# CHARACTERIZATION OF ILLEGAL DUMPSITE WASTES AND THEIR GREENHOUSE GAS EMISSIONS IN IBADAN SOUTHWEST LOCAL GOVERNMENT AREA, OYO STATE, NIGERIA



BY

UMEGO, IJEOMA MAUREEN

B.Sc. BIOLOGY (A.B.U. Zaria)

MATRIC NO: 146246



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DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES, FACULTY OF PUBLIC HEALTH, COLLEGE OF MEDICINE, UNIVERSITY OF IBADAN, IBADAN, NIGERIA

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# ABSTRACT

Most cities in Nigeria are notable for their unauthorised dumpsites which are one of the significant contributors to Greenhouse Gas Emissions (GHGE). These Greenhouse Gases (GHG) are known to cause climate change effects such as floods, proliferation of disease vectors, spread of infectious diseases and increased heat-related mortality. Information on the contribution of these illegal dumpsites to GHGE is inadequate in developing countries. Therefore, this study was designed to characterise wastes and assess their GHGE particularly carbon-dioxide ($CO_2$) and methane ($CH_4$) from illegal dumpsites in Ibadan Southwest Local Government Area (IBSWLGA), Oyo-state.

Thirty dumpsites were identified by snowballing with 15, 10 and 5 dumpsites in the high-, medium- and low-density areas of IBSWLGA respectively. Three dumpsites in each of the areas were selected using simple random sampling technique. A composite fraction of the wastes from each site was collected and characterised into physical components such as plastics, nylon, metals, paper and other wastes using the American Society for Testing and Materials Standard. The percentage weight of the wastes was determined. A $CO_2$ meter was used to measure the concentration of $CO_2$ emissions (ppm) at the dumpsites thrice weekly at specific periods of the day (8–10am, 12-2pm and 4-6pm), for 12 consecutive weeks. The values of $CO_2$ were compared with the United States Environmental Protection Agency (USEPA) limit (300-450ppm). The 2006 Intergovernmental Panel on Climate Change waste model was used to estimate the $CH_4$ emitted from each dumpsite per year using the weight of the wastes and population of the areas. Descriptive statistics and ANOVA were used for data analysis.

Composition of characterised wastes for the high-, medium- and low-density areas were: 21.7%, 35.2% and 50.0% for organics; 8.3%, 10.2% and 3.3% for plastics; 51.3%, 31.1% and 25.0% for nylon; 8.0%, 5.6% and 5.0% for metals; 5.3%, 10.6% and 13.3% for paper and 5.3% 7.0% and 3.3% for other wastes respectively. The overall mean $CO_2$ emission in the high-, medium- and low-density areas were: 372.5±92.1ppm, 385.6±114.5ppm and 380.8±82.4ppm respectively. Mean $CO_2$ emissions at different periods of measurement for the three areas were: 420.1±98.5ppm, 433.5±148.3ppm and 417.5±71.4ppm at 8-10am;

375.4±83.6ppm, 391.3±89.9ppm and 387.6±86.4ppm at 12-2pm and 321.9±65.4ppm, 331.9±68.1ppm and 337.3±69.4ppm at 4-6pm respectively ($p<0.05$). The highest (1157ppm) $CO_2$ emission was recorded at the medium-density area between 8-10am. The percentage composition of methane gas in the total potential gas emissions from the dumpsites in the high-, medium- and low-density areas was; 0.000158 Gg/yr., 0.000026 Gg/yr. and 0.000012 Gg/yr. respectively.

Levels of carbon-dioxide from illegal dumpsites were within acceptable limits, while methane emission quite small. Evacuation of wastes from illegal dumpsites to authorised locations for recovery of greenhouse gases and material recycling should be promoted.

**Keywords:** Waste characterisation, Illegal dumpsites, Greenhouse gas emissions

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## CERTIFICATION

I certify that this research work was carried out by Ijeoma Maureen UMEGO of the Department of Environmental Health Sciences, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan.

28/3/14

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Supervisor

**Godson R.E.E. Ana**

B.Sc (PH), M. Eng (PH), MPH (Ib), PhD (Ib), FLEAD (UK), MRSPH (UK), MAPHA (USA)

**Environmental Health Sciences**

28/03/2014

..........................................................................................

Co-supervisor

**Boluji O. M.**

B.Sc. (Lagos), M.Sc., Ph.D. (Ibadan)

**Environmental Health Sciences**

# DEDICATION

This work is dedicated to God the Almighty Father.

Thank you.

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# GLOSSARY OF ABBREVIATIONS AND TECHNICAL TERMS

| | | |
|---|---|---|
| CDM | – | Clean Development Mechanism |
| CFCs | – | Chlorofluorocarbons |
| $CH_4$ | – | Methane |
| $CO_2$ | – | Carbon dioxide |
| CPE | – | Centre for People and Environment |
| DECC | – | Department of Environment and Climate Change |
| DOC | – | Degradable Organic Carbon |
| EfW | – | Energy from Waste |
| EPA | – | Environmental Protection Agency |
| FEPA | – | Federal Environmental Protection Agency |
| FOD model | – | First Order Decay model |
| GHGs | – | Greenhouse gas |
| GPS | – | Global Positioning System |
| HFCs | – | Hydrofluorocarbons |
| IMG | – | Ibadan Municipal Government |
| IOM | – | Institute of Medicine |
| IPCC | – | Intergovernmental Panel on Climate Change |
| ISWM | – | Integrated Solid Waste Management |
| IUCN | – | International Union for Conservation of Nature |
| IUSB | – | Ibadan Urban Sanitation Board |
| IUSC | – | Ibadan Urban Sanitation Committee |
| JI | – | Joint Implementation |
| LFG | – | Landfill Gases |
| M2M | – | Methane to markets |
| MMTCE | – | Million Metric Tonnes of Carbon Equivalent |
| MRFs | – | Material Recovery Facilities |
| MSW | – | Municipal Solid Waste |
| MSWM | – | Municipal Solid Waste Management |
| $N_2O$ | – | Nitrous oxide |

| | | |
|---|---|---|
| NOAA | - | National Oceanic and Atmospheric Administration |
| NPC | - | National Population Commission |
| NUJ | - | Nigerian Union of Journalist |
| $O_3$ | - | Ozone |
| PEO | - | Protection of the Environment Operation |
| PFCs | - | Perfluorocarbons |
| Ppm | - | parts per million |
| ppmv | - | parts per million by volume |
| $SF_6$ | - | Sulphurhexafluoride |
| SPSS | - | Statistical Package for Social Sciences |
| UCH | - | University College Hospital |
| UI/UCH | - | University of Ibadan/ University College Hospital |
| UNCHS | - | United Nations Centre for Human Settlements |
| UNDP | - | United Nations Development Programme |
| UNEP | - | United Nations Environmental Programme |
| UNFCCC | - | United Nations Framework Convention on Climate Change |
| USEPA | - | United States Environmental Protection Agency |
| VOCs | - | Volatile Organic Compounds |
| WHO | - | World Health Organization |
| WtE | - | Waste to Energy |

## OPERATIONAL DEFINITIONS

### a. Waste

There is no definitive list of what is and is not waste. Wastes however can be defined:

- As an unwanted or unusable item, remains, or by- product, or household garbage.
- As a moveable object with no direct use that is discarded permanently.

Waste is a generalized word which can be divided into 3 major types. They include: solid, liquid and gaseous wastes.

- Liquid wastes must be transported in containers or through pipes. Examples include sewage, contaminated groundwater, and industrial liquid discharges.
- Gaseous wastes, of course, consist of gases. They are primarily generated by combustion (e.g., internal combustion engines, incinerators, coal-fired electrical generating plants) and industrial processes.
- Solid waste: It has been defined in various ways. Some definitions include:
- Solid waste is a useless, unwanted and discarded material without sufficient liquid to be free flowing. (EPA,1972).
- Solid waste is any solid material or substance that does not have any important value at the particular point in time to the user, (Adediba, 1985).

### b. Dumpsites

These are pieces of land or spaces where waste from households, commercial institutions refuse industries, or litter from the streets is dumped.

### c. Illegal dumpsites

These could also be dumpsites that are improperly sited or unplanned dump sites which are open and mostly uncared for. It is also the unlawful deposit of waste larger than litter onto areas (private or public land, isolated areas, water bodies, incomplete buildings etc.) that has not been approved by the government.

### d. Greenhouse gases

These are gases in the atmosphere that absorb and emit radiation within the thermal infrared range. These gases are known to occur naturally in the atmosphere and they make the earth's surface about 33°C warmer than it would be if it was not present but this makes the earth bearable and warm enough for humans to live in (Hopwood & Cohen, 1998). However due to human activities, the level of these gases has increased to a large extent. These greenhouse gases include: water vapour, carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), Perflurocarbons (PFCs), Hydroflurocarbons (HFCs), Sulphur Hexafluoride ($SF_6$) and ozone ($O_3$). However the four most important greenhouse gases are: Carbon dioxide ($CO_2$), Water vapour, Methane ($CH_4$) and Nitrous oxide ($N_2O$) (Russell, 2010); and out of these four the focus will be on carbon dioxide and methane in this study.

# CHAPTER ONE

# INTRODUCTION

## 1.1. Background Information

Over the last three decades there has been increasing global concern over the public health impacts attributed to environmental pollution. The World Health Organization (WHO) estimates that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution (Kimani, 2007). Most of these environment-related diseases are however not easily detected and may be acquired during childhood and manifested later in adulthood.

The very idea that waste needs to be "managed" is relatively new. Throughout much of human history waste was managed by the natural cycle, and in many parts of the world it still does. However, in poor agricultural societies there is not much of it to begin with. Broken tools and worn clothes are repaired, food scraps are fed to livestock, human and animal droppings were gathered up and spread on farmlands as fertiliser, and rags were used to make paper and so on. In such places waste is seen as having an inherent value. Waste first became a problem in cities, where it accumulated faster than it rotted away, creating an eyesore and a health hazard (The Economist, 2009).

The amount of waste a community generates tends to grow with its economy. H Human activities create waste, and it is the way these wastes are handled, stored, collected and disposed of, which can pose risks to the environment and to public health. In urban areas, especially in the rapid urbanizing cities of the developing world, problems and issues of Municipal Solid Waste Management (MSWM) are of immediate importance. This has been acknowledged by most governments, however rapid population growth overwhelms the capacity of most municipal authorities to provide even the most basic services.

Typically one to two thirds of the solid waste generated is not collected. As a result, the uncollected waste, which is often also mixed with human and animal excreta, is dumped indiscriminately in the streets and in drains, so contributing to flooding, breeding of insect and rodent vectors and the spread of diseases. Furthermore, even collected waste is often disposed of in uncontrolled dumpsites and/or burnt, polluting water resources and air. Illegal dumping also poses a threat to the environment, public health and safety. Some of these include: increase in rodents, insects and vectors population which lead to easy spread of diseases, pollution of the air, land and surface and ground waters leading to loss of biodiversity, emission of greenhouse gases from decomposition and burning of these wastes. Developing countries face challenges regarding environmental pollution (water, air and soil) and one of the most contributory factor is waste disposed illegally and/or without proper treatment. Across our country Nigeria, communities and rural areas have chronic illegal dumping sites, where wastes from organic, papers, plastics, bottles, refrigerators to tires are discarded. Most commonly, these items are dumped along roadsides, ditches and fields, wooded areas and remote sites. These sites can become breeding grounds for insects and rodents and, they diminish the beauty and quality of life near these areas.

The city of Ibadan is characterized by a large number of illegal solid waste dumps. Densely populated areas such as Oje, Oke-foko, Beere, Ojoo, and Agbowo, are characterized by poor housing quality and lack proper planning. In fact, houses built for commercial purposes were often built with no allowance for set-backs, facilities for sewage and solid waste disposal (Oyeniyi, 2011). Often the wastes are dumped in open abandoned land space or in some cases behind residential buildings. These wastes largely consist of organic matter which decompose under the favourable environmental temperature and pose serious pollution problems to the ecosystems (Agboola and Omueti, 1982). As a result urban dwellers residents in the state are continuously at risk of infections such as: cholera, typhoid, diarrhoea, and faecal oral infections. Stunted growth and malnutrition are also common diseases experienced.

Waste cannot always be confined within one locality or area of jurisdiction. Some forms of waste (particularly those associated with acid rain, greenhouse gases, and air quality in general) are transmitted in the atmosphere, which respects no political, terrestrial, or aquatic boundaries (Chopra, 2005).

Municipal solid waste is a significant contributor to greenhouse gas emissions and majority of these emissions result from open dumping and landfilling in developing countries including Nigeria (Chalvatzaki and Lazaridis, 2010). These landfill and open dumping contributes to the GHG effect via the emission of methane ($CH_4$) gas and carbon dioxide ($CO_2$) (Ishigaki et al., 2005). $CH_4$ and $CO_2$ are produced during the decomposition process of waste organic content under anaerobic conditions (Abushammala et al., 2009). United Nations Framework Convention on Climate Change (UNFCCC) alluded that the waste sector is an important source of greenhouse gas emissions (GHGEs). According to recent national estimates this sector produces on average 2 – 4 per cent of national greenhouse gas emissions (UNFCCC, 2005). Methane is regarded as one of the most important GHGs because its global warming potential has been estimated to be more than 20 times of that of carbon dioxide (Ekanem *et al*, 2013.).

Greenhouse gases are known to occur naturally in the atmosphere and they make the earth's surface about 33°C warmer than it would be if it was not present thus, making the earth bearable and warm enough for humans to live in (Hopwood and Cohen, 1998). Greenhouse gases are obtained from both natural and anthropogenic sources, though anthropogenic sources provide most of today's greenhouse gases. As these gases build up in the atmosphere, they trap more heat near the earth's surface, causing the earth's climate to become warmer (YeSeul et al., 2010). In the last decades, the GHGs produced as a result of anthropogenic activities have been prevalent over those of natural origin (Hansen, 2004). The waste sector is a significant contributor to GHGEs accountable for approximately 5% of the global greenhouse budget (IPCC, 2006). This 5% consist of methane ($CH_4$) emission from anaerobic decomposition of solid waste and carbon dioxide ($CO_2$) from wastewater decomposition (IPCC, 2006).

The evaluation of the emission rate of gaseous pollutants from landfills is very difficult to control, owing to several factors affecting the emission process, such as: the gas production rate, the gas migration properties through the waste layers and through the top layer of the landfill, the gas collection efficiency, and meteorological factors (Abushammala et al 2009). Enteric fermentation associated with domestic livestock, decomposition of wastes in landfills, and natural gas systems were among factors responsible for increase in greenhouse gas (GHG) emission in the United States (US EPA, 2010).

The disposal of solid waste produces greenhouse gas emissions in a number of ways viz: the anaerobic decomposition of waste in landfills produces methane; the incineration of waste also produces carbon dioxide as a by-product. The emission of these greenhouse gases have today become a global issue. Over the past two decades, The National Oceanic and Atmospheric Administration (NOAA, 2008) reported that carbon dioxide and methane increased by 0.6% and 0.5% respectively in 2007 while a total of 27% and 145% respectively since the pre-industrial times. The United Nations Framework Convention on Climate Change (UNFCCC) in 1992 alluded parties to the convention shall develop, periodically update, publish and make available national inventories of anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol, using comparable methodologies (USEPA 2009). However, there is no existence of literatures detailing anthropogenic emissions.

In Nigeria there is dearth of research on GHG emission from dumpsites hence there is no quantitative data on $CH_4$ and $CO_2$ emission in the numerous dumpsite and landfill scattered across the country and also infonnation on the dumpsites are lacking. Therefore quantitative data on the emission of selected GHGs will provide stakeholders in climate change the significant contribution of illegal dumpsites to GHG emission. It also will stir relevant action in adopting effective waste management methods or technologies, because effective mitigation of greenhouse gas emissions is important and could provide environmental benefits and sustainable development, as well as reduce adverse impacts on public health (Papageorgiou et al., 2009). Therefore this study was designed to characterize wastes, assess $CO_2$ and annual $CH_4$ emissions from selected illegal dumpsites in Ibadan Southwest Local Government Area (IBSWLGA), Oyo state, Nigeria.

## 1.2. PROBLEM STATEMENT

Illegal dumping poses a threat to the environment, public health and safety. Some of these include: increase in rodents, insects and vectors population which lead to easy spread of insect/vector propagated diseases, air pollution, land, surface and ground water pollution; leading to loss of biodiversity, emission of greenhouse gases from decomposition and waste incineration.

The demographic expansion and increased industrial and commercial activities have caused an astronomical increase in the volume and diversity of solid wastes generated in Nigeria (Aluko, 2001). As the population increases, the urban centres generate large quantities of solid and liquid wastes, whose disposal poses serious problems to the governments (Agboola and Omueti, 1982). Ibadan, like other urban centres in Nigeria is characterized by large numbers of illegal solid waste dumpsites. Most of the illegal dumpsites are located in the high and medium density areas and they are not evacuated regularly.

Ibadan is experiencing the problem of municipal waste management, principally as a result of unplanned development, rural -urban migration and natural increase within the city (Akinbiyi, 1992). For instance, the population of Ibadan based on 1963 census was 582,000 with 468,000 (80.4%) living in the inner core with a growth rate of 3.0% because the low income group dominates the population of Ibadan city, the core areas are always inundated with organic wastes especially leaves which are used for wrapping foods from time immemorial.

People collect all the wastes into a common bin or basket without any segregation and dispose of at convenient places e.g. vacant lots on public or private property, abandoned residential or commercial buildings, which are often illegal, contaminating surface and ground water and posing major health hazards.

These waste dumps decomposing under the tropical heat pose serious threats as they can cause a variety of impacts if not properly managed. One of these impacts is the threat of climate change. Climate change which is a growing concern in the world today is caused largely by the presence of greenhouse gases in the atmosphere more than is required.

## 1.3. RATIONALE OF THE STUDY

In the 21st century, management of municipal solid waste (MSW) continues to be an important environmental challenge facing the world because it bears the intrinsic consequence of climate change. The World Health Organisation WHO has estimated that over 10 percent of preventable ill-health is due to poor environmental quality, to which inadequate waste management is a prime contributor. Diarrhoea, malaria and protein energy malnutrition alone caused more than 3.3 million deaths globally in 2002 with 29% of these deaths occurring in African region. Early last year investigations revealed that over 200 people were killed by meningitis in Nigeria and Niger Republic in one week. There were outbreaks in 76 areas. There were 25,000 suspected cases and 1, 500 deaths in the first quarter of 2009 (Akingbade, 2010).

Most African cities today reveal waste-management problem such as heaps of uncontrolled garbage, roadsides littered with refuse; streams blocked with junk, disposal sites constituting a health hazard to residential areas, and inappropriately disposed toxic wastes. Across our country Nigeria, communities and rural areas have illegal dump sites. An estimated 48% of the waste generated in Nigerian urban centres is dumped on unauthorized locations, (National Bureau of Statistics, 2009).

Globally, efforts are being made to control greenhouse gas (GHG) emission from various sources; waste sector is one of them (Chalvatzaki and Lazaridis, 2010). Waste statistics are also lacking due to the low level coverage of waste collection. Yet, such infonnation is necessary for understanding the likely impact of the sector on emissions of greenhouses gases (USEPA 1998; ADB 1998; IPCC 2006).

For effective mitigation of Climate change/Global warming, all sources of GHGs are assessed and data obtained. When assessments are being carried out, it is GHGs from industries or vehicles that are the main targets assessed while other sources maybe ignored. However, dumpsites whether open or sanitary are known to generate GHGs though not as much as afore mentioned. Therefore, this study was carried out to generate data on $CO_2$ and $CH_4$ emissions from open, illegal dumpsites which will contribute to the generation of data and furthermore assist in the effective mitigation of GHGs and its effects and also provide information for advocacy and policies on waste management.

## 1.4. OBJECTIVES

### 1.4.1. Broad Objective

To assess the greenhouse gas emissions potential from selected illegal dumps in Ibadan south west Local Government Area of Oyo state.

### 1.4.2. Specific Objectives

The specific objectives of this research were to:

1. Document the environmental characteristics of each dumpsite.
2. Assess the concentration of greenhouse gas emissions (carbon dioxide & methane) from these illegal dumps using appropriate meters.
3. Characterize and quantify the solid wastes.
4. Determine the knowledge, attitude and practice of study participants located within selected illegal dumpsites on waste disposal and greenhouse gases.
5. Assess the health status of the illegal dump sites on study participants in the study area.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1. WASTE

Waste is generated from all activities of man and as man's activities increases and his environment gets more and more urbanised, the more waste that is generated. Man discards many things daily ranging from ordinary rubbish to old newspapers, packaging, cleaning materials and many different kinds of junk. There is no definitive list of what is and is not waste. Wastes however can be defined:

- According to the University of Minnesota (2009) waste is a material that is no longer needed, wanted or used. A waste is unusable or is intended to be discarded.
- Waste according to the Basel convention: Wastes are substances or objects which are disposed or are intended to be disposed or are required to be disposed of by the provisions of national laws.
- As any discarded, rejected, abandoned, unwanted or surplus matter, whether or not intended for sale or for recycling, reprocessing, recovery or purification by a separate operation from that which produced the matter (EPA, 1993)
- According to the United Nations Statistics Division (UNSD, 1997) wastes are materials that are not prime products (that is products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose.

### Types of wastes

Waste is a generalized word which can be divided into two major types. They include:

### 2.2.1. Hazardous Waste

According to the University of Minnesota and the Lone Star College (2009) Hazardous wastes is a waste or combination of wastes of a solid, liquid, contained gaseous or semisolid form which may cause, or pose a substantial present or potential danger to human health or the environment. It has certain hazard characteristics such as being radioactive, infectious, pathogenic, ignitable, toxic, corrosive, reactive, carcinogenic or mutagenic. Hazardous wastes are commonly handled by recycling, combustion, stabilization, chemical-physical-biological treatment, and land-filling.

Some special wastes are hazardous.

#### 2.2.1.1. Radioactive wastes

These are wastes that emit particles or electromagnetic radiation (e.g., alpha particles, beta particles, gamma rays, and x rays). Radioactive wastes can be high level, transuranic, or low level. High-level radioactive wastes are from spent or reprocessed nuclear reactor fuel. Transuranic wastes are from isotopes above uranium in the periodic table. They are generally low in radioactivity, but have long **half-lives**. Low-level wastes have little radioactivity and can often be handled with little or no shielding. Radiation can damage living cells and cause cancer. Although recycling and incineration may reduce waste amounts, the primary method for handling radioactive wastes is long-term storage (Everett, 2013).

#### 2.2.1.2. Medical wastes

These are wastes generated at hospitals, clinics and other medical facilities. They can either be infective, poisonous, and/or emit radiation. Though they may have hazardous characteristics, they are not regulated as hazardous wastes. Medical wastes are sterilized, disinfected, or incinerated, especially infectious wastes. They can also be disposed by recycling or landfilling (Everett, 2013).

### 2.2.2. Non-hazardous wastes

These are wastes or combination of wastes of a solid, liquid, contained gaseous or semisolid form that does not cause a hazard to the public or the environment (www.zerowasteamerica.com). Non-hazardous solid wastes cause issues such as littering and odours, leachate from the infiltration of water through the waste, and off-gases ensuing from biodegradation. Non-hazardous solid wastes are commonly handled by recycling, combustion, land-filling, and composting (Everett, 2013)

However, under these 2 major headings, wastes can be further sub-divided into solid, liquid or gaseous wastes.

### 2.2.2.1. Liquid wastes:

For a waste to be considered as non-liquid waste it has to have the following requirements: a solid content of at least 20% *and* liberate no free liquids when transported; *or* no free liquids when tested in accordance with the US EPA Paint Filter Liquids Test (Ministry for the Environment, 2004) and liberate no free liquids when transported.

Therefore, we can infer that liquid wastes will not have the above requirements. While according to the Encarta dictionary, liquid waste is any unwanted flowing substance that is fluid at room temperature or otherwise.

It must be transported in containers or through pipes. Examples include sewage, contaminated groundwater, and industrial liquid discharges. In some cases, direct discharge to the environment may be allowed. However, depending on the waste's characteristics, direct discharge may cause unacceptable environmental harm. Waste may contain pathogens and could be toxic. This could lead to disease or death. Liquid wastes are often handled at wastewater treatment plants, followed by discharge to the environment (Everett, 2013).

Sludges result from liquid waste treatment operations such as sedimentation tanks. They contain various ratios of liquid and solid material. Sludges are commonly handled with treatment, combustion, land-filling, and land application (Everett, 2013).

### 2.2.2.2. Gaseous wastes

Gaseous wastes are uncontained airborne emissions and effluents that may consist of particulate matter, dust, fumes, gas, mist, smoke, vapor, or any combination. They are primarily generated by combustion (e.g., internal combustion engines, incinerators, coal-fired electrical generating plants) and industrial processes. Depending on their characteristics, gaseous wastes can be odiferous or toxic. Some are implicated in global warming, ozone depletion, and smog. Gaseous wastes may be released to the atmosphere or captured/treated with pollution control equipment (Everett, 2013).

#### 2.2.2.3. Solid waste

The Environment Protection Agency, (1972) defined waste as a useless, unwanted and discarded material without sufficient liquid to be free flowing. According to Adediba, (1983), Solid waste is any solid material or substance that does not have any important value at the particular point in time to the user. Also, Savas, (1977) reported that waste consists of discarded solid materials resulting from domestic and community activities and from industrial, commercial and agricultural operations.

The United States Congress, in the 1976 Resource Conservation and Recovery Act defines solid waste as any garbage, refuse sludge from a waste treatment plant or air pollution control facility and other discarded materials including solid liquids, semi solid or contained gaseous materials resulting from industrial commercial mining and agricultural community activities. Examples include paper, wood, metals, glass, plastic, and contaminated soil.

### 2.2.3. Classification of Solid Wastes

Solid waste also has various classifications since there are various definitions.

Ngeh, 2008 classified waste into biodegradable and non-biodegradable wastes. Biodegradable wastes are substances that are readily decomposed either in the presence or absence of oxygen. E.g. vegetables, animal, plant or food remains. It can be changed back to the natural state by the action of bacteria and will therefore not damage the environment. While non-biodegradable wastes are substances that do not decompose. They retain their original form. E.g. metals, plastics, glass, nylon etc.

Adediba (1983), classified waste into combustible and non-combustible wastes. Combustible wastes are the substances that can be destroyed easily through burning, though this method may be harmful to the environment especially the air e.g. paper, dry plant and animal remains, nylons, plastics etc. While non-combustible wastes are substances are that are difficult to burn e.g. metals, glass.

While Hoornweg and Thomas, 1999 classified wastes based on their sources. They include:

- Residential – wastes obtained from homes, single or multiple dwellings. E.g. food wastes, paper, metals, wood, textiles, special wastes (such as consumer electronics, oil, tires) and household hazardous wastes.
- Institutional – wastes obtained from hospitals, prisons, schools etc. Examples include: paper, plastics, food wastes, metals, hazardous wastes.
- Industrial/Manufacturing – wastes obtained from industries such textile industry, chemical industry, construction industry, refineries. Examples include: housekeeping wastes, food wastes, construction and demolition materials, special wastes, packaging materials, scrap materials, wood, steel, concrete etc.
- Agricultural – wastes obtained from orchards, poultry farms, feedlots, vineyards, dairies etc. They include: animal wastes, plant wastes, hazardous wastes – pesticides, spoiled food wastes.
- Commercial – wastes obtained from hotels, restaurants, market places, office buildings, stores. Examples include: paper, food wastes, glass, plastics, wood, metals, special and hazardous wastes.
- Municipal – wastes obtained from street cleaning, landscaping, parks, beaches, other recreational centres, treatment plants. Examples are: sludge, street sweepings, general wastes from parks etc.

### 2.2.4. Municipal solid waste (MSW)

MSW is defined non-air and sewage emissions created within and disposed of by a municipality or government authorities, including household garbage, commercial refuse, construction and demolition debris, dead animals, and abandoned vehicles (Cointreau, 1982). The World Bank in 1994 defined municipal wastes as wastes generated by households and also wastes of similar character derived from shops, offices and other commercial units. The majority of substances composing municipal solid waste include paper, vegetable matter, plastics, metals, textiles, rubber, and glass (USEPA 2003).The proportion of different constituents of wastes varies from season to season and place to place, depending on the lifestyle, food habits, standards of living, the extent of industrial and commercial activities in the area and so on (Katju, 1994).

In Nigeria municipal waste density generally ranges from 280 – 370 kg/m3. Waste generation rate is 25 million tons annually and daily generation rate ranging from 0.44 kg/cap/day in rural areas to 0.66 kg/cap/d in in urban areas (Ogwueleka, 2009). Waste generation and composition is greatly influenced by population, income, economic growth, season, climate and social behaviour. In Nigeria waste stream generally consist of putrescible, plastics, paper, textile, metal, glass. In 2009, Ibadan had a population of 307,840 and the waste generation was 0.51kg/capita/day (Ogwueleka, 2009). Also, the mean generation rate per day obtained from a study done by the Sustainable Ibadan Project (SIP), Oyo State Ministry of Environment in association with United Nations Environment Programme (UNEP) are 0.52 kg/capita/day, 0.69 kg/capita/day, 0.45 kg/capita/day and 0.30 kg/capita/day in Ibadan southwest, Iyaganku GRA, Okefoko and NTC Joyce B respectively. In industrialized countries, however 0.7 kg to 1.8 kg/person/day generation rate is common. The more waste we generate, the more we have to dispose of.

### 2.1.3. Composition of Wastes

Solid waste is made up of various materials which may be dependent on the source. It can be seen that great majority of the total solid waste generated in Nigeria is organic. The high level of reuse of recyclable waste reflects the extent of poverty in the developing countries. In developing countries, waste stream is over 50% organic material (Hoornweg *et. al.*, 1999) (e.g. food wastes, animal and plant remain etc); those things that can decay easily. The remaining is made up of non-biodegradable wastes (e.g. metals, glass, rubber, etc).

## 2.3. Waste Management

Waste management includes all activities that seek to minimise the health, environmental and aesthetic impacts of solid wastes (Kantalgavi, 2012). Also, Business dictionary defined Waste management: that it encompasses management of all processes and resources for proper handling of waste materials, from maintenance of waste transport trucks and dumping facilities to compliance with health codes and environmental regulations.

According to Encarta, another name for management is treatment. Waste treatment techniques seek to transform the waste into a form that is more manageable, reduce the volume or reduce the toxicity of the waste thus making the waste easier to dispose of. Treatment methods are selected based on the composition, quantity, and form of the waste material (www.cyen.org).

### 2.3.1. Dumpsites

According to the American Heritage Science Dictionary (2009) a dumpsite is a disposal site where solid waste, such as paper, glass, and metal, is buried between layers of dirt and other materials in such a way as to reduce contamination of the surrounding land.

### 2.3.2. Illegal waste disposal

Illegal dumping is disposal of waste in an unpermitted area. It is also referred to as 'open dumping', 'fly dumping' or 'midnight dumping' because materials are often dumped in open areas, from vehicles along roadsides, and late at night (US EPA, 1998). Illegal garbage dumping can be defined as intentional and illegal abandonment of household or industrial material on public or private property (Brown *et al.*, 2002). Illegal dumping is the unlawful deposit of wastes larger than litter onto land (Department of Environment and Climate Change – DECC, 2009). It includes waste materials that have been dumped, tipped or otherwise deposited onto private or public land where no licence or approval exists to accept such waste. Illegal dumping varies from small bags of rubbish in an urban environment to larger scale dumping of waste materials in isolated areas, such as bush land. Illegal dumping is a nuisance because of the physical dangers, aesthetic distaste, and costs associated with it. Illegal dumpsites could also be dumpsites that are improperly sited or unplanned dump sites which are open and mostly uncared for.

Improperly sited open dumps deface several cities, thereby endangering public health by encouraging the spread of odours and diseases, uncontrolled recycling of contaminated goods, and pollution of water sources (Adegoke 1989, Singh, 1998).

The waste generated in a community is the reflection of the way of life, wealth and culture of the people (UNCHS, 1989). A community's waste disposal perceptions study was carried out by International Union for Conservation of Nature (IUCN) in Abbottabad showed that there was no difference in behaviour between poor and non-poor households in the method of disposal. The only difference was that the poor households tend to dispose their wastes closer to their places of residence. Solid waste is mainly disposed of on controlled landfills, open dumps, and water bodies. Uncontrolled burning of dumps as well as burning of refuse from homes such as secret documents, rags, and tires is common.

### 2.3.3. Solid Wastes Management Processes

According to Rousta, 2008 the processes of waste management include:

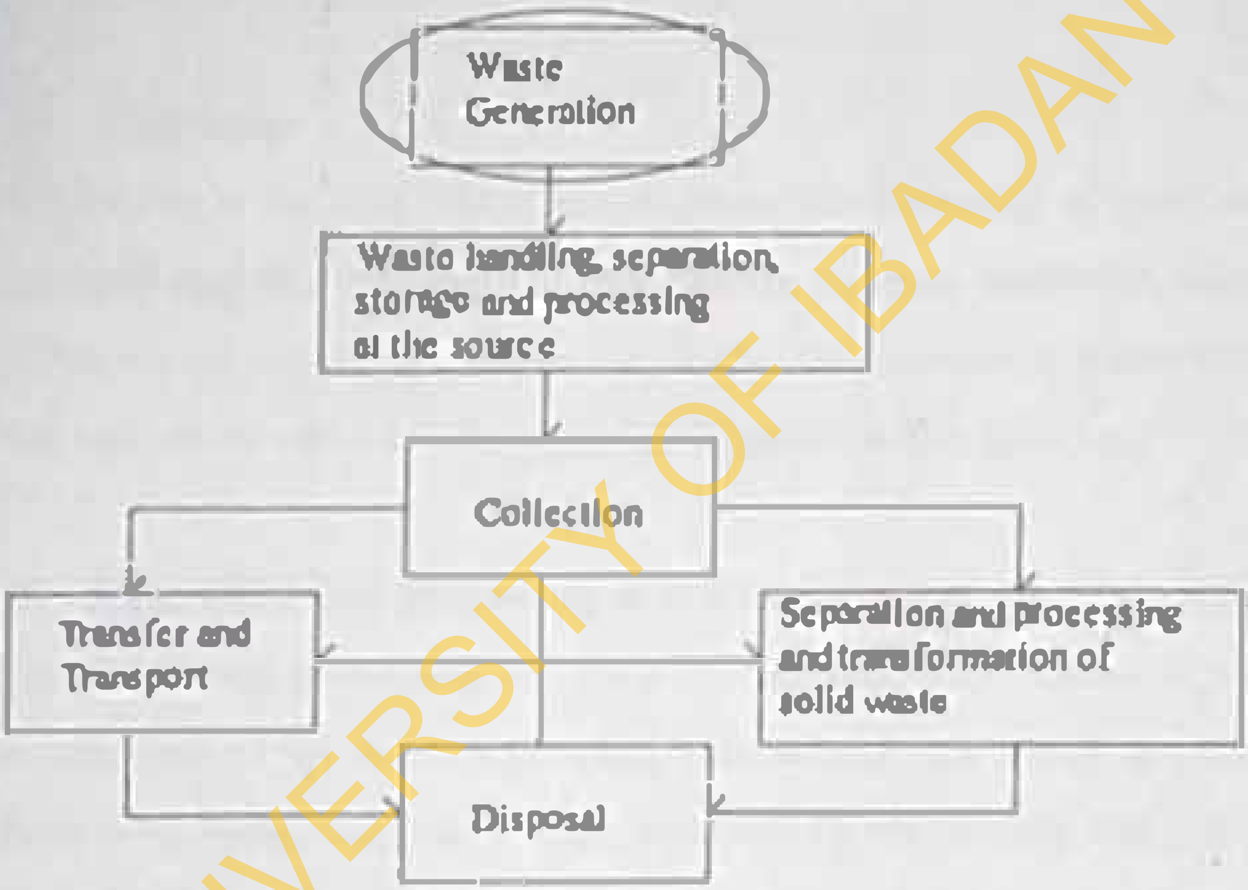


**Figure 2.1: Solid waste management functions and the interrelations between them**

Fig. 2-1 is demonstrated the simplified of the function of solid waste management. The functions of solid waste management encompass (1) waste generation, (2) waste handling and separation, storage and processing at the source (3) collection, (4) separation and processing and transformation of solid waste, (5) transfer and transport, (6) disposal.

a) **Waste generation**

All the activities which cause to throw away the useless and unwanted material during the process, manufacturing, distribution and consumption are defined as waste generation.

b) **Waste handling and separation, storage and processing at the source**

This second function itself is included handling and separation which are the activities involve to store the waste in the containers. Handling means the movement of loaded containers to the point of collection. The important function which can be traced is separation at source. It can not only prepare the material in the waste for recovery and recycling but also it can decrease the hazards of waste. Many developed cities start their MSWM from this point.

c) **Collection**

Collection is the task which encompasses the gathering of solid waste and separated the material and also transport of them to the location where the vehicles must be emptied. Always cost of this function is very high. The distance to waste transfer station as well as the amount of waste are the significant factors in this function.

d) **Separation and processing and transformation of solid waste**

Separation and processing are the activities which are related to recovery, recycling, and combustion of the waste separation manually or machinery shredding, and separation of ferrous by using magnets, volume reduction by compacting and combustion.

Transformation means to reduce the volume and the weight of waste before disposal by transforming them to the usable source by chemical or biological treatment. Producing biogas during anaerobic digestion is a clear example of this function.

e) **Transfer and transport**

Transfer of waste from the smaller trucks to the big one as well as transport the waste from the collection stations to the process station or disposal one is a description of this function.

f) **Disposal**

This is the final step in MSWM. Some materials transferred directly to the landfills but there are other wastes which are generated during other activities in waste management that also must be transferred to the landfills too. The important factors of landfilling are considering its environmental impacts and health-problems. However landfilling is a task which should be responsible for the public health and the need of the future generation on the land.

## 2.4. Waste Disposal Options

Waste disposal is the throwing away or dumping of unwanted material through land filling on dumpsites, incineration, and composting, among other methods (Miller, 1996; Michaels, 2002). The four most common methods of municipal solid waste treatment/management are land-filling, incineration, composting and anaerobic digestion. Incineration, composting and anaerobic digestion are volume reducing technologies; ultimately, residues from these methods must be land-filled (Seo et al 2004). In Nigeria, the major means of waste disposal are landfilling, composting and incineration. Landfilling is the major method of waste disposal used in Lagos and Ibadan but most are not sanitized and as such release harmful emissions into the environment which among these are greenhouse gases e.g. methane and nitrous oxide.

Before any of these methods maybe used there are other means of preventing wastes. They include:

### 2.4.1. Waste Segregation

It refers to a solid waste management practice of separating different materials found in solid waste in order to promote recycling and re-use of resources and to reduce the volume of waste for collection and disposal (www.skoola.com)

### 2.4.2. Waste reduction and reuse

It eliminates the production of waste at the source of usual generation and reduces the demands for large scale treatment and disposal facilities. Methods of waste reduction include manufacturing products with less packaging, encouraging customers to bring their own reusable bags for packaging, encouraging the public to choose reusable products such as cloth napkins and reusable plastic and glass containers, backyard composting and sharing and donating any unwanted items rather than discarding them (www.cyen.org)

### 2.4.3. Recovery

It involves the extraction of a substance or energy from a source of waste.

### 2.4.4. Recycling

The term of recycling in the solid waste management concerns the activities which involve the separation and collection of the recyclable materials for reusing, remanufacturing and recycling of new products (Rousta, 2008).

## 2.5. Conventional Waste Management Methods

### 2.5.1. Anaerobic Digestion

It is defined as the breaking down the organic waste by bacteria in an oxygen-free environment (Rousta, 2008). The by-products in this process are:

(1) Biogas, which is made up about 60% methane ($CH_4$) and 40% carbon dioxide ($CO_2$). This can be burnt to generate heat and/or electricity,

(2) Bio liquid or liquor digestate, which can be used, if of suitable quality, to improve soils as a conditioner or fertiliser

(3) Fibre digestate, which can also be used, if of suitable quality, as a compost to apply to soil.

Anaerobic decomposition occurs naturally in swamps, water-logged soils and rice fields, deep bodies of water, and in the digestive systems of termites and large animals. Anaerobic processes can be managed in a "digester" (an airtight tank) or a covered lagoon (a pond used to store manure) for waste treatment. The primary benefits of anaerobic digestion are nutrient recycling, waste treatment, and odour control. Anaerobic digestion has been used extensively to stabilize sewage sludge, and has been adapted more recently to process the organic fraction of MSW.

Biogas is scrubbed so it is fit to be used in the generation of electricity or as a fuel. The methane gas that is produced can be used to generate electricity. Anaerobic sewage plants produce significant quantities of methane, which can be used to generate electricity. Liquid and solid organic fertilisers are also formed, and can be sold to cover operating costs. Denmark for example, treats 1.1 million tonnes of waste by anaerobic digestion every year (Twigg *et al.*, 2002).

Waste management using anaerobic digestion has started in Nigeria though still at small scales. The United Nations Development Programme (UNDP) funded a project in which methane gas was generated from animal wastes in Moniya, Ibadan. The gas generated was then used as cooking gas.

### 2.5.2. Incineration

This is the combustion of waste in the presence of oxygen. After incineration, the wastes are converted to carbon dioxide, water vapour and ash (www.eyen.org). Incineration is carried out both on a small scale by individuals and on a large scale by industry. It is used to dispose of solid, liquid and semi-liquid waste. It is recognized as a practical method of disposing of certain hazardous waste materials (such as biological medical waste).

Combustion in an incinerator is not always perfect and there have been concerns about micro-pollutants in gaseous emissions from incinerator stacks In the UK, in the 1990s, many hospitals had clinical waste incinerators. However, emissions from the burning of hazardous hospital waste were said to be too high under the Environmental Protection Act of 1990. Many hospitals could not meet the new regulations and were forced to shut the incinerators down. Today, hospitals tend to share one large incinerator to dispose of the wastes for a number of hospitals ((Twigg *et al.*, 2002). For example, the University College Hospital has an incinerator in which medical wastes are disposed by burning. Also, particular concern has focused on some very persistent organics such as dioxins which may be created within the incinerator and which may have serious environmental and health consequences in the area immediately around the incinerator. This is so because dioxins are a group of dangerous chemicals known as persistent organic pollutants. Dioxins are of concern because of their highly toxic potential (WHO, 2010).

Incineration is common in countries such as Japan where land is scarcer, as these facilities generally do not require as much area as landfills. Waste-to-energy (WtE) or energy-from-waste (EfW) is a broad term for facilities that burn waste in a furnace or boiler to generate heat, steam and/or electricity (en.wikipedia.org).

Incineration can lead to the following ecological impacts:

- Atmospheric pollution and the incombustible solid waste which requires further disposal.
- Leads to global warming (methane – greenhouse gas).
- Release of toxins e.g. Dioxins and furans from burning plastics. Short-term exposure of humans to high levels of dioxins may result in skin lesions, such as chloracne and patchy darkening of the skin, and altered liver function. Long-term exposure is linked to impairment of the immune system, the developing nervous system, the endocrine system and reproductive functions (WHO, 2010).
- Chronic health effects such as increased rates of bronchitis and reduced lung function (WHO, 2000), shortened life span, and elevated rates of respiratory symptoms and lung cancer (EPAQPS, 2001).
- Reduces visibility due to smog being formed. This could lead to road accidents.

### 2.5.3. Land filling

It is a disposal site for nonhazardous solid wastes or in some cases hazardous wastes. The waste is spread into layers, compacted to reduce its volume, and covered by material such as clay or soil, which is applied at the end of each operating day (USEPA, 2002A). Landfill is the most common means of waste management even though landfills have been proven to contaminate drinking water in certain areas. It is the most cost effective method of disposal (Sandhu, 2010). Presently, in Nigeria, landfilling is a major form of waste disposal. In Ibadan, there are landfills at Aba-Eku also known as Afofunra on Akanra Road, Lapite on Oyo Road, Awotan also known as Apete on Akufo-Ibadan Polytechnic Road and Ajakanga on Challenge Road (CPE, 2010).

Some wastes from sewage sludge, mining and quarrying are also placed in landfill sites. Gases are produced in landfills due to the anaerobic digestion by microbes on any organic matter. This gas can be collected and flared off or used to generate electricity in a gas fired power plant (Twigg, Cresswell & Buchdahl, 2002). Landfill gas monitoring can be carried out to assess the presence of a build-up of gases to a harmful level.

According to Kampo-uno.com, 2013 poorly maintained landfills can cause the following ecological impacts:

- landfills can cause impacts such as wind-blown litter, attraction of vermin, spread of diseases
- Generation of leachate which can pollute groundwater and surface water.
- Emission of landfill gas (mostly composed of methane and carbon dioxide), which is produced as organic waste breaks down anaerobically. This gas can create odor problems, kill surface vegetation, and is a greenhouse gas.
- Where landfill sites are unlined or unconfined, leachate fluids formed from decomposing waste can permeate through the underlying and surrounding geological strata, polluting groundwater which may be used for drinking water supplies. The leachate may contain a range of chemical contaminants, including high levels of phenols (which can give rise to significant taste and odour problems in drinking-water following chlorination), ammonia, nitrate and heavy metals.
- Fatal accidents (e.g., scavengers buried under waste piles); infrastructure damage (e.g., damage to access roads by heavy vehicles).

These impacts are best to intercept at the planning stage where access routes and landfill geometrics can be used to mitigate such issues. Vector control is also important, but can be managed reasonably well with the daily cover protocols.

### 2.5.4. Composting

Composting is the controlled aerobic decomposition of organic matter by the action of microorganisms and small invertebrates (www.cyen.org). These materials are put through a composting and/or digestion system to control the biological process to decompose the organic matter and kill pathogens. The resulting stabilized organic material is then recycled as mulch or compost for agricultural or landscaping purposes (Kampo-uno.com 2013). This method of waste disposal can be found at the Waste Treatment Plant in Alesinloye, Ibadan.

2.6.1. Based on a visit to the waste treatment plant, Alesinloye, the composting process involves: Wastes Collection - organic wastes are collected using yellow carts while blue carts are used for collecting inorganic wastes. The organic wastes are then taken for composting.

Composting occurs at the wind roll system. During composting organic waste are placed in pits and cow dung is added to these waste to maintain the Carbon-Nitrogen ratio of 30:1; and the necessary conditions such as temperature, pressure, pH, air and water. Turning provides air while wetting is done to provide water and leaching. These conditions are provided for 30 days and the end product is subjected to Curing in order to remove odour associated with composting. Also, conditions that promote microbial growth are altered / stopped. At this point the temperature is below 30°C.

The compost product is placed in a Rotatary drier where hot air is blowing into it. Dried compost products are transported via an elevator into a mechanical sorter in order to separate compost materials from those that have not undergone complete decay (rejects). The rejects are taken back to the pits where they undergo another composting process until they are completely decomposed. The sorted compost product is conveyed via a conveyor to the pulverizer where it is cut into bits. At this stage, the product is passed to another conveyor where you can fortify it (if required) with nitrogen and phosphorus which could be got from urea and single super-phosphate and then it is moved to the pelletizing machine where it cut into pellets and it is then bagged at the bagging unit. They bagged as Grade A or Grade B fertilizer in bags that indicates the proportion of nutrients present. Nitrogen, Phosphorus and Potassium are normally present in the ratio of 3%: 25%:1.5%.

**N.B.** pellets are used depending on the farm type. If the farm is porous, it is good for it, if not pelletizing is not necessary.

### 2.5.5. Bioremediation

The use of biological methods to restore contaminated lands, especially the addition of bacteria and other organisms that consume or neutralize contaminants in the soil

### 2.5.5. Deep well Injection

This involves the pumping of hazardous wastes into deep wells (Kampo-uno.com, 2013). However, despite the various means of waste disposal available people tend to dispose their wastes carelessly by dumping the wastes illegally on open surfaces, water bodies, uncompleted buildings etc or burn them close homes creating uncountable and unsightly dumpsites and causing nuisances to the environment and human beings.

## 2.6. Factors That Influence Solid Waste Disposal

US EPA (1998), reported that the factors affecting the disposal of solid waste includes:

### 2.6.1. Urbanization/Globalization

Globalization has raised some troubling concerns for the developing world, including Africa. For Africa this has meant fueling the already unprecedented urban growth phenomenon and increasing the challenges that go with it. One key challenge is the management of municipal solid waste. With larger population come the greater production of waste and the problem of disposal. Urbanization also contributes to a change in consumption type and volume which affects the volume and type of waste that will be generated and disposed. A rapidly growing urban area without a proper master plan may present a problem of waste disposal as dump sites may not be planned and designated due to the improper or no planning of the area. Though globalization is seen as an economic transformation, it has raised some troubling concerns for the developing world, including Africa. Globalization has been identified as playing a negative role in solid waste management in African cities (Achankeng, 2003).

### 2.6.2. Demographics

The characters of a people also affect their method or choice of disposal of their solid waste. Communities subject to illegal dumping are typically areas with limited access to convenient, affordable waste disposal facilities or services and recycling programs. The problem tends to be worse in areas with a high population of renters who have fewer stakes in the community or absentee property owners who do not respond to problems

### 2.6.3. Income level

In Asia, about 90% of solid waste is collected in high income countries, versus 50-80% in middle income and 30-60% in low income countries (Cointreau 2006). In lower-income areas, residents may have difficulty affording trash pickup and disposal fees and this would contribute greatly to having illegal and open surface dump sites in such areas. Collins *et al.*, (1977) established that the higher income households generate a greater quantity of solid waste than their low-income counterparts. Supporting this assertion were the findings of Cointreau (1982) on the lower-, middle- and higher-income countries. She established that the daily per capita waste generation in the lower-income countries ranged between 0.4 and 0.6 kg, the middle-income countries generated between 0.5 and 0.9 kg per day and the values for higher-income countries ranged from 0.7 to 1.8 kg. However, per capita waste generation varies between 2.75 and 4.0 kg per day in high income countries but it is as low as 0.5kg per day in countries with lowest incomes (World Bank report, 1994). It was also found that the proportion of organic waste declined with increase in income.

### 2.6.4. Education

Ignorance of the impacts of illegal waste disposal in our community has led to many illegal dumpsites being created. Sometimes, residents in rural areas where illegal dumping is common may not be aware of applicable laws. In 2009 a study carried out in Ijebu Ode showed that a higher percentage of those with relatively higher education (SSCE and/or tertiary education) thought it was appropriate for individual to properly dispose their waste (Banjo *et al.*, 2009). While in a study carried out in secondary schools in Ogun state showed that there was a significant difference between students within ages 10 – 15years and students within ages 16 – 20 years in the their knowledge and practice of waste management. The latter age group had a higher percentage in the practice of waste management. (Ifegbesan, 2010).

### 2.6.5. Industrial development / stage of development

The more developed/advanced a country, the higher the level of technology and vice versa. Therefore a developed country will know how to produce biodegradable products and also have technologies for reducing wastes. You will find more of recyclables than organic wastes in such (developed) places more than undeveloped places. This would affect method of waste disposal and their volume of waste too.

### 2.6.6. Physical characteristics

Unsecured properties, including undeveloped lots, abandoned structures, unused industrial facilities, and remote spaces; others places such as poorly lit access roads, property along railways, highways and alleys, charity drop box locations, and construction sites or public areas with waste containers are inviting and are prime targets for illegal dumping because of the reduced potential of being sighted or the lack of police presence.

### 2.6.7. Lack of solid waste codes and ordinances

Illegal dumping is a problem in many areas because of a lack of effective legal codes or ordinances prohibiting open dumping or burning of wastes. Both activities are prohibited by federal and most state laws, but enforcement by local authorities is typically done under local codes, which may be less stringent or not carried out at all.

### 2.6.8. Poor maintenance of waste facilities, equipment and staff

Poorly maintained waste facilities would discourage people from making use of such facilities and so encourage dumping of refuse in other site which may be unapproved while a well maintained waste facility with adequate equipment and staff would encourage use of such facility and thus reduce illegal dumping.

## 2.7. Risks of Illegal Waste Disposal

Waste pollution is considered a serious threat by many and can broadly be defined as any pollution associated with waste and waste management practices. Typical materials that are found in household waste, and which have specific environmental impacts, include biodegradable wastes, batteries, aerosols, oils, acids and fluorescent tubes.

Areas used for illegal dumping may be easily accessible to people, especially children, who are vulnerable to the physical (protruding nails, sharp edges) and chemical (harmful fluids or dust) hazards posed by wastes. Rodents, insects and other vermin attracted to dumpsites may also pose health risks. In addition, countless neighbourhoods have been evacuated and property damage been significant because of fires at the sites by spontaneous combustion or by arson. Also, runoff from dump sites containing chemicals may contaminate wells and surface water used as sources of drinking water (US EPA, 1998).

Dumpsites pose health problems because of their attraction of mosquitoes, rats, cockroaches, and flies leading to malaria and cholera outbreaks (Masundire and Sanyanga, 1999). Severe illnesses, including encephalitis and dengue fever, have been attributed to disease-carrying mosquitoes originating from scrap tire piles (US EPA, 1998). Most dumpsites are poorly located beside streams or estuaries with little or no attempt to stop wastes discharging into water.

Dumping activities in such areas can also have a negative impact on plants and wildlife. Illegal dumping can impact proper drainage of runoff, making areas more susceptible to flooding when wastes block ravines, creeks, culverts, and drainage basins. They also alter the edaphic and aquatic environments whose geographical extent is difficult to determine (Masocha and Tevera, 2003). Also, improper disposal of waste prevents resources from being reused. This is particularly true of plastics, metals and paper. This loss of resources means a heavier reliance on virgin materials, which often require more energy to make new products than required by reusing existing resources.

The UN body carried out a study on the implications of uncontrolled dumping around Nairobi where wastes from hospitals and industries are dumped near a residential estate in Nairobi's Dandora estate, Nairobi, Kenya - The UN Environment Programme (UNEP) warned that poor waste dumping within African cities constitutes such public health risks as increasing incidences of blood-borne diseases such as hepatitis and HIV/AIDS. Poorly managed dumpsites in Africa is leading to high lead and other heavy-metal pollutants which affect millions of people living near dumpsites who are affected by these substances during the destruction of these metals through smoke. Blood and urine samples were analysed for the same pollutants and for signs of diseases associated with them. "The results show dangerously high levels of heavy metals, especially lead, mercury and cadmium, at the dumpsite, in the surrounding environment and in local residents," Steiner, UNEP Executive Director said the Dandora dumpsite is also a mirror to the condition of rubbish sites across many parts of Africa and other urban centres of the developing world. (The African Perspective, 2008).

Some effects of landfills and dumpsites are not easily seen but may include contamination of ground and surface water and the release of greenhouse gases. Poorly managed dump sites often smell bad and as the organic matter in waste dumpsites rots, it gives off gases, mainly methane and carbon dioxide (Miller, 1996). Rising levels of greenhouse gases in the Earth's atmosphere are gradually changing our climate. Some of these emission increases can be traced directly to our solid waste. Solid waste contributes directly to greenhouse gas emissions through:

- Release of carbon dioxide by burning of wastes
- The generation of methane from the anaerobic decay of waste in landfills, and
- The emission of nitrous oxide from our solid waste combustion facilities.

The latter of these greenhouse gases (methane and nitrous oxide) have high global warming potential: methane has 21 times the warming potential of carbon dioxide and nitrous oxide has 310 times the warming potential.

## 2.8. Waste Disposal in Nigeria

Open dumping of solid waste is a common practice in Nigeria. While some employ the service of streams to transport their solid wastes out of their sight, some directly dump their solid wastes by the road sides. In some parts of Nigeria, refuse is generally buried, though some heedless burning is sometimes observed (Igoni, et al., 2007). Several Nigerians have considered it a cheap way of disposing off their solid wastes by setting the mixed wastes on fire in a little corner in their backyard or in a very open place. Sometimes in order to reduce the volume of waste and conserve space, these waste or refuse in open dumps, even, mountains of mixed solid wastes in so-called designated places are set on fire, causing serious and dangerous environmental pollution. Some thick and dark smokes from burning of plastic components of electronics have been seen spiralling up the sky in computer villages. Saw millers set the mountain of wood wastes on fire, while awaiting heavy rains to transport the ashes away

In most urban centres in Nigeria, where these wastes are disposed of by dumping in open areas, health and pollution problems produced encourage the growth of organisms that can transmit diseases to people living around that vicinity. As countries become richer and more urbanized their waste composition changes (Freeman, 1979 and Lictman, 1995). Unarguably, one of the main problems facing Ibadan City and which has become an intractable nuisance is open and indiscriminate dumping of refuse, human and animal faeces. Piles of decaying garbage which are substantially domestic in nature dominate strategic locations in the heart of the city including the Ibadan- Lagos express way. Wastes in such dump sites obviously are sources of air and water pollution, land contamination, health hazards and environmental degradation. The risks that may be anticipated include bad odour, aesthetic nuisance, fire outbreak, water pollution, proliferation of insects such as flies, cockroaches, rats and other small and dangerous insects which can endanger public health through breeding of ailments such as dysentery, cholera, diarrhoea, yellow fever, plague and filariasis. Furthermore, the fumes, including carbon monoxide from atmospheric pollution may cause and also aggravate bronchial and asthmatic disorder. Regrettably, this condition characterises environmental culture in Ibadan. It is important to note that endangered public health situation can exert excessive pressure on the health budget, curtails productivity and worsens urban condition of health.

This ugly situation persisted for the past decades (since independence) and will continue to be so in Ibadan because of the following factors:

(1) High rate of illiteracy,
(2) Ignorance,
(3) Uncivil culture of indiscriminate waste littering (i.e. throwing of wastes on bare ground)
(4) People's inability to maintain a sanitarily clean environment and
(5) Reluctance of people to cooperate with the authority by disposing solid waste in illegal dumps, rather than using the means provided by the Government. (Omoleke, 2004).

Other factors that militate against decent environment in Ibadan include

i. Uncontrolled population creating slum condition;

ii. Poor planning; and

iii. Violation of town planning regulations.

Most houses in the core of the city have no toilet facilities hence human faeces and other wastes are dumped inside streams. This assertion lends credence to Adesiyan (2000) when he noted that: Clustered configuration inhibits mechanized refuse collection: As a result, high proportion of solid waste is dumped into drain and stream channels which often results in dogging and flooding. The solid-waste composition in Ibadan comprises leaves, paper, food waste, tins, glass, and rags (Maclaren International Ltd., 1970) This is because Ibadan is located in the heart of a rich agricultural land and has a large old and unplanned section. Table 2.1 below shows an estimation of solid waste generated per year alongside its population from 1992 – 2000.

**Table 2.1.** Population and solid-waste generation estimates for Ibadan, 1992–2000.

| Year | Population ($\times 10^3$) | Waste generation per year ($t \times 10^4$) |
|---|---|---|
| 1992 | 8 480 | 781 |
| 1994 | 8 620 | 764 |
| 1996 | 8 633 | 797 |
| 1999 | 9 749 | 921 |
| 2000 | 8 880 | 845 |

**Source:** Haskoning and Konsadem Associates (1994)

### 2.8.1. Management and Operation of Wastes in Ibadan

Three governmental agencies are charged with the responsibilities of managing environment in Ibadan. They are:

(i) The Local Government Councils

(ii) The Ibadan Solid Wastes Management Authority; and

(iii)The newly established Ministry of Environment and Water Resources.

There are five Local Government Councils in Ibadan metropolitan City– They are:

(i) Ibadan South West Local Government Council;

(ii) Ibadan North Local Government Council.

(iii)Ibadan South East Local Government Council;

(iv)Ibadan North West Local Government Council, and

(v) Ibadan North East Local Government Council.

### 2.8.2. Current Waste Collection and Disposal Methods at Ibadan Urban Sanitation Committee (IUSC)

Solid waste is collected by skip eaters from the available 50 skips located at major roads and markets in different parts of the city and transported to the ring-road disposal site. The locations of the skips have a few flaws.

- They are too few and inadequately scattered. Too few skips are allotted per depot, and when these are full, people dump refuse in the surrounding areas.
- Many of the dumps are located far from the intended users. One consequence is that residents resort to dumping their refuse everywhere, such as on vacant lands.
- The skips located beside the major roads are aesthetically offensive.

The private waste collectors in Ibadan are all members of the Association of Environmental Contractors. In 1994, they served an estimated 10 000 households in the Ibadan urban area. At present, 28 private firms are registered with IUSC, but only 10 of these are functioning. Many companies and institutions in the city make use of these private collectors.

Some small-scale operators use wheel barrows to collect wastes over short distances. They operate in the Sabo area and in some markets and motor parks and charge their clients agreed sums of money. However, they dispose of the refuse they collect in refuse depots within the neighbourhood. These are often not cleared regularly and therefore constitute both an environmental hazard and an impediment to traffic (Onibukun and Kumuyi, 1999).

In Nigeria, municipal solid wastes are collected from various sources and transported by collection vehicles directly to the dump sites. The local agencies do not have adequate capacity and resources to handle the amount of waste being generated.
According to the Centre for People and Environment (CPE, 2010), the problems with solid waste management in Nigeria can be summarized as follows:

- Policy : Government policy on solid waste management in Nigeria is not comprehensive
- Recycling: There are no significant recycling programs. The limited recycling programs are where scavengers look for recyclables items such as cans, plastics, bottles, and papers for resale or reuse.
- Disposal: There are no sanitary landfills in Nigeria.
- Funding: There are limited or no funding for solid waste management in Nigeria.

In Nigeria, municipal solid waste is collected and taken by collection vehicles directly to the disposal site. The waste accumulates in open dumps at roadsides. The open dumps provide harbourage for diseases causing organisms, bacteria, insects, and rodents (Ogwueleka, 2009).

Open dumping, land filling, incineration, recycling and composting are the various methods of wastes disposal in Nigeria. However, in Nigeria like most developing countries, wastes are commonly dumped in open dumps, uncontrolled landfills where a waste collection service is organised. Incineration is the high temperature combustion of wastes. Incineration and waste to energy (WTE) is not practiced in Nigeria except in the hospitals where medical wastes are incinerated at a small scale. There are no formal recycling or resource recovery programmes in Nigeria (Ogwueleka, 2003) and no policy on composting. Currently, recovery/recycling operations are carried out mostly by the informal sector.

Different types of vehicles are used for solid waste collection in Nigeria. The compactor trucks, side loaders, rear loaders, mini trucks, tippers, skip trucks and open back trucks are the commonly used collection trucks. It was observed that 60% of trucks available are always out of service at any one time. In Onitsha, the few available trucks breakdown frequently due to overuse (Agunwamba *et al*, 2003). The collection vehicles are in a state of disrepair in most cities of Nigeria. There is inadequate service coverage in most urban areas and in rural areas there is no collection. Rural dwellers have no access to waste collection service. They dump waste at any vacant plot, public space, and river or burn it in their backyard, thereby polluting the air. Less than 60% of MSW generated is collected in developing countries (Ogwueleka, 2003). Solid waste generation exceeds collection capacity.

## 2.9. Greenhouse Gases

Greenhouse gases are gases in the atmosphere that absorb and emit radiation within the thermal infrared range. They prevent heat from escaping from the atmosphere. This makes the earth warmer causing an effect known as greenhouse effect. The gases include: water vapour, methane, carbon dioxide, nitrous oxide, ozone, per fluorocarbons (PFCs), hydro fluorocarbons (HFCs) and sulphur hexafluoride ($SF_6$). Without these gases the earth's climate would be 33°Celsius (59°F) cooler – too cold for most living organisms to survive. Greenhouse gases cause "greenhouse effect" which is the heating of the Earth. It is named this way because of a similar effect produced by the glass panes of a greenhouse. These greenhouse gases prevent the escape of infrared waves by absorbing them and reemit the waves downward, causing the lower atmosphere to warm.

The contribution to the greenhouse effect by a gas is affected by both the characteristics of the gas and its abundance. For example, on a molecule-for-molecule basis methane is about eighty times stronger greenhouse gas than carbon dioxide (Houghton, 2005), but it is present in much smaller concentrations so that its total contribution is smaller. When these gases are ranked by their contribution to the greenhouse effect, the most important are:

- water vapour, which contributes 36–72%
- carbon dioxide, which contributes 9–26%
- methane, which contributes 4–9%
- ozone, which contributes 3–7%

It is not possible to state that a certain gas causes an exact percentage of the greenhouse effect. This is because some of the gases absorb and emit radiation at the same frequencies as others, so that the total greenhouse effect is not simply the sum of the influence of each gas. The higher ends of the ranges quoted are for each gas alone; the lower ends account for overlaps with the other gases (Kiehl & Trenberth, 1997).

Since the advent of the Industrial Revolution in the 1700s, humans have devised many inventions that burn fossil fuels such as coal, oil, and natural gas. Burning these fossil fuels, as well as other activities such as clearing land for agriculture or urban settlements, releases some of the same gases that trap heat in the atmosphere, including carbon dioxide, methane, and nitrous oxide. These atmospheric gases have risen to levels higher than at any time in at least the last 650,000 years. The National Oceanic and Atmospheric Administration (NOAA, 2008) reported that carbon dioxide and methane increased by 0.6% and 0.5% respectively in 2007 while a total of 27% and 145% respectively since the pre-industrial times. As these gases build up in the atmosphere, they trap more heat near Earth's surface, causing Earth's climate to become warmer than it would naturally. This is a phenomenon known as Global warming or Climate change.

**Climate change** refers to any significant changes in climate (such as temperature, precipitation, or wind) lasting for an extended period of time - decades or longer (*Yeseul et al.* 2010). Climate change may result from:

. Natural causes (changes in the sun's intensity, changes in ocean circulation, etc.)

. Human activities (burning fossil fuels, deforestation, urbanization, etc.)

Global warming refers to climate change that causes an increase in the average temperature of the lower atmosphere (*YeSeul et al*, 2010). Global warming can occur from a variety of causes, both natural and human. Today, "global warming" commonly refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities (Department of Natural Resources, 2006).

A French mathematician and physicist, Jean Baptiste Joseph Fourier was the first person to investigate the greenhouse effect. He compared the atmosphere to a glass vessel in 1827 and recognized that the air around the planet lets sunlight, much like a glass roof. Svante August Arrhenius, a Swedish chemist predicted that when earth's temperature warms, water vapour in the atmosphere would then contribute to the greenhouse effect and global warming (Cowie, 2007).



## 2.10. Sources of Greenhouse Gases

Greenhouse gases are obtained from both natural and anthropogenic sources, though anthropogenic sources provide most of today's greenhouse gases. Below is a diagram showing the various sources of greenhouse gases and their respective contributions into the environment. It can be seen below that power stations and industrial processes are among the largest generators.

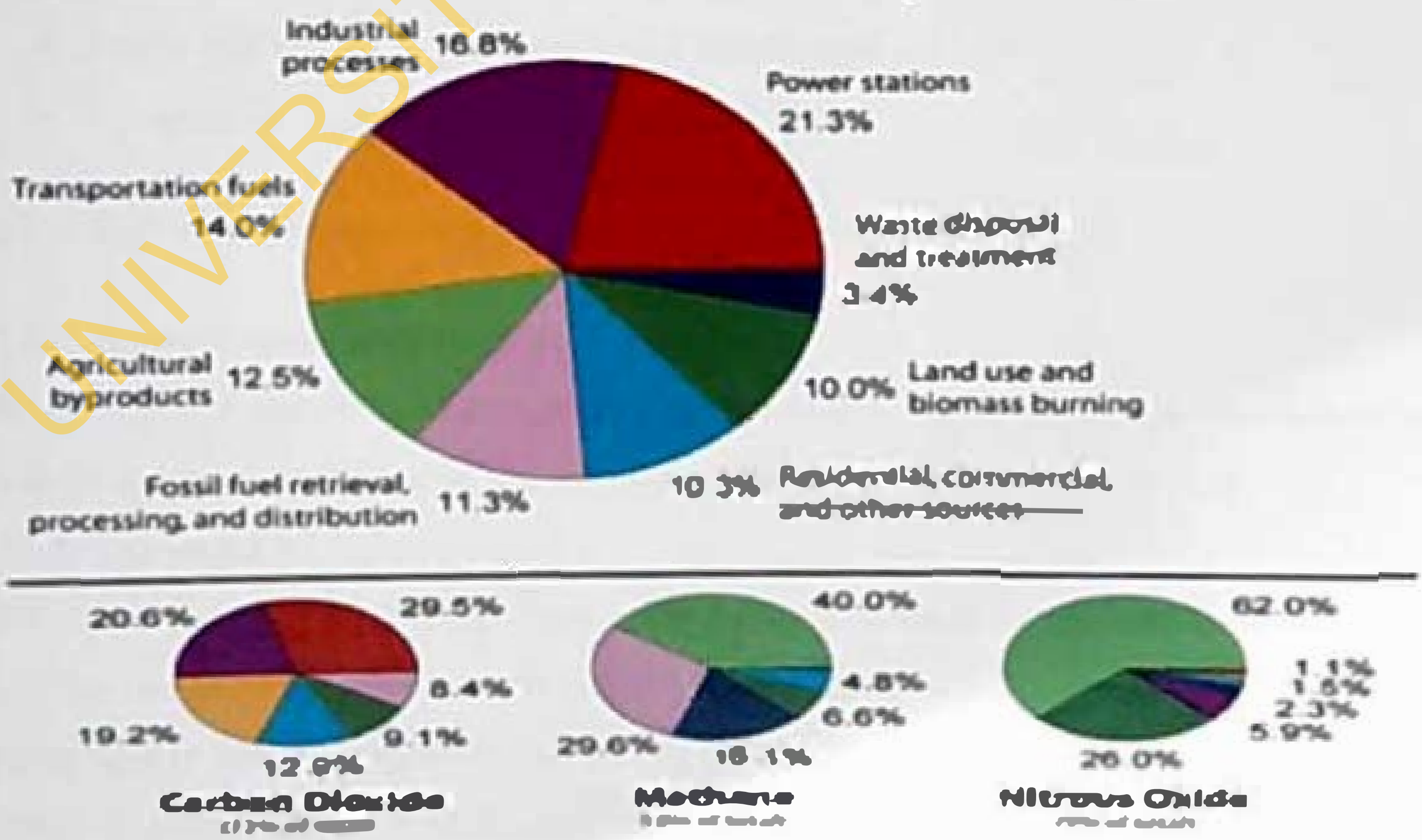


Fig.2.2: Annual Greenhouse Gas Emissions by Sector

*The lower part of the picture shows the sources for carbon dioxide, methane and nitrous oxide.

Source: http://en.wikipedia.org/wiki/Image:Greenhouse_Gas_by_Sector.png)

The natural sources according to Betsy Young (2009) include:

- Carbon dioxide comes naturally from plant respiration, fermentation and the decay of organic matter, active volcanoes, oceans and fire.
- Methane resides in frozen slush in the northern artic permafrost regions and in the depths of the ocean.

- Nitrous Oxide results from the denitrification of soil and water brought on by certain anaerobic conditions particularly in wet tropical regions.

From the above diagram, the anthropogenic sources of greenhouse are obtained from various sectors in the society (Lerner and Wilmoth, 2006). They include:

- Agricultural by-products – 12.5%
- Waste disposal and treatment – 3.4%
- Transportation – 14.0%
- Industrial processes – 16.8%
- Power stations – 21.3%
- Land use and biomass burning – 10.0%
- Fossil fuel retrieval, processing and distribution – 11.3%
- Commercial and residential sectors – 10.3%

## 2.11. Types of Greenhouses gases

### 2.11.1. Water vapour ($H_2O$ (gas))

This is naturally occurring and so cannot be controlled. The rising global temperature may act to increase water vapour in the atmosphere www.climatechangesask.com.

### 2.11.2. Ozone ($O_3$)

This is also naturally occurring. Also created by reactions involving nitrogen oxide gases resulting from motor vehicles and power plants. Ozone at ground level and in the lower atmosphere is linked with smog and health problems. However, in the upper atmosphere, it helps to protect the earth from ultra-violet radiation and chemicals which tend to destroy ozone in the upper atmosphere are regulated under the Montreal Protocol www.climatechangesask.com.

### 2.11.3. Carbon dioxide ($CO_2$)

This colourless, odourless, faintly acidic and non-flammable gas is the largest in concentration. Carbon dioxide comes naturally from animal and human's respiration, fermentation and the decay of organic matter, active volcanoes, oceans and fire. Humans enhance the mix by burning fossil fuels to create energy. Deforestation, illegal waste disposal and changing land use as in the case of agriculture and urban development are also human factors (Young, 2009).

Humans use carbon dioxide for different things such as its use in soft drinks and beer, to make them fizzy, as fire extinguishers (because $CO_2$ is denser than air); also used in a technology called 'supercritical extraction' used to decaffeinate coffee. The solid form which is known as 'dry ice' is used in theatres to create stage fogs and make things like 'magic potions' bubble. Carbon dioxide as a greenhouse gas has risen from 280 ppm in 1850 to 364 ppm in the 1990s.

The quantity of carbon dioxide generated in various sectors can be seen below:

- Power stations – 29.5%
- Industrial processes – 20.6%
- Transportation fuels – 19.2%
- Residential, commercial and other sources – 12.9%
- Land use and biomass burning – 9.1%
- Fossil fuel retrieval, processing and distribution – 8.4% (Lerner and Wilmoth, 2006).

### 2.11.4. Methane ($CH_4$)

This is a colourless, odourless but flammable gas is the second largest greenhouse gas. It is often called 'swamp gas' because it is abundant around water and swamps. Methane resides in frozen slush in the northern arctic permafrost regions and in the depths of the ocean. Bacteria that breakdown organic matter in wetlands and bacteria that are found in cows, sheep, goats, buffalo, termites, and camels produce methane naturally.

However, due to increase in raising livestock, coal mining, drilling for oil and natural gas, rice cultivation, and garbage sitting in landfills, more methane is generated. Uncapped and unlined landfills spew out methane gas which is a threat to human health and a documented factor in global warming. (Bogart, 2009).

The quantity of methane generated in various sectors in the society can be seen below:

- Agricultural products – 40.0%
- Fossil fuel retrieval, processing and distribution – 29.6%
- Waste disposal and treatment – 18.1%
- Land use and biomass burning – 6.6%
- Residential, commercial and other sources – 4.8% (Lerner and Wilmoth, 2006).

### 2.11.5. Nitrous oxide ($N_2O$)

It is a colourless, non-flammable, sweet smelling gas. It is commonly known as 'laughing gas due to the euphoric effects of inhaling it.' This gas is released naturally from oceans and by bacteria in soils and artificially by using nitrogen based fertilizers, disposing of human and animal waste in sewage treatment plants, automobile exhaust, etc. Nitrous Oxide results from the denitrification of soil and water brought on by certain anaerobic conditions particularly in wet tropical regions (Young, 2009). Also, it is used in surgery and dentistry for its anaesthetic and analgesic effects. The quantity of nitrous oxide generated in various sectors in the society can be seen below:

- Agricultural by-products – 62.0%
- Land use and biomass burning – 26.0%
- Industrial processes – 5.9%
- Waste disposal and treatment – 2.3%
- Residential, commercial and other sources – 1.5%
- Transportation fuels – 1.1%
- Power stations – 1.1% (Lerner and Wilmoth, 2006).

### 2.11.6. Per fluorocarbons (PFCs)

These are mainly produced by human-made chemicals. It is a by-product of aluminium smelting. It is also used as a replacement for CFCs in manufacturing semi-conductors (www.climatechangeasask.com).

### 2.11.7. Sulphur hexafluoride ($SF_6$)

It is used largely in heavy industry to insulate high voltage equipment and to assist in the manufacture of cable cooling systems (www.climatechangesask.com).

### 2.11.8. Chlorofluorocarbons (CFCs)

Mainly human-made chemicals. Used largely in refrigeration and insulation foam (www.climatechangesask.com).

## 2.12. Composition of Greenhouse Gases

- **Dumpsites**

The composition of solid waste landfill emissions is typically 50 to 60 percent methane, with the balance being mostly carbon dioxide. Various trace gases such as hydrogen sulphide, water vapour, ammonia, and a variety of volatile organic compounds (VOCs) are also found in landfill gases (LFG). Usually, gas production begins within a year of waste placement and may continue for as long as 50 years after landfill closure (IPCC, 2006; IPCC, 2001b).

- **Atmosphere**

The EPA has determined that emissions from MSW landfills cause, or contribute significantly to, air pollution that may reasonably be anticipated to endanger public health or welfare. Emissions from MSW landfills are of concern locally (odours and potential health effects), regionally (photochemical activity of the VOCs), and globally (methane is a major greenhouse gas). It has been estimated that the United States contributed 8 to 16 teragrams per year (Tg/yr) of methane to the atmosphere in 1990, about 40 percent of the worldwide amount of methane emitted from landfills and open dumps (Thorneloe and Pacey, 1994; Thorneloe et al., 1994).

The effects of greenhouse gases can be significant. World Health Organization (WHO) quantitative assessment, taking into account only a subset of the possible health impacts, concluded that the effects of the climate change that has occurred since the mid-1970s may have caused over 150,000 deaths in 2000. It also concluded that these impacts are likely to increase in the future.

The effects of global warming are complex, but studies of their impact on biotic communities clearly point toward secondary effects that could be detrimental to human health (Rogers et al, 2006). The atmospheric concentration of carbon dioxide ($CO_2$) has increased by 31% since 1750. The present $CO_2$ concentration has not been exceeded during the past 420,000 years and likely not during the past 20 million years. The rate of increase of atmospheric $CO_2$ concentration has been about 1.5 ppm (0.4%) per year over the past two decades. During the 1990s the year to year increase varied from 0.9 ppm (0.2%) to 2.8 ppm (0.8%). As of April 2010, carbon dioxide in the Earth's atmosphere is at a concentration of 391 ppm by volume. Atmospheric concentrations of carbon dioxide fluctuate slightly with the change of the seasons, driven primarily by seasonal plant growth in the Northern Hemisphere (NOAA, 2008).

The atmospheric concentration of methane ($CH_4$) has increased by 1060 ppb (151%) since 1750 and continues to increase. The present $CH_4$ concentration has not been exceeded during the past 420,000 years. The annual growth in $CH_4$ concentration slowed and became more variable in the 1990s, compared with the 1980s. Slightly more than half of current $CH_4$ emissions are anthropogenic (e.g., use of fossil fuels, cattle, rice agriculture and landfills). The atmospheric concentration of nitrous oxide ($N_2O$) has increased by 46 ppb (17%) since 1750 and continues to increase. The present $N_2O$ concentration has not been exceeded during at least the past thousand years. About a third of current $N_2O$ emissions are anthropogenic (e.g., agricultural soils, cattle feed lots and chemical industry) (Enzler, 2010).

Since 1995, the atmospheric concentrations of many of those halocarbon gases that are ozone-depleting and greenhouse gases (e.g., $CFCl_3$ and $CF_2Cl_2$), are either increasing more slowly or decreasing, both in response to reduced emissions under the regulations of the Montreal Protocol and its Amendments. Their substitute compounds (e.g., $CHF_2Cl$ and $CF_3$ $CH_2F$) and some other synthetic compounds (e.g., Perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$)) are also greenhouse gases, and their concentrations are currently increasing.

## 2.13. The Link Between Wastes and Greenhouse Gases

According to EPA's Global Anthropogenic Emissions of Non-$CO_2$ Greenhouse Gases report, Nigeria's estimated anthropogenic methane emissions ranked ninth in the world (EPA, 2005). About 2.23 million metric tons of carbon equivalents (MMTCE) of world methane emission are generated in Nigeria dump sites, a Methane-to-Markets (M2M) member country (EPA, 2005). Hence, Nigeria is a major contributor to the global methane emission.

For many wastes, the materials in MSW represent what is left over after a long series of steps:

(1) Extraction and processing of raw materials;

(2) Manufacture of products;

(3) Transportation of materials and products to markets;

(4) Use by consumers; and

(5) Waste management.

Virtually every step along this "life cycle" impacts GHG emissions. Several million tons of municipal solid waste (MSW) are disposed of in sanitary landfills (controlled landfill) and dump sites (uncontrolled landfills) daily around the world. Landfill gas (LFG) is a natural by-product of decomposing organic matter, such as food and paper that are disposed of in these landfills. Methane, the primary component of natural gas, is the primary constituent (about 50%) LFG and a potent greenhouse gas when released to the atmosphere (CPE, 2010).

The disposal of solid waste produces greenhouse gas emissions in a number of ways. First, the anaerobic decomposition of waste in landfills produces methane, a greenhouse gas 21 times more potent than carbon dioxide. Second, the incineration of waste also produces carbon dioxide as a by-product. Additionally, in transporting waste for disposal, greenhouse gases are emitted due to the combustion of fossil fuels from the vehicles. Finally, fossil fuels are also required for extracting and processing the raw materials necessary to replace those materials that are being disposed with new products (www.epa.gov).

## 2.14. Wastes Disposal and Greenhouse gas Studies

Ogwueleka, 2009 stated that the common constraints faced in current solid waste management practices and problems in Nigeria include: lack of institutional arrangement, insufficient financial resources, absence of bylaws and standards, inflexible work schedules, insufficient information on quantity and composition of waste, and inappropriate technology. While in 2008, Agunwamba emphasised on the problems of solid waste management in Nigeria. He stated that at the core of the problems of solid waste management are the absence of adequate policies, enabling legislation, and an environmentally stimulated and enlightened public. Government policies on the environment are piecemeal where they exist and are poorly implemented. Public enlightenment programs lacked the needed coverage, intensity, and continuity to correct the apathetic public attitude towards the environment. Up to now the activities of the state environmental agencies have been hampered by poor funding, inadequate facilities and human resources, inappropriate technology, and an Inequitable taxation system.

A pre-feasibility study carried out on the landfill recovery and use in Nigeria by Centre for People and Environment in four Nigerian landfills showed that there are some major problems with landfill recovery and utilization in Nigeria. A number of the problems identified are:

1. Policy: Government policy on solid waste management in Nigeria is not comprehensive.
2. Recycling: There are no significant recycling programs. The limited recycling programs are where scavengers look for recyclables items such as cans, plastics, bottles, and papers for resale or reuse.
3. Disposal: There are no sanitary landfills in Nigeria.
4. Funding: There are limited or no funding for solid waste management in Nigeria.

Other challenges that were encountered during the studies are

(i) Lack of proper record keeping.

(ii) Information sharing between the different organizations is lacking;

(iii) Public and researchers have little or no access to the limited information that is available;

(iv) Improper waste management at the landfills.

In a study carried out in Abbottabad by the International Union for Conservation of Nature, 78% of surveyed households were aware of the issues related to poor waste management, with similar figures in both urban (80.5%) and rural (73.4%) households. But awareness was higher among the non-poor (67.9%), compared to poor families (9.9%). There was, however, a high degree of awareness regarding the risks of disease, with 86% of those surveyed indicating an understanding of the link between poor health and improper garbage disposal (9.9%). Babayemi & Dauda in 2009 carried out a study that involved 201 respondents in Abeokuta, Nigeria. Of the 201 respondents, 35.8% used waste collection services, 64.2% used other waste disposal options, 16.4% used both, 68.7% and 58.7% were aware of waste collection service and waste management regulations, respectively; while 28.4% separated their solid wastes at source. It also shows the waste generation per person in various cities in Nigeria. They include: Abeokuta in Ogun state (0.60Kg/person/day), Ado-Ekiti in Ekiti state (0.71Kg/person/day), Akure in Ondo state (0.54Kg/person /day), Ile-Ife in Osun state (0.46Kg/person/day) and Ibadan in Oyo state (0.71Kg/person/day) (Adewumi *et al.*, 2005). About 55 200Kg per day of solid wastes were estimated to be generated in the traditional city of Oyo in Oyo state (Abel and Afolabi, 2007).

In a survey done in Ibadan by Adelekan & Gbadegesin (2005), the outcome of the study indicates that a significant proportion (92%) of the public is aware of the dynamics of the local climate. In addition, almost 70% of the respondents have heard of global climate change but less than 25% know the causes. Abushammala et al (2009) in their study attempted to assess, in quantitative terms, the amount of $CH_4$ that would be emitted from landfills in Malaysia over the years 1981-2024 using the Inter-governmental Panel on Climate Change 2006 First Order Decay Model. The First Order Decay (FOD) model is one of the most important and widely used models for estimation of $CH_4$ emissions. It was used by many researchers for estimation of $CH_4$ emission from landfills (Wangyao *et al.*, 2009; Chiemchaisri *et al.*, 2007; Kumar *et al.*, 2004).

Both the IPCC and USEPA recommend this model as a standard tool for the estimation of $CH_4$ emissions from landfills. The FOD model provides a time-dependent emission profile reflecting the pattern of waste degradation over time. It assumes that the degradable organic carbon (DOC) in waste decays slowly over time during which $CH_4$ and $CO_2$ are formed. Thus, the $CH_4$ emission from deposited waste is highest during the first few years after deposition then gradually declines with the decline of DOC content in the waste (IPCC, 2006).

## 2.15. Policy/Legislation on Waste Management and Greenhouse Gases

In Nigeria, the state is responsible for the protection of the environment and in accordance with Sec. 20 of the Nigerian 1999 constitution "The state shall protect and improve the environment and safeguard the water, air and land, forest and wild life of Nigeria," and the same constitution specifically assigns the responsibility of environmental sanitation to the Local Government, the third tier of government". Perhaps, the above constitutional provision informed the Federal Military Government to promulgate Decree No 58 of 1988 which consequently charged Federal Environmental Protection Agency with the responsibility of maintaining decent environment in Nigerian cities and towns. The decree made provisions for the post of a Chairman who has the knowledge of environmental matters, four distinguished scientists, and one representative from Federal Ministries of Health, Science and Technology, Works and Housing, Agriculture, Water Resources and Rural Development, Industries, Mines, Power and Steel, Employment, Labour and Productivity, Petroleum Resources, Transport and Aviation.

Dumping in unauthorized areas is illegal and federally enforceable under the Protection of the Environment Operation Act of 1997 (U.S EPA, 2000), which allows the government to fine companies and individuals for a variety of harmful environmental operations and negligence. Protection of the Environment Operation Act (PEO) fines range from $600 to 1 million dollars per day. Local laws are also often used to prosecute these types of crimes.

At the core of the problems of solid waste management are the absence of adequate policies, enabling legislation, and an environmentally stimulated and enlightened public. Government policies on the environment are piecemeal where they exist and are poorly implemented (Agunwamba, 1998). The poor state of waste management in Nigeria is attributable to an inadequately formulated and poorly implemented environmental policy, among other factors. The mountainous heaps of solid wastes that deface Nigerian cities and the continuous discharges of industrial contaminants into streams and rivers without treatment motivated the federal government of Nigeria to promulgate Decree 58 for the establishment of a Federal Environmental Protection Agency (FEPA) on 30 December 1988 (Federal Military Government, 1988). A national policy on the environment was formed and the goals of the policy include:

- To secure for all Nigerians a quality of environment adequate for their health and well-being;
- To raise public awareness and promote understanding of the essential linkages between the environment and development; and
- To encourage individual and community participation in environmental protection and improvement efforts (FEPA 1989).

In spite of the formulation of FEPA and a national environmental policy, the environment has not been adequately protected. Interest is mainly on aesthetics, which is rarely achieved. Waste collection is irregular and restricted to the major cities.

Pollution prevention is another important principle of environmental policy; the rungs of the pollution prevention ladder go from the most preferable strategy, reduction of pollution at the source (source reduction), to waste minimization, reuse, recycling, emissions controls, and, least preferably, clean-up. It is generally less expensive to reduce pollution at the source and thus avoid costs of emissions controls and environmental clean-up.

Pollution and its consequences are not distributed equally in society, and thus it is important to consider environmental justice issues in assessment of hazard (IOM, 1999). Unfortunately, in the past there was a failure to do so, accounting for concentrations of polluting industries, sources of air pollution, and waste disposal operations in certain low-income and minority communities. In addition, there are higher rates of many diseases in poor and minority communities in the United States and elsewhere, lending support to the notion of differential exposure and risk.

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC). The objective of the Kyoto climate change conference was to establish a legally binding international agreement, whereby all the participating nations commit themselves to tackling the issue of global warming and greenhouse gas emissions. The target agreed upon was an average reduction of 5.2% from 1990 levels by the year 2012.

The UNFCCC is an international environmental treaty with the goal of achieving "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." (UNFCCC, 2005). Under the Treaty, countries must meet their targets primarily through national measures. However, the Kyoto Protocol offers them an additional means of meeting their targets by way of three market-based mechanisms.

The Kyoto mechanisms are:

- Emissions trading – known as "the carbon market"
- Clean development mechanism (CDM)
- Joint implementation (JI).

The mechanisms help stimulate green investment and help Parties meet their emission targets in a cost-effective way.

# CHAPTER THREE

# METHODOLOGY

## 3.1. Study design

The study was a cross sectional survey which involved onsite observations within and around the dumpsite waste characterisation and environmental field sampling.

## 3.2. Study area

The study was carried out in Ibadan southwest local government area of Oyo state, Nigeria. Ibadan Southwest local government, which is one of the five urban local governments in Ibadan, was carved out of the defunct Ibadan Municipal Government (IMG) on the 27th of August, 1991. It is geographically located between longitude 7°21 and 7°22 North and latitude 3°51 and 3°52 East. It is bounded by Ibadan Northwest and Ido local government in the west and by Ibadan Northwest and Southeast local government in the east. It has a landmass of about 244.55km square. This feature makes it one of the largest local governments in Oyo state. The principal inhabitants are the Yoruba. Their occupation includes carpentry, welding, battery smelters, trading, tailoring among others.

Ibadan Southwest local government area has a population figure of 277,047 according to the final result of 1991 census released by National Population Commission (NPC). The present population size according to 2006 census was 282,585. It has 10 political wards and 5 health districts (Secretariat, IBSWLGA). Ibadan southwest local government is reputed to be the most potentially viable in Oyo state. The reason is not far-fetched because it has the largest concentration of industries and companies in the whole of Oyo state. Some of them include: 7-Up bottling Company, Zartech, and Procter & Gamble and so on. About 50% of companies in the local government are located in Oluyole estate while the remaining 50% are spread across other parts of the local government. Ibadan Metropolis has been stratified based on population density by the National Population

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Commission (NPC) into high medium and low density areas. In Ibadan southwest local government area, communities within the high density area include: Agbeni, Oke-foko, Ogunpa, Dugbe; medium density includes: Oke-Bola, NTC, Oke-Ado, Liberty Stadium Road and low density includes: Jericho, Iyaganku, Oluyole Layout, Oluyole Extension (Secretariat, IBSWLGA). Below is a map of IBSWLGA showing the sampled sites.

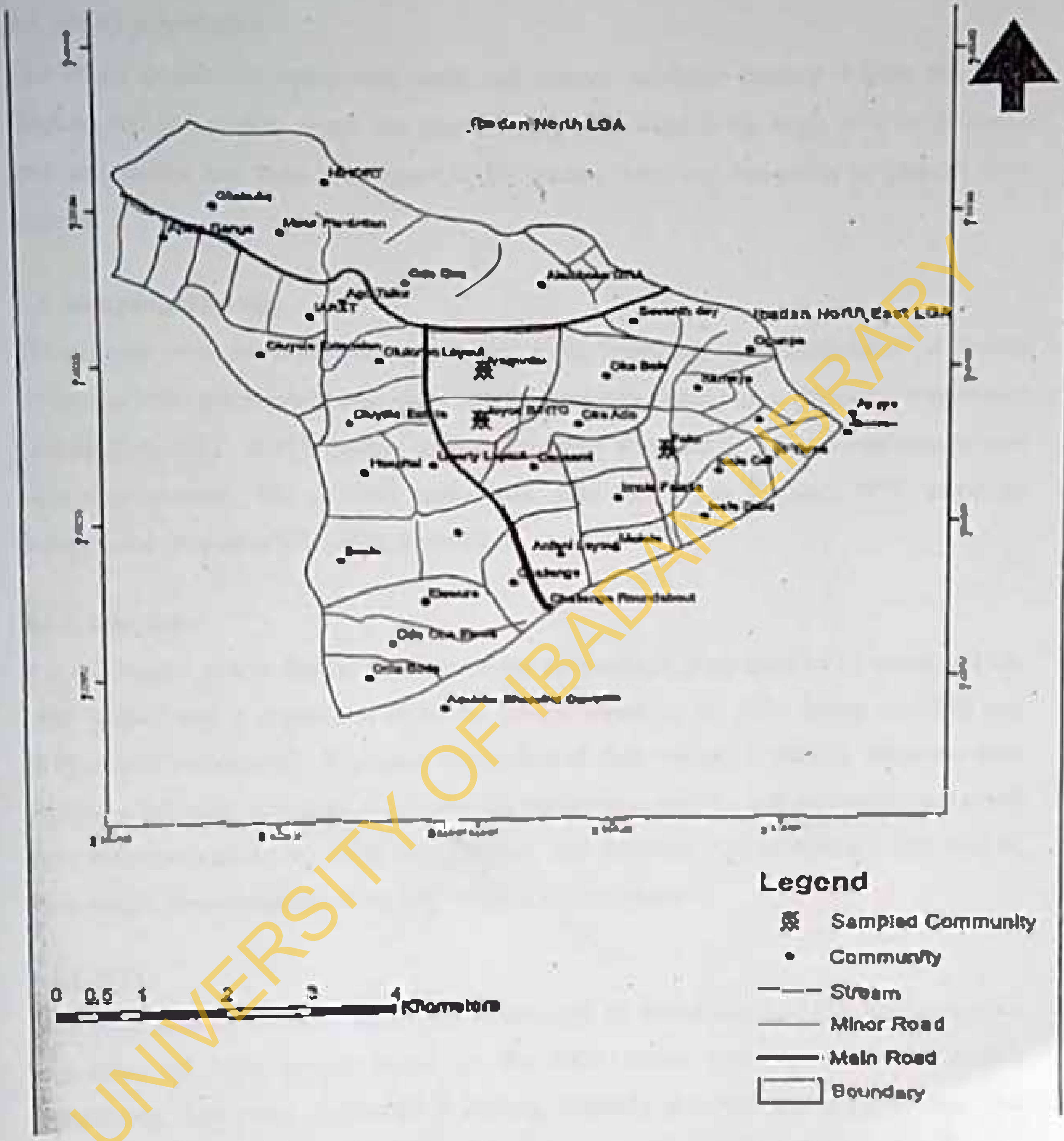



**Fig. 3.1: Sampled Sites in Ibadan Southwest Local Government Area**

Source: Ministry of Lands and Housing, Ibadan, 2008

### 3.3. Study population

The study population comprised male and female residents located within the high, medium and low density areas. The residents that have lived in the study area for at least a year and within less than 150 metres to 500 metres from the dumpsites of interest were selected.

### 3.4. Sampling Strategy

Three areas were selected to carry out this study based on the stratification of Ibadan southwest local government into high, medium and low density area (National Population Commission, NPC, 1991). Simple random sampling was used to select a community/area from each stratum. The selected areas were: Oke-foko (high density), NTC (medium density) and Iyaganku GRA (low density).

#### 3.4.1. Oke-foko

It is the biggest area in Ibadan southwest local government. It consists of 12 zones and has 1990 houses with a population of 36,255 people based on the 2001 house counting and 1996 census respectively. The main occupation of their women is trading while the men engage in tailoring, activities of artisans like mechanics, welders and carpenters and small scale business such as recycling plastics from lead batteries. The sampling points will be three illegal dumps and sampling will be done at each dump.

#### 3.4.2. NTC

This is an area of medium density. It consists of 12 zones and has 835 houses with a population of 5850 people based on the 2001 house counting and 1996 census respectively. The main occupation is trading, artisan's activities and civil service. The sampling points will also be three illegal dumps and sampling will be done at each dump.

#### 3.4.3. Iyaganku GRA

This is one of the government reserve areas in Ibadan. It has 383 houses based on the 2001 house counting and an estimated population of 2,681. It is located close to the local government office. Also the Press Centre of the Nigerian Union of Journalists (NUJ) Oyo state council is in Iyaganku. Here the houses are much spaced. The location has three illegal dumps from where sampling was carried out.

Figure 3.2 shows the map displaying the selected areas and the dumpsites of interest. Further on, are plates showing sections of the dumpsites from the three density areas selected for the study.


Fig. 3.2: Map showing the three density areas and the selected dumpsites

Plate 3.1a: A cross section of dumpsites in the high density area (Okefoko)

Plate 3.1b: A cross section of dumpsites in the medium density area (NTC Joyce B)

Plate 3.1c: A cross section of dumpsites in the low density area (Iyaganku GRA)


**Plate 3.2: A Global Positioning System**


Plate 3.3: A Carbon dioxide meter

### 3.5. Sample size determination

The sample size of the study was calculated using a prevalence rate of 78% (0.78) from a reported survey of households that are aware of the issues related to poor waste management (Environmental Fiscal reform in Abbottabad, Solid Waste management – IUCN, 2006).

The sample size was calculated using the formula:

$$n = \frac{Z\alpha^2 pq}{d^2}$$

Where n = Sample size

$Z\alpha = 1.96$

p= prevalence of awareness of issues related to poor waste management

q= 1-p

d= precision limit.

Where n =?

$Z\alpha$ = Confidence interval 95% = 1.96

p = Prevalence of poor waste management issues = 78% (0.78)

q = 1-p = 0.22% = 0.22

d = precision limit =0.05

$$\text{Therefore } n = \frac{(1.96)^2 \times 0.78 \times 0.22}{(0.05)^2} = \frac{3.8416 \times 0.78 \times 0.22}{0.0025}$$

n = 263.68

The sample size calculated was 263.8 however to increase the precision of the study and compensate for non-response 30% of the sample size was taken and the total became 342.

### 3.6. Selection of Sampling Sites

Using proportional allocation method:

Total population in Foko, NTC and Iyaganku GRA were 36255, 5850 and 2681 respectively. This gave a total of 44786 people.

**For each area:**

Foko: $\frac{36255 \times 342}{44786} = 277$

NTC: $\frac{5850 \times 342}{44786} = 45$

Iyaganku GRA: $\frac{2681 \times 342}{44786} = 20$

Onsite observations, characterization of wastes and measurements of carbon dioxide and methane gases were carried out in each of the three (3) dumpsites which were purposively selected while cluster sampling technique was used to select houses in which questionnaires were interviewer administered to respondents.

### 3.7. Data Collection

#### 3.7.1. Determination of Sampling Coordinates

A Global Positioning System (GPS) device was used to obtain the coordinates of the sampling points presented as Latitudes and Longitudes.

#### 3.7.2. Onsite Observation

The nature of the selected dumpsites was documented using a well designed observation checklist reflecting indicators such as presence or absence of combustion activities, scavenging, skip bins, functional vegetation, smoke, proximity to residential areas and so on.

#### 3.7.3. Wastes Characterization

Waste characterisation involved the description of the dumpsite into different components based on the American Society for Testing and Materials (ASTM).

Grab samples were collected to make a composite sample of 5kg of waste from each site of interest. The wastes obtained were then separated into its different components (i.e. organics – food remains, plant debris etc and recyclables - plastics, nylons, metals, others) and the percentage composition of each component was determined This gives an idea about the recycling potential of the wastes disposed.

### (d) Gas or Emission Monitoring

#### Determination of Carbon dioxide ($CO_2$) Concentration

A carbon dioxide meter (Telaire 7001 model) made in Mexico was used to measure the concentration of $CO_2$ emissions at the dumpsites thrice weekly at specific periods of the day (8-10 am, 12-2 pm, and 4-6 pm), for 12 consecutive weeks. The values of $CO_2$ were measured in parts per million (ppm) and compared with the United States Environmental Protection agency (US EPA) normal outdoor exposure (300 – 450 ppm) for $CO_2$ exposure in the environment (IDPH, 2011 and www.EngineeringToolBox.com)

#### Determination of Methane ($CH_4$) Concentration

The IPCC default method is a simple mass balance calculation which estimates the amount of $CH_4$ emitted from the Solid waste dumpsites assuming that all $CH_4$ is released the same year the waste is disposed of. The 2006 Intergovemmental Panel on Climate Change (IPCC) waste model was used to estimate the $CH_4$ emitted from each dumpsite in a year using the weight of the wastes and population of the areas which was 36255, 5850 and 2681 in Oke-foko, NTC and Iyaganku GRA respectively (NPC, 2006).

Using, the following equation for methane emission in Gg/year

**Methane emissions (Gg/yr) = (MSWT • MSWF • MCF • DOC • DOCF • F • 16/12-R) • (1-OX)**

Where:

$MSW_T$ = Municipal Solid Waste generation rate for Ibadan x population of study site

= 0.51 kg/cap/yr x population of study site

For Okefoko = 0.51 x 36,255 = 18,490.05

NTC Joyce B = 0.51 x 5850 = 2983.5

Iyagank uGRA = 0.51 x 2681 = 1367.3

MCF = methane correction factor

Default value forshallow unmanaged dumpsite with depth >5m = 0.4

For deep unmanaged dumpsite = 0.8

$MSW_F$ = fraction of MSW disposed to the dumpsite default value for Nigeria = 0.4

$DOC_F$ = fraction of DOC actually converted to gas

= 0.014T + 0.28

Where T is the temperature of the dumpsite

Mean temperature for Okefoko = 29°C

Mean temperature for NTC Joyce B = 29.6°C

Mean temperature for Iyganku GRA = 28.9°C

Therefore, the $DOC_F$ for the three density areas are:

$DOC_F$ Okefoko = (0.014 x 29) + 0.28 = 0.686

$DOC_F$ NTC Joyce B = (0.014 x 29.6) + 0.28 = 0.694

$DOC_F$ Iyganku GRA = (0.014 x 28.9) + 0.28 = 0.685

**Table 3.1: West Africa default data on waste composition of MSW**

| Waste type | Default Composition by percentage (%) |
|---|---|
| Food waste | 40.4 |
| Paper/cardboard | 9.8 |
| Wood | 4.4 |
| Textile | 1.0 |
| Plastics | 3.0 |
| Metals | 1.0 |

Source: IPCC 2006



**Default (National) values for DOC generation or each waste type**

DOC (by weight) = 0.4 (A) + 0.17 (B) + 0.15 (C) + 0.30 (D)

Where A = fraction of MSW that is paper and textile i.e. 0.108 (i.e. 9.8 + 1 = 10.8 / 100)

B = fraction of MSW that is given waste and other non-food organic putrescible i.e. no default value available

C = fraction of MSW that is food waste i.e. 0.404

D = fraction of MSW that is wood or straw i.e. 0.044

DOC (by weight) = 0.4 (0.108) + 0.17 (0) + 0.15 (0.404) + 0.30 (0.044)

= 0.0432 + 0 + 0.0606 + 0.0132

= 0.117

F = 0.5 default value

16/12 = conversion of Carbon to $CH_4$

R = methane recovery = 0

OX = oxidation factor = 0 since the dumpsite is shallow

(Note: 1000 tonnes = 1Gg)

To get the methane concentration (%vol.) =

$$\frac{CH4\ emission\ for\ a\ density\ area}{Total\ CH4\ emission\ of\ the\ 3\ density\ areas} \times 100$$

### 3.7.5. Survey

A semi-structured questionnaire was designed specifically to address the knowledge, attitude practice and public health effects in the study area. The questionnaire was divided into 5 sections as follows:

- Section A: Socio-demographic information
- Section B: Knowledge
- Section C: Attitude
- Section D: Practice
- Section E: Public health effects

All the study instruments were cross-checked for completeness by the supervisors and investigator before leaving for the field and they were used at each of the dumpsites.

≥ 70% - Excellent, 60 – 69% - Good, 50 – 59% - Fair and < 50% - Poor

| | Knowledge | Attitude |
|---|---|---|
| **Total number of variables** | 16 | 11 |
| **Total obtainable score** | 32 | 55 |
| **Highest score** | 2 | 5 |
| **Lowest score** | 0 | 1 |
| **Excellent** | ≥ 22 | ≥ 39 |
| **Good** | 19 – 21 | 33 – 38 |
| **Fair** | 16 – 18 | 28 – 32 |
| **Poor** | < 16 | < 28 |

i.e. 70/100 x 32 = 22

**3.7.2.1. Inclusion Criteria**

- Any resident that has lived in the study area for at least a year
- Residents that live within 0 – 500 metres from the dumpsites of interest

**3.7.2.2. Exclusion Criteria**

- Any resident who did not give voluntary consent to be interviewed was exclu from the study.
- Any resident within the study area who has lived less than a year was excluded from the study.
- Any resident that lived in area >500 metres from the dumpsites of interest was excluded from the study.

### 3.8. Ethical Consideration

Ethical approval was obtained from the joint UI/UCH institutioonal review board. Informed consent informing respondents' on their rights to either take part or not was done before any interaction with the respondent after having shown full understanding of the study. Confidentiality of information obtained from respondents was ensured. Identifiers were stripped from the respondents' responses and number codes used for respondent.

### 3.9. Data Management and Statistical Analysis

All data from questionnaires and the environmental field sampling collected were analyzed. Data editing was done concurrently with data entry to clarify unclear values. Data cleaning was done by running frequencies of all variables to check for missing values or inaccurate entries. Descriptive statistics was used to summarize data. Inferential statistics was used to test for association between qualitative and quantitative variables. Data collected was analyzed using Statistical Package for Social Sciences (SPSS) software for parameters such as chi-square, ANOVA at 5% level of significance.

### 3.10. Limitations of The Study

The limitations of this study include lack of information on the dumpsites such as the age of the dumpsite, actual volume since they are illegal and were pushed into streams during rainy seasons or burnt.

# CHAPTER FOUR

# RESULTS

## 4.1. Coordinates of Sampling Points

Data were collected in order to determine the location of the illegal dumpsites in each of the area of interest using a GPS. Table 4.1 gives the coordinates of each of the selected dumpsites.

**Table 4.1: Geographical Coordinates of the Selected Areas**

| Areas | Longitude | Latitude |
|---|---|---|
| Area 1 | 3°52'7.70°E | 7°22'22.75°N |
| Area 2 | 3°52'8.22°E | 7°22'16.55°N |
| Area 3 | 3°52'12.05°E | 7°22'18.38°N |
| Genesis | 3°52'32.26°E | 7°22'22.31°N |
| Cele | 3°52'22.00°E | 7°22'25.35°N |
| Jogor | 3°52'17.89°E | 7°22'22.44°N |
| Amole | 3°53'14.98°E | 7°22'34.62°N |
| Amule | 3°53'8.64°E | 7°22'24.56°N |
| Ede | 3°52'54.94°E | 7°22'27.24°N |

## 4.2. Onsite Observations

An observational checklist was used to assess the nature of the selected dumpsites. Each density area had three dumpsites namely:

- Oke-foko: Amole, Amule and Ede
- NTC Joyce B: Genesis, Cele and Jogor
- Iyaganku GRA: Area 1, Area 2 and Area 3

Amole, Amule and Area 2 dumpsites were the largest dumpsites observed. Ede is a partially abandoned dumpsite. Almost all the dumpsites had functional vegetation i.e. the vegetation is in good health and all were exposed to rainfall. The vegetation was highly present in Amole, Amule, Jogor and Area 2 while in the other sites it was moderately present. Also, Area 2 dumpsite was a mainly a fruit site. Most of the dumpsites in the three density areas have never been cleared.

The walls in Amole and Amule buildings were moderately cracked and mainly made of mud though some were made with blocks while in the other sites their walls were in good conditions though some had changed color. The roofs of the buildings around Amole, Amule and Cele dumpsites were rusted and some had holes. Smoke was observed at Ede, Genesis, Jogor and Area 1 dumpsites. Some were still burning as at the period of observation.

Based on the locations, all the dumpsites except Ede dumpsite were close to residential areas. However, Ede was close to a fish market; Genesis and Cele dumpsites were close to shops, food, wood and metal shops etc. and Area 2 was close to fruit-sellers. Amule, Ede, Genesis, Area 1, 2 and 3 dumpsites were by the roadside. Also, Amole, Amule, Cele and Jogor dumpsites were situated on water bodies. Scavengers, both animal and human, were highly present in Amole, Amule, Ede, Genesis, Cele and Jogor dumpsites as at the period of observation. Table 4.2 below shows a detailed report of the findings.

Table 4.2a: Onsite Observations

| Dumpsites | Vegetation | Walls | Roofs | Smoke | Exposure to rainfall |
|---|---|---|---|---|---|
| Amole | +++ | ++ | + | - | +++ |
| Amule | +++ | ++ | ++ | - | +++ |
| Ede | + | - | - | ++ | +++ |
| Genesis | ++ | - | - | ++ | +++ |
| Cele | ++ | - | + | - | +++ |
| Jogor | +++ | - | - | +++ | +++ |
| Area 1 | + | - | - | + | +++ |
| Area 2 | +++ | - | - | - | +++ |
| Area 3 | ++ | - | - | - | +++ |

Key: (+++) – Highly Present; (++) – Moderately present; (+) – Present and (-) – Absent

Table 4.2b: Onsite Observations contd.

| Location | Market | Roadside | Residential area | Scavengers | On water |
|---|---|---|---|---|---|
| Amole | - | - | +++ | +++ | +++ |
| Amule | - | ++ | ++ | +++ | +++ |
| Ede | ++ | +++ | - | +++ | - |
| Genesis | + | +++ | + | +++ | - |
| Cele | + | - | + | + | +++ |
| Jogor | - | - | ++ | +++ | +++ |
| Area 1 | - | + | +++ | - | - |
| Area 2 | - | +++ | + | - | - |
| Area 3 | - | +++ | + | - | - |

Key: (+++) – Highly Present; (++) – Moderately present; (+) – Present and (-) – Absent

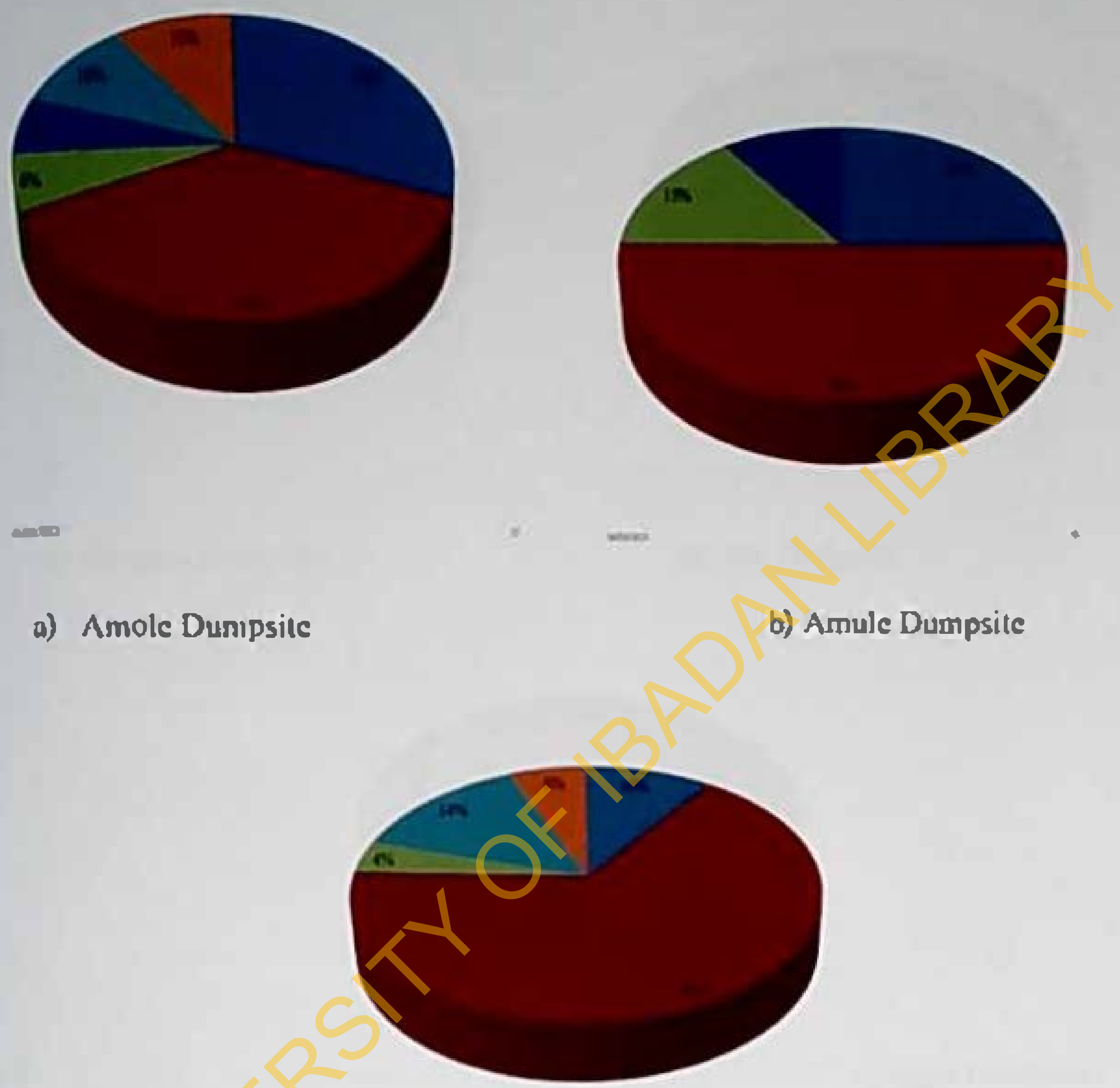
### 4.3. Waste Characterization

Figures 4.1a – c show the different proportion of solid wastes components at the different dumpsites. The solid wastes from the different dumpsites were organics, nylons, plastics, paper, metals and other wastes.

Okefoko: In Amole dumpsite, the largest proportion of waste components were 30% organics, 38% nylon, 10% metals and other wastes and 6% plastics and paper. In Amule dumpsite, it consisted of 50% nylon, 25% organics, 15% plastics and 10% paper. While, in Ede dumpsite it consisted of 66% nylon, 14% metal, 10% organics, 6% other wastes and 4% plastics.

NTC Joyce B: Genesis dumpsite was composed of 50% organics, 40% nylon, 4% plastics and 2% paper, metals and other wastes. Cele dumpsite had 30% organics, 25% plastics, 20% nylon and paper, 6% other wastes and 4% metals. While in Jogor dumpsite, 44% nylon, 20% organics, and 12% other wastes, 10% metals and 8% paper.

Iyaganku GRA: Area 1 dumpsite had 40% organics, 30% nylon, 10% plastics and paper and 5% metals and other wastes. In Area 2 dumpsite, it was composed majorly of organic waste (90%) and 10% metals. While Area 3 dumpsite had 45% nylon, 30% paper, 20% organics and 5% other wastes.



a) Amole Dumpsite

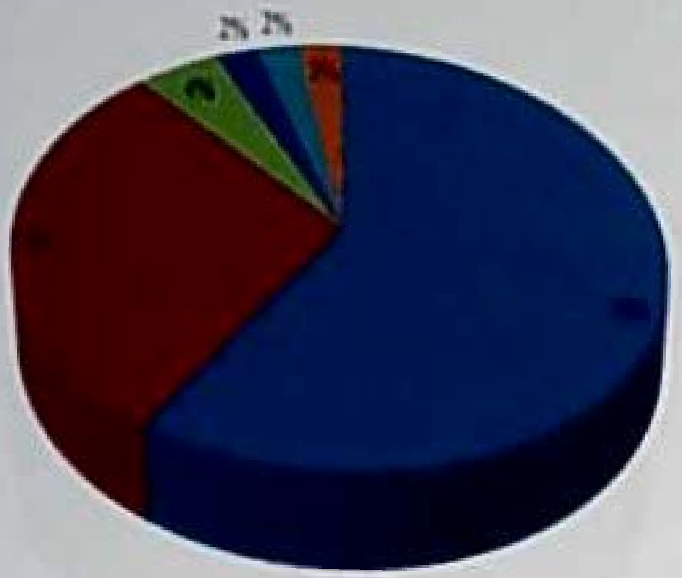
b) Amule Dumpsite

c) Ede Dumpsite

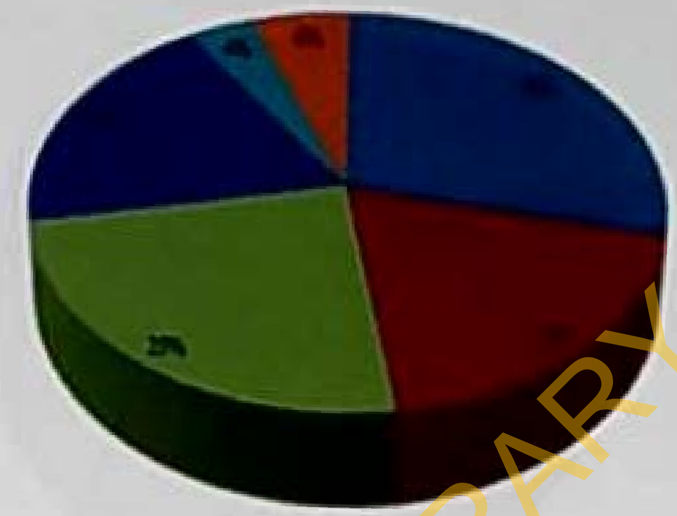
Key:

| | | | | | |
|---|---|---|---|---|---|
| Organic | Nylon | Plastics | Paper | Metal | Others |

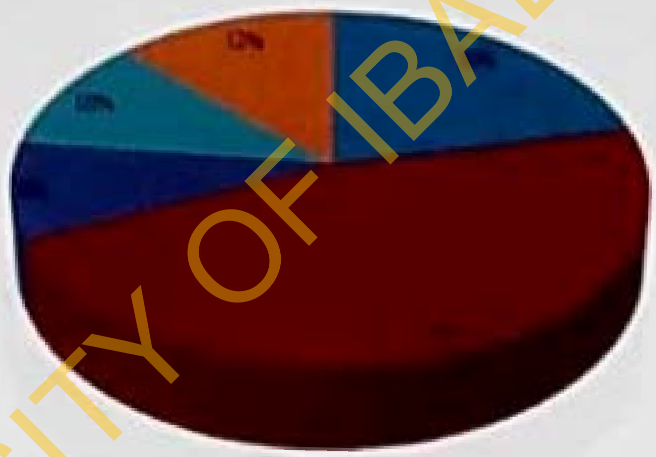
Fig.4.1a, b & c: A Proportion of different waste components in the high density area (Oke-Foko)



a) Genesis Dumpsite



b) Cele Dumpsite

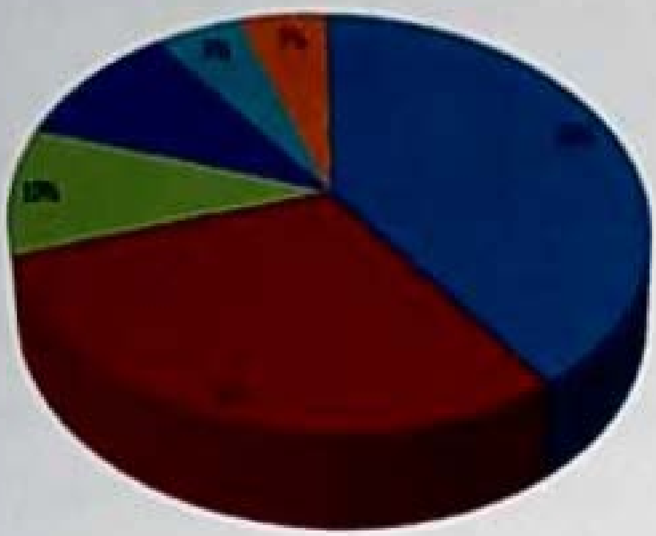


c) Jogor Dumpsite

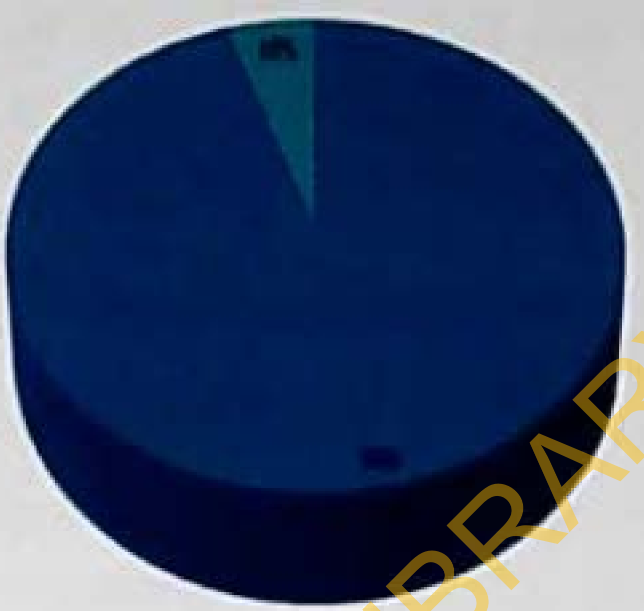
Key:

| | | | | | |
|---|---|---|---|---|---|
| Organic | Nylon | Plastics | Paper | Metal | Others |

Fig.4.2a, b & c: A Proportion of different waste components in the medium density area (NTC Joyce B)



a) Area 1 Dumpsite



b) Area 2 Dumpsite

c) Area 3 Dumpsite

Key:

| | | | | | |
|---|---|---|---|---|---|
| Organic | Nylon | Plastics | Paper | Metal | Others |

Fig.4.3a, b & c: A Proportion of different waste components in the low density area (Iyaganku GRA)

### 4.4. Concentration of Carbon Dioxide

The following results were obtained based on the measurements of carbon dioxide emissions from each dumpsite over a period of 12 weeks.

#### 4.4.1. Concentrations of $CO_2$ in the high density area (Okefoko)

Amole dumpsite: The $CO_2$ concentration for the first week was 525 ppm, 484 ppm and 385 ppm in the morning, afternoon and evening periods respectively. The minimum and maximum $CO_2$ concentration ranges in the morning, afternoon and evening were: 291 – 572 ppm, 270 – 532 ppm and 219 – 410 ppm respectively. The highest $CO_2$ concentration (572 ppm) for Amole was recorded in the morning of the 8th week; while the lowest (219 ppm) was recorded in the evening of the 6th week.

Amule dumpsite: The $CO_2$ concentration for the first week was 524 ppm, 498 ppm and 361 ppm in the morning, afternoon and evening periods respectively. The minimum and maximum $CO_2$ concentration ranges in the morning, afternoon and evening were: 307 – 580 ppm, 275 – 534 ppm and 228 – 413 ppm respectively. The highest $CO_2$ concentration (580 ppm) for Amule was recorded in the morning of the 8th week; while the lowest (228 ppm) was recorded in the evening of the 5th week.

Ede dumpsite: The $CO_2$ concentration for the first week was 523 ppm, 446 ppm and 389 ppm in the morning, afternoon and evening periods respectively. The minimum and maximum $CO_2$ concentration ranges in the morning, afternoon and evening were: 291 – 570 ppm, 290 – 508 ppm and 212 – 435 ppm respectively. The highest $CO_2$ concentration (570 ppm) for Ede was recorded in the morning of the 8th week; while the lowest (212 ppm) was recorded in the evening of the 6th week.

#### 4.4.2. Concentrations of $CO_2$ in the medium density area (NTC Joyce B)

Genesis dumpsite: The $CO_2$ concentration for the first week was 468 ppm, 461 ppm and 462 ppm in the morning, afternoon and evening periods respectively. The minimum and maximum $CO_2$ concentration ranges in the morning, afternoon and evening were: 309 – 560 ppm, 316 – 482 ppm and 224 – 462 ppm respectively. The highest $CO_2$ concentration

(560 ppm) for Genesis was recorded in the morning of the 8th week; while the lowest (224 ppm) was recorded in the evening of the 6th week.

Cele dumpsite: The $CO_2$ concentration for the first week was 457 ppm, 422 ppm and 402 ppm in the morning, afternoon and evening periods respectively. The minimum and maximum $CO_2$ concentration ranges in the morning, afternoon and evening were: 306 – 551 ppm, 281 – 480 ppm and 228 – 427 ppm respectively. The highest $CO_2$ concentration (551 ppm) for Cele was recorded in the morning of the 8th week; while the lowest (228 ppm) was recorded in the evening of the 6th week.

Jogor dumpsite: The $CO_2$ concentration for the first week was 436 ppm, 429 ppm and 437 ppm in the morning, afternoon and evening periods respectively. The minimum and maximum $CO_2$ concentration ranges in the morning, afternoon and evening were: 301 – 1157 ppm, 309 – 803 ppm and 224 – 437 ppm respectively. The highest $CO_2$ concentration (1157 ppm) for Jogor was recorded in the morning of the 11th week; while the lowest (224 ppm) was recorded in the evening of the 6th week.

### 4.4.3. Concentrations of $CO_2$ in the low density area (Iyaganku GRA)

Area 1 dumpsite: The $CO_2$ concentration for the first week was 452 ppm, 449 ppm and 467 ppm in the morning, afternoon and evening periods respectively. The minimum and maximum $CO_2$ concentration ranges in the morning, afternoon and evening were: 316 – 547 ppm, 250 – 548 ppm and 247 – 467 ppm respectively. The highest $CO_2$ concentration (547 ppm) for Area 1 was recorded in the morning of the 8th week; while the lowest (247 ppm) was recorded in the afternoon of the 5th week.

Area 2 dumpsite: The $CO_2$ concentration for the first week was 459 ppm, 450 ppm and 450 ppm in the morning, afternoon and evening periods respectively. The minimum and maximum $CO_2$ concentration ranges in the morning, afternoon and evening were: 315 – 548 ppm, 265 – 512 ppm and 245 – 450 ppm respectively. The highest $CO_2$ concentration (548 ppm) for Area 2 was recorded in the morning of the 8th week; while the lowest (245 ppm) was recorded in the evening of the 6th week.

Area 3 dumpsite: The $CO_2$ concentration for the first week was 422 ppm, 439 ppm and 433 ppm in the morning, afternoon and evening periods respectively. The minimum and maximum $CO_2$ concentration ranges in the morning, afternoon and evening were: 309 – 544 ppm, 267 – 516 ppm and 240 – 456 ppm respectively. The highest $CO_2$ concentration (544 ppm) for Area 3 was recorded in the morning of the 8$^{th}$ week; while the lowest (240 ppm) was recorded in the evening of the 6$^{th}$ week.

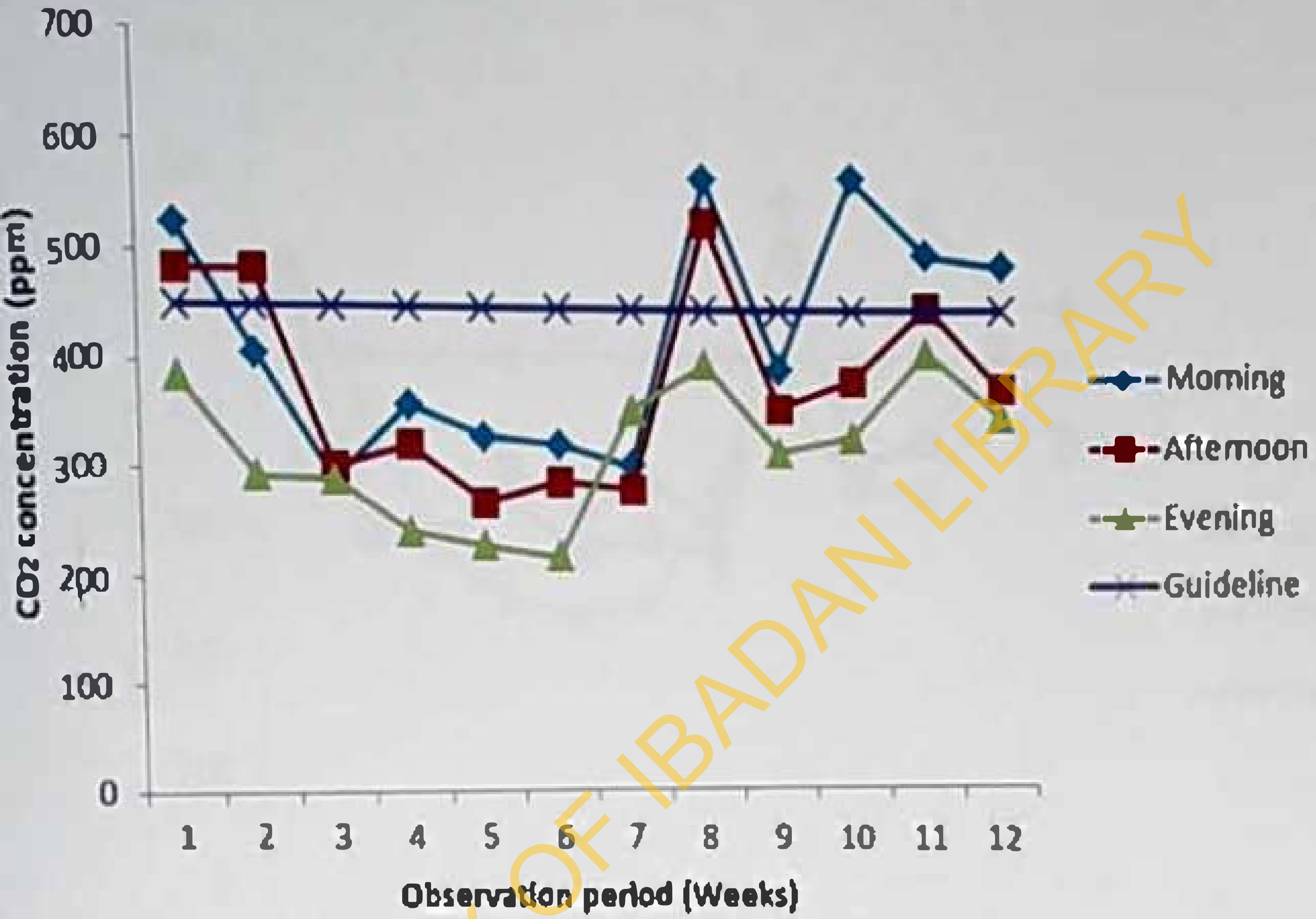



Figure 4.4a: Level of $CO_2$ in Amole Dumpsite

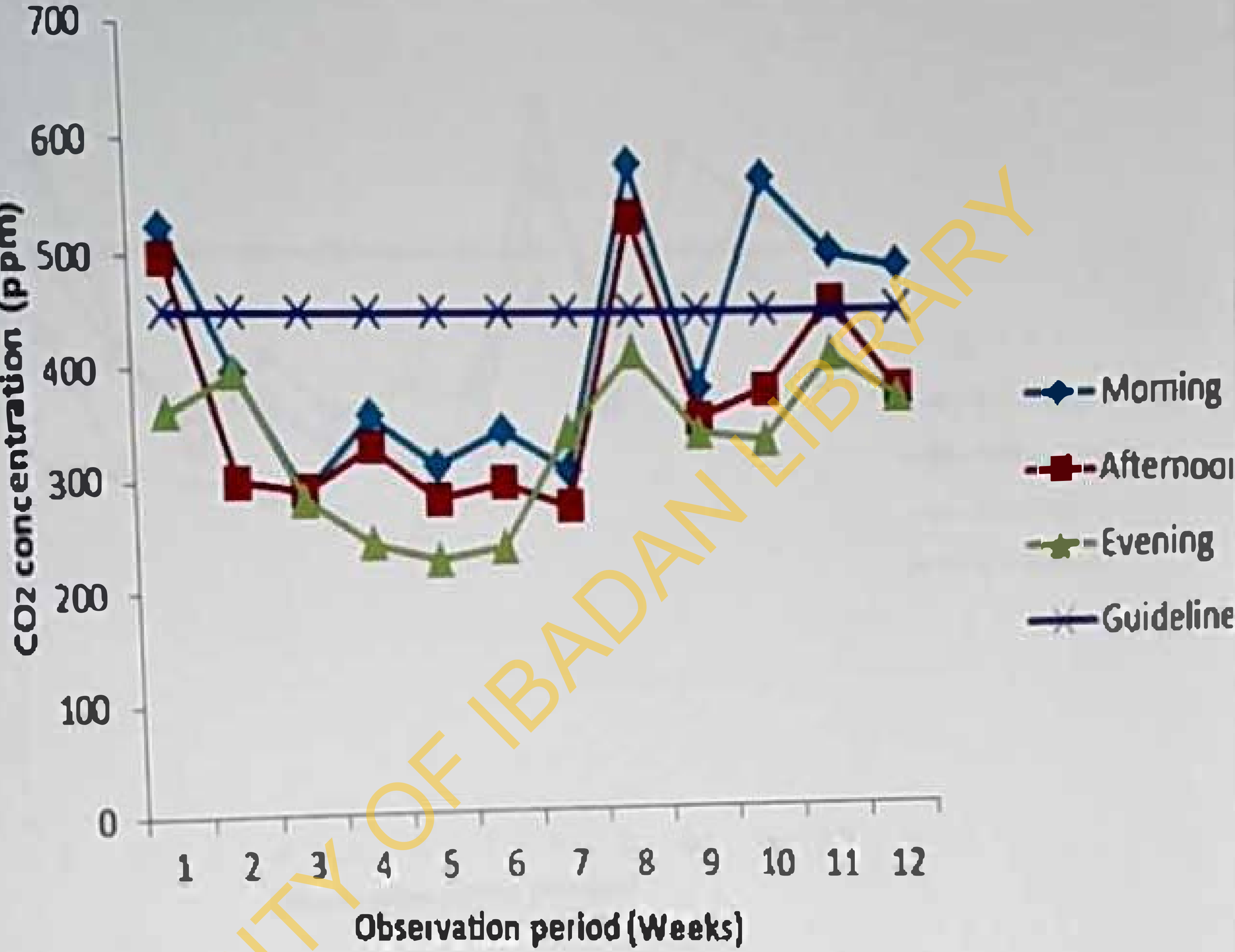



Figure 4.4b: Level of $CO_2$ in Amule Dumpsite

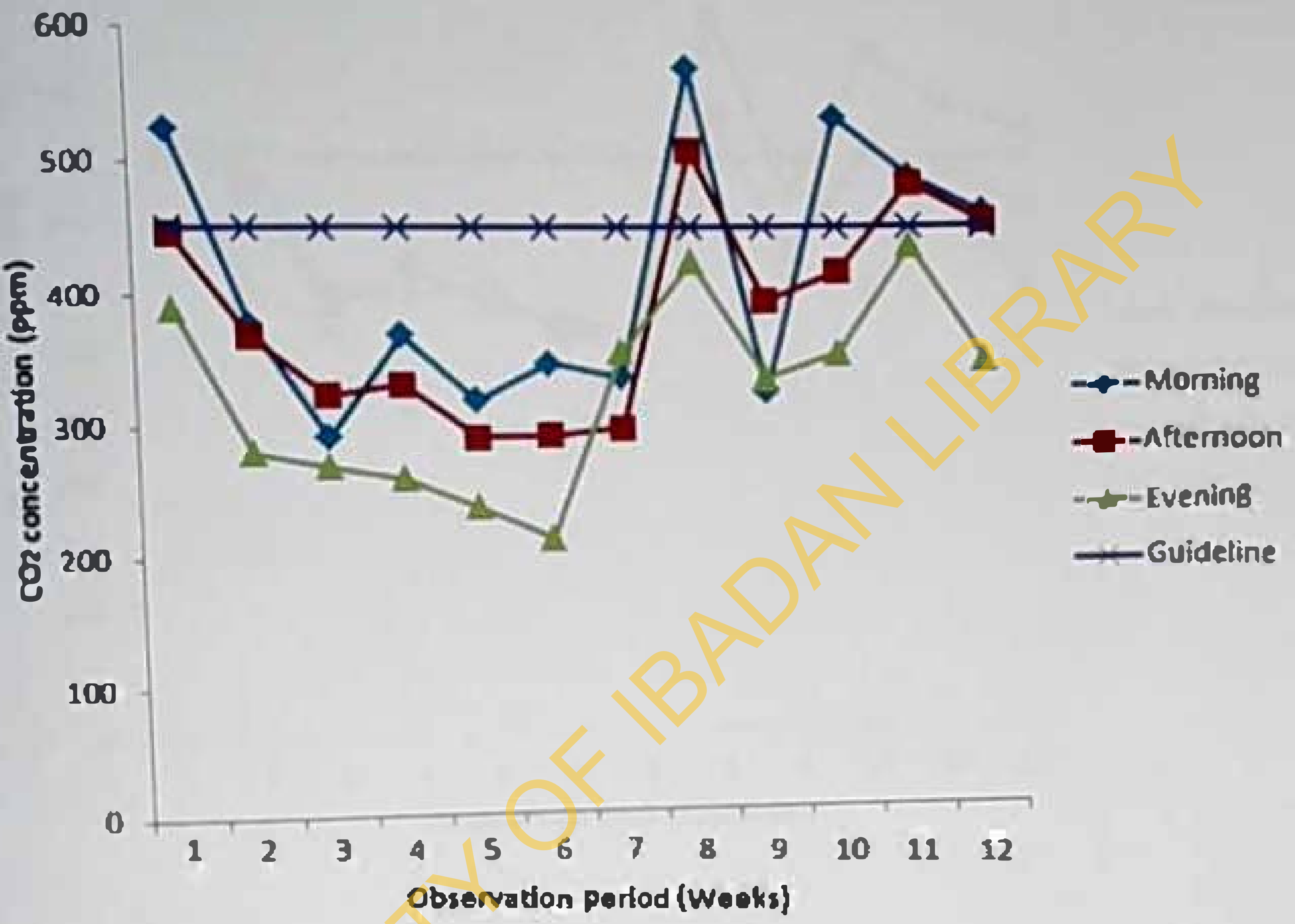



Figure 4.4c: Level of $CO_2$ in Ede Dumpsite

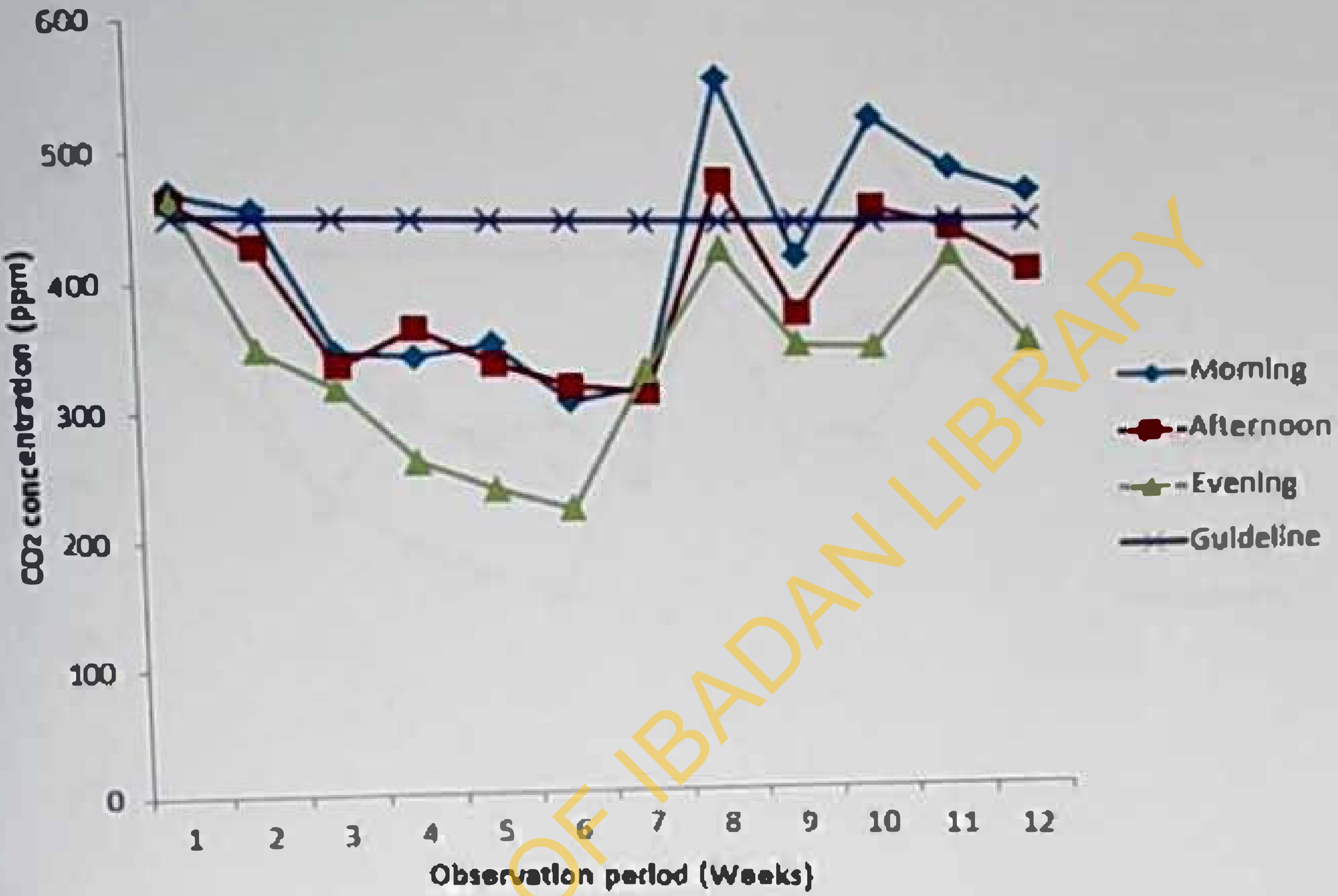



Figure 4.4d: Level of $CO_2$ in Genesis Dumpsite

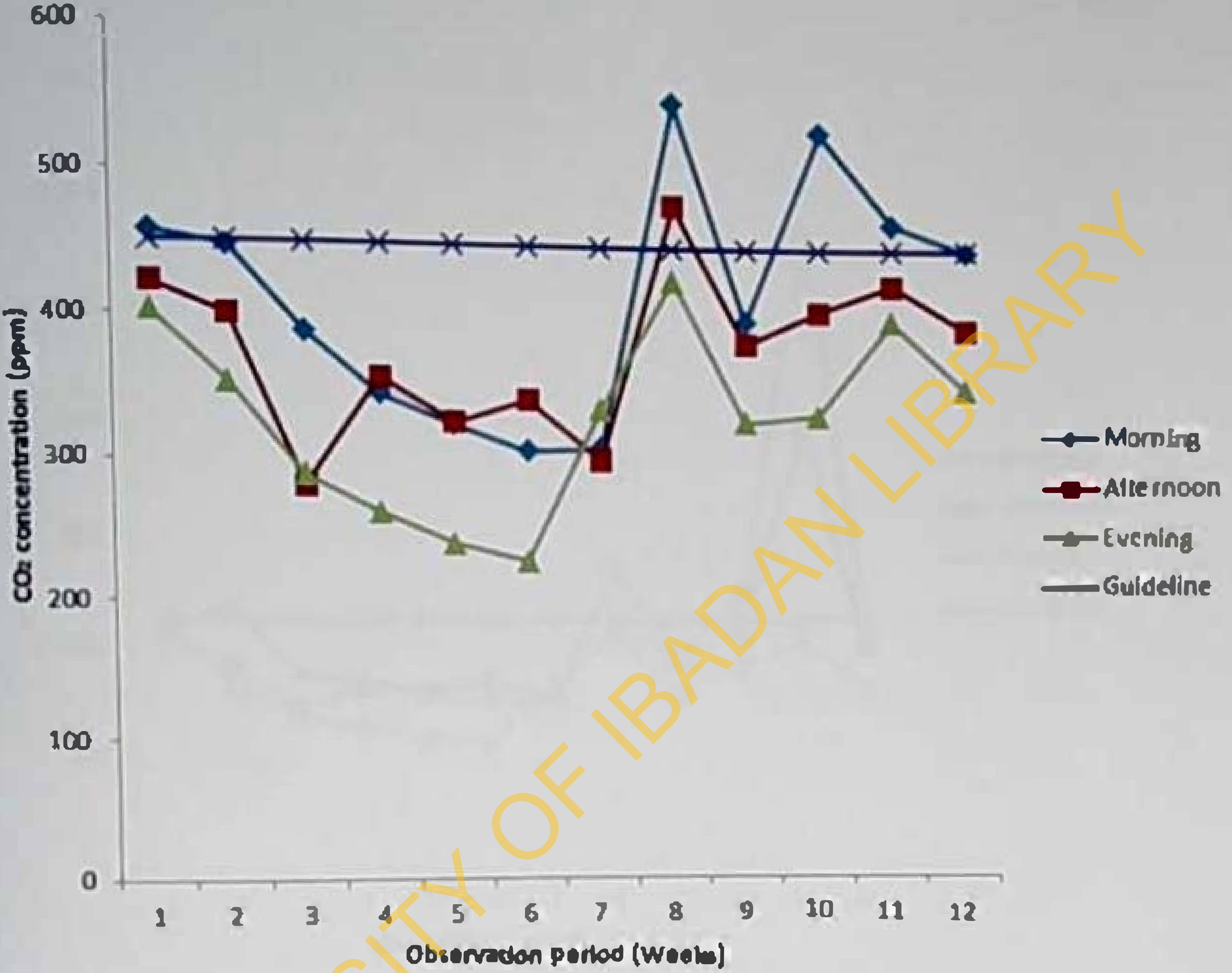



Figure 4.4c: Level of $CO_2$ in Cele Dumpsite

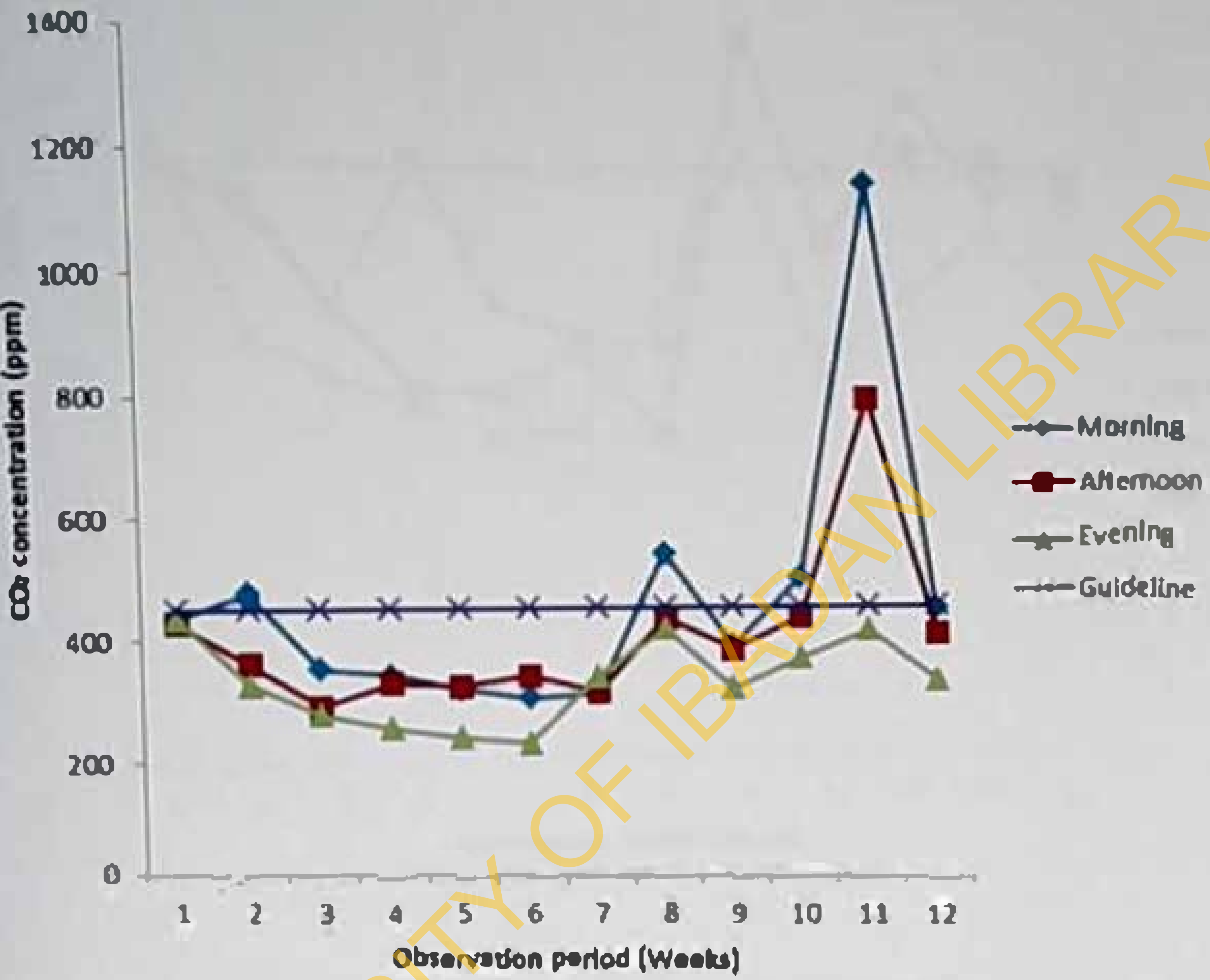



Figure 4.4f: Level of $CO_2$ in Jogor Dumpsite

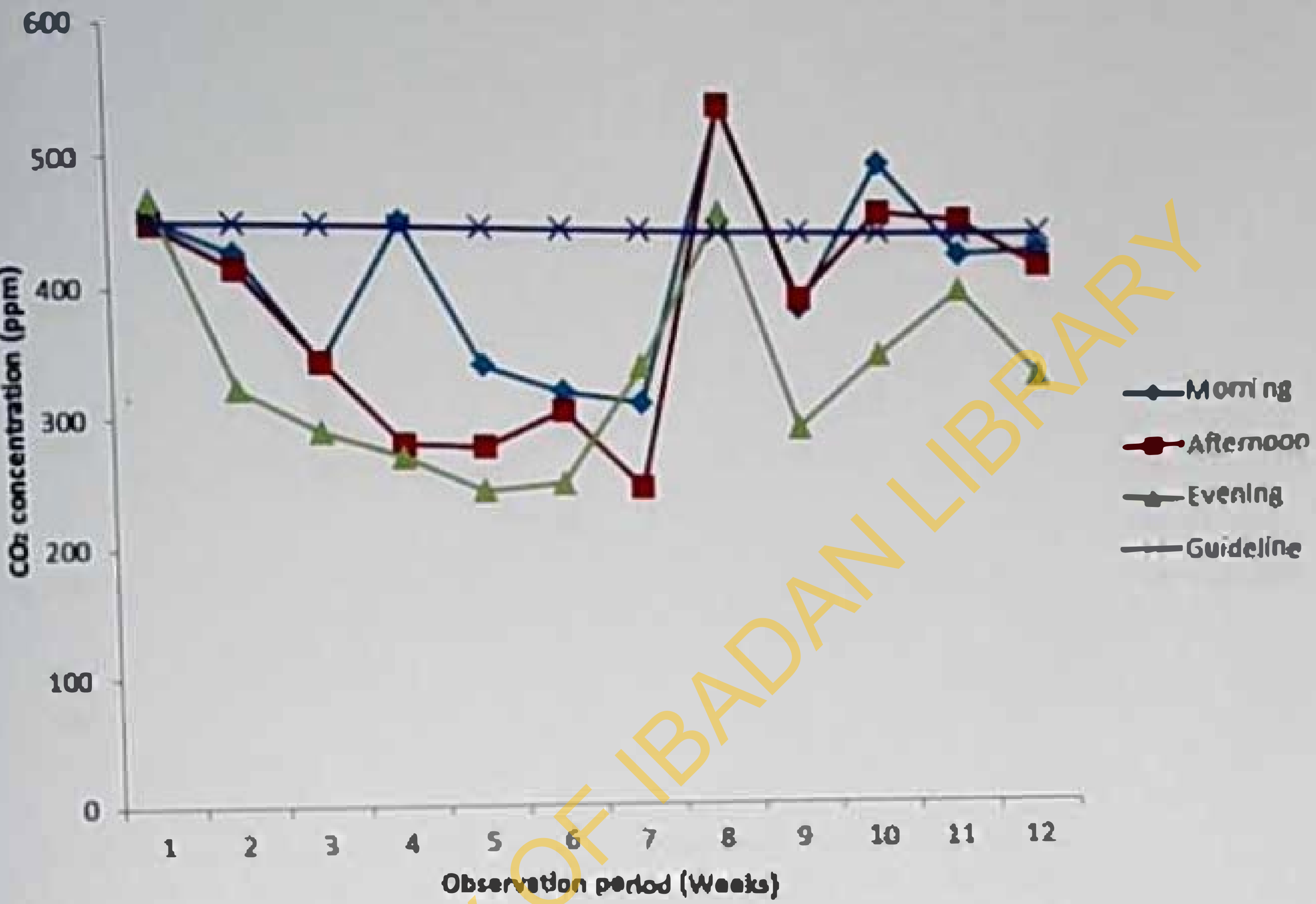



Figure 4.4g: Level of $CO_2$ in Area 1 Dumpsite

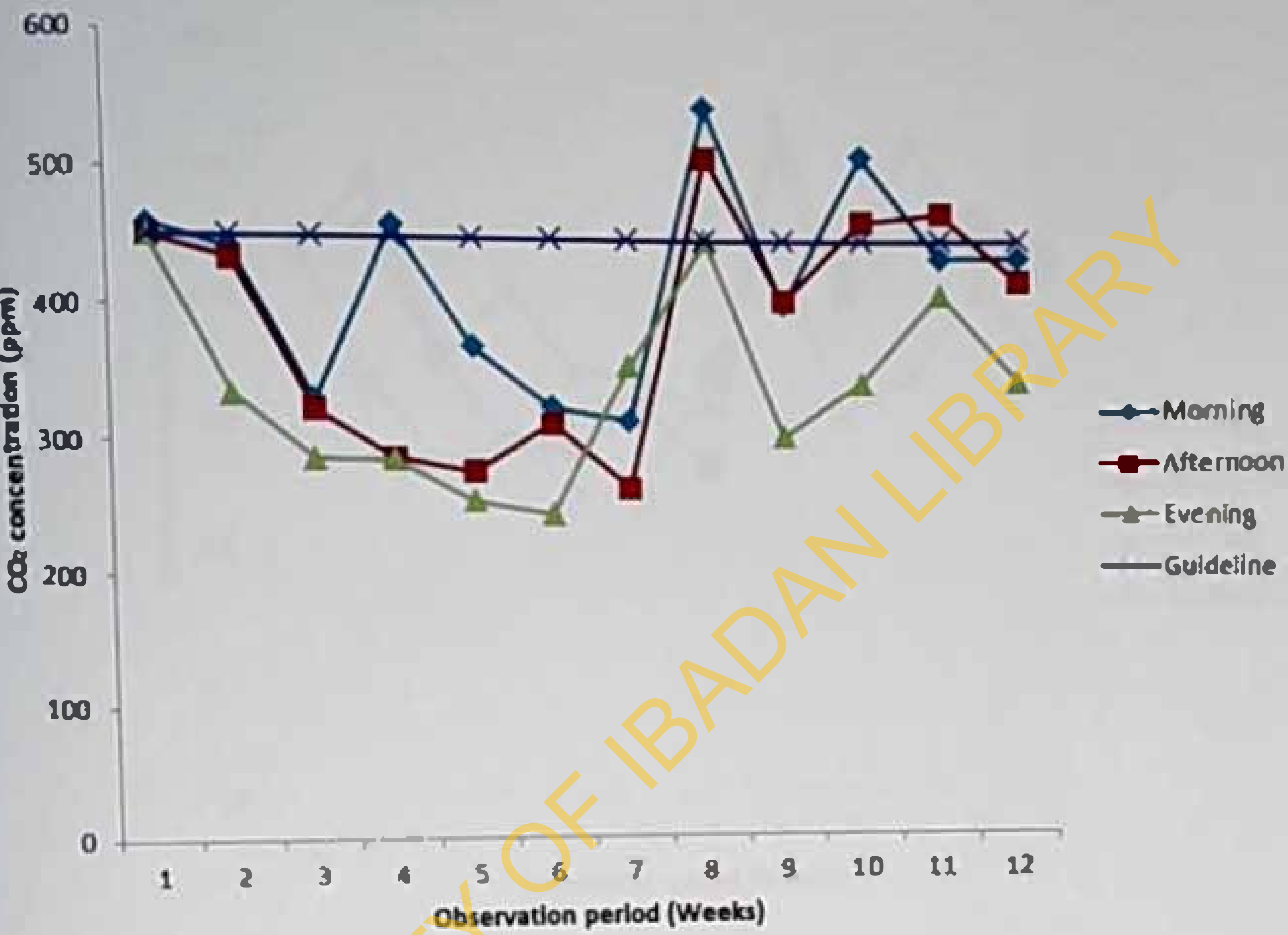



Figure 4.4b: Level of $CO_2$ in Area 2 Dumpsite

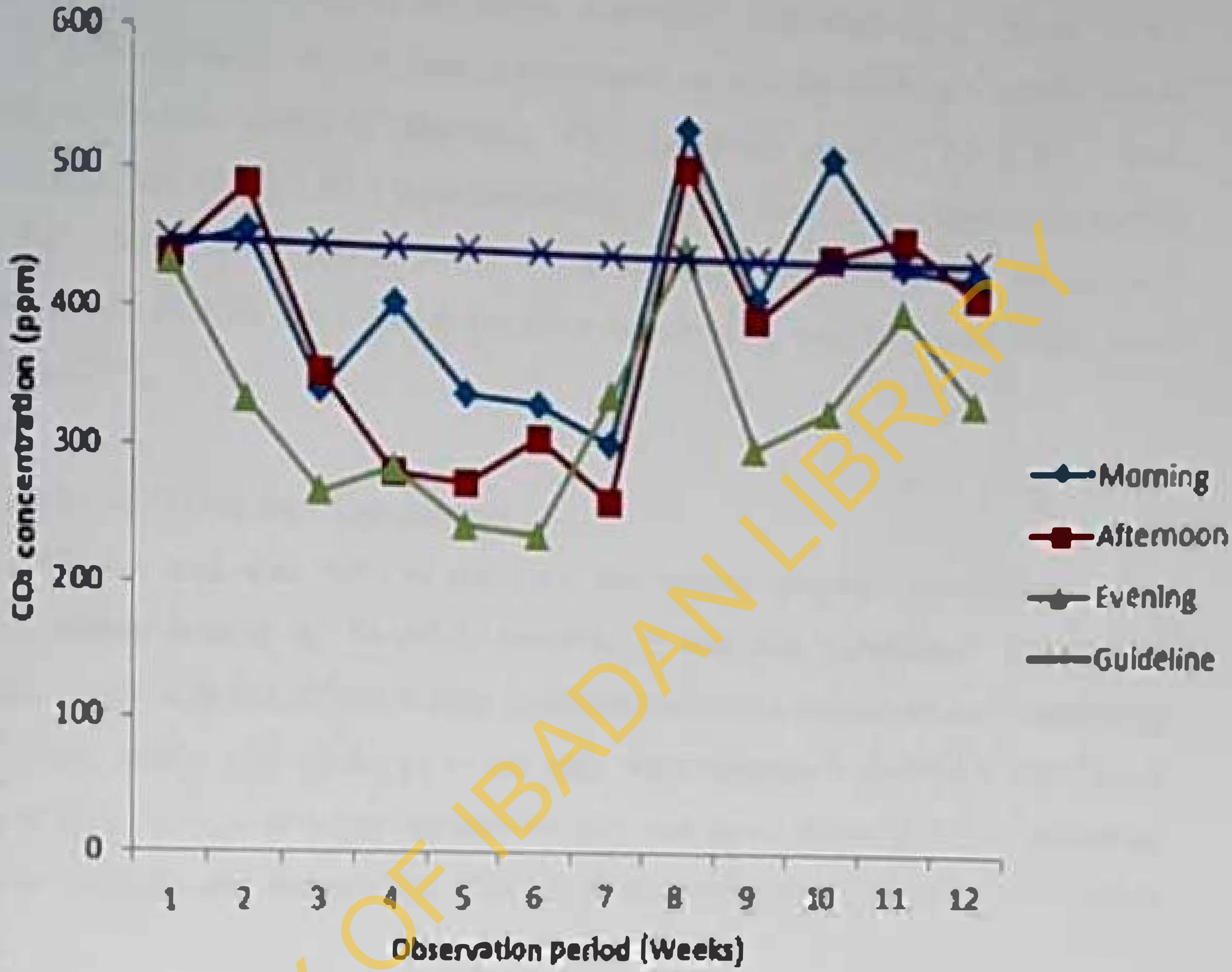



**Figure 4.4l: Level of $CO_2$ in Area 3 Dumpsite**

### 4.4.4. Mean $CO_2$ and Temperature levels

Table.4.3 shows the mean, standard deviation, minimum and maximum values of the temperature of each dumpsite at the time of measurement and the carbon dioxide levels. The mean carbon dioxide levels in Oke-foko, NTC, Iyaganku were: 372.5 ± 92.1 ppm, 385.6 ± 114.5 ppm and 380.8 ± 82.4 ppm respectively while the mean temperature scores were 29 ± 3.0°C, 29.6 ± 3.1°C and 28.9 ± 2.7°C. Also, from the table, it can be deduced that the mean carbon dioxide level across the three density area was 380 ppm while mean temperature was 29°C.

### 4.4.5. Analysis by ANOVA and Correlation

A one-way ANOVA test was used to compare the carbon dioxide levels from each dumpsite i.e. carbon dioxide by location, however it was not significant. Comparing carbon dioxide levels with the different days in which they were measured and comparing the carbon dioxide levels with weeks in which they were measured showed a significant difference ($p<0.05$). Also, a bivariate correlation test was done showing the relationship between carbon dioxide and temperature. The result showed a weak positive correlation ($R^2 = 0.0163$).

### 4.4.6. Relationship between $CO_2$ concentrations and other variables

The $CO_2$ concentrations were grouped into three (3) concentrations ≤ 350 ppm, 351 – 450 ppm and >450 ppm and were crossed tabulated with periods of the day (Table 4.4a), with the density areas (Table 4.4b) and with the weeks in which they were measured (Table 4.4c). There was a significant difference between the grouped $CO_2$ and the periods of the day and the weeks they were measured ($p<0.05$).

**Table 4.3: Variations in the Mean $CO_2$ and Temperature Levels across the three Density Areas**

| Statistics | Oke-foko | NTC Joyce B | Iyaganku GRA |
|---|---|---|---|
| **Carbon dioxide** | | | |
| Mean (ppm) | 372.5 | 385.6 | 380.8 |
| Standard deviation | 92.1 | 114.5 | 82.4 |
| Minimum value (ppm) | 212 | 224 | 240 |
| Maximum value (ppm) | 580 | 1157 | 548 |
| **Temperature** | | | |
| Mean (°C) | 29.0 | 29.6 | 28.9 |
| Standard deviation | 2.97 | 3.07 | 2.67 |
| Minimum value (°C) | 20.3 | 22.0 | 22.3 |
| Maximum value (°C) | 35.4 | 39.4 | 34.5 |

Table 4.4a: Relationship between $CO_2$ levels and the periods of the day

| $CO_2$ ranges (ppm) | Morning | Afternoon | Evening | P – value |
|---|---|---|---|---|
| ≤ 350 | 35 (32.4%) | 43 (39.8%) | 69 (63.9%) | |
| 351 – 450 | 33 (30.6%) | 40 (37%) | 35 (32.4%) | $p < 0.05$ |
| > 450 | 40 (37%) | 25 (23.1%) | 4 (3.7%) | |

Table 4.4b: Relationship between $CO_2$ levels and the different density areas

| $CO_2$ ranges (ppm) | Oke-foko | NTC Joyce B | Iyaganku GRA | P – value |
|---|---|---|---|---|
| ≤ 350 | 51 (47.2%) | 46 (42.6%) | 50 (46.3%) | |
| 351 – 450 | 32 (29.6%) | 42 (38.9%) | 34 (31.5%) | $P > 0.05$ |
| > 450 | 25 (23.1%) | 20 (18.5%) | 24 (22.2%) | |

Table 4.4c: Relationship between $CO_2$ levels and the various weeks of monitoring

| $CO_2$ ranges (ppm) | Week 1 | Week 2 | Week 3 | Week 4 | P – value |
|---|---|---|---|---|---|
| ≤ 350 | 33 (40.7%) | 71 (87.7%) | 32 (39.5%) | 11 (13.6%) | |
| 351 – 450 | 31 (38.3%) | 8 (9.9%) | 30 (37%) | 39 (48.1%) | $P < 0.05$ |
| > 450 | 17 (21%) | 2 (2.5%) | 19 (23.5%) | 31 (38.3%) | |

## 4.5. METHANE

The 2006 Intergovernmental Panel on Climate Change (IPCC) Waste model was used to predict the methane concentration in each dumpsite for a year.

### 4.5.1. Estimation of Methane Emissions

Data on amount of solid waste disposed to the illegal dumpsites were not available and the quantity of solid waste was estimated from urban population solid waste generation and disposal rate per person in developing countries which is 0.29 tonnes/capita/year (IPCC, 2006).

According to 2006 census report, the population of

Ibadan southwest = 282,585

Oke-foko = 36,255

NTC Joyce B = 5850

Iyaganku GRA = 2681

**IPCC default methodology**

Using the following equation for methane emission in Gg/year

Methane emission = $MSW_T \times MSW_F \times MCF \times DOC \times DOC_F \times F \times 16/12 \times (1 - OX)$

$MSW_T$ = Municipal Solid Waste generation rate for Ibadan x population of study site

= 0.51 kg/cap/yr x population of study site

$MSW_T$ (Ibadan southwest) = 0.51 x 282,585 = 144118.35 kg/year

For Okefoko = 0.51 x 36,255 = 18,490.05

NTC Joyce B = 0.51 x 5850 = 2983.5

Iyaganku GRA = 0.51 x 2681 = 1367.3

Based on the results obtained from the 2006 IPCC Waste Model it can be seen that highest methane emission was 0.000158Gg/yr for Oke-foko (high density area); 0.000026Gg/yr for NTC Joyce B area and 0.000012Gg/yr for Iyaganku GRA area. The table below shows the values obtained for each location. Below is a table showing all the variables and the result of the 2006 IPCC waste model.

Table 4.5: Shows the values for each constant and the $CH_4$ emission obtained using the 2006 IPCC waste model

| Parameters | Study Locations | | |
|---|---|---|---|
| | A | B | C |
| $MSW_T$(tonnes/yr) | 18490.05 | 2983.5 | 1367.3 |
| MCF | 0.4 | 0.4 | 0.4 |
| $MSW_F$ | 0.4 | 0.4 | 0.4 |
| $DOC_F$ | 0.686 | 0.694 | 0.685 |
| DOC | 0.117 | 0.117 | 0.117 |
| F | 0.5 | 0.5 | 0.5 |
| 16/12 | 16/12 | 16/12 | 16/12 |
| R | 0 | 0 | 0 |
| OX | 0 | 0 | 0 |
| $CH_4$ (kg/yr) | 158.298 | 25.840 | 11.689 |
| $CH_4$ (tonnes/yr) | 0.158 | 0.026 | 0.012 |
| $CH_4$ (Gg/yr) | 0.000158 | 0.000026 | 0.000012 |

Key: Okefoko (A); NTC Joyce B (B) and Iyaganku GRA (C)

Note: 1000tonnes = 1Gg

## 4.6. Socio-demographic Characteristics of Respondents

Table 4.6a shows the age of the respondents ranged from 12 – 81 years with a mean age of 33.3 ± 12.6 years and the age distribution followed a normal distribution pattern with the modal age group < 30years. The respondents were made up of 50% females and 50% males. The major ethnic group was Yoruba (92.7%) and 4.7% were Igbo. The major occupations of the respondents' include: trading, tailoring, carpentry, welding, teaching and so on; with 39% traders and 18% artisans. Classification of the respondents based on educational qualification into tertiary, secondary and others (primary, no formal education and Qur'an school) showed 198 (58%) stopped education at secondary school while 66 (19.4%) attained tertiary education and 77 (22.5%) others. 58% of the respondents are Christians and 43% are Muslims. About 184 (54%) of the respondents were married as at the time of the survey and 137 (40%) were unmarried, 15 (4.4%) were widowed.

Table 4.6b shows the occupation of the people. Trading (39%) was seen to be the major occupation of the people. The rest of the table shows that most of the respondents 44.6% had lived in their respective areas for about 1 – 5 years and 95 (27.9%) for 6 – 15 years, though 69.2% of all respondents live in rented houses and 102 (29.9%) live in their private homes. Most homes (51%) had 5 – 10 persons per household and 142 (43%) > 5 persons. While table 4.7c displays the respondents were grouped based on their density area: 276 (80.9%) were Oke-foko, while 45 (13.2%) NTC and 20 (5.9%) were from Iyaganku GRA. Also, higher proportions (69.2%) of the respondents live in houses that are rented.

Table 4.6a: Socio-demographic Characteristics of Respondents

| Variables | Frequency | Percentage (%) |
|---|---|---|
| **Age (years)** | | |
| ≤30 | 183 | 53.7 |
| 31 – 50 | 111 | 32.6 |
| >50 | 47 | 13.8 |
| **Sex** | | |
| Male | 170 | 49.9 |
| Female | 171 | 50.1 |
| **Ethnic group** | | |
| Yoruba | 316 | 92.7 |
| Others | 25 | 7.3 |
| **Marital Status** | | |
| Single | 137 | 40.2 |
| Married | 184 | 54 |
| Others | 20 | 5.9 |

Table 4.6b: Socio-demographic Characteristics of Respondents Contd.

| Variables | Frequency | Percentage (%) |
|---|---|---|
| **Educational Level** | | |
| Tertiary | 66 | 19.4 |
| Secondary | 198 | 58.1 |
| Others | 77 | 22.6 |
| **Occupation** | | |
| Trader | 133 | 39 |
| Artisan | 60 | 17.6 |
| Others | 148 | 43.4 |
| **Religion** | | |
| Christianity | 196 | 57.5 |
| Islam | 145 | 42.5 |
| **Number of persons /household** | | |
| <5 | 142 | 43.0 |
| 5 – 10 | 167 | 50.6 |
| >10 | 21 | 6.4 |

Table 4.6c: Socio-demographic Characteristics of Respondents Contd.

| Variables | Frequency | Percentage (%) |
|---|---|---|
| **Length of stay (years)** | | |
| 1 – 5 | 163 | 48.1 |
| 6 – 15 | 95 | 28.0 |
| 16 – 25 | 25 | 7.4 |
| >25 | 56 | 16.5 |
| **House Owner** | | |
| Private | 102 | 29.9 |
| Rented | 236 | 69.2 |
| Government | 3 | 0.9 |
| **Areas of distribution** | | |
| Oke-foko | 280 | 82.1 |
| NTC Joyce B | 38 | 11.1 |
| Iyaganku GRA | 23 | 6.7 |

## 4.7. Respondents' Knowledge

### 4.7.1. Greenhouse gases.

Based on the questions related to greenhouse gases, 156 (47.1%) agreed that greenhouse gases are harmful to the public and to the environment while 155 (46.8%) did not know if it was harmful. A higher number of the respondents 175 (52.7%) did not know that greenhouse gases cause climate change and 96 (28.2%) said that they were aware while 61 (17.9%) said greenhouse gases do not cause climate change. Also, 167 (50.6%) of the respondents did not know that municipal household wastes generate greenhouse gases while 154 (46.7%) agreed that household wastes produce greenhouse gases. 184 (55.4%) among all the respondents did not know that greenhouse gases cause increase in atmospheric temperature. From the information gathered 120 (35.2%) had an excellent knowledge of greenhouse gases while 179 (52.5%) had a fair knowledge. There was no significant difference across the three density areas.

### 4.7.2. Waste management

Based on the questions for waste disposal and management, 293 (86.4%) of the total respondents agreed that an illegal dumpsite is one that is not approved by government authority while 254 (75.6%) of respondents agreed that wastes thrown away can be used for other useful things such as farm manure, raw materials or reusable containers and 67 (19.6%) said they do not agree. Based on the survey of the good means of waste disposal methods: 196 (58.2%) agree that incinerator is a good means while 101 (30%) did not agree. For dig and bury, 189 (56.3%) did not accept it as a good means of waste disposal while 127 (37.8%) accepted it. For open dumping, 275 (82.6%) said no to open dumping while 47 (14%) said yes. For recycling, 236 (70.2%) agreed that recycling is a good means of waste disposal while 20.8% said no and 8.9% did not know if it was good. For disposal in gutter or streams, 250 (74.4%) do not agree that it was a good means of waste disposal while 75 (22.3%) accepted it as a good means of waste disposal. For composting, 187 (56%) agreed that composting was a good means of waste disposal, 87 (26%) did not agree and 60 (18%) did not know if it was good. Finally on knowledge, 312 (95.4%) of the total respondents accepted that diseases can be transmitted to humans from illegal dumpsites while 11 (3.4%) did not know if it was possible. From the information gathered 136 (39.9%) had good knowledge of waste disposal and management while 85 (24.9%) had a poor knowledge. There was a significant difference (p<0.05) across the three density areas.

The general knowledge of the respondents on waste management and Greenhouse gases across the three density areas showed 83% excellent knowledge, 72% Good knowledge, 79% fair knowledge and 82% poor knowledge at Okefoko; 10% excellent knowledge, 20% good knowledge, 14% fair knowledge and 18% poor knowledge for NTC Joyce B and 7% excellent knowledge, 8% good knowledge, 7% fair knowledge and 0% poor knowledge for Iyaganku GRA. Figure 4.3 shows the general knowledge of respondents on Greenhouse gases and waste management across the density areas.

### 4.7.2. Relationship between Respondents' Knowledge and some Socio-demographic Characteristics

Several socio-demographic characteristics were compared to the knowledge categories (Excellent, Good, Fair and Poor). When age was compared, 58% of respondents <30years had excellent knowledge, 31% of those between ages 31 – 50 years and 10% of those aged >50 years had excellent knowledge. In comparison with sex, men had a higher percentage (59%) of excellent knowledge while 61% of respondents who had attained secondary education had excellent knowledge. There was a significant difference between the socio-demographic characteristics and knowledge category (p <0.05). This can be seen in table 4.7. below.

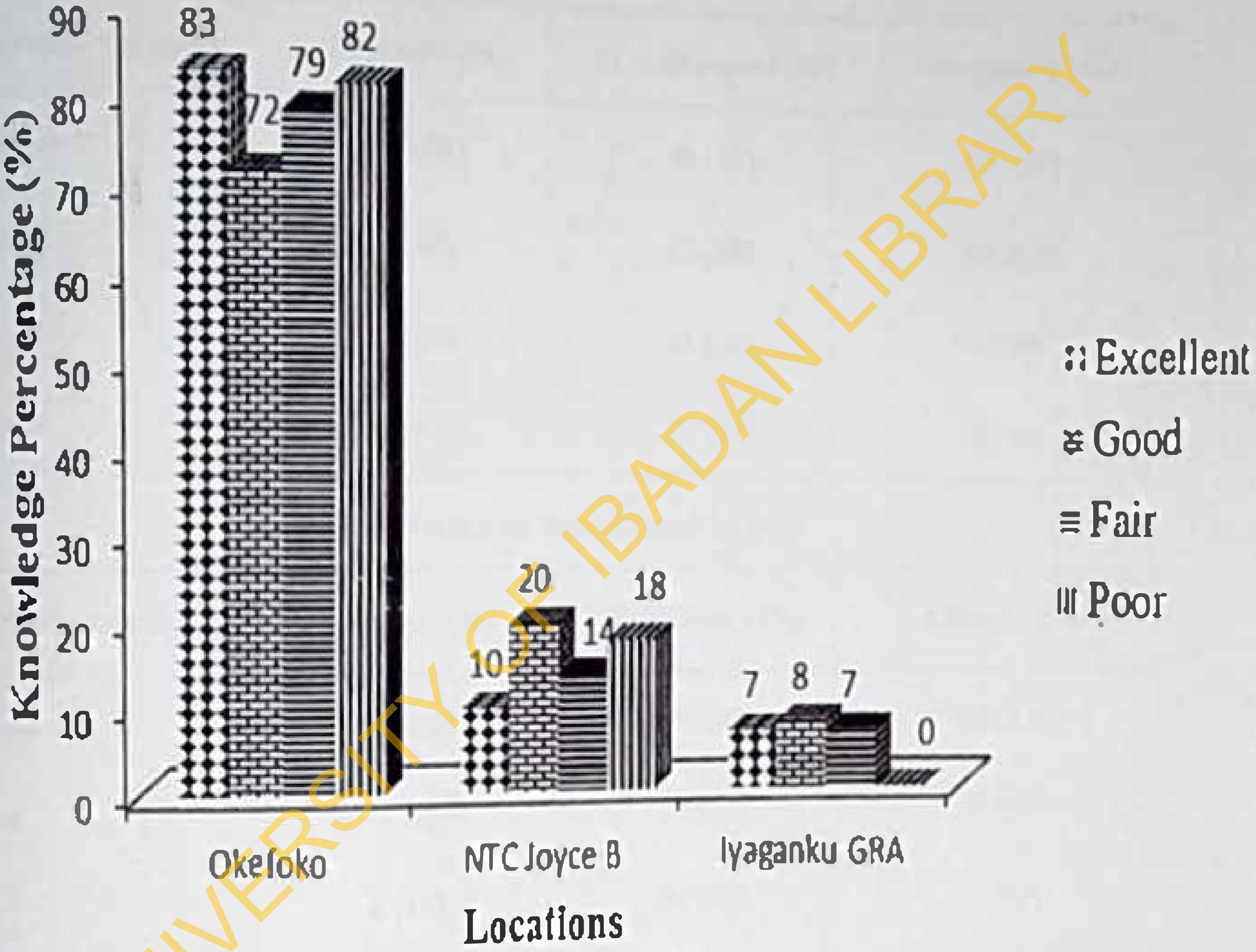



Fig.4.5: Respondent's knowledge across the density areas

Table 4.7a: Relationship between knowledge and some socio-demographic characteristics

| Knowledge vs. Age | | | |
|---|---|---|---|
| Knowledge Category | <30years f (%) | 31 – 50 years f (%) | >50 years f (%) |
| Excellent | 122 (58) | 66 (31) | 22 (10) |
| Good | 16 (40) | 11 (28) | 13 (33) |
| Fair | 23 (55) | 15 (36) | 4 (9) |
| Poor | 22 (45) | 19 (39) | 8 (16) |

| Knowledge vs. Educational level | | | |
|---|---|---|---|
| Knowledge Category | Tertiary f (%) | Secondary f (%) | Others f (%) |
| Excellent | 53 (25) | 129 (62) | 28 (13) |
| Good | 3 (7) | 22 (55) | 15 (38) |
| Fair | 6 (14) | 24 (57) | 12 (29) |
| Poor | 4 (8) | 23 (47) | 22 (45) |

Table 4.7b: **Relationship between knowledge and some socio-demographic characteristics contd.**

| Knowledge vs. Sex | | |
|---|---|---|
| Knowledge Category | Male f (%) | Female f (%) |
| Excellent | 124 (59) | 85 (40) |
| Good | 15 (38) | 25 (63) |
| Fair | 14 (33) | 28 (67) |
| Poor | 17 (35) | 32 (65) |

## 4.8. Respondents' Attitude towards Waste management

Results obtained from the attitude of respondents showed the general mean attitude score was 36.6 ± 5.58 while the mean attitude score for high, medium and low areas were 36.0 ± 4.96, 39.1 ± 8.04 and 38.2 ± 5.27 respectively. About 201 (59%) of the respondents strongly disagreed with wastes being dumped anywhere while 111 (33%) disagreed that separation of wastes at source is a good means of waste management and 109 (32%) agreed that it was a good means of waste management. Also, 174 (51%) of the respondents agreed to the fact that illegal dumping of wastes was harmful to health while 156 (46%) support the fact that waste dumpsites should not be located near residential areas. When asked if government was responsible for waste management or individuals or combination of both, a higher proportion of 138 (41%) said government should be responsible, 110 (33%) agreed to individuals while 123 (37%) agreed to a combination of both. However when asked if they were willing to pay for their wastes to be cleared, 79% supported but 54% were willing to pay only twenty naira (₦20).

From the information gathered 143 (42%) had good attitude towards waste management while 12 (3.5%) had poor attitude. There was no significant difference across the three density areas.

The general attitude of the respondents on waste management and Greenhouse gases across the three density areas showed 68% excellent attitude, 89% Good attitude, 87% fair attitude and 83% poor attitude at Okefoko; 23% excellent attitude, 8% good attitude, 5% fair attitude and 17% poor attitude at NTC Joyce B and 9% excellent attitude, 3% good attitude, 8% fair attitude and 0% poor attitude at Iyaganku GRA. Figure 4.4 shows the general attitude of respondents towards Greenhouse gases and waste management across the density areas.

### 4.8.1. Relationship between Respondents' Attitude and some Socio-demographic Characteristics

In table 4.8, attitude to waste management was compared to respondents' age, a higher percentage (45%) was obtained among respondents' within the <30 years age group. Comparison of attitude category with sex showed women had a higher percentage of 52% of good attitude while 50% of respondents; who had attained secondary education had excellent attitude. There was a significant difference between the socio-demographic characteristics and knowledge category ($p < 0.05$).

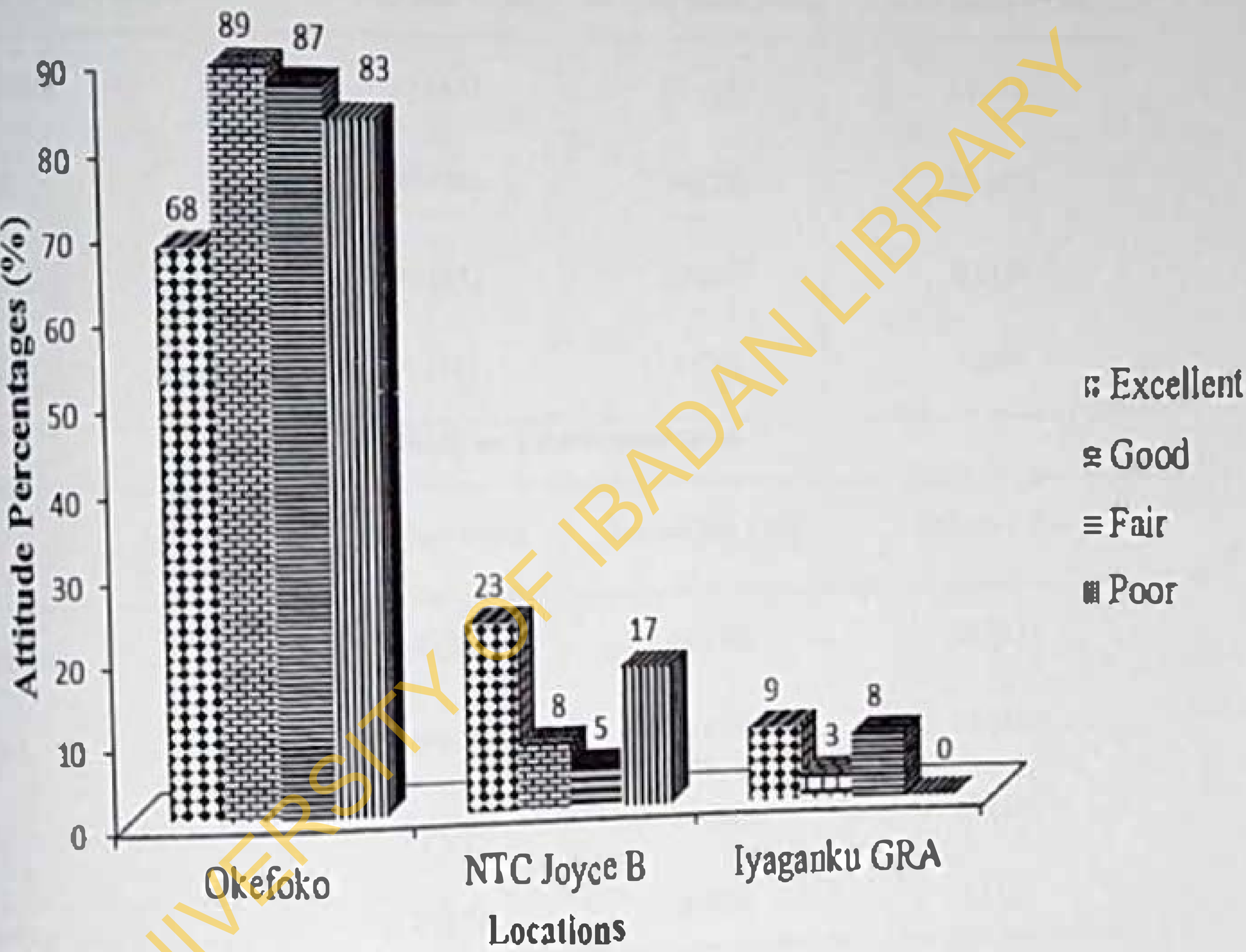



Fig.4.6: Respondent's attitude towards waste management across the density areas.

**Table 4.8a: Relationship between Attitude and some Socio-demographic Characteristics**

| Attitude vs. Age | | | |
|---|---|---|---|
| Knowledge Categories | < 30 years f (%) | 31 – 50 years f (%) | >50 years f (%) |
| Excellent | 55 (45) | 53 (43) | 14 (12) |
| Good | 80 (56) | 38 (27) | 25 (17) |
| Fair | 39 (61) | 17 (27) | 8 (12) |
| Poor | 9 (75) | 3 (25) | 0 (0) |
| **Attitude vs. Educational level** | | | |
| | Tertiary f (%) | Secondary f (%) | Others f (%) |
| Excellent | 35 (29) | 61 (50) | 26 (21) |
| Good | 19 (13) | 85 (59) | 39 (28) |
| Fair | 10 (16) | 44 (68) | 10 (16) |
| Poor | 2 (17) | 8 (67) | 2 (16) |

Table 4.8b: Relationship between Attitude and some Socio-demographic Characteristics contd.

| Attitude vs. Sex | | |
|---|---|---|
| | Male f (%) | Female f (%) |
| Excellent | 63 (52) | 59 (48) |
| Good | 68 (48) | 75 (52) |
| Fair | 35 (55) | 29 (45) |
| Poor | 4 (33) | 8 (67) |

## 4.9 Respondents' Practice towards Waste Management

Table 4.9 shows some of waste management practices carried out by the respondents. The result showed that 70% burnt their wastes, 14% threw them into the streams and rivers around and 10% said government cleared their wastes in the high density area. In the medium density area 46.5% burn their wastes, 25.6% throw into streams or rivers while 18.6% said government cleared their wastes. In the low density area 40% burn their wastes, 10% throw into rivers or gutters and 50% said government clear their wastes.

Considering the different containers used in collection of wastes in homes, Table 4.9 shows that a higher proportion (42.2%) in the high density area use bucket/drum for storing their wastes, while 41.5% and 33.3% in the medium and low density areas respectively make use of nylons for collecting their wastes at home.

Table.4.9: Respondents waste management practices

| | Oke-foko Frequency (%) | NTC (Joyce B) Frequency (%) | Iyaganku GRA Frequency (%) |
|---|---|---|---|
| **How do you manage the dumpsite** | | | |
| Burn it | 170 (70) | 20 (46.5) | 8 (40) |
| Push into river | 34 (14) | 11 (25.6) | 2 (10) |
| Government clears it | 24 (9.9) | 8 (18.6) | 10 (50) |
| Others | 15 (6.2) | 4 (4.1) | 0 (0) |
| **What do you use to store your waste?** | | | |
| Carton | 9 (3.3) | 14 (34.1) | 2 (16.7) |
| Nylon | 100 (36.4) | 17 (41.5) | 4 (33.3) |
| Bucket/drum | 116 (42.2) | 2 (4.9) | 3 (25) |
| Basket | 42 (15.3) | 4 (9.8) | 2 (16.7) |
| Nothing | 8 (2.9) | 4 (9.8) | 1 (8.3) |

## 4.10. Respondents' Health Status and Health Risks

Table 4.10 shows the health risks and status of respondents. Here, the respondents who replied that their wastes were being burnt were further questioned what problems they encountered when burning and 63.5% in Oke-foko, 82.8% in NTC and 81.8% in Iyaganku GRA complained of smoke disturbance while 12.2%, 17.2% and 18.2% stated they faced no problems whatsoever respectively. When questioned if the dumpsite disturbed them in any way, 28% in Oke-foko, 41.2% in NTC and 30.8% in Iyaganku GRA responded that it does.

The following are some of the indicators used to assess health risks such as rodent infestation, water contamination, and sickness and so on: about 30.9%, 47.4% and 33.3% in the high, medium and low density areas affirmed they suffer from rodent infestation. 91.2%, 57.9% and 66.7% in the high, medium and low areas complained about bad odour emanating from the dumpsites. Also, 10.45 and 5.3% of the residents in the high and medium density areas respectively affirmed the dumpsites contaminate their water. While 26.9% and 5.6% in the high and medium density areas respectively said they suffered from sickness/ diseases due to the presence of the dumpsites.

Some of the common sickness/diseases suffered were grouped into malaria, cough/catarrh and others (cholera, diarrhoea, sore-throat, headaches) where 92.9% of the residents in the high density areas, 47.7% in the medium density area and 55.6% of the low density area had had malaria; 49.2%, 43.2% and 27.8% respectively had had cough/catarrh while 2.1%, 17.3% and 18.1% had suffered other diseases.

Table4.10a: Health status and Health risks of respondents

| | OKE-FOKO Frequency (%) | NTC (JOYCE B) Frequency (%) | IYAGANKU GRA Frequency (%) |
|---|---|---|---|
| | Problems faced when burning wastes | | |
| No problem | 24 (12.2) | 5 (17.2) | 2 (18.2) |
| Smoke disturbance | 125 (63.5) | 24 (82.8) | 9 (81.8) |
| Others | 48 (24.4) | 0 (0) | 0 (0) |

Table4.10b: Health status and Health risks of respondents contd.

| Health Indicators | Oke-foko Frequency (%) | | NTC Joyce B Frequency (%) | | Iyaganku GRA Frequency (%) | |
|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No |
| Does the dumpsite disturb you? | 75 (28.4) | 189 (71.6) | 14 (41.2) | 20 (58.8) | 4 (30.8) | 9 (69.2) |
| Rodent infestation | 21 (30.9) | 47 (69.1) | 9 (47.4) | 10 (52.6) | 2 (33.3) | 4 (66.7) |
| Bad odour | 62 (91.2) | 6 (8.8) | 11 (57.9) | 8 (42.1) | 4 (66.7) | 2 (33.3) |
| Spoils water | 7 (10.4) | 60 (89.6) | 1 (5.3) | 18 (94.7) | 0 (0) | 6 (100) |
| Sickness/diseases | 18 (26.9) | 49 (73.1) | 1 (5.6) | 17 (94.4) | 0 (0) | 8 (100) |
| Is there a water body near the dumpsite? | 135 (51.5) | 127 (48.5) | 14 (56) | 11 (44) | 0 (0) | 11 (100) |
| Do you make use of the water? | 10 (6.6) | 142 (93.4) | 13 (76.5) | 4 (23.5) | 0 (0) | 0 (0) |
| **Common sickness suffered** | | | | | | |
| Malaria | 248 (92.9) | 19 (7.1) | 21 (47.7) | 23 (52.3) | 10 (55.6) | 8 (44.4) |
| Cough and catarrh | 131 (49.2) | 135 (50.8) | 19 (43.2) | 25 (56.8) | 5 (27.8) | 13 (72.2) |
| Others | 22 (2.1) | 244 (97.9) | 29 (17.3) | 237 (82.7) | 12 (18.1) | 254 (81.9) |

# CHAPTER FIVE

# DISCUSSION

This study characterised illegal dumpsite wastes and assessed their greenhouse gas emissions in Ibadan Southwest Local Government Area, Oyo State. The chapter further explains the results obtained from the onsite observation of the dumpsites, characterization of the wastes into their different components, the monitoring of $CO_2$ and $CH_4$ emission levels and the knowledge, attitude and practices of the respondents to waste management and greenhouse gases and the health risks and status of the respondents.

## 5.1. Nature of vicinity within and around the dumpsites

Based on the onsite observation, there were about 30, 15 and 10 open dumpsites observed in Okefoko, NTC Joyce B and Iyaganku ORA respectively. They were scattered and lacked fences. This presents a host of problems as the open dumps expose people, animals, and the environment to serious risks (Remigios, 2010). The dumpsite composed of different types of wastes; they are not separated. In Ibadan, Nigeria, pathological wastes and sharps from the city's hospitals are dumped in an unregulated and haphazard manner in open dumpsites at Aba-Eku, Aperin-Oniyere, and Ajakanga (Agunwamba, 1998).

Two (2) dumpsites each at the high and medium density areas were situated on water bodies which could contaminate the groundwater by leachate which contains trace elements (Remigios, 2010). It also create breeding grounds for disease vectors such as mosquitoes, flies, cockroaches and so on since part of the organic wastes are human excreta in some of the dumpsites. Some of the wastes are washed into rivers or streams nearby when it rains.

In Oke-foko and NTC most of the roofs were moderately adequate i.e. it showed signs of rust; while the roofs in Iyaganku ORA were adequate. More than 50% of the dumpsites are situated close to residential areas and this exposes the people to odor, dust, diseases such as malaria, cholera, dengue, diarrhea etc (Adedipe et al, 2005). Rapid urbanization has resulted in existing dumping sites originally located at a safe distance outside the municipal boundaries to becoming increasingly encircled by settlements and housing estates (Schertenleib & Meyer, 1992). Oyaro (2003) noted that tests conducted on 328 children living near the Dandora dumpsite showed about 50% of them had large concentrations of lead in their blood. They were also disproportionately affected by anemia, skin infections, asthma, and other respiratory diseases. These conditions are associated with high levels of toxins at the dumpsite, which receives plastics, rubber, wood, metals, chemicals, and hospital waste (Environmental News Services, 2007; Oyaro, 2003).

Furthermore, the study areas lacked any form of waste disposal equipment such as skip bins and so most of their wastes were openly disposed on water bodies, roadsides or open spaces. Maintenance of the open dumps was also an issue; there was no compaction and covering of waste. As a result waste was easily dispersed by wind, making it an eyesore as plastics litter the area around the dump (Agunwamba, 1998). The uncontrolled manner in which solid waste is disposed of at most open dumpsites creates serious health problems to humans, animals, and environmental degradation. This inadequate waste disposal translates into economic and other welfare losses (Zurbrugg, 2002). The results of improperly managed solid waste are evident in public health-related disease incidence, sometimes leading to serious morbidity and mortality (Adedipe 2002; Onibokun et al. 2000).

Greater than 60% of the dumpsites had scavengers roaming through the wastes and picking items of interest. This could expose them to injuries and other health effects. Burning of these wastes disposed along roadside could pose risks such as accidents due to poor visibility. Also, smoke emissions from burning of solid wastes have been known to cause upper respiratory tract infections. More so, though most of these areas lacked industries, in Oke-foko battery smelters melting batteries were often seen releasing thick smoke containing harmful gases. In a study carried out on leachates collected from Ibadan and Lagos dumpsites; appreciable levels of dissolved solids, chloride, ammonia, chemical oxygen demand (COD), lead, iron, copper, and manganese were observed. This was most likely a result of rampant dumping of lead acid car batteries and metal scraps (Ikem *et al*, 2002).

## 5.2. Characteristics of Wastes at different Dumpsites

Among the three density areas studied none of them had any waste collection bin. However, Iyaganku GRA had drums or nylons while in Oke-foko and NTC most of them dumped in open places somehow commonly accepted. Though, NTC used to have skip bins but was removed while in Oke-foko it is said they have not had skip bins since the 80s. Municipal solid wastes are generally made up of paper, vegetable matter, plastics, metals, textiles, rubber and glass (USEPA 2002; Garg, 2009). The wastes characterized in this study were grouped into organic, nylons, plastics, paper, metals and others. Others include: cloths, attachments, rubber, leather, wood, sand etc.

However, in a study carried out by Bruinders *et al* (2010), the waste samples were sorted into 10 material classes; Paper, Beverage Containers, Plastics, Glass, Metals, Organics, C&D, Inorganics, Household Hazardous Waste (HHW), and Textiles. It was observed that Organics, Paper, and Plastics classes accounted for over 72% (31.9%, 28.0% and 12.4% respectively) of the wastes from the residential areas. While in a study carried out by Parizeau *et al* (2006) observed that the waste stream in the study area was mostly organic in nature (66% by weight). Also, Parizeau *et al*. (2006) stated that this amount is similar to that found in residential waste characterization studies in other developing countries For example, Bolaane and Ali, (2004) in Gabarone, Botswana found that 68% of waste by weight is putrescible; Bernache-Perez et al., (2001) discovered that 53% of waste by weight is putrescible in Guadalajara, Mexico, while Chung and Poon, (2001) discovered that 58% is putrescible by weight in Guangzhou, China.

In the total percentage of the wastes characterized across the three density areas, it can be seen that organics and nylon had the same proportion of 36%, plastics – 7.1%, paper – 10%, metals – 6% and others – 5.1%. Also, of the waste sample characterized in Oke-foko, 51.3% was nylon and 21.7% was organics while paper and others had the lowest percentage of 5.3%. Of the 5kg characterized in NTC (Joyce B), 35.2% was organics while 31.3% was nylon while metals had the lowest percentage of 5.6%. Finally, in

Iyaganku GRA, 50% was organics and 25% was nylon while plastics and others were as low as 3.3%. The high proportion of nylon could have been as a result of the increase in the use of water in sachets (pure water), nylons used to buy food stuffs and items from the market etc. The large amount of organics obtained from the low density area was due to the presence of the fruit sellers who dumped their decayed fruits into a nearby gully.

### 5.3. Levels of Carbon dioxide

The level of $CO_2$ measured over the 12 weeks in the three density areas showed a mean concentration of 372.5 ± 92.1, 385.6 ± 114.5 and 380.8 ± 82.4 ppm in Oke-foko, NTC Joyce B and Iyaganku GRA respectively. The $CO_2$ measured over the 12weeks of study showed an increase with increase in temperature. Also, within the 12 weeks monitoring period, a temperature range of 20.3°C to 39.4°C was observed. $CO_2$ also increased while burning the wastes. Jogor dumpsite had the highest $CO_2$ level (1157 ppm) on the 11th week which exceeded the guideline limit (350 – 450 ppm). This could be due to the fact the waste was being burnt at the time of measurement.

Continuous burning of wastes and other substances could lead to higher concentration of $CO_2$ in the environment exceeding the guideline limit thereby inadvertently leading to an increase in global warming and other $CO_2$ related effects such as stiffness, odor, drowsiness, headache, sight impairment and at extreme levels of 100,000 ppm, unconsciousness and death (www.EngineeringToolBox.com).

Also, there was a significant difference between the $CO_2$ emissions and the days measured though not significant with location. This means that wastes disposed vary with each day i.e. Some days could have more organic wastes while other days could have more plastics or nylons etc and when burnt, different wastes generate different gases at different concentrations.

### 5.3. Levels of Methane

Methane, the second largest greenhouse gas, is not toxic; however, it is highly flammable and may form explosive mixtures with air. When structures are built on or close to landfills, methane off-gas can penetrate the buildings' interiors and expose occupants to significant levels of methane.

The estimation of $CH_4$ emission from landfills is important for assessing landfills emission inventories. The IPCC 2006 Default Model allows countries with limited waste management data to estimate national $CH_4$ emissions over a time series. It could be seen that the municipal solid waste generation rate for Oke-foko, NTC and Iyaganku GRA were 18,490.05, 2983.5 and 1367.3 kg/year respectively. The generation rate is directly proportional to the population of the area i.e. the larger the population the more the generation rate of wastes.

The methane emission for Oke-foko, NTC and Iyaganku GRA were 0.000158 Gg/yr., 0.000026 Gg/yr. and 0.000012 Gg/yr. respectively. From the estimated methane emission generated in each of the areas, it is obvious that the quantity generated is quite small and this could be due to the fact that all the dumpsites were exposed to rainfall which increases oxygen levels thereby inhibiting anaerobic digestion. However, a combination of all the methane emissions from all the dumpsites in every nook and cranny in Ibadan accumulated every year for the next 50years could be enormous.

### 5.4. Effects of $CH_4$ & $CO_2$ Emissions

Improper waste management also increases greenhouse gas (GHG) emissions, which contribute to climate change. Literature has shown that methane gas has warming potential 21times than that of carbon dioxide gas. The higher the heat trapping potential of the gas, the greater the impacts on climate change (US EPA, 2002). Also, the sources of greenhouse gases are many and this study was only focused on greenhouse gases from solid wastes. Therefore, adding up other sources of these gases and their emissions, it will give us a clear picture of the greenhouse gases being emitted especially in developed and developing countries including Nigeria.

These greenhouse gases ($CH_4$ & $CO_2$) are known to be major contributors to climate change. Global climate changes, driven by increased concentrations of greenhouse gases such as $CO_2$, are having widespread impacts on biotic systems, including both direct and indirect effects on human health (Patz et al., 2005). The two best-defined 'global environmental changes' are the depletion of stratospheric ozone by the emission of ozone-destroying gaseous emissions (especially chlorofluorocarbons) and the accumulation of heat-trapping greenhouse gases in the lower atmosphere (McMichael, 1993). This implies that; although the gaseous emissions arise from diverse localized sources, in all continents; their environmental impact is of a diffuse globalized kind. Thus, these local emissions result in integrated global changes. These changes entail a range of hazards to the human health, some of which are beyond direct assessment from existing scientific knowledge (McMichael, 1993); this necessarily extends the environmental health research agenda.

The health effects of climate change would encompass direct and indirect, immediate and delayed effects. While some health outcomes in some populations would be beneficial—for example, some tropical regions may become too hot for mosquitoes or other disease vector organisms, or winter cold-snaps may become milder in temperate zones--most health effects would be adverse (McMichael and Haines, 1997).

The anticipated direct health effects include changes in mortality and morbidity from thermal extremes, the respiratory health consequences of altered exposures to photochemical pollutants and aeroallergens (spores, moulds, and so on), and the physical hazards of any resultant increases in storms, floods, and droughts.

Indirect health effects would include alterations in the range and activity of vector-borne infectious diseases (e.g. malaria, dengue fever, and leishmaniasis—the last of these is already present in Southern Europe). Predictive mathematical modelling has suggested that the geographic zone and seasonality of potential transmission of malaria, and of dengue fever, might increase in many parts of the world (IPCC, 1996; McMichael and Haines, 1997). In temperate Europe, climate-sensitive vector-borne infections include tick-borne encephalitis and Lyme disease.

Other indirect effects would include altered transmission of person-to-person infections (especially summer season food-poisoning and water-borne pathogens), the nutritional health consequences of regional changes in agricultural productivity in poorly-resourced populations, and the various physical and psychological health consequences of rising sea levels, northern sand winds and population displacement. Diffuse public health consequences would likely result from migration and the loss of employment caused by the disruptive effects of climate change upon various economic sectors and vulnerable populations.

In Nigeria, recent environmental conditions have become extreme. Today one finds dust blowing causing air pollution and tracheal infections; the intensity of the sun has increased, torrential rains causing floods which in turn pollute the rivers further leading to the spread of cholera and other diseases (BNRCC, 2008). Incidences of meningitis have been on the increase in Nigeria for the past one-year as a result of excessive heat. This year has been unbearably hot in Nigeria and other countries in Sub Saharan Africa. In Nigeria the eleven frontline states in the north that have suffered from desert encroachment have been suffering from heat related ailments (Akingbade, 2010). In one of his treatise on Climate Change in Nigeria and Niger, Professor Emmanuel Oladipo, a United Nations Development Programme (UNDP) Consultant and Nigeria/Niger Project, Niamey, confirmed that Climate change is a serious threat to efforts at poverty eradication, and sustainable development in Nigeria and Niger because the countries have large rural population directly depending on climate sensitive economic and development sectors (agriculture and fisheries); (Akingbade, 2010)

A rise in temperature of between 1.4°C to 5.8°C by 2100 according to Intergovernmental Panel on Climate Change, IPCC, will have serious negative effect on the socio-economic wellbeing of the country in the following ways: increase in amount of rains and number of rainy days, flooding in the coastal areas, landslides especially in erosion prone areas; wildlife will also be affected with possible effect on the entire food chain, desertification will increase and more droughts which encourage locusts and white flies, which in turn will affect food and water supply; among several others (Ngene, 2012).

At a meeting organized by the British Council in Abuja, experts in waste management were of the opinion that if the environment could be made clean and green, it would be a great contribution to reducing global warning. A resource person from Nigeria Institute of Social and Economic Research (NISER) in Ibadan, Dr. Felix Olorunfemi, mentioned the concept of Integrated Sustainable Waste Management (ISWM), which he said would take care of waste generation, prevention and management processes in such a way that would encourage recycling instead of piling them up and thereby constitute hazards to the environment.

$CO_2$ is a trans-boundary air pollutant and this basically means that pollution is not limited to the country where it is emitted. This is the same for all greenhouse gases and air pollutants. Therefore, there is the need to mitigate their emissions (Enzler, 2012). However, in a document by Professor Green and other coauthors D. James Baker of the William J. Clinton Foundation and Daniel H. Miller of the Roda Group, Berkeley, California, USA are of the opinion that "reducing greenhouse gas emissions alone is unlikely to mitigate the risks of dangerous climate change" adding that society should significantly expand research into geo-engineering solutions that remove and sequester greenhouse gases already in the atmosphere (Akingbade, 2010).

### 5.5. Demographic Features

Among the respondents administered questionnaires, the mean age was 33.31±12.55years with 53.7% belonging to ≤ 30 years age group. The high density area (Oke-foko) having the highest proportion. Also, the major ethnic group was Yoruba which is to be expected since the study area was situated in the Ibadan (west) which is a Yoruba speaking land. They major occupation across the 3 density areas was trading (39%) while artisans such as tailoring, carpentry, welding, etc had 17.6% and others which included bankers, nurses, doctors, clerks, Clergy/Alfa, engineers, students, teachers etc had 22.6%. Most (58%) of the respondents have attained secondary education while 22.6% have either not attended any form of education or have attained primary or Qur'an education. The predominant religion was Christianity with 57.5% and Islam 42.5%. In a study carried out by Apata (2012) he noted that farming experience and access to education were found to promote adaptation. This implies that education to improve awareness of potential benefits of adaptation is an important policy measure for future adaptation and mitigation strategies.

Furthermore, a large proportion of the respondents (69.2%) live in houses that were rented and 29.9% live in their Private houses. Also, 50.6% of the respondents have 5 – 10 persons living in a home/household while 43% had less than 5 persons. Most of the respondents have lived between 1-5 years (48.1%) in their respective study area while 16.5% have lived greater than 25 years. Poor level of knowledge was detected among 77% of the students and fair level was detected among 23%. Such levels were positively correlated to the socio-economic levels of the students (Abd El-Salam *et al.*, 2009).

### 5.6. Knowledge of Waste management and Greenhouse gases

In relation to knowledge of greenhouse gases, 47% of the total respondents were aware that greenhouse gases are harmful to health and environment. However, 70.6% of the total respondents did not know or did not agree that greenhouse gases could cause climate change. Again, about half of the respondents did not know that poor solid waste management generate greenhouse gases. That is could mean that most people think greenhouse gases are generated from souces other than solid wastes and it is also possible that they were not aware that some of the odours emanating from the decaying wastes was associated with a greenhouse gas (methane).

Respondents' knowledge on waste management showed that 86.4% of the total respondents know what an illegal dumpsite was and 75.6% were aware that wastes thrown away could be used for other things such as farm manure, raw materials or reusable containers. From the questionnaire administered 82.6% of the respondents were aware that open dumping was not a good means of waste disposal and 74.4% did not accept dumping of wastes in streams or gutter as a good means of waste disposal. However, from observation, most of the dumpsites were open or on water bodies. This could mean that they either lack adequate disposal means such as skip bins or the lack they finance to pay waste collectors or they did not care. Not withstanding, awareness and education and the provision of waste bins are needed to improve waste management. This statement could be supported by the study carried out by Babayemi & Dauda (2009) in Abeokuta. They observed 35.8% employed waste collection services, and 64.2% used other waste disposal options.

In addition, 236 (70.2%) out of the 341 respondents agreed that recycling was good and 56% accepted composting as a good means. However, from observations there was no recycling and composting being done. This could be due to the fact that there was lack of respondents have lived between 1-5 years (48.1%) in their respective study area while 16.5% have lived greater than 25 years. Poor level of knowledge was detected among 77% of the students and fair level was detected among 23%. Such levels were positively correlated to the socio-economic levels of the students (Abd El-Salam *et al.*, 2009).

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In addition, 236 (70.2%) out of the 341 respondents agreed that recycling was good and 56% accepted composting as a good means. However, from observations there was no recycling and composting being done. This could be due to the fact that there was lack of farm where compost manure could be used. Some of them reuse tin containers or plastics which could be the reason for the reduced metals and plastics in the dumpsites. Also, in Alesinloye, Ibadan there was a waste recycling plant where pure water sachets, plastics; organics are recycled though the plant is mainly for wastes collected from the Alesinloye market.

Finally, 312 (95.4%) of the total respondents accepted that diseases can be transmitted to humans from illegal dumpsites. A study carried out in Abbottabad in Pakistan stated that 78% of surveyed households were aware of the issues related to poor waste management, with similar figures in both urban (80.5%) and rural (73.4%) households. There is, however, a high degree of awareness regarding the risks of disease, with 86% of those surveyed indicating an understanding of the link between poor health and improper garbage disposal.

Across the density areas, Okefoko showed a higher proportion, 83% of people with excellent knowledge, NTC Joyce B had 10% and Iyaganku GRA had 7% of people with excellent knowledge respectively. When age was compared with the knowledge category 58% of respondents <30years had excellent knowledge, 31% of those between ages 31 – 50 years and 10% of those aged >50 years had excellent knowledge. This could mean that information on wastes management and greenhouse gases may have been recent or it could be that only those in charge of waste disposal in the homes are interested.

Also, when knowledge was compared with the level of education attained by the respondent, 61% of respondents who had attained secondary education had excellent knowledge. In a report prepared by Bruinders *et al* (2010), the student's level of education was reflected in their knowledge with more postgraduate students exhibiting an above average level of knowledge. The results show that with more knowledge on the subject students are more willing to participate.

## 5.7. Attitude and Practice of Waste Management

The general mean attitude score was 36.6 ± 5.58 while the mean attitude score for Oke-foko, NTC, Iyaganku GRA were 36 ± 4.96, 39.1 ± 8.04 and 38.2 ± 5.27 respectively. Of the total respondents, 59% were strongly against wastes being dumped anywhere though looking at the checklist it shows the wastes were dumped everywhere. This may imply that we know what is expected but it is not done and this could be due to either lack of resources or low awareness.

Only 33% of the total responses received supported that separation of wastes at source is a good means of waste management. When further enquiry was made, some respondents felt there was no need for separation when all the wastes were meant to be disposed of. While some felt the wastes could occupy space or they may not have the time to consider which waste should go into which container. Of all the respondents, only 37% were of the opinion that the management of wastes is both the government and individual's responsibility while 41% felt it was the government's responsibility. There was no significant difference across the three density areas. Though it is believed that women show good attitude towards cleanliness more than men, the study however, showed that there was a higher proportion of men with good attitude as compared to women.

About 50% of respondents; who had attained secondary education had excellent attitude. In 2003, a survey conducted in Lebanon showed that secondary school students had favorable attitudes toward the environment but lacked environmental knowledge, and that such poor environmental knowledge was significantly related to parental education level (Abd El-Salam *et al.*, 2009). As regards good attitude, respondents within Iyaganku GRA showed the highest proportion (61.9%) while NTC Joyce B had 48.9%. There was a significant difference between the attitude of the respondents' and their knowledge.

Of the respondents in the high density area (Oke-foko), 71.4% (172) burn their wastes while 72.6% of these complained of smoke disturbance. 147 (54.9%) respondents in the high density area (Oke-foko) live about 1 – 5 minutes from the dumpsites. This shows the level at which these residents are exposed to health risks from the dumpsites. A detailed study of landfill sites has identified a possible link between living close to a landfill site, and the occurrence of some birth defects (DEFRA, 2004). In 1995-96 a study at the Payatos dumpsite in Metro Manila, Philippines, showed out of 600 families living within 0.5 km of the open dump, the missionary clinic reported that there were 3 infants born with imperforate anuses and 9-10 cases of children with cerebral palsy (Cointreau, 2006).

Of all the 341 respondents, 92.9% had suffered malaria at least in the last three months. Vianna and Polan (1984) and Goldman *et al.* (1985) both found increased incidence of low birth weight in the populations around the Love Canal site, the former during the period of active dumping (1940–1953) and the latter among house owners (although not among those renting) from 1965 to 1978. Also, Environmental conditions, interacting with the biology of disease agents, can exert profound effects. Changes in how land is used affect the distribution of disease carriers, such as rodents or insects, while climate influences their range, and affects the timing and intensity of outbreaks (Epstein, 1997).

From literature review, it is being documented that awareness on waste management was higher among the non-poor (67.9%) compared to poor families (9.9%). In this study, the low density area had a higher proportion of respondents with excellent knowledge and good attitude and also the respondents in the high density area (Oke-foko) were very much aware of the effects of poor waste management and greenhouse gases but due to unavailability of resources such as good leaders, finance and facilities were unable to respond positively.

Oke-foko showed a higher percentage of burning of their wastes and the use of buckets/drums as disposal containers which inadvertently is taken and dumped indiscriminately. A large proportion of the respondents complained of smoke disturbance from the wastes being burnt. Also, 68% of the residents at Okefoko had excellent attitude.

# CHAPTER SIX

## CONCLUSIONS AND RECOMMENDATIONS

### 6.1. Conclusions

Industrialization and urbanization are seen as stages of development in under developed countries; But at what future cost? (Do they increase waste production, especially if not handled properly?). The improper disposal of municipal waste in Ibadan could have serious and dangerous impacts on a wide range of areas. This study was carried out in selected high- (Okefoko), medium-(NTC Joyce B) and low-density (Iyaganku GRA) communities of Ibadan Southwest Local Government Area, Oyo state to characterize the wastes obtained and to assess the $CO_2$ and $CH_4$ emissions from illegal dumpsites.

The dumpsites observed were open and illegal dumpsites in which about 50% of them were situated on water bodies while others had wastes disposed and burnt by the roadside and this created favourable conditions for the generation of GHGs. Nylon recorded the highest proportion (51.3%) in Okefoko while at NTC Joyce B and Iyaganku GRA organics had the highest proportion of 35.2% and 50% respectively. However, across the three (3) density areas nylon and organics had the highest proportions of 36% each.

The decomposition of solid wastes in dumpsites results in the production of carbon dioxide and methane of which both are important greenhouse gases. Though there was no significant difference across the density areas, the mean $CO_2$ emission in the high-, medium- and low-density areas were: 372.5±92.1 ppm, 385.6±114.5 ppm and 380.8±82.4 ppm respectively. Most of the $CO_2$ concentrations for each site were within the US EPA guideline (300 – 450 ppm). The $CH_4$ emissions for Okefoko, NTC Joyce B and Iyaganku GRA were 0.000158 Gg/yr., 0.000026 Gg/yr. and 0.000012 Gg/yr. respectively.

Questionnaires were used to survey the respondents to assess their knowledge, attitude and practices towards waste management and greenhouse gases. The knowledge and attitude of the respondents' ranged from good to excellent; however in areas related to greenhouse gases the level of knowledge ranged from fair to poor.

## 6.2. Recommendations

The management of the dumpsites is very poor and they are a serious threat to the environment. Based on the findings from this study there is the need for effective waste management and mitigation of GHGs. Therefore, below are some suggestions:

- It is important for public awareness and enlightenment to be done among the people.
- Education of the people on proper waste management and greenhouse gases. This will help in changing the people's attitude.
- Solid waste can be managed through a number of activities — waste prevention, recycling, composting, controlled burning, or land-filling. Using a combination of these activities together in a way that best protects our community and the local environment is referred to as integrated solid waste management (ISWM). This method can be adopted.
- Creation of well-planned sanitary landfills should be carried out in order to reduce the number of illegal dumpsites.
- Reinforcement on laws guiding waste collection and disposal systems in every state. i.e. environmental officers should be available to ensure compliance.
- Researchers in the country should be encouraged into soliciting to research into all possibilities of making sustainable solid waste management to stay in Nigeria.

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## APPENDIX 1

# QUESTIONNAIRE ON THE ASSESSMENT OF ILLEGAL WASTE DUMPSITES AND THEIR GREENHOUSE GAS EMISSIONS POTENTIAL IN IBADAN SOUTH WEST LOCAL GOVERNMENT AREA, IBADAN, NIGERIA

Serial No.__________.

Dear Respondent,

I am a student of the Faculty of Public Health, Department of Epidemiology, Medical Statistics and Environmental Health, University of Ibadan. I am carrying out a study on "Assessment of illegal waste dumpsites and their greenhouse gas emissions potential in three residential areas in Ibadan south-west local government". This research is purely for academic purpose, the findings will be of immense benefit in the area for greenhouse gas mitigation/reduction. Please note that you are not required to write your name on the questionnaire. Kindly feel free to express your opinion and I assure you that your responses will be kept strictly confidential. Your honest response to the following questions will be highly appreciated.

Thank you,

Umego, Ijeoma .M

**INSTRUCTION: INSTRUCTION: please Tick (√) the box that represents your opinion in the following question. Note that there is no right or wrong answer, so be free to express your opinion when required.**

House Number: __________ Area/Ward: ____________________

Street: ____________________

## SECTION A: SOCIO-DEMOGRAPHIC INFORMATION

1. Age: (as at last birthday) __________ years.
2. Sex: a. Male [ ] b. Female [ ]

3. Religion:

a. Christianity [ ] b. Islam [ ] c. Traditionalist [ ] d.Others(specify) ________

4. Ethnic group

a. Yoruba [ ] b. Igbo [ ] c. Hausa [ ]

d. Others (specify)...............................

5. Marital status:

a. Single [ ] b. Married [ ] c. Divorced [ ] d. Widowed [ ]

e. Separated [ ]

6. What is the highest educational level you have attained?

a. Primary [ ] b. Secondary [ ] c. Tertiary [ ]

d. No school [ ] e. Quaranic school [ ]

7. How many are you in your household/shop? _______

8. Occupation: ____________________

9. How long have you been living in this area?

a. 1 – 5 years [ ] b. 6 – 15 years [ ]

c. 16 – 25 years [ ] d. >25 years [ ]

10. Who owns the house/shop in which you live?

a. Privately owned [ ] b. Rented [ ] c. Government [ ]

**SECTION B: KNOWLEGDE**

This section seeks information on your understanding of illegal waste disposal and greenhouse gases, usefulness of wastes, and environmental hazards associated with illegal waste disposal and greenhouse gas emissions.

11. An illegal dumpsite is a dumpsite that is not approved by the government/authority

a. Yes [ ] b. No [ ] c. don't know [ ]

12. Wastes thrown away maybe used for other things?

a. Yes [ ] b. No [ ] c. don't know [ ]

13. If yes, the following are useful products that can be gotten/ derived from wastes.

| PRODUCTS | YES | NO | DON'T KNOW |
|---|---|---|---|
| Farm manure | | | |
| Reusable containers | | | |
| Raw materials for industries | | | |

14. The following are good means of waste disposal?

| Waste Disposal Means | YES | NO | DON'T KNOW |
|---|---|---|---|
| Incineration | | | |
| Dig and bury | | | |
| Open dumping | | | |
| Recycling | | | |
| Throwing into gutter or stream | | | |
| Composting | | | |

15. Diseases are transmitted to humans from illegal dumpsites
a. Yes [ ] b. No [ ] c. don't know [ ]
16. Greenhouse gases are harmful to you and your environment?
a. Yes [ ] b. No [ ] c. don't know [ ]
17. Greenhouse gas emissions is the major cause of climate change
a. Yes [ ] b. No [ ] c. don't know [ ]
18. Greenhouse gases causes increase in atmospheric temperature
a. Yes [ ] b. No [ ] c. don't know [ ]
19. Greenhouse gases are produced from municipal (household) wastes
a. Yes [ ] b. No [ ] c. don't know [ ]

## SECTION C: ATTITUDE TOWARDS WASTE DISPOSAL

Tick √ under the column that best fits your opinion in terms of SA – strongly agree, A – agree, U – undecided, D – disagree and SD – strongly disagree.

| | STATEMENTS | SA | A | U | D | SD |
|---|---|---|---|---|---|---|
| 20. | Wastes should be dumped/disposed anywhere | | | | | |
| 21. | Wastes can be a source for producing useful materials | | | | | |
| 22 | Separation of wastes at source is a good means of waste management | | | | | |
| 23 | Waste should be managed in a way that promotes health and protect the environment | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 24 | Illegal dumping of wastes is harmful to health | | | | | |
| 25 | Waste dumpsites should not be located close to residential areas | | | | | |
| 26 | Illegal waste disposal encourages the breeding of vectors that transmit disease | | | | | |
| 27 | Government should be totally responsible for effective waste management | | | | | |
| 28 | Individuals should be responsible for effective waste management in their community | | | | | |
| 29 | Community partnership with the government is necessary for proper waste management | | | | | |

30. Are you willing to pay for your wastes to be cleared?
    a. Yes [ ]   b. No [ ]
31. If yes, how much?
a. N20/drop [ ]   b. N50/drop [ ]   c. N100/drop [ ]   d. any amount [ ]

## SECTION D: PRACTICES OF WASTE DISPOSAL

32. Who owns/operates the dumpsite nearest to you?
    a. Private/personally owned b. Neighbourhood/landlord association
    c. government owned   d. Nobody [ ]
33. If answer to (32) is not (c), is it government approved?
    a. Yes [ ]   b. No [ ]
34. Do you make use of the dumpsite nearest your home?
    a. Yes [ ]   b. No [ ]
35. If yes, why? ................................................................................................
36. If no, why? ..........................................................................................
37. How long have you been using the dumpsite?
    a. <2years [ ]   b. 3 – 5years [ ]   c. 5 – 10years [ ]   d. >10years [ ]
38. How do you manage the illegal dumpsite near your home when the wastes accumulate?_______________________________________________

39. How frequently do you throw away wastes in your home?
    a. Everyday [ ]   b. Once a week [ ]   c. Once in 2 weeks [ ]
    d. Whenever the need arises [ ]
40. What are the components you throw away in the waste? (multiple response)
    a. Kitchen waste [ ] b. Paper [ ]   c. Plastics/nylons [ ] d. Metals
    e. Glass [ ]   f. Animal waste [ ]   g. Faeces [ ]
    h. Leaves/grass/plants [ ]   i. Rubber [ ]
    j. Others (specify).......................................
41. What do you use to store wastes in your house?
    a. Carton [ ] b. Bag (nylon) [ ]   c. Bucket [ ] d. Basket [ ]
    d. Nothing [ ]
42. Are there government trucks that come to clear waste from your area?
    a. Yes [ ]   b. No [ ]

43. If yes, what is the frequency of collection?

a. Once a week [ ] b. Once in two weeks [ ] c. Once a month [ ]
d. Every 6 months [ ] e. A year [ ] f. Never [ ]

44. Do you make use of any of the wastes generated in your house?

a. Yes [ ] b. No [ ]

45. If yes, list any that you use and for what you use them for

_______________________________________________

46. Do you normally burn the wastes in your area?

a. Yes [ ] b. No [ ]

47. How frequently do you burn them? ____________________

48. During which season of the year do you burn them?

a. Always [ ] b. Dry season [ ] c. Rainy season [ ]

49. Why do you burn these wastes?

a. Convenience [ ] b. Reduce waste [ ] c. easy to burn [ ]
d. Others (specify) ____________________

50. What are the problems you face when burning the wastes?

_______________________________________________

51. Do you have a toilet facility in your home?

a. Yes [ ] b. No [ ]

52. Do you excrete/defecate in the dumpsite?

a. Yes [ ] b. No [ ]

## SECTION E: PUBLIC HEALTH NUISANCES AND HEALTH EFFECTS

53. What is the distance of the nearest dumpsite from your house?

a. < 1 minute walk [ ] b. > 1 minute but less than 5 minutes [ ]
c. Between 5 and 10 minutes [ ] d. > 10 minutes [ ]

54. How did you know about greenhouse gases? (Multiple response)

a. Internet [ ] b. friends [ ] c. School [ ]
d. Television [ ] e. Newspaper [ ]

55. Does the dumpsite disturb you in anyway?

a. Yes [ ] b. No [ ]

56. If yes to (55), in what way? (multiple response)

a. Rodent infestation [ ] b. Insects [ ] c. Bad odour [ ] d. Spoils water [ ]
e. Causes sickness/diseases [ ] f. Criminal activities (maybe from people who pick things from dumps (scavengers)) [ ] g. Others specify)......................

57. If the wastes smell, at what time of the day does it smell most?

.............................................................................

58. Do the wastes from the dump block the flow of water when rain falls?

a. Yes [ ] b. No [ ]

59. Is there a water source/body near the dumpsite?

a. Yes [ ] b. No [ ]

60. If yes to (59), do you make use of the water?

a. Yes [ ] b. No [ ]

61. If yes to (60), what do you use the water for?

a. Cooking [ ] b. Washing clothes [ ] c. drinking [ ]

d. Cleaning the house [ ] e. Flushing toilet [ ]

62. What type of insects/rodents disturbs you in your house? (multiple response)

a. Rats [ ] b. Flies [ ] c. Cockroaches [ ]

d. Mosquitoes [ ] e. Ants [ ] f. Others (specify) ______________

63. Do people/children go looking for things in the dump?

a. Yes [ ] b. No [ ]

64. What are the common sicknesses/diseases that you have had? (Multiple response)

a. Malaria [ ] b. Cough and catarrh [ ] c. Cholera [ ]

d. Diarrhoea [ ] e. Sore throat [ ]

f. Others (specify)...................................................

65. What type of illness/sickness have you suffered from in the last three months?

a. Malaria [ ] b. Cough and catarrh [ ] c. Cholera [ ]

d. Diarrhoea [ ] e. Sore throat

f. Others (specify)...................................................

66. How long did you have the sickness in (65) above?

a. < 1 week [ ] b. 1 week – 2 weeks [ ] c. 1 month [ ] d. >1 month

67. Where do you receive medication?

a. Self [ ] b. Government health centres [ ] c. Private health centres [ ]

THANK YOU FOR YOUR TIME!!!

APPENDIX 2

## IWE IBEERE LORI AYEWO AKITAN TI O LETO ATI IPA IWON LATI FA GBIGBO NA AWO SANMO NI AGBEGBE IJOBA IBILE GUSU IWO ORUN ILU IBADAN, NI ORILE EDE NAIJIRIA.

Oludahun owon,

Mo je akeeko agba tie ka ilera ni ile eko giga unifasiti ti ilu Ibadan. Mon seise iwadi lori "Ayewo akitan ti ko leto ati ipa won latifa gbigbona awo sanmo ni ijoba ibile gusu iwo orun, ilu Ibadan". Ise iwadi yi wa fun ikeko gboye nikan ni ati wipe abajade ise yi yi o se anfanni fun kikapa gbigbona awo sanmo. E jowo e koni lati ko oruko yin sori iwe ibeere yi. Ki e si turaka lati fi ero inu yin han, awon idahun yi yio je ohun asiri.

Ese pupo

UMEGO, Ijeoma M.

**IMORAN: E jowo e lo ami yi (√) lati fi ero inu yin han si awon ibeere wonyi. E mo wipe ko si ibeere ti o to tabi eyi ti ko to, nitorina e turaka lati fi ero inu yin han.**

Numba ile ____________________ Agbegbe ____________________

Adugbo ____________________

**IPA A: AFE MO YIN ATI AGBEGBE YIN.**

1. Ojo ori (ojo ibi tie se kojo) ____________
2. Okurin tabi Obirin?
   a. Okurin [ ]  b. Obinrin [ ]
3. Esin:
   a. Kristeni [ ]  b. Musulumi [ ]  c. Alabalaye [ ]
   d. Iyoku (E daruko) ____________
4. Eya
   a. Yoruba [ ]  b. Ibo [ ]  c. Hausa [ ]
   d. Iyoku (E daruko) ____________
5. Ipo igbeyawo
   a. Mi o ti gbeyawo [ ]  b. Mo ti gbeyawo [ ]  c. ati ko ra wa sile [ ]
   d. Opo [ ]  e. Ati yapa [ ]
6. Kini ipele eko ti o gaju ti e ni?
   a. Alakobere [ ]  b. Ile eko girama [ ]  c. Ile eko giga [ ]
   d. Mi o ile iwe [ ]  e. Ile kewu [ ]
7. Eyin melo lengbe ninu ile yin/soobu? ____________
8. Ise wo len se? ____________
9. Oti to odun melo ti e ti ngbe ni agbegbe yi?
   a. Ko ti podun kan [ ] b. Odun kan si odun marun [ ]  c. Odun mefa si meedogun
   d. Merindinlogun si meedogbon [ ]  e. Ju odun meedogbon lo [ ]

10. Ta loni ile/soobu yi?

a. Aladani [ ] b. Ayalegbe [ ] c. Ijoba [ ]

**IPA B: IMO**

Ninu ipele yi a fe mo oye yin nipa dida idoti nu lona ti ko leto ati gbigbona awo sanmo, iwulo idoti ati ijamba ti o so po mo dida idoti nu lona ti ko leto ati gbigbona awo sanmo.

11. Akitan ti ko leto je eyi ti ijoba kofowo si?

a. Beni [ ] b. Beeko [ ] c. Mi o mo [ ]

12. N je awon idoti ti e odanu le wulo fun awon nkan miran bi?

a. Beni [ ] b. Beeko [ ] c. Mi o mo [ ]

13. Bi o ba je beni, nje e le so ohun kan ti owulo fun?

| PRODUCTS | BENI | BEEKO | MI O MO |
|---|---|---|---|
| Ajile fun Ogbin | | | |
| Ohun Elo | | | |
| Eroja fun ilese nlala | | | |

14. Ewo ninu awon wonyi ni ona ti o dara lati da idoti nu?

| Awon ona bi | BENI | BEEKO | MI O MO |
|---|---|---|---|
| Sisun ninu ina | | | |
| Gbigbele lati ri idoti | | | |
| Akitan | | | |
| Dida idoti sinu gota tabi odo | | | |
| | | | |
| Lilo idoti fun ohun miran | | | |
| Jije ki idoti jera | | | |

15. N je eniyan le ni aisan tabi arun lati pase akitan ti o leto?

a. Beni [ ] b. Beeko [ ] c. Mi o mo [ ]

16. Seategun gbigbona le se ijamba fun yin ati fun ayika yin?

a. Beni [ ] b. Beeko [ ] c. Mi o mo [ ]

17. Se Ategun gbigbina ma fa ayipadapa loju ojo?

a. Beni [ ] b. Beeko [ ] c. Mi o mo [ ]

18. Awon Ategun yi ama mu ki orun gbona?

a. Beni [ ] b. Beeko [ ] c. Mi o mo [ ]

19. Idoti inu ilea ma fa ategun gbigbona?

a. Beni [ ] b. Beeko [ ] c. Mi o mo [ ]

## IPA C: IHUWASI DIDA IDOTI NU

Eli aminyi (√) si iwaju idahun ti b aero inu yin mu ju niau: SA – Mo faramo gan, A – Mo faramo dic, U – Mi o mo, D – Mi o faramo ati, SD – Mi o faramo gan.

| | STATEMENTS | SA | A | U | D | SD |
|---|---|---|---|---|---|---|
| 20 | A le da idoti si ibikibi | | | | | |
| 21 | A le lo idoti fun ohun elo miran | | | | | |
| 22 | O ye ki a ma ya awon idoti soto lati ibi ti won ti inu ile | | | | | |
| 23 | Ilera ati idabobo agbegbe ye ki ojewa logun | | | | | |
| 24 | Akitan ti ko to ama fa ailera fun eniyan? | | | | | |
| 25 | Ko ye ki Akitan maa wa legbe ilegbe | | | | | |
| 26 | Akitan ti ko to ama fa aarun | | | | | |
| 27 | Ijoba loye ko ma mojuto didale nu lona ti o to | | | | | |
| 28 | Oju se mi ni lati toju akitan ti mon lo | | | | | |
| 29 | Oye ki agbegbe ma fowo sowopo pelu ijoba lati ma da ile nu. | | | | | |

30. Do you pay for your wastes to be cleared?
 a. Beni [ ] b. Beeko [ ]

31. If yes, how much? a. N20 [ ] b. N50 [ ] c. 100 [ ] d.

## IPA D: ISE DIDA IDOTI NU

32. Talo ni akitan ti o sunmo yin ju?
 a. Aladaani [ ] b. Igbimo agbegbe [ ] c. Ijoba loni [ ]
 d. Iyoku (e daruko) ____________________

33. Ti idahun re si (32) ko baje (c), se ijoba fowo si?
 a. Beni [ ] b. Beeko [ ]

34. Se e ma n lo akitan ti o sunmo ile yin ju?
 a. Beni [ ] b. Beeko [ ]

35. To ba je beeni, kini idi?
____________________

36. To ba je beko, kini idi?
____________________

37. Igba wo le tin lo akitan yi?
 a. Ko ti to odun meji [ ] b. Odun meta si odun marun [ ]
 c. Odun marun si si mewa [ ] d. Oti ju odun mewa [ ]

38. Ba wo le s e n seto akitan ti o leto ti o sunmo ile yin ti o ba kun?
____________________

39. E me lo le ma n da ile nu ni ile yin?
 a. Ojoojumo [ ] b. E nkan loso kan [ ] c. E nkan loso meji [ ]
 d. Igbaki gba ti o ba ye [ ]

40. Kini awon ohun ti o ma n wa ninu idoti yin? (E mu idahun pupo bi eba fe)
 a. Idoti onje [ ] b. Beba [ ] c. Ike tabi ora [ ] d. Iri [ ]
 e. Igo [ ] f. Idoti eran [ ] g. Igbe [ ] h. Roba [ ]
 i. Ewe/eweko tabi itugbin [ ] j. Iyoku (e daruko) ____________________

41. Kini eman ko idoti si ni ile yin?

a. Pali [ ] b. Apo olora [ ] c. Koroba [ ]
d. Apere [ ] e. Ko si [ ]

42. Se awon oko ijoba man wa ko idoti ni adugbo yin?

a. Beni [ ] b. Beeko [ ]

43. Bo ba je beeni, olo igba melo ti won ma wa n ko?

a. E n kan lose [ ] b. E n kan lose meji [ ] c. E n kan losu [ ]
d. Osu mefa mefa [ ] e. Ododun [ ] f. Rara [ ]

44. Se e man lo nwon idoti yi ni ile yin?

a. Beni [ ] b. Beeko [ ]

45. To baje beeni, e so eyi keyi ti e n lo ati ahun te n lo o fun

---

46. Se e man saba da na sun idoti ni adugbo yin?

a. Beni [ ] b. Beeko [ ]

47. E melo lema ndana sun won? ______________________

48. Inu osu wo le man dana sun won

a. Osoosu [ ] b. January si March [ ] c. April si June [ ]
d. July si September [ ] e. October si December [ ]

49. Kini idi ti e fin dana sun awon idoti yi?

a. Ororun [ ] b. K idoti le dinku [ ] c. O ya lati jo [ ]
d. Iyoku (e daruko)______________________

50. Ki ni awon isoro ti e man dojuko ti e ba n da na sun idoti yi?

---

51. N je eni ile iyagbe ni le yin?

a. Beni [ ] b. Beeko [ ]

52. N je e man ya gbe si ori akitan?

a. Beni [ ] b. Beeko [ ]

**APA E: IPO ILERA GBOGBOGBO**

53. Akitan ti sunmo o jinna to

a. koto iseju kan[ ] b. irin iseju kan si maarun. [ ]
c. larin iseju maarun si mewa[ ] d. oju iseju mewa lo[ ]

54. Bawo le se le mo nipa gbigbona awo sanmo?

a. Ero ayarabiasa [ ] b. Awon ore [ ] c. Ile iwe [ ]
d. Amohunmaworan [ ] e. Ipade imo[ ]

55. N je akitan yi man yo yin lenu?

a. Beni [ ] b. Beeko [ ]

56. To baje beenu, si (54) ni ona wo? (E le mu idahun pupo)

a. O man fa eku [ ] b. O man fa kokoro [ ] c. O man fa oorun buruku [ ]
d. O man ba omije [ ] e. O man fa aisan tabi arun [ ] f. O n fa iwa odaran (boya nipa se awon ti o sa akitan) [ ] g. Iyoku (e daruko)______________

57. Ti awon idoti yi ba n run, ago melo nioorun yi man wa?

---

58. N je awon idoti akitan yi man di lilo gere omi ti ojo baro

a. Beni [ ] b. Beeko [ ]

59. N je orison omi kankan suamo akitan yi?

a. Beni [ ] b. Beeko [ ]

60. To ba je beeni si (59), n je e n lo omi?

a. Beni [ ] b. Beeko [ ]

61. To ba je beeni si (60), kini e n lo omi fun?

a. Sise ounje [ ] b. Aso fifo [ ] c. Mimu [ ] d. Titun ile se [ ]

e. Fun iyagbe [ ]

62. Iru awon kokoro tabi eku wo lo ma n yo yin lenu ni ile yin? (Emu idahun pupo bi eba fe)

a. Eku [ ] b. Esinsin [ ] c. Ayan [ ] d. Efon [ ]

e. Eera [ ] f. Iyoku (e daruko) ______________________________

63. N je awon eniyan tabi omode ma lon sa n kan ninu akitan yi?

a. Beni [ ] b. Beeko [ ]

64. Awon aisan tabi arun wo lo wopo ju ti e ti ni? (Emu idahun pupo bi eba fe)

a. Iba [ ] b. Iko ati ofinkin [ ] c. Arun oru gba meji [ ]

d. Igba gburu [ ] e. Didun ona ofun [ ] f. Iyoku (e daruko) ______________________

65. Iru aisan tabi arun wo ni e ti ni ni iwon osu meta seyin?

a. Iba [ ] b. Iko ati ofinkin [ ] c. Arun oru gba meji [ ]

d. Igba gburu [ ] e. Didun ona ofun [ ] f. Iyoku (e daruko) ______________________

66. O ti to igba won ti e ti ni aisan ma?

a. ko ti to ose kan[ ] b. larin osekan si meji [ ] c. Oto osu kan[ ]

d. Oju osu kan lo [ ]

67. Ibo ni e tingba itoju?

a. Mo n toju ara mi [ ] b. Ile iwosan ti ijoba [ ]

c. Ile iwo san aladaani [ ] d. Iyoku (e daruko) ______________________________

**ESE PUPO FUN AKOKO YIN!!!**

## APPENDIX 3

## LIST OF OTHER COMMUNITIES IN THE THREE DENSITY AREAS

### HIGH DENSITY AREA

- Dugbe
- Agbeni
- Yemetu
- Eleta
- Apete
- Bere
- Ogunpa

### MEDIUM DENSITY AREA

- Samonda
- Mokola
- Challenge
- Sango
- Molete
- Iwo road
- Elewura
- Sabo
- Ashi
- Agbowo

### LOW DENSITY AREA

- Old Bodija
- Ikolaba
- Onireke
- Oluyole Layout
- New Bodija
- Secretariat
- Kongi

## APPENDIX 4

## SUPPLEMENTARY RESULTS

WEEK: 1

AREA: NTC

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| GENESIS | 468 | 25.5 | | 461 | 33.8 | | 462 | 31.1 | |
| CELE | 457 | 26.1 | | 422 | 34.5 | | 402 | 33.9 | |
| JOGOR | 436 | 29.2 | | 429 | 33.6 | | 437 | 31.5 | |

AREA: IYAGANKU GRA

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AREA 1 | 452 | 28.2 | | 449 | 31.2 | | 467 | 31.4 | |
| AREA 2 | 459 | 27.3 | | 450 | 32.6 | | 450 | 31.7 | |
| AREA 3 | 442 | 26.2 | | 439 | 34.5 | | 433 | 31.5 | |

AREA: OKE-FOKO

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AMOLE | 525 | 27.3 | | 484 | 30.8 | | 385 | 30.4 | |
| AMULE | 524 | 27.5 | | 498 | 28.7 | | 361 | 30.5 | |
| EDE | 523 | 28.1 | | 446 | 30.9 | | 389 | 31.3 | |

AREA: NTC

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| JOGOR | 477 | 26.6 | | 361 | 32.4 | | 326 | 30.7 | |
| CELE | 447 | 28.9 | | 400 | 31.8 | | 352 | 33.6 | |
| GENESIS | 455 | 29.5 | | 428 | 33.7 | | 348 | 33.6 | |

AREA: IYAGANKU

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AREA 1 | 427 | 29 | | 416 | 30.9 | | 323 | 32.1 | |
| AREA 2 | 442 | 28.8 | | 434 | 30.4 | | 334 | 32.4 | |
| AREA 3 | 458 | 28.7 | | 491 | 29.8 | | 335 | 32.4 | |

AREA: OKE-FOKO

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % |
| AMOLE | 407 | 28.5 | | 484 | 33.8 | | 293 | 33.5 | |
| AMULE | 396 | 29.0 | | 300 | 34.0 | | 319 | 33.7 | |

WEEK: 2

AREA: NTC

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % |
| GENESIS | 344 | 25.2 | | 366 | 30.1 | | 262 | 29.9 | |
| CELE | 345 | 26.2 | | 357 | 29.4 | | 262 | 29.3 | |
| JOGOR | 341 | 26.7 | | 327 | 29.8 | | 252 | 27.9 | |

AREA: IYAGANKU GRA

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % |
| AREA 1 | 454 | 24.1 | | 283 | 30.3 | | 279 | 30.4 | |
| AREA 2 | 460 | 24.2 | | 287 | 30.2 | | 285 | 30.5 | |
| AREA 3 | 409 | 24.2 | | 285 | 30.0 | | 288 | 30.6 | |

AREA: OKE-FOKO

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % |
| AMOLE | 360 | 26.2 | | 323 | 29.9 | | 242 | 29.6 | |
| AMULE | 358 | 26.2 | | 330 | 30.2 | | 244 | 29.9 | |
| EDE | 368 | 24.5 | | 331 | 30.0 | | 259 | 30.0 | |

AREA: NTC

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % | $CO_2$ (ppm) | TEMP ($^0C$) | $CH_4$ % |
| GENESIS | 354 | 22.0 | | 339 | 39.4 | | 240 | 29.0 | |
| CELE | 324 | 23.7 | | 326 | 30.8 | | 240 | 28.9 | |
| JOGOR | 316 | 25.0 | | 321 | 28.8 | | 235 | 28.4 | |

AREA: IYAGANKU GRA

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AREA 1 | 344 | 22.3 | | 281 | 30.2 | | 247 | 29.0 | |
| AREA2 | 370 | 22.4 | | 277 | 30.7 | | 255 | 29.2 | |
| AREA 3 | 344 | 22.4 | | 278 | 31.1 | | 246 | 29.2 | |

AREA: OKE-FOKO

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AMOLE | 331 | 20.8 | | 270 | 30.3 | | 229 | 27.8 | |
| AMULE | 313 | 20.5 | | 283 | 31.2 | | 228 | 27.9 | |
| EDE | 318 | 21.6 | | 290 | 20.3 | | 236 | 27.8 | |

AREA: NTC

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| GENESIS | 309 | 25.9 | | 321 | 33.0 | | 224 | 28.3 | |
| CELE | 306 | 26.0 | | 342 | 33.4 | | 228 | 28.0 | |
| JOGOR | 301 | 26.6 | | 338 | 29.6 | | 224 | 27.4 | |

AREA: IYAGANKU GRA

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AREA 1 | 324 | 26.9 | | 310 | 32.1 | | 253 | 28.6 | |
| AREA 2 | 325 | 27.0 | | 313 | 32.6 | | 245 | 28.6 | |
| AREA 3 | 338 | 27.0 | | 313 | 32.8 | | 240 | 28.5 | |

AREA: OKE-FOKO

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AMOLE | 324 | 25.7 | | 289 | 31.2 | | 219 | 31.3 | |
| AMULE | 344 | 25.6 | | 297 | 31.3 | | 239 | 31.6 | |
| EDE | 346 | 26.3 | | 291 | 29.3 | | 212 | 28.2 | |

WEEK: 3

AREA: NTC

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| GENESIS | 320 | 26.0 | | 316 | 32.6 | | 333 | 25.6 | |
| CELE | 308 | 25.9 | | 300 | 32.8 | | 336 | 25.1 | |
| JOGOR | 307 | 25.7 | | 309 | 29.3 | | 336 | 25.5 | |

AREA: IYAGANKU GRA

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AREA 1 | 316 | 25.8 | | 250 | 31.5 | | 344 | 24.9 | |
| AREA 2 | 315 | 25.8 | | 265 | 32.2 | | 356 | 24.9 | |
| AREA 3 | 309 | 25.7 | | 267 | 32.4 | | 346 | 24.9 | |

AREA: OKE-FOKO

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AMOLE | 304 | 25.1 | | 282 | 32.1 | | 357 | 25.7 | |
| AMULE | 307 | 25.0 | | 275 | 32.1 | | 341 | 25.8 | |
| EDE | 335 | 25.0 | | 296 | 30.8 | | 354 | 26.2 | |

AREA: NTC

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| GENESIS | 560 | 26.6 | | 482 | 31.6 | | 428 | 32.6 | |
| CELE | 551 | 26.7 | | 480 | 34.0 | | 427 | 32.6 | |
| JOGOR | 541 | 27.3 | | 433 | 31.4 | | 414 | 30.4 | |

AREA: IYAGANKU GRA

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AREA 1 | 547 | 26.9 | | 501 | 31.7 | | 465 | 28.2 | |
| AREA 2 | 548 | 27.1 | | 512 | 32.5 | | 450 | 28.4 | |
| AREA 3 | 544 | 27.3 | | 516 | 33.0 | | 456 | 28.4 | |

AREA: OKE-FOKO

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ ppm | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AMOLE | 571 | 26.0 | | 532 | 30.2 | | 399 | 31.9 | |
| AMULE | 580 | 26.0 | | 534 | 30.6 | | 413 | 32.4 | |
| EDE | 570 | 26.3 | | 508 | 30.2 | | 423 | 32.2 | |

AREA: NTC

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ ppm | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| GENESIS | 422 | 28.2 | | 378 | 34.3 | | 353 | 30.5 | |
| CELE | 398 | 28.6 | | 383 | 33.9 | | 327 | 30.5 | |
| JOGOR | 385 | 28.8 | | 379 | 32.2 | | 313 | 29.3 | |

AREA: IYAGANKU GRA

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ ppm | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AREA 1 | 391 | 28.4 | | 398 | 28.8 | | 297 | 25.2 | |
| AREA 2 | 402 | 28.7 | | 405 | 29.2 | | 303 | 25.0 | |
| AREA 3 | 421 | 29.5 | | 406 | 30.0 | | 308 | 24.7 | |

AREA: OKE-FOKO

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ ppm | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AMOLE | 395 | 27.1 | | 358 | 32.3 | | 317 | 30.6 | |
| AMULE | 381 | 27.1 | | 353 | 32.6 | | 340 | 30.7 | |
| EDE | 393 | 27.7 | | 393 | 33.2 | | 333 | 30.6 | |

WEEK: 4

AREA: NTC

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ ppm | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| GENESIS | 531 | 26.8 | | 461 | 33.2 | | 351 | 31.4 | |
| CELE | 532 | 27.0 | | 406 | 33.5 | | 332 | 30.9 | |
| JOGOR | 500 | 27.6 | | 433 | 31.9 | | 364 | 29.4 | |

**AREA: IYAGANKU GRA**

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AREA 1 | 504 | 28.1 | | 466 | 31.7 | | 354 | 29.9 | |
| AREA 2 | 513 | 28.2 | | 465 | 31.5 | | 343 | 29.8 | |
| AREA 3 | 526 | 28.6 | | 453 | 31.4 | | 338 | 29.8 | |

**AREA: OKE-FOKO**

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AMOLE | 572 | 24.8 | | 384 | 31.4 | | 331 | 30.6 | |
| AMULE | 567 | 25.1 | | 379 | 31.9 | | 333 | 30.8 | |
| EDE | 533 | 26.7 | | 416 | 31.3 | | 352 | 31.1 | |

**AREA: NTC**

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| GENESIS | 491 | 27.5 | | 446 | 28.6 | | 423 | 28.5 | |
| CELE | 468 | 27.8 | | 425 | 28.8 | | 399 | 28.3 | |
| JOGOR | 1157 | 29.8 | | 803 | 28.0 | | 410 | 27.8 | |

**AREA: IYAGANKU GRA**

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AREA 1 | 433 | 27.9 | | 460 | 28.0 | | 405 | 27.4 | |
| AREA 2 | 437 | 27.9 | | 471 | 27.8 | | 410 | 27.5 | |
| AREA 3 | 446 | 28.0 | | 468 | 27.8 | | 413 | 27.5 | |

**AREA: OKE-FOKO**

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AMOLE | 501 | 27.3 | | 454 | 29.0 | | 410 | 28.1 | |
| AMULE | 501 | 27.3 | | 458 | 29.3 | | 409 | 28.5 | |
| EDE | 488 | 26.8 | | 483 | 30.3 | | 435 | 28.1 | |

AREA: NTC

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| GENESIS | 472 | 25.8 | | 411 | 30.1 | | 354 | 30.4 | |
| CELE | 449 | 25.7 | | 394 | 29.8 | | 351 | 31.3 | |
| JOGOR | 447 | 25.6 | | 404 | 29.5 | | 323 | 29.9 | |

AREA: IYAGANKU GRA

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AREA 1 | 437 | 26.3 | | 425 | 28.5 | | 338 | 29.5 | |
| AREA 2 | 437 | 26.2 | | 420 | 28.8 | | 344 | 29.4 | |
| AREA 3 | 437 | 26.4 | | 425 | 28.8 | | 345 | 29.5 | |

AREA: OKE-FOKO

| SITES | MORNING | | | AFTERNOON | | | EVENING | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % | $CO_2$ (ppm) | TEMP (°C) | $CH_4$ % |
| AMOLE | 491 | 24.8 | | 377 | 29.9 | | 350 | 30.4 | |
| AMULE | 488 | 24.8 | | 378 | 30.5 | | 372 | 30.7 | |
| EDE | 460 | 25.3 | | 454 | 32.3 | | 346 | 29.9 | |

APPENDIX 5

## OBSERVATION CHECK LIST FOR ASSESMENT OF ILLEGAL DUMPSITES

1. Name of location:

2. Address of location:

| Dumpsites | Vegetation | Walls | Roofs | Smoke | Exposure To Rainfall |
|---|---|---|---|---|---|
| Amole | | | | | |
| Amule | | | | | |
| Ede | | | | | |
| Genesis | | | | | |
| Cele | | | | | |
| Jogor | | | | | |
| Area 1 | | | | | |
| Area 2 | | | | | |
| Area 3 | | | | | |

Key: (+++) – Highly Present; (++) – Moderately present; (+) – Present and (-) – Absent

Onsite Observation contd.

| Dumpsites | Market | Roadside | Residential area | Scavengers | On water |
|---|---|---|---|---|---|
| Amole | | | | | |
| Amule | | | | | |
| Ede | | | | | |
| Genesis | | | | | |
| Cele | | | | | |
| Jogor | | | | | |
| Area 1 | | | | | |
| Area 2 | | | | | |
| Area 3 | | | | | |

Key: (+++) – Highly Present; (++) – Moderately present; (+) – Present and (-) – Absent

## Informed Consent

**IRB Research Approval Number.......................**

**This Approval will elapse on ..../....../.......**

**Title of Research:**

Characterisation of Illegal Dumpsite and their Greenhouse Gas Emissions in Ibadan South-west Local Government Area, Ibadan, Nigeria

**Name and Affiliation of Researcher:**

This study is being conducted by Miss Umego Ijeoma Maureen, Department of EMSEH, Faculty of Public Health, College of Medicine, University of Ibadan.

**Purpose(s) of Research:**

To assess the greenhouse gas emissions potential from selected illegal dumps in Ibadan south west Local Government Area of Oyo state.

**Procedure of the research, what shall be required of each participants and approximate total number of participants that would be involved in the research:**

**Expected duration of research and of participant(s) involvement:**

This research will be expected to last for an approximately one month.

**Risk(s):**

It is expected that this research would pose no physical, biological or social harm to all the research participants as all the procedures involved are non invasive and no samples (blood, urine, saliva) are collected.

**Translation:**

The questionnaire has been translated into Yoruba language to make it easy for the people in the selected area to answer. Also an indigene of each area will be trained as a research assistant to assist in administering the questionnaire.

**Cost of Participating, if any, of joining the research:**

Your participating in this research will cost you nothing but your small amount of time and effort.

**Benefit(s):**

This research would help in determining the following

- Awareness about the health effects associated with greenhouse gas emissions
- Ways to mitigate the production of greenhouse gas emissions from illegal solid waste disposal.
- Predict the present level of greenhouse gas emissions released into the environment.

**Confidentiality:**

All information collected in the study would be given code numbers and no names will be collected. Phone numbers collected would only be used to contact the participants for Phase II and in the presentation of the findings only. This will ensure that no link would be established to you. As part of my responsibility to conduct this research properly, officials from the UI/UCH Ethics Review Committee may have access to these records.

**Voluntariness:**

Your participation in this research is entirely voluntary.

**Consequences of participant's decision to withdraw from research:**

You can also choose to withdraw from the research at anytime. Please note that some information that has been obtained about you before you choose to withdraw may have been modified or used in reports and publication. These cannot be removed anymore. However the researcher promise to make good faith efforts to comply with your wishes as much as is practicable.

**Any apparent or potential conflict of Interest:**

This research work is strictly for academic purpose and is self-funded.

**Statement of Person Obtaining Informed Consent:**

I have fully explained this research work to ______________________________

and have given sufficient information, including about risk and benefits, to make an informed decision.

DATE__________________SIGNATURE______________

NAME_______________________________

**Statement of person giving Consent:**

I have read the description of the research. I understand that that my participation in this research is voluntary. I know enough about the purpose, methods, risk and benefits of the research study to judge that I want to participate in it. I understand that I may freely stop being a part of the study at any time. I have received a copy of the consent form.

DATE__________________SIGNATURE______________

NAME____________________

**Detailed contact information including contact address, telephone, fax, e-mail and any other contact information of researcher(s), institutional HREC and Head of Institution:**

This research has been approved by the Health Research Ethics Committee of the University of Ibadan and University College Hospital and the chairman of this committee can be contacted at BIODE building, Room T10, 2nd Floor, Institute for Advanced Medical Research and Training (IMRAT), College of Medicine, University College Hospital. Email: uiuchirc@yahoo.com . If you have any question about your participation in this research you can contact the Principal Investigator Umego I.M. at the Department of EMSEH, College of Medicine, University of Ibadan. His phone number and email address are 08028169262 and reen_jay2002@yahoo.ca respectively. You can also contact the Head of Department of EMSEH, College of Medicine, University of Ibadan.

Thanks.