in dry and wet seasons to determine the residue levels of amitraz, cypermethrin and deltamethrin. The residue levels of the acaricides were BDL in all the river samples in both the dry and wet seasons. This low amount of the pesticides in water can be attributed to extreme instability of amitraz, cypermethrin and deltamethrin in aquatic ecosystems (USEPA, 1992) and further the low concentrations in dry season could be due to the nature of rainfall that is scarce allowing minimal leaching of pesticides to newer areas.

Other researchers have detected higher pesticides concentrations during the wet seasons than during the dry seasons due to leaching through water ways like Nyando River (Abong'o *et al.,* 2015). The study investigated levels and distribution of organochlorine pesticides residues used in six sites representative of Nyando catchment area of Lake Victoria. The research findings revealed amitraz

and pyrethroids presence in soil matrix. These acaricides are known to have very low persistence due to their rapid degradability. The phenomenon also implies that homemade cattle spray have not affected the environment significantly.

4.8 Acaricide Residue Levels in Soil in Dry and Wet Seasons

Determination of pesticides residue levels in soil is important to safeguard their fate in the environment and evaluation of their potential toxicity risks (Hladik and Megan, 2012). Investigation of loam soil samples from the ten sites where the spraying was carried out in dry and wet seasons to determine the concentration of the acaricides (amitraz, cypermethrin and deltamethrin). Table 4.11 shows the residue levels of acaricides in soil samples.

Table 4. 11. Acaricides Residue Levels in Soil (µg/Kg) in Dry Season

Site/Acaricide	Amitraz (µg/kg)	Cypermethrin (µg/kg)	Deltamethrin (µg/kg)
1	6,530+27.2	≤0.022	5,626+103.1
2	5,320+64.1	≤0.022	4,986+87.1
3	≤0.034	8,654+141.2	1,341+58.06
4	≤0.034	3,041+33.15	≤0.026
5	≤0.034	8,423+79.2	8,167+16.4
6	6,412+65.1	≤0.022	≤0.026
7	10,641+144.2	≤0.022	≤0.026
8	1,970+91.3	≤0.022	≤0.026
9	3,129+98.7	≤0.022	≤0.026
10	6,546+120.75	≤0.022	≤0.026

The residue levels of acaricides were analysed in soils during the dry season as shown (Table 4.11). Site 1 and 2 were found to have used amitraz and deltamethrin, while sites 3 and 5 had used cypermethrin (8,654+141.2 µg/kg) and deltamethrin (1,341+58.06 µg/kg) respectively with exception of site 4 that had only cypermethrin (3,041+33.15 µg/kg). The remaining sites 6, 7, 8, 9 and 10, use amitraz in controlling pests on their livestock. Upon change of season to wet, farmers at sites 1, 5, 6, 8, and 9 use amitraz only , site 3 use amitraz and deltamethrin while sites 4, 7 and 10 use cypermethrin

only (Table 4.12).

Table 4. 12. Acaricides Residue Levels in Soil (µg/Kg) in Wet Season

Site/Acaricide	Amitraz (µg/kg)	Cypermethrin (µg/kg)	Deltamethrin (µg/kg)
1	4,230+43.1	≤0.022	≤0.026
2	5,177+122.4	8,633+179.1	≤0.026
3	7,905+184.2	≤0.022	2,367+76.9
4	≤0.034	4,832+86.7	≤0.026
5	4,832+86.7	≤0.022	≤0.026
6	6,194+120.6	≤0.022	≤0.026
7	≤0.034	8,694+146.9	≤0.026
8	3,875+97.3	≤0.022	≤0.026
9	4,691+75.3	≤0.022	≤0.026
10	≤0.034	7,063+146.2	≤0.026

From the two seasons, most farmers are observed to mix either deltamethrin with cypermethrin with majority giving a preference to amitraz as the main acaricide. The comparison of the acaricide concentrations in Tables 4.11 (dry season) and 4.12 (wet season) reveals that amitraz residue levels are high in concentrations during the dry season than in the wet season in spite the use of cypermethrin and deltamethrin. This could be attributed to the ease of solubility of amitraz compared to cypermethrin and deltamethrin thus hastening their percolation to lower soil layers (Kagaruki, 1996).

4.9 Dissipation Rates of Acaricides in Soil Samples

Based on the soil concentrations results obtained, most farmers used amitraz and deltamethrin in Site 1 in dry season (Table 4.11) and amitraz alone in wet season with only one farmer at Site 2 mixing amitraz with cypermethrin during the wet season (Table 4.12). Farmers mixed cypermethrin with deltamethrin with only one farmer in Site 7 spraying cypermethrin alone, they reported that the use of deltamethrin mixed with cypermethrin was effective in controlling tsetse flies and ticks especially in tsetse fly prone areas. The concentration of acaricides in cattle spray (Tables 4.9 and 4.10) in all the homes were below the required concentration of 50 to 400 mg/L (Kagaruki, 1996) showing that the farmers do not use the right ratio of water and the acaricides required when preparing their homemade cattle sprays, this reduces the effectiveness of the acaricides hence the reoccurrence of the tsetse flies

and development of tick resistance to acaricides. The examples are shown in Tables 4.8 and 4.9 with low levels of Amitraz (11,620±120.1 µg/L) and **(**5,430±96.10 µg/L) at Site 1 in dry and wet seasons respectively. The manufacturers may also not be giving the correct concentrations of the active ingredients on labels of the containers, as this was not checked

4.10 Fate of Acaricides in Soil

4.10.1 Dissipation Rate of Acaricides in Soil from Site 1 in Dry and Wet Seasons

The research was carried out to investigate the fate of acaricide on the soil collected from ten (10) selected sites where the animals were sprayed. The concentration established on dry mass basis on degradation of acaricides in soil in dry and wet seasons are in Tables 4.13 and 4.14 respectively

Table 4. 13. Dissipation of Amitraz and Deltamethrin in Soil (µg/Kg) in Site 1 in Dry Season

Days after application	Amitraz (µg/Kg)	(%) Reduction	Deltamethrin (µg/Kg)	(%) Reduction
0	6,530±27.2	0	5,626±103.1	0
1	3,452±10.3	47	2,916±19.7	48
2	3,022±91.2	54	1,112±86.2	80
3	1,984±65.3	70	970±45.21	83
4	860±62.7	87	186±15.42	97
5	118±6.19	98	90±4.79	99
7	3.87±0.00	99.94	≤0.022	100
10	≤0.034	100	≤0.022	100

The acaricides used for spraying the animals at Site 1 were amitraz and deltamethrin in dry season (Table 4.13). The results for degradation of amitraz and deltamethrin in soil from Site 1 in dry season are shown in Table 4.13. The results show that amitraz (µg/Kg) dissipated to 0.06 % level in day 7 while the residue levels of deltamethrin (µg/Kg) was below the detection limit (BDL) of ≤0.022 µg/Kg by day seven this corresponds to 100 % reduction, by the 10th day, both amitraz and deltamethrin were below detection limit .

The observed dissipation trend may be attributed to decrease in concentration due to biological degradation (USEPA, 1992). The results show fast dissipation rate of amitraz in the soil, similar to

pervious study by Kagaruki, (1996). The results show the half-lives of some pesticides might differ a little subject to ecological settings (Chai *et al.*, 2013). Moreover, the Kenya tropical climate influences fast degradation of pesticides likened to the temperate ecological settings (Wandiga, 1996). Further studies by USEPA also showed that amitraz is not stable in earthly and river ecologies (USEPA, 1992).

In the wet season the acaricides used at Site 1 to spray their animals is amitraz (Table 4.14). The concentration for the degradation of amitraz in soil from Site 1 in the wet season is shown in Table 4.14.

Table 4. 14. Dissipation Rate of Amitraz in Soil (µg/Kg) in Site 1 in Wet Season

Days after application	Amitraz (µg/Kg)	(%) Reduction
0	4,230±43.1	0
1	2,647±22.4	37
2	480±9.3	89
3	83±0.07	98
4	≤0.022	100
5	≤0.022	100
7	≤0.022	100
10	≤0.022	100

The trend of reduction of acaricides during the dry season was obtained by drawing the determined residue level of amitraz and deltamethrin versus time in days for sprayed soil in dry season (Figure 4.7)

The trend of dissipation of acaricides during dry season (Figure 4.7) was obtained by drawing residue level of amitraz and deltamethrin against time for sprayed soil in Site 1 (Table 4.13)

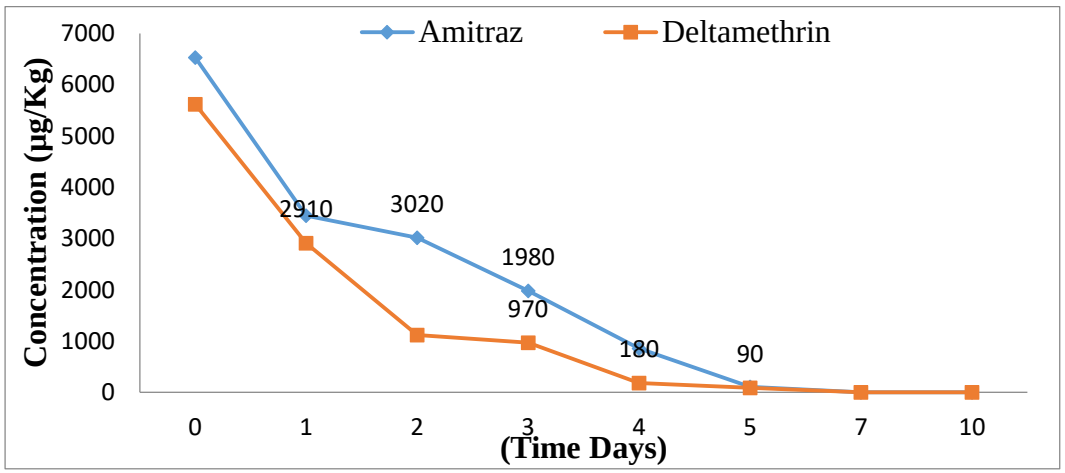

Figure 4. 7: Trend of Dissipation of Amitraz and Deltamethrin in soil at site 1 in dry season

The residue level of Amitraz in soil reduced over period of 10 days (Figure 4.7). The mean residue levels of amitraz deposited in soil in Site 1 was 6,530±27.2 µg/Kg (day 0) and the ending concentration was BDL at ≤0.034 µg/ Kg in day 10. After day 1 (47 %) of amitraz had reduced from the soil while by day 3 (70 %) of the initial sprayed acaricide reduced in the soil and 0.04 % of the initial concentration of amitraz remained in the soil by day 7 indicated that the amitraz had reduced by 99.94%. The data indicate fast degradation rate of amitraz in soil for the first 4 days and that the characteristic two-phase dissipation pattern showing the first faster degradation rate shadowed by slower rate opening after 3 days was observed and which is much consistent with other reports from other soils (Langat 2011).

The residue revel of deltamethrin in soil reduced over period of 7 days (Figure 4.7). The initial mean concentration of deltamethrin was 5,626±103.1 µg/Kg (day 0) and the final concentration was BDL at 0.034 ± 0.001 (Table 4.13) on day 10. After the first day 52 % of Deltamethrin remained in the soil while by day 3 after deposition in the soil, 17 % of the first concentration of acaricide persisted in the soil and 1.0 % of the first concentration in the soil by day 5 (Table 4.13). The results showed that there was rapid dissipation rate of Deltamethrin in soil for the 2 days and that the characteristic two-phase dissipation pattern showing the first faster degradation rate followed by slower rate opening after 2 days was observed.

The trend of dissipation in wet season (Figure 4.8) was obtained by drawing residue level of amitraz (Table 4.13) against time for sprayed soil in Site 1.

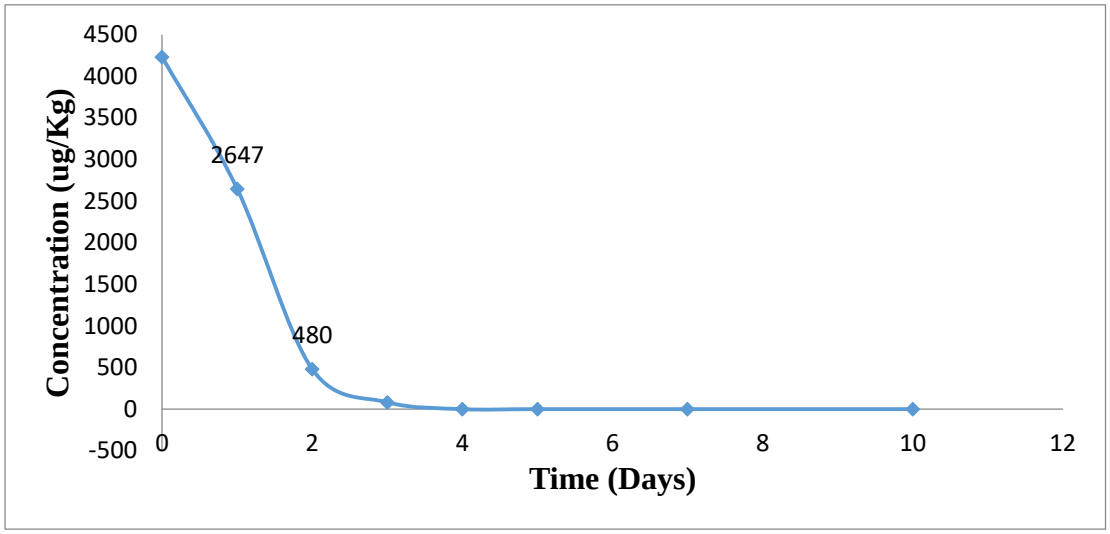

Figure 4. 8. Trend of Dissipation of Amitraz in soil at Site 1 against time in wet season

Figure 4. 8 shows the average first concentration of amitraz was 4,230±43.1 µg/ Kg (day 0) and the last concentration was BDL (Table 4.13) in day 10. After the first day (37 %) of amitraz had remained in the soil while by day 3 after the deposition of the acaricide in the soil, 2 % of the initial dropped amitraz persisted in the soil by day 3. The results exhibited fast degradation of amitraz in soil for the first day and then the rate was gradual after day one up to day four and that the characteristic two-phase dissipation design presenting the first faster degradation rate followed by slow rate commencing after twenty four hours.

Result obtained in Tables 4.13 for dry and 4.14 for wet seasons were fitted into Langmuir-Hinshelwood kinetic model for reaction rate dependence on initial reactant concentration (Karl *et al.*, 2013) to obtain rate constant (K_{obs}) and half-life ($t_{1/2}$)

Based on first order kinetic, a plot of negative Log concentration of residue versus time t (days)/Kobs was calculated to obtain regression curves for Amitraz (Figures 4.9) and Deltamethrin (Figure 4.10) in dry and Amitraz (Figure 4.11) for wet seasons respectively.

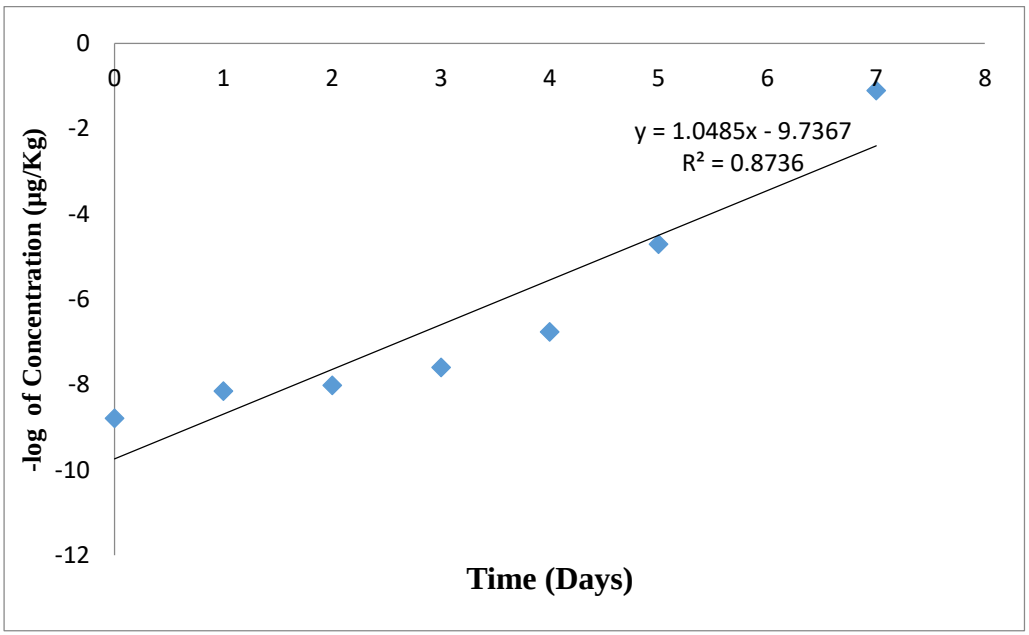

Figure 4. 9. Regression curve for Amitraz reduction in soil in Site 1 in dry season

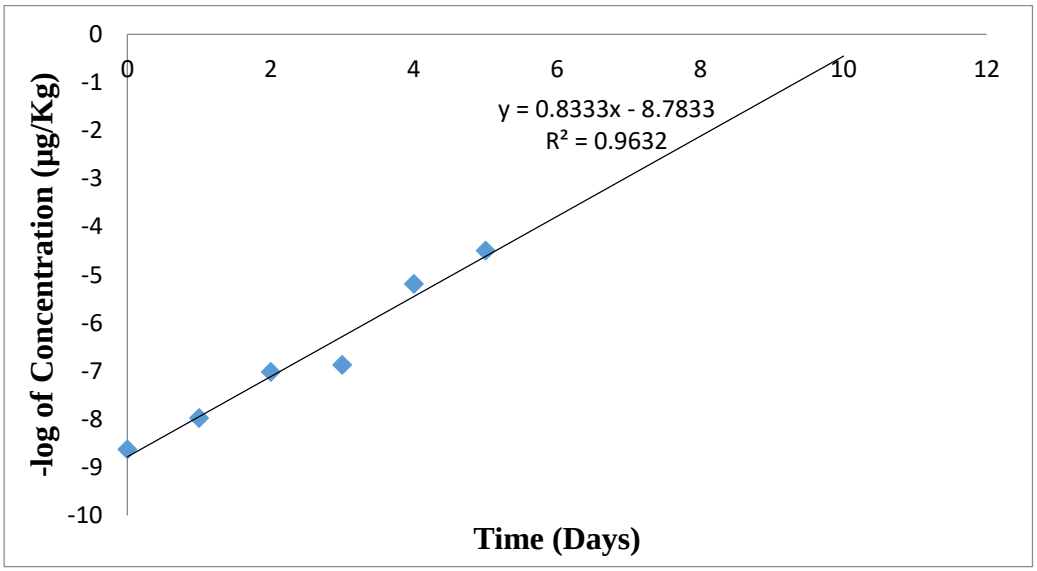

Figure 4. 10. Regression curve for Deltamethrin reduction in soil in Site 1 in dry season

Equation 4 can be written as follows Y= mX + C. A plot of ln (C_t) verses time (t) result into a straight line, the gradient in linear regression equivalents the first- order rate constant $K_{obs.}$ In this situation, the K_{obs} is the dissipation rate constant. The data obtained in the analysis were similar to exponential regression analysis founded on first order kinetic, a plot of ln concentration of residues versus time t (days). Figure 4.9 and 4.10 resulted in a regression equation, Y = 1.048X- 9.738, with R^2 = 0.8736 and. Y = 0.8352X- 8.7833 and R^2 = 0.9632 for Amitraz and deltamethrin in dry season respectively.

A gradient of 1.048 and 0.8352, were obtained for Amitraz and deltamethrin respectively (corresponding to their constant K_{obs}).

In wet season the data obtained in the analysis were similar to exponential regression analysis shown in Figure 4.11, that resulted in a regression equation, Y = 1.3501X-8.73011 and R^2 value of 0.9495. A slope of 1.3501 obtained which is equal to the constant K_{obs}

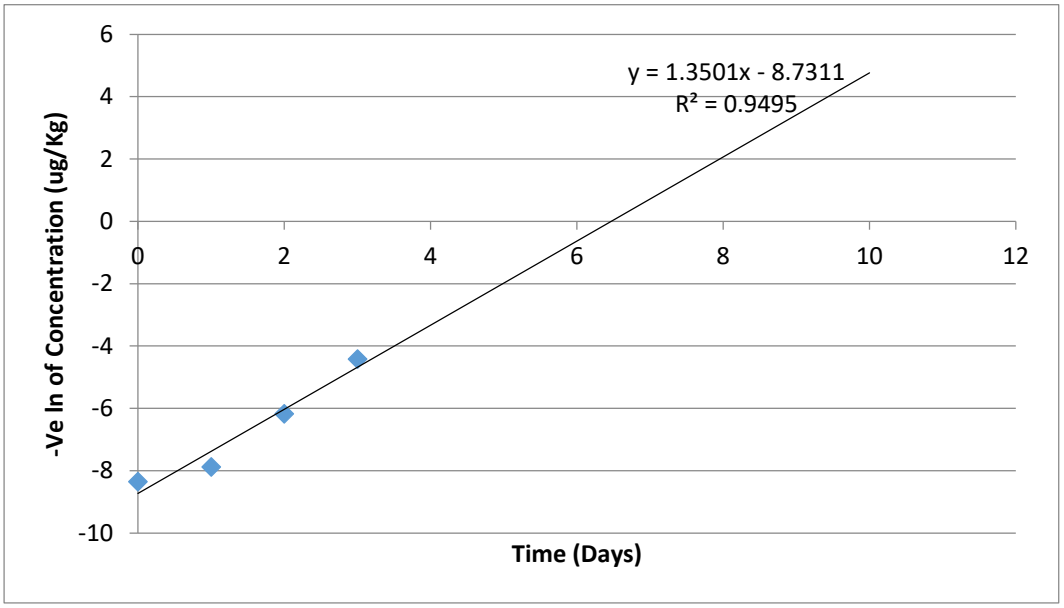

Figure 4. 11. Regression Curve for Amitraz reduction in soil in Site 1 in Wet Season

In this study the dissipation of Amitraz and deltamethrin follows Langmuir-Hinshelwood kinetic equation and using equation 7, the half-life of amitraz and deltamethrin in soil in dry season was 0.66 days and 0.83 days. During wet season, the half-life for amitraz was 0.51 days by the Langmuir-Hinshelwood kinetic model.

4.10.2 Dissipation Rate of Acaricides in Soil from Site 2 in Dry and Wet Seasons

The acaricides used in Site 2 to spray their animals during the dry season is cypermethrin and deltamethrin. The data for the degradation of cypermethrin and deltamethrin in soil from Site 2 is as shown in Table 4.15.

Table 4. 15. Cypermethrin and Deltamethrin dissipation rate in Soil (µg/Kg) in Site 2 in dry Season

Days after application	Cypermethrin	(%)Reduction	Deltamethrin	(%) Reduction
0	5,320±64.1	0	4,986±87.1	0
1	1,633±13.7	69	1,951±51.2	61
2	1,274±50.9	76	1,216±6.4	76
3	944±76.1	83	842±2.7	83
4	711±21.5	87	80±3.4	92
5	10±0.94	99.8	≤0.026	100
7	≤0.034	100	≤0.026	100
10	≤0.034	100	≤0.026	100

The acaricides used in Site 2 to spray animals in the wet season is cypermethrin and amitraz. The results based on dry mass for the degradation of cypermethrin and amitraz in soil at Site 2 are shown in Table 4.16.

Table 4. 16. Cypermethrin and Amitraz dissipation Rate in Soil at Site 2 in Wet Season

Days after application	Cypermethrin (µg/Kg)	(%) Reduction	Amitraz (µg/Kg)	(%) Reduction
0	8633±179.1	0	5177±122.4	0
1	2491±76.4	71	1670±98.0	68
2	837±43.7	90	896±22.5	87
3	101±3.5	99	92±10.8	99
4	≤0.022	100	≤0.034	100
5	≤0.022	100	≤0.034	100
7	≤0.022	100	≤0.034	100
10	≤0.022	100	≤0.034	100

The trend of dissipation for dry season (Figure 4.12) was gotten by drawing the residue level of cypermethrin and deltamethrin versus period for sprayed soil.

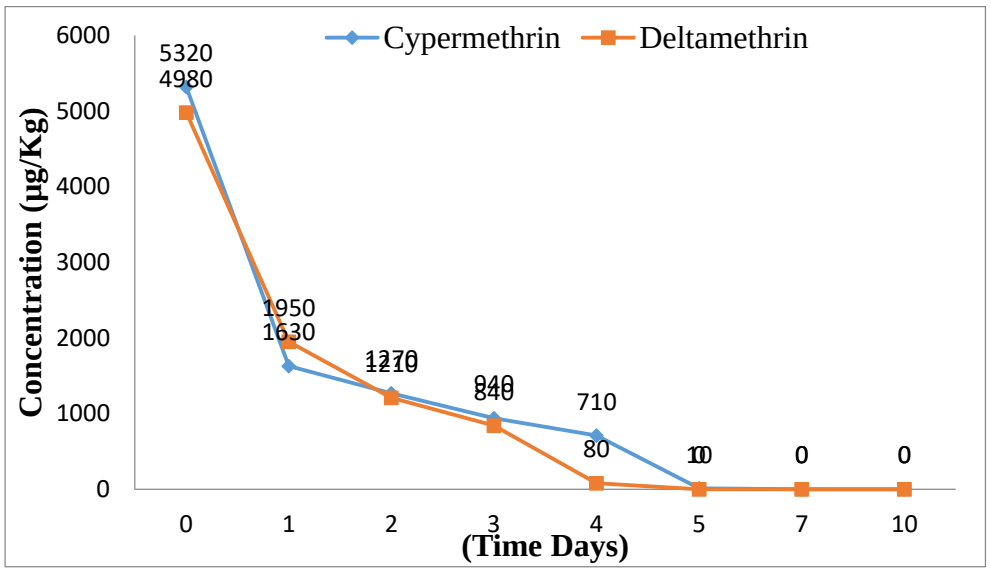

Figure 4. 12. Cypermethrin and Deltamethrin dissipation Rates in Soil at Site 2 in Dry Season

The residue level of cypermethrin in soil reduced with time (Figure 4.12). First concentration of cypermethrin was 5,320±64.1 µg /Kg (day 0) and the ending concentration was BDL on day 10. After the first day 69 % of cypermethrin remained in the soil while by day 3 after the deposition of cypermethrin in the soil, 76 % of the initial dropped acaricide persisted in the top soil and 0. 2 % of the initial deposits persisted in the soil by day 5. The results presented a fast degradation of cypermethrin in soil for the first day and then the rate was gradual in day one up to day four and that the characteristic two-phase degradation design displaying the first quicker degradation rate shadowed by slower rate commencing after twenty four hours (Figure 4.12) .

The trend of dissipation (Figure 4.13) in wet season was gotten by drawing residue of cypermethrin and amitraz versus time in days for sprayed soil sample from Site 2 in wet season

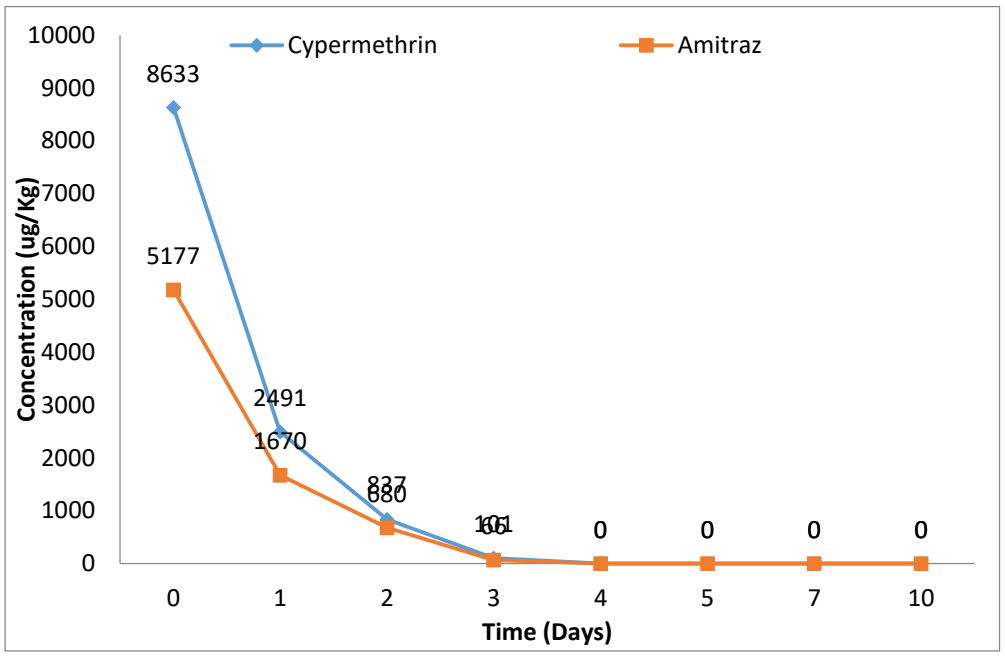

Figure 4. 13. Cypermethrin and Amitraz Dissipation Rates in Soil at Site 2 in Wet Season

The residue level of cypermethrin in soil reduced with time (Figure 4.13). The initial concentration of cypermethrin was 8,633±179.1 µg/ Kg (diurnal 0) and the final concentration was BDL on day 10. After the first day only 29 % of Cypermethrin was still remaining, while 1 % of the initial amount could be measured in soil by day 5 (Table 4.15). The data suggest fast degradation of cypermethrin in soil for the first day followed by a slower rate up to day four. This shows a characteristic two-phase degradation (Figure 4.13)

The residue level of amitraz in soil reduced with period (Figure 4.13). The mean first concentration was 4,986±87.1 µg/ Kg (day 0) and the last concentration was BDL on day 10. After the first day 3 % of amitraz remained in the soil while by day 3 after the deposition of amitraz in the soil, 12 % of the first concentration acaricide persisted in the soil and 1 % of the first concentration persisted in the soil by day 10 (Table 4.15). The results showed fast degradation of amitraz in soil from Site 2 the first two days and that the characteristic two-phase degradation design displaying the first quicker degradation rate shadowed by sluggish rate commencing after 48 hours (Figure 4.20).

Figure 4.13 shows the mean first concentration of deltamethrin was 4,986±87.1 µg/ Kg (day 0) and the last concentration was BDL on day 10. After day one 39 % of deltamethrin remained in the soil

while by day 3 after the deposits in the soil, 24 % of the initial deposits of the acaricide remained in the soil. The results show that there was quick degradation of deltamethrin in soil for the initial 2 days hence characteristic two-phase degradation shape displaying the first faster degradation rate shadowed by slower rate commencing 48 hours afterward was gotten (Figure 4.14).

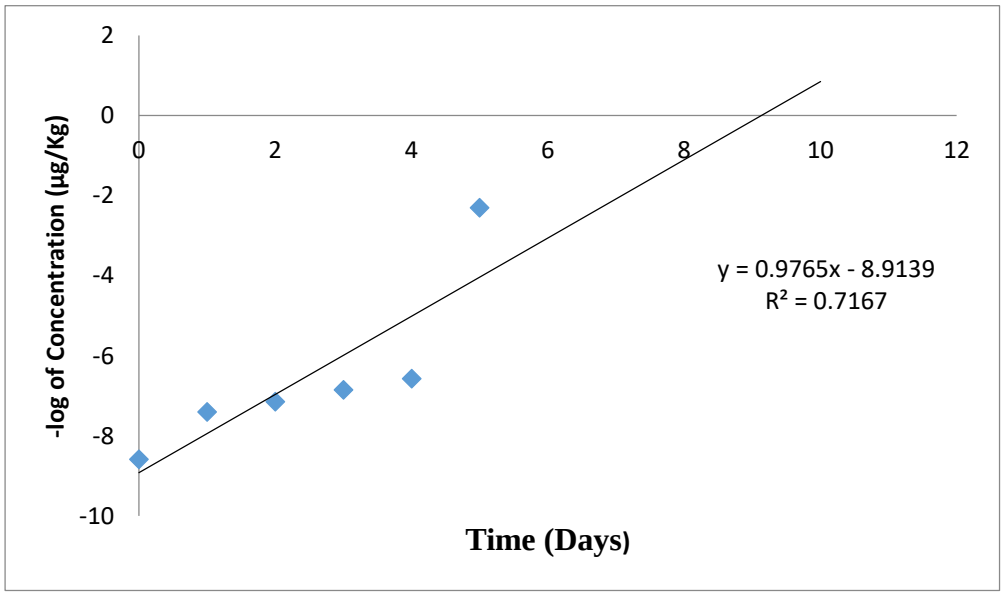

Figure 4. 14. Regression Curve for Cypermethrin degradation in Soil at Site 2 in Dry Season

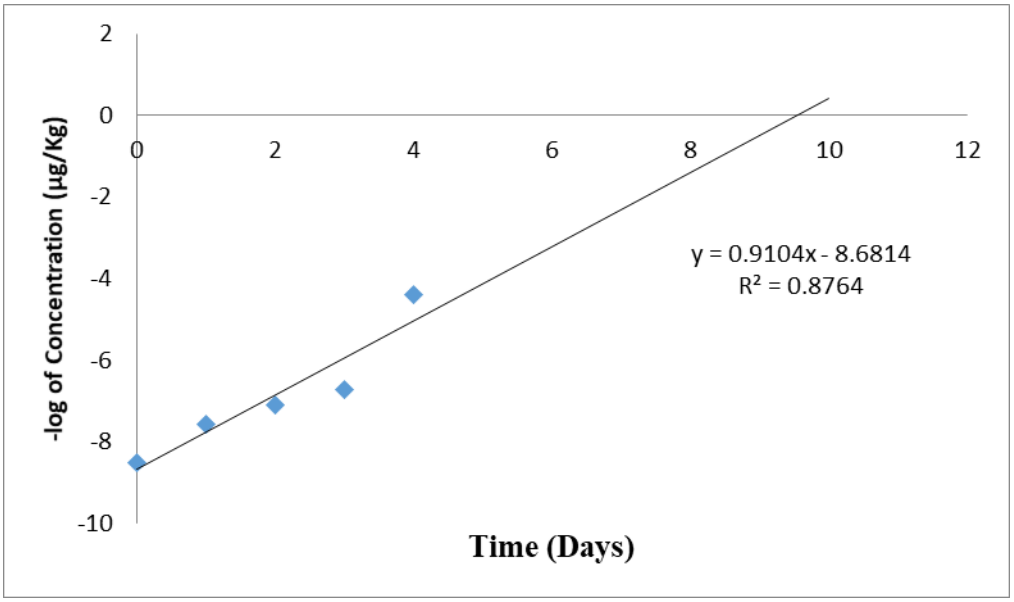

Figure 4. 15. Regression Curve for Deltamethrin degradation in soil at Site 2 in dry Season

Equation 4 can be written as Y= mX + C. A plot of ln (Ct) verses time (t) results to a straight line, the gradient is equivalent to the first- order rate constant K_{obs}. Hence, the Kobs is the dissipation rate constant. The values gotten in the analysis were similar to exponential regression analysis. Founded on first order kinetic, a plot of negative log concentration of concentration versus time t (days) Figure 4.14 gave a regression equation, Y = 0.9765+ 8.9139 with R^2 = 0.716 7 (Figure 4.14) and Y = 0.9104X+8.6814 and R^2 = 0.8764 (Figure 4.15) for Cypermethrin and deltamethrin respectively. A gradient of 0.9765 and 0.91.4 for cypermethrin and deltamethrin was gotten (similar to constant K_{obs}). The regression graph for the degradation of cypermethrin (Figure 4.16) and Amitraz (Figure 4.17).

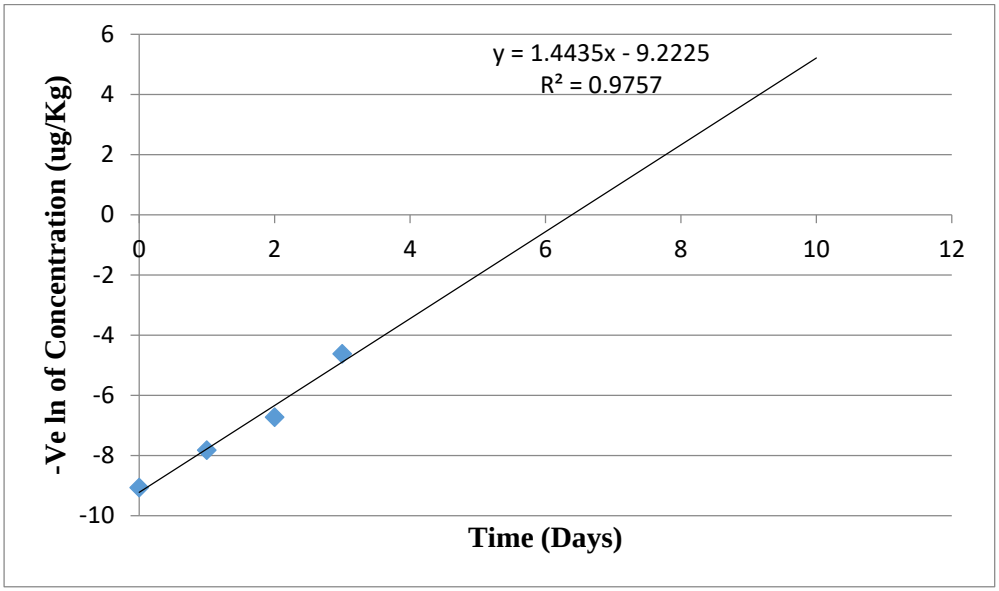

Figure 4. 16. Regression Curve for Cypermethrin degradation in Soil at Site 2 in Wet Season

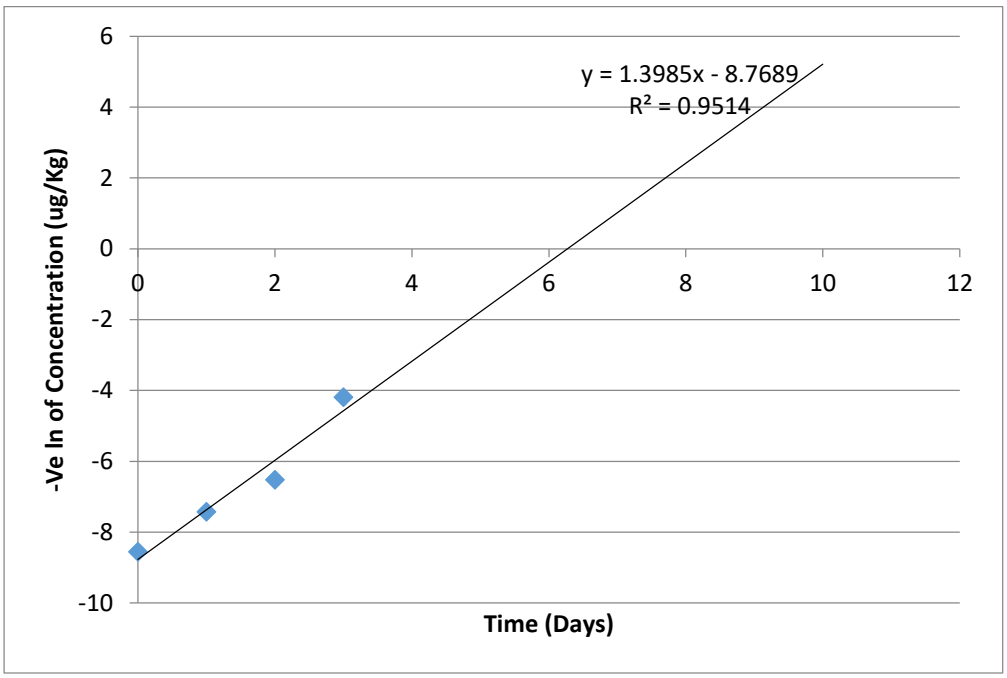

Figure 4. 17. Regression Curve for Amitraz degradation in Soil from Site 2 Wet Season

Equation 4 can be written as Y= mX + C. A plot of ln (Ct) verses time (t) results to a straight line, the gradient is equivalent to the first- order rate constant Kobs. Hence, the K_{obs} is the dissipation rate constant. The values gotten in the analysis were similar to exponential regression analysis founded on first order kinetic. A plot of negative log concentration of concentration versus time t (days) Figure 4.16 gave a regression equation, Y = 1.4435X+ 9.225 and Y = 1.3985X+8.7689 for cypermethrin and amitraz respectively. A gradient of 1.4435 and 1.3985 for cypermethrin and amitraz respectively was obtained (similar to constant K_{obs}).

In this study the degradation for cypermethrin and deltamethrin (dry season) follows Langmuir-Hinshelwood kinetic equation and using equation 7, $t_{1/2} = 0.693/K$, the half-life of cypermethrin and deltamethrin in soil at Site 2 were 0.71 days and 0.76 days respectively by the Langmuir-Hinshelwood kinetic model.

In this research the dissipation of cypermethrin and amitraz (wet season) follows Langmuir-Hinshelwood kinetic equation and using half-life equation , the half-life of cypermethrin (Figure 4.16) and amitraz (Figure 4.17) in soil was 0.48 days and 0.49 days respectively by the Langmuir-Hinshelwood kinetic model.

4.10.3 Dissipation Rate of Acaricides in Soil from Site 3 in Dry and Wet Season

The acaricides used in home three (Site 3) to spray animals were cypermethrin and deltamethrin. The results for the degradation of cypermethrin and deltamethrin in soil from the site are in Table 4.17.

Table 4. 17: Cypermethrin and Deltamethrin dissipation in Soil (µg/Kg) from Site 3 in dry season

Days after application	Cypermethrin (µg/Kg)	(%)Reduction	Deltamethrin (µg/Kg)	(%) Reduction
0	8,654±141.2	0	1,341±58.06	0
1	4,716±87.1	46	941±35.41	30
2	3,920±43.7	65	616±8.69	55
3	2,076±20.7	76	70±2.75	95
4	1,621±19.4	82	≤0.026	100
5	870±26.9	90	≤0.026	100
7	≤0.022	100	≤0.026	100
10	≤0.022	100	≤0.026	100

The acaricides used in Site 3 in the wet season to spray animals were cypermethrin and deltamethrin. The results founded on dry mass for the degradation of cypermethrin and deltamethrin in soil from Site 3 are in Table 4.18.

Table 4. 18: Cypermethrin and Deltamethrin dissipation in Soil (µg/Kg) at Site 3 in wet season

Days after application	Cypermethrin (µg/Kg)	% Reduction	Deltamethrin (µg/Kg)	% Reduction
0	7,905±184.2	0	2,367±76.9	00
1	4,793±61.9	39	872±48.1	63
2	1,006±508	87	278±58.1	89
3	278±18.4	96	18±0.6	96
4	9±0.00	99.89	0.91±0.00	99.89
5	≤0.022	100	≤0.026	100
7	≤0.022	100	≤0.026	100
10	≤0.022	100	≤0.026	100

The trend of dissipation (Figure 4.18) was gotten by plotting residue levels of cypermethrin and deltamethrin versus time in days for sprayed soil in dry season

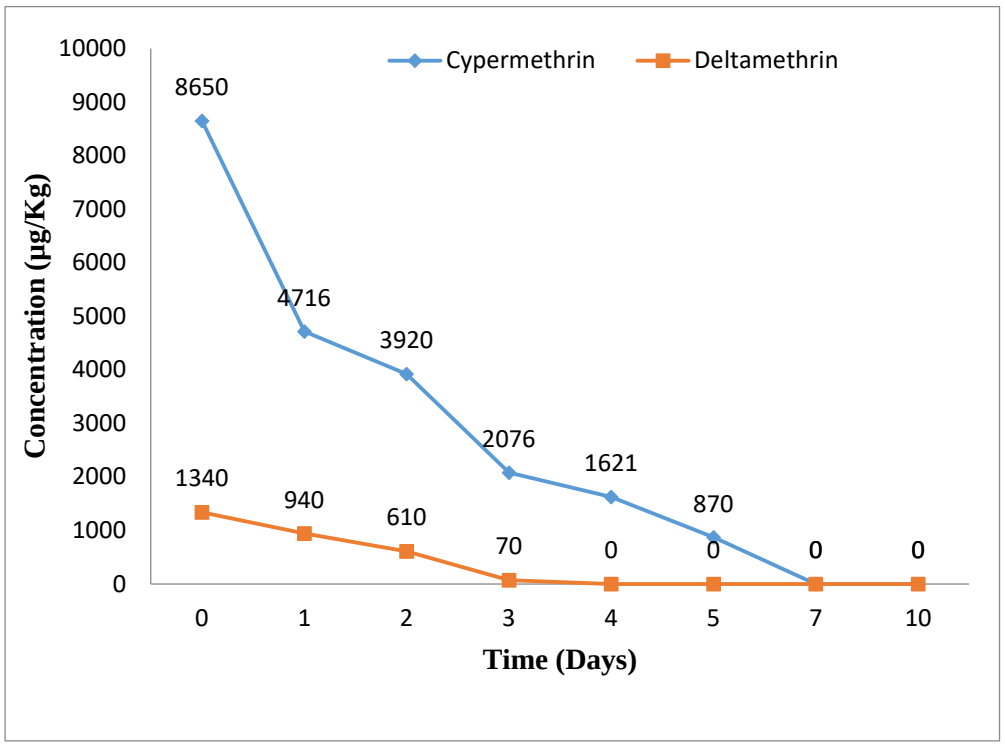

Figure 4. 18: Cypermethrin and Deltamethrin Dissipation rates in Soil at Site 3 in dry Season

Residue level of cypermethrin in soil reduced with the period (Figure 4.18). The first mean deposits of cypermethrin was 8,654±141.2 µg/ Kg (diurnal 0) and the last concentration was BDL on day 10. The residue level of deltamethrin in soil reduced with period (Figure 4.18). The first mean residue level of deltamethrin was 1,341±58.06 µg/ Kg (day 0) and last residue was BDL on day 10. At day four the acaricide levels were below detection limits in the soil showing a very first degradation processes (Figure 4.18).

The trend of dissipation (Figure 4.19) was gotten by plotting residue level of cypermethrin and deltamethrin versus time in days for sprayed soil from Site 3 in wet season

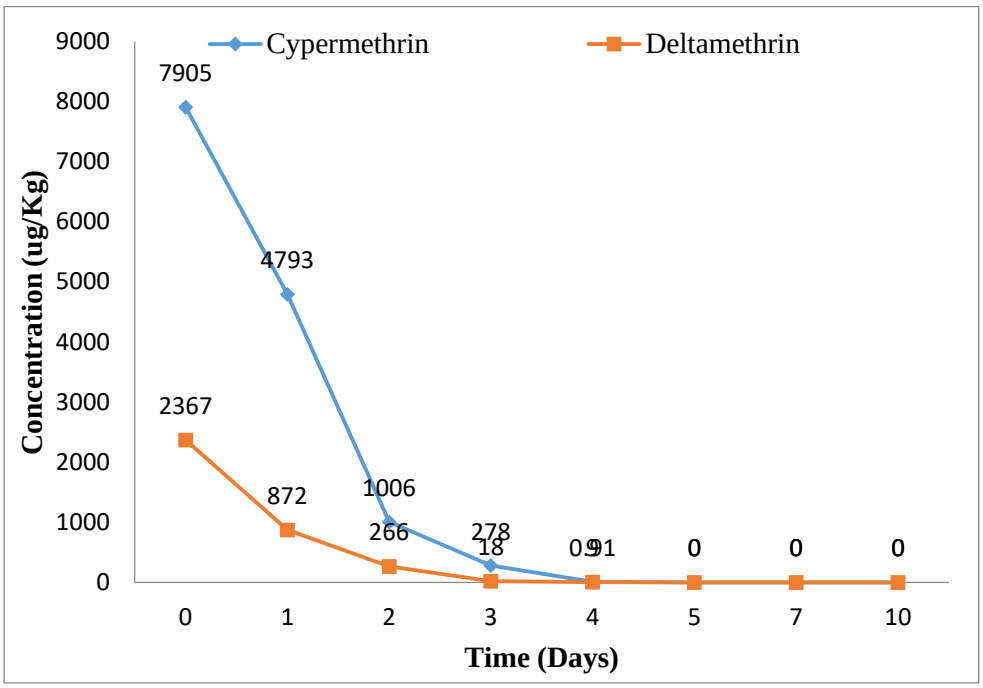

Figure 4. 19. Cypermethrin and Deltamethrin dissipation Rate in Soil at Site 3 in wet season

Residue level of cypermethrin in soil reduced with period (Figure 4.19). The mean initial concentration of cypermethrin was 7,905±184.2 µg/Kg (diurnal 0) and last concentration was BDL on day 10. The residue level of deltamethrin in soil reduced over time (Figure 4.19). The mean initial concentration of deltamethrin was 2,367±76.9 µg/ Kg (day 0) and the final concentration was BDL on day 10. At day four the acaricide could not be detected in the soil (Figure 4.19) showing a very first degradation.

The regression graph for the degradation of cypermethrin is in Figure 4.20.

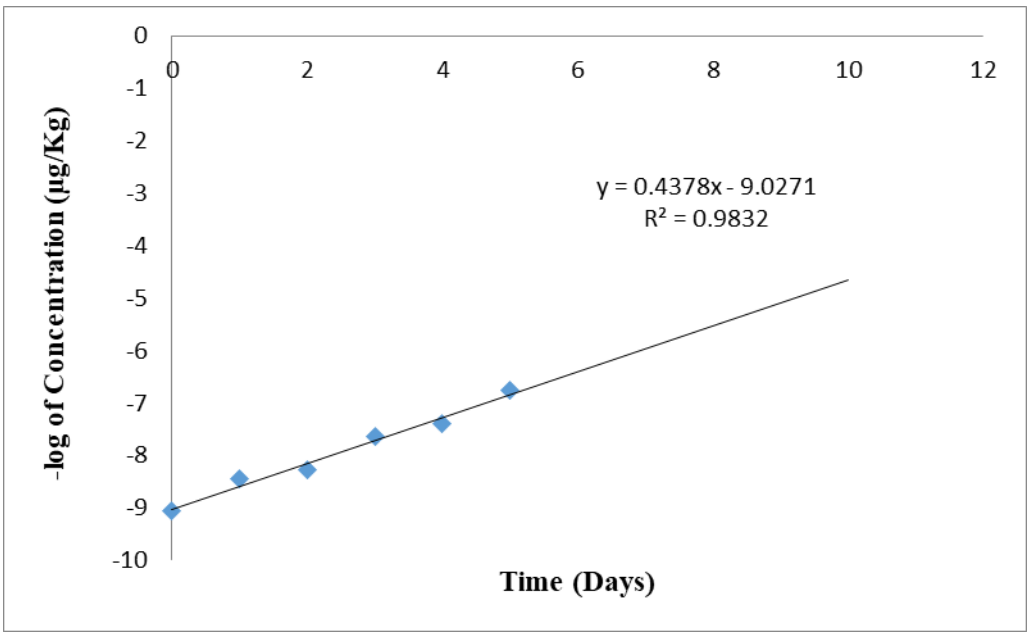

Figure 4. 20. Regression Curve for Cypermethrin degradation in Soil at Site 3 in dry Season

The regression graph for the degradation of deltamethrin is in Figure 4.21.

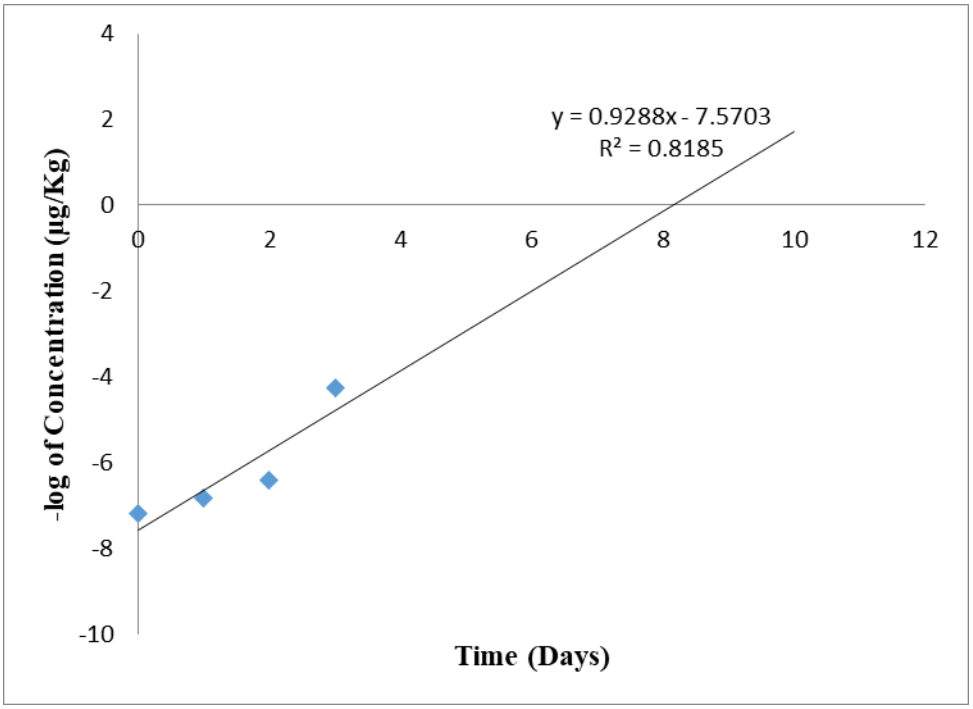

Figure 4. 21. Regression Curve for Deltamethrin degradation in Soil at Site 3 in dry Season

From the regression curve (dry season) and using equation 4, Y = 0.4378X-9.0271 (Figure 4.20) and. Y = 0.9288X-7.5703 (Figure 4.21) for cypermethrin and deltamethrin respectively. A gradient of 0.4378 and 0.9288 for cypermethrin and deltamethrin was obtained (equal to the constant K_{obs}).

The regression graph for the degradation of cypermethrin (Figure 4.22).

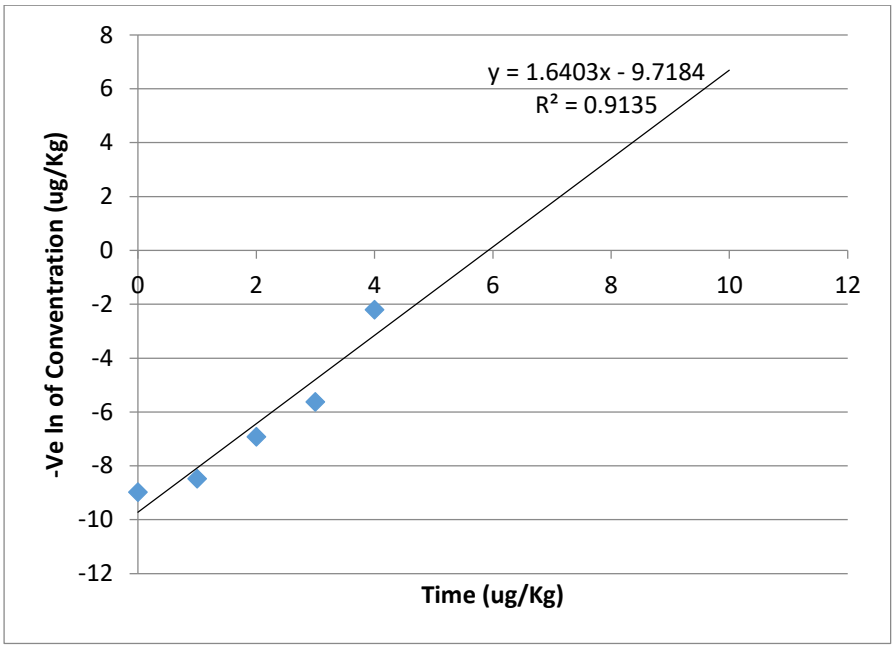

Figure 4. 22. Regression Curve for Cypermethrin degradation in soil at Site 3 in wet season

The regression graph for the degradation of deltamethrin is in Figure 4.23.

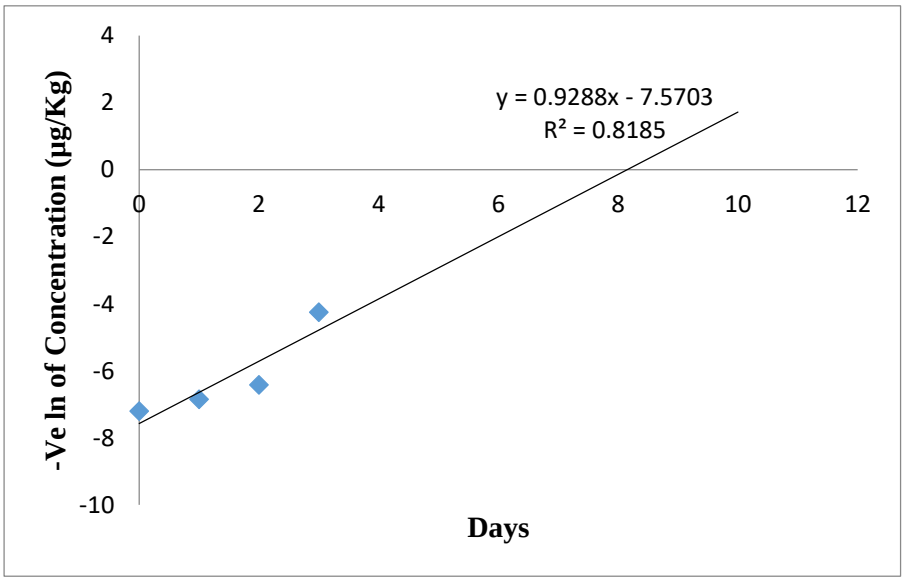

Figure 4. 23. Regression Curve for Deltamethrin degradation in Soil at Site 3 in Wet Season

From the regression curve (wet season) and using equation 4, Y = 1.6403X-9.7184 (Figure 4.22) and. Y = 0.9288X-7.5703 (Figure 4.23) for cypermethrin and deltamethrin respectively. A gradient of 1.6403 and 0.9288 for cypermethrin and deltamethrin was obtained (similar to the constant K_{obs}).

In the current research the dissipation of cypermethrin and deltamethrin (dry season) follows Langmuir-Hinshelwood kinetic equation and using half-life equation, the half-life of cypermethrin and deltamethrin in soil from Site 3 were 1.6 days and 0.75 days respectively by the Langmuir-Hinshelwood kinetic model.

The current research shows the degradation of cypermethrin and deltamethrin (wet season) follows Langmuir-Hinshelwood kinetic equation and using equation 7, the half-life of Cypermethrin and deltamethrin in soil was 0.42 days and 0.75 days respectively by the Langmuir-Hinshelwood kinetic model.

4.10.4 Dissipation Rate of Acaricides in Soil from Site 4 in Dry and Wet Seasons

Site 4 use cypermethrin to spray animals during the dry season. The data for the degradation of cypermethrin in soil from the site is in Table 4.19.

Table 4. 19. Cypermethrin Dissipation Rate in Soil (µg/Kg) from Site 4 in Dry Season

Days After Application	Cypermethrin (µg/Kg)	% Reduction
0	3,041±33.15	0
1	2,870±51.08	6
2	2,657±64.2	14
3	2,136±17.9	30
4	1,821±22.84	41
5	1,784±6.32	42
7	645±18.2	79
10	≤0.022	100

The farmer at Site 4 used cypermethrin during the wet season to spray animals.

Table 4. 20. Cypermethrin Dissipation in Soil (µg/Kg) from Site 4 in Wet Season

Days after application	Cypermethrin(µg/Kg)	% Reduction
0	4832±86.7	0
1	2195±50.5	55
2	927±41.3	81
3	304±12.6	96
4	65±8.1	99
5	≤0.022	100
7	≤0.022	100
10	≤0.022	100

The trend of dissipation (Figure 4.24) was gotten by drawing residue level of cypermethrin against period in days for sprayed soil from Site 4 in dry seasons

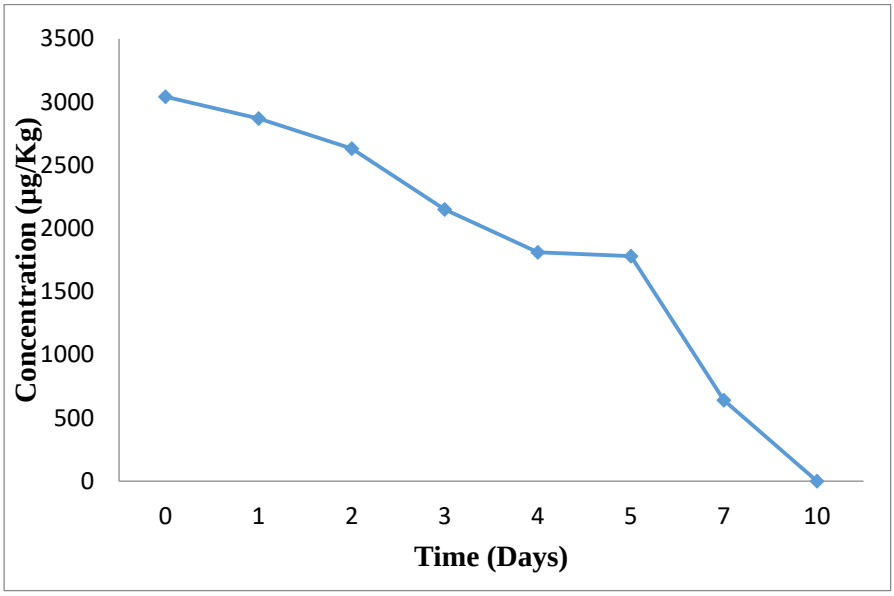

Figure 4. 24. Trends of Cypermethrin Dissipation in Soil at site 4 in Dry Season

Residue level of cypermethrin in soil (dry season) reduced with period (Figure 4.24). The first mean concentration of cypermethrin was 3,041±33.15µg/Kg and the last concentration was BDL in day 10. At day five the acaricide could not be detected in the soil showing a very first degradation.

The trend of dissipation (wet season) was gotten by drawing residue level of cypermethrin against period in days for sprayed soil from Site 4.

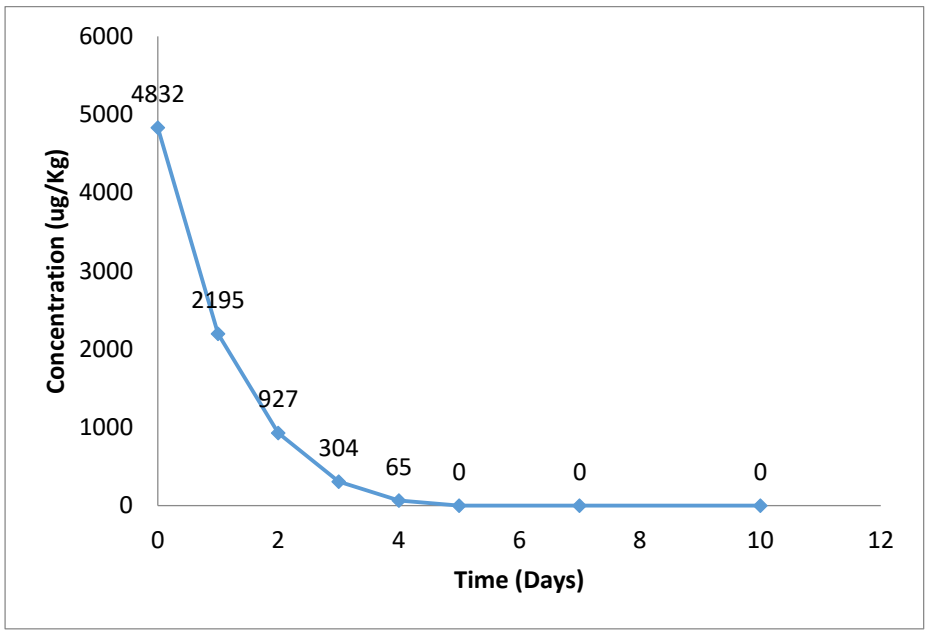

Figure 4. 25: Cypermethrin Dissipation in Soil at Site 4 in Wet Season

Residue level of cypermethrin in soil reduced over time (Figure 4.25). The first mean concentration of cypermethrin was 4,832±86.7 µg Kg^{-1} (diurnal l 0) and the last concentration was BDL on day 10. At day five the acaricide could not be detected in the soil showing a very first degradation. The regression graph for the degradation of cypermethrin (Figure 4.25).

The regression graph for the degradation of cypermethrin (Figure 4.26).

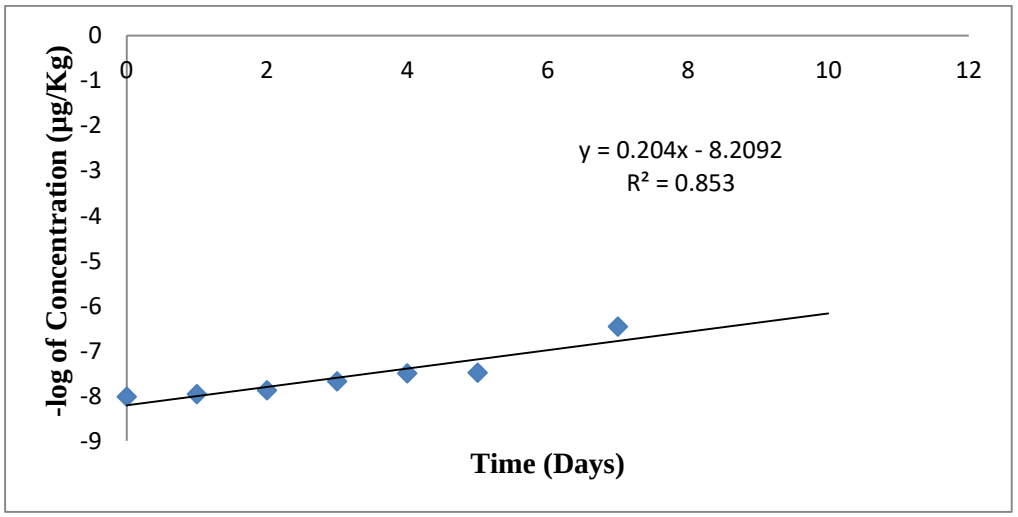

Figure 4. 26. Regression Curve for Cypermethrin degradation in Soil at Site 4 in dry Season

From the regression curve and using equation 7, Y = 0.204X+8.2092 for cypermethrin (Figure 4.26).

A slope of 0.204 was obtained (corresponding to constant K_{obs}).

The regression graph for the degradation of cypermethrin (Figure 4.27).

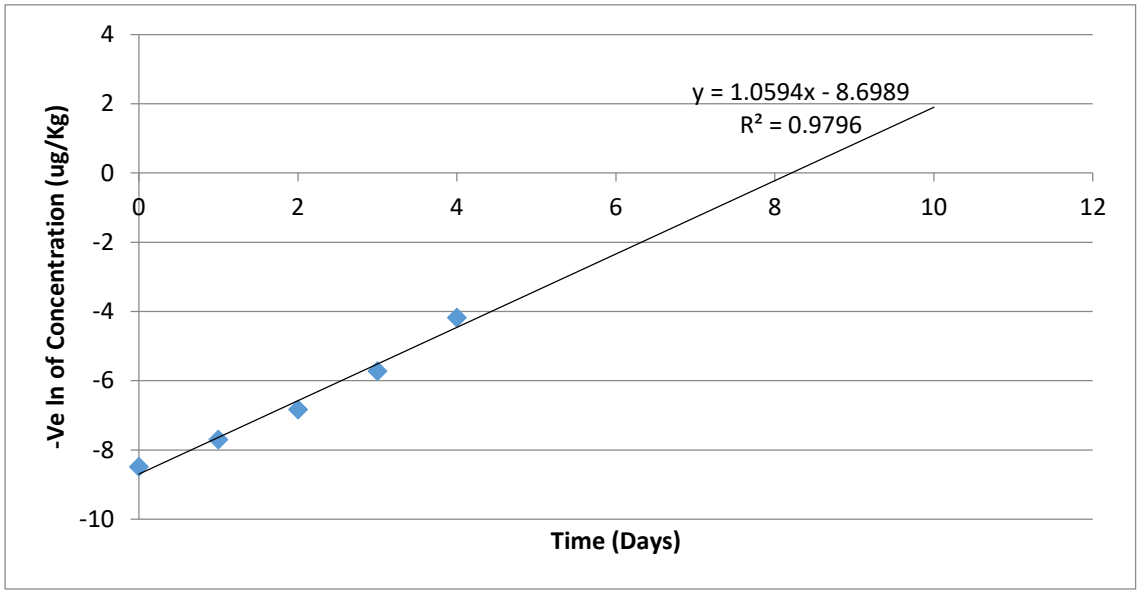

Figure 4. 27: Regression Curve for Cypermethrin degradation in Soil at Site 4 in Wet Season

From the Wet season, the regression curve (Figure 4.27) and using straight line equation, Y = 1.0594X + 8.6989 for cypermethrin. A slope of 1.0594 was obtained (hence equal to the constant K_{obs}). In the study the dissipation of cypermethrin (dry season) follows Langmuir-Hinshelwood kinetic equation and using half- life equation , the half-life of cypermethrin in soil from Site 4 was 3.4 days by the Langmuir-Hinshelwood kinetic model.

In this research the dissipation of amitraz (wet season) follows Langmuir-Hinshelwood kinetic equation and using equation, the half-life of cypermethrin in soil Site 4 four was 0.65 days by the Langmuir-Hinshelwood kinetic model.

4.10.5 Dissipation Rate of Acaricides in Soil from Site 5 in Dry and Wet Seasons

The acaricides used at Site 5 to spray animals are cypermethrin and deltamethrin. The data for the reduction of cypermethrin and deltamethrin in soil from home five are in Table 4.21.

Table 4. 21: Cypermethrin and Deltamethrin dissipation rate in Soil at Site 5 in Dry Season

Days after application	Cypermethrin (µg/Kg)	(%) Reduction	Deltamethrin (µg/Kg)	(%) Reduction
0	8,423±79.2	0	8,167±16.4	0
1	5,076±45.3	40	4,761±81.3	42
2	4,317±45	49	3,179±6.6	61
3	3,988±51.0	53	2,017±12.2	75
4	2,348±66.4	73	1,220±87	85
5	1,092±45.2	88	628±14.0	92
7	509±21.05	94	≤0.026	100
10	≤0.022	100	≤0.026	100

During the wet season the farmer at Site 5 used amitraz to spray animals. The results based on dry mass for the degradation of amitraz in soil (wet season) from Site 5 are in Table 4.22.

Table 4. 22. The Amitraz Dissipation Rates in Soil (µg/Kg) from Site 5 in Wet Season

Days after application	Amitraz (µg/Kg)	(%) Reduction
0	4832±86.7	0
1	2195±50.5	55
2	927±41.3	81
3	304±12.6	94
4	65±8.1	99
5	≤0.034	100
7	≤0.034	100
10	≤0.034	100

The dissipation curve was gotten by drawing residue level of cypermethrin and deltamethrin versus time in days for sprayed soil at Site 5 in dry season (Figure 4.28).

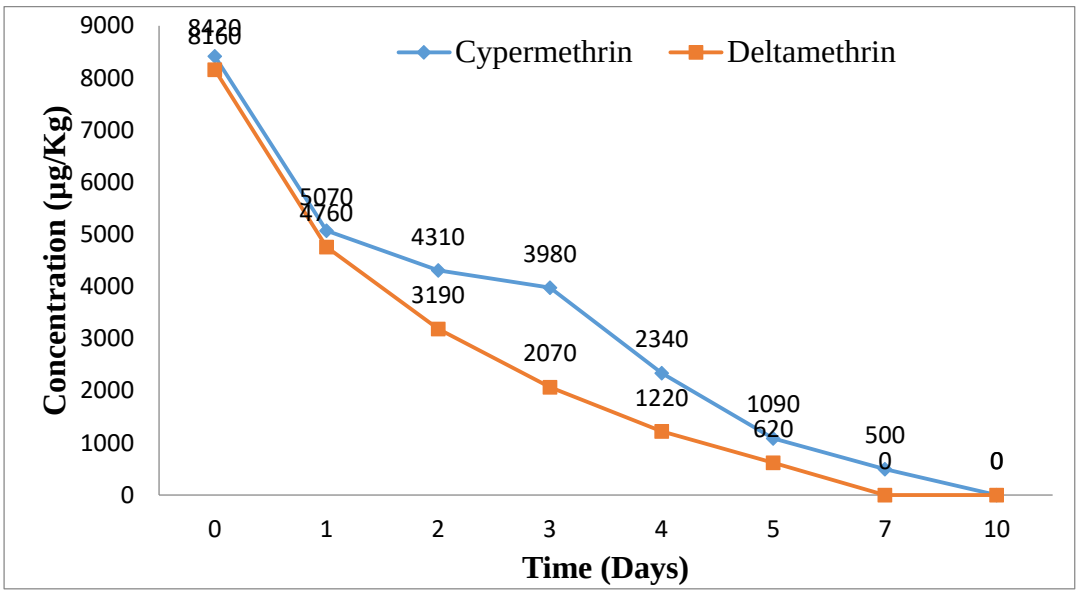

Figure 4. 28: Cypermethrin and Deltamethrin Dissipation in Soil at Site 5 in Dry Season

Residue level of cypermethrin in soil reduced with period (Figure 4.28). The first mean concentration of cypermethrin was 8,423±79.2µg/Kg (diurnal 0) and last concentration was BDL on day 10. The residue level of deltamethrin in soil reduced with period (Figure 4.28). The mean initial concentration of deltamethrin was 8,167±16.4µg/Kg (diurnal 0) and the final residue was BDL on day 10.

The dissipation in wet season was gotten by drawing determined residue level of Amitraz versus time in days for sprayed soil from site 5 in wet season (Figure 4.29)

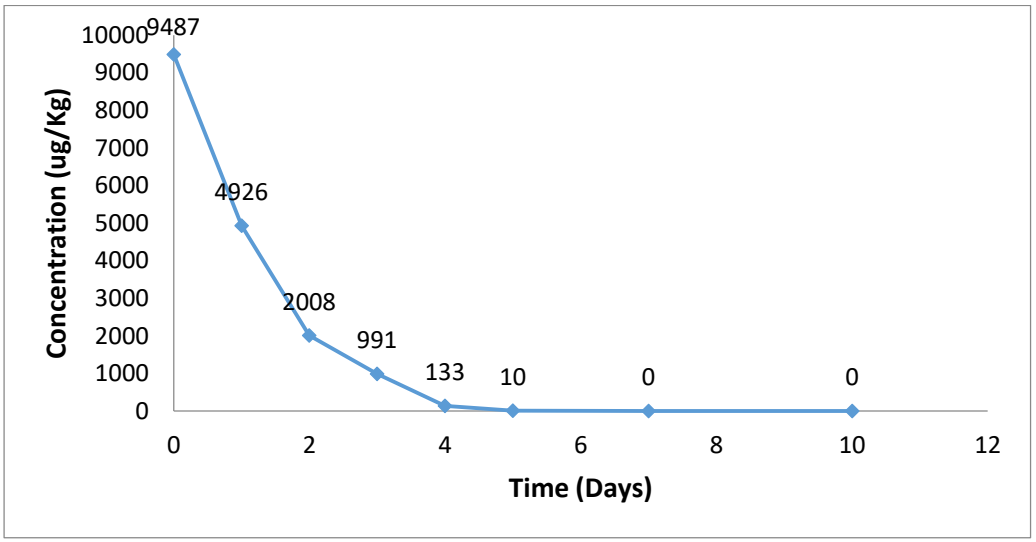

Figure 4. 29: Amitraz dissipation rate in Soil at Site 5 in Wet Season

Residue level of amitraz in soil reduced with time (Figure 4.29). The first mean residue level of Amitraz in home five was 9,487±103.1 µg/Kg (diurnal 0) and last concentration was BDL on day 10. At day seven the acaricide could not be detected in the soil showing a very first degradation.

The regression graph for the degradation of cypermethrin (Figure 4.30).

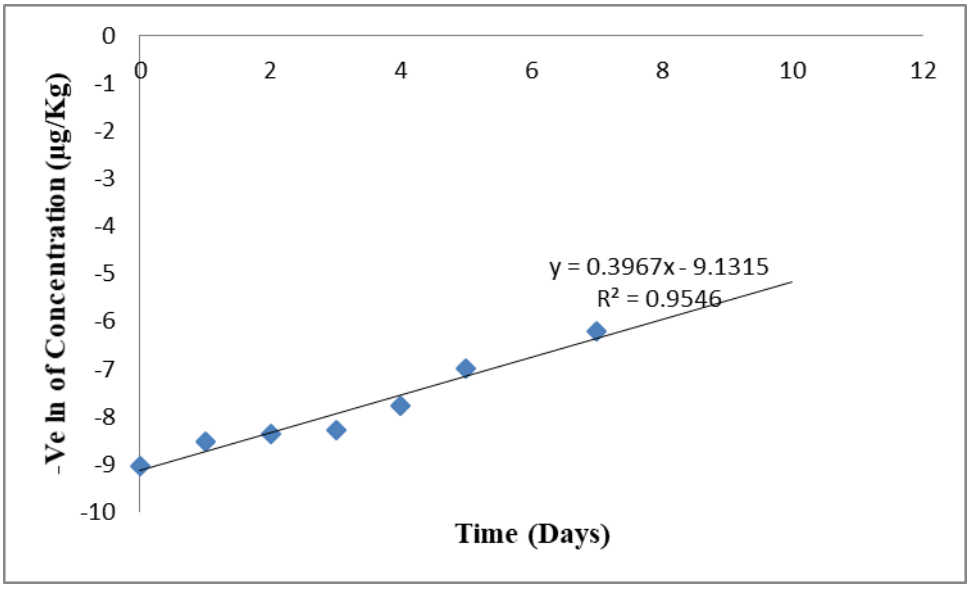

Figure 4. 30. Regression Curve for Cypermethrin degradation in Soil at Site 5 in Dry Season

The regression graph for the degradation of deltamethrin is shown in Figure 4.31.

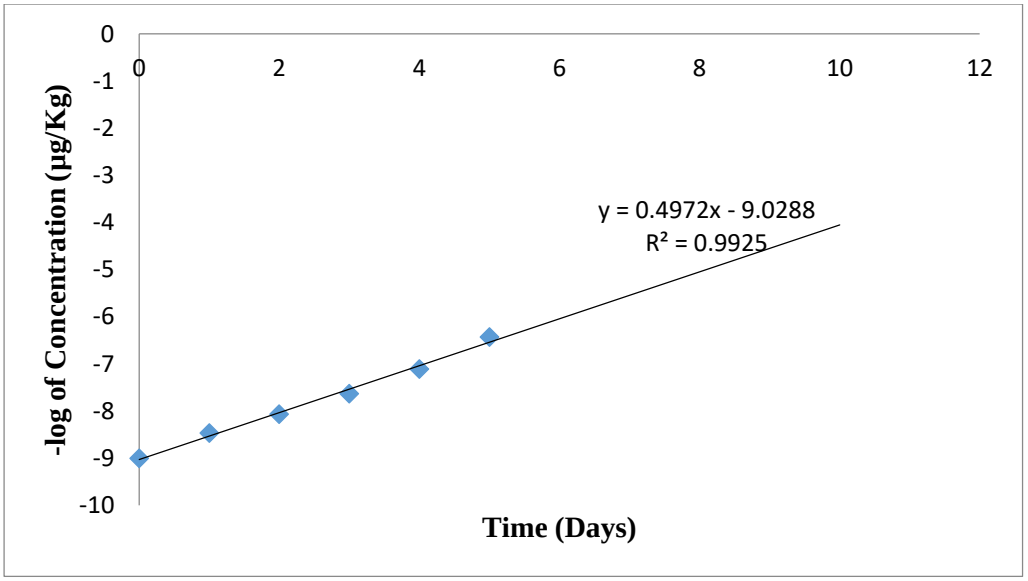

Figure 4. 31 : Regression Curve for Deltamethrin degradation in Soil at Site 5 in dry Season

From the regression curve and using straight line equation, Y = 0.397X+9.1395 (Figure 4.30) and. Y

= 0.4972X+9.0288 (Figure 4.31) for cypermethrin and deltamethrin, respectively. A gradient of 0.3967 and 0.4972 for cypermethrin and deltamethrin was obtained (which is the same as constant K_{obs}).

The regression graph for the degradation of amitraz (Figure 4.32).

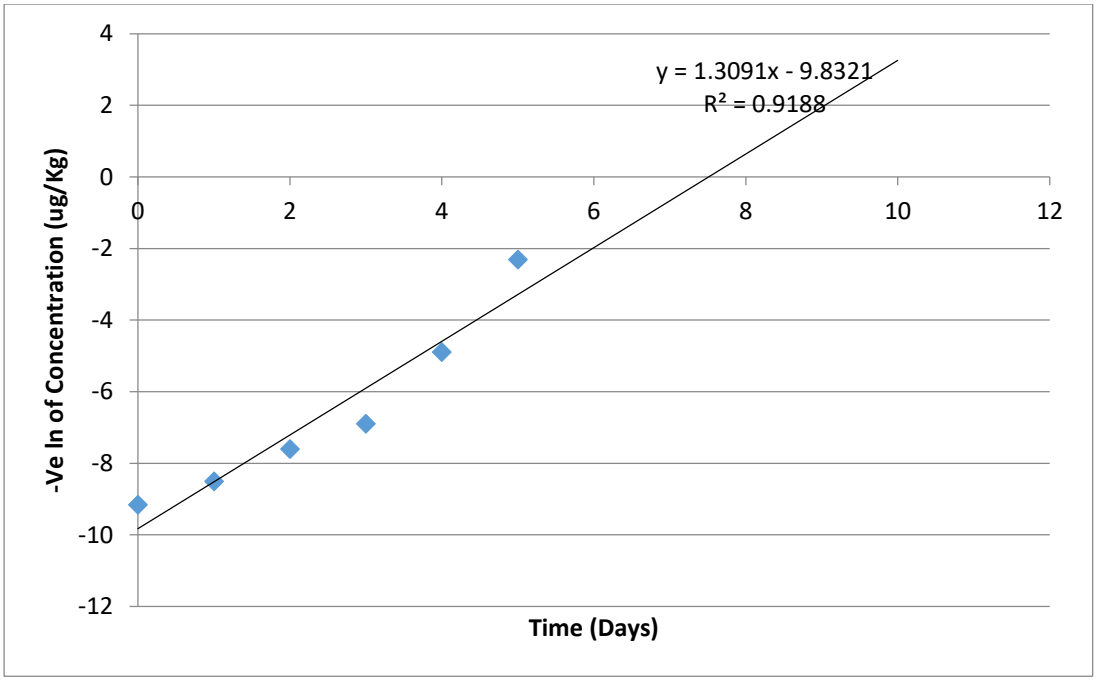

Figure 4. 32: Regression Curve for Amitraz degradation in Soil at Site 5 in Wet Season

From the regression curve and using straight line equation, Y = 1.3091X+9.8321 for amitraz. A slope of 1.3091 was obtained (equal to the constant K_{obs})

In the current research, the dissipation of cypermethrin and deltamethrin (dry season) follows Langmuir-Hinshelwood kinetic equation and using half-life equation , the half-life of Cypermethrin and deltamethrin in soil in Site 5 were 1.74 days and 1.39 days respectively by the Langmuir-Hinshelwood kinetic model.

In this research the dissipation of amitraz in the wet season follows Langmuir-Hinshelwood kinetic equation and using half-life equation, the half-life of amitraz in soil from site 5 was 0.53 days by the Langmuir-Hinshelwood kinetic model.

4.10.6 Dissipation Rate of Acaricides in Soil from Site 6 in Dry and Wet Seasons

The farmer in Site 6 used amitraz to spray livestock. The data for the degradation of amitraz in soil

from Site 6 is shown in Table 4.23.

Table 4. 23: The Amitraz Dissipation in Soil (µg/Kg) from Site 6 in Dry Season

Days after application	Amitraz (µg/Kg)	(%) Reduction
0	6412±65.1	0
1	3338±22.8	48
2	2163±76.9	66
3	1046±3.87	84
4	957±18.4	85
5	8±0.07	99.89
7	≤0.034	100
10	≤0.034	100

Site 6 use amitraz during the wet season to spray their animals. The data for the degradation of amitraz in soil from Site 6 is shown in Table 4.24.

Table 4. 24. The Amitraz Dissipation Rate in Soil from Site 6 in Wet Season

Days after application	Amitraz(µg/Kg)	(%) Reduction
0	6194±120.6	0
1	2866±79.1	54
2	1241±51.3	80
3	667±46.1	89
4	129±6.7	98
5	≤0.034	100
7	≤0.034	100
10	≤0.034	100

The dissipation rates were obtained by plotting determined residue level of amitraz versus time in days for sprayed soil at Site 6 (Figure 4.33).

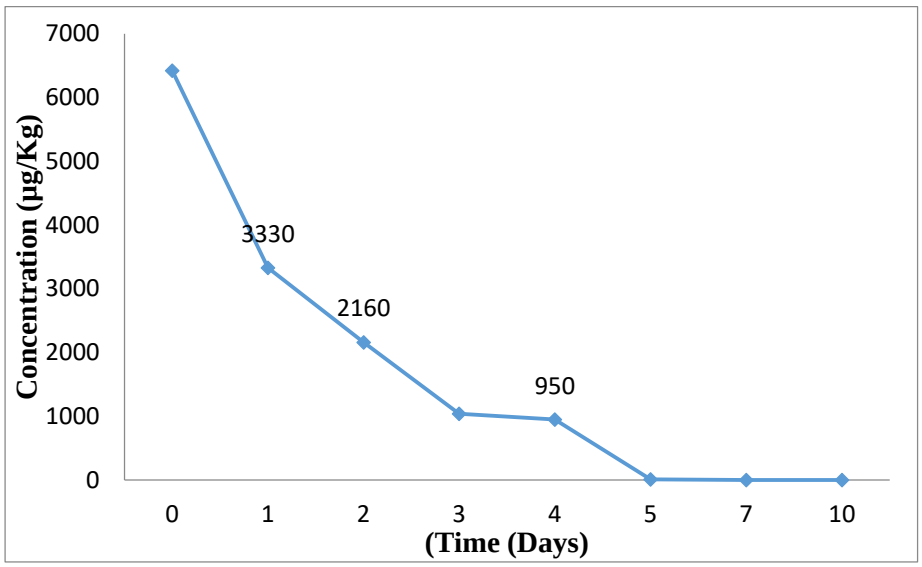

Figure 4. 33: The Amitraz Dissipation Rate in Soil from Site 6 in Dry Season

The residue level of amitraz in soil decreased with period (Figure 4.33). The first mean concentration of amitraz was 6,412±65.1 µg/Kg (diurnal 0) and the last concentration was BDL on day 10.

The dissipation rate for Amitraz was gotten by plotting determined residue level of amitraz versus time in days for sprayed soil from site 6 in wet season (Figure 4. 34)

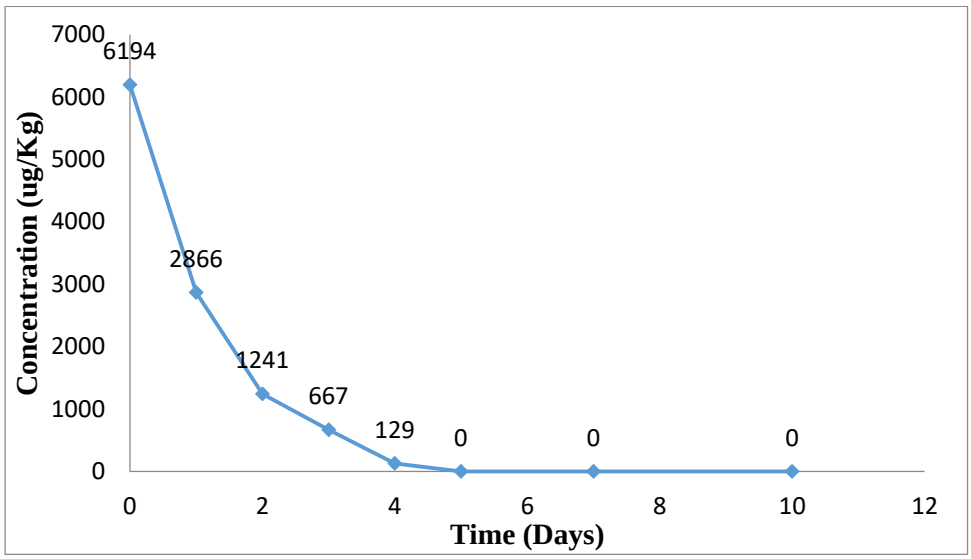

Figure 4. 34. Amitraz dissipation rates in Soil at Site 6 in Wet Season

The residue level of amitraz in soil reduced with time (Figure 4.34). The first mean concentration of amitraz was 6,194 ± 120.6µg/Kg (diurnal 0) and last concentration was BDL on day 10.

The regression graph for the degradation of amitraz is shown in Figure 4.35.

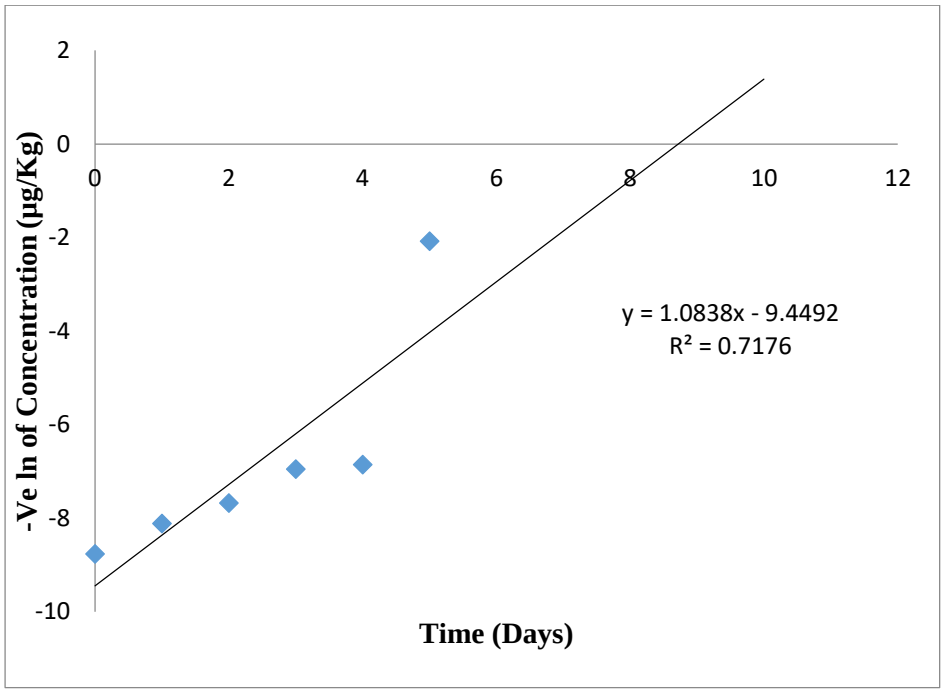

Figure 4. 35: Regression Curve for Amitraz degradation in Soil at Site 6 in Dry Season

From the regression curve (Figure 4.35) and using equation for straight line, Y = 1.0838X-9.4492 slope for amitraz obtained. A slope of 1.0838 was obtained (which is corresponding to the constant K_{obs}).

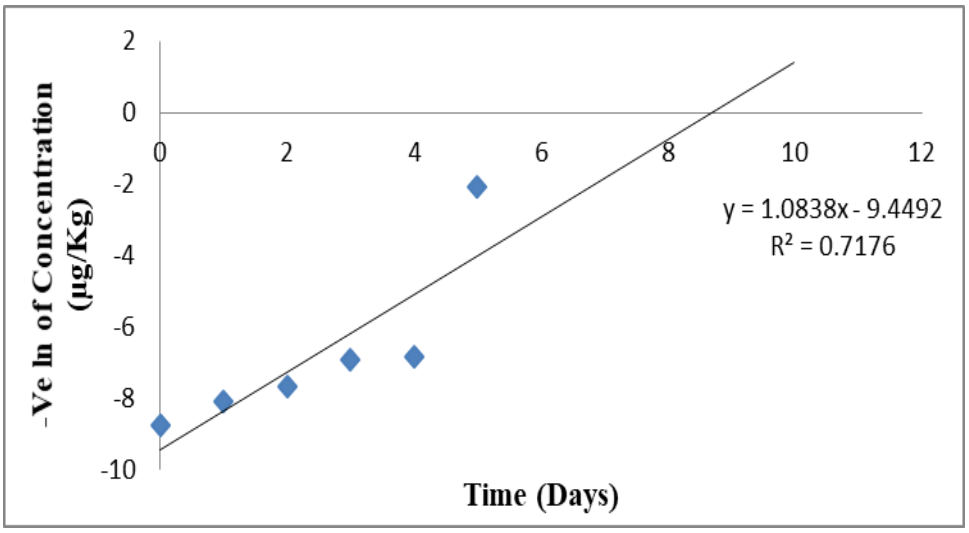

Figure 4. 36. Regression curve for of Amitraz degradation in soil at site 6 in wet season

From the regression curve in Figure 4.36 and using straight line equation, Y = 0.9201X-8.8758, the gradient for amitraz was obtained. A slope of 0.9201 was obtained (same as constant K_{obs}).

In this research the dissipation for amitraz follows Langmuir-Hinshelwood kinetic equation and using half-life equation, the half-life of amitraz in soil from Site 6 was 0.64 days in dry season by the Langmuir-Hinshelwood kinetic model.

The current research degradation for amitraz follows Langmuir-Hinshelwood kinetic equation and using equation 7, the half-life of amitraz in soil from site 6 was 0.75 days in wet season by the Langmuir-Hinshelwood kinetic model.

4.10.7 Dissipation Rate of Acaricides in Soil from Site 7 in Dry and Wet Seasons

The farmer at Site 7 used amitraz to spray animals. The data for the dissipation of amitraz in soil from site seven is in Table 4.25.

Table 4. 25: Amitraz dissipation in Soil (µg/Kg) from Site 7 in Dry Season

Days after application	Amitraz (µg/Kg)	(%) Reduction
0	10,641±144.2	0
1	6,226±171.7	42
2	5,338±92.9	50
3	4,017±66.7	62
4	2,696±32.4	75
5	1,128±68.17	89
7	501±22.1	95
10	≤0.034	100

The farmer from Site 7 use cypermethrin in wet season to spray animals. The data for the degradation of cypermethrin in soil from Site 7 is shown in Table 4.26.

Table 4. 26: Cypermethrin Dissipation Rate in Soil (µg/Kg) from Site 7 in Wet Season

Days after application	Cypermethrin(µg/Kg)	(%) Reduction
0	8694±146.9	0
1	4241±61.3	51
2	2067±84.1	76
3	834±17.6	90
4	244±20.8	97.2
5	22±1.7	99.7
7	≤0.022	100
10	≤0.022	100

The dissipation rate for Amitraz was obtained by plotting determined residue level of amitraz against time in days for sprayed soil from site 7 in dry season (Figure 4.37)

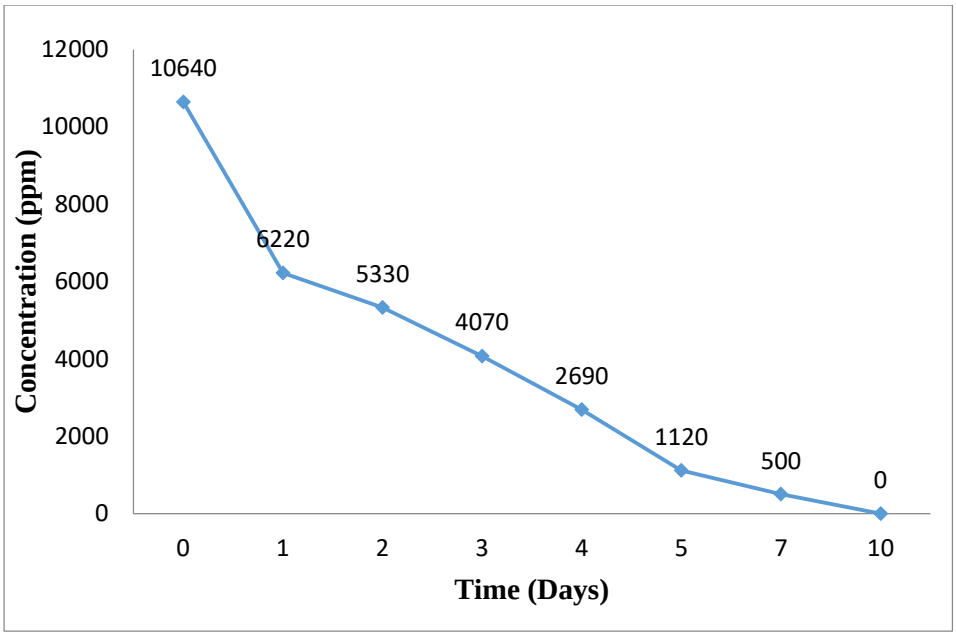

Figure 4. 37. Amitraz dissipation Rate in Soil at Site 7 in Dry Season

The residue level of amitraz in soil reduced with time (Figure 4.37). The first mean residue level of amitraz was 10,641±144.2 µg/Kg (diurnal 0) and the last concentration was BDL on day 10.

The degradation rate in wet season (Figure 4.38) was gotten by drawing determined residue level of cypermethrin against period in days for sprayed soil from site 7

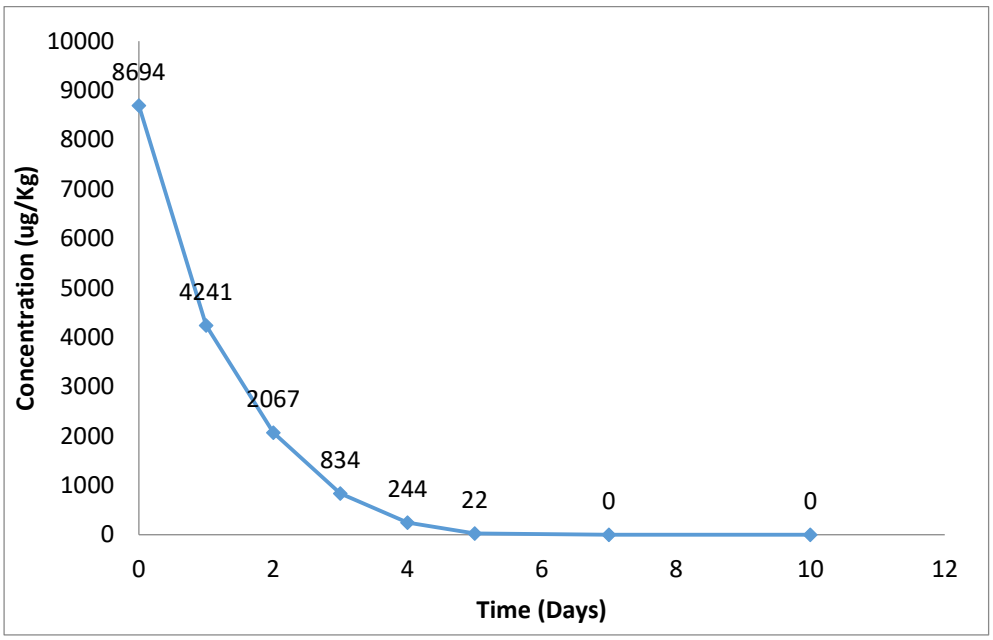

Figure 4. 38. Cypermethrin Dissipation Rate in Soil at Site 7 in Wet Season

The residue level of cypermethrin in soil reduced with period (Figure 4.38). The first mean concentration of cypermethrin was 8694 ± 146.9µg/Kg (diurnal 0) and the last concentration was BDL on day 10.

The regression graph for the degradation of amitraz in soil in dry season is shown in Figure 4.39.

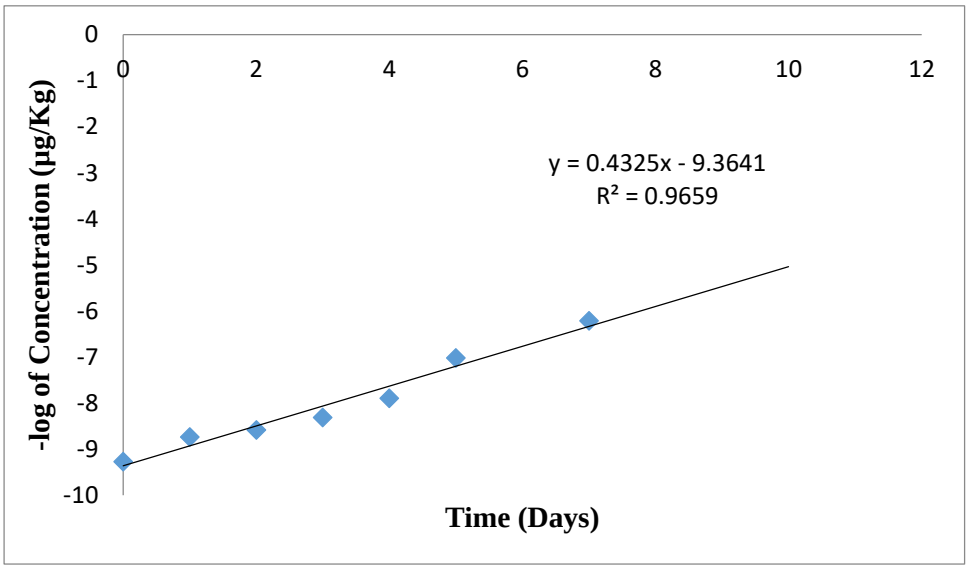

Figure 4. 39. Regression Curve for Amitraz degradation in Soil at Site 7 in dry Season

From the regression graph in Figure 4.39 and using equation for straight line, Y = 0.4325X-9.3641 for amitraz. A slope of 0.4325 was obtained (similar to constant K_{obs}). The regression graph for the

degradation of cypermethrin (Figure 4.40).

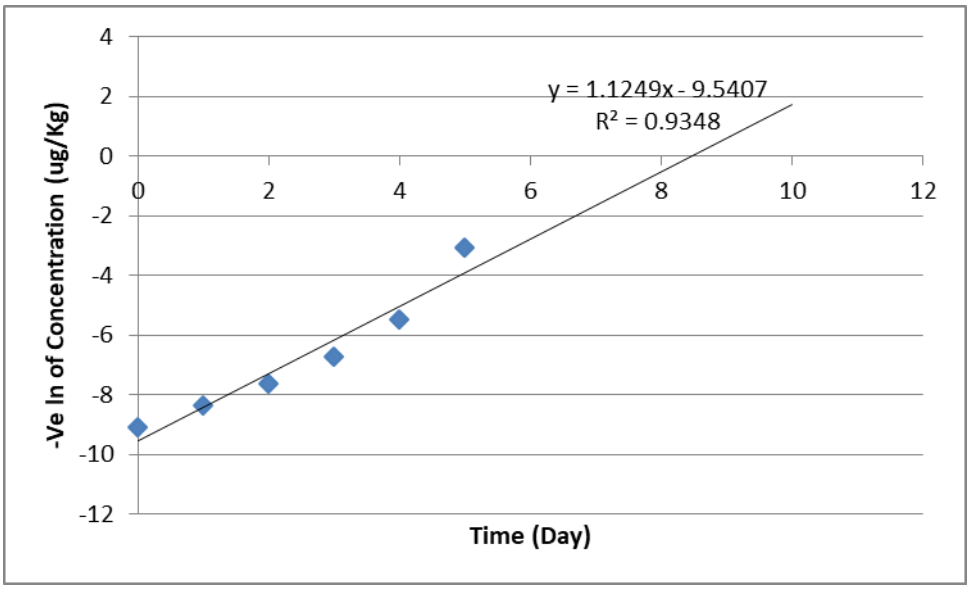

Figure 4. 40. Regression Curve for Cypermethrin degradation in Soil at Site 7 in Wet Session

From the regression graph (Figure 4.40) and using straight line equation, Y = 1.1249X - 9.5407 for amitraz. A slope of 1.124 was obtained (equal to constant K_{obs}).

From the research, the dissipation of amitraz (dry season) follows Langmuir-Hinshelwood kinetic equation and using equation for half-life, the half-life of amitraz in soil from site 7 was 1.60 days by the Langmuir-Hinshelwood kinetic model.

Current research dissipation of cypermethrin (Wet season) follows Langmuir-Hinshelwood kinetic equation and using equation for straight line, the half-life of cypermethrin in soil from home seven was 0.62 days in soil in wet season by the Langmuir-Hinshelwood kinetic model.

4.10.8 Dissipation Rate of Acaricides in Soil from Site 8 in Dry and Wet Seasons

The farmer from site 8 used Amitraz during dry season to spray animals. The data for the degradation of amitraz in soil from site 8 are in Table 4.27.

Table 4. 27: The Amitraz Dissipation Rate in Soil (µg/Kg) from Site 8 in Dry Season

Days after application	Amitraz (µg/Kg)	(%) Reduction
0	1970±91.3	0
1	562±35.1	72
2	90±8.74	96
3	≤0.034	100
4	≤0.034	100
5	≤0.034	100
7	≤0.034	100
10	≤0.034	100

The farmer at site 8 used amitraz during wet season to spray the animals. The data for the degradation of amitraz in soil from site 8 are in Table 4.28.

Table 4. 28. Amitraz Dissipation in Soil (µg/Kg) from Site 8 in Wet Season

Days after application	Amitraz (µg/Kg)	(%) Reduction
0	3875±97.3	0
1	1682±41.7	57
2	594±11.1	85
3	98±10.4	97.5
4	1.3±0.71	99.97
5	≤0.034	100
7	≤0.034	100
10	≤0.034	100

The dissipation rate (Figure 4.41) was gotten by drawing residue level of Amitraz against period in days for sprayed soil from site 8 in dry season.

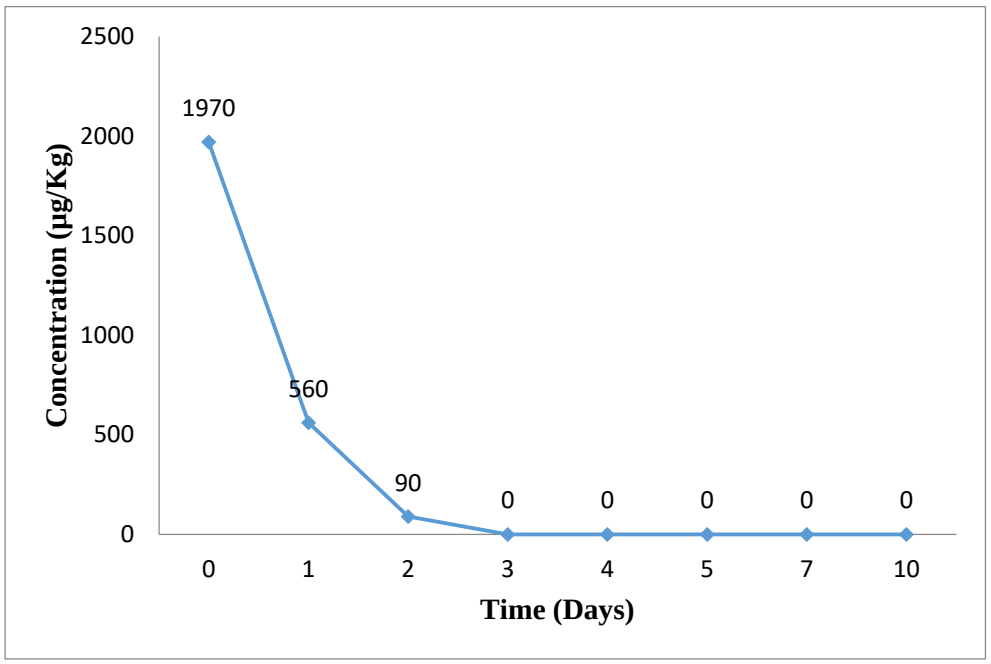

Figure 4. 41: Amitraz Dissipation rates in Soil at Site 8 in Dry Season

The concentration of amitraz in soil reduced with time (Figure 4.41). The first mean concentration of amitraz was 1970±91.3 µg/Kg (diurnal 0) and last concentration was BDL on day 10.

The dissipation rate in wet season (Figure 4.42) was gotten by drawing determined concentration of Amitraz against period in days for sprayed soil.

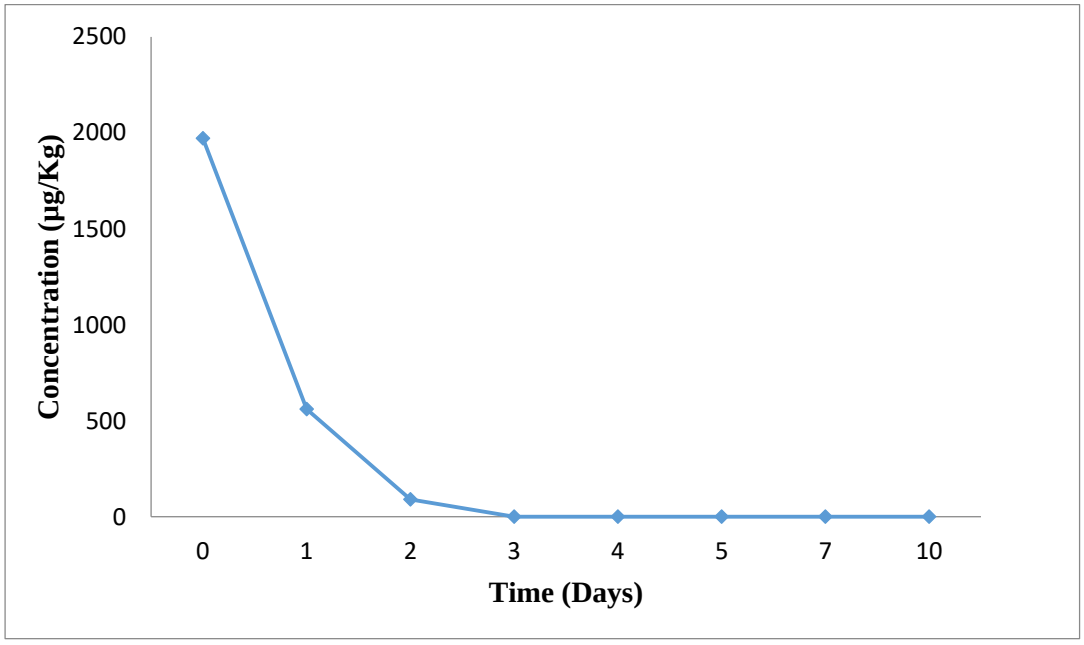

Figure 4. 42. Amitraz Dissipation rates in Soil at Site 8 in Wet Season

The residue level of amitraz in soil reduced with period (Figure 4.42). The first mean concentration of amitraz was 3875±97.3µg/Kg (diurnal 0) and last concentration was BDL on day 10.

The regression graph for the degradation of amitraz (Figure 4.43).

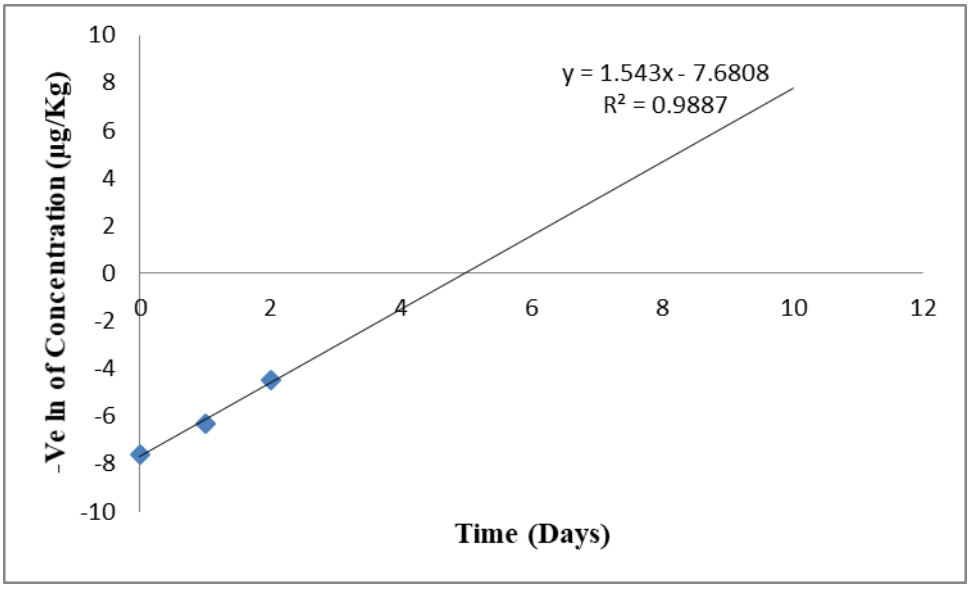

Figure 4. 43: Regression Curve for degradation of Amitraz in Soil from Site 8 in dry Season

From the regression graph (Figure 4.43) and using equation for straight line, Y = 1.543X-7.6808 for amitraz. A slope of 1.543 was obtained (same as constant K_{obs}).

The regression graph for the degradation of amitraz is shown in Figure 4.44.

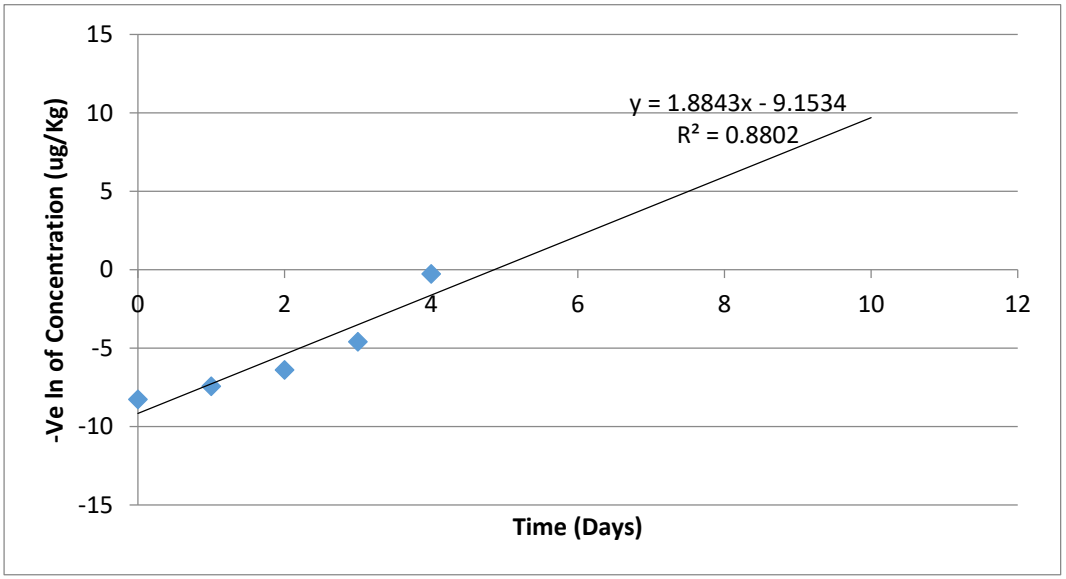

Figure 4. 44. Regression Curve for Amitraz degradation in Soil at Site 8 in Wet Season

From the regression graph (Figure 4.44) and using equation, Y = 1.8843X-9.1534 for amitraz. A slope

of 1.8843 was obtained (same as constant K_{obs}).

Current research the dissipation for amitraz (dry season) follows Langmuir-Hinshelwood kinetic equation and using equation 7, the half-life of amitraz in soil from home 8 was 0.45 days by the Langmuir-Hinshelwood kinetic model.

Current research dissipation for amitraz (wet season) follows Langmuir-Hinshelwood kinetic equation and using straight line equation, the half-life of amitraz in soil from home 8 was 0.37 days by the Langmuir-Hinshelwood kinetic model.

4.10.9 Dissipation Rate of Acaricides in Soil from Site 9 in Dry and Wet Seasons

In site 9, farmers used amitraz to spray the animals during the dry season. The data for the dissipation of amitraz in soil from Site 9 are in Table 4.29.

Table 4. 29: The Amitraz Dissipation in Soil (µg/Kg) From Site 9 in Dry Season

Days after application	Amitraz (µg/Kg)	(%) Reduction
0	3129±98.7	0
1	912±23.5	40
2	163±16.4	95
3	75±0.25	98
4	≤0.034	100
5	≤0.034	100
7	≤0.034	100
10	≤0.034	100

In site 9 the farmers used amitraz during wet season to spray the animals. The data for the degradation of amitraz in soil from site 9 is in Table 4.30.

Table 4. 30. Amitraz Dissipation in Soil (µg/Kg) From Site 9 in Wet Season

Days after application	Amitraz (µg/Kg)	(%) Reduction
0	4691±75.3	0
1	2234±23.8	52
2	996±14.1	79
3	354±8.1	92.5
4	67±3.9	97
5	0.9±0.00	99.9
7	≤0.034	100
10	≤0.034	100

The dissipation rate (Figure 4. 45) was gotten by drawing residue levels of amitraz against period in days for sprayed soil from site 9 in dry season

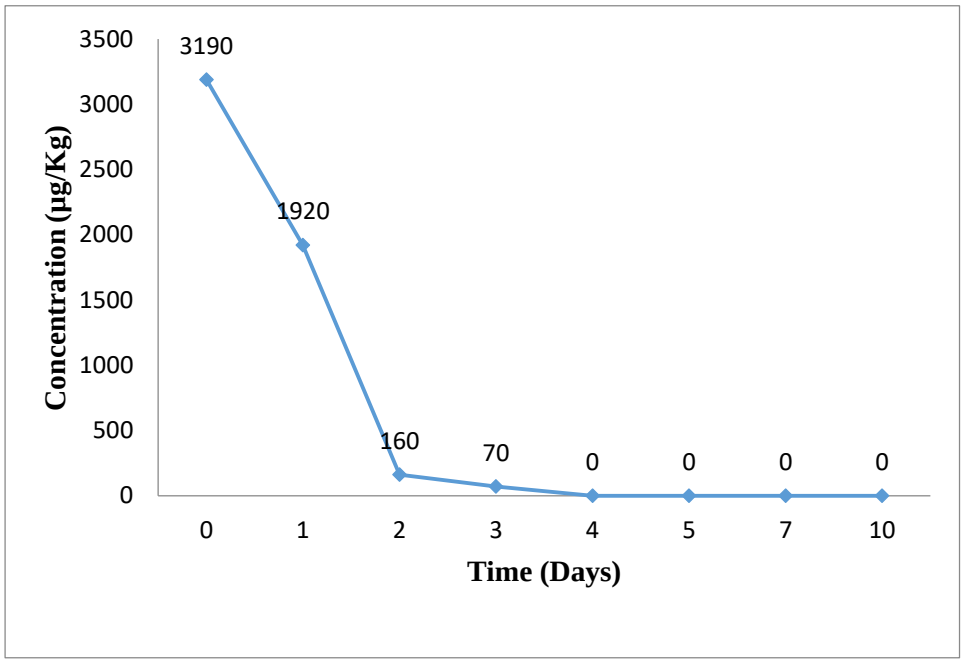

Figure 4. 45 : Amitraz Dissipation rates in Soil at Site 9 in dry Season

The residue level of amitraz in soil reduced with period (Figure 4.45). The first concentration of amitraz was 3129 ± 98.7 µg/Kg (diurnal 0) and last concentration was BDL on day 10.

The dissipation rate (Figure 4.46) was gotten by drawing determined residue level of amitraz against period in days for sprayed soil.

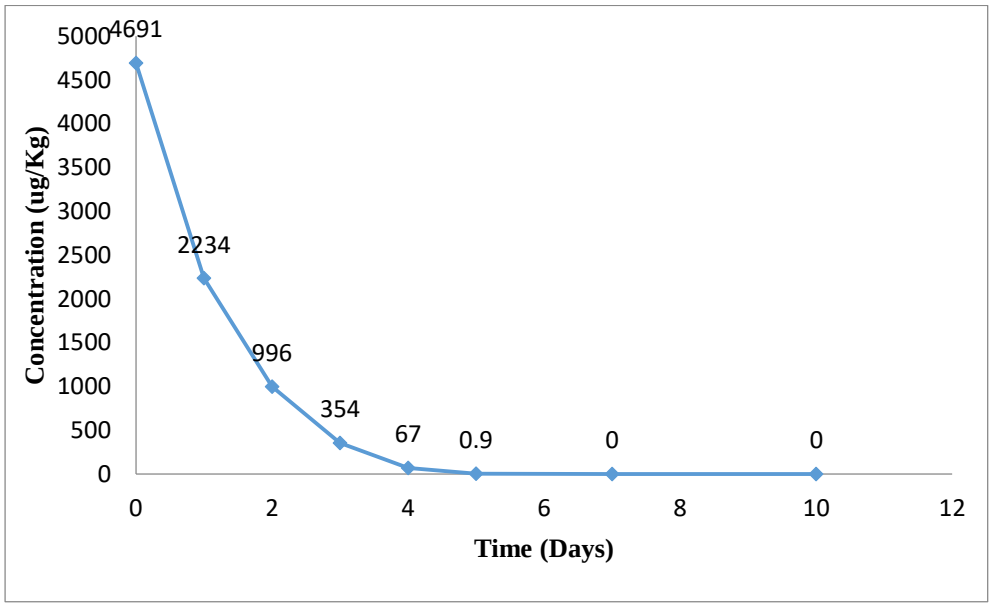

Figure 4. 46. Amitraz dissipation rates in Soil from Site 9 in Wet Season

The residue level of amitraz in soil reduced with period (Figure 4.46). The first mean concentration of amitraz was 4691±75.3 µg/Kg (diurnal 0) and last concentration was BDL on day 10.

The regression graph for the degradation of amitraz is soil from site 9 in dry season (Figure 4. 47).

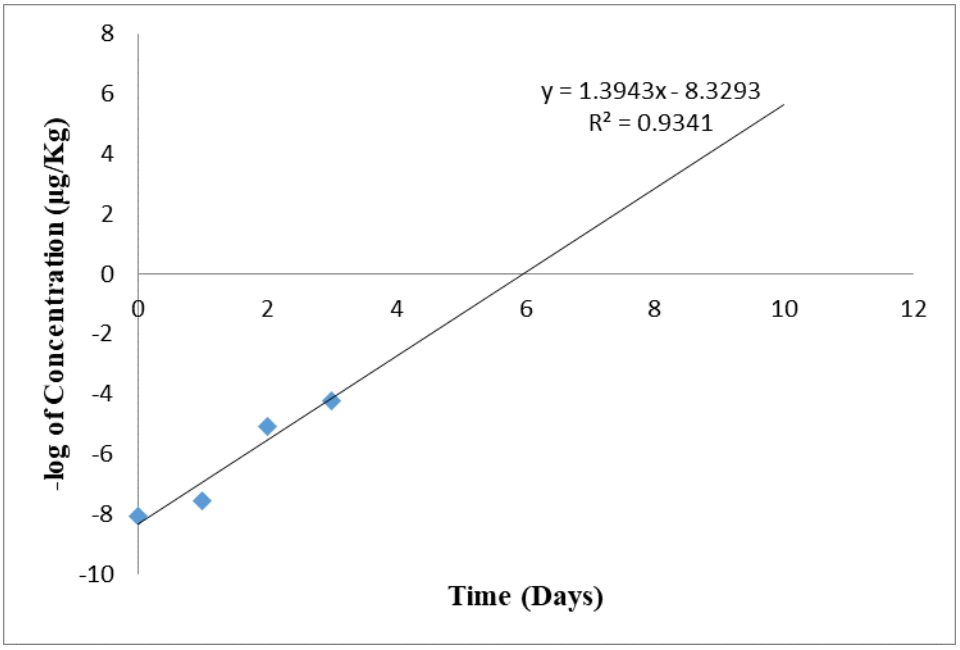

Figure 4. 47. Regression Curve for Amitraz degradation in Soil from Site 9 in dry Season

From the regression graph (Figure 4.47) and using straight line equation, Y = -1.3943X-8.3293 for amitraz. A slope of 1.3943 was obtained similar to constant K_{obs}).

The regression graph for the degradation of amitraz in soil from site 9 in wet season is in Figure 4.48.

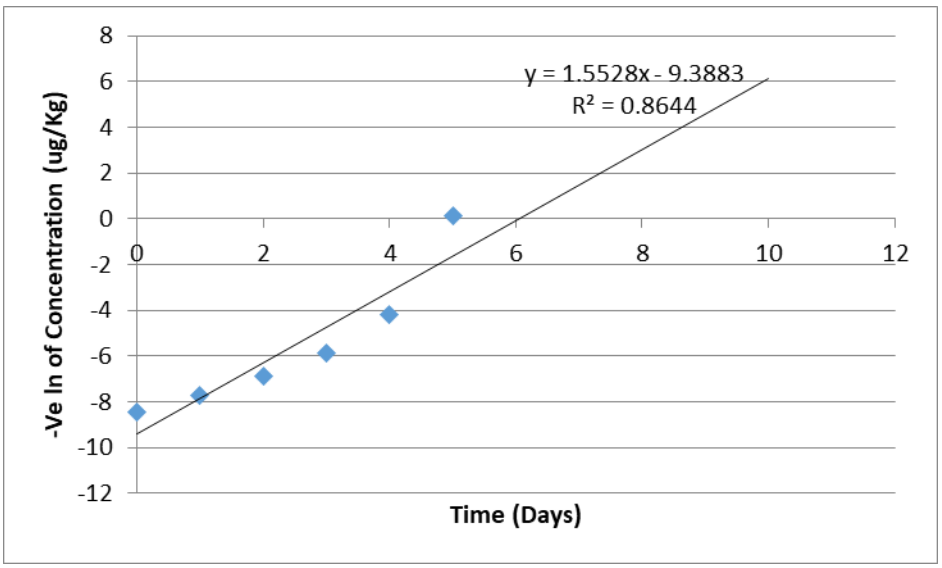

Figure 4. 48. Regression Curve for Amitraz degradation in Soil from Site 9 in wet season

From the regression graph and using equation 4, Y = 1.5528X-9.3883 for amitraz. A gradient of 1.5528 was obtained (equivalent to constant K_{obs}).

Current research degradation for amitraz follows Langmuir-Hinshelwood kinetic equation and using equation for half-life, the half-life of amitraz in soil from site 9 was 0.50 days in soil from site 9 in dry season by the Langmuir-Hinshelwood kinetic model.

Current research the degradation for amitraz follows Langmuir-Hinshelwood kinetic equation and using equation for half-life, the half-life of amitraz in soil from site 9 was 0.45 days in soil in wet season by the Langmuir-Hinshelwood kinetic model.

4.10.10 Dissipation Rate of Acaricides in Soil from Site 10 in Dry and Wet Seasons

The farmers at site 10 used amitraz to spray the animals during dry season. The data for the degradation of amitraz in soil from site 10 are in Table 4. 31.

Table 4. 31. Amitraz Dissipation Rate in Soil (µg/Kg) from Site 10 in Dry Season

Days After Application	Amitraz (µg/Kg)	(%) Reduction
0	6546±120.75	0
1	2914±31.8	56
2	1243±35.1	82
3	622±36.7	91
4	178±24.9	98
5	11±0.21	99
7	≤0.034	100
10	≤0.034	100

The farmers at site 10 use amitraz in wet season to spray the animals. The data for the degradation of amitraz in soil from site 10 are in Table 4.32.

Table 4. 32. Amitraz Dissipation in Soil (µg/Kg) from Site 10 in Wet Season

Days after application	Amitraz (µg/Kg)	(%) Reduction
0	7063±146.2	0
1	1671±31.6	76
2	892±10.4	87
3	325±11.9	95
4	4.1±0.00	99.94
5	≤0.034	100
7	≤0.034	100
10	≤0.034	100

The dissipation rate (Figure 4.49) was gotten by drawing residue level of Amitraz against period in days for sprayed soil from site 10 in dry season.

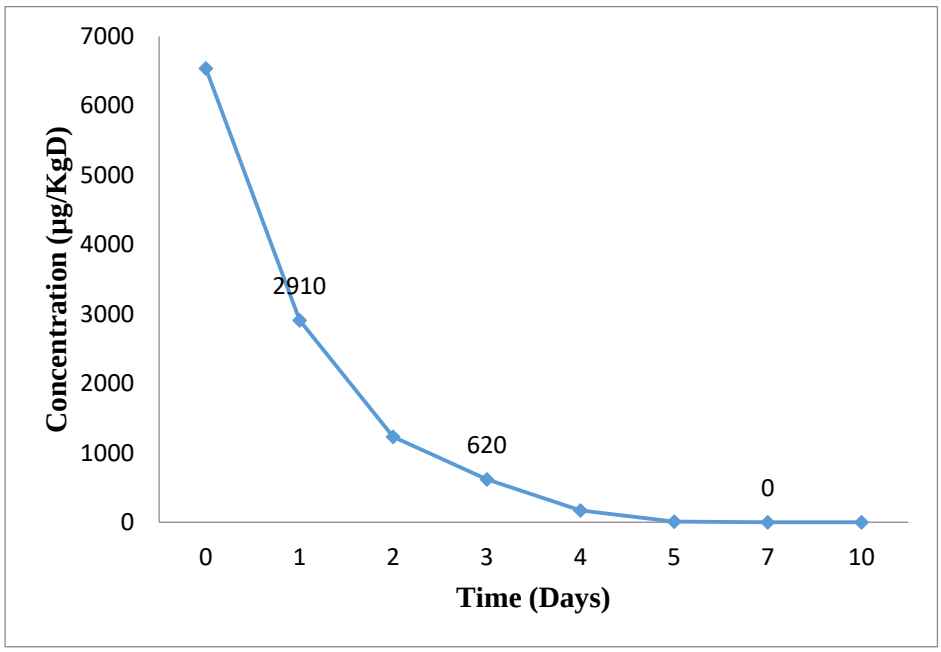

Figure 4. 49. Amitraz dissipation rates in Soil at Site 10 in dry Season

The residue level of amitraz in soil reduced with period (Figure 4.49). The first mean concentration of amitraz was 6,546±120.75µg/Kg (diurnal 0) and the last residue level was BDL on day 10.

The dissipation rate (Figure 4.50) was gotten by drawing concentration of Amitraz against period in days for sprayed soil from site 10 in the wet season

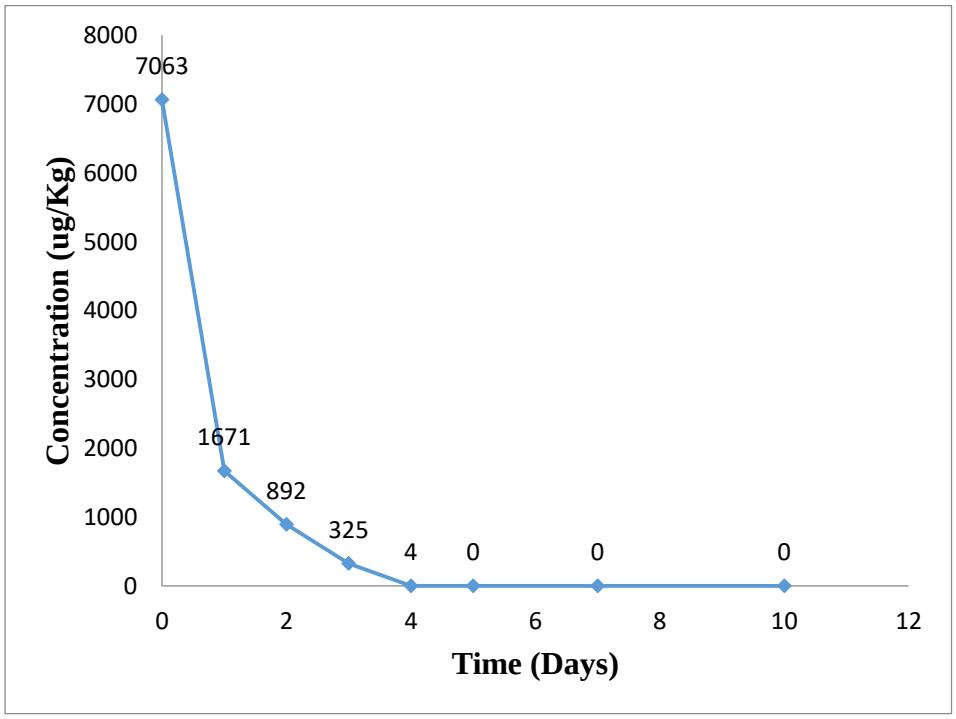

Figure 4. 50. Amitraz dissipation rates in Soil at Site 10 in Wet Season

The concentration of amitraz in soil reduced with time (Figure 4.50). The first mean concentration of amitraz was 7,063±146.2 µg/Kg (diurnal 0) and the last residue level was BDL on day 10. Regression graph for the degradation of Amitraz (Figure 4.51).

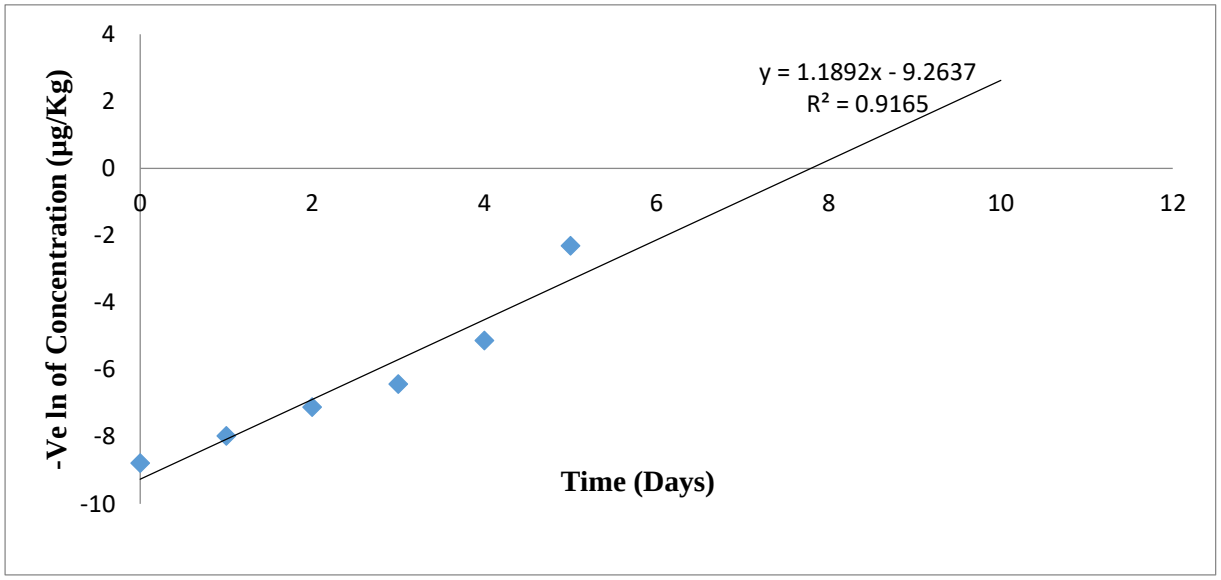

Figure 4. 51. Regression Curve for Amitraz degradation in Soil at Site 10 in dry Season

From the regression graph (Figure 4.51) and using straight line equation, Y = 1.1892X-9.2637for amitraz. A slope of 1.1892 was obtained (equivalent to the constant K_{obs}).

The regression graph for the degradation of Amitraz in soil from site 10 in wet season (Figure 4.52).

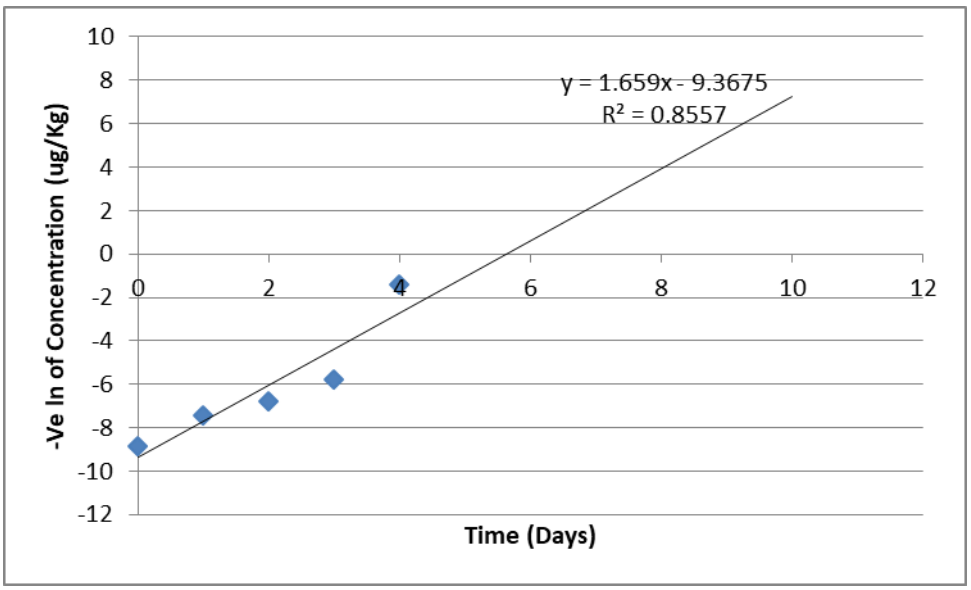

Figure 4. 52. Regression Curve for Amitraz degradation in Soil at Site 10 in Wet Season

From the regression graph (figure 4.52) and using straight line equation, y = 1.6959x-9.3675 for amitraz, a gradient of 1.6959 was obtained (equivalent to the constant K_{obs}).

From study, the degradation for amitraz (dry season) follows Langmuir-Hinshelwood kinetic equation and using equation for half-life, the half-life of amitraz in soil from site 10 was 0.58 days by the Langmuir-Hinshelwood kinetic model.

In this study the degradation for amitraz (wet season) follows Langmuir-Hinshelwood kinetic equation and using equation, the half-life of amitraz in soil from home nine was 0.42 days by the Langmuir-Hinshelwood kinetic model. Table 4.33 shows the summary of dissipation ranges, half-lives for the three acaricides.

Table 4. 33. Summary of Dissipation Ranges, Half-Lives for the Acaricides

Site Name	Dry Season	Dissipation Range	Half Life	Wet Season	Dissipation Range2	Half life
Empaleki site 1	Cypermethrin	6,530±27.2 - 3.87±0.00	0.66	Amitraz	4,230±43.1 - 83±0.07	0.51
	Deltamethrin	5,626±103.1 - 90±4.79	0.83			
Empaleki site 2	Cypermethrin	5,320±64.1 - 10±0.94	0.71	Cypermethrin	8,633±179. - 101±3.5	0.48
	Deltamethrin	4,986±87.1 - 80±3.4	0.76	Amitraz	5,377±122.4 - 92±10.8	0.49
Oldoraja site 3	Cypermethrin	8,654±141.2 -870±26.9	1.6	Cypermethrin	7,905±184.2 - 9±0.00	0.42
	Deltamethrin	1,341±58.06 -70±2.75	0.75	Deltamethrin	2,357±76.9 - 0.91±0.00	0.75
Esaginy site 4	Cypermethrin	3,041±33.15 -645±18.2	3.4	Cypermethrin	4,832±86.7 - 65±8.0	0.65
Esaginy site 5	Cypermethrin	8,423±79.2 - 509±21.05	1.75	Amitraz	4,832±86.7 - 65±8.0	0.53
	Deltamethrin	8,167±16.4 - 628±14.0	1.39			
Esaginy site 6	Amitraz	6412±65.1 - 8±0.07	0.64	Amitraz	6,194±120.6 - 129±6.7	0.75
Oldonyonyokie site 7	Amitraz	10641±144.2 -501±22.1	1.6	Cypermethrin	8,694±146.9 - 22±1.7	0.62
Oldonyonyokie site 8	Amitraz	1,970±91.3 - 90±8.74	0.45	Amitraz	3,875±97.3 - 1.3±0.71	0.37
Kamkuru site 9	Amitraz	3,129±98.7 - 75±0.25	0.5	Amitraz	4,691±75.3 - 0.9±0.00	0.45
Kamkuru site 10	Amitraz	6,546±120.75 - 11±0.21	0.42	Amitraz	7,063±146.2 - 4.1±0.00	0.42

The findings demonstrate fast dissipation rate of acaricides. Amitraz had half-life ranging from 0.37-1.60 days, the three acaricides were found to vary in mean in both seasons. Cypermethrin in the sites studied had a mean of 1.624±0.99 days in dry season with a variance of 0.987 while in wet season had a mean of 0.5067±0.08 days with a variance of 0.0070; Amitraz had a mean of 0.722±0.45 in dry season and 0.503±0.11 in wet season at variance of 0.015 and deltamethrin had a mean of 0.93±0.27 days in dry season and 0.75±0.00 days in wet season respectively. Cypermethrin half-life ranged 0.42 – 3.40 days and Deltamethrin half-life ranged 0.75 – 1.39 days. According to the findings of the previous studies the half-lives of certain acaricides can differ a little subject on the current ecological

situations (Chai *et al.,* 2013). Moreover, pesticides experience faster degradation under Kenyan tropical environment in relation to other temperate environments (Wandiga, 1996). Further studies by USEPA also showed that amitraz is very unstable in terrestrial and water ecosystems (USEPA, 1992). The efficiency of amitraz against different species of ticks that are unaffected to other group of acaricides has made it one of the supreme widespread acaricides internationally (BCPC, 1987).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The survey revealed that 9 different acaricides were commercially available, hand sprays through use of manual knapsack sprayers were the most preferred method of pesticides application in Kajiado West Sub-County instead of cattle dips. Farmers based much focus on the tick control system than environmental pollution and had good knowledge in the names and effectiveness of most acaricides sold in the area. In Kajiado West Sub-County farmers use class II at 33.3 % and 66.7 % class III pesticides under WHO classification. The acaricides used by the farmers in the sub county were all registered by the Pest control products board of Kenya (PCPB, 2018). The major challenges faced by the farmers was poor infrastructure leading to poor transport system to agro vet centre which are in far towns of Magadi and Kiserian, low income, high costs of acaricides because of increased frequency of application due to tick and tsetse flies vectors reoccurrences causing diseases on the livestock yields. Farmers spray their animals once or twice a week and very few for more than two weeks as found by Mugambi (2012) without following manufactures recommendations. This study agreed with that done in Serere County Soroti district in Uganda where agro-pastoral communities leave and have tick borne diseases caused by both vectors affecting livestock production. The coexist of livestock and wildlife animals inhabiting the Ewaso Nyiro river banks was a problem that may cause increased human-wildlife conflicts.

In Kajiado West Sub-County, 53 % of farmers were male and 47 % female adults (40 to 50) years with different literacy levels, 32 % having informal schooling, 47 % primary, 18 % Secondary and 3 % tertiary. Information on training 32 % of the cattle farmers were trained on safe handling of acaricides an indication that there is need for refresher trainings for the 68 % untrained farmers.

The pH of the homemade spray and water samples from Ewaso River were alkaline (> 7) across all the sampling sites except in sites 2 (pH = 6.96) and 4 (pH = 5.21). Total dissolved solids and conductivity of homemade spray were higher than those for water samples these slight increase, were due to buffering reagent added by the manufactures in acaricides. Farmers' acaricides application

levels were lower than those recommended by the manufactures, probably due to revealed illiteracy levels. This findings are consistent with those for Mugambi et al. (2012) which reported on farmers' confusion by information on acaricide labels due to low trainings.

The laboratory analysis of the homemade cattle sprays revealed three active ingredients (a.i) amitraz, alpha-cypermethrin and deltamethrin that were consistent with manufacturers' labels on the commercial products. All acaricides sprayed during the dry and wet seasons were detected in the soil samples in both seasons with about 50 % of initial acaricides concentration ending up in the soil samples within the sheds (spray areas). The concentrations were higher in dry than in wet seasons. These shows the need to devise a better method of application of acaricides to the livestock to minimize contamination to ecosystem. Acaricides residues levels in the water was below the detection limits (BDL) probably due to the forests at the river banks acting as sinks. Dissipation rates depended on the initial concentrations of acaricides applied. Dissipation was faster in wet season than dry season indicated in Table 4.33. The results from the dissipation rates of amitraz, cypermethrin and deltamethrin were higher in wet season than in dry season with half-lives ranging 0.37- 1.60 days, 0.42 – 3.40 days and 0.75 – 1.39 days respectively. The amitraz half live is consistent with studies by Kipngetich, 2017 who investigated on amitraz dissipation in cattle dips in Bureti, Kericho county and reported half-lives of 17 hours and 18 hours for cattle dips 1 and 2 respectively. Other studies by Lalah. 1993 showed insecticides to be less persistent in Kenyan environment though recommended further investigations on them.

5.2 Recommendations

5.2.1 Policy Recommendations

1) Low level of education was witnessed among the livestock farmers during this study henceforth awareness crusades should be carried out by count government of Kajiado and manufactures to educate the livestock farmers on safe use of acaricides.
2) The Kajiado County government should put in place a steady ecological checking program

and plans to monitor the acaricides residue levels in the environment.

3) Awareness campaigns should also be conducted to educate the general public on acaricide use and their adverse environmental and human health impacts.

5.2.2 Research Recommendations

1) Study should be conducted to determine the frequency at which the acaricides can be sprayed to animals this can be completed with the help of government and the manufactures.
2) Acaricides residue level should be analysed in in plants and animal products e.g. blood, milk, animal furs etc., in Kajiado County and counties.
3) Further studies should be conducted to determine the concentration of other chemical pesticides that are frequently applied in the county.
4) Study of acaricides residues levels in the sediments from the river Ewaso Nyiro can be conducted in order to establish the undetectable levels in river water.

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APPENDICES

Appendix 1: Questionnaire

Interview-guided Questionnaire for livestock farmers in Kajiado West sub-county

Introduction

This questionnaire seeks to gather information on the challenges faced in the economic management of ticks through cattle homemade spraying. The information gathered will be used to make recommendation for intervention measures on the challenges which will lead to improved efficacy of the cattle home spraying ultimately increasing production of the livestock.

The researcher is pursuing a Master of Science Degree in Environmental Chemistry at the University of Nairobi. Your honest response to this questionnaire is highly appreciated. Tick as appropriate.

Note that any information you give will be treated with outmost confidentiality.

SECTION 1: General information

Questionnaire No..... Date .....

Name (optional) .....

Address..... Cell phone No: .....

Gender: Male ☐ Female ☐

Age: Below 20 years ☐ 20-30 years ☐ 30-40 years ☐ 40-50 years ☐ Above 50 ☐

SECTION 2: Level of Education and Training

What is your highest academic qualification?

a) KCPE ☐ b) KCSE ☐ c) University ☐ d) Other ☐ Specify ----------

1. Have you had any training on pesticide management and safety? If yes, name the training body. .....

SECTION 3: Information on tick control strategies

2. Name the acaricide you employ in controlling ticks in your livestock ----------
3. What is your preferred method of controlling ticks in your livestock?

Spraying ☐ Hand picking ☐ Other ☐ Specify ----------

4. If homemade spraying is your choice, how long have you been using the services of cattle dip?

a) Less than 5 years ☐ b) 5-10 years ☐ c) More than 10 years ☐

5. Do your livestock encounter tick and tick-borne diseases (TBDs)?

a) Yes, frequently ☐ b) Yes, sometimes ☐ c) No ☐

6. Do you know the kind of acaricide used in this Home Spray?

a.) Yes ☐ b.) No ☐

7. If your response in (9) above is no, what could be the reason?

---

12. How frequently do you spray your animals for dipping services?

a. Once a week ☐
b. After two weeks ☐
c. Once a month ☐
d. Other ☐ Specify .....

SECTION 4: Information on socio-economic impacts

13. Have you experienced any ill health as a result of treating your animals with acaricides?

a) Yes ☐ No ☐

14. Has there been any change on crop yields as a consequence of controlling ticks using acaricides?

a) Yes ☐ No ☐

15. If Home is your preferred mode of tick control, name the acaricide you employ in controlling ticks and state how you dispose of either used acaricide containers or expired acaricides? .....

Thank you for responding to this questionnaire

APPENDIX 2: SUMMARY OF RESPONSE

Table 2a: Summary of responses to the questionnaire

Sex	**Frequency**	**Percentage**	
Gender			
Male	20	53	
Female	18	47	
Total	38	100	
Age brackets			
Below 18	1	2	
19-30	11	29	
30-40	9	24	
41-50	12	32	
51 and above	5	13	
Totals	38	100	
Level of education			
Informal education	12	7	
Primary	18	58	
Secondary	7	33	
Tertiary	1	2	
Total	38	100	
Pesticide Training and Knowledge by Farmers			
Trained	12	32	
Untrained	26	68	
Total	38	100	
Pest and disease identification and control by the farmers			
Pest	Local Name	Mode of application	Percentage (%)
Ticks	Mashiri	Spraying	40
Tsetse fly	Oligibai	Spraying	60

APPENDIX 3: CALIBRATION CURVES OF THE ANALYSED ACARICIDES

The calibration curves of the analysed acaricides

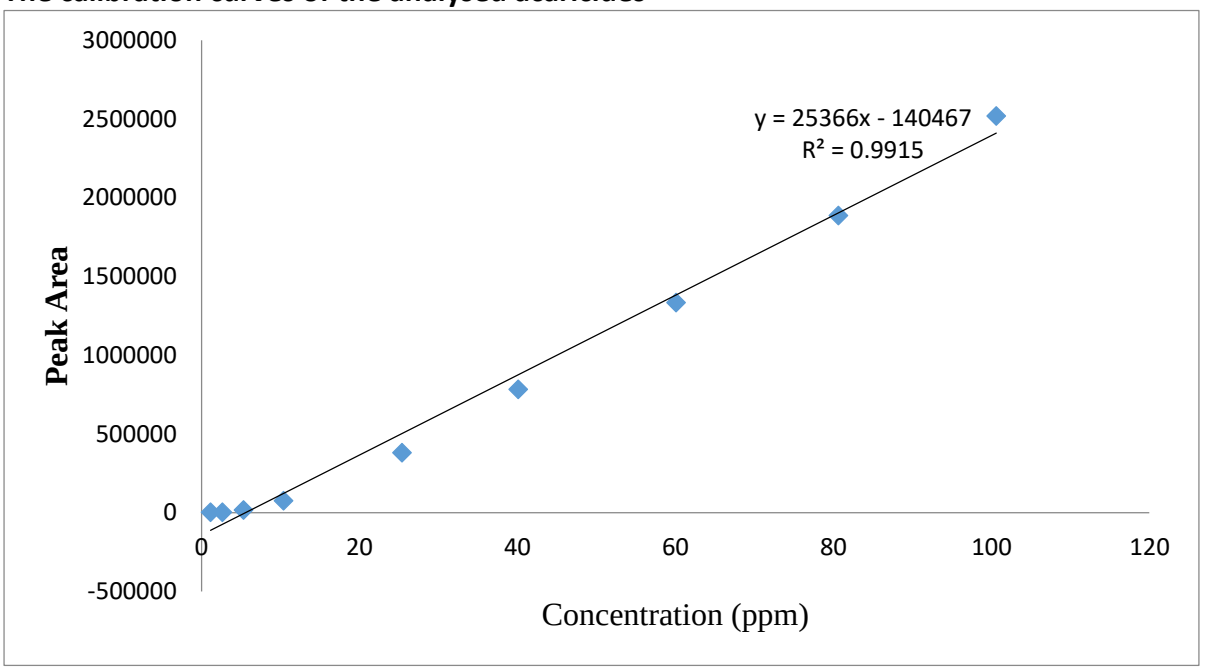

Figure 3a: Calibration Curve for Amitraz

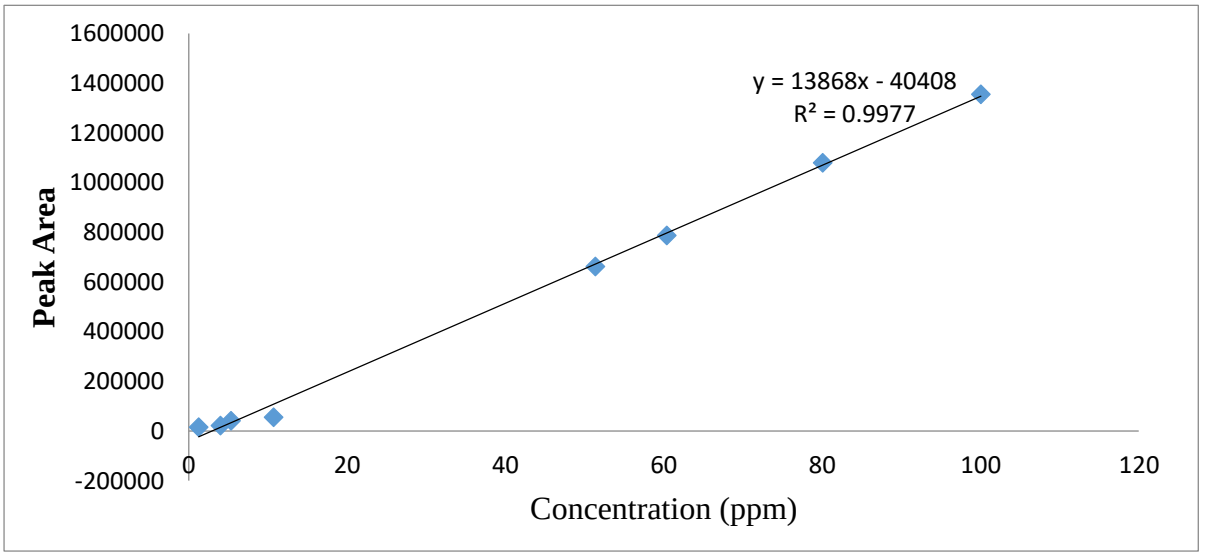

Figure 3b: Calibration Curve for Cypermethrin

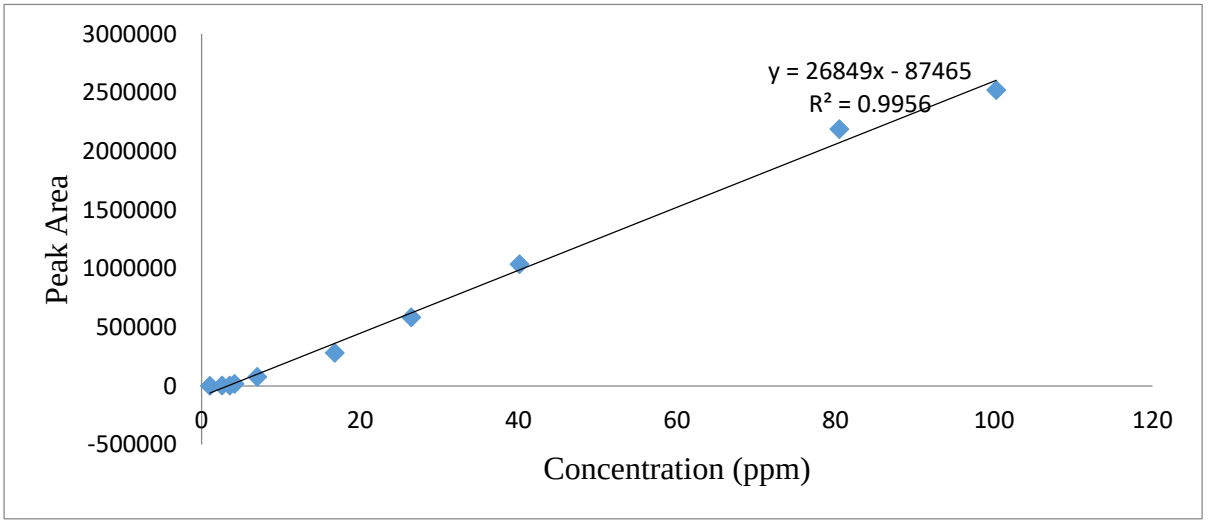

Figure 3c: Calibration Curve for Deltamethrin

APPENDIX 4: CHROMATOGRAMS

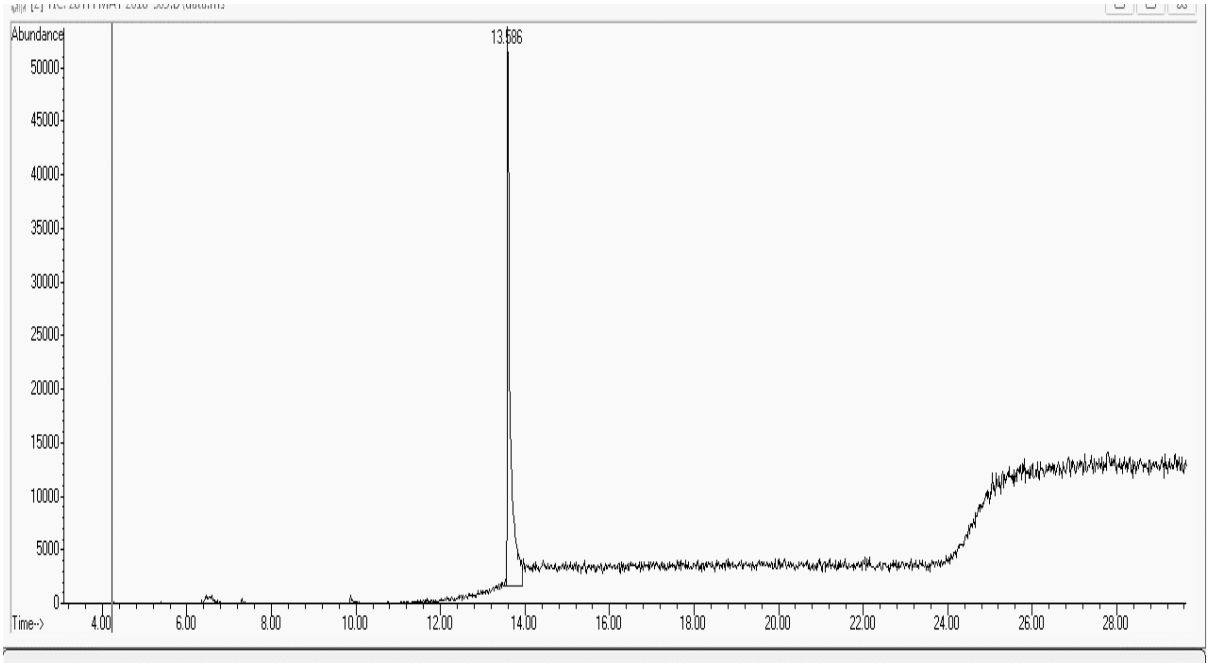

Figure 4 a: The chromatogram for Amitraz Standard

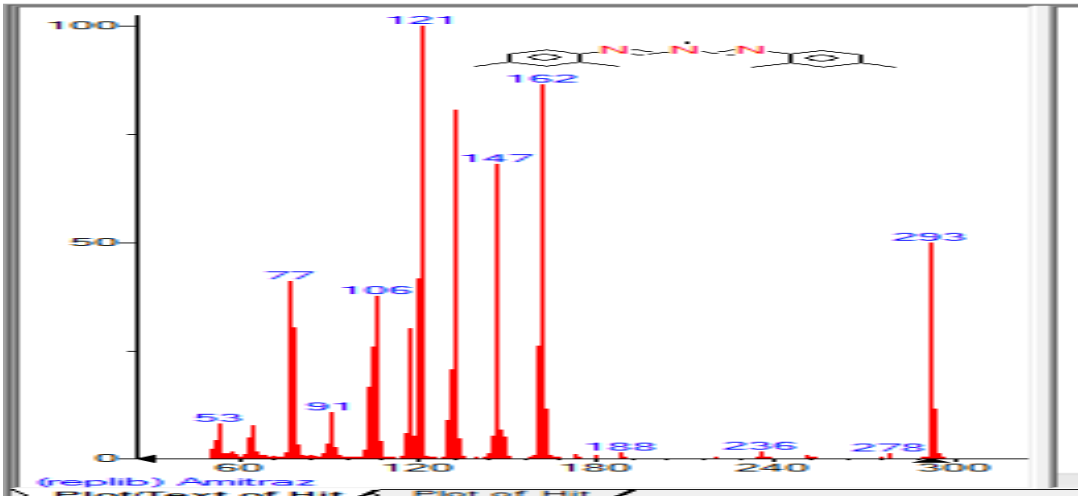

Figure 4b: Chemical structure and ionic Mass Spectra for Amitraz Standard

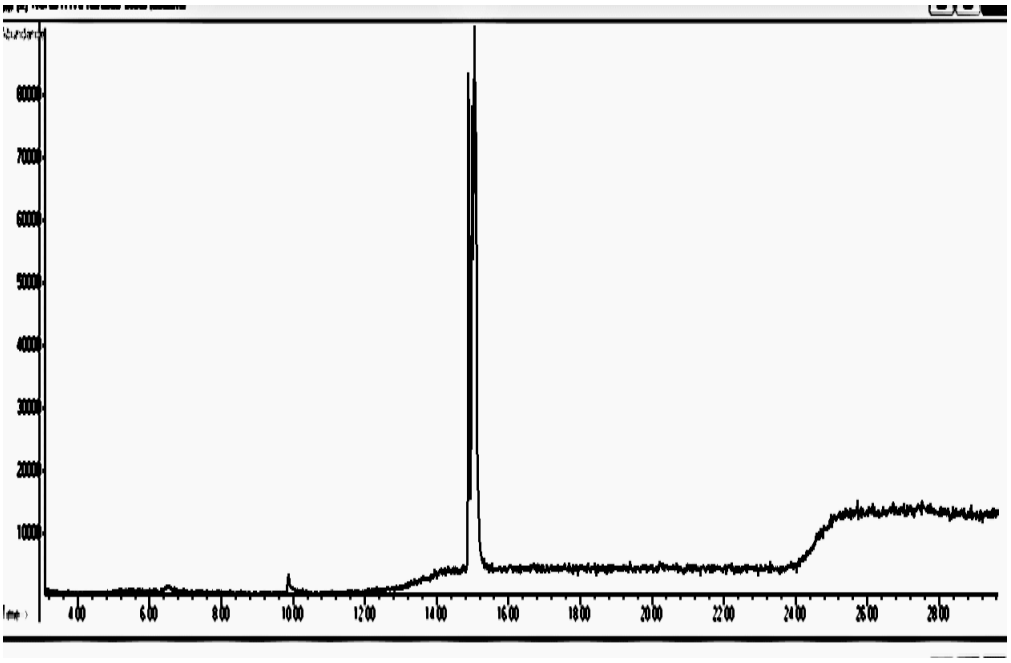

Figure 4c: The chromatogram for Cypermethrin Standard

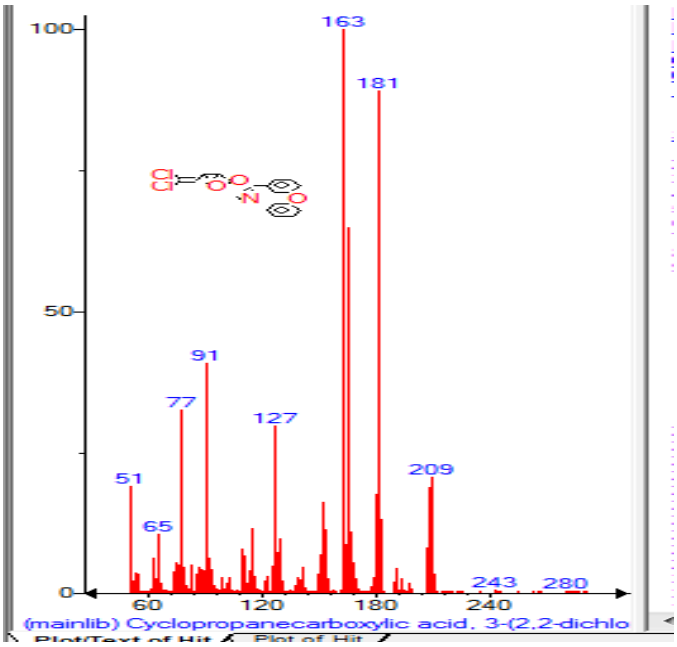

Figure 4d: The chemical structure and ionic Mass Spectra for Cypermethrin Standard

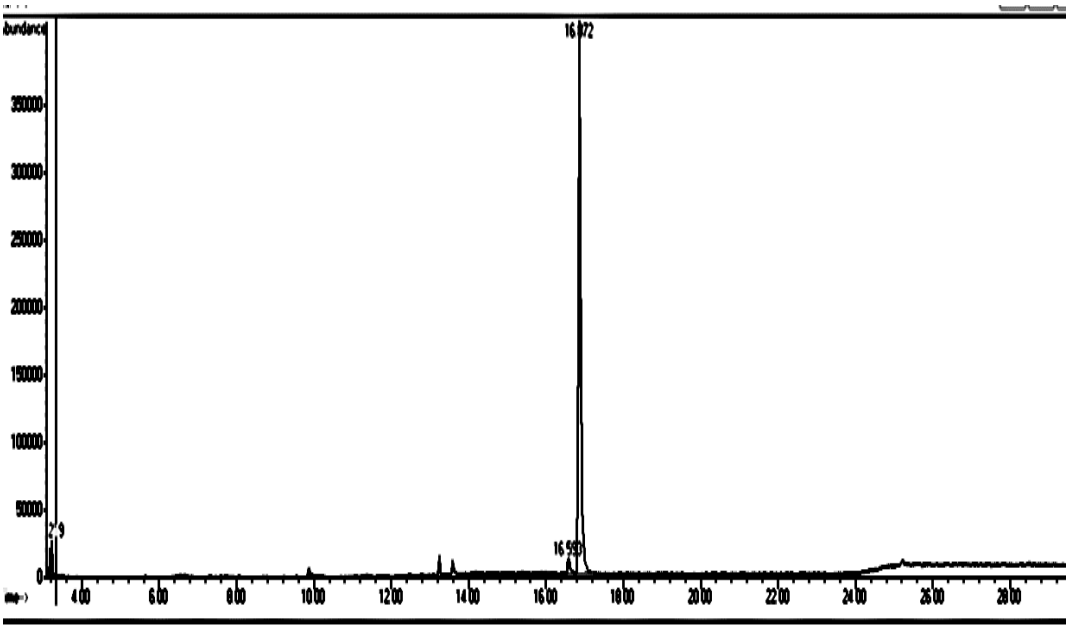

Figure 4e: The chromatogram for Deltamethrin Standard

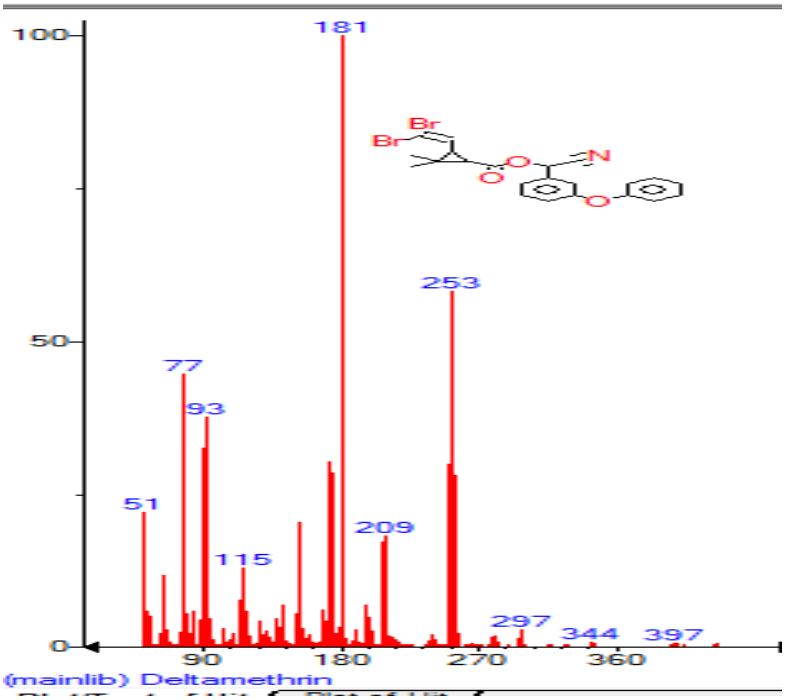

Figure 4f: Chemical structure and ionic Mass Spectra for Deltamethrin Standard

GC- Chromatograms for the Acaricides Pesticide Standard Mixture, Water and Homemade Cattle Spray

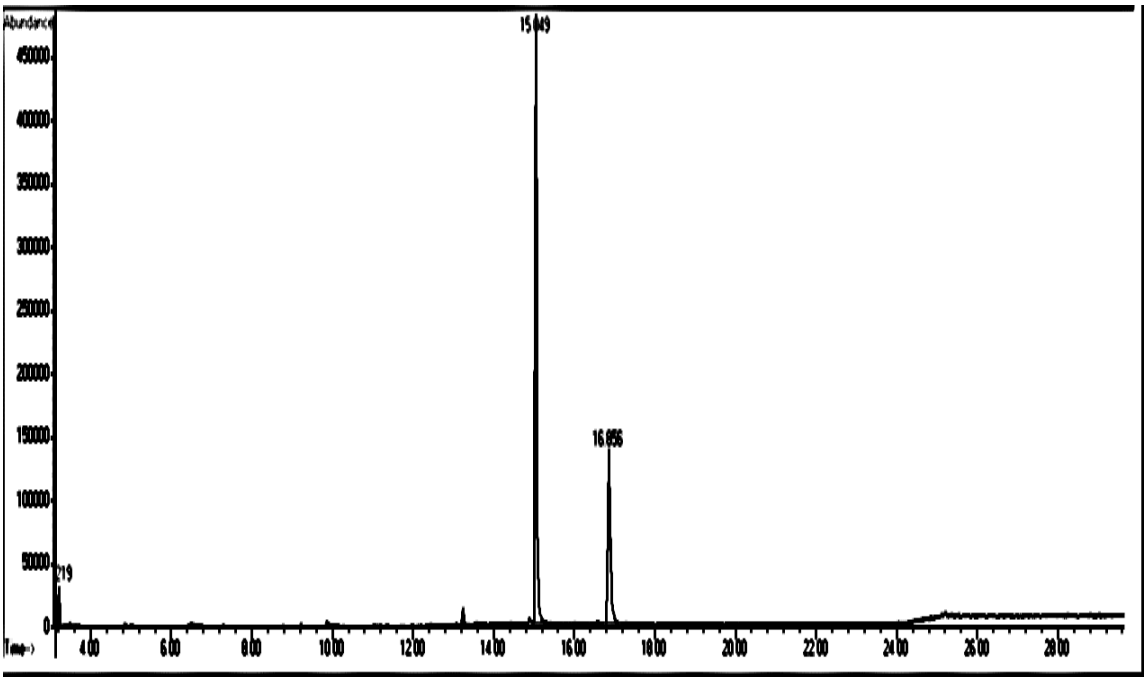

Figure 4 g: The chromatograms of Acaricide pesticide Standard mixture

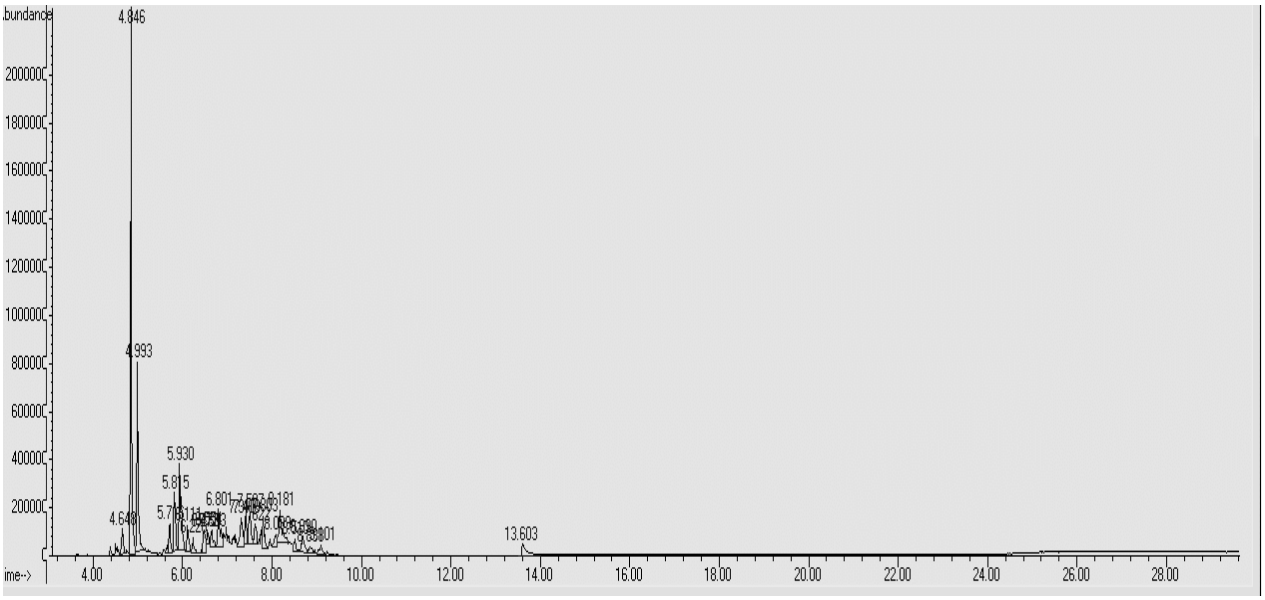

Figure 4 h: The chromatograms of the water sample at site 1.

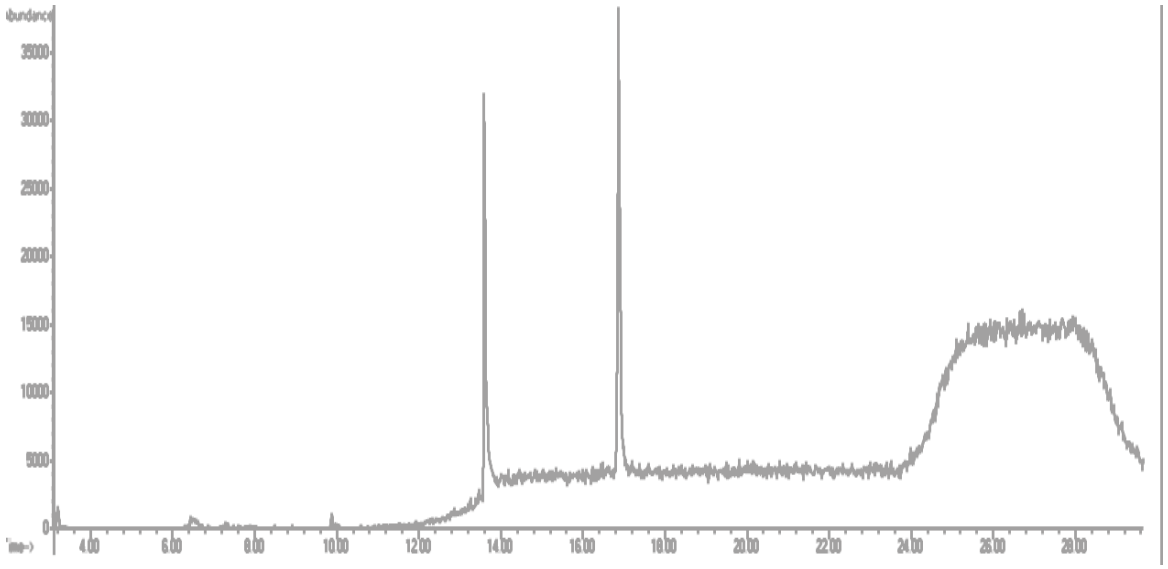

Figure 4 I: The chromatograms of the Homemade Spray Sample at site -2