PROXIMITY OF WASTE DUMP SITESTO RESIDENTIAL NEIGHBOURHOODS AND THE INCIDENCE FOR MALARIA AMONG UNDER FIVE CHILDREN IN PORT HARCOURT, RIVERS STATE

BY

AMACHREE, MIKIAI TUBOIBIBO KIENI (B.Sc., PGD)

20075590459

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CERTIFICATION

This is to certify that this work **"PROXIMITY OF WASTE DUMP SITES TO RESIDENTIAL NEIGBOURHOODS AND THE INCIDENCE FOR MALARIA AMONG UNDER FIVE CHILDREN IN PORT HARCOURT RIVER STATE"** was carried out by **AMACHREE, MIKIAI TUBOIBIBO KIENI (Reg. No. 20075590459)** in partial fulfillment for the Award of Master of Technology, (M.Tech) in Environmental Technology, Federal University of Technology, Owerri.

______________________	15/01/2016 ______________________
Dr. E.E. NKWOCHA (Supervisor)	**Date**
______________________	16/~/16 ______________________
Dr. C.O. Nwoko (H.O.D)	**Date**
______________________	18/03/16 ______________________
Prof. (Mrs.) R.N. Nwabueze (Dean, SOES)	**Date**
______________________	______________________
Engr. Prof. K.B. Oyoh (Dean, Postgraduate School)	**Date**
______________________	______________________
External Examiner	**Date**

DEDICATION

This thesis is dedicated to God Almighty.

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KEY WORDS USED

Container: Any portable device in which waste is stored

Disposables: Consumer products, other items, and packages used for a few times and discarded

Dump: A site used to dispose of solid waste without environmental controls

Garbage: Animal and vegetable waste resulting from the handling, storage, sale, preparation, cooking, and serving of foods

Landfill: Disposal sites for nonhazardous solid wastes spread in layers, compacted to the smallest practical volume, and covered by material applied at the end of each operating day.

Litter: The highly visible portion of solid waste discarded outside the regular garbage and trash collection and disposal system

Malaria: Malaria is an infectious disease caused by a parasite (*plasmodium*) which is transmitted from human to human by the bite of an infected female Anopheles mosquito

Open burning: Uncontrolled fires in an open dump

Open dump: Uncovered site used for disposal of waste without environmental controls.

Refuse: This refers to non-putrescible solid waste constituents such as paper, tin cans, glass, wood etc.

Rubbish: Solid waste, excluding food waste and ashes, from homes, institutions, and workplaces.

Sewage: This can be defined as waste discharges from human body together with the liquid waste from household and factories. It consists chiefly of feaces, urine, washings and secretions from the skin, mouth and nose.

Solid waste: Non-liquid, non-soluble materials ranging from municipal garbage to industrial wastes. Solid wastes also include sewage sludge, agricultural refuge, demolition wastes, and mining residues. Technically, solid waste also refers to liquid and gases in containers.

Storage: the holding of waste for a temporary period.

Transfer point: An area where waste material is bulked for eventual removal, a break/bulk area.

Transfer station: Facility where solid waste is transferred from collection vehicles to larger trucks or rail cars for longer-distance transport.

Trash: Materials considered worthless or offensive that is thrown away. Generally defined as dry waste material, but in common usage it is a synonym for garbage, rubbish, or refuse

Treatment: Methods used to change the physical chemical and biological characteristics of waste

Urban waste: These include domestic and commercial wastes. They are garbage materials which result from food preparations both in the home and in the restaurants, and also rubbish produced in residences and commercial establishments.

Waste: Unwanted materials left over from a manufacturing process. Refuse from places of human or animal habitation.

Waste dump: Final depository site for waste

Waste management: The collection, storage, transfer, treatment and disposal of waste

Waste pile: A non-containerized accumulation of solid waste

Waste stream: The total flow of solid waste from homes, businesses, institutions, and manufacturing plants that is recycled burned or disposed of in landfills or segments therefore such as the "residential waste stream" or the "recyclable waste stream".

ABSTRACT

Epidemiological studies suggest that there may be an association between environmental exposure to waste dumpsites and malaria. The aim of this study was to investigate whether residential proximity to waste dumpsites result in increased rate of morbidity for malaria among the most vulnerable population groups such as children under the age of five. A total of 150 children between the ages of one and five years were sampled in a residential neighbourhood in Eneka, Port Harcourt. Data were obtained from the parents of the subjects with the aid of a specially- designed and well-structured questionnaire, review of hospital records, assessment of exposure and assessment oflarval abundance. Results showed that among the subjects within the total sample of 150 subjects, there were 1670 reported cases of malaria among the subjects within 11months study period. Of this total, 1272 (76.1%) cases were treated in zone A (distance below 500 meters) and 398 (23.8%) in zone B (distance more than 500 meters). The Spearman correlation coefficient calculated between rate of morbidity and distance from dumpsite in zone A was $r = 1.12$ ($p < 0.05$) and was adjusted for other factors that may have contributed to the disease. The overall results showed that children living within a distance below 500 meters from the dumpsite (zone A) are 3.5 times more likely to suffer malaria than those living beyond 500meters' distance (zone B). A trend of lower incidence of malaria was therefore noted among children living in zone B. These results show that municipal waste dumpsites create pathological zones in which disease vectors proliferate and pose significant dangers within the residential neighbourhood.

CHAPTER ONE

INTRODUCTION

1.0 Background to the Study

Most cities of the world are in a serious state of environmental crisis which threatens the quality of life of their inhabitants. They suffer from myriads of problems such as air and water pollution, urban crimes, traffic congestion, poor sanitation, water crisis, to name a few.

One of the most serious problems is the increasing quantity of urban solid waste (Sahoo, 2006, Adapti *et al*, 2013). Increased population urbanization, industrialization and most especially, the increasing demand for consumer goods have encouraged massive importation of goods, which invariably has increased the per capita rate of waste generation in urban areas resulting in a serious strain on the environment (Ashtelli, 2012, Wood, 2006)

Nigeria towns and cities also experience this trend. The problem of solid waste management in the country has become more and more complex due to high rate of population growth, urbanization and industrialization (Aguwamba, 2003). A study conducted in 1982 by a group of environmental specialists in 15 selected towns in Nigeria found that the volume of dumped waste ranged from about 2×10^6 kg/year to as high as 56×10^6 kg/year in these areas. It was also found out that those areas within a radius of 0.5km of the city centres, accounted for about 40% of the uncleared volume of solid waste (Abumere, 1983)

In recent times, it is estimated that each person in Nigeria generates about 0.85kg of waste per day (Cookey, 2004). In all, about 119 million tons of municipal and industrial waste are generated per day based on projections of the 2006 National Population estimates of 140 million (Ngwulaka et. al; 2009). The problem of how to manage these wastes is reaching critical proportion (Nkwocha and Ekeoma, 2009, Anurigwo, 1995, Adegoke, 1990)

In response to this problem, and other emerging environmental challenges, the Federal Government of Nigeria enacted the National Policy on Environment (1989) and the National Environmental Sanitation policy (2006) as the key policy documents guiding environmental management and protection.

The implementation of these policies is presently saddled with weak infrastructural base, coupled with poor institutional and inadequate managerial capacities to run towns and cities as political,social and economic entities (Nkwocha, Pat-Mbano and Nnaji, 2011).Nigeria still lacks an integrated approach to waste management which has resulted in uncertainties within the waste management sector, weak local accountability and poor strategic planning capabilities (Ayuba *et al.* 2013, Igoni *et al.* 2007). The continuous degradation of the environment, coupled with unsanitary disposal of various waste materials pose serious challenge to achieving the ecological sustainability in our development process.

Moreso, it has continued to endanger the life of urban residents who are exposed to different diseases associated with unsanitary waste disposal practices (Okereke, 2012; Odocha, 1994).

1.1 Statement of the Problem

The state of solid waste management in Rivers State in general and in Port-Harcourt in particular since in the early 1990s has been generally poor. Ever since the present democratic dispensation in 1999, local authorities and the government of Rivers State have made efforts to search for cost-effective and efficient methods of managing urban solid waste and keeping the streets clean. Efforts have been geared towards the provision of more trucks, equipment and recruitment of more personnel for the collection and disposal of the ever increasing volume of municipal waste.

The present administration went extra mile and contracted the waste collection services to private companies whose efforts have led to quantum improvements in the level of urban cleanliness. But unfortunately, waste dumps keep on proliferating especially in the outskirts of the city. The throw–away mentality continues to gain ground with residents, pedestrians, hawkers and most street users littering the environment with impurity. The most serious phenomenon is the emergence of large waste dumps in proximity to residential areas. Nkwocha and Emeribe (2008) identified more than 28 authorized and unauthorized waste dumpsites in Port-Harcourt to include those at Elekahia, Olu-Obasanjo, Rivoc, Choba, and Stadium Road. Most of these dumpsites are located at open lands and are poorly managed. These dumps constitute breeding grounds to disease vectors and may be associated with some of the diseases prevalent in the area. Few studies have attempted to investigate the waste-disease relationships especially in the city of Port-Harcourt. This study therefore tried to investigate whether the nearness of waste dumps to residential neighbourhoods in the town could lead to increased rate of morbidity for malaria. This study will certainly help, not only to collect information on this neglected area of waste management but will also help to improve understanding on waste-human relations in the area.

1.2 Aim and Objectives

- **Aim**

  The aim of this study is to investigate whether proximity of waste dumpsite to residential neighbourhoods may increase the incidence of malaria around Eneka waste dump sited along Eneka/Igwuruta Road.

- **Objectives**

  This aim will be achieved through the following objectives:-

  i. to characterize the types of solid wastes dumped in the area;
  ii. to delineate the pathological zone created by the waste dumpsite in the study area;
  iii. to choose a representative sample of children living within zone who are exposed to malaria;
  iv. to investigate the rate of incidence for malaria among these subjects;
  v. to investigate the effect of distance from the dumpsite on the rate of incidence for malaria, and
  vi. to recommend possible ways of mitigating the rate of incidence for the disease in the study area.

1.3 Research Questions

i. What causes the proliferation of illegal dumpsites in Port- Harcourt?
ii. Does living close to these dumpsites increase the rate of incidence for malaria?
iii. What is the effect of distance of residential houses from dumpsite on the rate of incidence for malaria?
iv. What possible measures could be taken to mitigate malaria parasitemia in the area?

1.4 Research Hypothesis

This study will be based on the following hypothesis:

H_O: The rate of incidence for malaria among children does not depend on the distance of their residence from waste dumpsites.

1.5 Justification of the Study

The importance of this study cannot be over emphasized.

Firstly, it will help to know the rate of incidence for malaria in people residing close to dumpsites and why illegal waste dumpsites are still on the increase in Port- Harcourt.

The government, especially the Local Government Areas would benefit from this study if attention will be given to the findings and recommendations of this study.

Also, this research will serve as a reference material to students who may want to make further research on this topic or on related topics in the future.

1.6 Scope of the Study

The study focuses on investigating the rate of incidence for malaria among children between the ages of 1 and 5 years living within a radius of 500 metres from Eneka dumpsite within Port-Harcourt town. Quantititative analysis of residential waste generated by the population living within Eneka residential district will be carried out in terms of the amount and types of waste generated.

Other assessments such as exposure of children to malarial infection;larval abundance etc will be carried out in the area. Data on the socio-economic characteristics of parents of exposed children will be collected (sex, age, educational level, housing conditions etc); as well as exposure characteristics within study area (high fever,body weakness, loss of appetite etc).

CHAPTER TWO

LITERATURE REVIEW

2.1 Problem of Waste Generation in Nigeria

Ologhobo (1991) states that the generation of waste material is a problem that is not peculiar to Nigeria alone. In fact, the problem is more profound in the industrialized countries of the world where the pollutant effects of industrial wastes have caused considerable concern to environmental scientists. The depletion of the ozone layer by gases released into the atmosphere, and deforestation and pollution of rivers by acid rain, are some of the traumatic effects of environmental pollution experienced in some of these countries. However, these problems which result mainly from gaseous waste discharged into the atmosphere, are not common in Nigeria.

Our problems are essentially those of solid and liquid waste which emanates from discarded materials, generated from domestic and community activities or from industrial, commercial and agricultural operations. The problems are compounded by the advent of industrialization and urbanization in different states of Nigeria, high population density, intensive land use and improper handling and disposal of accumulated wastes.

The rapid growth in size and population of towns and cities, have brought about great changes in the volume and diversity of wastes generated and because these changes have no concomitant increase in waste disposal facilities, the environmental and health problems are compounded of which malaria is one of major concern. Ologhobo (1991) opined that an obvious way of reducing the problem of environmentally induced diseases in Nigeria is to manage wastes properly and waste disposal with resource recovery which may offer an attractive solution to the communities where shortage of resources is a perennial problem.

2.2 Concept of Waste

Waste is described as substances produced in our daily (consumption, recreational, production and living) activities which are unwanted and no longer useful to us. (FMOH, 2004).

According to Oyediran (1995), wastes may be defined as “substances or objects discarded as worthless or unwanted, defective or of no further value from a manufacturing or production process”. Furthermore, wastes may also be defined as “substances or objects which are disposed of, or intended to be disposed of, or are required to be disposed of, according to the provision of a national law” (Oyediran, 1995) Disposal however, means “the final placement or discharge or deposit of waste into the environment, or the destruction of waste without residue” (Oyediran 1995). These substances must be handled and disposed of with care so that they do not constitute danger to public health. The waste matter must be stored, collected, and finally disposed of in such a way as not to cause nuisance. Nuisance in this context includes conditions which are offensive or likely to be injurious or dangerous to health such as bad smells, fly breeding, attraction of rats and other vermin, mosquito breeding and the spread of infectious diseases. Ejike (2000) also opined that on an international scale, the distinction between “Waste” and “products” is not always clear. This is because of the possibility of reuse or recycling. Wastes are therefore the back end of the cycle of production whereby energy is applied to transform natural resources into food or into material or non-material e.g. electricity, heat, cooling products for human consumption (Ejike, 2000). The distinction is often made between wastes for disposal and wastes for recycling or recovery. The latter are excluded from international agreements even though there may be little prospect of them being returned to the production process. Therefore, this ambiguity surrounding definition of waste makes effective regulation and control difficult.

Also Nkwocha and Ekeoma (2009) states that wastes are those materials, objects, goods that are discarded and unwanted, by their owners/holders which might exist in solid, liquid, gaseous or even semi-solid forms and can be recovered, collected, treated, recycled and re-used for the good of the society.

Waste within human society are products of human beings i.e. they are mainly anthropogenic. Wastes cannot be produced without human beings.

Wastes cannot be said to be valueless. The value of waste depends on current and existing technology. Wastes that cannot be treated by man due to lack of technology are usually classified as "ultimate waste (e.g. nuclear wastes).

2.3 Classification of Wastes

West Africa Health Examination Board (WAHEB) (1991), argued that several attempts made to classify waste have resulted in the classification being done in different ways by individuals and groups. For example, wastes have been classified by WAHEB (1991) according to their:

I. Origins or Sources e.g.

- Household waste
- Individual waste and
- Recreational waste

II. Chemical Composition e.g.

- Organic waste
- Toxic waste
- Inorganic waste and
- Radioactive waste

III. Appearance, Texture or State e.g.

- Dry waste
- Liquid waste
- Wet or solid waste

IV. Location e.g.

- Urban waste
- Rural waste

Conventionally, however, wastes have been grouped into two categories: Solid waste and Liquid waste (Feachem *et al* 1978, Anderson, Morton and Green, 1978)

2.4 Solid Waste

Solid waste a bye product of human activity. Garbage results from processing and marketing, storing and preparing food. Other kinds of solid waste result from the normal processes of living. Residents of cities and towns continuously produce large quantities of waste materials which they cannot ordinarily dispose off safely, effectively or economically by themselves. Such materials cannot be accumulated on individual's property without creating a menace to public health, fire hazards and utilizing valuable space needed for other purposes and generally detracting from community appearance.

The World Health Organization (WHO) Expert Committee (1971) defined solid waste as useless, unwanted or discarded materials that arise from man's activities and are not free flowing.

Solid waste also includes deposited waste particles, even when temporarily suspended in air or water. It refers to the heterogeneous mass of throw-away from urban community as well as the homogenous accumulation of agricultural, industrial and mineral wastes (Songonuga, 1979). Solid waste is otherwise called refuse and it is found in the human environment.

Also, solid wastes comprise all the wastes arising from human and animal activities that are normally solid, discarded as useless or unwanted.

2.4.1 Classification of Solid Waste

Solid waste can be classified in different ways. The first is the division of solid waste or refuse into two broad groups: domestic and industrial solid wastes.(Feachem et al, 1977)

Secondly, a simple system that recognizes three categories of solid wastes namely:

- Animals
- Vegetables and
- Minerals

Thirdly, a more complex system of classification which recognizes that "solid wastes generation is a function of land use and their composition consequently must bear some relation to this fact. (Federal Ministry of Health, (FMOH), 2004)

The components of refuse are many and varied, and they include:

- Garbage
- Ashes and dust
- Dead animals
- Rubbish
- Abandoned vehicles
- Industrial sewages
- Sewage treatment residue
- Explosives

- Pathological and radioactive wastes.

However, other forms of classification also exist.

Akhionbare (2009) classified solid waste as:

1. Domestic
2. Commercial
3. Industrial
4. Due to construction and demolition
5. Agricultural
6. Institutional
7. Miscellaneous

According to the classification of American Public Works Association (APWA) 1966),solid wastes comprises two major groups:

A. Combustible Items-such as:

- Cartons
- Boxes
- Papers
- Grass
- Plastics
- Beddings and
- Clothings.

B. Non-Combustible Materials e.g.

- Ashes
- Cans

- Metal furniture
  Glass
- Bathtubs etc.

These two broad groupings can further be subdivided or classified according to how and where they are generated. They include garbage, rubbish, ashes, sweepings, bulky waste, industrial waste, hospital waste, agricultural waste, construction waste and institutional waste.

i. Garbage

This term is used to denote or designate those putrescible wastes resulting from growing, handling, preparation, cooking and consumption of food. This type of waste attracts and breeds flies and other insects, rats and emits odour.

Akhionbare, (2009) also stated that garbage is a wasted or rejected food constituents which have been produced during the preparation, cooking or storage of meat, fruits, vegetables etc.

ii. **Rubbish**

This comprises all non-putrescible wastes except ashes. That is both combustible and non-combustible substances such as cans, papers, glasses, scrap metals, beddings, card boards etc. Rubbish is frequently responsible for creation of nuisances when it becomes scattered by wind and careless handling.

iii. Ashes

When wood or coal is used as a source of energy, ashes are the residues collected after combustion. It should be noted that ashes are still being generated in large quantity in our community today because large segment of the population still depend on either wood or coal as fuel.

iv. **Street Sweepings**

These consist principally of material worn from street surface, dirts and other materials, dropped leaves, sweeping from side walk and a bit of waste papers.

v. **Bulky Wastes**

This type of waste includes such items as wood furniture, metal furniture, refrigerators, rubber tyres and abandoned auto-bodies.

vi. **Municipal Wastes**

Municipal waste consists of street litters, discarded auto-bodies, power plant residues, dead animals such as cats, dogs, fishes, and abandoned trucks.

vii. **Urban Wastes**

These include domestic and commercial wastes. They are the garbage materials, which result from food preparations both in the home and in the restaurants, and also rubbish produced in residences and commercial establishments. (Akhionbare, 2009)

viii. **Industrial Wastes**

This includes waste from industries, sawdust, paper and iron industries. These wastes cause concern to public health due to obnoxious odours, pollution of land, water and air.

Akhionbare, 2009 describes industrial wastes as wastes produced by industrial processes. That generally, the character of the refuse produced in the manufacturing/processing operation will depend on the mechanics of the particular manufacturing operation e.g. the wastes produced by steel production will defer considerable from those produced in the chemical industry. Usually, the wastes produced in a food processing industry closely resemble the garbage produced in residential areas. Also, the waste materials from the paper and plastics industries are similar to the paper and plastic packaging materials found in domestic rubbish. On the other hand, the metal-processing industry will obviously generate metallic wastes, but in addition will, also create large quantities of slugs, processing chemicals, and other residues, many of which are produced in air-pollution and water-pollution control activities. The wastes produced by chemical industries and other specialized industries will in general depend upon the particular end product of the manufacturing process.

ix. Hospital Wastes

These are special waste arising from hospitals and medical laboratories. Examples are discarded dressing materials, swabs, bandages, disposable articles such as syringes, needles and encasing plaster that have been removed from limbs.

x. Agricultural Wastes

These are wastes emanating from agricultural farms e.g. corncob, plantain and banana skins, leaves etc.

Also agricultural wastes constitute significant proportion of solid wastes produced in the country. They include crop residue, animal wastes such as manure, urine and bedding wastes from confined feeding operations for livestock. Much of these wastes are disposed by recycling them into agricultural lands. Increased use of feeder lot operations and the increasing loss of agricultural land to urbanization has produced a significant problem of waste disposal in the agricultural industry today. (Akhionbare, 2009).

xi. Demolition/Construction Waste

These wastes arise from demolition of houses and construction sites. This includes rubbles, bricks, concrete blocks, sand, roof sheets, iron rods, planks etc. However, Akhionbare buttress that demolition wastes are quite heterogeneous in character and are non-degradable except for the wood waste which will exhibit very little decomposition with time. It is often quite useful as solid fill. (Akhionbare, 2009)

xii. Institutional Waste

These include those materials produced in hospitals, schools, nursing homes, prisons and other large facilities for greater number of persons. In general, these wastes are similar to domestic and commercial types but contains slightly larger amount of paper and clothes. However, in such facilities as hospitals and nursing homes contaminated wastes may pose a special disposal problem. (Akhionbare, 2009).

2.4.2 Solid Waste Management

Solid waste management is the collection, storage, transportation, treatment and disposal of waste in such a way as to render them innocuous to human and animal life, ecology and the environment generally. (Oreyomi, 1998).

According to Oyediran (1995), the institutional arrangement for solid waste management in the country is usually weak, being vested in local government authorities which often lack capability and appropriate resources to cope with the problems. Nigeria has tried to mobilize mass participation in environmental improvement and beautification efforts through monthly sanitation exercises nationwide. The effectiveness of these campaigns as well as the public perception of the environmental achievements is worth a special duty.

At a recent national meeting of the directors of Environment/General Managers of State Environmental Protection Agencies in the country, it was decided that a new strategy be developed for solid wastes management in the country with greater involvement of the Federal Government through the Federal Environmental Protection Agency (FEPA). Another option proffered is the privatization of wastes management. Any new initiate must however re-assess existing waste disposal practices in terms of public health and environmental impacts, cost and effectiveness.

FEPA has made a bold endeavor to halt industrial pollution by introducing guidelines and standards for industrial pollution in 1990, and enacting appropriate regulations for hazardous waste control, while the regulations are comprehensive and adequate, the enforcement mechanisms for compliance and monitoring are weak due to lack of capacity and capability, including poor funding.

The variables to be considered in the management of solid waste are;

- Types of waste to be handled
- Amount generated per day
- Transport distance and
- Amount budgeted for the operations

With respect to Nigeria, Oluwande (1974) pointed out that the collection and transportation of solid wastes from refuse dump take up to 75% of the total expenses of waste disposal. While some countries have transfer stations or volume reducing centres between the collection and disposal sites, Nigeria has no organized waste management system.

In planning for appropriate solid waste management, the following key factors will be considered: sorting of garbage at source, collection, storage, transportation, treatment and disposal practices.

2.4.3 Sorting of Garbage at Source

Sorting of garbage at source is the starting point for realistically tackling the problem of waste disposal in Nigeria. Sorting will reveal the types of waste. Close observation of waste types will then draw everybody’s attention to the need for devising strategies for appropriate disposal (recycling, reuse, or use as landfill), as well as the need for reduction of waste types through environmental friendly lifestyles.

For sorting of garbage at source to achieve the desired purpose, collection must be according to types. Germany practices sorting of wastes and provides separate waste bins for certain items. In Nigeria, dumpsite should be created for different items. At least two major dumpsites and a container per town are suggested. The first major dumpsite should be for the biodegradables (food, waste and peels). These form the bulk of wastes and are the components that create the mess and odour in the common dump.

The second dump should be for non-biodegradables, excluding cellophane bags. A container should be provided for cellophane bags because by their nature they cannot be restricted. Thus where possible, dumpsites should be three: for food wastes, for combustible materials and for other materials. A container should be provided separately for cellophane bags (Okpala et al, 1994).

2.4.4 Collection of Refuse

As revealed by Oreyomi (1998), prompt collection, efficient storage, transportation and treatment methods are the contributory factors for proper and effective solid waste management.

Succinctly put, the importance of refuse collection in effective solid waste management cannot be over-emphasized.

This point is buttressed by the fact that collection of refuse requires large labour force, equipment and adequate planning for success to be achieved in this regard. From the forgoing, it has been established that refuse collection is the most expensive of all the areas of refuse disposal.

As expected, refuse collection starts with the sweeping of our rooms or house. The collected refuse is usually put or collected in a metal or plastic dustbin and stored for few days before it is emptied into a bigger dustbin stationed within or at the frontage of the premises. Refuse collection at home must be handled with care in other to prevent health hazards associated with improper collection method at this level.

The refuse collected in homes which are deposited in refuse container placed within or at the frontage of individual premises are emptied directly at the communal refuse depots strategically located in the community. Where a community has no collection service, conditions are generally favourable for high fly and rat populations. Even where service is available, a careless collection employee may spill refuse on the premises or street. Rough handling may damage the container rim so that the rim may not fit properly, thereby making the refuse accessible to flies and rats.

Lucas and Gilles (1991) suggested that collection of refuse should be frequent, systematic and reliable and bin points should be maintained by government or municipal cleansing services. Great improvements in collection by specially constructed vehicles have been developed in recent years.

Where combined refuse collection is practiced, this service should be provided daily or at least thrice a week. This practice will favour storage and will contribute to an environment adverse to flies, mosquitoes and rats. Collection crews must be properly trained.

2.4.5 Storage of Refuse

The method of refuse storage prior to final disposal will make or mar the efficiency of solid waste management programme.

Lucas and Gilles (1991), opined that the process involves:

i. Provision of a sufficient number of containers to hold the volume of refuse produced between collections

ii. The selection of an approved container
iii. The placement of containers where they will provide maximum convenience for the user and easy access to the collection crew and
iv. The maintenance of the containers and their surroundings in a sanitary condition.

Before a container can be used for refuse storage, it must satisfy the following conditions:

i. The dustbin or garbage can should be water-tight and provided with a tight-fitting lid.
ii. It should be rust resistance,
iii. Structurally sound
iv. Easily filled, emptied and cleaned and furnished with side handles
v. The bin should rest on a concrete slab, the sweepings from which should be put in the bin and not cleared off on to the adjacent ground.

2.4.6 Treatment and Disposal of Refuse

In Nigeria, waste disposal has continued to pose a serious challenge as an environmental problem. Nigerian Environmental Study/Action Team (NEST)(1991),observed that there has been a phenomenal increase in the volume and range of solid wastes generated daily in Nigeria within the past few years, due largely to the increasing rate of population growth, urbanization, industrialization and general economic growth. This has led to various government efforts/programmes aimed at environmental sanitation such as War Against Indiscipline (WAI), and the “National Last Saturday of the Month Environmental Sanitation Exercise.”

In spite of all these, the problems of waste disposal continue to plague the country unabated. Report abounds that the various government waste disposal boards cannot cope with the volume of waste generated in the country (Nwokoh, 1993; Noibi, 1992, NEST, 1991). It is therefore not uncommon to find urban streets and roads blocked by solid waste.

The waste disposal problems are found in virtually all the Nigerian cities. It is therefore, necessary that individuals, families, communities and voluntary bodies join government in seeking ways of achieving effective waste disposal practices in the country.

However, certain unit processes are adopted to ensure that waste do not cause nuisance in human environment. These unit processes may be divided into the following groups:

- Those involving hiding the waste from human environment
- Those involving removal of the waste from human environment to other environment
- Those involving stabilizing the waste
- Those involving physical conversion of the waste into other forms

Usually, a combination of two or more methods of disposal will be needed. American Public Works Association (APWA) (1966); Department of Environment (1971) enlisted important factors to be considered in other to select an appropriate disposal method as:

- Characteristics of the waste
- Economic consideration (how much money is available and how much the method will cost)
- Availability of disposal site
- Cost of labour and
- Technical implications of the method.

A thorough consideration of the above will enlighten the waste management committee or engineer on the type of treatment required by the waste before final disposal.

Methods frequently practiced as enunciated by Oreyomi (1998), Lucas and Gilles (1991) and Oluwande (1983) are:

- Open dumping
- Burying
- Controlled tipping or sanitary landfill
- Composting
- Incineration
- Pulverization
- Sorting and salvaging

I. **Open Dumping**

This is where refuse is dumped on open lands. Open dump sites receive waste of all description in a community.

It is cheap, requires little or no planning and is therefore unfortunately too frequently found in tropical communities.

It provides ideal breeding place for rats, flies and mosquitoes. Oreyomi (1998) highlights that rats and mice transmit plague, murine, typhus, leptospirosis, rat bite-fever, trichinosis and food poising to man. Flies in dumps have been implicated in transmission of diseases like typhoid fever, cholera, dysentery, tuberculosis, anthrax and intestinal worms while mosquitoes which breed rapidly in tyres, cans, bottles and other materials that collect and retain water at dumpsites are transmitters of malaria fever, yellow fever, dengue fever, encephalitis and elephantiasis.

Open dump site attracts swam of men or scavengers who besiege the site to salvage materials such as discarded pots, rubbers, plastics etc. for economic purposes. This practice is fraught with danger because of the inhalation of noxious gases by these men at the site. Continuous exposure to hazardous wastes at the site will inevitable affect their health adversely. Every effort should be made to eliminate this health menace and to replace it with sanitary and practical methods of waste disposal.

II. Dumping at Sea or Barging into the Sea

Dumping at sea is a method of solid waste disposal commonly practiced in communities very close to the coastal areas and riverine towns. It results in littering of shorelines with refuse and becomes a health as well as an accident hazard. It is a deterrent to the tourist trade because it damages the beauty or aesthetic of the beaches. It is also hazardous to the aquatic life arising from water pollution. (Oreyomi, 1998; Lucas and Gilles,1991).

III. Burying

Another method of solid waste disposal is by burying. Burying waste can be a satisfactory solution as long as there is public land available for this purpose. Precaution must be taken so as to prevent the leaching out of the waste in other to forestall the contamination of the underground water. (Oreyomi, 1998)

IV. Controlled Tipping or Sanitary Landfill

The sanitary landfill method of waste disposal may be defined as the method whereby waste is deposited in a place, and it is compacted and then covered immediately with at least 150-millimeter-thick of stable material (laterite).

This is an effective and proven method for the hygienic disposal of refuse and can be used wherever sufficient and suitable land is available.

Basically, Lucas & Gilles (1991) said, it consists of four steps:

i. Depositing refuse in a planned and controlled manner
ii. Spreading and compacting it in layers to reduce its volume
iii. Covering the material with a layer of earth
iv. Compacting the earth cover.

However, in Nigeria as observed by the Department of Environment (1971), for a waste disposal site to meet the condition of sanitary landfill, it must possess the following qualities:

- The waste deposit must be in layers
- No layer is to exceed 1.8metres in depth
- Each layer is to be covered with stable material, the cover being 150mm thick for domestic waste and at least 600mm for animal waste.
- No refuse should be left uncovered for more than 24 hours.
- Sufficient screens or other suitable apparatus should be provided where necessary to prevent paper or other debris from been blown away by wind.
- No refuse should be deposited in water; waterlogged areas must be drained before tipping.
- All reasonable precautions should be taken to prevent outbreak of fire and also to prevent breeding of vectors
- Deposit to be maintained in a tidy condition for aesthetic reasons.
- Sufficient and competent labour should be provided in connection with the deposit to prevent nuisance.
- Each layer of covered deposit should be above the adjoining ground

- The surface of the waste site (sanitary landfill) should not be above the adjoining ground
- All waste should be dispatched of with and should be properly protected during transit as to avoid risk of nuisance.
- The sanitary landfill site should be fenced to prevent uncontrolled access of unauthorized people
- The provision of essential facilities to personnel such as:

a. Shelter from bad weather
b. Toilet facilities
c. Changing room
d. Washing facilities
e. Weighing facilities – which is necessary to accurately record the quantity of waste handled.

V. Composting

This is a process in which under suitable environmental conditions, aerobic micro-organisms (principally thermophilic) break down organic matter to a fairly stable humus (Lucas and Gilles, 1991).

The primary requisite for proper functioning of a compost operation is the removal or separation out of such non-compostibles as glass wares, metals and ceramic items.

Composting requires frequent turning to enable the bacteria micro-organism act properly on the refuse. There are many methods being used, but two are very popular.

These are:

i. Refuse without night soil e.g. Trengganu method.

ii. Refuse with night soil e.g. Calcutta and Indore method

Mechanism of Composting as Stated by Oreyomi (1998)

Waste of all description, apart from glass wares etc together with excreta are dumped in a trench or excavated ditch. There are usually four of such trenches at a time. These wastes are left in the ditch for some time. During this decomposition stage, intense fermentation accompanied by rapid rise in temperature occurs. As a result of this process, all the eggs, flies, maggots, worms in the wastes are destroyed. These fermented wastes are then turned periodically from the first trench until they finally reach the fourth trench.

After the last turning, the materials would have broken down completely into a black mould or manure. The first turning to the last takes between three or four months.

Composting is particularly advantageous because it has a three-fold usefulness:

i. The disposal of many types of refuse

ii. The disposal of sewage sludge and

iii. The product is usually utilized to enrich depleted soil as a soil conditioner.

VI. Incineration

This is a method of refuse disposal by burning. The waste is burnt to reduce the volume of refuse by up to 90%. It is a widely used method for refuse disposal in the developed world.

An incinerator is an apartment constructed for the burning of refuse. The apartment can be a trench, a refuse bin, a mud brick incinerator etc. (Akinsola, 1993).

If there is enough fund, modern incinerator can be built in place of the open air burning often practiced in urban areas of Nigeria, especially market places. Modern incinerators have chimneys to control the flow of smoke and thus prevent atmospheric pollution. Apart from producing less smoke, it also allows more complete combustion although, the non-combustible portion and the residue of combustion have to be disposed by sanitary landfill.

Incineration as practiced in Nigeria reduces weight of solid wastes to between 50-80% and the volume to between 70-80% but there is still the problem of cost and final disposal of the ashes, which are often used for land filling (Oluwande, 1974).

Advantages of Incinerators

According to Oreyomi (1998), the advantages of incinerators are as follows:

i. Less land is required than for landfills
ii. Ash and other residue produced are practically free of organic matter, nuisance free and acceptable as fill material.
iii. Many kinds of refuse can be burnt. Even non-combustible materials will be reduced in bulk.
iv. Flexibility is possible. Incinerator may be operated for 24 hours.

Disadvantages

- Malfunctioned incinerator will produce large quantity of smoke and other pollutants which will contaminate or pollute the air.
- There is no gainsaying that the direct results of improperly maintained incinerator are enormous in the air surrounding us as flash and smoke.
- These particulates that are temporarily suspended in the air ultimately find their ways into our lungs and settle where they can cause diseases e.g. Emphysema, (Oreyomi, 1998).

VII. Pulverisation

Pulverization is a method of refuse disposal and is effected by pulverizing or grinding the refuse into powder. The resultant powder is mostly used to fill depression or lowland. With this method, large quantity of refuse is reduced in to small volume. Pulverization of refuse is a method that is commonly used in developed countries (Oreyomi, 1998).

VIII. Sorting and Salvaging

Some of the materials in refuse can be sorted and re-used. Thus, paper, rags, metal containers, bottles and similar objects can be salvaged (Lucas and Gilles, 1991).

Recycling in the broadest sense, encompasses the full range of resources recovery and re-use techniques, including repair, re-manufacturing, material recovery and energy conversion of refuse materials.

Linderberg and Akagi (1974), reported that maintenance of human condition can only be achieved through a swift rise in recycling, and survival of the world culture may well depend on a quick and complete shift to the practice of returning materials at the end of the product life to nature or to production. Recycling could play an important role in the food and feed industries serving as alternative strategies for the development of food production.

In general, solid waste recycling has three levels of recovery and re-use:

- Sorting and clearing, when the items discarded are re-used, repaired or re-manufactured,
- Sorting, clearing, processing and recycling as new product or material and
- Converting wastes directly into different material or into energy

Nkwocha and Ekeoma (2009), states that Recycling is modern, widely acceptable if properly done in the treatment of waste. It presents a lot of advantages such as

i. Recycling extends the life cycle of resources
ii. It helps to control pollution
iii. It helps to minimize the quantity of wastes entering into the environment
iv. It saves money
v. It creates wealth and employment
vi. It reduces the demand for new products
vii. It reduces the importation of materials especially dependency on imported goods and materials
viii. It lessens the burden of landfills.
ix. It encourages waste minimization.

Types of Recycling

i. Re-use
ii. Direct recycling
iii. Indirect recycling

2.4.7 Laws Governing Waste Disposal in the State

i. Public Health Law section 7 punishable under section 8, 4(b) cap. 103 vol.6, 1999 of the law of Eastern Nigeria as applicable in the Rivers State of Nigeria.

ii. Harmful waste (special criminal provision etc) Decree No. 42 of 25^{th} November, 1988 by the Federal Government of Nigeria.

iii. The council Bye-laws executed by Public Health officers attached to the Port Harcourt Local Government Area Office.

iv. The Rivers Environmental Sanitation Edict of 1984.

2.5 Waste and Diseases

Malaria is a febrile illness caused by the protozoan parasite plasmodium, of which four species are known to affect the human namely: plasmodium ovale, Plasmodium falciparum, Plasmodium vivax and Plasmodium malariae. Plasmodium falciparum is the most important cause of the malaria disease and responsible for about 80% of infections and 90% of deaths.

Patients can present with non-specific flu-like symptoms like headache, malaise, myalgia, fever and chills. Complications especially with falciparum malaria are cerebral malaria, metabolic acidosis, anaemia, hyper-parasitaemia, hypoglycaemia, acute renal failure and pulmonary oedema.

Diagnosis is by the use of thin and thick blood films for microscopic examination. This is the gold standard for malaria diagnosis; it can detect 50 parasites/ml and with an accuracy of 98%. This method is a difficult procedure, time consuming, and also requires the training of experts.

Other methods of diagnosis include the Rapid Diagnostic Test: The need for quick diagnosis for patients with suspected acute malaria has necessitated the need for Rapid Diagnostic test (RDT). The advantages of this process include quick diagnosis, cost effective and a reduced manpower requirement.

Transmission of the disease is through; the bite of the female anopheles mosquito, blood transfusion – People in endemic areas may have parasitaemia without clinical features, organ transplant, transplacental malaria transmission- Semi immune mothers with placental parasitaemia can vertically transmit malaria to their babies.

Malaria has been reported since ancient times dating as far back as 4000 years ago. (WHO 2005)

It derived its name from the Italian word for “bad air”. The symptoms of malaria were described in ancient Chinese medical writings Nei Ching, the canon of medicine in 2700 BC (WHO 2005)

Malaria was widely recognised in Greece by the 4th century BCE and was responsible for the decline in many city-state populations.

Malaria is not only a health burden but also a heavy economic burden on many endemic countries most of which are poor countries, therefore increasing the level of poverty in families. Africa is estimated to lose at least $12 billion every year, WHO (2005). This is due to cost of health care, absence from work due to ill-health, decreased productivity due to brain damage from cerebral malaria and loss of revenue from investment and tourism.

Various measures at eradication of the disease have failed despite concerted efforts by Governmental and Non-Governmental Organisations.

The first attempt at malaria control was the use of dichloro-diphenyl-trichloroethane spray (D.D.T.) in houses and the immediate environment and the utilization of chloroquine anti-malaria drug on a wide scale. This attempt at eradication failed in Africa due to drug resistance, donor fatigue, environmental concerns about DDT use and inadequate health infrastructure (WHO 2005).

Presently, there is a global push to contain the scourge of malaria by the establishment of the Millennium Development goal for malaria, which aims at halting and reversing the incidence of malaria by 2015. The Roll Back Malaria (RBM) partnership of the World Health Organization (WHO) has a goal of halving the burden of malaria by 2010. Malaria prevention is an important component of the RBM. It aims at making insecticide treated nets (ITN) available to 80% of children under 5 years.

In Africa, leaders in the continent under the auspices of the African Summit on Roll Back Malaria which held in Abuja Nigeria in the year 2000 committed themselves to halving malaria mortality in Africa by 2010 by implementing the RBM strategies and actions. They resolved amongst other things, that 60% of children under 5 years should benefit from personal and community protective measures like utilization of ITN.

Various studies have been done to appraise the level of utilization of ITN with varying results. In rural South Central Somalia which is a low transmission area, the utilization of ITN is 12.4% with consistent protection effect on those using Insecticide Treated Nets (RBM, and WHO 2005).

Study on the spatial effect of benefits on child mortality in Southern Tanzania showed reduction in child mortality in proportion to the density of household bed net ownership (RBM,and WHO 2005).

A study to investigate the influence of socio economic factions on the use of bed nets by mothers in Gabon found that bed nets (untreated) use was inversely proportional to socio-economic status. The prevalence of bed net use was 88% although only 6.4% used ITN mostly due to economic reasons (RBM, 2005).

Socio-cultural beliefs and practices have been known to play a role in determining care seeking behavior of people. Study in North-Eastern Nigeria revealed that local beliefs, mother's parity and previous child mortality influenced treatment practices and sources of help; that mothers preferred herbal medication and the use of health facilities was a third line of action (RBM, and WHO 2005). Convulsions were attributed to supernatural causes.

This was also the finding in a study in central Cote d' voire, where respondents also attributed malaria to 'natural' causes like sun, fatty foods, and supernatural causes. RBMand WHO (2005) also noticed that treatment seeking behavior did not differ along ethnic, religious and educational lines.

Respondents utilized traditional medicine; this was due to the fact that, traditional medication was easily accessible and affordable.

Most respondents were rural dwellers and are more in touch with traditional practices could also be responsible for their tendency to utilize traditional medicine.

This differs from a survey in South-Eastern Nigeria, which showed that the initial choice of care for malaria for most respondents was patent medicine dealers. This may not be unconnected within the fact that patent medicine dealers are more in this part of the country. Poorer households were also noticed to practice more self-diagnosis (this is due to their low socioeconomic status and trying to reduce cost) and receiving treatment from patent medicine dealers, while, the wealthier household were more likely to use health centres (RBM,and WHO 2005).

Study in Tanzania revealed a higher health facility usage for severe malaria presenting with convulsion than for normal fever, the authors noticed that poor services at health facilities and economic considerations were factors negating against the use of health facilities; Female children were less likely to receive timely treatment (RBM,and WHO 2005).

2.5.1 Definition of Malaria according to the Health Encyclopedia Diseases and Control

Malaria is an infectious disease caused by a parasite (plasmodium) which is transmitted from human to human by the bite of infected female Anopheles mosquitoes.

2.5.2 Description of Malaria

Four species of the parasite plasmodium are responsible for **malaria** in humans: plasmodium vivax, plasmodium malariae, plasmodium ovale, and plasmodium falciparum.

Malaria continues to be endemic in many parts of the tropics and subtropics. Today the number of cases is rising worldwide. Malaria parasites cause clinical illness in an estimated 300 to 500 million people in every year and cause 1.5 to 2.7 million deaths per year.

2.5.3 Symptoms of Malaria

Malaria attacks present over 4 to 6 hours with shaking chills, high fever, and sweating, and are often associated with fatigue, headache, dizziness, nausea, vomiting, abdominal cramps, dry cough, muscle or joint pain, and back ache. The attacks may occur every other day or every third day.

Cerebral malaria and death can occur, sometimes within 24 hours, if the infection is caused by plasmodium falciparum.

Fever or other symptoms can develop in malaria as early as 8 days or as late as 60 days after exposure or stopping prophylaxis. For plasmodium vivax in temperate areas, the delay may be up to one year.

2.5.4 Diagnosis of Malaria

Methods of diagnosis are:

i. Complete medical history of symptoms and travel
ii. Physical examination
iii. Blood tests, including thick and thin blood films, to identify the plasmodium species responsible for infection.

2.5.5 Roll Back Malaria (RBM) Initiative

Roll back malaria is a global movement to reduce malaria in cases and death through co-ordinated approach to strengthen public and private health care and multiple strategies targeted at meeting local malaria needs.

RBM was established by United Nations Agencies namely by the World Health Organization (WHO), United Nations Development fund (UNDP), United Nations Children's Fund (UNICEF), and the World Bank adopted in Nigeria on 31st July 1998.

The primary objective of RBM is to halve the malaria burden worldwide by the year 2010 through a multi-sectoral and multi-actor (sectional) approach.

On April 2000, the President and Commander in Chief of the Armed Forces Chief Olusegun Obasanjo hosted a summit of Africa leaders in Abuja with the with the agencies in attendance. The summit adopted the RBM programme and set targets that should be achieved within the limited time frames.

April 25thof each year is celebrated as the Africa Malaria day as a commemoration of this event, now celebrated as World Malaria Day.

2.6 Current Strategies for the Roll Back Malaria Programme

In Nigeria the following strategies have been adopted with a view to meeting the Abuja declaration and realizing the overall RBM objective.

i. ITN use through massive promotion and awareness (IMPACT) Pre-package drugs (PPD)
ii. Prepackage drugs (PPD) for home management of malaria.
iii. Intermittent Preventive Treatment of malaria in pregnancy (IPT)

iv. Integrated Vector Management (IVM)

a. Environmental management for vector control.

Larviciding: The general objective of integrated vector management is the reduction of vector-borne disease particularly, malaria morbidity and mortality, through the prevention, reduction and or interruption of disease transmission, via the utilization of multiple control measures in a compatible manner such as:

- Reduction of vector breeding sites to the strictest minimum and within the shortest possible time.
- Reduction of abundance and sustenance of disease vectors to a minimal level at which transmission is no longer effective.
- Reduction of human-vector contact.

Components of IVM include:

- The use of personal protective measures such as:
- Long lasting insecticidal nets (LLINs)
- Wearing of protective clothing
- Use of repellants which appear in various forms.
- Chemical control such as:
- Indoor Residual Spraying.
- Larviciding
- Outdoor spraying
- Environmental control measures
- Biological Control Measures.

Strict monitoring and evaluation of these activities in the communities is the bed rock of success in malaria control. In addition, health workers of all categories are encouraged to apply the formal referral systems in dealing with the cases of malaria to prevent avoidable death.

A national anti-malaria treatment policy is in place and every health worker should be familiar with it.

The purpose for the policies are as follows.

i. To provide rapid and long rapid clinical cure.
ii. To reduce morbidity, including malaria related anaemia.
iii. To prevent progression of uncomplicated malaria into severe and potentially fatal malaria.
iv. To reduce the unfavourable effects of malaria in pregnancy through chemoprophylaxis or intermitted therapy.
v. To minimize the likelihood and rate of development of drug resistance.

The basic contents of the anti-malaria policy include the following:

i. Decision on whether a sick patient requires anti-malaria treatment not.
ii. First and second line anti-malarial; indication and dosages by age for treatment of uncomplicated and severe malaria.
iii. Chemoprophylaxis for various at risk groups.
iv. Criteria for changing treatment choice.
v. Distribution and drug delivery.

2.6.1 Insecticide Treated Nets (ITNs)

i. The changing pattern of malaria calls for a need to supplement and strengthen control activities with preventive efforts.

ii. Insecticide treated mosquito nets have had significance impact in reducing morbidity and mortality particularly among children under five years old and pregnant women where ITN has been appropriately and extensively used in malaria endemic areas.

iii. It has recorded that insecticide treated materials can reduce childhood mortality by 17-33%.

iv. Treatment of mosquito net with insecticide in the group called synthetic pyrethroids.

v. These insecticides which have been approved by World Health Organization Pesticide Evaluation scheme (WHOPES) are safe.

Insecticide Treated Nets have the Following Advantages:

i. Provide personal protection for mosquito bites and kills mosquitoes.

ii. Effective against other insects including bedbugs, flies and cockroaches.

iii. Has a community and household effect.

Treating and Retreating Mosquito Nets

i. Mosquito nets need to be treated with insecticide to increase their effectiveness.

ii. There are several insecticides that can be used which have proven to be safe.

iii. The insecticide recommended by the National Malaria and Vector Control Programme for treatment/re-treatment of nets are those approved by **WHOPES & NAFDAC.**

2.6.2 Treatment of Malaria

Malaria treatment is done by prescribing only anti-malaria combination which ensures that no malaria parasites are exposed to an Artemisinin compound alone, but only together with longer-acting anti-malarias such as Lumefantrin, Mefloquine, Amodiaquine etc.

This is because resistance to anti-malaria drugs has been documented for P. Falciparum, P. Vivax and recently P. Malariae. With some differences with respect to the geographical distribution and the level and rate of spread, resistance of P. falciparum has been observed against almost all currently used anti-malarials, except for the Artemisinins. P.vivax is resistance only against chloroquine hence treatment is by use of Artemisinin Based Combination Therapy (ACT).

First line treatment is by use of the combination of Artemether and Lumefantrin drugs (AL). Examples of these drugs are: Coartem, Amatem, Lonartetc.

Second line treatment is by use of the combination of Amodiaquine and Artesunate drugs (AA) e.g Larimal, Artesunate and SP (Sulfamedoxine & Pyrimethamine) e.g Co-Arinate FDC.

Other forms of treatment is by use of Quinine Therapy.

Strategies for Case Management of Malaria

As stipulated in the National Strategic plan;

- Promoting early diagnosis, prompt and effective case management
- Provision of ACTs to public health facilities to manage malaria in under five
- Provision of SP for the prevention of malaria during pregnancy
- Improving malaria diagnosis through capacity building and health system strengthening
- Work closely with other units (BCC, M&E, IVM) in providing a comprehensive package
- Collaborate actively with line programmes i.e. Integrated Management of Childhood Illnesses (IMCI), Reproductive Health (RH), National Primary Health Care Development Agency (NPHCDA) to improve case management package deliveries

- Expanding coverage of malaria treatment through the promotion of other novel intervention such as the Home Management of Malaria in the communities
- Maintaining surveillance on the use of ACTs through sentinel sites and pharmaco vigilance.

Research Design

Every scientific research has a specific framework for controlling data collection. This framework is research design. It is the blue print that addresses the problem of scientific enquiry. Its function is to ensure that the required data are collected accurately and economically (Nworgu, 1991).

Allaby (2007) defined research design as the structure of investigation aimed at identifying variables and their relationship to one another with the view to obtaining data to enable the researcher test hypothesis or answer research questions. It is a model proof that allows the researcher to draw inferences concerning causal relationships among variables under investigation.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Presentation of the Study Area

Port Harcourt being the study area is characterized with a low lying plain which forms an integral part of the deltaic formation of the modern Niger Delta.

The land surface of the whole project area is generally between 100 and 300 meters above sea level and slopes towards Atlantic Ocean in southward direction. The climate of Southern Nigeria is humid, semi hot equatorial type. Okonkwo and Mbajiorgu (2010), reported that there are two seasons in Nigeria, the wet season (March to November) and the dry season (December to February) but even the dry season is not free from occasional rainfall. According to Okonkwo and Mbajiorgu (2010), the dry season starts with a dusty atmosphere brought about by the North East winds blowing from the Arabian Peninsula across the desert. Also that during the rainy season, a marked interruption in the rains occurs during August, resulting in a short dry season often referred to as the ‘August break’ though for some years now this has not been consistent in August due to climatic change. Annual rainfall is estimated at over 3,000mm, with mean monthly temperature of 27^{0}C and relative humidity of about 80%. Port Harcourt city falls within the coastal zone. Oyebande (1982), confirmed this by grouping the area into zone one, because it has one of the highest rainfall intensities in Nigeria.

The current city of Port Harcourt is mapped with a network of roads which link the entire city and its environs. The major roads include:

i. Port Harcourt Aba Express Road, linking Port Harcourt up to Borikiri metropolis and to Oyigbo and Abia State.

ii. Ikwerre Road, which runs from Education bus stop to Rumuokoro, and to the international airport at Omagwa, Owerri (Imo State) and beyond.

iii. The East West Road, which links Rivers State to Bayelsa State.

These major roads are linked to minor roads which connect the length and breadth of the city and its environs.

Port Harcourt Metropolis has five district councils which are as follows:

i. The Port Harcourt City Council which includes Borikiri area, the main or old town and the end of Emenike junction at Diobu.
ii. The Diobu Urban Council which includes the whole of Diobu and extend to Obio
iii. The Obio/Akpor district Council
iv. The Woji/Obio Urban council
v. The Trans Amadi Urban Council

Because Port Harcourt is grouped into zone one by Oyebande (1982), it has the highest rainfall intensity in Nigeria. Consequently, its open waste dump sites are prime breeding sites for mosquito causing malaria attacks in residents especially those living close to dump sites.

3.1.1. Location of the dumpsite.

The Eneka Dumpsite:

Eneka dumpsite is situated at the western part of the City of Port Harcourt, along Igwuruta/Eneka road on Longitude 7°02’33.18” E and Latitude 4°53’32.82” N. The site is about 200 m in length and 42 m width tapering to about 130 m along Igwuruta/Eneka highway.

The Eneka dump area is located in a seasonally flooded area (Plates 1 and 2). Although the waste dump is located at the outskirt of the city, some residential areas are close to the site located along one of the roads entering the city. According to Steve and Elijah (2010),the groundwater of the area is relatively shallow. The permeability and porosity of the soil of the area is high. The site is flooded most part of the year and the rainfall in the area exceeds 2500mm per annum. The aquifers are mostly unconfined. Also, Steve and Elijah (2010) posit that the Eneka dumpsite had a total risk index score of 452.3 which correspond to moderate hazard potential, meaning that immediate rehabilitation of the dumpsite into sustainable landfill is required.

Plate 1: View of Eneka dumpsite from the front

3.1.2. Population and activities

Eneka has a total population of 39,324 (National Population Census, 2006). It has several companies, schools, churches etc. The area is rich with natural resources such as sand, clay, gravel with a vast arable land and forest-based resources such as fruits and vegetables. The primary occupation of the people is farming, fishing and hunting. Cassava (processed into Garri), Yam, Cocoyam, Plantain, Banana, Sweet potatoes are some common food crops that are cultivated in the area. The neighbouring settlements to Eneka town include Rumuokwurushi/Elimgbu in the North, Igwuruta in the south and Rumuduru town (in Oroigwe) in the east. The nearest building to the dumpsite has a distance of about 150m though initially the area was a thick bush and has been earmarked by the State government as an industrial area.

Plate 2: Truck disposing waste at Eneka dumpsite

Source of waste at the dumpsites are: Domestic waste, Commercial waste**,** Agricultural waste**,** Institutional waste**,** Sewage, Miscellaneous waste

According to Steve and Elijah, (2010), the quantity of waste dumped at the site per day is about 100,000kg (100tons).

Wastes generated are disposed of by burning occasionally at the dumpsite, especially during the dry season.

3.2 Research Design

To achieve the objectives of the study, this study adopted two approaches, namely field survey and experimental design method. Field survey was used to collect information from subjects by using a well-structured questionnaire. Experimental design approach was used to determine larval abundance within the study area.

3.3 Sources of Data

3.3.1 Secondary Sources

A lot of useful information and data were obtained from secondary sources for writing the project. These include those from text books, scientific journals, seminar proceedings, monographs, conference materials and maps. These were cited throughout the report especially in the literature review.

Others include, hospital records of subjects that helped to indicate the number of times they suffered from malaria during the past 11 months. These records also indicated the symptoms experienced by subjects and results of their blood and urine specimens examined in the laboratory.

3.3.2 Primary Sources

To obtain data for the research involved the use of different techniques which are as follows:

i. Quantitative analysis of solid waste
ii. Questionnaire Survey on parents of Exposed Children.
iii. Assessment of Exposure
iv. Assessment of Larval abundance at the dumpsite

i. Quantitative analysis of solid waste

An analysis of the amount of waste generated was conducted at Eneka District of the town. This analysis was conducted to determine the amount of waste generated per week by a population estimated at 39,324 living within the area. A sample of 150 households was used for the study and sample size determined by applying Yaro Tamane's Equation:

$$n = \frac{N}{1 + (Ne^2)}$$

where n = Sample size

N = Population size

e^2 = level of error tolerance (e= 5% for confidence level of 95%)

The amount of waste generated was analysed together with the type of wastes and separation at source was also analysed to determine whether residents knew about waste separation. The amount of waste that was generated in a period of seven days was used to calculate the quantity generated daily.

During the survey, each family was provided with a polythene bag into which all waste generated on daily basis was emptied for a period of seven days, as recommended by Mwanza and Phiri(2013). After the seventh day, the amount of waste generated was noted by weighing the quantity generated by each family and the total volume divided by the number of family members. A sample of ten families from different residential groups was selected through simple random sampling (number of houses used) and mixed together to identify the type of wastes generated in the area.

Four research assistants were used during the period of the survey and each of them was assigned specific duties.

The five samples from each residential groups in the area were emptied to a measuring wooden box of 500 litres after which the box was rocked back and front during the filling. The box is then weighed to find the density of the wastes. This was followed by sorting the waste items by hand placing them on sorting table. The smaller particles are mixed together and each of these items are weighed and values obtained converted into simple percentages.

ii. Survey on Parents of Exposed Children

A well-structured questionnaire containing basic socio-economic characteristics of the children and their parents (age and sex of children, education and income status of parents, etc.) was carefully prepared. Other important variables on the housing conditions of the subjects such as presence of waste bins around homes, use of mosquito nets and insecticides were all included in the questionnaire. 200 copies of the questionnaire were then distributed to the subjects who were given a period of three days to fill them. 173 copies were later collected, but after serious examination of the responses from subjects, only 150 were adjudged fit for the study because the other 23 copies were not correctly filled.

Parents of the subject were also asked to indicate the number of times and the month of the year their children fell sick and were taken to the clinic, diseases they suffered from, names of clinics visited, and their hospital card number. Cases were retrospectively verified in the various clinics where the children were treated using their card numbers. Data on these variables were requested for the past months preceding our visit. For easy identification and compilation by the parents, all the requested variables were enlisted in a simple matrix format. These covariates were chosen based on previous literature identifying potential risk factors disease exposure (Tonne *et al*, 2007; Khitoliya, 2004.)

iii. Assessment of Exposure to Malaria Infection

The study considered one important measure of exposure to malaria infection, namely: the distance between subjects from the dumpsite. Thus, in the study area, two cordon zones were carefully delineated. The first Zone designated as Zone A has the range of a distance between 100 and 500 meters from the dumpsite. While 100 of our subjects live in this zone. The remaining 50 subjects reside in the second zone designated as Zone B which was also in the same neighborhood but beyond 500 meters from the dumpsite. These two zones are separated from each other by Eneka and Igwuruta Roads. Zone B may therefore be likened to as the “clean or control” zone.

iv. Assessment of Larval Abundance

In order to elucidate the breeding ecology of mosquitoes in Eneka, this study was carried out to assess the larval abundance in conventional mosquito breeding sites, evaluate the physico-chemical characteristics, and establish the relationship between such characteristics and larval abundance in the area.

- **Mosquito Larval Collection, Processing, Identification and Analysis:**

Three kinds of conventional mosquito breeding habitats namely, containers from the dumpsites, drains, and domestic containers were selected for investigation. Four replicates of each larval habitat were randomly selected across the area, and mosquito larvae were sampled weekly from such habitats during the rainy season of 2010. Sampling was done between 0900hr and 1100hr, using a standard 300ml capacity dipper. Where this was not possible, especially with domestic containers, water from a number of breeding sites was pooled to make-up the required volume. Twenty dipper samples were taken randomly from each sampling site, and the mosquito larvae recovered were preserved immediately using 4% formaldehyde solution. The specimens were identified to genus level using aids provided.

- **Collection and Fixing of Water Sample for Physico-chemical Analysis:**

Water samples, for physico-chemical analysis, were collected concurrently with larvae from the three habitat types investigated, using 500ml capacity specimen bottles. The water was fixed immediately, using standard procedures, in preparation for laboratory analysis. However, water temperature and transparency were determined at the sites, during larval collection, using ordinary mercury thermometer and secchi disc, respectively.

Analyses of these samples were carried out at Entomology Laboratory, Department of Applied Biology, Rivers State University of Science and Technology, Port Harcourt.

3.4 Statistical Analysis

Given the limited sample size, three age groupings of the children were made (< 1 year, 2-3 years, and 4-5 years) based on the distribution of their ages within the population. Descriptive statistics were used to explore the minimum and maximum values, obtained for the samples as well as means, percentages and standard deviation. To neutralize the effect of variables such as housing conditions, income of parents, housing density, and feeding, a logistic model was used. The exposures measure among subjects and total sample population were made using logistic regression (for malaria and hospitalization rates).

Because of the limited sample size, the odd-ratios (ORs) were not adjusted for potential confounders. Regression ANOVA and chi-square tests were used to compare differences between the zones. Coefficients were calculated using the Spearman Rank-Order correlation test. Data was analyzed using SPSS and Excel with Microsoft windows 10.0.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF RESULTS

4.1 Quantity and Types of Waste Generated

4.1.1 Quantity of Waste Generated

The result of the survey carried out in the area showed the following results (Table 1)

Table 1: Summary of the Amount of Waste Generated

Variable	Sample
Number of Households	150
Population	39,324
Daily per capita waste generation	0.89kg
Estimated total amount generated per day	34.99 tons

The above tables show that the daily per capita waste generation is 0.89kg. This figure gives an estimated daily generation of 34.99 tons of waste and an estimated monthly quantity generated at 1049.7 tons in the area. This value may be far below expectations, as the study focused only on domestic wastes. Other wastes generated from hospitals, institutions (schools, offices etc.) were not included in the study.

4.1.2 Types of Wastes Generated

The types of wastes generated in the area are shown in Table 2 below

Table 2: Composition of wastes

Waste Composition	%
Putrescible waste	65
Plastic	20
Paper	7
Glass	3
Metal	4
Others	1
Total	**100**

Table 2 shows that 65% of household waste generated in the area are degradable wastes. These include food waste, leaves, garden wastes, sweepings etc. These wastes in constant biodegradation process form breeding grounds to different disease vectors when they are taken to the dump sites.

Survey results also reveal that plastic materials occupied a major position in the domestic waste composition forming about 20% of the total waste generated. Although plastic materials are not easily biodegradable, its volumetric increase in the household waste is preoccupying as plastic waste recycling is still very low in the country.

Other waste components include; paper (7%), glass or bottle (3%), metals (4%) and others including textiles, bones etc making only 1% of the total.

4.1.3 Composition of Waste at Eneka Dumpsite

A sample of waste collected from Eneka and analyzed shows that the waste generated from domestic and commercial activities form the major component.

Commercial wastes have almost the same composition as domestic wastes including putrescible wastes (remnants, leaves etc.) metals, papers plastics, bottles and some wood, bones, textiles and miscellaneous inert materials (sand, ash). Most wastes deposited at the dumpsites are therefore of domestic and commercial origins.

The high percentage of biodegradable materials with high moisture content, makes it a favourable breeding ground for proliferation of micro-organisms and disease vectors such as rats, cockroaches, flies and mosquitoes.

4.2 Socio –Economic Characteristics of Parents of Exposed Children.

The descriptive information focused mainly on the socio-economic status of the parents (income, education) as well as some variables on the children (age, sex).

4.2.1 Age and Sex of Subjects

The average age of the children was 2.8 years. Based on the three age groupings 54 (36%) of the subjects were less than 1 years old, 50 (33.33%) between2 and 3 years old and 46 (30.67%) between 4 and 5 years old. There were 80 males (53.33%) and 70 females (46.67%) which shows almost equal representations in both sexes in the total sample. The highest number of children within the study age group per family was two while the least was one. All families surveyed have lived in their apartments for more than five years, indicating that the majority of the subjects have been exposed since birth.

4.2.2 Income and Educational Level of Parents

The average educational level of parents was the West African School Certificate, with an average monthly income level hovering between ₦ 15,000 and ₦ 20,000. This results show that most of the children are of poor parentage.

4.2.3 Housing Conditions

The average household consists of 7 persons residing in a concrete dwelling of three rooms properly ventilated with sufficient doors and windows. Only 9 families of the subjects (6.9%) used Insecticide Treated Bed Nets (ITNs) while the greater majority made up of 121 families or 93.1% of the total sample did not. Also, while 102 families of the subjects (78.5%) did not apply insecticides within their homes only 28 families (21.5%) used it regularly to kill mosquitoes. All the families surveyed kept their waste bins outside their home as shown in Table 6, 7, 8 and 9.

Table 3: Age of children in years (n = 150)

Age of children (years)	No%
< 1	54(36.0)
2 – 3	50(33.33)
4 – 5	46(30.66)

Table 3 shows that 54 (36.0%) of the children were less than 1 year, 50 (33.33%) were between 2 and 3 years while 46 (30.66%) were between 4 and 5 years old.

Table 4: Income of Parents

Income of parents	No%
15,000 – 20,000	90(69.2)
21,000 – 30,000	16(12.3)
31,000 – 35,000	14(10.76)
>35,000	10(7.69)

Table 4 reveals that 90 (69.2%) of the parents earn between ₦15,000 and ₦20,000, 16 (12.3%) earn between ₦21,000 and ₦30,000, 14 (10.76%) earn between ₦31,000 and ₦35,000 and only 10 (7.69%) earn above ₦35,000.

Table 5: Educational Status of Parents

Education status of father	No%
Higher Education	13(10.0)
Average Education	25(19.23)
Lower Education	92(70.76)

Education status of mother	No%
Higher Education	15(11.5)
Average Education	18(13.8)
Lower Education	97(74.6)

Table 5 reveals that 92 (70.76%) of the fathers of the subjects have lower education while 97 (74.6%) of the mothers also have lower education. Also that only 13 (10.0%) of the fathers and 15 (11.5%) of the mothers had higher education and 25 (19.23%) of the fathers and 18 (13.8%) of the mothers had average education.

Table 6: Housing Conditions

Housing Condition	No%
Well ventilated	121(93.1)
Poorly ventilated	9(6.9)

Table 6 reveals that 121 (93.1%) of the families live in well ventilated homes while only 9 (6.9%) live in poorly ventilated homes.

Table 7: Presence of waste bins in homes

Presence of waste bins	No%
Yes	130(100.0)
No	0(0.00)

Table 7 shows that all the homes (130) have waste bins for storage of wastes

Table 8: Use of mosquito nets (ITNS)

Use of mosquito nets	No%
Yes	9(6.9)
No	121(93.1)

Table 8 exposes the fact that only 9 (6.9%) of the families sleep under mosquito nets (ITNs) while 121 (93.1%) of them do not sleep under ITNS.

Table 9: Use of insecticides

Use of insecticides	No%
Yes	28(21.5)
No	102(78.5)

Table 9 reveals that most of the families 102 (78.5%) of them do not use insecticides to kill mosquitoes in their homes while only 28 (21.5%) of them use insecticides to kill mosquitoes in their homes.

4.3 Exposure Characteristics

Data used for the study spanned for a period of 11 months (October 2012 – July 2013) as most parents could no longer remember what happened beyond this period when filling the questionnaire. However, information obtained therefore revealed the prevalence of malaria among subjects in the two zones investigated. A trend of greater frequency was noted in Zone A in comparison with Zone B.

Table 10: Number of subjects treated for malaria in zones A and B (n=150)

Months	**Zone A (<200m)**		**Zone B (>500m) Control**		**Total**	**Cum. %**
	No. Treated (F)	%	No. Treated (F)	%		
Sept. 12	120	9.4	53	13.3	**173**	10.4
Oct. 12	140	11.0	47	11.8	**187**	11.2
Nov. 12	150	11.7	30	7.5	**180**	10.8
Dec. 12	100	7.9	12	3.0	**112**	6.7
Jan. 13	80	6.3	20	5.0	**100**	5.9
Feb. 13	88	6.9	30	7.5	**118**	7.0
Mar. 13	110	8.6	45	11.3	**155**	9.3
April 13	100	7.9	33	8.3	**133**	7.9
May 13	121	9.5	40	10.0	**161**	9.6
June 13	128	10.1	42	10.6	**170**	10.2
July 13	135	10.6	46	11.6	**181**	10.8
Total	**1272**	**76.1**	**398**	**23.8**	**1670**	**100.0**

Among the total sample of 150 subjects, there were 1670 reported cases of malaria among the subjects within 11 months' study period. Of this total, 1272 (76.1%) cases were treated in zone A (d < 500 meters) and 398 (23.8%) in zone B (d > 500 meters) as shown in Table 10. Medical notes from hospital records revealed that the infected subjects showed symptoms of the disease (high fever, body weakness, loss of appetite, etc.).Results of their blood analysis also indicated that each of the infected children had malaria parasite, though with different degrees of infection. While the highest incidence of malaria was recorded in the month of October 2012 with 187 cases (11.2%) the least incidence occurred in January 2013 with 100 cases (5.9%). The rate of malaria incidence decreased with age and was significantly higher among subjects living around the dumpsites. Also the Ratio Rate (RR) was significantly high (6%) among subjects in Zone A than those in Zone B (0.76%). However, this ratio decreased with age in both zones. There was no significant difference in the rate of morbidity between the two sexes in the overall sample.

Table 11: Cases of Malaria Resulting from Proximity of Eneka Waste Dumpsites to Residential Neighborhood

Months	Total No. of Children Treated for Malaria	%	Serious Cases	%	No of Deaths	%	Total Alive	%
Sept.'12	173	10.4	13	2.9	2	0.4	171	10.2
Oct.’ 12	187	11.2	9	1.9	1	0.2	186	11.1
Nov.’ 12	180	10.8	11	2.5	2	0.4	178	10.6
Dec.’ 12	112	6.7	5	1.1	2	0.4	110	6.6
Jan. ‘13	100	5.9	7	1.5	3	0.6	97	5.8
Feb.’13	118	7.0	18	3.9	5	1.1	113	6.8
Mar.’13	155	9.3	8	1.8	1	0.2	154	9.2
Apr.’13	133	7.9	11	2.5	0	0	133	7.9
May.’13	161	9.6	10	2.2	2	0.4	159	9.5
Jun.’13	170	10.2	3	0.7	0	0	170	10.2
Jul.’13	181	10.8	5	1.1	1	0.2	180	10.8
Total	**1670**	**100**	**100**	**5.9**	**19**	**1.1**	**1651**	**98.7**

4.4 Relationship Between Distance from Dumpsite and Morbidity for Malaria

The rate of morbidity correlated positively with distance from dumpsite (0.83). The Spearman correlation coefficient calculated between rate of morbidity and distance from dumpsite in Zone A was 1.12 ($p<0.05$) and was adjusted for other factors that may have contributed to the disease. This negative correlation indicated that proximity to the dumpsite exposed children to the hazards of malaria infection. Similarly, the correlation coefficient of 0.14 in Zone B indicates that long distance from dumpsite lowers exposure to the disease. This also implies that the rate of morbidity decreased with increasing distance from the dumpsite with a strong evidence of a spatial trend ($p<0.0001$). Correlations during seasonal exposures (dry and wet season) were 0.77 and 0.52 and positive. Results also showed a strong association between distance from the dumpsite and malaria disease in the overall sample (OR=3.2, 95% C1.7-7.2). The association varied among the age groupings of the children and relative distance from the dumpsite. It was strongest for the children below 3 years of age (adjusted OR=3.3, 95%, Cl 1.19-8.1) than those above 4 years in Zone A (OR=2.5, 95%, Cl 1.3-6.7) and those in Zone B (OR=2.7, 95% Cl 1.38-5.7). Furthermore, the effect estimate for cumulative malaria infection increased the odds of the disease for children below 3 years of age 9.3% per inter quartile range (IQR). The overall result showed that children living within a distance below 500 meters from the dumpsite (Zone A) are 3.5 times more likely to suffer from malaria than those living beyond 500 meters' distance (Zone B). A trend of lower incidence of malaria was therefore noted among children living in Zone B, which was the less exposed zone.

4.5 Assessment of Larval Abundance

Table 12: Mean Mosquito Larval Abundance and Distribution in breeding habitat in Eneka.

Species/Habitat	Dump site containers	Drains	Domestic containers
Aedes	1	1	2
Anopheles	10	6	4
Culex	1	2	2
Total	**12**	**9**	**8**

Table 12 shows the mean occurrence of mosquito types in the different breeding habitats in Eneka. The frequency of larval occurrence in the positive habitats occurred in the following order of decreasing abundance Dumpsite containers > Drains > Domestic containers. The distribution of mosquito types in the positive habitat varied considerably. Aedes occurred more frequently in domestic containers with equal presence in drains and dumpsites. Generally, the Anopheles individuals were the most frequently occurring mosquitoes. The mosquitoes preferred breeding in dump sites containers, with some presence in drains and least encountered in Domestic containers.

Table 13: Physico-chemical properties of mosquito larval breeding habitats in Eneka

Parameters	**Dumpsite**	**Drains**	**Domestic containers**	**Mean ± S.D**
Temperature℃	25.50[oc]	25.90[oc]	26.20[oc]	25.9 ±4
Dissolved Solids (mg/l)	5.80[a]	93.30[b]	123.60[c]	49.6 ± 7.04
Transparency	0.14[c]	0.06[b]	0.02[a]	0.07 ± 0.22
Dissolved oxygen (mg/l)	26.5[a]	30.20[b]	38.10[c]	31.6 ± 4.6
Nitrate (mg/l)	0.50[a]	0.87[b]	14.30[c]	5 ± 2
Phosphate (mg/l)	0.19[a]	0.21[b]	0.24[c]	0.21 ± 0.4
Sulphate (mg/l)	0.44[c]	0.40[a]	0.43[b]	0.42 ± 0.5
Carbonate (mg/l)	0.51[a]	0.81[b]	0.99[c]	0.77 ± 0.7
Conductivity (ps/cm)	228.60[b]	245.9[c]	129.70[a]	201.4±11.6
Ph	8.26[b]	8.44[c]	8.22[a]	8.30 ± 2.35

Table13 values followed by same superscript alphabets in a row are not significantly different, at p= 0.05 level of significance.

The mean physico-chemical characteristics of water in the three larval breeding habitats are shown in Table 13, Temperature, Phosphate, Sulphate, Carbonate and Transparency were not significantly different ($p > 0.05$) among the three larval habitat categories. However, the same cannot be said for the remaining physico-chemical parameters that varied significantly ($p < 0.05$) among habitats.

Total dissolved solids in dump sites and drains were significantly different ($p > 0.05$), and lower than recorded in domestic containers, with the latter having the highest amounts of Total dissolved solids (Table 13). The Dissolved Oxygen content of the breeding habitats ranged from 26.5mg/l in dump site to 38.10mg/l in Domestic containers. Dissolved Oxygen in Dump site was significantly lower than in drains ($p < 0.05$) which was in turn significantly lower than in Domestic containers ($p < 0.05$). On the other hand, Conductivity was least in domestic containers but highest in the drains, and it varied significantly ($P < 0.05$) among the breeding habitats. pH was more or less uniform.

Table 14: Correlation coefficients between mosquito larval abundance and physic-chemical properties of breeding habitat

Parameters	Aedes	Anopheles	Culex
Temperature^{o}C	0.6401	0.9588	0.7475
Dissolved Solids (mg/l)	0.3842	0.6269	0.5905
Transparency	0.7321	-0.1098	0.1875
Dissolved oxygen (mg/l)	0.9071	-0.2915	-0.0927
Nitrate (mg/l)	0.7828	-0.9014	-0.8626
Phosphate (mg/l)	0.2777	0.7084	0.4875
Sulphate (mg/l)	0.9276	-0.6192	-0.4134
Carbonate (mg/l)	-0.4831	0.9872	0.773
Conductivity (ps/cm)	0.2777	0.7085	0.4875

Table 14 shows the relationships between physico-chemical parameters and larval abundance. The correlation coefficients between physico-chemical properties and larval abundance were mostly high though, while some were negative. The weak correlation coefficients were mostly restricted to Aedes and Culex mosquitoes. The abundance of Anopheles mosquitoes correlated weakly only with Dissolved Oxygen.

4.6. Answers to Research Questions and Hypothesis Testing

4.6.1 Research Questions and Answers

i. *What causes the proliferation of illegal dumpsites in Port Harcourt?*

From our findings, our major cities like Port Harcourt have several illegal dumpsites due to rapid population growth, uncontrolled urbanization, rapid industrialization and inability of the waste management authorities to manage the waste that accompany socio-economic development activities in these urban centres. This is because it is estimated that each person in Nigeria generate about 0.85 kg of waste per day (Cookey, 2004).

ii. *Does living close to waste dumpsites increase the rate of morbidity for malaria?*

The overall result showed that children living within a distance below 500 meters from the dumpsite (Zone A) are 3.5 times more likely to suffer from malaria than those living beyond 500 meters' distance (Zone B).

iii. What is the effect of distance of residential houses from dumpsite on the rate of incidence for malaria?

The rate of incidence correlated positively with distance from dumpsite (0.83). The Spearman correlation coefficient calculated between rate of incidence and distance from dumpsite in Zone A was 1.12 ($p<0.05$) and was adjusted for other factors that may have contributed to the disease. This negative correlation indicated that proximity to the dumpsite exposed children to the hazards of malaria infection. Similarly, the correlation coefficient of 0.14 (p.05) in Zone B indicates that long distance from dumpsite lowers exposure to the disease. This also implies that the rate of morbidity decreased with increasing distance from the dumpsite with a strong evidence of a spatial trend ($p<0.0001$). Results also showed a strong association between distance from the dumpsite and malaria disease in the overall sample (OR=3.2, 95% C 1.7-7.2).

v. What possible measures could be taken to mitigate malaria parasitaemia in the area?

In Nigeria the following strategies have been adopted with a view to meeting the Abuja declaration and realizing the overall RBM objective in order to mitigate malaria parasitaemia in the area:

- ITN use through massive promotion and awareness (IMPACT)
- Prepackage drugs (PPD) for home management of malaria.
- Intermittent Preventive Treatment of malaria in pregnancy (IPT)
- Integrated Vector Management (IVM)

i. Environmental management for vector control.

ii. Larviciding

The general objective of integrated vector management is the reduction of vector-borne disease particularly, malaria morbidity and mortality, through the prevention, reduction and or interruption of disease transmission, via the utilization of multiple control measures in a compatible manner such as:

- Reduction of vector breeding sites to the strictest minimum and within the shortest possible time.

- Reduction of abundance and sustenance of disease vectors to a minimal level at which transmission is no longer effective.
- Reduction of human-vector contact.

Components of IVM include:

- The use of personal protective measures such as:
- Long lasting insecticidal nets (LLINs)
- Wearing of protective clothings
- Use of repellants which appear in various forms.
- Chemical control such as:
- Indoor Residual Spraying.
- Larviciding
- Outdoor spraying
- Environmental control measures
- Biological Control Measures.

4.6.2: Testing of Research Hypothesis

A hypothesis is a statement of the expected relationship(s) between two or more variables. It is a personal statement that guides an investigation. We are going to test the application of Hypothesis. The statistical methods of testing used were chi-square and Regression ANOVA. Coefficients were calculated using the Spearman rank order correlation test. Data was analysed by SPSS for Window. ll-0 (SPSS Chicago. ll, USA).

Hypothesis

Reject: Ho (null hypothesis) if X^2cal>X^2e at 0.95 critical cal value

Accept H_1 (Alternative hypothesis) if X^2cal< X^2e 0.95 critical value

A test is conducted to reject or accept the null hypothesis.

Hypothesis Tested

H_o: ***The rate of incidence for malaria among children does not depend on the distance of their residence from waste dumpsites***

H_1: ***The rate of incidence for malaria among children depends on the distance of their residence from waste dumpsites***

The following hypothesis is tested in this study. In the Chi-Square test for the above hypothesis the values obtained at 0.05% critical values were as follows:

X^2 calculated: 0.23

X^2 tabulated or (critical value) 0.31

<u>Decision Rule</u>

If X^2cal> X^2exp, Reject result (H_o)

If X^2cal< X^2exp, Accept result (H_o).

Since the X^2cal (0.23) < X^2exp (0.31), H_1 is hereby accepted which shows that the rate of morbidity for malaria among children depends on the distance of their residence from waste dumpsites.

4.7: Discussion

Results from our study shows a high waste generation rate of 0.89kg per capita per day in the study area, although lower than 1.25kg obtained for the whole of Port Harcourt by Ayotamuno and Gobo (2004) but largely higher than 0.22kg per person per day obtained by Ibiebele (1986).

Observations revealed that since Eneka dumpsite is located at a trek able distance for most people living within the neighbourhood, most of the wastes they generate are sent to the dumpsite.

The results obtained from the study site suggested that children are vulnerable to environmental diseases such as malaria. They also indicate that the level of vulnerability is a function of the level of exposure and distance to the source of the disease (Anderson and May, 1982; Fasan, 1969). It was observed that the peak period of malaria infection corresponds with months of climatic transition with low rainfall, which encouraged the breeding of anopheles' mosquitoes at the dumpsite (Okogun, 2003). This corroborates Tibbetts (2007) observation that mosquitoes and the disease they carry are especially sensitive to temperature changes. In the same vein, Tibbetts and Epstein (2005) maintained that warm temperatures accelerate the maturation of the disease-vectors such as mosquitoes as they tend to concentrate in the same places which enhance the transmission of the parasite they carry. It is known that if the plasmodium parasite is not properly killed in the human blood stream, it might lead to emergence of a strain that might be resistant to drugs and frequent morbidity of the patient (William, 1996; Mendis and Cater, 1995). The low value of infection recorded in the months of December 2012 and January 2013 may be attributed to the chilling effect caused by the Harmattan wind, when all the children are properly covered against cold, which consequently protected them from frequent mosquito bites. Other cogent reasons emerged to buttress our argument that proximity to the waste dump increased the incidence of malaria and high rate of morbidity among children living in the study area and these include:

i. All the parents of the subjects indicated in the questionnaire that the incidence of malaria before the appearance of the waste dump in the area was minimal.

ii. The presence of the dumpsite and the accumulation of waste provided breeding ground for mosquitoes that vehicle this disease.

iii. The exposure route was only through mosquito bites among a population group that is highly vulnerable and less mobile.

Overall, our results show that the growing health disparities that result from poverty and inadequate infrastructure and service provision in our urban areas raise serious concerns about environmental justice (Thomas et al, 2006; Pellow and Brulle, 2005). The high rate of morbidity due to malaria especially among the most vulnerable groups such as children under five, and other likely diseases arising from poor management of municipal solid waste should make this sector an obvious priority. Our results constitute an eloquent testimony that children living in low income and poor neigbourhoods are often at greater risk of exposure to environmental-based hazards than other groups (Mabunde *et al,* 2009; Sievere *et al*, 2008).

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1: Summary of Findings

The following are the major findings of this study.

i. This study seeks to prove that there is relationship between proximity to waste dumpsites to Residential neigbourhoods and increased rate of morbidity for malaria in children under five years of age.
ii. Results obtained from findings using Questionnaires, Assessment of Exposure and Assessment of larval abundance at the dumpsite reveal high rate of morbidity due to malaria especially among the most vulnerable groups such as children under five and other likely diseases arising from poor management of municipal solid waste.
iii. The presence of dumpsite and the accumulation of waste provided breeding ground for mosquitoes that vehicle this disease. The exposure route was only through mosquito bites among a population group that is highly vulnerable and less mobile.
iv. The overall result showed that children living within a distance of below 500 metres from the dumpsite (zone A) are 3.5 times more likely to suffer malaria than those living beyond 500 metres distance (zone B). A trend of incidence of malaria was therefore noted among children living in zone B, which was the less exposed zone.
v. Results also show strong association between distance from the dumpsite and malaria disease in the overall sample (OR-3.2,95% Cl.7-7.2)

5.2: Conclusion

This study is one of the evidences that support the argument that exposure to environmental pollutants such as waste dumps can compromise urban public health and the pathology of related diseases (Steve and Elijah, 2010). Several risk factors for malaria were not controlled (diet, use of net and insecticides, latent period, etc.) which may appear as important co-founders when their frequency in the sub-population are associated with exposures. Despite these limitations, we argue that if our results could show high rates of malaria incidence and morbidity among our subjects when our exposure assessment fraught with certain limitations, then it could be that the real relationship between malaria and proximity to waste dumps may likely be stronger.

Nonetheless, the case study is a clear demonstration that accumulation of solid waste in proximity to residential areas constitutes a path way to many chronic diseases including malaria. There is a great need to further explore the waste-malaria paradigm in environmental health studies with the view to developing new strategies for intervention and prevention of this disease. Ultimately, the promotion of urban cleanliness and effective management of municipal wastes may be the most sensible strategies to Roll Back Malaria in Nigerian urban areas in the years ahead.

5.3: Recommendations

i. Dumpsites should be sited far away from residential homes (>500m) since municipal wastes create pathological zones, in which disease vectors proliferate and pose significant dangers to human health and the environment.

ii. There is the need to educate the public on proper waste generation and disposal practices, including sorting of waste and the use of correct dumpsites.

iii. There should be adequate information at dumpsites for users on where and how to deposit wastes.

iv. Government should establish regulations and by laws on waste disposal, including specifications on types of bins, and form in which wastes should be deposited at dumpsites.

v. Government should provide more funds towards the disposal of waste. Such funds should be used for the provision of necessary facilities such as equipments, vehicles and for the regular maintenance of the dumpsites.

vi. Dumpsites should be adequately constructed and maintained. Should be accessible to users and regular collection of wastes should be ensured to prevent dumpsites from overflowing and blocking roads.

vii. There is need for regular monitoring and surveillance of public dumpsites and even private premises especially in the high population density areas like Port Harcourt by government sanitation officers.

viii. More sanitation workers and waste management contractors should be employed and adequately trained to cope with the ever increasing waste disposal problems in the LGA, State and Country.

ix. Insecticides treated nets and other preventive measures for malaria should always be provided for all citizens especially those living close to dumpsites.

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APPENDIX I

School of Postgraduate Studies

Federal University of Technology,Owerri.

QUESTIONNAIRE

Dear Sir/Madam,

I am a Student of the above named School in the Department of Environmental Technology, conducting a Research on Proximity of Waste Dump sites to Residential Neighbourhoods and the incidence for Malaria among Under-Five Children in Port Harcourt, Rivers State.

I solicit your co-operation in providing information for this study. Be assured that all information given here will be kept confidential.

Thank you.

Amachree, Mikiai T.K.

Please tick [√] the answers you feel appropriate in the boxes provided and also give your answers where necessary.

SECTION A

Background

1. Age of children (years)
   a. <1yrs [ ]
   b. 2-3yrs [ ]
   c. 4-5yrs [ ]
2. Income of parents
   a. ₦15,000-20,000 [ ]
   b. ₦21,000-30,000 [ ]
   c. ₦31,000-35,000 [ ]
   d. ₦35,000 [ ]
3. Education status of father
   a. Higher education [ ]
   b. Average education [ ]
   c. Lower education [ ]
4. Education status of mother
   a. Higher [ ]
   b. Average [ ]
   c. Lower education [ ]

SECTION B

5. Housing condition
   a. Well ventilated [ ]
   b. Poorly ventilated [ ]
6. Presence of waste bins at home
   a. Yes [ ]
   b. No [ ]
7. Use of mosquito Nets
   a. Yes [ ]
   b. No [ ]

8. Use of insecticides
    a. Yes ☐
    b. No ☐

x. No of times children fell sick and reasons for the attacks of malaria?

………………………………………………………………………………………

……………………………………………………………………………………..

xi. Months of the year children fell sick and what can be done to reduce malaria attack in the area?

………………………………………………………………………………………………

……………………………………………………………………………..

APPENDIX II

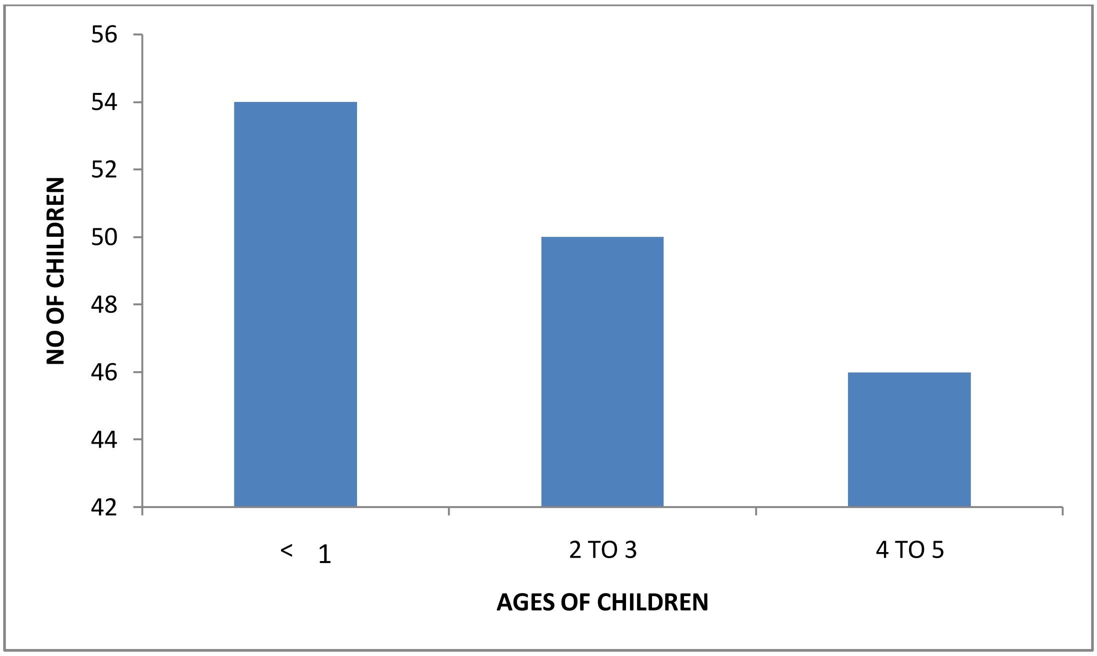

FIGURE1: AGES OF CHILDREN IN YEARS (n = 150)

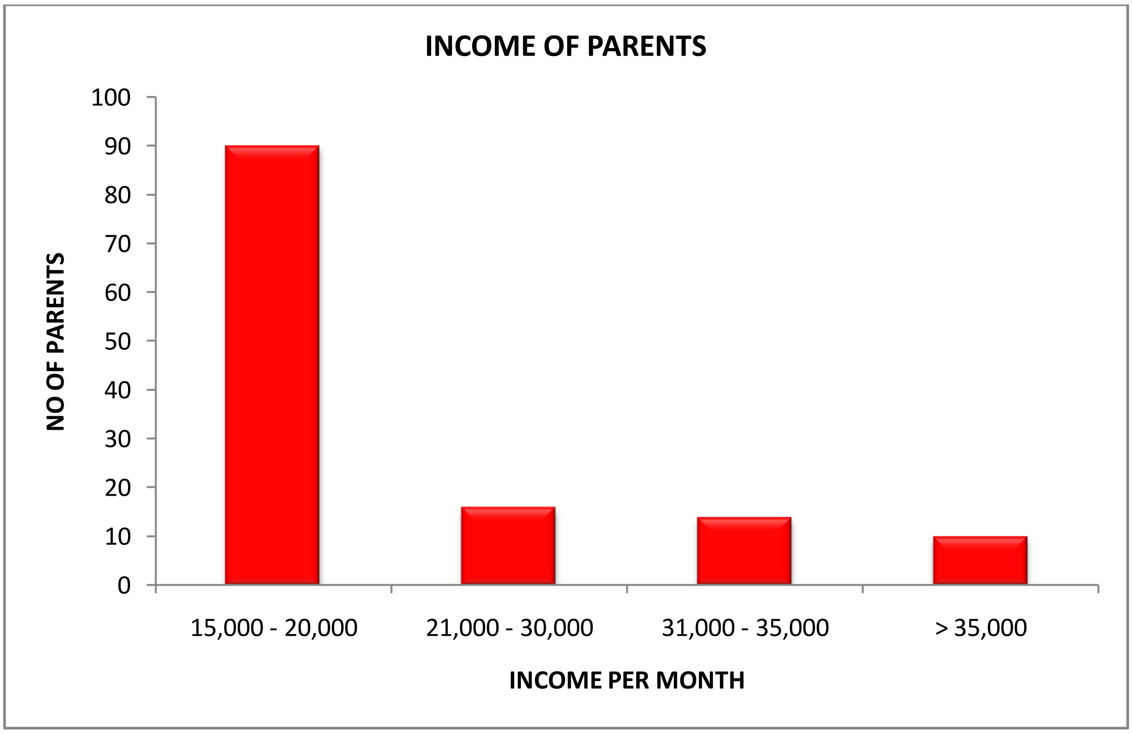

FIGURE 2: INCOME OF PARENTS

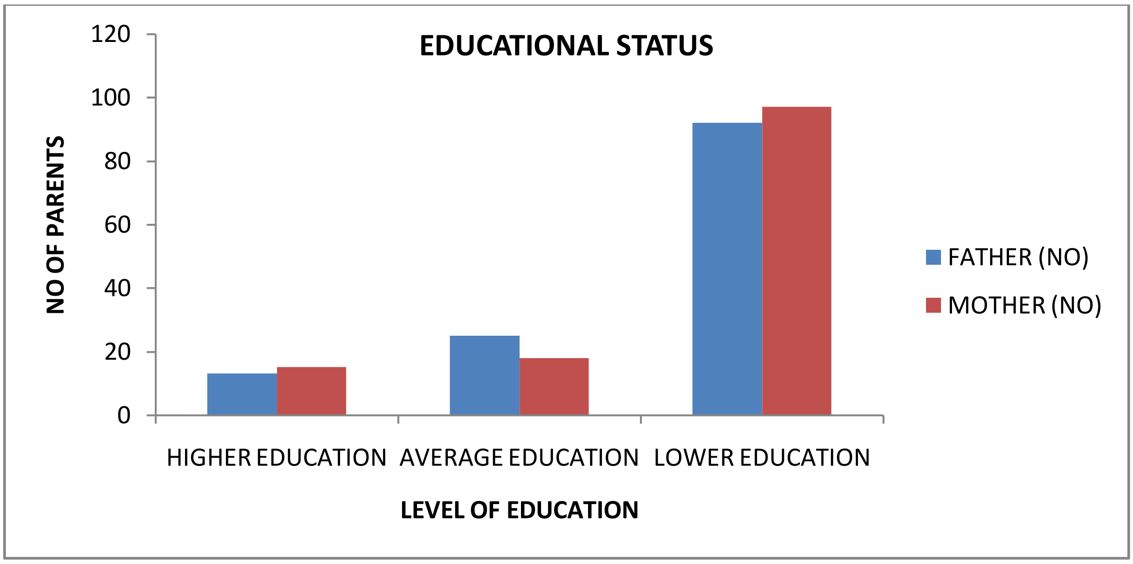

FIGURE 3: EDUCATIONAL STATUS OF PARENTS

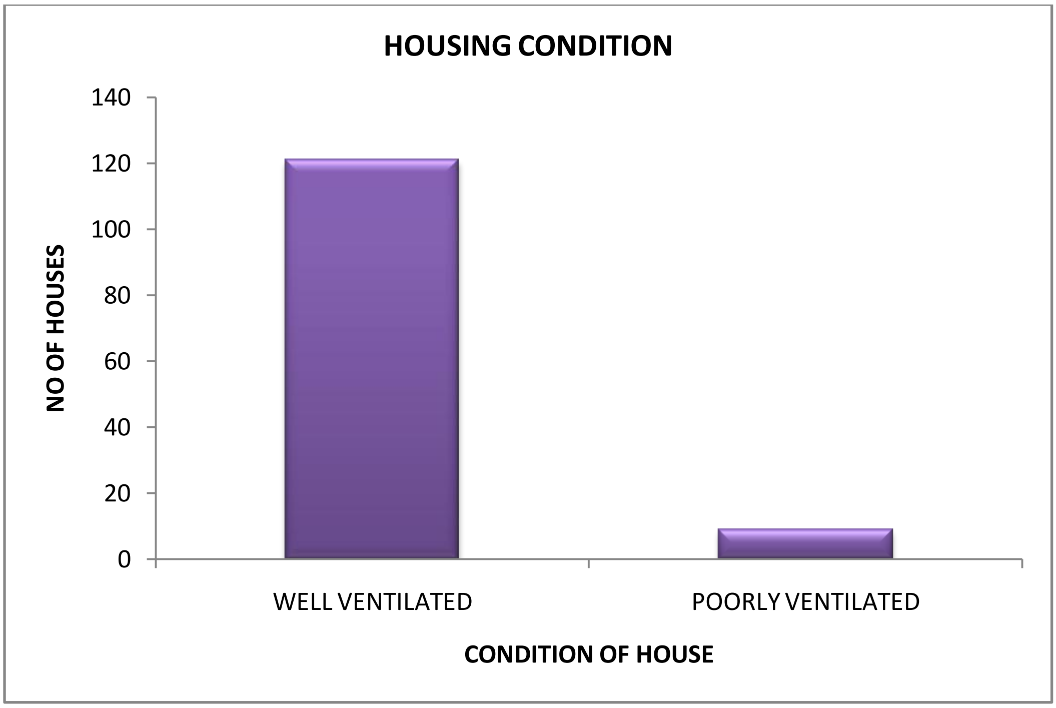

FIGURE 4: HOUSING CONDITIONS

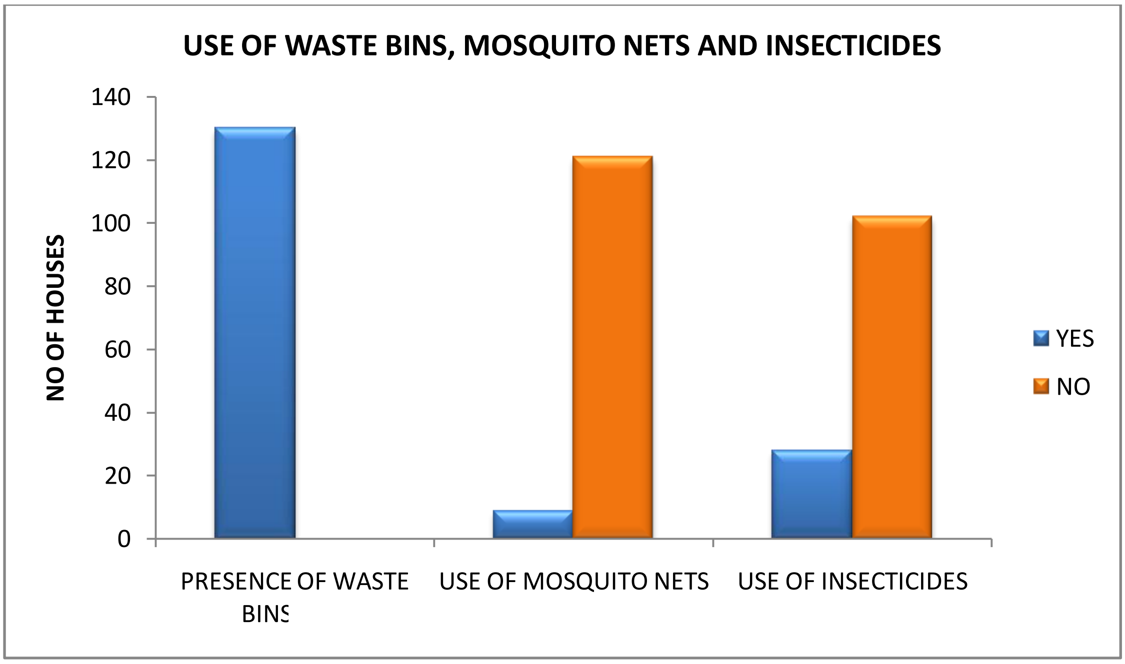

FIGURE 5: USE OF WASTE BINS, MOSQUITO NETS AND INSECTICIDES

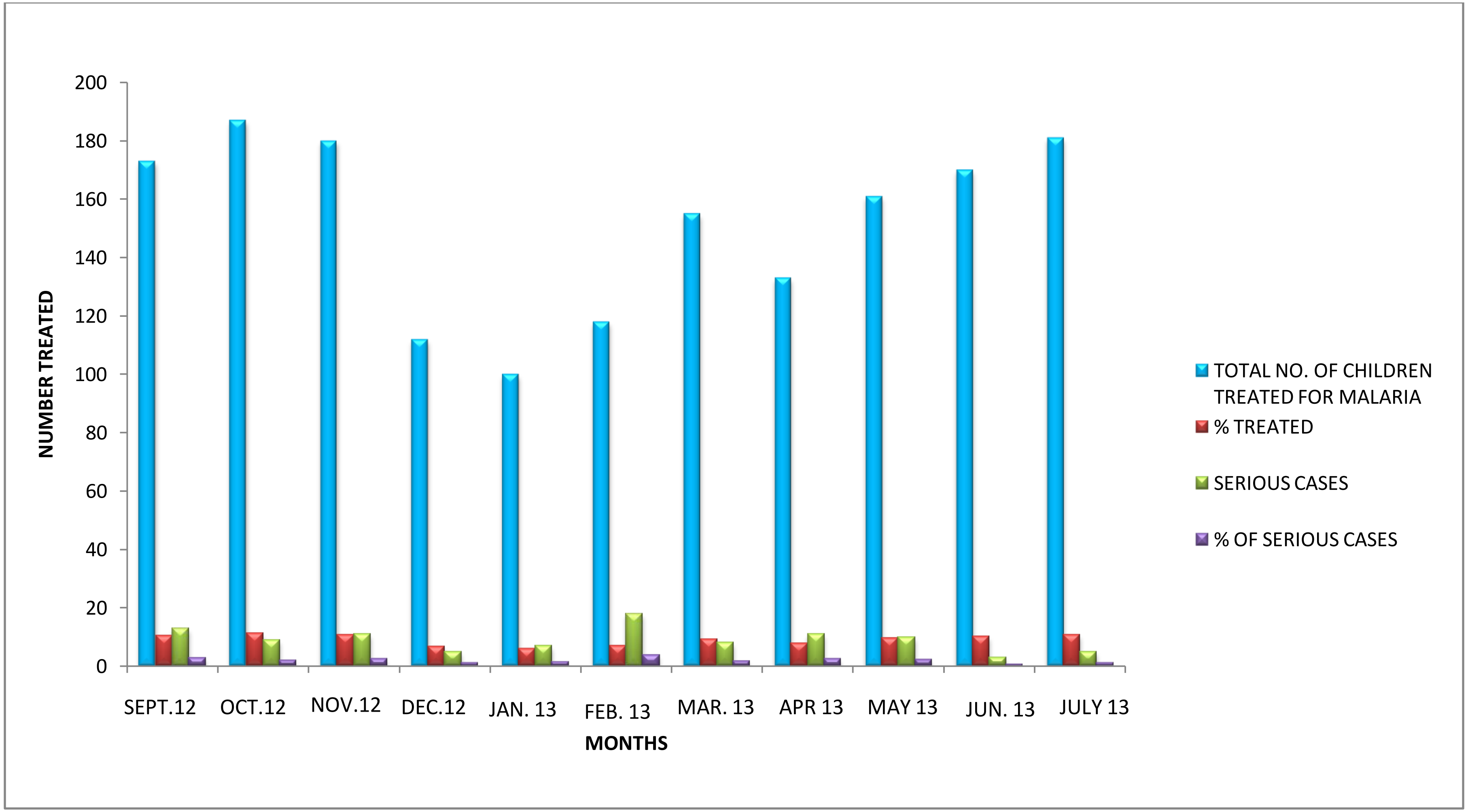

FIGURE 6: NUMBER OF SUBJECTS TREATED FOR MALARIA IN ZONES A AND B

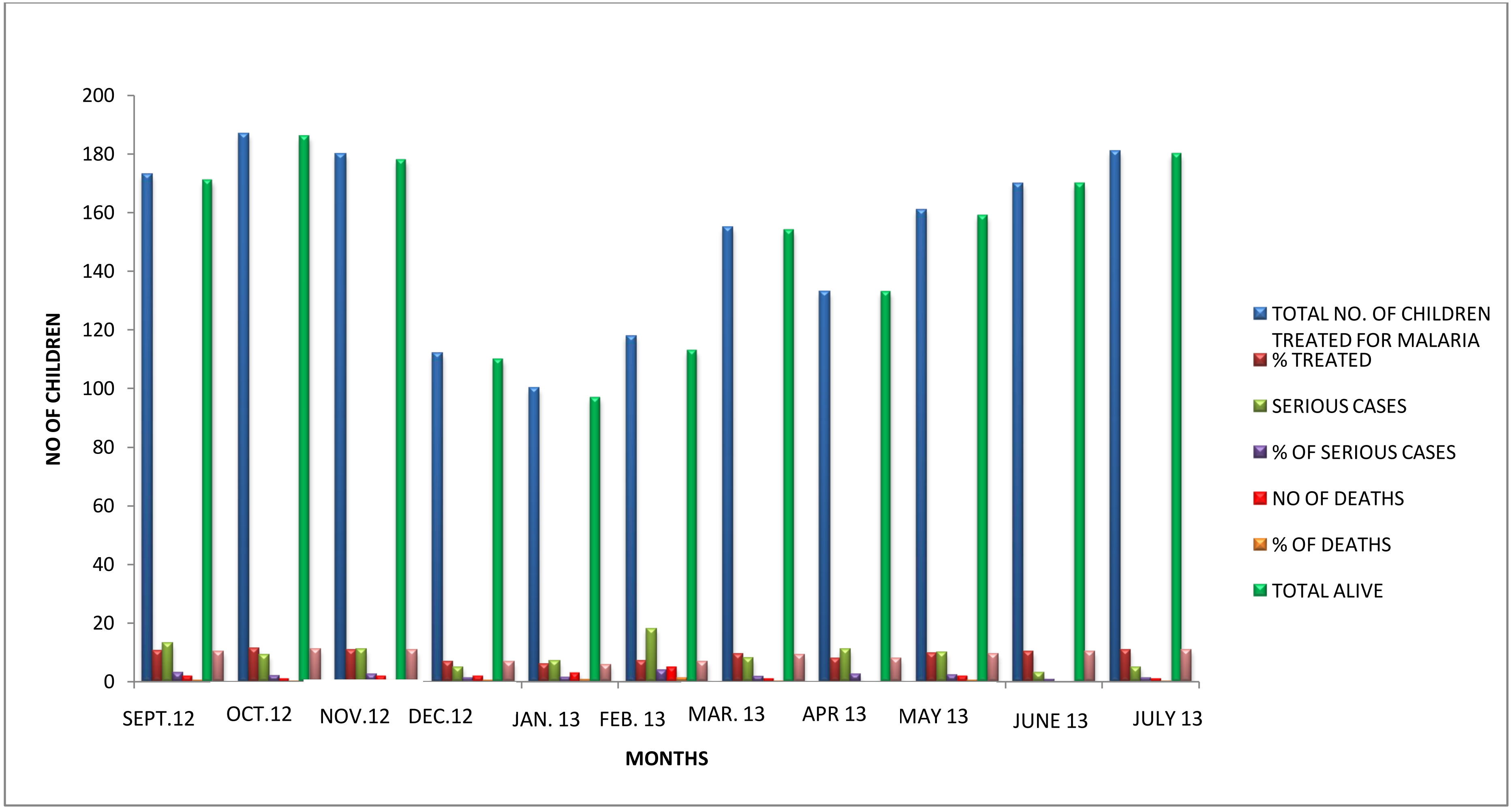

FIGURE 7: CASES OF MALARIA RESULTING FROM PROXIMITY OF ENEKA WASTE DUMP SITE TO RESIDENTIAL NEIGHBOURHOODS

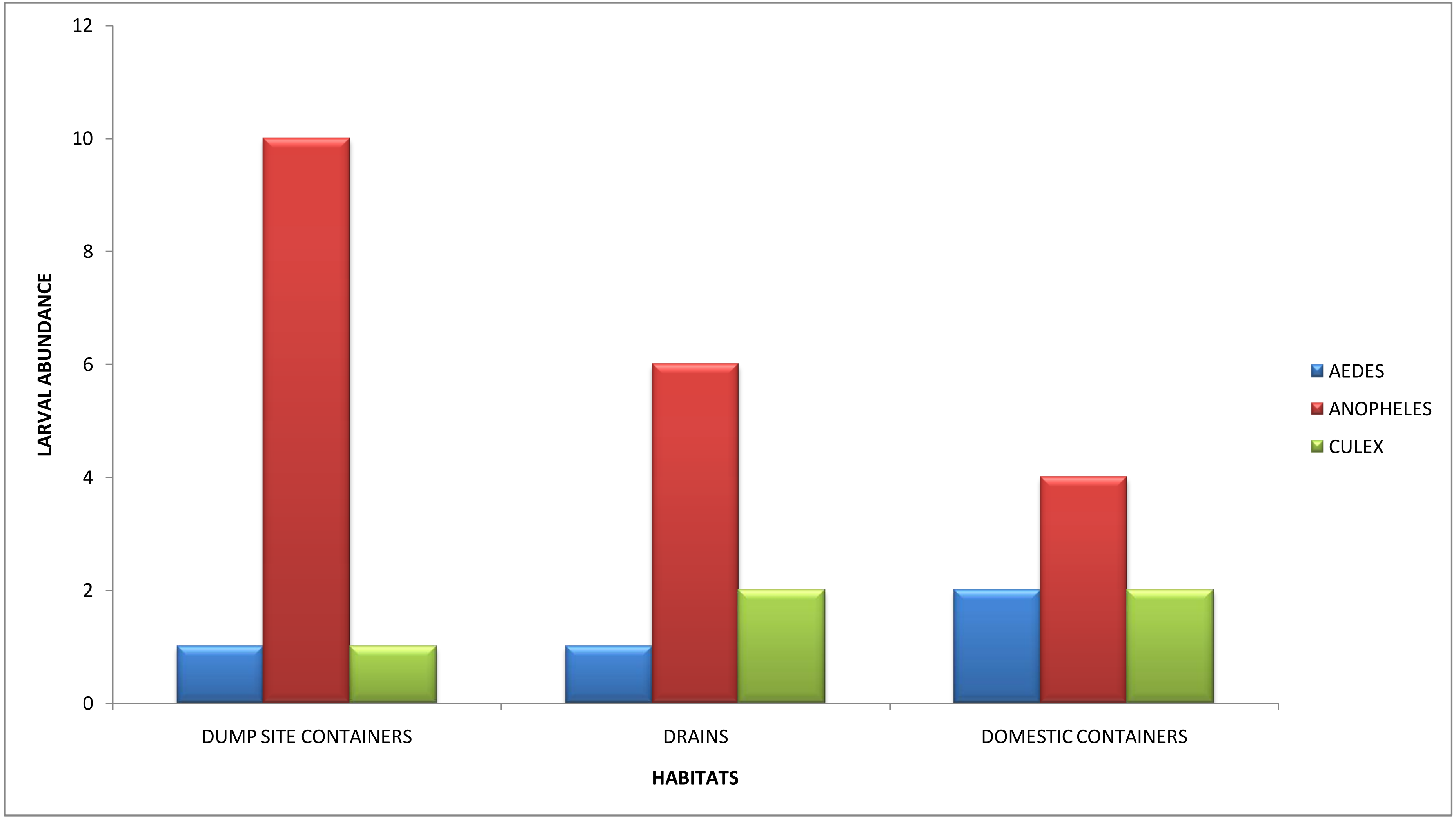

FIGURE 8: MEAN MOSQUITO LARVAL ABUNDANCE AND DISTRIBUTION

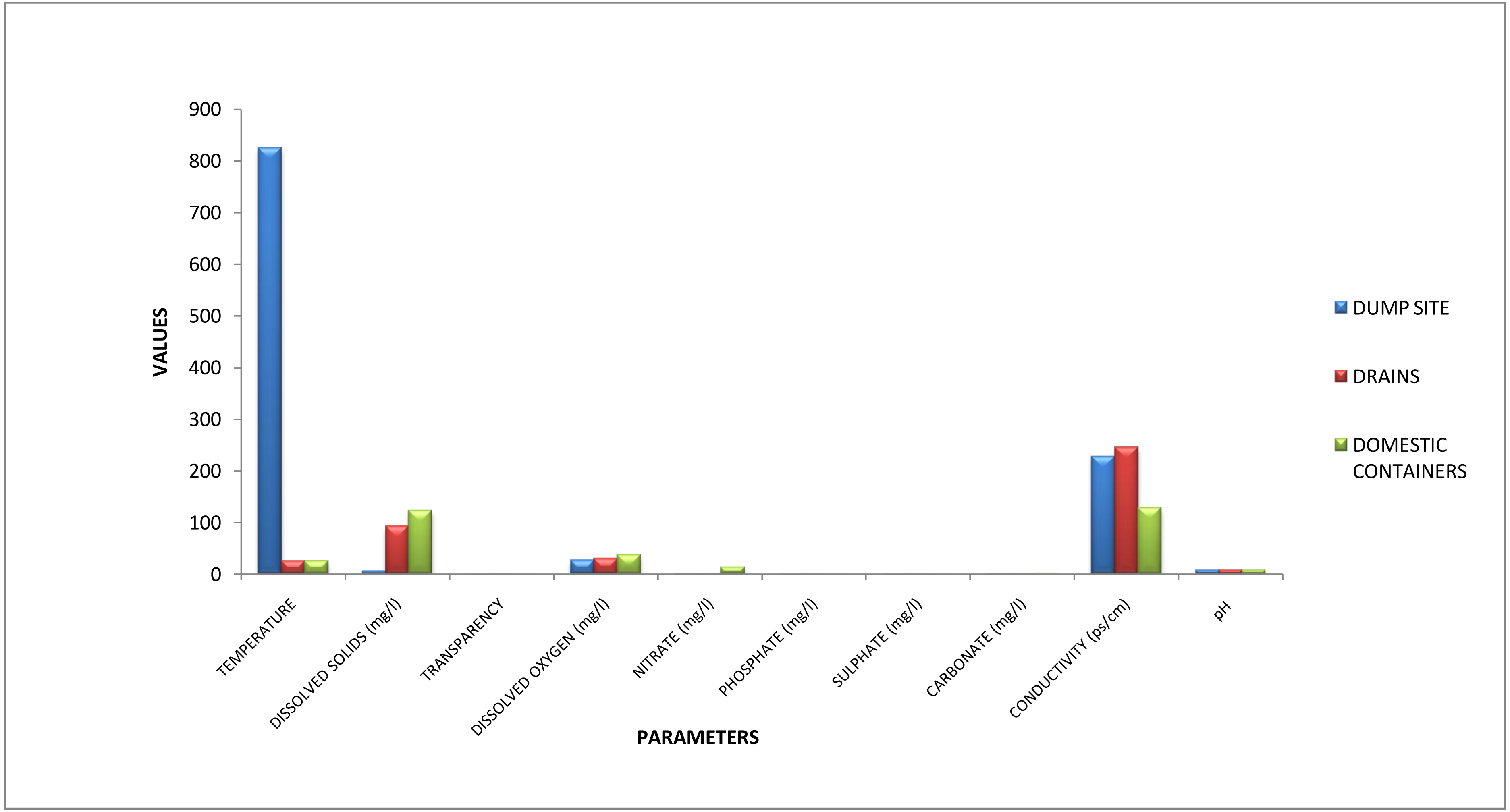

FIGURE 9: PHYSICO-CHEMICAL PROPERTIES OF MOSQUITO LARVAL BREEDING HABITATS IN ENEKA

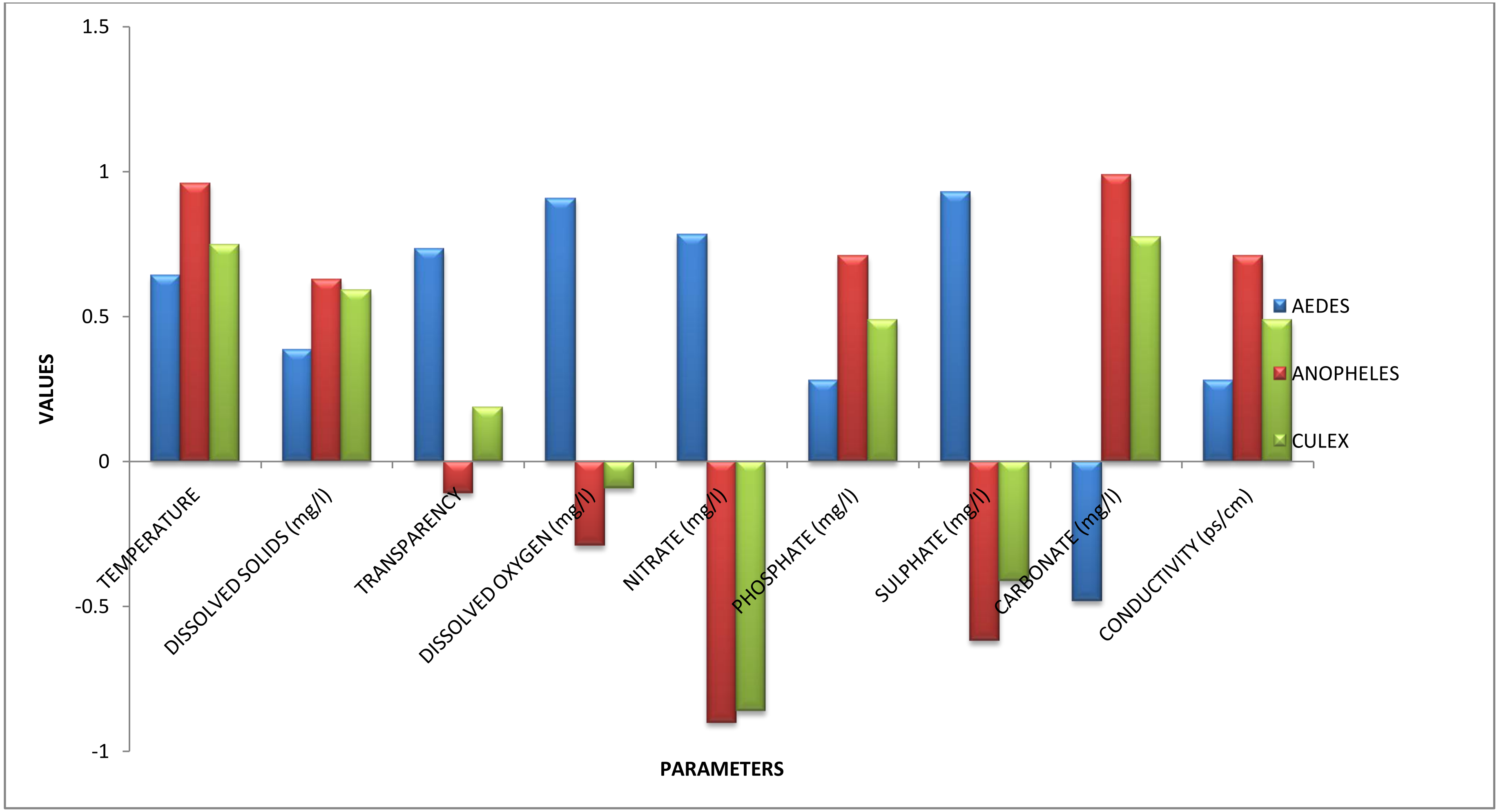

FIGURE 10: CORRELATION COEFFICIENTS BETWEEN MOSQUITO LARVAL ABUNDANCE AND PHYSICO-CHEMICAL PROPERTIES OF BREEDING HABITAT