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MALARIA CONTROL: THE NEED FOR TARGETING MOSQUITO BREEDING HABITATS

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE MASTER OF SCIENCE (MSc) DEGREE IN ENVIRONMENTAL SCIENCE

BY

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DECLARATION

I declare that, this Thesis being submitted in partial fulfillment of the requirement for the award of Master of Science (MSc) degree in Environmental Science is the result of my own investigation. It has not been submitted or accepted for any degree elsewhere. Due acknowledgment has been given to those authors whose work served as a source of information and have been cited in this book.

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ABSTRACT

In the early 1990s, malaria was controlled using environmental management for vector control in cities in sub-Sahara Africa. However this approach lacked effectiveness due to unsustainability as compared with the residual insecticides that appeared in the 1950s. Today, malaria control in Africa is entirely focused on the use of anti-malarials and insecticide-treated bed nets and not on biophysical environmental modifications or on strengthened social systems to perform effective environmental manipulation. Even though drugs and insecticides are extremely effective weapons, the development of resistance by the parasite and the vector mosquitoes, respectively, are a growing concern for the long-term costs and in addition, the environmental impacts of insecticides have been a challenge. The present study assessed the impact of controlling malaria in two communities by means of targeting the habitat of the vector mosquito. The overall goal was to assess the impact of mosquito habitat reduction on malaria incidence and prevalence in two selected endemic communities in the Agortime-Ziope district of the Volta Region. Kakadedzi and Takuve are both rural communities in the town of Ziope. They experience a tropical climate with rain fall throughout much of the year. Data on malaria cases recorded was collected from the Ziope Health Centre, the only health facility serving the two rural communities in order to review the diagnosed malaria cases in the selected communities. The selected communities were surveyed and the mosquito breeding grounds identified. Interventions involving manipulation and elimination of the breeding habitats were introduced in the two identified communities. Data collected before and after the interventions were compared. The diagnosed malaria cases in the health centre were again reviewed monthly for seven months. The inhabitants and school pupils were interviewed during the study period in order to determine their level of knowledge on malaria and its control. Results from both Kakadedzi and Takuve communities revealed the breeding habitats of mosquitoes to be open water tanks, depressions on farm lands, drinking pots and dams. The reviewed malaria cases in the health centre indicated that malaria cases were more prevalent during the rainy season than during the dry season. The arithmetic means of the number of mosquitoes collected from each room before the interventions were carried out, were significantly more **(p value of 0.0002**) than those collected after the interventions. The number of the malaria cases recorded in the Health centre after post-interventions also reduced significantly **(p value of 0.0019)**. The interviews conducted in the communities revealed that 20% of the total population of the elders lacked basic knowledge on malaria and how it could be controlled. The pupils from the community school could not transfer the knowledge they acquired on malaria and its control during school lessons to control malaria in their homes. The findings from this study suggest that managing the environment by practising good sanitation can reduce the breeding habitats of mosquitoes. This in turn can reduce the human-vector contact leading to the control of the disease, malaria.

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LIST OF ABBREVIATIONS AND ACRONYMS

AFRO Africa Region of World Health Organization

API Annual Parasite Index

CDS Communicable Disease Surveillance

DDT Dichlorodiphenyltrichloroethane

EM Environmental Management

GDP Gross Domestic Product

IPT Intermittent Preventive Treatment

IRS	Indoor Residual Spraying
ITNs	Insecticide Treated Nets
MOH	Ministry Of Health
NGOs	Non-Governmental Organisations
NMCP	National Malaria Control Programme
OPD	Out Patients Department
RBCs	Red Blood Corpuscles
RBM	Roll Back Malaria
RDT	Rapid Diagnostic Test Kits
UN	United Nations
UNICEF	United Nations Children's Education Fund
WHO	World Health Organisation
WHOPES	World Health Organisation Pesticides Evaluation Scheme

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Malaria is a serious health problem in many developing countries, infecting between 300 and 500 million people annually, and the disease is a leading cause of infant and child mortality in sub-Saharan Africa (Walker 2002). In addition to children, pregnant women and migrating populations are most vulnerable to malaria. Miscarriage, stillbirth, and low birth weight are common among pregnant women who are infected with the disease. It is also a highly complex disease caused by five different pathogens and vectored by many different mosquito species of the genus Anopheles. The disease causes a huge burden on many countries. Malaria remains one of the worst killers in the world today and is the cause of even greater suffering in human, social and economic terms (Wadhwa. *et al.*2010).

Malaria is caused by a *Protozoan* parasite of the genus *Plasmodium* .The genus that causes the disease is of five species, namely *Plasmodium falciparum, P. vivax, P.malariae, P.ovale and P.knowlesi.*

Malaria begins with a bite from an infected female *Anopheles* mosquito, which introduces *sporozoites* (cells that cause infections) through saliva into the human circulatory system. In the human bloodstream, the s*porozoites* are carried to the liver to mature and reproduce. In the liver, the *sporozoites* firstly grow into *trophozoites* (active feeding- stage cells) and then into *schizonts* (mother cells) which are for asexual reproduction. The *schizonts* go on to divide into *merozoites* (daughter cells), invade red blood corpuscles (RBCs) and eventually break out of the damaged RBCs and invade new ones. This causes the typical malaria symptoms of chills, fever and headache, which in severe cases can progress to coma or death. After a time, some of the *merozoites* entering the red blood cells develop and differentiate into male and female gametocytes, which enter the mosquito as it feeds on humans again. Male and female gametes produced by the gametocytes undergo fertilization in the stomach of the mosquito to form a zygote which grows and transforms into a motile and but short-lived diploid of diploid ookinete which migrates and embeds in the mid-gut wall of the mosquito and forms *oocyst*. Within the *oocyst further* divisions occur resulting in the formation of *sporozoites*, which then move to the salivary glands of the mosquito and the entire cycle begins again. Parasite viability depends upon favourability of environmental conditions for the vector (mosquito), on the availability of food, or access to human blood (Wadhwa *et al*.2010).The vast majority of deaths are caused by *P.falciparum* and *P.vivax*. It is a disease that can be treated in just 48 hours, yet it can cause fatal complications if the diagnosis and treatment are delayed.

The disease is widespread in tropical and subtropical regions in a broad band around the equator including much of Sub-Sahara Africa, Asia, and the Americas. Malaria is prevalent in tropical and subtropical regions because rainfall, warm temperatures and stagnant waters provide habitats for mosquito larvae. Malaria is also more common in rural areas than in cities; for example, cities in Asia are malaria –free, but the disease is prevalent in many rural areas including along international borders and forest fringes (Kar *et al,* 2014). In contrast, malaria in Africa is present in both rural and urban areas though the risk is lower in the larger cities (Donnelly *et al*. 2005). Only female mosquitoes feed on blood, male mosquitoes feed on plant nectar, and so do not transmit the disease. The female of the *Anopheles genus* of mosquitoes prefer to feed at night. They usually start searching for a meal at dusk and will continue throughout the night until a meal is taken. The malaria parasite can also be transmitted by blood transfusions although this is rare.

According to the World Malaria Report (2008), 109 countries or territories were malaria prone in 2006, placing 3.3 billion people at risk of malaria transmission. Every year, several 100 million cases of malaria occur, and cause an estimated death toll of over a million of which over 90% occur in Africa. The World Malaria Report estimates that the number of cases of malaria rose from 233 million in 2000 to 244 million in 2005 but decreased to 225 million in 2009. Also, according to this report, the number of deaths due to malaria decreased from 985,000 in 2000 to 781,000 in 2009.

On World Malaria Day in 2008, the United Nations Secretary-General called for efforts to ensure universal coverage with malaria prevention and treatment programmes by the end of 2010. In 2005, the World Health Assembly established a goal, that the Roll Back Malaria (RBM) Partnership should reduce the number of malaria cases and death recorded in 2000 by 50 % or more by the end of 2010 and by 75% or more by 2015.

Also, in September 2008, the RBM Partnership launched the Global Malaria Action Plan which defineds the steps required to accelerate achievement of the 2010 and 2015 targets for malaria control and elimination (Aregawi *et al*. 2009).

The goals set have not been achieved yet; instead, over the past 35 years, the incidence of malaria has increased 2-3 fold and this continuing upsurge has come from several factors such as the weakening of public health systems in some poor countries, continuing poverty and political instability, drug-resistant parasites, insecticide-resistant mosquitoes, deforestation, global climate change, population movements into malarious regions, changing agricultural practices including the building of dams and irrigation schemes, etc.(Raval, 2013).

Malaria is a major cause of illness and death in Ghana, particularly among children and pregnant women. In 2006, it accounted for 38.6% of all outpatient illnesses and 36.9% of all admissions (Pharm, 2013). Malaria prevalence per thousand population was 171 and 2,835 malaria attributable deaths representing 19% of all deaths were recorded. As many as 13.7% of all admissions of pregnant women in 2006 was as a result of malaria whilst 9.0% of them died from the disease (Pharm., 2013).

In most areas, malaria and poverty co-exist, with the average GDP and average growth of per capita GDP in malarious countries being about one fifth of those in non-malarious countries. The economic burden of malaria is huge, estimated to be $12 billion a year in Africa alone. However, the global spending on malaria control is only meager, with US$ 652 million disbursed in 2007 and US$ 1.7 billion committed in 2009. (In comparison, in the year 2008, HIV/AIDS accounted for 33.4 million of cases prevalence and 2 million deaths but a total global spending of US$ 13.7 billion).

More than 30,000 cases of malaria are reported annually among travelers from the developed world visiting malarious areas. With the increasing globalization, perennially prevalent malaria, therefore, remains an ever existing danger for humanity, in every part of the globe (Raval, 2013).

Many malaria control initiatives have been implemented by Governments, NGOs, WHO, Roll Back Malaria, Bill & Melinda Gates Foundation and other Charitable Organizations, Academic and Research

Institutes, Corporate and other Private Organizations in different parts of the world. Some progress has been made due to the initiatives put in place. Malaria mortality rates have been estimated to have decreased by forty five percent globally across all age groups between 2000 and 2012, and by fifty one percent in children under five years of age. In the Africa Region alone, malaria death rates decreased by forty nine percent across all age groups and by fifty four percent in children under five years of age (W.H.O., 2009).

1.2 Problem Statement

Regrettably, in Ghana, and probably other malaria endemic countries in Africa, malaria control efforts have been fragmented and in some cases antagonistic. Prior to 1993, malaria control was restricted to urban areas with emphasis on source reduction and chemoprophylaxis. A 5-year (1993-1997) National
Malaria Action Plan (Ganle, 2012) was implemented with focus on case management as was an Accelerated Control Program initiated in 30 selected districts in Ghana with W.H.O./AFRO support.

Since 1991, Ghana has been undertaking an integrated malaria control programme in the context of the Roll Back Malaria (RBM) Initiative, aimed at providing at least 60% of those at risk access to insecticidetreated bed nets, prompt and effective treatment and Intermittent Preventive Treatment (IPT) for at least 60% of pregnant women (W.H.O., 1999).

According to the Anti-Malaria Drug Policy for Ghana, since 1998, Ghana has committed itself to the Roll Back Malaria initiative of the World Health Organization, which builds on the Global Malaria Strategy with a focus on Africa and a goal to halve the world‘s malaria burden by 2010. Consequently, the country drew up a Medium Term Strategic Plan for Malaria Control in Ghana, which sought to improve the coverage of malaria control activities by adopting an inter-sectoral approach involving and promoting partnership with the private sector and the community. It has also committed itself to the Abuja Declaration on Roll Back malaria in Africa, which similarly seeks to achieve specific targets on malaria prevention and control. (Nabarro & Tayler, 1998)

In spite of these initiatives, Malaria remains hyper- endemic in Ghana and is the single most important cause of mortality and morbidity especially among children under five years, pregnant women and the poor. Apart from the health consequences, malaria puts a heavy burden on productivity and hence economic development.

According to The Africa Malaria Report (W.H.O., 2006) a study conducted in Ghana found that the cost of malaria treatment consumes 34% of the income of poor households while the richer ones spend only 1% of their wealth on malaria treatment. Also, the high burden of malaria is responsible for an estimated average annual reduction of 1.3% in economic growth, US$12 billion loss, and serious social disruptions. Other studies estimate of the economic burden of malaria in endemic countries showed that the direct cost of a single episode of malaria to a household was US$6.87 in Ghana, US$4.8 in Uganda and US$4.5 in Mali. Eliminating malaria by 2015 is one of the United Nations' Millennium Development Goals. But an estimated amount of $26.9 billion is needed in the next three years to reach this goal. (www.voa news.com) (25th April, 2013).

According to UNICEF Ghana Fact Sheet-Malaria of July 2007, 3.5 million people contract malaria every year whilst 20,000 children die from malaria every year. Even when a child survives, the consequences from severe malaria such as convulsions or brain dysfunction can hamper long term development and schooling. In Ghana the annual economic burden of malaria is estimated to be 1-2% of the Gross Domestic Product. (Asante & Asenso-Okyere, 2003).

According to Keiser *et al* (2005), the underlying principles of Malaria Control range from measures aimed at preventing the breeding of mosquitoes to getting rid of the parasites in humans. In preventing the breeding of mosquitoes efforts have to be made not to create breeding sites and also to destroy the sites which have already been created. This involves strategies to permanently modify the environment where the mosquitoes breed and also periodically fill potholes and promote behavioral activities in humans to prevent malaria transmission.

The WHO stresses the need for a range of malaria control approaches in its Global Malaria Control Strategy (WHO 1993). WHO recommends an integrated approach that relies on early case identification and treatment as well as selective and sustainable preventive measures; including vector control Options for vector control include environmental management, chemical control, biological control, and personal protection. Malaria can therefore, be prevented by reducing the breeding source of the female *Anopheles* mosquito responsible for transmitting the *Plasmodium* parasite resulting in the disease.

1.3 Aim and specific objectives

The aim of the present study, therefore, was to assess the impact of anti-mosquito interventions on malaria incidence and prevalence in two selected endemic communities (Kakadedzi and Takuve) in the Agortime-Ziope district of the Volta Region.

Specifically, the objectives were;

1. To review the malaria situation in the selected communities over the past year (April 2011 to April 2012).
2. To survey and identify malaria vector breeding grounds in the selected communities.
3. To determine the effect of anti-mosquito intervention activities such as spraying rooms with insecticides, weeding and cutting down bushes and grasses around residences, burying opened cans, emptying opened containers of water, covering opened containers and filling depressions around the communities, on indoor mosquito population numbers in selected rooms of residences
4. To review the malaria cases diagnosed in the Health Centre after the anti- mosquito interventions.

CHAPTER TWO

2.0 LITERATURE REVIEW

The malaria parasite was first recognized in the red corpuscles of an infected patient by a French Army surgeon, Charles Louis Aphonse Laveran (1845-1922).However, Ronald Ross (1897) discovered the cause of malaria by proving that the *Anopheles* mosquito was responsible for the transmission of the disease. In 1898, Ronald Ross used avian hosts and further discovered the mechanism of transfer of the parasite from the mosquito‘s stomach wall to its salivary glands and further on to the host. May (1961) summed up the disease ecology of malaria as the interaction between the environment and the triad of agent, vector, and host.

The factors that determine the epidemiology of malaria are the environment, vector, and the host. Environmental factors such as temperature, humidity, rainfall and altitude affect the transmission of *P. falciparum* which requires a minimum temperature of 20ºC to develop in the female mosquito, while the other species of human malaria parasites can develop in temperatures as low as 16ºC (Lucas and Gilles, 2003). A relatively high humidity is required for survival of adult vectors while rainfall is essential to provide breeding sites. The trend of Global warming presents a risk of serious epidemics through an extension of malaria into areas of Africa previously considered free from the disease.

Malaria vectors bite between dusk and dawn and generally choose well-oxygenated water rather than stagnant polluted pools to lay their eggs. For the host, genetic, immune, nutritional and behavioural factors influence the epidemiology of malaria. Many elements of human behaviour affect the epidemiology of malaria. Uncontrolled urbanization, subsistence agriculture, population movements, wood-gathering in the forest, open-cast mining, agricultural production of certain crops such as cotton, sugar cane, rubber and rice contribute to the human behavior. Introduction of electricity into rural areas has resulted in promoting late night outdoor human activities and this increases biting opportunities for mosquitoes (Lucas and Gilles, 2003).

2.1.0. Environmental Management of Malaria Vectors

Since the discovery of the role of *Anopheles* mosquitoes in malaria transmission over one hundred years ago, malaria control experts have recognized the value of changing mosquito larval habitats to reduce or eliminate malaria transmission. Habitat elimination or modification efforts have included general programs to reduce the abundance of all mosquitoes as well as more targeted projects of ―species sanitation‖ directed at the principal malaria vectors (Bruce-Chwatt, 1987). The concept of modifying vector habitat to discourage larval development or human vector contact is generally referred to as environmental management (EM). The WHO Expert Committee on Vector Biology and Control (W.H.O., 1988) defined environmental management as the following:

The planning, organization, carrying out and monitoring of activities for the modification and/or manipulation of environmental factors or their interaction with man with a view to preventing or minimizing vector propagation and reducing man-vector-pathogen contact. This approach is naturalistic and involves an attempt to extend and intensify natural factors which limit vector breeding, survival and contact with man.

The specific techniques of EM are generally grouped into three main categories:

(1) Environmental modification,

(2) Environmental manipulation, and

(3) Modification of human habitations and behaviours (WHO 1982).

2.1.1 Environmental modification

This involves a physical change (often long term) to potential mosquito breeding areas designed to prevent, eliminate, or reduce vector habitat. The principal methods of achieving these changes include drainage, land leveling, and filling (Walker, K. 2002). Draining operations include the creation of ditches or drains to keep water moving and to carry the water used as breeding sites away in a managed way. Drains may be lined or unlined and located at the surface or subsoil level. In some instances, marshes have been drained through pumping (Walker, 2002).

As an alternative to complete elimination of wetlands, modification projects could involve the creation of channels to improve water flow in areas of standing water, filling small ponds or water-collecting depressions, or changing the banks of water impoundments to reduce mosquito populations. As rivers and streams can create *anopheline* larval breeding sites, particularly in slow-moving pools with heavy vegetation, regrading streams and even straightening riverbanks may reduce vector populations (Thevasagayam, 1985). Some of these activities require regular maintenance, whereas others represent permanent changes to the landscape (which may require substantial initial effort and expense). An important component to environmental modification addresses problems of man-made vector breeding sites associated with water-holding structures in mini-dams and small-scale irrigation projects. The creation of favorable vector habitat can often be avoided through careful design (Malaria, 2005).

Large-scale environmental modification projects as part of broad-based programs to control and eventually eradicate malaria were implemented successfully prior to the 1940s in Italy and the Tennessee Valley in the United States (Kitron and Spielman 1989). In Italy, modification efforts involved substantial investment of money and time to achieve major engineering feats including the 16 km diversion of the Ombrone River into a canal and draining the almost 100,000-hectare (ha) Pontine Marshes, using an elaborate series of ditches and canals. In Indonesia, many smaller-scale modification projects focused on eliminating the coastal habitat for *An. sundaicus*. Methods included draining or filling brackish water swamps, lagoons, and fishponds and raising, diking, and improving tidal drainage to coastal zones near towns and ports. More recently, a saltwater marsh drainage project was initiated along with larviciding and drug treatment to contain a malaria epidemic in Haiti (Spielman, Kitron, & Pollack, 1993). In Kitwe, Zambia, a project was begun in the 1950s to use lined drains, filling and leveling, and planting eucalyptus and other water-intensive vegetation to convert a large peri-urban wetland into a public park (Beier *et al*. 2008).

Many modification projects require regular maintenance, as they are designed to make permanent changes in the environment. In fact, poorly maintained drainage projects may actually increase larval breeding habitat (Kirby *et al.* 2004). As modification projects tend to require significant initial investments in construction, such a method may be feasible only where the water body or wetland under consideration is clearly the main larval breeding site for the malaria vector species.

2.1.2 Environmental manipulation

This refers to activities that reduce larval breeding sites of the vector mosquito through temporary changes to the aquatic environment in which larvae develop. Water management activities include changing water levels in reservoirs, flushing streams or canals, providing intermittent irrigation to agricultural fields (particularly rice), flooding or temporarily dewatering man-made or (where feasible) natural wetlands, and changing water salinity.

Manipulation of vegetation may also be useful. Planting water-intensive tree species, such as *Eucalyptus robusta*, can reduce standing water in marshy areas (Malaria 2005); (Sharma & Sharma 1997). Planting shade trees near potential larval habitats may help reduce the abundance of vectors, such as *An. gambiae, An. funestus, An. minimus, and An. sundaicus* that prefer sunny conditions for larval development (Rafatjah, 1988).

The feasibility of flushing streams to control *An. culicifacies* was recently examined in rural Sri Lanka (Konradsen *et al.* 2004). The seasonal nature of vector activity and the species' preference for breeding in drying stream beds led the researchers to conclude that periodic flushing of a natural stream whose water flow was already controlled for irrigation could reduce malaria cases and reduce the need for larviciding. However, further field testing would be needed to demonstrate the efficacy of flushing and to indicate the level of inter-sectoral collaboration required for successful implementation. Flushing has also been used successfully in Mexico to remove *An. pseudopunctipennis* larvae associated with rice fields (Rafatjah, 1988).

Tree planting to help drain marshy land was included both as part of an integrated vector control program and to address other environmental problems associated with deforestation in the Kheda District in Gujarat, India (Sharma & Sharma, 1997).

Furthermore, different environmental conditions, including humidity, rainfall, and soil composition, may also affect particular interventions on the malaria vector and disease transmission. Finally, as environmental manipulations are aimed at reducing overall vector population density, good coordination of activities at a local level is needed. In the case of intermittent irrigation, poor soil drainage may result in standing pools that permit vector larvae to complete development, which may have reduced the impact of this method in the Mwea irrigation scheme in Kenya (Mutero *et al.* 2004).

2.1.3 Changes in Placement and Habitats

Changes in placement and structure of human habitations as well as changes in behaviour may reduce human-vector contact (Rozendaal 1997a; Malaria 2005). Humans have long practiced a simple form of malaria prevention by locating houses away from breeding sites, although settlements must be near enough to a water source to supply domestic needs. Many *anopheline* adults can fly as far as 3 km from their larval habitat, locating settlements 1.5 to 2 km away from major breeding sites may significantly reduce transmission (Walker, 2002). Preferred housing sites should also be on well drained, high ground, upwind (rather than downwind) of probable breeding sites (Rozendaal. 1997b). Raising houses on poles may also reduce transmission, as many vector species tend to fly fairly low (Reiter, 2001). Although it has often been suggested that removing vegetation from around houses may control mosquitoes by removing resting sites, one of the few studies evaluating this practice found it had no effect on anophelines (Colgrove, 2002).

Mosquito-proofing dwellings by covering windows, eaves, and doors with screening and repairing cracks and holes by which mosquitoes enter may reduce transmission both by protecting people from bites and by preventing the spread of the disease from infected human reservoirs.

Screening and general housing improvements may reduce malaria transmission while raising overall living conditions. Improved house construction played a role in controlling malaria in the United States in the early 20th century (Colgrove, 2002). In the early 1940s, residents of several Jewish settlements in northern Palestine employed a range of measures to protect themselves from malaria, including careful screening of rooms and the restriction of human activity to screened areas between sunset and sunrise (Kitron & Spielman, 1989). More recent research in Sri Lanka indicated that residents of poorly constructed houses were as much as 2.5 times more likely to contract malaria than neighbors in houses of good construction (Gamage-Mendis *et al*. 1993). Economic calculations suggested that government investments to improve the most vulnerable houses would be offset within 7.2 years by savings in malaria treatment (Walker, 2002). In rural Gambia, it was found that children sleeping in houses with closed eaves and metal roofs experienced fewer malaria infections than children sleeping in houses with open eaves (Lindsay, 1998). However, not all forms of housing improvement will reduce malaria transmission: for example, compulsory house improvements to reduce rat-vectored plague epidemics implemented in Java in the 1930s resulted in a dramatic increase in malaria transmission (Walker, 2002).

In areas where wet rice or other heavily irrigated crops are implicated in providing larval habitat for malaria vectors, the practice of dry-belting is recommended (Thevasagayam 1985; Rafatjah 1988). Drybelting involves maintaining a band of pasture or other dry crop around a village or town that would otherwise be bordered or even surrounded by wet fields.

In a malaria control project carried out in Crosset, a rural area in Arkansas of the United States, workers cleaned 9,244 linear yards of old ditches and installed 3,177 yards of new ditches. The workers cleaned 4,844 yards of street ditches and applied oil or larvacide to borrow pits, streams and ditches as well as four ponds and 311 water barrels kept in sawmill and along the railroad lines. The results were remarkable, in

1915, the year before the project local Physicians had an estimated 2,500 calls to treat malaria. After the project had taken off in 1916, the number dropped to 741 with per capita cost of $1.24, well below the $2 cost of a visit to a Physician. The other benefits were that, Crossett became virtually free of mosquitoes, malaria was practically eliminated and the sanitary and general health conditions greatly improved. (Hardenburg, 1922)

In poor rural areas of many tropical countries, traditional house design or construction materials may not be suitable for mosquito proofing (W.H.O., 2008). These is especially true where houses lack walls on all four sides or are made of thatch or other materials that are full of cracks and holes. House improvements may also be ineffective for malaria control where people frequently sleep outdoors. In these situations, personal protection, such as impregnated bed nets, may be more appropriate. In comparison with the present project study areas, Takuve and Kakadedzi are both rural areas and the type of houses as depicted in fig. 1c were mostly constructed with local materials such as thatch sealed with straw mats. Few houses were built with local clay and then roofed with Aluminium sheets.

2.2. Chemical Control of Malaria Vectors

Chemical control of adult female mosquitoes has been the most widely successful vector control method since the 1940s. The most common practice is indoor residual house spraying (IRS), in which the inside walls, the ceiling, and sometimes the outside eaves, porches, and nearby animal sheds is sprayed with a persistent insecticide. The rationale for IRS is based on the behavior of those *Anopheles* species that rest on walls before or after biting humans. Dramatic reductions in the annual parasite index (API) achieved by pilot IRS projects in many parts of the world inspired the World Health Assembly to adopt malaria eradication as a goal in 1955 (Feachem, 2008). However, the goal of eradication proved elusive in most malaria-endemic countries in the tropics.

The effectiveness of IRS is, nonetheless, well established (Kouznetsov, 1976). Many different insecticides could be suitable for IRS. An appropriate insecticide, however, should be highly toxic to the insect, safe for humans and non-target organisms, persistent on the wall or ceiling surface, acceptable to the inhabitants of the house, easy to apply, and fairly inexpensive (Rozendaal, 1997c). House spraying programs are most likely to be effective when the principal vectors are endophilic and endophagic and where strong financial support can ensure timely chemical application by well-trained operators, using appropriate equipment and insecticides (Chavasse & Yap 1997). DDT has been the most widely used insecticide for vector control since the 1940s.

DDT spraying has been widely demonstrated as a valuable tool for the prevention of malaria transmission (Shiff, 2002). During the WHO-sponsored malaria eradication program of the 1950s and 1960s, global DDT use was high, but it has declined significantly over the past 30 years. According to a preliminary WHO inventory, DDT is still used or stockpiled for use in about 26 countries; however, several countries have planned to phase it out in the near future. One factor motivating countries to examine alternatives may be the global treaty on persistent organic pollutants, including DDT, currently being negotiated through the UN Environment Program (UNESCAP, (n.d.); UNEP (2010). The treaty was expected to allow countries to continue to use DDT for vector control, but UNEP would collaborate with WHO to provide technical and financial support to assist countries in safely phasing out DDT over time.

In some countries that still use indoor house spraying for vector control, other insecticides have been employed in place of DDT. Early replacements have included organophosphates (*Malathion, Pirimiphosmethyl,* and *Fenitrothion)* and carbamates (*Bendiocarb, Carbosulfan,* and *Propoxur*). More recently, light-stable Pyrethroids— including *Permethrin, Deltamethrin*, *Cypermethrin, Cyfluthrin*, and *Lambda- cyhalothrin*—and the Pyrethroid mimic *Etofenprox* have also been used (Chavasse & Yap 1997.). WHO has established a program, the Pesticide Evaluation Scheme (WHOPES), to test various insecticides used for vector control, including IRS, larviciding, and space spraying, to provide recommendations on the appropriate formulations and application doses (Chavasse & Yap 1997). WHO and other technical information sources stress the need to apply insecticides following the appropriate techniques to ensure effective control (Rozendaal, 1997 b). However, even when insecticides are applied as directed, other factors, such as the type of house structure and building material, can reduce the impact of IRS. Insecticides tend to last longest on wooden or painted walls and to break down quickly (especially pyrethroids) on mud walls with a high clay content (Rozendaal, 1997a). IRS may also be less effective where houses are not walled on all sides. As stated above, vector behavior is also important, as different species rest on different types of surfaces. Species that tend to bite outdoors are not easily controlled through IRS (Walker, 2002).

Due to the hyper-endemic nature of malaria in Ghana, IRS was needed as an intervention at targeted areas where maximum impact on reduction of malaria transmission could be achieved. Implementation of IRS conforms to the internationally accepted standards (WHO/CDS/WHOPES/GCD PP/2001.3) and the National guidelines. A wide range of insecticides which falls under specific groups such as *Organochlorines*, *Organophosphates, Carbamates* and *Pyrethriods* are used for IRS. The choice of insecticides is informed by a number of considerations such as insecticide susceptibility and vector behavior, safety for humans and the environment, efficacy and cost effectiveness, and public acceptability.

A wide range of chemical, biological, and environmental management techniques may be used to control malaria vectors. Nonchemical approaches generally require substantial information about vector ecology, distribution of larval habitats, and local environmental conditions. Furthermore, these interventions tend to be effective only under certain conditions, and successful control in one location may not be predictive of results elsewhere. Chemical control, particularly IRS, appears more consistently effective across a wide range of vectors and environmental conditions, although problems with insecticide resistance and concerns about pesticide exposure risks suggest that selective and limited applications of this technique may be desirable.

Research on malaria vector control in Africa is more limited and tends to focus mainly on urban areas. Published reports describing large-scale implementation of nonchemical techniques suggest that combinations of several interventions appropriate to local conditions and vectors may provide good control (Walker & Lynch 2007)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Period, Area-Communities and Population

The study was carried out within fourteen months period (from April 2011 to June 2012) in two communities; Kakadedzi and Takuve both being rural communities of Ziope in the Agortime-Ziope District of the Volta Region. Agortime-Ziope District as shown in Fig. 1 below has a population of 62,852 (2010 Population and Housing Census Report).The females constitute about 54.2 percent whilst the males constitute 45.8 percent. Kakadedzi has a population of six hundred and five (605) whilst

Takuve has a population of four hundred and three (403). The District annual growth rate is 1.17 percent. The most populated areas are Kpetoe, Ziope and Akpokope. The average household size in these settlements is 4.8 i.e. 5 people. People within the ages of 15 and 64 make up the District labour force. According to the 2010 Population and Housing Census, 52.3 percent of the population falls within this cohort. However as a result of increasing poverty among the people in the district, children between the ages of 10-14 are highly engaged in active labour. The populaces of Kakadedzi are mainly farmers and alcohol distillers while those of Takuve are only farmers. The settlements of these communities are areas of rural housing, with lower income families as shown on figs. 2, 3 and 4 below.

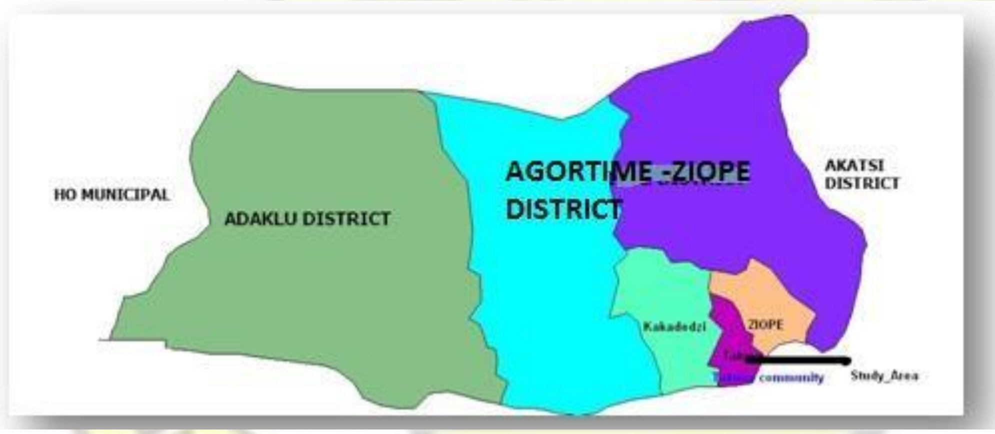

Fig. 1: The study area and specific communities.

Fig. 2: A back yard used as a refuse / waste dumping ground and discarded motor vehicle tyres and other opened containers which provide ideal mosquito breeding habitats may be seen in the background.

Fig. 3: A typical unkempt compound with large water containers which collect water after rains and provide ideal site for egg-laying by mosquitoes.

Fig. 4: A typical poor housing with unscreened windows and doors in the rural community of Takuve

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The typical pattern of rainfall in Ziope consists of two annual rains each year: from March to June as major rainy season and from September to November as the minor rainy season, interspersed with dry periods. However, in recent years the pattern appears to be changing resulting in less clearly defined rainy seasons. Sources of drinking water for these communities are dams, boreholes and harvested rain water.

There is only one Health centre which is centrally located in Ziope to serve the entire Ziope townships. The Health situation in the District has been improving over the years with significant improvements having been made in the eradication and elimination of diseases such as polio, guinea worm and cholera as no cases was reported in the District between the years 2009 to 2012. However, malaria continues to be the largest contributor to the diseases in the district.

There is also one Basic School which is located at Takuve a few kilometers from Kakadedzi and a Senior High School which is also located in Ziope about 2km from Kakadedzi.

The types of toilet facilities commonly in use are Institutional KVIPs and pit latrines. Solid waste disposal is a challenge in these communities (Kakadedzi and Takuve).The practice of indiscriminate disposal of refuse is high in these communities (Fig.2) because there are no designated public refuse dumps. The common practice is the composting of refuse in excavated pits. Unlike in the large towns, the small communities normally set a place aside at the outskirt of the community as a refuse dump.

3.2 Study Design

The study was in four stages:

1. Preliminary Data Gathering on Malaria in the study communities as the pre-intervention period.
2. Anti-mosquito measures as intervention period.
3. Review of Malaria situation after the intervention.
4. Interviewing of the lower Primary pupils, Basic school pupils and the rest of the community inhabitants on malaria and its control.

3.3 Community Sensitization

The community inhabitants were briefed on the aims and objectives of the study and their consent to participate in the study was sought.

3.4 Sampling Procedure.

3.4.1 Health Facility Records.

There was a review of hospital records on reported malaria cases at Ziope Health Center which serve the catchment areas of the study. A sorting mechanism was employed using the Excel software to identify the location of reported cases of infection. This finally showed the number of malaria patients from Kakadedzi and Takuve communities that reported at the Ziope Health Centre.

3.4.2 Egg and Larval Collection.

Mosquito eggs and larvae were collected from randomly sampled breeding sites at Takuve and Kakadedzi monthly from November 2011 to June 2012 between 11:00 am and 1:00 pm. A dipper was lowered gently at an angle of 45 degree just below the surface of the water of the breeding site so that water flowed in together with any eggs and larvae that might be present. The sampling was done by displacement suction taking care not to disturb the water too much since that would make the larvae dive downwards. Three hundred cubic millimeters (300cm^3) of water was collected from each of the breeding sites, identified as drinking pot, depression on farm, dam in both Kakadedzi and Takuve and a reservoir in Kakadedzi which served as a water storage container during _akpeteshie' distillation. This volume of water from each breeding site (Figs.5, 6 and 7) was then gently transferred into labeled plain plastic jars and placed into separate experimental cages each for the eggs to hatch and larvae to develop into adult mosquitoes. The adult mosquitoes were starved to die, identified and then counted. This sampling was done to identify potential mosquito breeding sites, determine the availability of mosquito breeding sites all year round, and determine the preferred breeding sites for mosquitoes and the type of mosquitoes present.

Fig. 5: Depression created on a farm in Takuve for irrigation purposes.

Fig. 6: A reservoir (local condenser) which stores water for condensing the alcohol vapour during the distillation of "akpeteshie" (the local gin) at Kakadedzi

Fig. 7: An overgrown dam (a mosquito breeding habitat) which is a domestic source of water for Kakadedzi community.

Fig. 8: Samples of water collected from different habitats and placed in cages for emergence of adult mosquitoes.

3.4.3 Adult Mosquito Collection and Identification

A random sample of eight houses was taken in each community. This involved a systematic selection of houses with a random **start**. *The first house was selected at random and after that every third house from the first selected house was selected for sampling*. These identified houses were used for routine adult mosquito collection.

Mosquitoes usually stay in the net or the room after feeding on blood because they become inactive due to their heavy weight. So when the rooms are sprayed early in the morning with safe and effective insecticides, the adult mosquitoes will die and fall down.

Every Sunday for eight weeks in the mornings between 6:00 am and 8:00 am a bedroom in each of these selected houses was sprayed for indoor resting mosquitoes using Raid insecticide. The dead mosquitoes were collected on a white calico fabric and counted. This schedule was done before and after the intervention stage. The sampling was done in order to determine the densities of mosquitoes present in the two communities and to evaluate the impact of control measures on these communities.

The adult mosquitoes were identified by microscopic examination of their physical characteristic features and used as a key. The palp of the Anopheles mosquito was as long as the proboscis and on its wings were discrete blocks of black and white scales.

3.4.4 Intervention Stage

The community inhabitants were educated on the disease malaria, how to control it, and some of the benefits of controlling malaria. Some proposed interventions were emptying opened containers of water and covering opened containers, weeding or cutting down bushes and grasses around homes, burying open tins, screening doors and windows and filling depressions around the communities. The inhabitants understood that these interventions, when carried out religiously could reduce the breeding grounds of mosquitoes.

The inhabitants cleared their surroundings by weeding and later burned the weeds. Empty cans were buried. Alcohol distillers emptied their local condensers of water at the end of every distillation. The reservoirs were properly covered with lids .The main source of water for the community was also cleared of overgrown vegetations to expose the water body to enough sunlight and also reduce the hideouts for mosquitoes. The men and women had a thorough general cleanup of their rooms; hanged clothes were neatly folded into bags to reduce hideouts for mosquitoes. After these interventions, eight rooms were selected from eight houses by systematic random sampling with a random start. Numbers 1, 2, 3 and 4 were written on pieces of paper and folded. The folded papers were thrown on a table and one of them picked. The fourth number on the picked paper was then chosen as the first house. After this every fourth house was counted and chosen for the spraying. This yielded the systematic random sampling of selecting the eight rooms for the spraying.

The selected eight rooms from each house in each of the two communities were sprayed with insecticides at 6.00am on each Sunday of every week for eight weeks. The dead mosquitoes were then collected on white calico and counted.

3.4.5 Focus Group Discussion

Anthropological research techniques such as Focus group discussions and interviews were employed to collect qualitative narrative accounts of the community members.

Focus group discussions were held for children of the basic levels of the educational ladder, namely the Primary level and the Junior High School level, and another for the adults in the two communities. The lower Primary pupils were put into one group for the discussions. The upper Primary and the Junior High School pupils were also put into one group for the discussions. This was because the Junior High pupils were very few in the school. The objectives of this discussion were to assess the inhabitant‘s knowledge on malaria: the disease, its cause, transmission and control.

3.5 Data Analysis

Both qualitative and quantitative methods of Data collection were used. Data entry and analysis were done using Microsoft Excel for weekly records from the selected houses.

At the end of each week during the data collection period number of dead mosquitoes as a result of insecticide action were counted and entered into Microsoft Excel database for analysis. Pivot tables were used to run the number of dead mosquitoes against weeks of collection and rooms sprayed for mosquito collection. Means and proportions were obtained regarding the number of mosquitoes feeding per night per room.

Invivo 9 software was used to run responses from the focus group discussion into themes for common results obtained from the discussion.

CHAPTER FOUR

4.0 RESULTS

4.1 Review of Malaria cases in Ziope Health Centre from April 2011 to April 2012

Malaria was reported at the Health Centre throughout the year but the trend peaked between June and August. This period saw a lot of human activities especially farming and more habitats for mosquitoes being created as depressions in farms, drinking pots stored with rain water and empty containers filled with water.

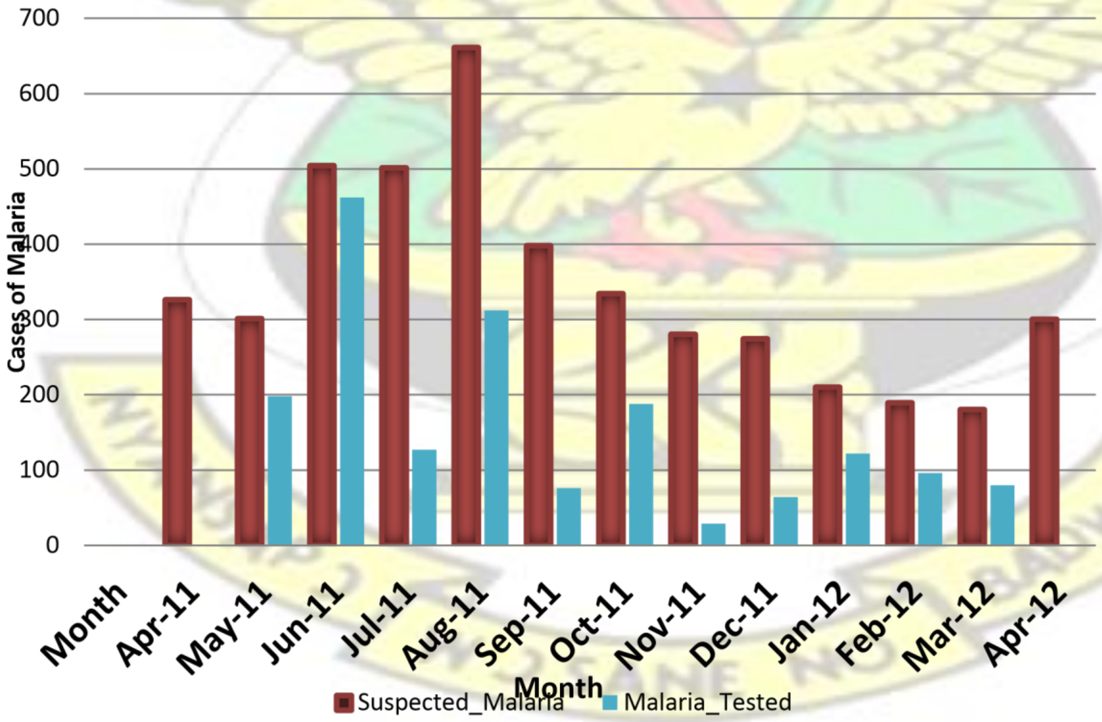

Fig. 9: Cases of Presumptive malaria and Diagnosed malaria at Ziope Health Centre-April 2011 to April 2012.

From Fig. 9 above, it is evident that the Health Centre recorded increasing cases of presumptive malaria from April to August; the month of August recorded the highest number of cases. From September to March the number of cases declined steadily; the lowest number of cases was recorded in the month of March. The suspected malaria cases indicate the number of Out Patients Department (OPD) attendants who were presumed to have malaria based on symptoms exhibited by the patients. The diagnosed malaria cases were the number of OPD attendants who tested positive by either the use of microscopy or Rapid Diagnostic Test Kits for Malaria or both. The result of the tests confirmed that the patients had the causative agent *Plasmodia i*n their blood.

4.2 Identification of Breeding Grounds

The breeding habitats for mosquitoes in the Kakadedzi and Takuve communities were not different in terms of environmental factors except that human activities in Kakadedzi such as alcohol distillation stored large volumes of water which served as breeding ground. The other environmental difference was a shrine constituted by a thick forest and surrounded by open basins containing water which serves as drinking pots for the deities in the community but which was also a mosquito breeding reservoir. Table 1 shows the number of mosquito larvae and the adults emerging from a 300ml sample of water collected each month from different breeding containers (habitats) during the period October of 2011 to June 2012 in Kakadedzi. The local condenser which is a water storage container used for condensing alcohol vapour during alcohol distillation had the highest number of larvae and adult mosquitoes throughout the study period.

Table 1: Mosquito (larvae and adult) content of 300 ml of water collected from different habitats in Kakadedzi community

Date	Drinking pot		Depression on farm		Local condenser		Dam	
	Larvae	Adult mosquitoes	Larvae	Adult mosquitoes	Larvae	Adult mosquitoes	Larvae	Adult mosquitoes
October 2011	3	2	4	2	15	6	6	2
November 2011	1	0	1	0	13	5	4	3
Dec 2011	0	0	0	0	11	3	5	3
January2012	2	1	0	0	7	4	4	2
February 2012	0	0	0	0	10	4	3	2
March 2012	0	0	0	0	18	11	4	3
April 2012	2	0	4	1	16	9	2	0
May 2012	6	2	6	4	20	8	6	4
June 2012	9	4	8	5	15	8	8	5
Cumulative	**23**	**9**	**23**	**12**	**125**	**58**	**42**	**24**

A Total number of one hundred and twenty five (125) larvae were collected in the samples from the local condenser within the eight month sampling period and 46.4% of these larvae matured into adult mosquitoes. Forty one 41 larvae were sampled from the Dam and 63.41% of these larvae emerged as adult mosquitoes. Cumulatively, twenty three (23) larvae were collected from the drinking pot at

Kakadedzi which stored rain water but only 39.1% of the larvae emerged as adult mosquitoes. The local condenser emerged the highest number of adult mosquitoes followed by the Dam, whilst the least number of adult mosquitoes emerged from the drinking pots.

Table 2: Mosquito (larvae and adult) content of 300 ml of water sample collected from different habitats in Takuve community.

Date	Drinking pot/Water tank		Depression on farm		Dam	
	Larvae	Adult mosquitoes	Larvae	Adult mosquitoes	Larvae	Adult mosquitoes
October 2011	5	4	3	1	5	3
November 2011	6	3	2	1	4	2
December 2011	4	3	0	0	4	1
January 2012	0	0	0	0	4	3
February 2012	2	0	0	0	3	2
March 2012	5	2	0	0	4	4
April 2012	2	0	2	0	6	4
May 2012	4	2	5	3	7	5
June 2012	5	3	7	3	4	2
Cumulative	**33**	**17**	**19**	**8**	**41**	**26**

In Takuve, only three habitats of mosquitoes were identified. They were the Drinking pot or Water tank, Depression on farm, and a Dam. The same volume of water samples were collected from these habitats. The Dam, which was the main source of water for the community, cumulatively recorded the highest number of larvae and 63.4% out of these larvae developed into adult mosquitoes. The drinking pot or water tank which stored water for domestic use recorded thirty-three (33) larvae in the water samples and

51.5% of these larvae emerged as adult mosquitoes. The least number of larvae were contained in the water sample of a depression on a farm. Cumulatively, nineteen (19) larvae were collected and 42.1% of these larvae emerged as adult mosquitoes.

Table 3: Number of Adult mosquitoes collected from eight rooms at Kakadedzi two hours after spraying (IRS) the rooms with insecticides (RAID) at the pre-intervention stage.

Period	**Room 1**	**Room 2**	**Room 3**	**Room 4**	**Room 5**	**Room 6**	**Room 7**	**Room 8**
Week1	13	7	5	8	5	12	10	9
Week2	9	12	3	6	6	8	6	6
Week 3	11	10	5	5	7	11	7	8
Week 4	13	14	11	10	9	7	11	13
Week 5	17	16	13	8	12	10	8	9
Week 6	15	13	17	15	11	13	12	11
Week 7	14	9	12	19	8	16	11	10
Week 8	8	20	14	21	15	14	10	17
Cumulative	100	101	80	92	73	91	75	83
Mean per week	**12.5**	**12.625**	**10**	**11.5**	**9.125**	**11.38**	**9.375**	**10.38**
Approximated mean	**13**	**13**	**10**	**12**	**9**	**11**	**9**	**10**

Table 3 above, shows the number of adult mosquitoes collected from eight randomly selected rooms at Kakadedzi. From this table (Table 3), the approximated arithmetical mean of adult mosquitoes collected from each room for eight weeks indicated that the highest approximated mean was thirteen (13) and the lowest was nine (9).The approximated mean is in the range of 13 to 9 a difference of 4.

Table 4: Number of Adult mosquitoes collected from eight rooms at Kakadedzi two hours after spraying (IRS) the rooms with insecticides (RAID) at the post-interventions stage.

Period	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7	Room 8
Week 1	5	3	2	4	3	6	4	3
Week 2	2	2	4	3	2	5	4	4
Week 3	6	4	3	3	3	2	3	4
Week 4	3	5	8	6	4	3	2	3
Week 5	7	9	5	5	3	7	7	9
Week 6	8	5	5	6	4	5	4	3
Week 7	8	10	7	6	6	9	10	7
Week 8	5	11	6	10	9	8	6	8
Cumulative	44	49	40	43	34	45	40	41
Mean per week	**5.5**	**6.125**	**5**	**5.375**	**4.25**	**5.625**	**5**	**5.125**
Approximated mean	**6**	**6**	**5**	**5**	**4**	**6**	**5**	**5**

Table 4 contains data on the number of mosquitoes collected from the same eight randomly selected rooms at Kakadedzi community after the interventions. The interventions applied in the communities were clearing the weeds surrounding the houses and along water courses, burying empty cans, removing cobwebs from the rooms, removing hanged clothes and packing them into bags, covering the drinking pots with lids and emptying the water reservoir which was used to condense alcohol vapour during distillation of alcohol after every distillation. The approximated mean of adult mosquitoes collected from these rooms after the interventions indicated (Table 4) a reduction in the number of adult mosquitoes collected. The highest approximated mean number of mosquitoes reduced to six (6) and the lowest was reduced to four (4).

Table 5: Overall reduction in the number of mosquitoes for each study room in Kakadedzi (from the pre-intervention stage to the intervention stage).

Period	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7	Room 8
Pre-intervention stage	100	101	80	92	73	91	75	83
Post -Intervention stage	44	49	40	43	34	45	40	41
% Reduction in number of mosquitoes	**56**	**51.5**	**50**	**53.3**	**53.4**	**50.5**	**46.7**	**50.6**

Table 5 above depicts the eight randomly selected rooms in Kakadedzi community showing a significant percentage reduction in the number of adult mosquitoes collected after the environmental interventions stage. The least percentage reduction in the number of mosquitoes collected was 46.7 and the highest percentage reduction was 56. Figure 10 below gives a clear picture of the reduction in the number of mosquitoes after applying the environmental interventions. Overall Mean Reduction in the study rooms in Kakadedzi community was 51.5.

An independent t-test was run for the two sets of data (per- and post-) to determine whether or not there were statistical differences in mosquito numbers based on the interventions. The result showed that rooms in Kakadedzi, after the interventions, had statistically significant reduction in numbers of mosquito (42 ± 1.5600) at the end of the experiment compared to rooms during the pre-intervention (86.8800 ± 3.8000), $p = 0.0000$.

A graph of overall number of mosquitoes in each study room in Kakadedzi during the pre-intervention period and the post-intervention period is shown below (Fig.10).

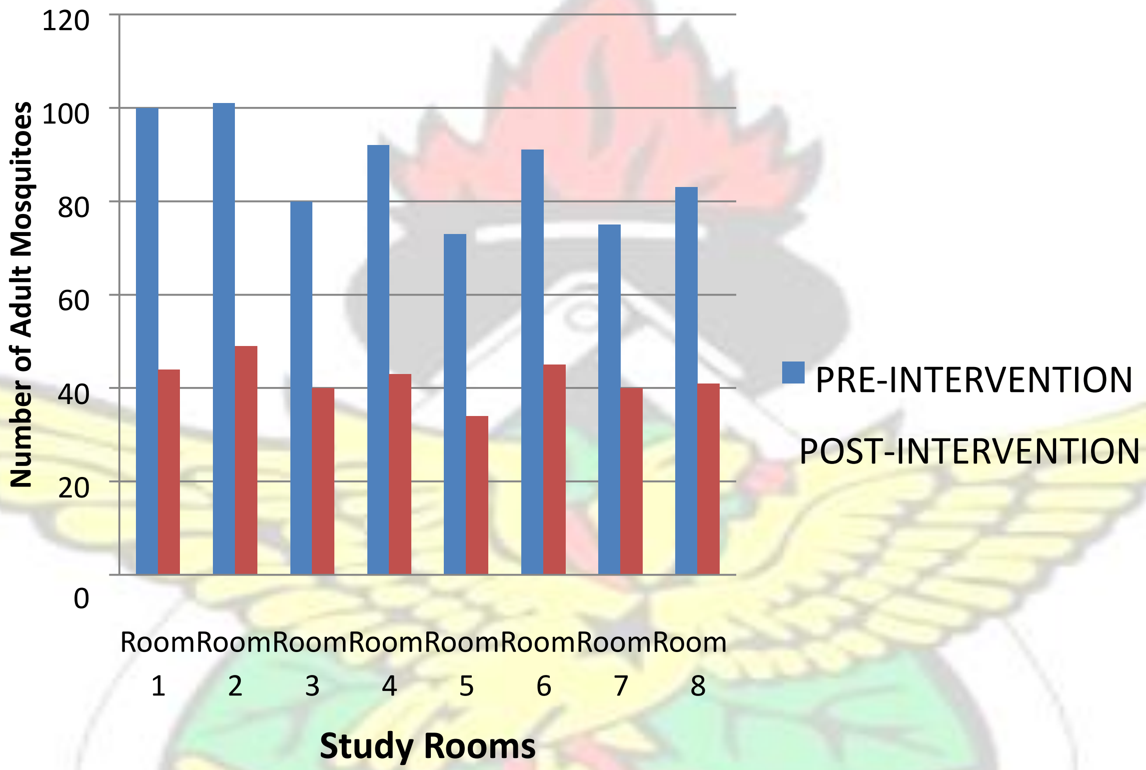

Fig. 10: Overall number of Dead Mosquitoes Collected From Study Rooms During PreIntervention And Post-Intervention Period In The Kakadedzi Community.

Table 6: Adult mosquitoes collected in eight randomly selected rooms at Takuve after spraying (IRS) with insecticides (RAID) before the intervention stage.

Period	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7	Room 8
Week 1	9	6	10	6	5	6	8	7
Week 2	3	5	8	9	0	3	12	5
Week 3	6	0	3	12	9	7	9	3
Week 4	2	4	0	4	6	4	7	1
Week 5	7	6	7	4	5	3	4	4
Week 6	5	8	5	0	4	6	5	4
Week 7	8	7	6	3	4	5	3	3
Week 8	4	5	2	4	4	0	2	2
Cumulative	44	41	41	42	37	34	50	29
Mean per week	**5.5**	**5.125**	**5.125**	**5.25**	**4.63**	**4.25**	**6.25**	**3.625**
Approximated mean	**6**	**5**	**5**	**5**	**5**	**4**	**6**	**4**

Table 6 shows the number of dead mosquitoes collected from eight randomly selected rooms at Takuve before the application of the environmental interventions. The highest cumulated number of mosquitoes collected within eight weeks was fifty (50) and the lowest number was twenty-nine (29). The highest approximated mean of the mosquitoes for the eight weeks was six (6) and the lowest was four (4).

Table 7: Adult mosquitoes collected in eight randomly selected rooms at Takuve after spraying (IRS) with insecticides (RAID) a day after the intervention stage.

Period	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7	Room 8
Week 1	6	2	5	2	2	5	4	5
Week 2	3	1	4	3	3	2	6	2
Week 3	5	2	1	4	4	3	3	4
Week 4	4	0	0	1	3	3	1	0
Week 5	0	4	3	3	1	4	5	3
Week 6	7	5	2	5	4	1	4	5
Week 7	5	3	4	2	1	7	3	1
Week 8	2	2	2	4	3	1	5	6
Cumulative	32	19	16	24	21	26	31	26
Mean	**4.0**	**2.375**	**2**	**3.0**	**2. 625**	**3.25**	**3.825**	**3.25**
Approximated mean	**4**	**2**	**2**	**3**	**3**	**3**	**4**	**3**

Table 7 shows that after applying the environmental interventions, the number of dead mosquitoes collected from each of the eight rooms had reduced. Room 7, for example, had an accumulated number of fifty (50) mosquitoes in Table 6 before the interventions stage but this figure was reduced to thirty-one (31) after the environmental interventions had been applied. The highest approximated mean after the intervention stage was 4 and the lowest was 2 whilst before the intervention period the highest approximated mean was 6 and the lowest mean was 4.

The overall reduction in the number of mosquitoes in each of the eight randomly selected rooms at Takuve from the pre-intervention to the post- intervention periods, are given in Table 8 below.

Table 8: Overall reduction in the number of mosquitoes in eight randomly selected rooms at Takuve before and after the intervention periods

Period	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7	Room 8
Pre-intervention	44	41	41	42	37	34	50	29
Post-Intervention	32	19	16	24	21	26	31	26
% Reduction in mosquito numbers	**27**	**54**	**61**	**43**	**43**	**24**	**38**	**10**

Overall Percentage Mean Reduction in the number of mosquitoes in Takuve community after the environmental intervention was 31.38.

An independent t test was run for the two periods (pre and post intervention) to determine whether there were significant differences in mosquito numbers or not based on the interventions. The result showed that rooms in Takuve after the interventions had statistically significant reduction in numbers of mosquitoes **(24.3750 ± 1.9700**) after the intervention compared to the mosquito numbers in these rooms at the pre-intervention stage (**39.7500 ± 2.2600), t(14)=5.1180; P=0.0002**

Generally, the overall number of mosquitoes killed and collected in all the eight rooms was higher during the pre-intervention IRS application than the number collected after the intervention period. The percentage reduction in the number of mosquitoes killed and collected in each room showed a range of 10% to 61%.

4.3 Responses from Focus Group Discussion

4.3.1 Responses from Upper Primary and Junior High School Pupils

Knowledge of the upper primary pupils from the community on what malaria was varied; however, most of them, sixty-eight percent (68%), knew it was a sickness transmitted by mosquitoes through their bites and a further seven percent (7%) incriminated mosquitoes whilst the remaining twenty-five percent (25%)

attributed it to dirty or unkempt surroundings (Table 9). There is, therefore, established knowledge among the communities that malaria was a sickness gotten from mosquitoes.

Table 9: Pupils knowledge on malaria.

Serial no.	Responses	No. of respondents	% of Total Response
1	It is a kind of sickness given to man through mosquito bite.	41	68
2	Malaria is gotten through dirt in the surrounding.	7	12
3	We get Sickness from mosquitoes.	4	7
4	We get Sickness from unkempt environment.	8	13
	Total	**60**	**100**

When asked what the host of malaria was, 50% of the total respondents said man, 35% said sheep and 15% of the total respondents said goats (Table 10).

10: Pupils' knowledge of the host of malaria

Serial no.	Responses	Number of Respondents	% of Total Response
1	Goats	9	15
2	Sheep	21	35
3	Man	30	50
	Total	**60**	**100**

When asked how would one know that he or she was suffering from malaria, 39% of the total respondents said one would have headache, 20% said one would have coldness and chills, 13% said one would have yellow eyes, 7% said one would have high fever, 4% said one would feel feverish, 6% said one would be vomiting and 13% said one would be passing frequent stool (Table 11). **Table 11: Pupils' knowledge of Symptoms of Malaria**

Serial no.	Responses	Number of Respondents	% of Total Response
1	Headache	21	39
2	Vomiting	3	6
3	Yellow eyes	6	11
4	High fever	4	7
5	Frequent stool	7	13
6	Feeling feverish	2	4
7	Coldness and chills	11	20
	Total	**54**	**100**

When asked who could be **infected** with malaria, 38% of the total respondent said those who kept their environment dirty, 25% of the total respondents said they themselves could be affected by malaria, another 25% of the total respondents also said children could be infected with malaria and 12% of the total said that their parents could be affected by malaria (Table 12).

Table

Table 12: Pupils' response as to "who could be infected with Malaria"

Serial no.	Responses	Number of Respondents	% of Total Response
1	Self	15	25
2	Those who keep the environment dirty	23	38
3	Children	15	25
4	Parents	7	12
	Total	**60**	**100**

When asked where to find mosquitoes, the answers were even more varied (Table 13.) although each answer was characteristic of mosquito breeding places:18% of the total respondents said mosquitoes could be found in drinking pots; 17% said mosquitoes could be found in pools of rainwater; 12% said mosquitoes could be found along river banks whilst another 12% said mosquitoes could be found in toilets rooms, 8% said mosquitoes could be found in dumping areas, another 8% said mosquitoes could be found in dirty places, 7% said mosquitoes were found in bathroom waste waters. 5% also said mosquitoes could be found inside small cans containing water. Again 5% of the total respondents said mosquitoes were found in bushy places whilst 3% said that mosquitoes were found in ponds.

13: Pupils' response to "where to find mosquitoes?"

Serial no.	Responses	Number of Respondents	% of Total Response
1	in gutters ,	3	5
2	along river banks,	7	12
3	in pools of rain water,	10	17
4	in ponds,	2	3
5	inside small cans with water,	3	5
6	in dumping areas,	5	8
7	in toilet rooms,	7	12
8	inside pots containing drinking water,	11	18
9	in bathroom waste waters,	4	7
10	in dirty places,	5	8
11	in bushy places	3	5
	Total	**60**	**100**

When the pupils were asked how they could drive away mosquitoes from their environment, (Table14), their responses were as follows: 22% said that dirty cans should be emptied of water, 13% said gutters should be cleaned regularly,11% said gutters should be sprayed with insecticides, 10% of them said dirty places should be swept, 9% said mosquitoes could be driven away from the environment by adding Kerosene to the surface of stagnant waters, 6% said rubbish dumps should be burnt, 4% said living rooms should be sprayed with insecticides and 3% said that weeds in the surroundings should be cleared (Table 14).

Table 14: Response to: "How can we drive mosquitoes away from our immediate surroundings?"

Serial no.	**Responses**	**Number of Respondents(N =94)**	**% of Total Response**
1	Clearing bushy areas	21	22
2	Adding kerosene to surface of stagnant waters,	8	9
3	Cleaning gutters,	12	13
4	Spraying gutters,	10	11
5	Sweeping all dirty places,	9	10
6	Pouring out water from dirty cans or containers	21	22
7	Clearing weeds in the surroundings,	3	3
8	Burning rubbish dumps,	6	6
9	Spraying living rooms with mosquito spray.	4	4
	Total	**94**	**100**

To know the background of these children, they were asked the type of work their parents engaged in for a living. The responses (Table 15) indicated that their parents belonged to low income earning groups. When asked, how they dealt with waters stored in tanks for brewing alcohol? The response (Table 16) showed that 70% of them occasionally threw the water away.

Table

15: Occupation of Parents of study school Pupils

Serial no.	Responses	Number of Respondents(N=87)	% of Total Response
1	Farming	21	24
2	Trading	11	13
3	Store keeping	6	7
4	Brewing alcohol	12	14
5	Tapping palm wine	7	8
6	Driving	2	2
7	Corn milling	6	7
8	Carpentry	7	8
9	Bricklaying	2	2
10	Dressmaking	9	10
11	Grass cutter hunting	4	5
	Total	**87**	**100**

Table

16: .Disposal of water stored in local brewing tanks, after use.

Serial no.	Responses	Number of Respondents(N=30)	% of Total Response
1	We occasionally throw the water in them away	21	70
2	We also clean the inside of the tank.	3	10
3	We keep the water for other uses such as bathing and for animals to drink.	6	20
	Total	**30**	**100**

4.3.2 Responses from Lower Primary Pupils.

To the question what malaria was, there was a 100% response that malaria was a fever. (Table 17) When asked what caused malaria, 1.96% said eating unripe mangoes caused malaria, 58.82% said mosquitoes caused malaria, 5.88% said dirty hands caused malaria, 11.76% said houseflies caused malaria,7.84% said stomachache caused malaria and 13.73% said not washing hands after visiting the toilets caused malaria (Table18).

Table 17: Pupil's knowledge on Malaria

Serial no.	Responses	Number of Respondents(N=56)	% of Total Response
1	Malaria is fever	56	100

Table

18: Pupil's knowledge on what causes malaria.

Serial no.	Responses	Number of Respondents	% of Total Response
1	eating unripe mango	1	1.96
2	mosquito,	30	58.82
3	dirty hands,	3	5.88
5	housefly,	6	11.76
6	stomachache,	4	7.84
7	Not washing hands after using toilet.	7	13.73
	Total	**51**	**100**

To the question on the symptoms of malaria, 65% of the pupils mentioned vomiting, 8% mentioned eyes become yellow, 16% mentioned chills and shivering whilst 11% mentioned headache (Table 19).

Table 19: Pupil's knowledge of the Symptoms of Malaria

Serial no.	Responses	Number of Respondents(N=37)	% of Total Response
1	When one is attacked he/she would vomit.	24	65
2	One's eyes become yellow,	3	8
3	When there is chills and shivering	6	16
4	Headache	4	11
	Total	**37**	**100**

Table

When asked whether or not there were insecticide-treated mosquito nets (ITN) in their homes, all responded positively indicating that 100% of the total respondents have ITNs in their homes (Table 20).

As a follow up to this question, the pupils were asked, whether they sleep under ITN every night? Fifty percent of the total respondents admitted, they slept under ITN every night, 30% replied in the negative whereas 20% said sometimes they slept under ITN (Table 21)

Table 20: Possession of ITN at home

Serial no.	Have ITN at home	Number of Respondent (N=56)	% of Total Response
1	Yes	56	100
2	No	0	0

Table 21: Pupils response on whether or not they slept under mosquito net.

Serial no.	Sleeping under ITN every night	Number of Number of Respondents(N=60)	% of Total Response
1	Yes	30	50
2	No	18	30
3	Sometimes	12	20
	Total	**60**	**100**

Reasons given by the pupils on why they do not sleep under the ITN every night varied; however, as indicated in Table 22, thirty one percent (31%) of them attributed it to the weather being hot, sixteen percent (16%) said the net was torn, twenty two percent (22%) said the net was dirty and the remaining thirty one percent (31%) said the only net in the house was being used by their fathers.

22: Reasons for not sleeping under ITN every night.

Table

Serial no.	Reasons for not sleeping under ITN every night	Number of Respondents(N=49)	% of Total Response
1	Weather is hot	15	31
2	The net is dirty	11	22
3	It is torn	8	16
4	It is only one net in the house being used by our father	15	31
	Total	**49**	**100**

When asked why it was necessary to sleep under ITN, 35% of the sampled pupil populations said it was necessary to sleep under ITN in order to avoid mosquito bites, 19% said to avoid mosquito‘s disturbance, 40% also said it was to prevent malaria, whereas 6% said it was necessary to sleep under ITN because it keeps oneself warm (Table 23).

Table 23: Reasons for sleeping under ITN

Serial no.	Reasons for sleeping under ITN	Number of Respondents(N=63)	% of Total Response
1	To escape from mosquito bite	22	35
2	To avoid mosquito disturbances	12	19
3	To prevent malaria	25	40
4	To keep ourselves warm	4	6
	Total	63	100

When asked about the habitats of the mosquitoes, 22% said mosquitoes could be found in empty cans containing water, 20% said mosquitoes could be found in gutters 15% said mosquitoes could be found in the toilet rooms, 8% answered that mosquitoes could be in plantain trees. Fifteen percent said mosquitoes could be found in collection of pools of water and 20% said mosquitoes could be found in their rooms (Table 24).

Table 24: Pupils knowledge on where to find mosquitoes

Serial no.	Where to find mosquitoes	Number of Respondents (N=100)	% of Total Response
1	In an empty cans with collection of water after raining,	22	22
2	Inside gutter,	20	20
3	Inside toilet,	15	15
4	In plantain trees,	8	8
5	In collection of pools of water,	15	15
6	In our rooms	20	20
	Total	**100**	**100**

Table

To the question on how could malaria be prevented or controlled, 13% said water collected in cans should be thrown away,17% said gutters should be desilted regularly,19% answered that weeds around pools of water should be cleared quite often.26% said they should sleep under ITN, 11% said they have to use mosquito coil, which is an insecticide. Also, as shown in Table 25, 15% said they have to cover their bodies with protective clothing.

Table 25 Pupils' knowledge on how to prevent malaria.

Serial no.	**Responses**	**Number of Respondents(N=47)**	**% of Total Response**
1	We throw away all collection of water in cans	6	13
2	desilt gutters,	8	17
3	we clear weeds away from collection pools,	9	19
4	we sleep under nets (ITN) ,	12	26
5	we use mosquito coil,	5	11
6	We cover ourselves with protective clothing.	7	15
	Total	**47**	**100**

When the pupils were asked how they would educate their parents on malaria, 21% said they would inform their parents that malaria is gotten through the bites from infected female *anopheles* mosquitoes. Seventeen percent (17%) said they would inform their parents that storing water in containers could increase mosquito breeding and so that must be prevented. Thirty one percent (31%) said pools of water after rains must be avoided, 17% said that they would inform their parents that sleeping under ITN must be regular since this would reduce human-vector contacts. The pupils also said they would inform their parents that houseflies do not cause malaria (Table 26).

Table 26: Pupils Educating Parents about malaria.

Serial no.	Responses	Number of Respondents (N=72)	% of Total Response
1	That we get malaria through mosquito bite and therefore mosquito bites must be prevented,	15	21
2	That we should throw away all collection of water in homes	12	17
3	We do away with pools of water after rains,	22	31
4	We should sleep regularly under nets,	12	17
5	Houseflies do not cause malaria.	11	15
	Total	**72**	**100**

When asked how they would get rid of mosquitoes from their surroundings, their responses cited environmental cleaning activities as follows: twenty six percent (26%) of them said empty cans should be buried, 44% said bushes should be cleared around homes and 30% said cobwebs should be removed from their rooms (Table 27).

Table 27: What to do to get rid of mosquitoes from our environments

Serial no.	Responses	Number of respondents (N=50)	% of Total Response
1	We bury all empty cans,	13	26
2	we clear bushes around us,	22	44
3	we remove cobwebs from our rooms	15	30
	Total	**50**	**100**

As to what happens to those bitten by mosquitoes, 40% said they fell sick, 28% said the mosquitoes suck their blood, 20% said mosquito bites reduce their strength and 12% said it produces sore and wounds on their skins.(Table 28).

Table 28: What happens after mosquito bites?

Serial no.	Responses	Number of Respondents(N=124)	% of Total Response
1	We become sick,	50	40
2	It sucks our blood,	35	28
3	It reduces our strength,	25	20
4	It produces wounds or sores on the skin.	14	12
	Total	**124**	**100**

When the lower primary pupils were asked how they were treated when they fell sick with malaria, 35% said their parents bought medicines over the counter for them, 17% said they were sent to the clinic. 8% said they were inoculated and 40% said their parents squeezed herbs such as the leaves of the nim tree or lemon leaves in hot water for them to drink (Table 29).

Table 29: Treatment Action against Malaria.

Serial no.	Responses	Number of Respondents(N=63)	% of Total Response
1	We Purchase drugs	22	35
2	We visit the clinic,	11	17
3	We are injected	5	8
4	We squeeze herbs including nim tree leaves or lemon in hot water and drink.	25	40
	Total	**63**	**100**

4.3.3 Responses from Parents

In a group discussion, parents were asked questions on malaria, its symptoms and control. To the question what malaria was, thirty three percent (33%) said Malaria was a disease caused by mosquito bites, 21% said malaria was a disease caused by staying for long hours under the hot sun, 29% said malaria was caused by drinking too much ―akpeteshie‖ which is a local alcohol, 17% said malaria was caused by eating certain food items (Table 30).

Table 30: Community response on what malaria is.

Serial no.	What is malaria	Number of Respondents(N=24)	% of Total Response
1.	Disease caused by mosquito bites.	8	33
2.	Disease caused by staying for long hours under the hot sun.	5	21
3.	It is caused by drinking too much akpeteshie (alcohol).	7	29
4.	It is caused by eating certain food items.	4	17
	TOTAL	**24**	**100**

On the signs and symptoms of malaria, thirty three percent (33%) said dizziness, 25% said coldness, another 25% also said joint pains and 17% said the mouth tasted bitter (Table 31).

Table 31: Knowledge of the signs and symptoms of malaria attack.

Serial no.	Responses	Number of Respondents (N=24)	% of Total Response
1	Dizziness	8	33
2	Joint pains	6	25
3	Coldness	6	25
4	Bitter taste in the mouth	4	17

	Total	24	100

As to what group of people suffer from malaria, thirty three percent (33%) said children, 21% said pregnant women another 21% also said elderly people, 25% said people who always stay in cool places suffer from malaria (Table 32).

Table 32: Group of people who suffer from malaria.

Serial no.	Responses	Number of Respondents (N=24)	Percentage of Total Response
1	Pregnant women.	5	21
2	Children.	8	33
3	Elderly People	5	21
4	People who always stay in cool places	6	25
	Total	**24**	**100**

On reducing population of mosquitoes from their communities, majority (67%) of the total respondents said they should regularly remove all waters collected around their bathhouses whereas 33% said the ″akpeteshie‖ distillers should regularly remove water from their reservoirs and clean them (Table 33).

Table 33: How to reduce the population of Mosquitoes from our communities?

Serial no.	Responses	Number of Respondents(N=12)	% of Total Response
1	We should regularly remove all waters collected around our bath houses.	8	67
2	Akpeteshie distillers should regularly remove water from their reservoirs and clean the reservoirs	4	33
	Total	**12**	**100**

On prevention of mosquito bites, 43% said they should sleep under ITN during the night, 36% also said they should keep their surroundings clean all the time and 21% said everybody should clear bushes around their homes (Table 34).

Table 34: How to prevent mosquito bites

Serial no.	Responses	Number of Respondents(N=14)	% of total Response
1	We should keep ourselves in mosquito nets during night sleep.	6	43
2	We should keep our surroundings clean.	5	36
3	Everybody should clear bushes around their houses.	3	21
	Total	**14**	**100**

On the question of how malaria was treated, twenty five percent (25%) said they used herbs such as ―fever grass and lemon leaves‖, 35% also said they reported at the Health Centers for treatment and 40% said they purchased drugs from peddlers (Table 35).

Table 35: How is malaria treated?

Serial no.	Responses	Number of Respondents(N=20)	% of Total Response
1	We use herbs such as fever grass, lemon leaves etc.	5	25
2	We go to the health centers.	7	35
3	We buy medicines from peddlers.	8	40
	Total	**20**	**100**

When finally asked whether they attended the Health Centers with National Health Insurance Cards or not, 42% of the said with Health Insurance cards they were given only one medicine whilst 58% said that on payment of cash full treatment was given to them (Table 36)

Table 36: Use of Health Insurance cards in attendance to Health Care Centres

Serial no.	Responses	Number of Respondents(N=12)	% of Total Response
1	With Health Insurance card you are given only one medicine.	5	42
2	When you pay cash, full treatment is given to you.	7	58
	Total	**12**	**100**

4.4 The Effect of Interventions on Malaria Cases at the Ziope Health Centre

Before carrying out the interventions, a total number of one hundred and twenty patients reported to Ziope Health Centre with malaria from Kakadedzi whilst seventy five patients with the same condition were from Takuve (Table 37).

After clearing the surroundings of weeds, burying empty cans, emptying water reservoirs after every alcohol distillation, packing unused clothes into bags and removing cobwebs from rooms, a total number of fifty one patients reported sick to the Ziope Health Centre with Malaria from Kakadedzi and thirty four reported with the same condition of sickness from Takuve, as shown by records from the Health centre the following year (table 38).

Indicating there was significant difference in the number of patient that attended hospital from the two towns before the intention. For Takuve (M=17.143, SD=3.0390) and Kakadedzi (M=17.1430, SD=5.0143), P value=0.0133 and that there were more patient from Kakadedzi than Tarkuve.

Table

37: Number of Malaria Patients who reported at the Ziope Health Centre before the interventions period

Serial no.	Month	Kakadedzi	Takuve	Total
1	April 2011	15	10	25
2	May 2011	17	8	25
3	June2011	20	13	33
4	July 2011	21	12	33
5	August 2011	24	15	39
6	September 2011	14	11	25
7	October 2011	9	6	15
	Total	**120**	**75**	**195**

Table

38: Number of Malaria Patients who reported at Ziope Health centre After the interventions period

Serial no.	Month	Kakadedzi	Takuve	Total
1	April 2012	5	1	6
2	May 2012	9	3	12
3	June 2012	7	4	11
4	July 2012	3	0	3
5	August 2012	11	14	25
6	September 2012	10	5	15
7	October 2012	6	7	13
	Total	**51**	**34**	**85**

Table

39: Total number of Malaria-diagnosed Patients Reporting at Ziope Health Centre Before and After the Interventions

Serial no.	Month	Before	After	Difference	Percentage drop
1	April	25	6	19	76%
2	May	25	12	13	37. 1%
3	June	33	11	22	66.7%
4	July	33	3	30	90.9%
5	August	39	25	14	35.9%
6	September	25	15	10	40%
7	October	15	13	2	13.3%
8	**TOTAL**	**195**	**85**	**110**	**56.4%**

The results from Table 38 suggested that, there were no difference in relation to the number of Malaria Patients from Kakadedzi (M=7.2857, SD=2.8702) and Takuve (M=4.857, SD=4.6701), P value =0.2639 who reported at Ziope Health Centre after the interventions. Whereas before the interventions there were significant difference, thus patient from Kakadedzi frequent the hospital with malaria cases more often.

Table 39 above, shows that before interventions were carried out, a total number of one hundred and ninety five (195) cases of malaria were recorded in the Health Centre within the period of April to October 2012. After the intervention stage, a total number of eighty five (85) cases of malaria were recorded in the same Health Centre from both Kakadedzi and Takuve communities. The highest percentage drop in malaria cases

Table

was 90.9% and this occurred in the month of July and the least percentage drop was 13.3% and this was recorded in the month of October. Within the seven months of the study, the average percentage drop in malaria cases in the two communities was 56.4% and this can be infer from the statistical result, which indicates that the interventions had statistically significant (p value = 0.0019) reduced the number of malaria diagnosed patients.

Table 40: Percentage Reduction in Number of Malaria cases at the Ziope Health Centre before and after the interventions in each of the two communities

Serial no.	Community	Total number of cases before intervention	Total number of cases after interventions	Percentage reduction in Malaria cases
1	Kakadedzi	120	51	57. 5
2	Takuve	75	34	54.7

Table 40 above shows the percentage reduction in number of Malaria cases in each of the two communities, Kakadedzi and Takuve, before and after the intervention periods. The results show that the intervention had statiscally significant reduced the number of malaria diagnosed patients (M=12.143, SD=7.03) after the intervention compared to malaria diagnosed patient before the pre-intervention period (M=27.857, SD=7.8).

CHAPTER FIVE

5.0 DISCUSSION

5.1 Review of Malaria cases at Ziope Health Centre from April 2011 to April 2012

At the Ziope Health Centre, the number of malaria suspected cases were those suspected to have malaria due to the symptoms reported by the patients. However, when the Health Centre is in short supply of the Rapid Diagnostic Kits (RDT) or when the patient has no money for purchasing the (RDT) kit then the case was treated as suspected malaria. The malaria diagnosed cases were those that have been diagnosed by laboratory examination of patients' blood samples using the Rapid Diagnostic kits and the results proved positive that the patient has malaria parasite in his or her blood smear. With reference to Fig. 9, malaria cases increased from April to a peak in August and decreased from September to March. January to March was normally a dry season in this study area and the breeding grounds for mosquitoes were usually dry. Mosquito population also decreased because the seasonal conditions in the study areas were no longer favorable for breeding mosquitoes.

The present study has not accounted for patients who could not report to the Health Centre for treatment. It was possible that some of these inhabitants got infected with malaria and purchased drugs from the counter or took herbal preparations.

5.2 Identification of breeding grounds

Malaria is essentially an environmental disease because the vector (mosquito) requires specific habitats with surface water for reproduction. Humidity is also needed for adult mosquito survival whilst temperature influences the development rates of both the vector and parasite populations (Dhiman *et al*. 2008).

Tables 1 and 2 list the breeding grounds for mosquitoes in these two communities as local condenser, dams, depressions on farm, and drinking pots. This is because they contained larvae which later developed into adult mosquitoes.

Global Health Reporter, Tupil Mazumdar (2013) proposed that Malaria researchers should target breeding sites in order to control malaria in Africa and Asia. In His Presidential address to the Arkansas Medical

Society in 1914, Dr. Frank B. Young noted that malaria remained widespread and was economically the most harmful disease in the State at the time. Young said that Physicians must not only treat individuals, but also destroy the breeding habitats of the mosquitoes. He also said that the eradication of malaria can only be accomplished by a persistent educational campaign in which every doctor should be the leader in his home community (Gallup *et al* 2001).

The results of the current study do indicate that identifying the mosquito breeding habitats in the Kakadedzi and Takuve communities and destroying them could make a beneficial impact on controlling malaria in these two communities. This meant that the number of patients who would report to the health centre with malaria cases after the breeding habitats have been destroyed would also reduce.

Malaria control implies reducing malaria transmission to a level where it is no longer a public health problem (W.H.O., 2008). If there can be increases in resources, increases in political will and increases in commitment of policy implementers including community members then malaria could be controlled

.

Figure 11: A dam which serves as a source of water and a breeding ground for mosquitoes in Takuve community.

5.3; Intervention Period

Mosquitoes usually stay in the net or the room after feeding, so when the rooms were sprayed early in the morning with safe and effective insecticides the adult mosquitoes died and fell on a white calico which was laid on the floor of the room.

Kakadedzi is larger in size and more populous than Takuve. There were more mosquitoes in the rooms of the Kakadedzi inhabitants as a result of the favourable conditions and suitable habitats of the vector mosquitoes. Putting interventions such as emptying local condensers, bush and grass clearance, burying open cans, screening doors and windows, killing adult mosquitoes by spraying with effective and safe insecticides, covering water pots, avoiding storage of water for too long in the reservoirs and filling depressions on farms in place were some of the interventions used in the study communities. Also, a health education forum at which the inhabitants were educated on the benefits of malaria control, through reduction of mosquito breeding habitats and their involvement deployed were measures that expectedly reduced adult mosquito populations in the study communities (Table 8).

According to David Moyers (1917), workers were tasked in 1916 to clean 9,244 linear yards of old ditches, install 3,177 yards of new ditches and clean 4,844 yards of street ditches. The workers also applied oil (larvacide) to borrow pits, streams and ditches, four ponds and 311 water barrels which were kept in sawmill and along railroad lines. The results of this project were remarkable: in 1915, the year before the project, Physicians received an estimated 2,500 calls to treat malaria but with the control project in 1916, the number of calls dropped to 741. Also, according to the Global Health-Division of Parasitic Diseases and Malaria (last reviewed on 9th November 2012), in the United States, the National Malaria Eradication Program commenced operations on July 1, 1947 and by the end of 1949 over 4,650,000 house spray applications had been made. In 1947, 15,000 malaria cases were reported but by 1950, only 2,000 cases were reported. By 1951, malaria was considered eliminated from the United States.(www.cdc.gov/malaria/about/history/panama_canal.html) (20th August, 2013).

5.4 Responses from the Primary School Pupils

The responses from the group discussion with the pupils suggest that the pupils knew that malaria was a disease transmitted by mosquitoes and they were able to list a number of the symptoms of the disease, however, fifty percent of them did not know that man was the host of malaria. The pupils also said that everybody, young or old, could be infected with malaria. The pupils recognized and mentioned various habitats of mosquitoes (Table 13) and also knew how to prevent mosquitoes from breeding around their homes (Table 14).

Anopheles mosquito does not breed in garbage or polluted gutters. However, removal of garbage or filth is good for public health in general and reduces the number of nuisance mosquitoes but it has little impact on malaria control.

The lower Primary pupils‘ responses revealed that about forty percent of them knew that malaria was a disease caused by infected anopheles mosquito bites. This exercise was very important because it is these lower primary pupils who liked playing with empty cans and afterwards leave these cans around their homes. It has also been revealed from table 22 that torn and dirty nets are not mended and used. Also about thirty one percentage of the fathers of the children used the only available net in the homes. Children are at particular risk from malaria so they could contribute to malaria control programs by helping to prevent mosquitoes from breeding and biting people. According to the responses in Table 29, most parents did not send their sick children to the clinics or hospitals for the required diagnosis and treatment. Most parents still used herbs for treatment and they were ignorant of the fact that patients had to be first examined for parasites before diagnosing the disease.

5.5. Adult Responses

The parent‘s responses in Table 30 was so amazing that they had to be educated on the fact that malaria was caused by only infected female anopheles mosquitoes and that staying under the scorching sun, eating certain foods or drinking too much alcohol would not cause malaria. However eating food contaminated with bacteria and drinking too much alcohol were dangerous to one‘s health.

About the signs and symptoms of malaria the parents were again informed that in addition to what they have mentioned, headache and body temperature rise are also some of the symptoms of malaria. Also malaria could affect anybody who was exposed to infected female anopheles mosquitoes. Children and pregnant women however were the most vulnerable ones because of their low immunity level. About how the population of mosquitoes in the communities could be reduced, the parents and elders of the communities were educated on the facts that mosquitoes breed in places which contain standing water. They were advised to clear their surroundings of weeds and bushes and make sure that the drinking pots were well covered. Parents were also informed to fill in or drain places where water collects.

The efficacy of insecticide treated nets (ITNs) is not in the netting itself but the insecticide that it is treated with. The ITNs must be retreated, they must be placed properly over the bed so that there will be no gaps and if they are damaged, then they should be rendered useless. The ITNs are only distributed to pregnant women and children and this means only part of the population is protected from mosquito bites.

The adults were further educated on the importance of seeking health care from the clinics. Most of them were of the opinion that visiting the clinic meant they had to be in a long queue and that wastes a lot of time. Information which needed to be investigated was the Health Insurance Cards. Forty two percent of adults surveyed said ―with health insurance cards they were given only one medicine and that on payment of cash full treatment with plenty medicines was given to them‖. Parents and elders in the communities were advised to desist from the use of herbs in treating fever or malaria and rather, report to the clinics for effective diagnosis and treatment.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Review of malaria cases in the Ziope Health Centre indicated that even though malaria was recorded throughout the year (April 2011 to April2012) it was more prevalent during the rainy season (from June to September 2011) than in the dry season.

The local condenser, depression on farms and the dam from which the people got water for both farming and domestic activities turned to be the most breeding grounds for mosquitoes in the two communities. The mean number of mosquitoes collected from each room before the interventions were significantly more than those collected after the interventions and this reflected in the malaria cases recorded in the Health Centre.

Results from the Health Centre indicated that the environmental management interventions applied reduced the number of malaria cases significantly because there was 56.4% drop in the reported malaria cases at the Health Centre.

Twenty percent of the total population of elders in the communities had little or no knowledge on malaria and its control.

The lower primary pupils were educated by the facilitator of the focus group discussion on the facts that; malaria parasites are found in man: the parasites attack the red blood cells, break the cells down and this results in chills and a bite from a female *Anopheles* mosquito can spread the parasite unknowingly: that the malaria parasite is not in goats, sheep or in other animals, however, the yellow fever parasite can be found in animals and that it is different from the malaria parasite.

6.2 Recommendations

1. Housing structures have to be monitored by Health or Local Authorities to make sure that Environmental Control strategies such as mosquito proof windows and doors are developed and incorporated within housing development projects.
2. By-laws preventing people from obstructing drainage channels or creating potential mosquito breeding sites, should be enforced. Therefore, politicians and environmental health officers should be encouraged to review and possibly implement these bye-laws to sustain environmental management in order to control malaria and other diseases.
3. To help ensure the success of source reduction for malaria control, the younger generation has to be educated about the benefits of a healthy lifestyle. A miniature home can be built by school children on the school grounds using local materials to construct a local house but with added features such as piped water, a VIP latrine, screened doors and windows on the school compound.
4. Local Authorities should be encouraged to put a day aside every month on the calendar for General Cleaning of homes and surroundings so that the younger generation will cultivate the culture of source reduction of mosquito breeding as a method for malaria control.

5. Bore holes should be drilled at vantage points in the communities so that the inhabitants would not store water in containers for long periods of time.
6. The ITNs should be subsidized by the Government so that they are affordable by all segments of the society instead of distributing the nets to segments of the population free of charge.
7. There should be a sustained educational campaign in all the communities for community participation in reducing mosquito breeding grounds. The lower Primary Pupils should not be left out of this, because they are the very ones who play with these empty cans and afterwards leave them around their homes.
8. The inhabitants of both Kakadedzi and Takuve have to be educated on the Health Insurance Policy. This will help them to understand the usage of the Health Insurance Cards.
9. Local mosquito control committees should be formed in the two communities to work in collaboration with the environmental units of the District Health Administration and the District Assembly.
10. Domestic water storage containers should be covered to prevent breeding of mosquitoes.
11. Empty cans and containers, car tyres, abandoned fridges, vehicles, televisions, which collect rainwater, should be drained and properly disposed of to prevent them serving as breeding grounds for mosquitoes.

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APPENDICES

APPENDIX 1: GUIDE FOR GROUP DISCUSSION AT TAKUVE JHS

Questions

1. What is malaria
2. What is the host of malaria?
3. How will one know he/she is suffering from malaria?
4. Who can be affected by malaria?
5. Where do you find mosquitoes?
6. How can you reduce the population of mosquitoes from your communities?
7. . What types of work do your parents engage in?
8. How do you deal with waters stored in tanks used for local brewing?

APPENDIX 2: GUIDE FOR GROUP DISCUSSION AT TAKUVE PRIMARY

1. What is malaria?
2. What causes malaria?
3. How do you know you have malaria?
4. How many of you have ITN in your homes?
5. Do you sleep under ITN every night?
6. What are the reasons for not sleeping under ITN every night?
7. Where do you find mosquitoes?
8. How does mosquito breed?
9. How can you prevent malaria?

10. How will you educate your parents about malaria?

11. What can you do to get rid of mosquitoes from our environments?

12. What happens to you after mosquito bites?

13. How are you treated when you have malaria?

APPENDIX 3: GUIDE FOR FOCUS GROUP DISCUSSION AT TAKUVE

Questions

1. What is malaria?
2. What is the host of malaria?
3. What are the signs and symptoms of malaria attack?
4. Who can be affected by malaria?
5. Where do you find mosquitoes?
6. How can you reduce the population of mosquitoes from your communities?
7. How can you prevent mosquito bites?

8. How is malaria treated?

9. Do you attend health care centres with National Health Insurance cards?

APPENDIX 4

Analysis of table 37

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
Kakadedzi	7	0	7	9.0000	24.0000	17.1429	5.0143
Takuve	7	0	7	6.0000	15.0000	10.7143	3.0394

Difference	**6.4286** t (Observed value) **2.9007** |t| (Critical value) **2.1788**

DF	**12** p-value (Two-tailed) **0.0133**	
Alpha		**0.05**

Test interpretation

H0: The difference between the means is equal to 0.

Ha: The difference between the means is different from 0.

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.The risk to reject the null hypothesis H0 while it is true is lower than 1.33%.

The results suggested that, there were no difference in relation to the Number of Malaria Patients from Kakadedzi (M=7.2857, SD=2.8702) and Takuve (M=4.857,SD=4.6701), T(12)=1.772, P value= 0.2639, who reported at Ziope Health centre after the intervention

APPENDIX 5

Analysis of Table 38

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
Kakadedzi	7	0	7	3.0000	11.0000	7.2857	2.8702
Takuve	7	0	7	0.0000	14.0000	4.8571	4.6701

Difference	2.4286
t (Observed value)	1.1722
|t| (Critical value)	2.1788
DF	12
p-value (Two-tailed)	0.2639
Alpha	0.05

Test interpretation:

H0: The difference between the means is equal to 0.

Ha: The difference between the means is different from 0.

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.The risk to reject the null hypothesis H0 while it is true is 26.39%.

The results suggested that, there were no difference in relation to the Number of Malaria Patients from Kakadedzi (M=7.2857, SD=2.8702) and Takuve (M=4.857,SD=4.6701), T(12)=1.772, P value= 0.2639, who reported at Ziope Health centre after the interventions.

APPENDIX 6

Analysis of table 39:

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
Before	7	0	7	15.0000	39.0000	27.8571	7.8194
After	7	0	7	3.0000	25.0000	12.1429	7.0339

Difference	15.7143
t (Observed value)	3.9530
|t| (Critical value)	2.1788
DF	12
p-value (Two-tailed)	0.0019
Alpha	0.05

Test interpretation:

H0: The difference between the means is equal to 0.

Ha: The difference between the means is different from 0.

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.The risk to reject the null hypothesis H0 while it is true is lower than 0.19%.

The result shows that the intervention had statistically significant reduced the number of malaria diagnosed patients (M=12.143, SD=7.03) after the intervention compared to malaria diagnosed patient during the pre intervention era (M=27.857, SD=7.8)