ASSESSMENT OF POLLUTION POTENTIAL OF GASEOUS EMISSION FROM A WASTE DUMPSITE IN UBAKALA, UMUAHIA SOUTHEASTERN NIGERIA

BY

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CERTIFICATION

This is to certify that this work "Assessment of Pollution Potential of Gaseous Emission from a Waste Dumpsite in Ubakala, Umuahia Southeastern Nigeria" was carried out by Chikezie, Precious Onyinyechi (20154994768) in partial fulfillment for the award of the degree of M.Sc in Environmental Geology in the Department of Geology of Federal University of Technology, Owerri.

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DEDICATION

This research is dedicated to Almighty God, who gave me life to undertake this project

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ABSTRACT

Gaseous emission from Ubakala waste dumpsite in Umuahia area of Abia State was analyzed and evaluated in order to determine the pollution potential. This research was aimed at understanding the pollution dispersion patterns and impact from source to adjoining communities. Air Tester Model CH-HAT 200 **and** Aeroqual series 200 gas analyzers with VOCs sensor were used to measure particulate matters and VOC whereas GA-21 plus flue gas monitor as a multi-functional flue gas analyzer with electronic- chemical sensors, was used for the detection and measurement of gas concentrations of individual pollutant gases such as Methane (CH_4), oxides of Sulphur (SO_x) and (CO) directly in the field in different communities within the study area. The mean relative humidity value ranged from 58.65 % to 77.6 % in the wet season; whereas in the dry season, it ranged from (57.80 % to 64.00 %). The mean relative humidity was generally low during the dry season, while during the wet season, it was generally high within the dumpsite. The wet season show temperature range from 24.40 to 30.70 ^{o} C. The dry season also show temperature range from (29.50 % to 40.20 %) The mean ambient temperature was generally high during the dry season while, during the wet season, it was generally low within the dumpsite. The wind speed ranged from (0.6 ms^{-1}) in the northwest direction to (2.25 ms^{-1}) in the southeast direction. The mean wind speed was generally high during the dry season. During the wet season it was generally low within the dumpsite and also at the control site. In the dry season, the mean concentrations of particulate matters, H_2S, VOCs, CO, NH_3 CH_4 and SO_2 measured at 0 km and 3.6 km ranged from 22.60 - 74.93 µg/m^3, 0 - 4 ppm, 0.3 - 2 ppm, 0.32 -2.8 ppm, 0.4 - 4.2 ppm, 0.01 - 0.11 ppm and 0.10 - 1.6 ppm respectively.. Similarly, in wet season, the mean concentrations of particulate matters, H_2S, VOCs, CO, NH_3 CH_4 and SO_2 measured at 0 km and 3.6 km ranged from 63.50 - 20 µg/m^3, 0.2 -3.4 ppm, 0.5 - 2.9 ppm, 0 - 2.3 ppm, 0.9 - 8 ppm, 0.01 - 0.07 ppm and 0.09 – 1.05 ppm respectively. Dumpsites are associated with hazards which are caused by the breakdown of organic materials producing methane (CH_4), (CO), hydrogen sulphide (H_2S) and other gases. This research work provided base line information on the level of pollutant emission of the dumpsites and impact of the activities of the dumpsites on the host environment as well as measures aimed at minimizing the impact of disposal of solid waste.

Keywords: , Evaluation, Pollution, Potential, Emission, Waste, Dumpsite, Ubakala, Umuahia

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Solid waste is the term used to describe non-liquid phase of waste materials arising from domestic, commercial, agricultural, industrial activities and from public services (Aibor and Olorunda, 2006). Wastes comes from homes, schools, hospitals, and businesses (EPA, 2011).

The amount of waste produced by human activities is increasing in most parts of the world, accompanied by problems of disposal (Microsoft Encarta Premium Encyclopedia Suite, 2004). The increase in solid waste generation all over the world is as a result of continuous economic growth, urbanization and industrialization. Man, in an attempt to satisfy his daily needs, engages in the production of goods and services and in the process of which waste is generated (Beede and Bloom, 1995). Virtually all aspects of man's productive activities involve the generation of waste.

Dumpsites are locations where waste are deposited and allowed for gradual decomposition of the biodegradation parts of the waste materials on being consumed by bacteria and in the process, gas is released into the surrounding atmosphere (Chen et. al, 2008). Open dumping of solid waste (SW) is a primitive method of waste disposal, which is practiced by three fourths of countries and territories round the world (Rushbrook, 2001). Dumpsites undergo physical, chemical and biological changes and these changes depend on the composition of the waste, the bacteria present, the acidity and the temperature (Einola, *et al.*, 2007). They are chiefly responsible for environmental degradation and pose public health risk in many developing countries including the study area.

Papers, vegetable matter, wood, textiles and plastics make up large chunk of waste in modern dumpsite, about 65 % of which is biodegradable (Rushbrook, 2001).

According to the Department of Environment, Food and Rural Affairs (DEFRA), (2007) landfill starts producing gases at a reasonably stable rate after about two years. At this stage, the major constituents include methane (70%), CO_2 (30%) with small amounts of H_2S and other trace gases, depending on conditions. At the initial stage, the volume of methane produced per tonne of waste per year is about 5 -10 m^3. After 20 years, the quantity of gas produced will be reduced by approximately 85 %, with concentrations of DEFRA, (2007).

Leachate and landfill gas are the two major hazards associated with waste dumpsites. Leachate is formed when water passes through the waste in the dumpsite, picking up organic and inorganic compounds (Onakpohor, 2013). The toxic liquid collects at the base of the landfill cell, if not properly controlled; can contaminate the surrounding soil, groundwater and nearby water course EA (Environmental Agency, 2003).

The percentage of oxygen available in freshly generated waste is usually high. First of all, aerobic degradation takes place in order to produce Carbon monoxide (CO), sulphur (iv) oxide (SO_2), etc. As the oxygen is used up, under the right temperature, and acidity condition (pH), anerobic degradation is initiated, producing methane (CH_4), hydrogen sulphide (H_2S) and Carbon monoxide (CO) and other gases. Methane poses a severe explosion risk, damages plant life and constitutes one of the major greenhouse gases. Carbon monoxide is another greenhouse gas, that is toxic, asphyxiant and depletes local oxygen levels, while hydrogen sulphide is very toxic even at low concentration (Hill, 2009).

These wastes sometimes contain radioactive substance which could be dangerous when burnt and exposed to scavengers. There are a number of major risks associated with open dumpsite. They include: air pollution, surface and groundwater pollution, offensive odor, and fire outbreak. The World Health Organization estimated that about a quarter of diseases facing mankind today occur due to prolonged exposure to environmental pollution (UNEP, 2006).

1.2 Problem Statement

Ubakala, the study area has been experiencing rapid population growth and urbanization. As a result, enormous quantities of solid waste were being generated.

Uncontrolled dumping of solid wastes lead to environmental problems like traffic high way, blockage of drainage channels (when dumped on waterways), and pollution of land and near-by water bodies that should have been serving both irrigation and domestic purposes. The odor emanating due to degradation of the waste in the dumpsites causes illness to people living closer to the dump, it decreases the economic and social values in the locality.

As these organic wastes materials decompose, they emit dangerous and harmful gases including green house gases (CH_4, CO_2, H_2S, CO) into the environment. These gases are responsible for global warming, acid rain deposition, and air pollution (obnoxious odour harmful to the residents and adjoining communities).

1.3 Objectives of Study

1.3.1 Main Objective

The main objective of study is to understanding the dispersion pattern of pollutants and impact from source to adjoining communities.

1.3.2 Specific Objectives

The specific objectives of the study include:

i. To identify individual pollutant gases present around the dumpsite
ii. To determine the concentration levels of these emitted pollutant gases
iii. To determine seasonal variation in the concentration levels of pollutant gases.
iv. To compare the measured pollutants concentrations with standards.
v. To determine a geospatial variation and trend for each of the pollutant

1.4 Justification of Study

According to marshal (1995), open dumpsites are problem to the environment. Especially on the air that people inhale. Emission of gases from dumpsites is known to be dangerous and harmful to the neighborhoods surrounding the dumpsite, (host environment). Dumpsites are associated with hazards which are caused by the breakdown of organic materials producing methane (CH_4), carbon monoxide (CO), hydrogen sulphide (H_2S) and other gases. The odor emanating due to degradation of the waste in the dumpsites causes illness to people living closer to the dump, it decreases the economic and social values in the locality.

This research work shall provide base line information on the level of pollutant emission of the dumpsites and impact of the activities of the dumpsites on the host environment. Hence shall help in the policies and practices aimed at minimizing the impact of disposal of solid waste.

1.5 Scope of the Study

Gaseous emission at Ubakala open dumpsite was used as a case study in this research with other existing literature on the basis of comparison of the results of the study. In-situ emissions analyses were used in the study.

The sampling instruments used to obtain global coordinates and elevation above sea level, wind direction /speed, gaseous emission air pollutants, particulates and meteorological parameters include: Global Positioning system (GPS), wind Vane, GA- 21 Plus Flue Gas Analyzer, Air Tester Model CH- HAT 200, Aeroqual Series 200 Gas Monitor and Kestrel model No. 4500 pocket weather tracker.

Air quality parameters determined in the study area include: Sulphur Dioxide (SO_2), (CO), Hydrogen Sulphide (H_2S), (C_4) methane Total Suspended Particulate Matter (TSPM), and Volatile Organic Compounds (VOCs).

CHAPTER TWO

LITERATURE REVIEW

2.1 Concept of Solid Waste Dumpsite

Dumpsites are places selected for disposal of normally solid or semisolid materials, resulting from human and animal activities that are considered useless, unwanted or hazardous. Dumpsites are essential part of any waste management system. According to El-Fadel *et al*, (1995), dump sites are historically the most employed method for waste disposal in the world. Disposal in this context means discharge, injection, dumping, spilling, or placing of any solid waste or hazardous waste into environment (land, air or water including ground waters) (US Law-Solid Waste Act 2, 1999). But, Asian Institute of Technology (AIT) (2004), revealed that final disposal in most developing countries was usually a matter of transporting the collected waste to the nearest available open space and discharging them. In this part of Africa; most solid waste is disposed of indiscriminately without regard to the environment. Dumpsites are sited usually at the outskirts of the urban areas, which become sources of contamination to the incubation and proliferation of flies, mosquitoes, and rodents (Mustafa, 1993). This phenomenon creates significant economical and environmental problems when dumpsites sites overflow with plastics (Najem & Strunk, 1994).

Then Jung et al, (2005) discovered that open dumping had the potential to degrade environmental quality in neighbourhood and could also pose a threat to public health, the environment and even scavengers that depended on scavenging materials for their livelihood. Hence, environmental pollution results due to man's quest to adopt contemporary technologies, urbanization, industrialization, with corresponding inefficient waste management strategies (Rajaganapathy, et al. 2011).

Now the consequences of open dumping associated with environmental and health hazards and risks include: offensive odour, dust emissions, poor aesthetics, environmental nuisances, attraction of vermin, vector and pest, severe health risks to human beings and animal, breeding of disease vectors, flies and rats. Gray (1993) observed that insects and rats are potential disease transmitters.

Solid wastes are unwanted or needless non-liquid substances which can be referred to as garbage or refuse. Solid wastes are different from liquid waste or effluent. The American Public Works Association defined solid waste as needless or ready to be discarded substances with inadequate liquid component.

Municipal solid waste (MSW) is one of the categories of solid wastes. Municipal solid waste refers to solid or non-gaseous wastes arising from domestic, industrial, commercial or agriculture origin (Adedibu, 1985). Trash, garbage, refuse or rubbish is used to describe municipal solid waste (MSW) in different countries of the world. "Garbage" refers to food waste.

2.2 Sources and Fate of Solid Wastes

Human activities create vast streams of wastes and pollutants, which are capable of infringing on vital components of the ecosystem (Angaye and Abowei, 2017). There are basically two sources of MSWs, which are domestic and commercial sources (Momodu et al., 2011). Domestic sources, refers to general household wastes which includes food waste, rubbish, ashes and special wastes. While commercial sources refers to waste originating from commercial activities like restaurants, shops, auto-mechanic repairs, medical facilities, schools, construction activities and other special wastes (Angaye and Abowei, 2017).

Sources of contamination include: spills during transportation, poor containment of waste, surface runoff, combustion, inability to segregate waste, impromptu disposal of waste, siting of dumpsites close to water way and residential area etc. (Worksafe, 2005; Shayley *et al*., 2009; Stavrianou, 2007).

The toxicity and fate of pollutants released was largely dependent on the source and target (Shayley et al. 2009), as well as its leachability to the environment. Fate of contaminants could be intensified by certain factors including soil porosity, permeability, mineralogy, pH, organic matter, moisture, temperature etc (Shayley et al., 2009). Bioavailability can also play vital role in the fate of some contaminants, for instance in aquatic ecosystems, recalcitrant waste toxicant like heavy metal are usually soluble or suspended in water and their persistence make them settle to the basal zone where they are bonded with sediment, and others form abyssal biota (Aderinola *et al*., 2009; Ene *et al*., 2009; Obodai *et al*., 2011)

Notwithstanding, there are several routes of exposures which includes inhalation, oral ingestion, eye or dermal contamination or through other human body orifices. Besides, the adverse effects of any pollutant are largely dependent on its toxic properties, including the exposure rate and concentration of the toxicant (Stavrianou, 2007). Leachates from dumpsites can be transported by runoffs to contaminate either soil or other sources of water, thereby posing danger to species which depends on such soil and water resources.

The group at risk from the improper disposal of solid waste include: the pre-school children; waste workers; and workers in facilities producing toxic and infectious material. Other high-risk groups include the population living close to a waste dump and those whose water supply has become contaminated, either due to waste dumping or leakage from landfill sites. Uncollected solid waste also increases risk of injury and infection (Onakpohor, 2013).

2.3 Methods of Solid Waste Disposal

Landfill is a method of waste disposal where waste materials are buried under ground. Wastes are usually disposed in abandoned quarries, mining or borrow pits. Disposing wastes in landfill is not expensive compared with other methods. However, some of the environmental problems associated with open waste dump include wind-blown litter, attraction of vermin, and generation of liquid leachate.

According to the United Nations Environmental Protection Agency (2006), incineration is the process of destroying waste material by burning it. The burning of the waste materials generates into residue and gaseous products and the gaseous pollutants are emitted into the atmosphere.

Other methods of waste disposal include recycling, biological reprocessing; energy recovery and avoidance and reduction methods.

2.4 Impact of Dumpsite on the Surroundings

Solid waste; when left unattended to for a long time, constitutes health hazards, causes offensive odour, and pollutes the underground water sources and decreases aesthetics and quality (Federal Ministry of Environment). Nwosu and Tamunobiekiri (2016) argued that the inability to manage these wastes effectively in Nigeria had become an issue of great concern. This is because apart from the destruction of aesthetics of landscape by the waste dumpsites, some of the municipal solid wastes contain both organic and inorganic toxic pollutants (such as heavy metals) that threaten the health of humans and the entire ecosystem.

Statistical data based on mortalities revealed that air pollution was critical role to the development of respiratory diseases (Barakat-Haddad, 2015), the World Health Organization has recently identified air pollution as a basic health hazard

(WHO, 2014). Air Pollution associated with solid dumpsites has become a major source of concern due to foul odour released and the emission of greenhouse gases like: Carbon monoxide , oxides of Nitrogen and Sulphur as well as release of suspended particulate matter during in situ burning (Angaye and Abowei, 2017).

The consequences of air pollution include nasal, eyes and airway irritation; wheezing, coughing, anoxia, and even lung and heart problems, which increase risk to asthma. Whereas in extreme cases it can result to mortality, the chronic exposure to air pollution can compromise the immune system and cause systemic cancer of the nervous, reproductive, and respiratory systems.

Besides toxic emission during burning of waste, suspended particulate matter with carcinogenic substances can irritate the nasal cavity or the lungs and cause infections ranging from cold to other air-borne diseases (Angaye and Abowei, 2017). Another report indicated that people whose abode are close to dumpsite are predisposed to cardiovascular diseases (Barakat-Haddad, 2015), like bronchitis, lung cancer, cardiovascular disease, birth defect, asthma, and premature mortalities (Agwu and Ozeh, 2013). Another study on the relative aerobic microbial distribution of a dumpsite in Nigeria showed, 37% Escherichia coli, 19% Klebsiella spp, 13% Pseudomonas spp, 15 % Serratia spp, 8 % of Staphylococcus spp, 7% of Enterococcus spp, with the least being 1% of Salmonella spp. (Odeyemi, 2012).

The major route of exposure of air pollution is by the process of inhalation (Barman, et al, 2010).

World Bank (2003) reported that proper management of solid waste was critical to the health and well-being of urban residents. However, poor management of municipal solid waste in developing countries and other vital resources has become a major challenge (Abur et al., 2014). Inefficient waste management impairs human health and biodiversity with corresponding adverse effects on major resources (Sharholy et al., 2008).

The composition of the gas varies according to the type of waste and phase of degradation of the waste. It also includes small amounts of nitrogen, oxygen, ammonia, sulfides, hydrogen, and non methane organic compounds (NMOCs) such as trichioroethylene, benzene, and vinyl chloride. (Wang-Yao et al, 2006).

Formation of dumpsite gas involves the processes of volatilization, chemical reactions and bacterial decomposition. Volatilization is the change from a liquid or a solid waste into a vapor. NMOCs in dumpsite gas may be the result of volatilization or reaction of certain chemicals disposed of in the dumpsite (Cernuschi and Guigliano, 1996). For example, a harmful gas is produced, when chlorine bleach and ammonia react within the dumpsite. (Cemuschi and Guigliano, 1996)

Microorganisms such as bacteria and fungi decompose dumpsite waste in four phases and the composition of the gas changes during each phase. During the first phase of decomposition, bacteria that live only in the presence of oxygen (aerobic bacteria) consume oxygen while breaking down the long molecular chains of complex carbohydrates, proteins, and lipids that comprise organic waste. The primary by-product of this process is carbon dioxide. Nitrogen content is high at the beginning of this phase, but declines as the dumpsite moves through the four phases. Phase I continues until available oxygen is depleted.

Phase II decomposition involves bacteria that do not require oxygen (anaerobic bacteria) to convert compounds created by aerobic bacteria into acetic, lactic, and formic acids and alcohols such as methanol and ethanol. The dumpsite becomes highly acidic. As the acids mix with the moisture present in the dumpsite, they cause certain nutrients to dissolve, making nitrogen and phosphorus available to the increasingly diverse species of bacteria in the dumpsite. The gaseous by - products of these processes are carbon dioxide and hydrogen.

Phase III decomposition involves certain kinds of anaerobic bacteria that consume the organic acids produced in Phase II and form acetate, an organic acid. This process provides a more neutral environment in which methane-producing bacteria are present.

Phase IV decomposition begins with the composition and production rates of dumpsite gas remaining relatively constant. Gas is produced at a stable rate in

Phase IV, typically for about 20 years; however, gas will continue to be emitted for 50 or more years after the waste is placed in the dumpsite (Maurice and Lagerkvist, 2003).

The factors affecting dumpsite gas formation include composition and age of the refuse, the presence of oxygen in the dumpsite, moisture content, and temperature. The rate and volume of dumpsite gas produced at a specific site depend on the characteristics of the waste (Cernusehi and Guigliano, 1996)

The quantity of dumpsite gas produced by bacterial decomposition is proportional to the amount of organic waste materials present in a dumpsite (Gurijala *et al*., 1997). The presence of certain nutrients, such as sodium, potassium, calcium, and magnesium in organic waste increases dumpsite gas production. However, some –nutrient- content of wastes (salt concentrations) that inhibit gas production by the methane-producing bacteria.

According to Nastev *et al*., (2001) more recently buried waste (i.e., waste buried less than 10 years) will produce more gas than older waste (buried more than 10 years) through bacterial decomposition, volatilization, and chemical reactions than does older waste (buried more than 10 years).

The presence of a certain amount of water (unsaturated conditions) in a dumpsite increases gas production because moisture encourages bacterial growth and transports nutrients and bacteria to all areas within a dumpsite (Christensen et al., 1996). Waste compaction slows gas production because it increases the density of the dumpsite contents, decreasing the rate at which water can infiltrate the waste.

Once gases are produced under the dumpsite surface, they generally move away from the dumpsite (Zhang *et al*., 2008). Gases tend to expand and fill the available space, so that they move, or “migrate,” through the limited pore spaces within the refuse and soils covering of the dumpsite. The natural tendency of dumpsite gases that are lighter than air, such as methane, is to move upward, usually through the dumpsite surface. Upward movement of dumpsite gas can be inhibited by densely compacted waste or dumpsite cover material (e.g., by daily soil cover and caps). When upward movement is inhibited, the gas tends to migrate horizontally to other areas within the dumpsite or to areas outside the dumpsite, where it can resume its upward path. Basically, the gases follow the path of least resistance. Some gases, such as carbon dioxide, are denser than air and will collect in subsurface areas, such as utility corridors. Three main factors influence the migration of dumpsite gases: diffusion (concentration), pressure, and permeability (Naranjo *et al*., 2004)

Gases in a dumpsite move from areas of high gas concentrations to areas with lower gas concentrations. Because gas concentrations are generally higher in the dumpsite than in the surrounding areas, dumpsite gases diffuse out of the dumpsite to the surrounding areas with lower gas concentrations.

Gases accumulating in a dumpsite create areas of high pressure in which gas movement is restricted by compacted refuse or soil covers and areas of low pressure in which gas movement is unrestricted. The variation in pressure throughout the dumpsite results in gases moving from areas of high pressure to areas of low pressure. Movement of gases from areas of high pressure to areas of lower pressure is known as convection. When pressure in the dumpsite is higher, gases tend to move to ambient or indoor air.

Gases will also migrate according to where the pathways of least resistance occur. Permeability is a measure of how well gases and liquids flow through connected spaces or pores in refuse and soils. Gases tend to move through areas of high permeability (e.g., areas of sand or gravel) rather than through areas of low permeability (e.g., areas of clay or silt). Dumpsite covers are often made of low-permeability soils, such as clay.

Human exposure to municipal emission occurs through three primary pathways: release of the gas to ambient air, subsurface vapor migration by convection and subsequent indoor vapor infiltration, and indoor vapor infiltration from contaminated groundwater below buildings. Other pathways include inhalation, ingestion and dermal exposure to dumpsite gas.

Release of dumpsite gas to ambient air is most prevalent when a permeable cover is used or when the cover has been breached either intentionally or unintentionally, that is, in an uncontrolled emission condition. Under such conditions, the internal pressure transports the gas to the surface or through passive vents to the outside air. Human exposure may occur onsite and offsite as a function of the actual emission rate and atmospheric dispersion. The significance of the human exposure is determined by the chemical's toxicity and concentration as well as by the duration and frequency of exposure. Duration and frequency of exposure are functions of the dumpsite gas emission rate, the atmospheric dispersion, and human life style.

2.5 The Concept of Air Pollution

Air pollution consists of substances present in the atmosphere in high concentration to cause harm or discomfort to humans, other animals, plants or materials or damages the natural environment. The industrialization of society, the introduction of motorized vehicles, and population growth responsible for increased use of fossil fuel for industry, electricity generation, transportation or waste generation are all factors contributing to the growing air pollution problems of today. Activities responsible for the releasing of pollutants in the atmosphere were classified into two major categories: anthropogenic and natural sources (Coils, 2002b). Natural sources of pollutants include smoke from forest fires caused by lightening and from wildfires, volcanic eruptions, which produce sulphur, chlorine, and ash particulates.

In addition, Onakpohor, (2013) classified sources of pollutants in urban areas into transportation (automobiles), municipal waste emissions and fuel combustion in stationary sources, including residential, commercial, and industrial heating and cooling, waste incinerators and coal-burning power plants.

2.6 Air Pollutants and their Health Implications

Oxides of carbon, sulphur oxides, nitrogen oxides and particulates are some of the air pollutants capable of impacting negatively on man, plants and environment.

Dumpsite activities have the potential to produce both fine and coarse particulates.

Exposure to particles greater than 10 um in diameter (PM_{10}) are unlikely to penetrate beyond the nose and larynx. Particles less than about 2.5um diameter ($PM_{2.5}$) are referred to as fine particles and are deposited relatively efficiently in the deeper parts of the lung-for example, in alveolar spaces. Particles between 2.5 and l0 um in diameter are referred as comprising the coarse fraction of PM_{10}.

Dust emitted from dumpsite will fall into the PM_{10} and $PM_{2.5}$ categories. Particulates emitted from dumpsites may also contain metals such as arsenic, cadmium, cobalt, copper, lead, and manganese.

People with pre-existing lung and heart disease, the elderly and children are particularly sensitive to particulate air pollution. Dusts from dumpsites can become airborne and move off site by a number of mechanisms. The distance traveled and amount of dust lifted from the surface of the dumpsite is dependent upon the speed of the wind, the condition of the surface and the size of the dust particles.

Ammonia is a colourless, pungent, hazardous caustic gas composed of nitrogen and hydrogen (i.e. a compound with the formula NH_3).

Ozone is a pale blue gas with a strong odour and a powerful oxidant. It is the most common photochemical oxidant. Ozone is created naturally in the high atmosphere when an oxygen molecule is broken apart by ultraviolet radiation and combines with another oxygen molecule. Ozone in the upper atmosphere shields us from ultraviolet radiation, whereas at ground level, it is highly toxic to both plants and animals as it can damage lungs (WWFT, 2009). It penetrates the leaves and needles of vegetation by ways of the stomata.

Ozone irritates the eyes, nose and throat, and it causes chest pain and damages crops and vegetations. Some Agricultural crops such as tobacco and spinach are very sensitive to damage by ozone (Direct Gov, 2010). It can develop slowly as a yellowing or chlorosis of the leaf. Depending on the crops and the concentration involved, ozone may reduce yields from 1 to 20 % (Jean-Paul, 2009). It has been estimated that wherever the mean daily O_3 concentration reaches 40, 50, or 60 ppb (parts per billion, or per l0), the combined yields of soybean, maize, winter wheat, and cotton would be decreased by 5, 10, and 16 %, respectively (Eduardo, 2006).

Carbon monoxide is a colourless, odourless and non-flammable gas that composes 0.04 % of the atmosphere. Dumpsites accounts for around 45 % of total Carbon monoxide emissions in developed countries (15 % worldwide) (Jean-Paul, 2009).

Exposure to low concentrations of CO_2, increases the depth and rate of respiration, blood pressure and pulse (HPA, 2009a).

Hydrogen sulphide (H_2S) is a colourless, flammable gas with a characteristic odour of rotten eggs. The composition of the waste material and the design and management of the site will determine the amount of H_2S produced and concentration in landfill gas can vary considerably. Since July 2005, the authorities of England and Wales have prohibited landfill of biodegradable waste materials with high sulphur content (EA, 2010a).

Methane is a hydrocarbon compound (CH_4). It is very flammable and is produced predominantly by anaerobic bacteria that feed on organic material where oxygen is deficient (Einola et al, 2007).

2.7 Location of Study Area

The study area Mbarakuma Ubakala, is in Umuahia South Local Government, Abia State. It is geographically located within longitudes 7^0 24' and 7^0 30'E and Latitude 5^0 31'N and 5^0 34'N (Fig. 2.1). It is located on an elevation of 160m above sea level. It is adjoined by Eziama community at the North, Lagura and Omosu at the East, and Abam at the West.

The waste dumpsite is located along Umuahia-Aba Road. The dumpsite has an average depth of 3.47 m and a mean surface area of about 4200 m^2 with an estimated capacity of 21, 400 m^2 and has been in use since 1996 just after the creation of Abia State.

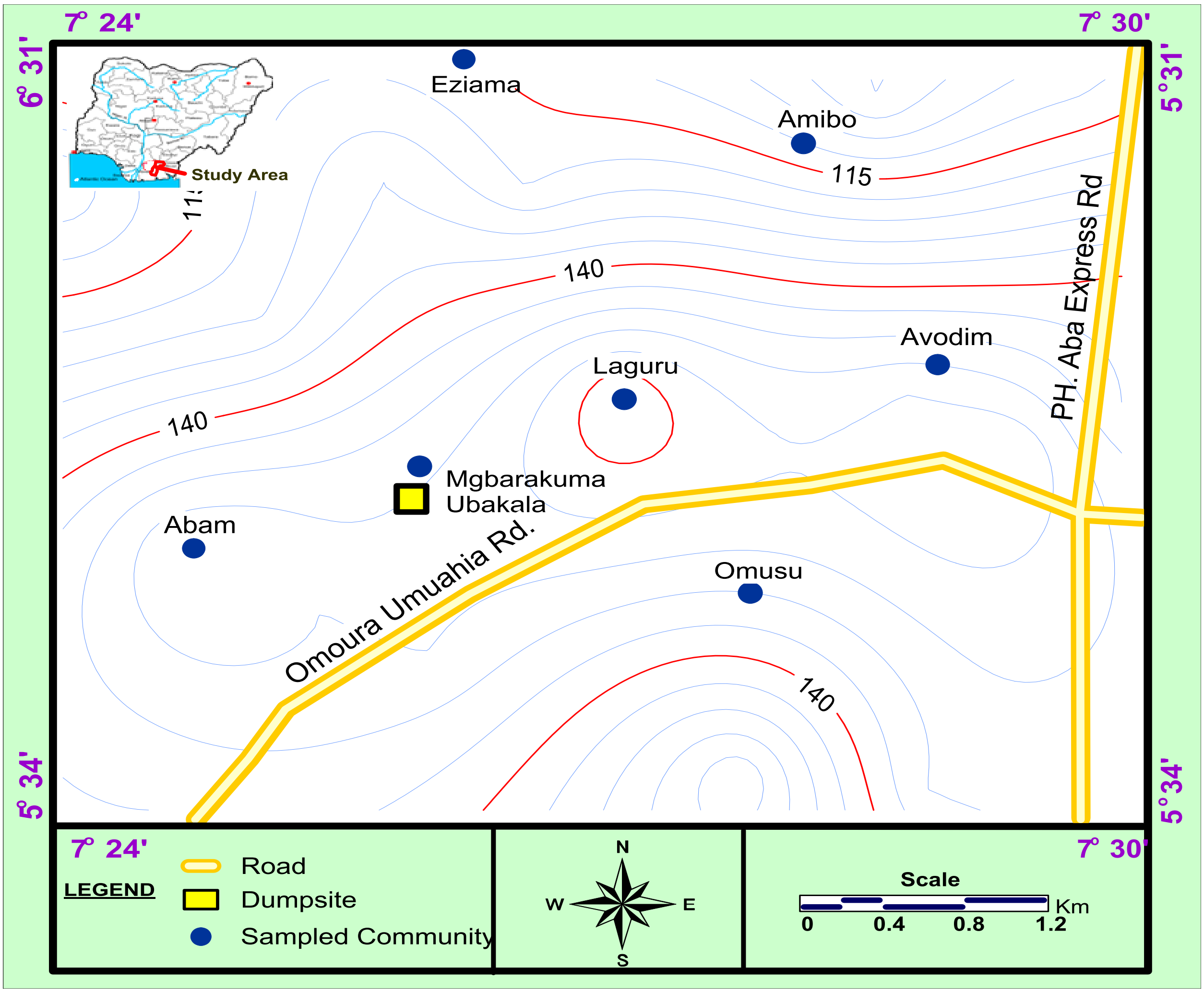

Fig. 2.1: Topographic Map of the Study Area

2.8 The Geology of the Study Area

The study area is within Benin Formation (Fig. 1.2) which is characterized by sands, gravel and intercalations of clay.

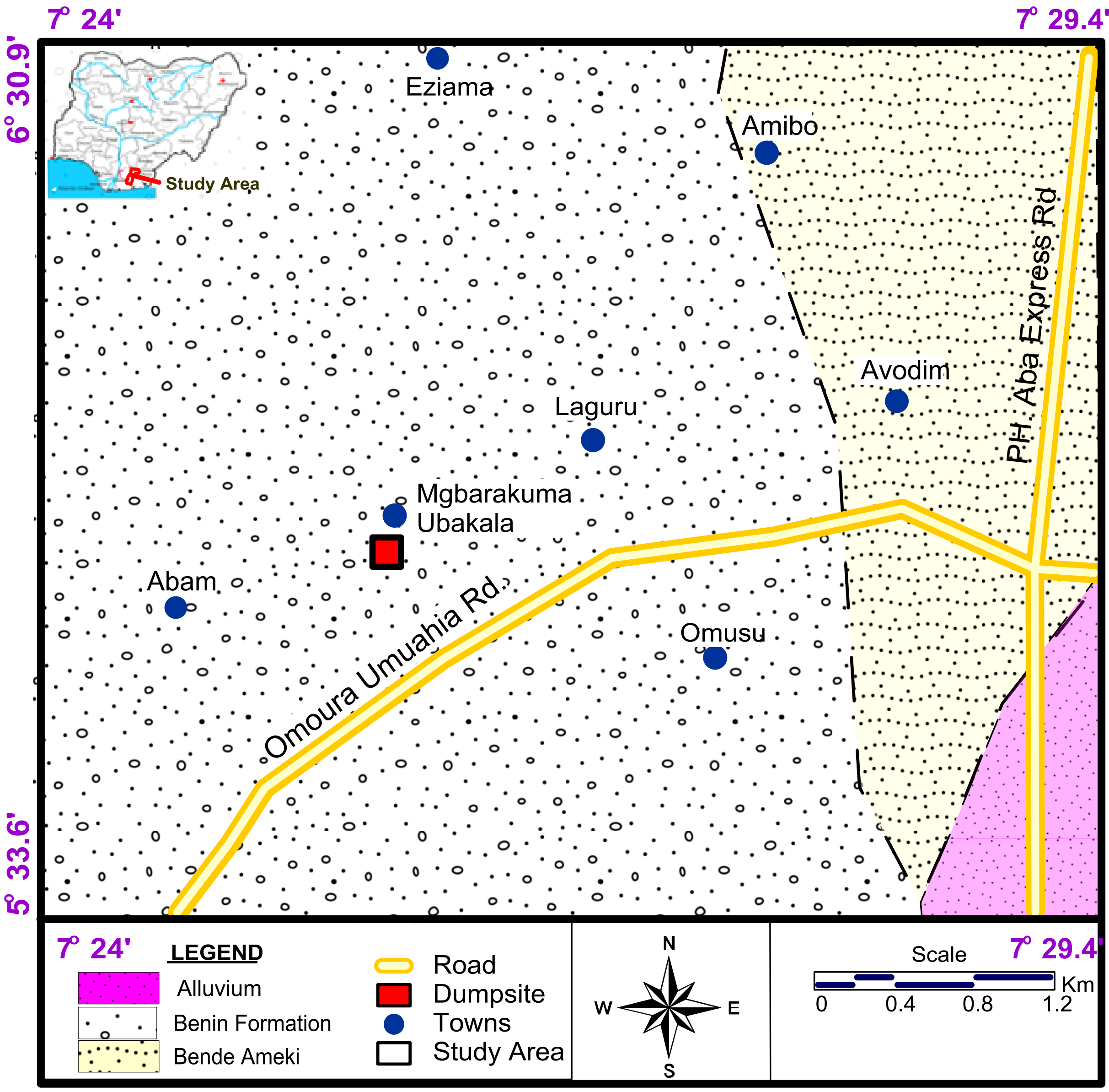

Fig. 2.2: Geologic Map Showing the Study Area (Source: Nigerian Geological Survey Agency (NGSA, 2006)

It is a part of Imo River Basin with boundaries defined by its surface drainage divide. The Imo River Basin is based on bedrock of a sequence of sedimentary rocks of about 5480 m thick and with ages ranging from Upper Cretaceous to Recent (Uma, 1989).

About 80 % of the basin consists in Coastal Plain Sand, which is composed of non-indurated sediments represented by the Benin and Ogwashi-Asaba Formations, and alluvial deposits at the estuary at the Southern end of the Imo River Basin. The remaining 20 % is underlain by a series of sedimentary rock units that get younger southwestward, a direction that is parallel to the regional dip of the formations.

The Ajali Sandstone of Maastrichtian age as seen in fig. 1.2 is the oldest exposed formation in the basin, outcropping at its north-eastern fringe along a NW-SE band (2 to 4 km width). It consists of thick friable, loosely consolidated sandstones. Overlying the Ajali Sandstone conformably is the Nsukka Formation (Maastrichtian-Lower Paleocene), which extends to a relatively broader stretch of land than the former. It consists of alternating sequences of sandstones, shales, and sandy shales. It dips at about 6°, on the average, to the south - west. The Imo Shale of Paleocene -Lower Eocene age overlies the Nsukka Formation unconformably. It consists of a thick sequence of blue and dark grey shales with occasional bands of clay-ironstones and subordinate sandstones (Ekwe *et al*., 2006).

Next in the depositional sequence is the Ameki Formation (Eocene), which consists of sand and sandstones. The lithologic units of the Ameki Formation fall into two general groups (Whiteman, 1982); an upper grey-green sandstones and sandy clay and a lower unit with fine to coarse sandstones, and intercalations of calcareous shales and thin shelly limestone. Next in the depositional sequence is the Ogwashi/Asaba Formation (Oligocene to Miocene), which is generally made up of clays, sands, grits and seams of lignite alternating with gritty clay. This formation is characterized by its up dip and down dip pinch outs within the Imo Basin.

The Ogwashi/Asaba Formation is overlain by the Benin Formation (Miocene to Recent) which is the most extensive of all the formations, which covers more than half of the area of the basin. It consists of sands, sandstones, and gravels, with intercalations of clay and sandy clay. The sands are fine -medium-coarse grained and poorly sorted. The Benin formation is made of porous sand and gravels with localized shales/clay interbeds occurring as point bars or channel fills. They are deposited in a continental fluvatile conditions. The geology within the specific area of interest comprises of Alluvium, Benin Formation, and Bende Ameki formation.

2.9 **Climate of the Study Area**

The rainfall of southern Nigeria generally is heavy and aggressive. Rainfall amount ranges from over 2500 mm in the southernmost region towards the Atlantic Ocean to about 1500 mm annually around River Benue in the northern borders. Rainfall intensities are high and often above 50mm/h with short interval intensities in excess of 100 mm/h. Rainfall often comes between the month of March and last till October. In some years the rainy period is unduly prolonged while in other years their onset may be delayed for more than 5 weeks

CHAPTER THREE

MATERIALS AND METHODS

3.1 Reconnaissance Survey of the Study Area

This involves a preliminary site visit to the study area to identify sources of pollution and potential receptors within the area. The geologic map and topographic map were matched with physical observation of terrain and specific land feature for an effective planning of air quality monitoring. At this stage, sampling stations were identified and marked for air sampling and measuring of pollutant concentration.

3.2 Field Sampling Procedures

Gas analyzers (GA-21 plus flue gas monitor) were used to identify and measure the concentration of pollutant gases directly in the field in different communities within the study area. These communities are Mbarakuma Ubakala, Umosu-Laguru, Eziama, Amibo, Avodim, Lagura-Ubakala, and Abam. Two measurements of each parameter were taken at the interval of 30 minutes between each.

Sampling points were selected for the air quality measurement. National Environmental guidelines (2009) were used to determine the parameters whose concentrations are within or above acceptable limits.

3.2.2 General Methodology

Air quality within and around the dumpsite was monitored in-situ at seven different strategic stations.

Standard methods for air quality sample collection and analysis were employed according to specified International standards. Monitoring was done at rainy and dry season.

Also, atmospheric dispersion models were developed with the aid of a simple linear regression approach to predict the behaviour of different gases as they dispersed away from the dumpsite. The models were derived from the field work of this project. Concentrations of different gases were measured four times during the dry and wet season within the study area. A distance of 3.6 km was covered using measurement intervals of 0.6 km.

3.3 Data Acquisition, Quality Assurance and Control (QA/QC).

Digital instruments that capture data in instantaneous digital format were integrated. The digital systems eased data capture, reporting, and reduced noise in the recording of gas data, thereby improving sensitivity. It controlled internal diagnostics, calibration and mitigated data quality problems. Quality assurance relates to the measurement process which ensures that measurements meet defined and appropriate standards objectives for quality, with a certain level of confidence.

Quality control directly covered measurement-related activities such as site operation, calibration, data management, selecting sampling points, evaluating equipment and training and is concerned primarily with output (Bower and Mucke, 1999).

3.4 Research Instruments/ Calibration of Instruments

The sampling instruments used to obtain geographic coordinates and elevation above sea level, gaseous emission air pollutants, particulates and meteorological parameters include:

(i) Global Positioning System (GPS): This device was used in measurement of the elevation and coordinate (longitudes and latitudes) of the sample locations.

(ii) Wind Vane: A portable wind vane was used to determine the prevalent direction of wind in the area. Gases dispersed along the lines of dominant wind movement.

(iii) Kestrel model No. 4500 pocket weather tracker: was used for the measurement of the wind speed in m/s, ambient temperature in ^{0}C and Relative Humidity in %.

(iv) GA- 21 Plus Flue Gas Analyzer

GA-21 plus flue gas monitor is a multi-functional flue gas analyzer with electronic- chemical sensors, was used for the detection of gas concentrations such as Methane (CH_4), oxides of Sulphur (SO_x) and (CO). GA-21 plus gas analyzer has the capability to measures CO_2, SO_2, and CH_4. Measurement was taken by placing the gas monitor in the direction of the wind, the probe (nozzle) of the gas analyzer suck the gases (CH_4, SO_x and CO) through the connector, the filter dry the gases entering the sensor, then the sensor separate the gases into their various component, result were display on the screen of the gas analyzer and readings were recorded at stability.

(v) Air Tester Model CH- HAT 200

Air Tester Model CH-HAT 200 with sensors was used for the detection of Total Suspended Particulate Matter (TSPM). CH-HAT 200 is a portable digital air sampler for particulate (TSPM). Measurement was done by placing the gas analyzer in the direction of the wind and readings were recorded at stability.

(vi) Aeroqual Series 200 Gas Monitor

Aeroqual series 200 gas monitor with VOCs sensor head was used for the detection of Volatile Organic Compounds (VOCs). The instrument detects VOCs via a Flame Ionization Sensor. It has a very high resolution.

3.5 Measurement of Air Quality Parameters

Air quality parameters determined in the study area include:

(i) Sulphur Dioxide (SO_2)

GA-21 plus flue gas monitor is a multi-functional flue gas analyzer with electronic-chemical sensors, was used for the detection of SO_2. SO_2 is monitored continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any SO_2 in the sample is excited to a higher energy level and upon returning to its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the SO_2 concentration.

(ii) Carbon Monoxide (CO)

GA-21 plus flue gas monitor, a multi-functional flue gas analyzer with electronic-chemical sensors was used. The equipment detects CO via an Electrochemical Sensor that generates a signal linearly proportional to the concentration of the pollutants.

CO is monitored continuously by either non-dispersive infrared photometry or gas filter correlation. The non-dispersive infrared photometry process is based upon the absorption of infrared light by CO. Gas filter correlation is operated on the same principle as non-dispersive infrared photometry but is more specific to CO by eliminating water vapor, CO_2 and other interferences.

(iii) Hydrogen Sulphide (H_2S)

H_2S is measured continuously by pulsed fluorescence (the same principle as the sulphur dioxide (SO_2) analyzer). Initially, all SO_2 in the air sample is scrubbed out so that it does not interfere with the measured H_2S concentration. The remaining H_2S in the sample is then converted to SO_2. The sample is then drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any SO_2 in the sample is excited to a higher energy level and upon returning to its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the SO_2 (converted from H_2S or TRS) concentration. The TRS analyzer works on exactly the same principle as the H_2S analyzer. The only difference is that the conversion of sulphur compounds to SO_2, occurs at a much higher temperature. Therefore there is a more complete conversion of sulphur compounds to SO_2.

(iv) Total Suspended Particulate Matter (TSPM)

Air Tester Model CH-HAT 200 with sensors was used for the detection of Total Suspended Particulate Matter (TSPM).

The sampler consists of a vacuum system and filter housed in a shelter and operates on the same principle as a vacuum cleaner. A known volume of air is drawn through a pre-weighed filter for 8-hour period. The filter is then re-weighed to determine the mass of the particles collected.

(v) Volatile Organic Compounds (VOCs)

Aeroqual series 200 gas monitor with VOCs sensor head was used for the detection of Volatile Organic Compounds (VOCs). The instrument detects VOCs via a Flame Ionization Sensor. It has a very high resolution. Measurements were done by placing the sensor to a height of about five meters in the direction of the prevailing wind and readings recorded at stability.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

4.1.1 General Dumpsite Waste Characterizations

Activities which bring about emission from the dumpsite ranges from transportation of waste to the site, deposition, use of heavy-duty plants or machines and scavenging activities of scavengers who salvage valuable reusable materials for recycling. Emissions from the dumpsite are generated due to the use of heavy duty plants in shifting and compacting the waste, dust from the surface of the dumpsite when waste was unloaded, previously deposited waste, gases and leachate from decomposed wastes.

The plates below show various activities taking place at the Mgbarakuma Ubakala Umuahia as at the time of this research. Plate 4.1a and 4.1b show the front view of the Mgbarakuma Ubakala municipal dumpsite and how the readings were recorded.

Plate 4.1a: Front View of the Mgbarakuma Ubakala Municipal Dumpsite

Plate 4.1b: Recording Experimental Readings (Data).

Solid wastes at the dumpsite were classified according to their types (Table 4.1).

Table 4.1: Classification of Solid Waste Based on Source

S/N	Classes of Waste	Characteristics and Sources of Wastes	Typical Examples	Percentage Composition (%)
1	Organic	Solid biodegradable waste	Leaves vegetables fruits, food scraps, carcass, wood etc.	50
2	Plastic	Semi-degradable or non degradable	Polythene bags, package water bags, plastic products, used tyres, old electrical appliances. Phone casting	35
3	Metal	Metallic waste recalcitrant could be toxic due to their leachability	Buckets, spoons. Plates, pots pans, sinks, poles, scrap cars refrigerator, generator	5
4	Glass	Originates from broken or discarded glassware	Drug, wine and chemical bottles, container, broken windscreen, ceramic plates and cups empty tins etc	10

4.1.2 Variation in Meteorological Parameters

The seasonal variation in the Meteorological parameters measured from Ubakala dumpsite for both dry and wet seasons are presented in Table 4.2.

Table 4.2 Seasonal Meteorological Parameter of Ubakala Dumpsite

Wet and Dry Season Data of Mgbarakuma Ubakala Dumpsite and its Environs Air Quality 2017									
Location	**Period**	**Ambient Temp. (^{o} C)**		**Rel. Humidity (%)**		**Wind Speed (s)**		**Wind Direction**	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Mbarakuma Ubakala	Day	26.40	40.2	76	58.6	0.5	0.9	NW	NW
	Night	24.40	36.6	79.2	62.3	0.7	1	NW	NW
	Mean	**25.40**	**38.4**	**77.6**	**60.45**	**0.6**	**0.95**		
Laguru	Day	26.40	39.4	65.6	58.2	0.4	0.9	NW	NW
	Night	25.40	34.6	71.2	63.6	0.8	1	NW	NW
	Mean	**25.90**	**37**	**68.4**	**60.9**	**0.6**	**0.95**		
Abam	Day	26.60	38.4	65.7	60.2	1.3	1.7	NE	NE
	Night	26.00	34.7	68.3	63.5	1.8	1.9	NE	NE
	Mean	**26.30**	**36.55**	**69**	**61.85**	**1.55**	**1.80**		
Omusu	Day	29.30	37.4	69	61.7	1.7	1.9	SE	SE
	Night	28.00	34.7	73.2	66.3	2.3	2.6	SE	SE
	Mean	**28.65**	**36.05**	**71.1**	**64**	**2**	**2.25**		
Eziama	Day	30.20	36.2	60.7	58.1	0.7	1.1	SE	SE
	Night	30.00	33.7	63.3	60.3	1.2	1.6	SE	SE
	Mean	**30.10**	**34.95**	**62**	**59.2**	**0.95**	**1.35**		
Avodim	Day	31.1	35.4	59.6	56.7	0.8	1	SE	SE
	Night	29.4	30.7	61.6	58.9	1.1	1.3	SE	SE
	Mean	**30.25**	**33.05**	**60.6**	**57.8**	**0.95**	**1.15**		
Amibo	Day	32.5	34.4	59.6	57.2	1.5	1.9	NW	NW
	Night	28.9	29.5	61.6	59.6	2.1	2.3	NW	NW
	Mean	**30.7**	**31.95**	**60.6**	**58.4**	**1.71**	**2.10**		
Afara Ibeku/ Control	Day	35.1	37.7	57.8	53.7	1.1	2	SW	SW
	Night	32	36.2	59.8	57.2	1.9	1.4	SW	SW
	Mean	**33.55**	36.95	**58.8**	**55.45**	**1.5**	**1.70**		

4.1.2.1 **Relative Humidity (%)**

Variations in relative humidity with season and stations are shown in Table 4.2. In the wet season, the mean relative humidity value range from 58.65 % to 77.6 %. Mbarakuma Ubakala had the highest percentage of 77.6 % while Amibo had the lowest. The dry season also show percentage range from (57.80 % to 64.00 %) with Mbarakuma Ubakala and Amibo having the lowest and the highest percentage respectively. The mean relative humidity was generally low during the dry season, while in the wet season, it was generally high within the dumpsite.

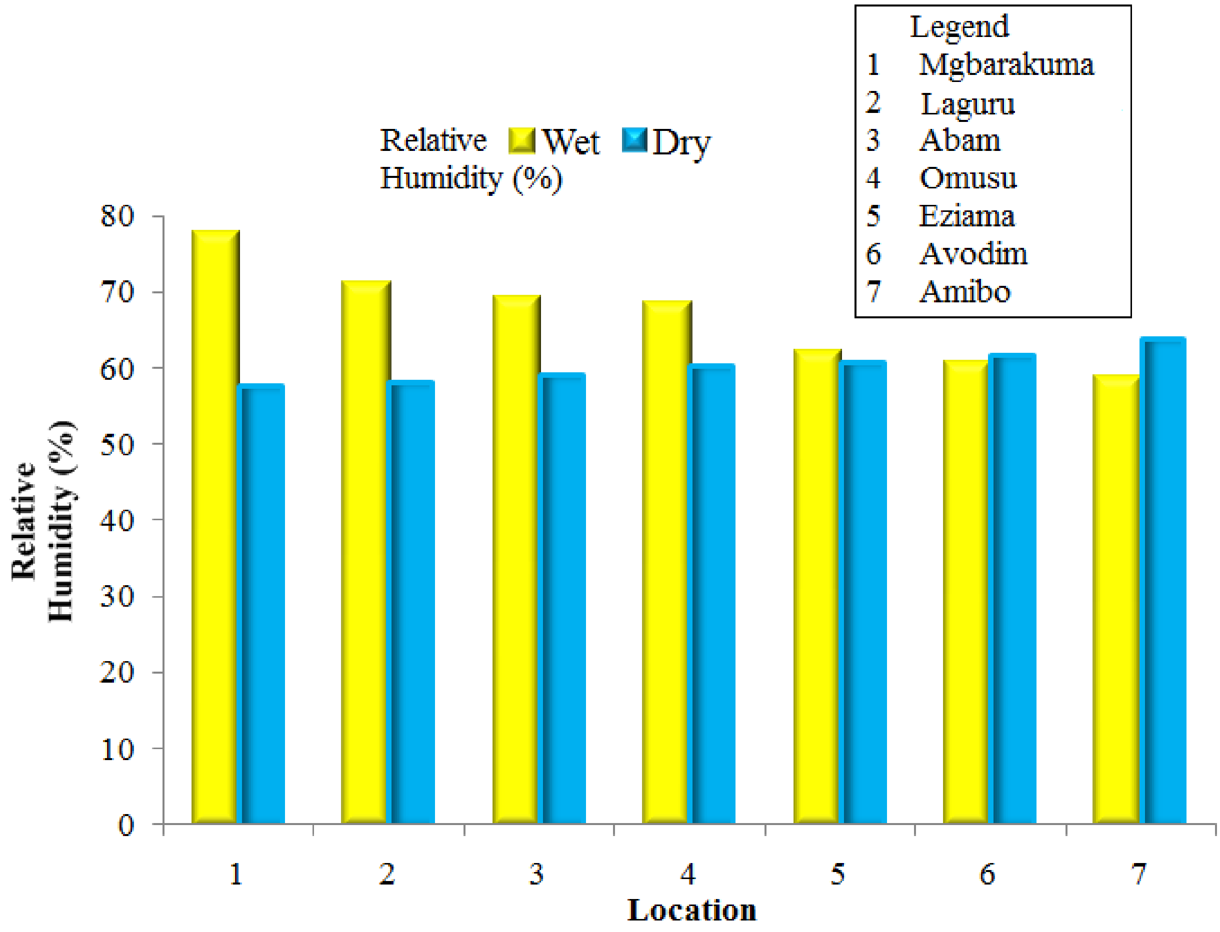

Fig. 4.1 Comparison of Wet and Dry Relative Humidity (%) at study Locations

4.1.2.2 Ambient Temperature (^{o} C)

Variation in ambient temperature with seasons and stations are shown in Table 4.2. The wet season show temperature range from 24.40 to 35.70 ^{o} **C** Mgbarakuma and Amibo (Control), having lowest and highest temperature respectively. The temperature of the dry season also ranged from (29.50 ^{o} **C** to 40.20 ^{o} **C**) with Mgbarakuma having the highest Temperature and Amibo having lowest temperature.

The graph showing the mean ambient temperature against stations is shown in figure 4.2. The mean ambient temperature was generally high during the dry season while, during the wet season, it was generally low within the dumpsite (Fig. 4.2).

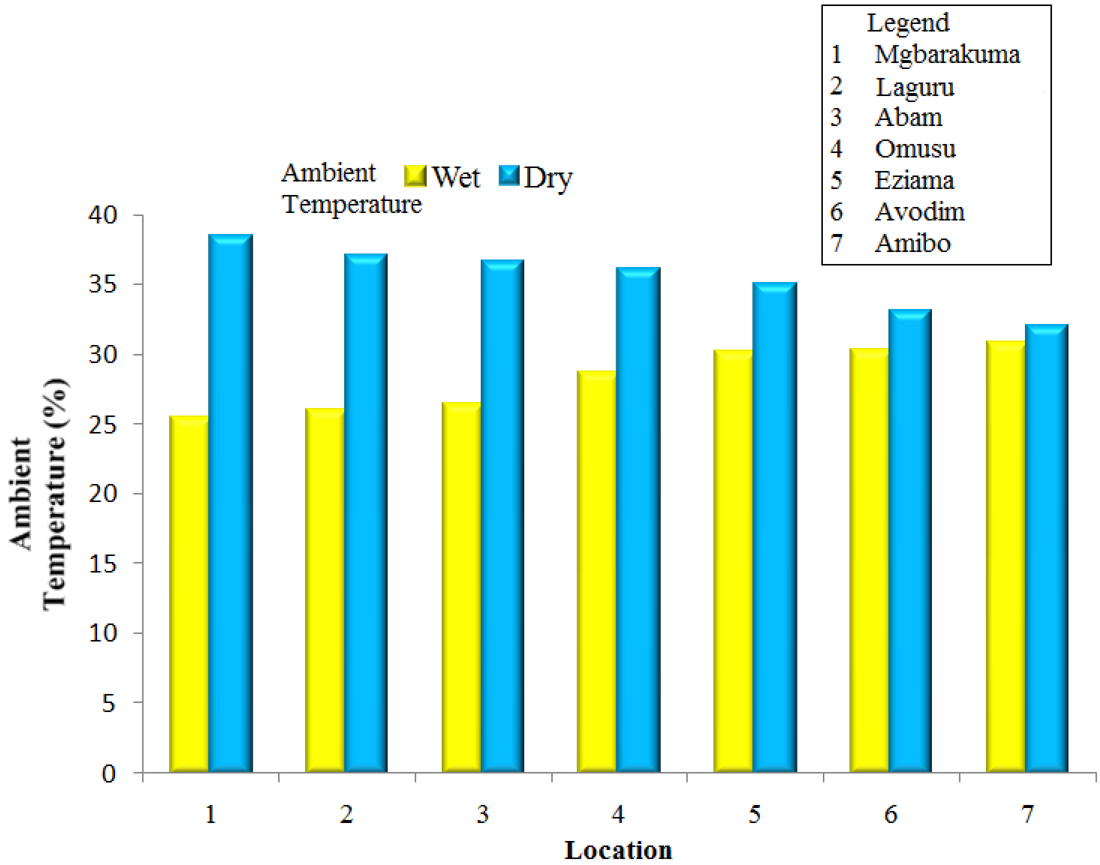

Fig. 4.2 Comparison of Wet and Dry Mean Ambient Temperature (^{o} C) at study Locations

4.1.3 **Wind Speed (S) Variation**

Variation in wind speed with seasons and stations are shown in Table 4.2. The distribution of wind speed and wind direction at a particular location over a period of time is displayed graphically in a wind rose diagrams.

The average wind speed in the wet season is 1.24 m/s, while the maximum wind speed is 2.3 m/s. The dominant wind direction that dispersed pollutant gases in the wet season were in the SE and NW direction (Fig 4.3a). The wind speed ranged from 0.6 – 2.0m/s.

The average wind speed within the dry season was 1.53 m/s, while the maximum wind speed stood at 2.6 m/s. Therefore, gaseous pollutants are dispersed in the SE and NW prevailing wind direction (Fig.4.2). The wind speed ranged from 0.95 – 2.6m/s.

This implies that pollutant gases dispersed more in the dry season than in the wet season in the line of dominant wind speed and direction. Wind movement was more pronounced in the dry season than in the wet season.

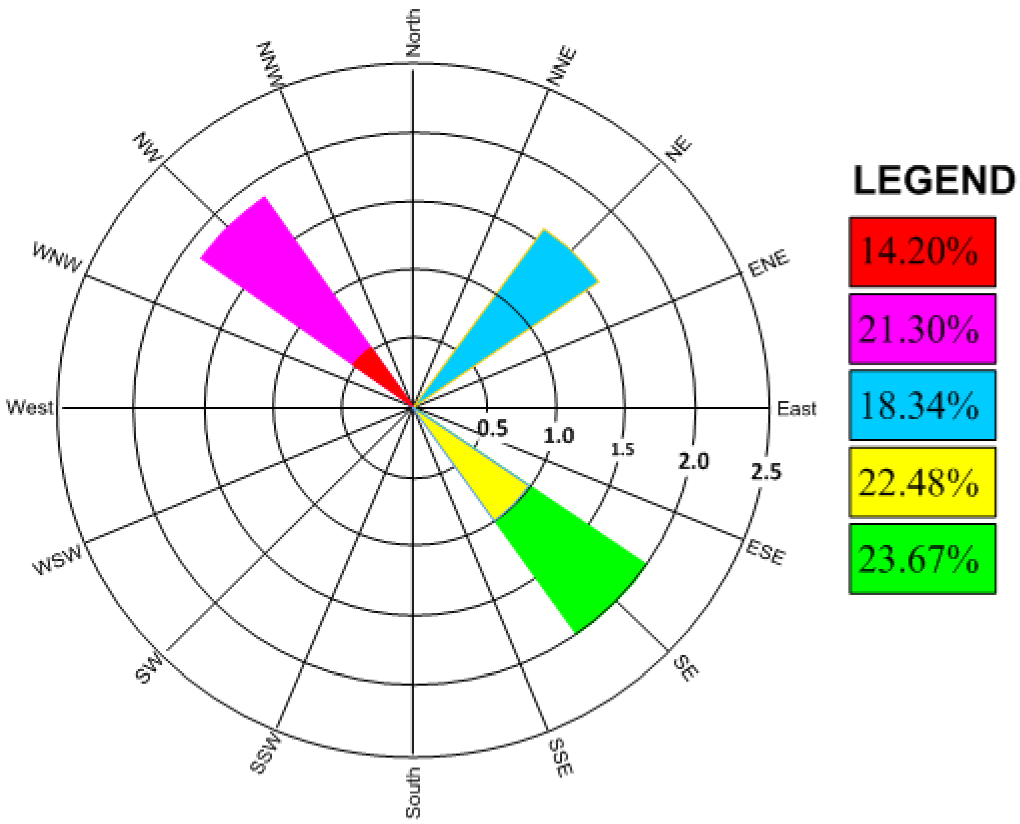

Fig. 4.3a: Wet Season Distribution of Wind Speed and Wind Direction

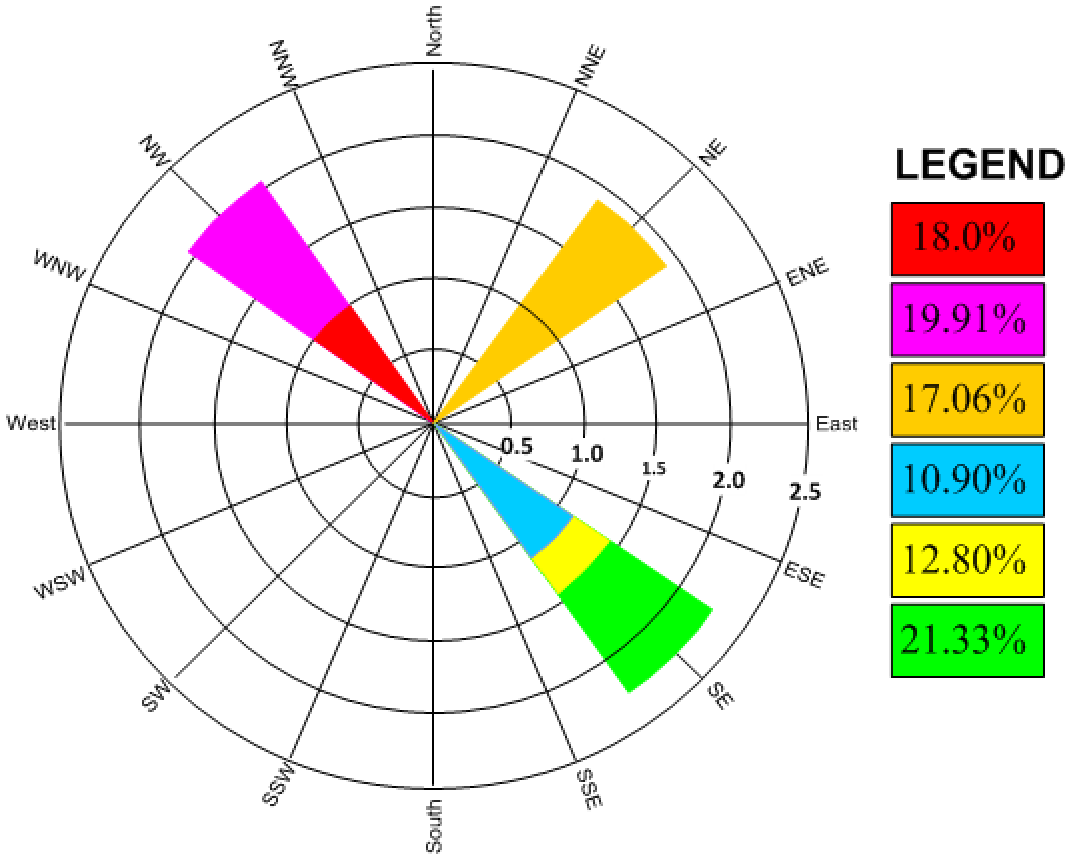

Fig. 4.3b: Dry Season Distribution of Wind Speed and Wind Direction

The mean wind speed was generally high during the dry season. During the wet season it was generally low within the dumpsite and also at the control site (Fig. 4.3).

Results of the wind rose diagrams (Fig. 4.3) suggest that the dispersion and migration of the measured air pollutants are associated with the prevailing wind speed and directions observed at the study locations. Wind speed and direction also determine the gas concentration in the air. The gas is emitted to the surface of dumpsite and the concentration disperses and diffuses at different rates.

Naturally, wind speed and direction determines whether the local residents will perceive waste odour so that the degree of the problem will vary from day to day (Chan et. al, 2008).

4.1.4 Particulate Matter and Gases Concentration

The result of the seasonal variation of particulate matter and gaseous air pollutants are presented in Table 4.3. The values used in plotting Figures 4.1-4.9 are shown in Table A1 in Appendix 1.

4.2 Discussion

4. 2.1 Effect of Distance on the Distribution of Total Suspended Particulate Matter Air Pollutants

In the dry season, the mean concentrations of total suspended particulate matter air pollutants measured at 0 km (station 1- source) was 74.93μg/m^3 while the mean concentrations measured at 3.6 km away from the source was 22.6µg/m^3. The average mean concentration particulate matter was 35.35µg/m^3.

Similarly, in wet season, the mean concentrations of particulate matter air pollutants measured at 0 km (station 1- source) was 63.5µg/m^3 while the mean concentrations measured at 3.6 km away from the source was 20µg/m^3. The average mean concentration of particulate matter was 30.43µg/m^3.

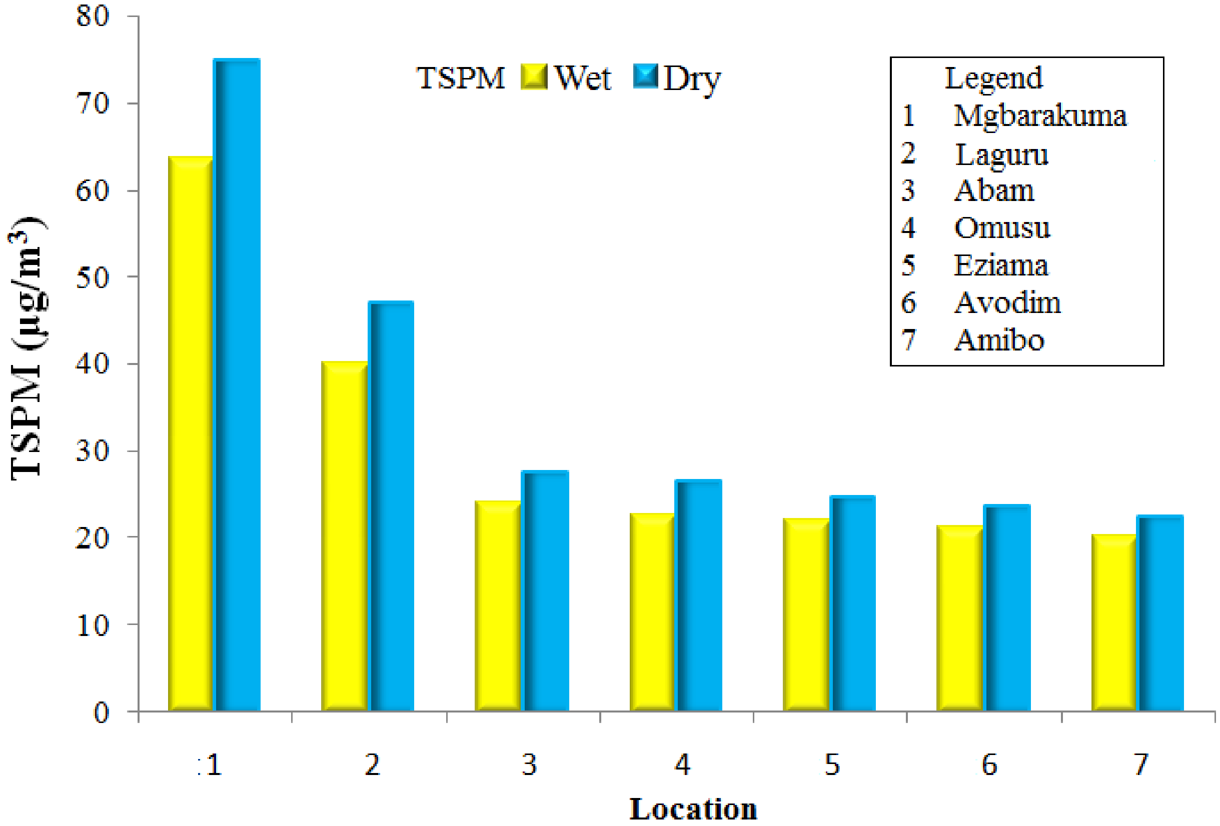

Fig. 4.4 Comparison of Wet and Dry Mean concentration of TSPM at study Locations

The average mean concentration of particulate matters were compared with permissible limits recommended by the National Environmental Regulations (2009) and found to be below limits. The concentrations of total suspended particulate matter across the study site were below the permissible limit of 250µg/m^3 for TSPM. The air quality on basis of Total Suspended Particles Matter (TSPM) could be classified as high quality and hence do not pose serious environmental problems (Table 4.3).

Table 4.3 Air Quality Classification Based on Total Suspended Particles (TSPM) Values

Range of TSP Values (µg/m^3)	**Class of Air Quality**
0 – 75	High Quality
76 – 230	Moderate Quality
231 – 600	Poor Quality

Source: Ibe et. al (2017)

Therefore, the mean concentrations of total suspended particulate matter measured at 0 km were significantly different from the mean concentrations measured at 3.6 km away from the dumpsite.

The higher concentration of total suspended particulate matter measured at the dumpsite is because of the high degree of dumpsite activities such as high vehicular activities as they bring waste to the site, transport and heavy plant used on site, waste blown by wind as they are tipped or deposited at the dumpsite, particles generated from the surface of the dumpsite, burning of waste (worn-out tyres), etc (Gobo *et al.*, 2009). This observation is in line with the findings of (Efel, 2008).

Also, particulate matter often affects plants and trees via blocking of leaf stomata (pores of a plant leaf) by which plants undertake the gas exchange necessary for photosynthesis and respiration (Farmer, 1997). Other effects include blocked stomata, increased leaf temperature, reduced photosynthesis, reduced fruit set, leaf growth, pollen growth, reduced tree growth, leaf necrosis and chlorosis, bark peeling (TRFA, 2010). These particulate matters include ozone, cement dust; magnesium-lime dust and carbon soot deposited on vegetation can inhibit the normal respiration and photosynthesis mechanisms within the leaf.

In addition, accumulation of alkaline dusts in the soil can increase soil pH to levels adverse to crop growth (Heather, 2009).

4.2.2 Effect of Seasonal Variation on the Concentration of Particulate Matter

Statistical analysis showed wet season concentrations to be significantly lower than the dry season concentrations. This observation is in consonance with the report by Efel, (2008), Gobo et al, (2009) and Onakpohor, (2013). The increase in the concentrations of particulate matters as observed in the dry season could be attributed to high content of dust particles from the North -East Trade wind (Hamarttan).

4.4 Gases Concentration Variation with Study Stations and Season

Table 4.4: Showing Average mean and Federal Ministry of Environment (FME) Standard (2009).

Station		**TSPM**		**H_2S**		**VOC_S**		**CO**		**NH_3**		**CH_4**		**SO_2**	
		(µg/m^3)		Concentration (ppm)											
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
1	Day	68.00	80.24	3.4	4	2.9	2	2.3	2.8	8.00	4.2	0.07	0.11	1.05	1.6
	Night	59.00	69.62	2.8	3	2.6	1.8	1.7	2.2	6.00	3.9	0.05	0.09	0.95	1.4
2	Day	41.00	48.38	2.6	3.2	2	1.7	1.6	2.63	5	3.6	0.06	**0.05**	0.6	1.4
	Night	39.00	46.02	2.4	2.8	2	1.25	1.2	2.31	3	3	0.04	**0.03**	**0.8**	**1**
3	Day	25.00	28.75	2	3.3	1.1	1.07	1.04	2.57	4.6	2.5	0.05	0.07	**0.5**	1
	Night	23.00	26.45	2	2.1	1	0.95	0.76	2.03	3.4	1.5	0.03	0.05	**0.3**	0.8
4	Day	24.00	28.32	1.7	2.2	0.9	0.6	0.68	2.5	4.6	1	0.04	**0.05**	0.7	0.8
	Night	21.00	24.78	1.25	2	0.7	0.8	0.32	1.2	3.2	1.5	0.02	**0.03**	0.5	0.6
5	Day	23.00	25.99	1.22	1.8	0.9	0.8	0.4	1.6	3.2	1	0.03	0.036	**0.5**	0.6
	Night	21.00	23.73	1	1.4	0.6	0.5	0.2	1.3	2	0.6	0.02	0.024	0.3	0.3
6	Day	22.00	24.86	0.7	1.2	0.8	0.7	0.11	1.05	3	0.7	0.016	0.025	0.25	0.3
	Night	20.00	22.60	0.5	0.8	0.6	0.5	0.09	0.95	1.8	0.9	0.012	0.015	0.15	0.2
7	Day	21.00	23.73	0.4	1	0.8	0.6	0	0.76	1.1	1.04	0.01	0.01	0.11	0.2
	Night	19.00	21.47	0.2	0	0.5	0.3	0	0.32	0.9	0.4	0.01	0.01	0.09	0.1
Mean		**30.43**	**35.35**	**1.58**	**2.06**	**1.24**	**0.97**	**0.74**	**1.73**	**3.56**	**1.85**	**0.03**	**0.043**	**0.49**	**0.74**
Average Mean		**32.89**		**1.82**		**1.11**		**1.24**		**2.70**		**0.04**		**0.62**	
FMEn (2009)		250		**0.008**		0.05		**5.0**		**0.2**		**5.0**		**0.01**	

4.2.2.1 Sulphur (iv) oxide (SO_2)

The concentration of Sulphur (iv) oxide (SO_2) measured during the wet season ranged from 0.1 to 1.0 ppm. The highest and lowest concentrations of SO_2 were observed at Mgbarakuma and Amibo respectively. The concentration of SO_2 in dry season ranged from 0.15 to 1.5 ppm with Mgbarakuma having the highest concentration.

Concentration of SO_2 measured in the dry was observed to be higher than the concentration measured in the wet season (Fig 4.5).

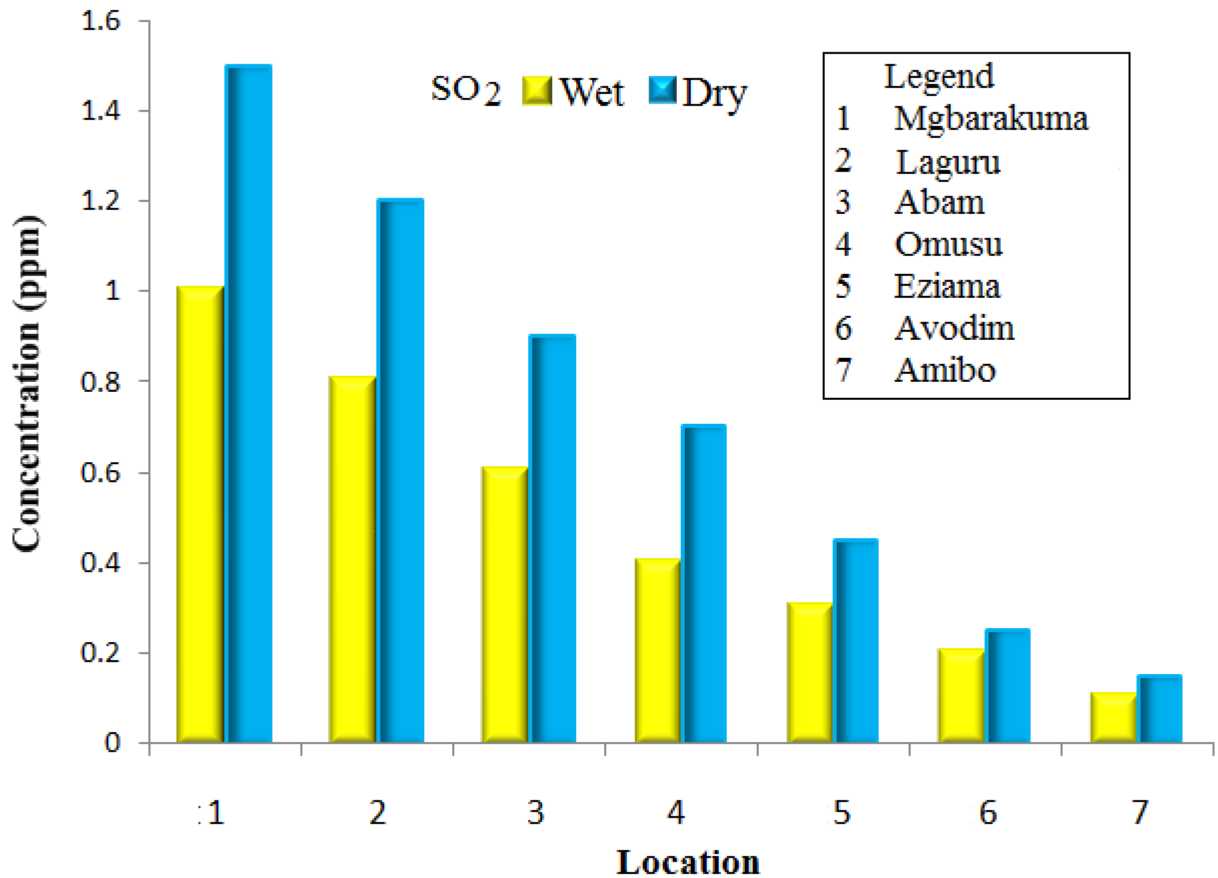

Fig. 4.5 Comparison of Wet and Dry Mean Concentration of Sulphur (iv) oxide (ppm) at study Locations

Sulphur (iv) oxide react with water vapour in the atmosphere to form acid rain (sulphuric acid (H_2SO_4)) which causes serious damage to plants and alter the ecological balance of continental ecosystems, notably in industrialized areas (Coils, 2002b; Carter, 2003). Both sulphuric acids are corrosive and colorless liquid. The standard pH of fresh water ranges between 6.5 and 7.5. However, acid rain deposition (sulphuric acids) lowers the pH of water and soil (higher concentrations of hydrogen ions), which kills off aquatic lives and plants.

Large quantities of sulphur dioxide are also produced by car engines and are emitted from the exhaust. Transportation accounts for 5 % of sulphur dioxide emissions, 45 to 50 % of nitrogen oxides emissions and 40 % of HC/HOV emissions. (Jean-Paul, 2009).

Sulphur (iv) oxide (SO_2) can also have an irritant effect on the airways and can cause broncho constriction. Asthmatic children and the elderly are particularly sensitive and concentration requires to produce an effect in asthmatic individual would typically be far less than that required for non-asthmatic individuals. High concentrations of SO_2 may trigger asthma attacks. However, asthmatic individuals will vary considerably in their response to SO_2 (EA, 2010a). It can be poisonous to both plants and animals (EPA 2009).

In plants, Sulphur dioxide enters the leaves mainly through the stomata (microscopic openings) and the resultant injury is classified as either acute or chronic. It causes yellowing or chlorosis of the leaf, and occasionally as a bronzing on the under surface of the leaves (Heather, 2009). It results in the death of cells and tissues of plants. The following crop plants are generally considered susceptible to sulphur dioxide: alfalfa, barley, buckwheat, clover, oats, pumpkin, radish, rhubarb, spinach, squash, Swiss chard and tobacco. Resistant crop plants include asparagus, cabbage, celery, corn, onion and potato (Heather, 2009). It is the leaves in mid-growth that are the most vulnerable, while the older and younger leaves are more resistant (Carter, 2003).

4.2.2.2 (CO)

The concentration of CO measured during the wet season ranged from 0 to 2 ppm with Mgbarakuma and Amibo having the highest and lowest concentration of CO respectively. Also, the concentration of CO in dry season ranged from 0.54 to 2.5 ppm. The concentration of CO was highest at Mgbarakuma (Fig 4.6).

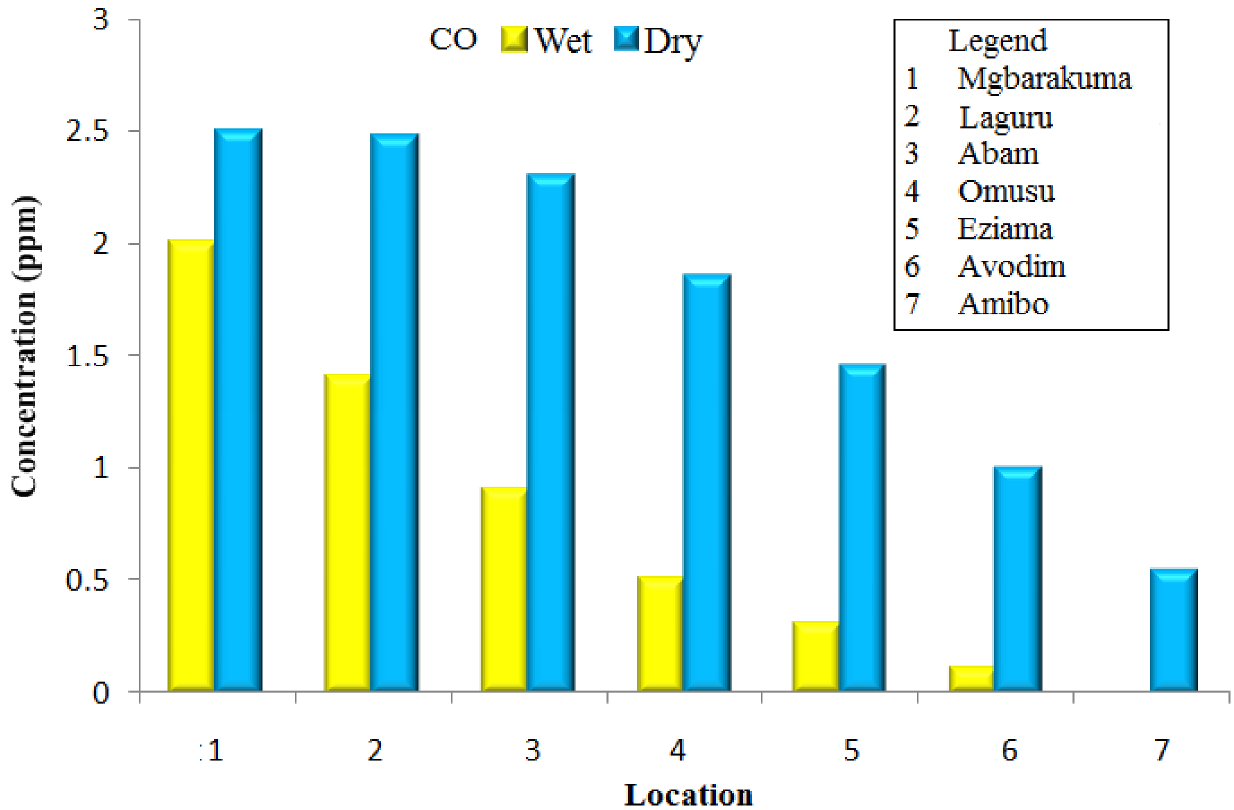

Fig. 4.6 Comparison of Wet and Dry Mean Concentration of Carbon Monoxide (ppm) at study Locations.

is a colourless, odourless and poisonous gas that is highly toxic to air-breathing animals because it interferes with the blood's ability to transport oxygen (Jean-Paul, 2009). It results from the incomplete combustion of hydrocarbons and accounts for 70 to 90 % of total emissions.

Exposure to even low levels, (CO) can start or increase damage to the heart in individuals with artery or heart problems. At medium concentration, CO causes headaches and fatigue. As the concentration increases, reflexes slow down and drowsiness occurs. At high levels, CO causes death. People at greatest risk of CO include pregnant women, infants, and those with heart or respiratory diseases.

4.2.2.3 **Methane (CH_4)**

Methane concentration measured during the wet season ranged from 0.01 to 0.06 ppm. Mgbarakuma and Amibo had the highest and lowest concentration of CH_4 respectively. In the same veil, the dry season concentration ranged from 0.01 to 0.1 ppm with Mgbarakuma having the highest concentration (Fig 4.7).

The high concentration of methane measured at Mgbarakuma was due to rapid and constant decomposition of organic waste materials by bacteria.

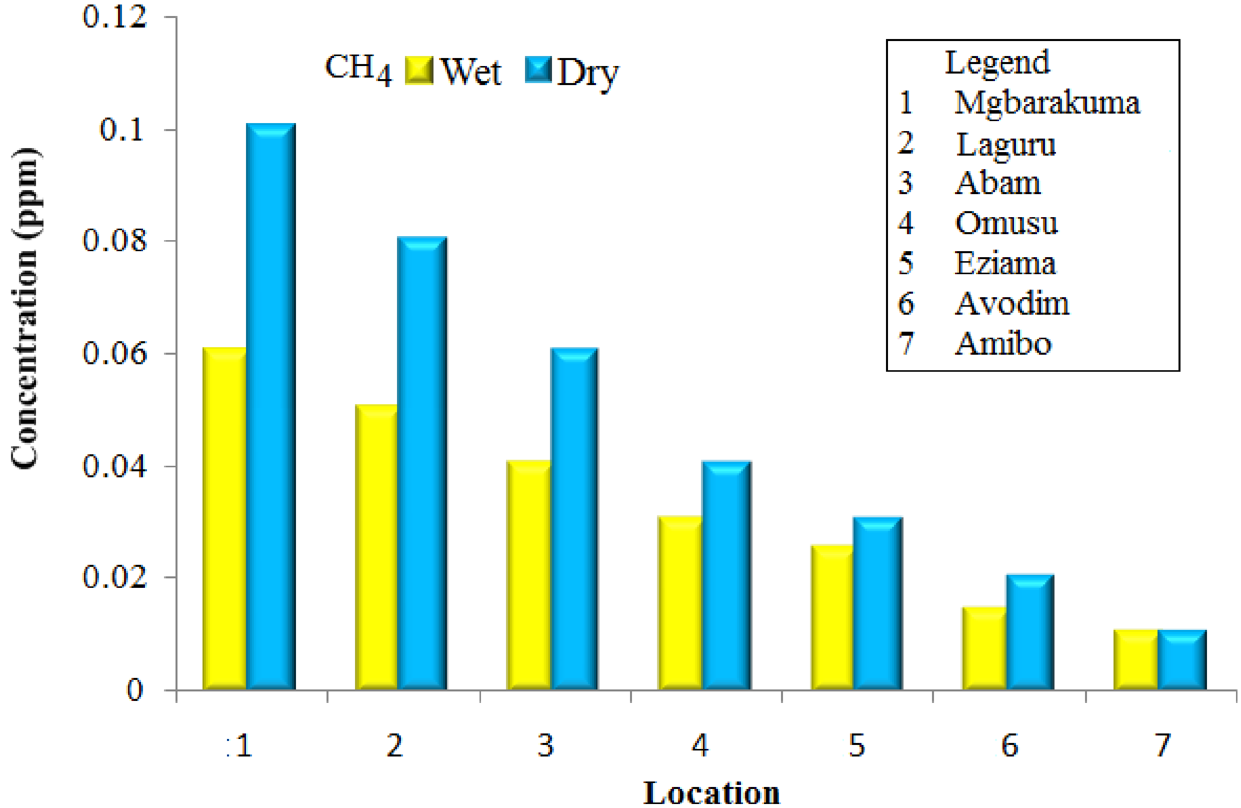

Fig. 4.7 Comparison of Wet and Dry Mean concentration of Methane (ppm) at study Locations.

Dumpsites are one of the main human related sources of methane. It can lead to hydrogen sulphide poisoning, asphyxiation, and explosion and fire. Prolonged exposure to methane gas can be fatal. Common symptoms of methane gas poisoning include dizziness, headaches, nausea, drowsiness and unconsciousness. In plants, it may cause premature fall of leaves and flower buds, discolouration of sepals and curling of petals. Methane is 23 times more potent than Carbon monoxide in trapping heat in our atmosphere, according to Stem et al. (2007). Controlling methane emissions would constitute a major step toward limiting climate change because concentrations of atmospheric methane gas have risen more than 150 percent since 1750.

4.2.2.4 Hydrogen Sulphide (H_2S)

The concentration of Hydrogen Sulphide (H_2S) measured during the wet season ranged from 0.3 to 3.1. Mgbarakuma and Amibo had the highest and lowest concentration of H_2S respectively. In the same veil, the dry season concentration ranged from 0.5 to 3.5 ppm with Mgbarakuma having the highest concentration (Fig 4.8).

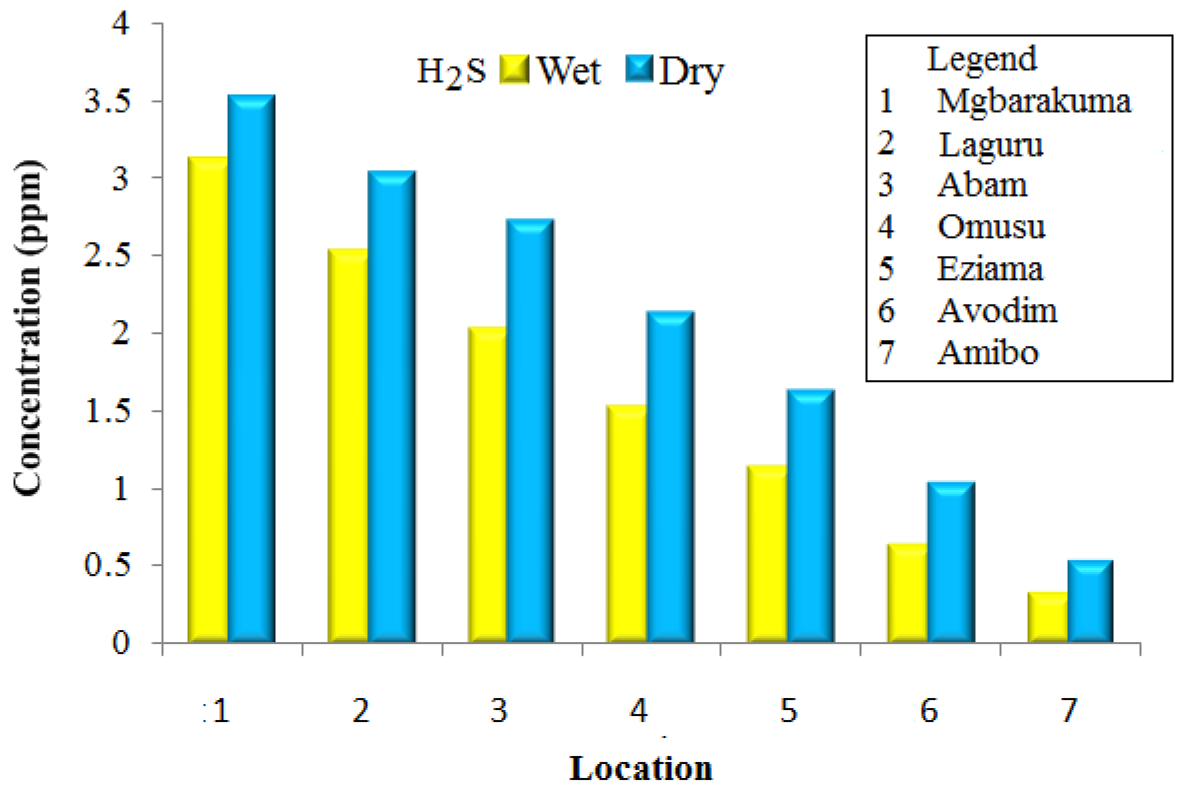

Fig. 4.8 Comparison of Wet and Dry Mean Concentration of Hydrogen Sulphide (ppm) at study Locations.

The high concentration of Hydrogen sulphide emitted from the dumpsite was due to the reaction of high sulphate bearing materials (such as gypsum and plasterboard) and biodegradable waste.

At low concentrations, H_2S may result in irritation of the mucous membranes of the eye and respiratory tract. Exposure to high concentrations results in depression of the central nervous system, loss of consciousness and respiratory paralysis (EPA 2009b). Other health effects have been reported, although data on the effects in human following repeated exposure are limited and difficult to interpret because of co-exposure to other chemicals.

The World Health Organization recommends an air quality guideline for H_2S of 150 ugm^3 over a 24-hour averaging period. Owing to the odorous properties of H_2S, the WHO also recommends a value of 7 ugm^3, with a 30-minute averaging period to avoid substantial complaints about sensory annoyance.

4.2.2.5 **Ammonia (NH_3)**

The concentration of Ammonia **(NH_3)** measured during the wet season ranged from 1 to 5.53 ppm. The highest and lowest concentrations of **NH_3** were observed at Mgbarakuma and Amibo respectively. In the same veil, the concentration of **NH_3** in dry season ranged from 0.72 to 4.05 ppm with Mgbarakuma having the highest concentration.

The concentration of ammonia in the wet season was observed to be higher than the concentration in the dry season. The concentration of ammonia in both seasons generally decreases away from the dumpsite. This was quite different from the concentration of other gaseous pollutants (Fig 4.9).

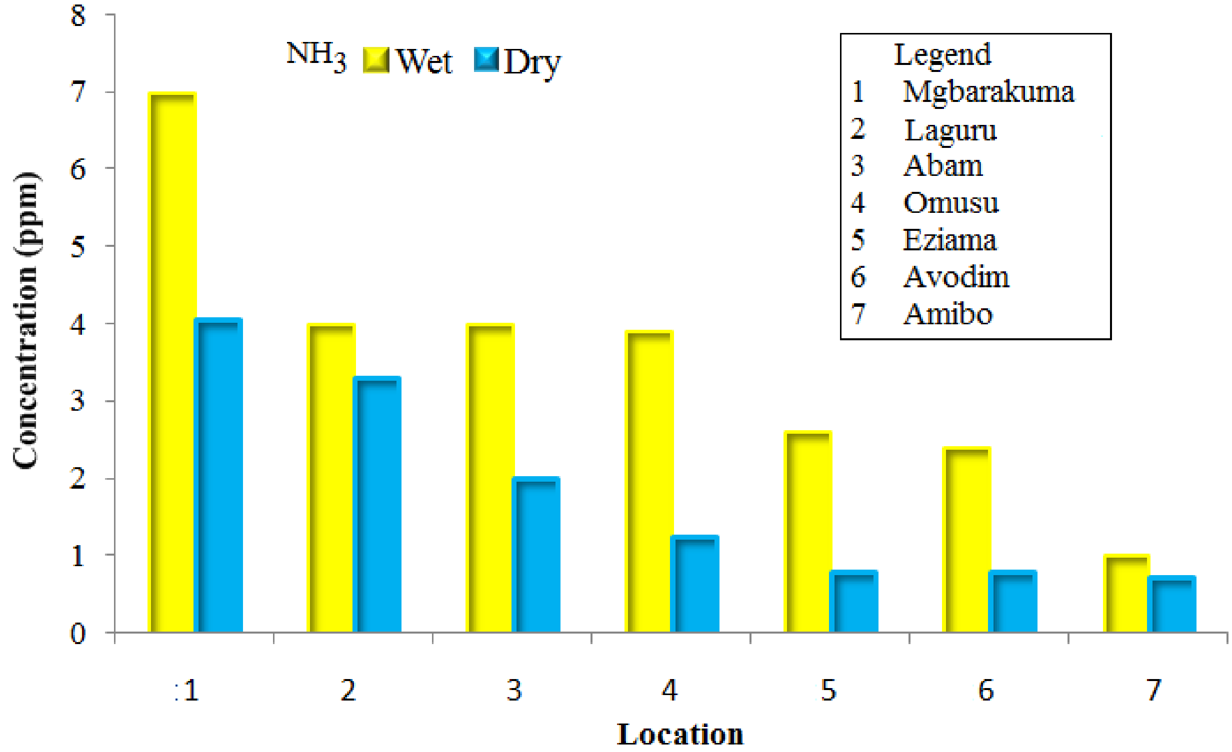

Fig. 4.9: Comparison of Wet and Dry Mean concentration of Ammonia (ppm) at study Locations.

Livestock farming, animal waste and fertilizer application are the biggest sources of atmospheric ammonia emissions within the agricultural sector.

Exposure (breathing) to high concentration of gaseous ammonia can cause death (Coils, 2002a). When plants are exposed to ammonia, they often show reddish, interveinal necrotic streaking or dark upper surface discolouration. However, flowers, fruit and woody tissues usually are not affected, and in the case of severe injury to fruit trees, recovery through the production of new leaves can occur. Sensitive species include apple, barley, beans, clover, radish, raspberry and soybean. Resistant species include alfalfa, beet, carrot, corn, cucumber, eggplant, onion, peach, rhubarb and tomato (Heather, 2009).

4.2.2.6 Volatile Organic Compounds (VOC)

VOC concentration measured during the wet season ranged from 0.65 to 2.75 ppm with the station 1 and 7 having the highest and lowest values respectively. Similarly, the dry season concentration ranged from 0.45 to 1.9 ppm with the station 1 having the highest concentration. The concentration of VOC in both seasons decreases away from the dumpsite (Fig 4.10).

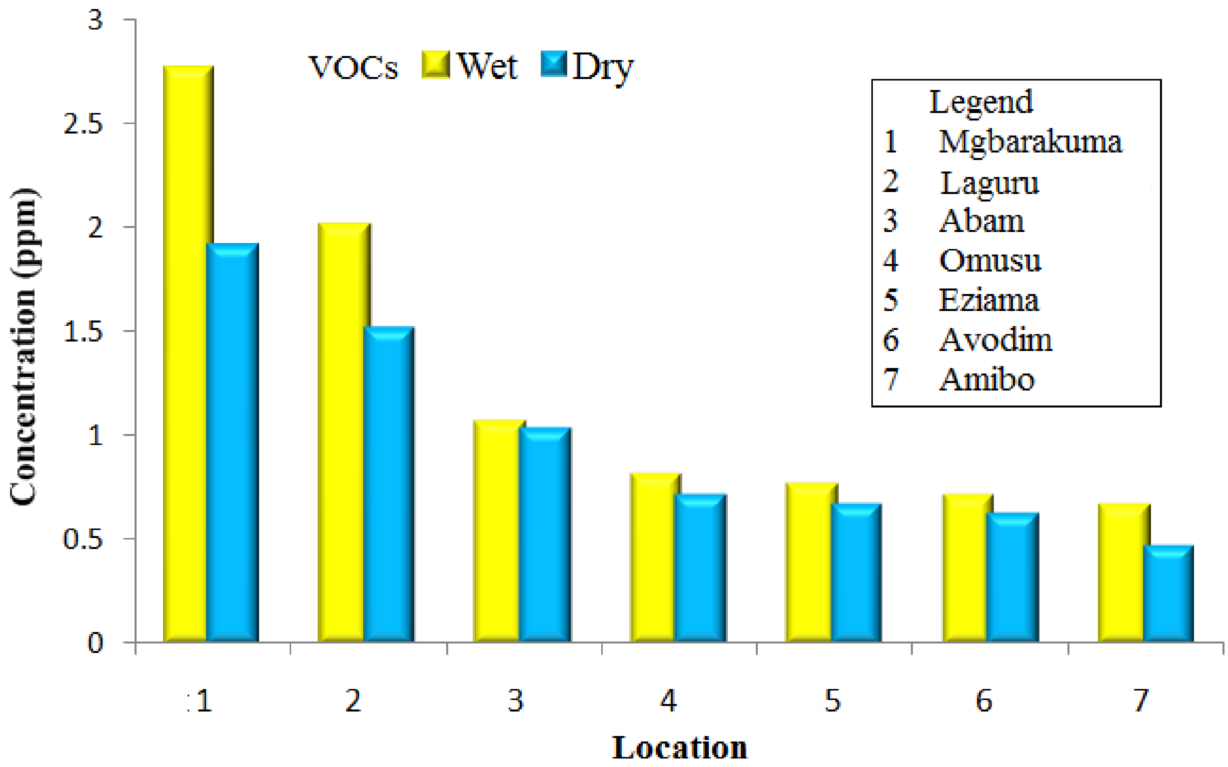

Fig. 4.10: Comparison of Wet and Dry Mean concentration of VOC (ppm) at study Locations.

Varieties of sources of volatile organic compounds include motor vehicles, waste dumps, factories, consumer and commercial products, and other industrial sources. They are also emitted by natural sources such as vegetation (EPA, US, 2001).

Key signs or symptoms associated with exposure to VOCs include conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels, memory impairment, nausea, emesis, epistaxis, fatigue, dizziness, loss of coordination, damage to liver, kidney, and central nervous system. The extent and nature of the health effect will depend on many factors including level of exposure and length of time exposed.

4.2.3 Effect of Seasonal Variation on the concentration of Gaseous Air Pollutants

The mean concentrations of gaseous air pollutants in the dry season were: SO_2 (0.74 ppm), CO (1.73 ppm), H_2S (2.06 ppm) and CH_4 (0.043 ppm) whereas concentrations in the wet season showed SO_2 (0.49 ppm), CO (0.74 ppm), H_2S (1.58 ppm) and CH_4 (0.03 ppm). Statistical analysis showed that dry season concentrations of gaseous air pollutants were higher than that of wet season.

However, the concentrations of VOC (1.24 ppm) and NH_3 (3.56 ppm) were observed to be higher in the wet season and lower (0.97 ppm) and (1.85 ppm) respectively in the dry season.

This variation could be attributed to the cleansing or scrubbing effects of rain fall on the atmosphere and also the effect of meteorological conditions. Low temperature, high humidity and moderate wind speed were observed during the wet season (Table 4.2). During the wet season a combination of heavy rainfall and in some cases a high wind speed off the oceans significantly improve air quality (Efel et al., 2005). Winds are variables in space and time, in direction and speed, and this variability is applicable to air pollution emission and concentration (Chima and Pius, 2009). It has been observed that during low wind speeds and stable atmospheric conditions, pollutants tend to accumulate in the stagnant air around emission sources. Concentration of gaseous pollutants is higher during the dry season than the wet season because of higher percentage of calm period observed during the dry season.

The elevated concentration of ammonia in the wet season could also be attributed to high deposition of agricultural and animal wastes on the dumpsite. Agriculture is the largest producer of Ammonia with livestock farming, animal waste and fertilizer application being the biggest source of atmospheric ammonia emission (TRFA, 2010). There is high occurrence of natural vegetation in most dumpsite (parts that are less busy) due to favorable atmospheric conditions (EPA, US, 2001).

The average mean concentrations of gases VOCs (1.11 ppm), NH_3 (2.70 ppm) and SO_2 (0.62 ppm) recorded across the study area for both seasons exceeded their permissible limits. Whereas, CO (1.24 ppm), H_2S and CH_4 (0.04 ppm) were below standard. FMEn, (2009) recommended 5 ppm for CO, 0.05 ppm for VOC, 0.01 ppm for SO_2, and 0.2 ppm for NH_3 while CH_4 and CO_2 has 0.0002 % and 0.03% in ambient air respectively. These levels of pollutants are of serious environmental concern for residents living close to dumpsites, waste workers, scavengers, etc.

4.2.4 Percentage of Emission of Various Gases

Gaseous emission at the Ubakala dumpsite at both seasons amounted up to 7.35 ppm. The break analysis shows that NH_3 has the highest concentration of 35.86 % followed by H_2S with 24.17 %. 16.47 % of the concentration was the third highest in the total emission. This is followed by VOCS with 14.74 %. The gases concentration reduces with SO_2 having 8.23 %, and CH_4 (0.53 %).

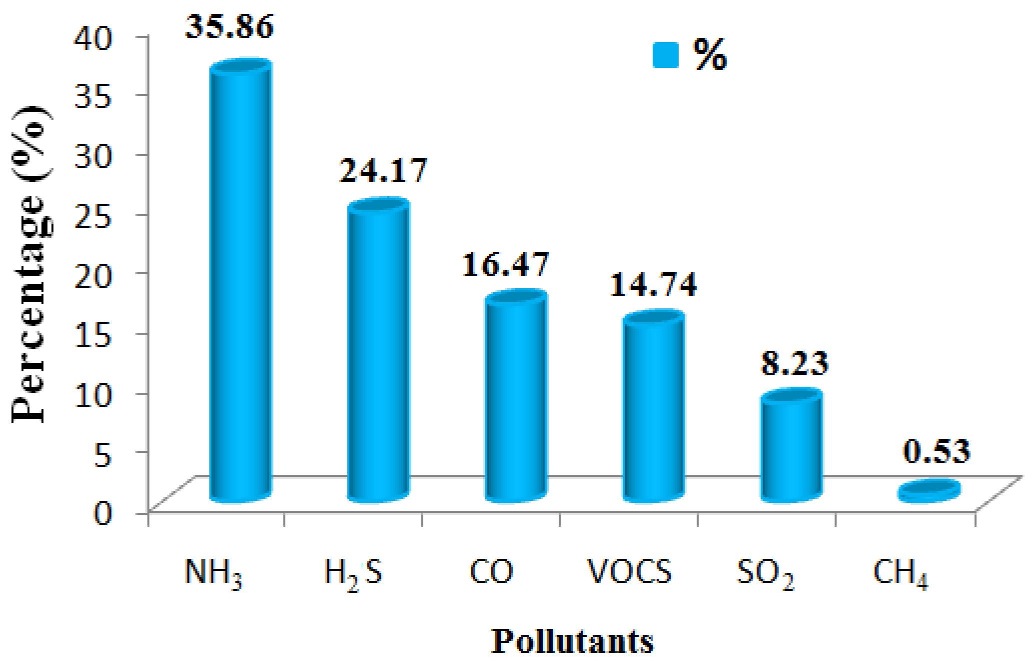

Fig.4.11: Showing Percentage of Emission of Various Gases

4.2.5 Dispersion and Dilution Model

Atmospheric dispersion models developed with the aid of a simple linear regression approach was employed to predict the behaviour of different gases as they disperse away from the dumpsite. The models were derived from the field work of this project. Table 4.5 shows the various concentrations of pollutants and their corresponding distances as they move away from the dumpsite.

Table 4.5 **Mean Concentration of Gases with their Corresponding Distances (Experimental)**

S/N	Dist. (Km)	H_2S (ppm)	VOC (ppm)	CO (ppm)	NH_3 (ppm)	CH_4 (ppm)	SO_2 (ppm)	Sum of the gases
1	0	3.3	2.325	2.25	5.525	0.08	1.25	14.73
2	0.6	2.75	1.738	1.935	3.65	0.045	0.504	10.622
3	1.2	2.35	0.736	1.6	3.00	0.05	0.65	8.386
4	1.8	1.788	0.75	1.175	2.575	0.035	0.65	6.973
5	2.4	1.355	0.7	0.875	1.7	0.028	0.258	4.916
6	3.0	0.8	0.65	0.55	1.6	0.017	0.225	3.842
7	3.6	0.4	0.55	0.27	0.86	0.01	0.125	2.215

The regression model is given as

$$Y = a + bx \qquad 4.1$$

Where “a” is intercept on y, and “b” is the coefficient of regression called the predictor are constants to be determined (Onakpohor, 2013). The regression models were developed by determining the constant values “a” and “b” for the different gases under study using the experimental data presented in Table 4.5. The two variables distance (X) and concentration (Y) was then determined by substituting the values of "a" and "b" into eq. (4.1) to obtain the regression model equation.

The process was repeated for each gas to generate different model equation for the gases. These models are then simulated to predict the concentrations of the gases using regular intervals of the distance (kilometer), until a point of zero or minimum positive concentration is attained called the point of dilution of that gas away from the dumpsite at that given distance.

Table 4.6 **Summarized Regression Data for the Various Using Experimental Data**

S/N	Gases (ppm)	a.	b	Regression Model
1	H_2S	3.30	-0.917	Y = 3.30 - 0.917 X
2	VOC	2.33	-0.978	Y = 2.33 - 0.978 X
3	CO	2.25	-0.525	Y = 2.25 - 0.525 X
4	NH_3	5.525	-3.125	Y = 5.525- 3.125 X
5	CH_4	0.08	-0.058	Y = 0.08 - 0.058 X
6	SO_2	1.25	-1.243	Y = 1.25 - 1.243 X

The regression models predicted the behaviour of the gases H_2S, VOC, CO, NH_3, CH_4 and SO_2 respectively at regular interval distance of 0.6 km ranging from 0 to 4.2 km.

Figures 4.12 (a-f) shows the relationship between distance and concentration, where concentration decreases with increase in distance. Each of the plots suggests that: the gaseous concentration was higher in the dumpsite and so diffused and dispersed away from source into the surrounding atmosphere with lower concentration. This decrease in concentration of the gases with distance is in accordance with the fundamental law of diffusion. EPA, US. (1995) reported that; dumpsite gas naturally is carried by the wind and the wind dilutes the gas with fresh air as it moves to areas beyond the dumpsite.

Figure 4.12 shows that SO_2 diluted at 1.01 km away from the dumpsite, VOC (2.4 km), H_2S (3.6 km), CO (4.3 km), NH_3 (1.8 km), and CH_4 (1.4 km).

It implies that distances of dilution are the safe distances away from dumpsites where habitation can take place.

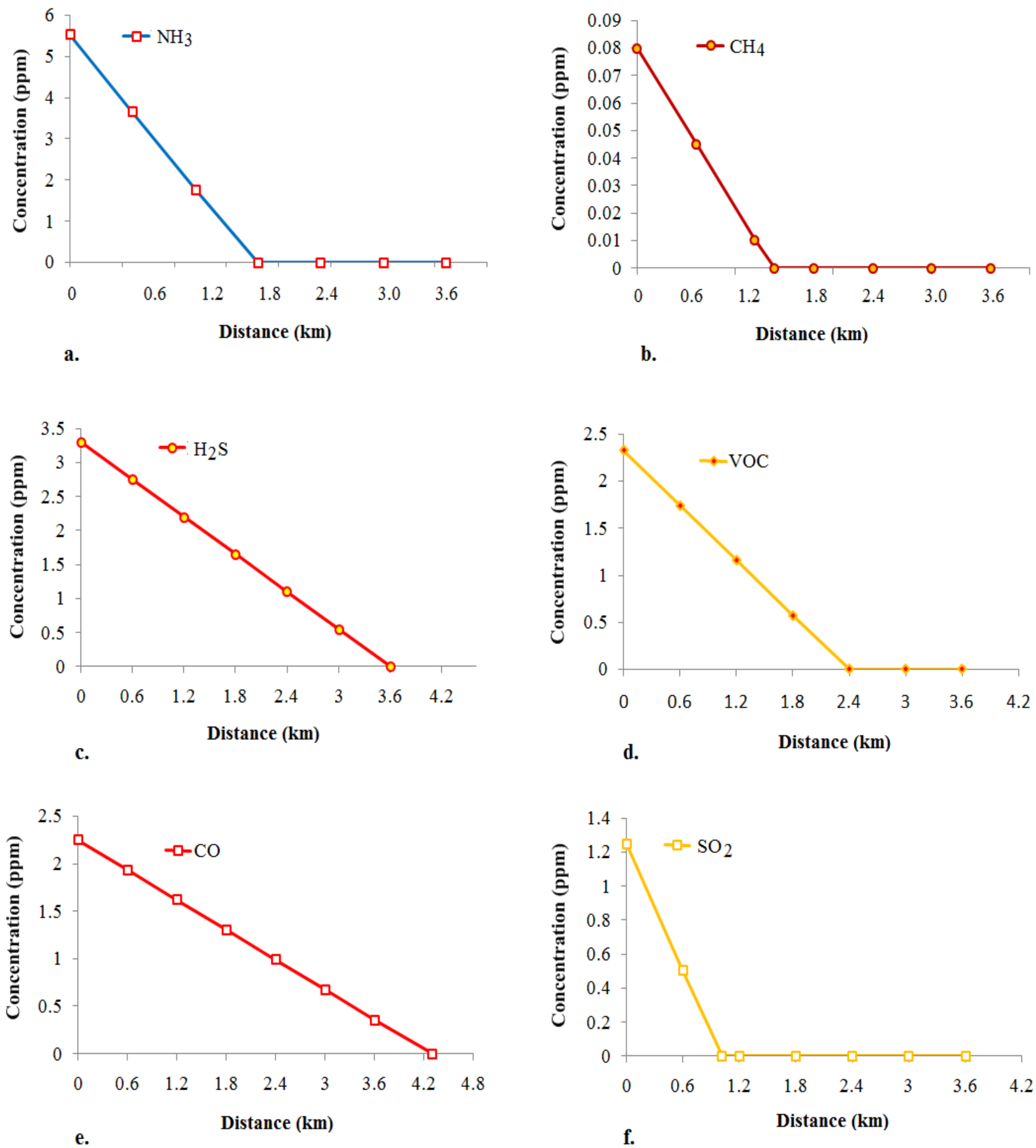

Fig. 4.12 (a-f): Effect of Distance on the concentration of Gaseous Air Pollutants

My findings are consistent with the report of Salam (2010). Salam (2010) compared the impact of solid waste disposal on nearby residence <200 m and far away ones >200 m. Salam (2010) observed that the residents whose houses are less than 200 meters from the dumpsite suffer more from malaria, chest pains, cholera, and diarrhea than those far away from the dumpsite. However, residents whose houses are more than 200 meters away are also affected with the chest pain and bad smell from the dumpsite. The result shows that both residents were affected by the location of the dumpsite closer to their settlements.

Akinjare, *et al.*, (2010) in their study identified various environmental contaminants and hazards associated with dumpsites in Lagos State via perception on residents living within 1.2 km distance.

4.2.6 Effect of Distance on the Distribution of Gaseous Air Pollutants

Gas concentrations are generally higher in the dumpsite than in the surrounding areas. However, dumpsite gases diffuse out of the dumpsite to the surrounding areas with lower concentrations. It accounts for the diffusivity of dumpsite gases due to high concentration at point source. Gases in a dumpsite move from areas of high concentration to areas with lower concentration (EPA, 1995).

The models presented above predicted that pollutants diffuse and dilute to an inhabitable limit at distances of 1.01 km and above. Hence, residential homes found located within 1.01 km distances where pollutant concentrations are still almost at their peak are suspected to be exposed to the dangers of dumpsite emissions. Residents living within 1.01 km distance from the dumpsite are likely to be exposed to hazards (poisonous odour, truck traffic, stigma, noise pollution and threats of insects, pests and rodents).

Hence, communities exposed to the dangers of gaseous emissions include Mgbarakuma, Laguru and Abam. Whereas communities like Eziama, Amuzu, Avodim, Amibo, and Omosu are likely not be affected by the dumpsite gas emission (Fig.4.13).

Also, the direction of the arrow on the map reveals that the movement of these gaseous pollutants migrate from areas of higher concentration (source) to areas of lower concentration (Fig.4.13).

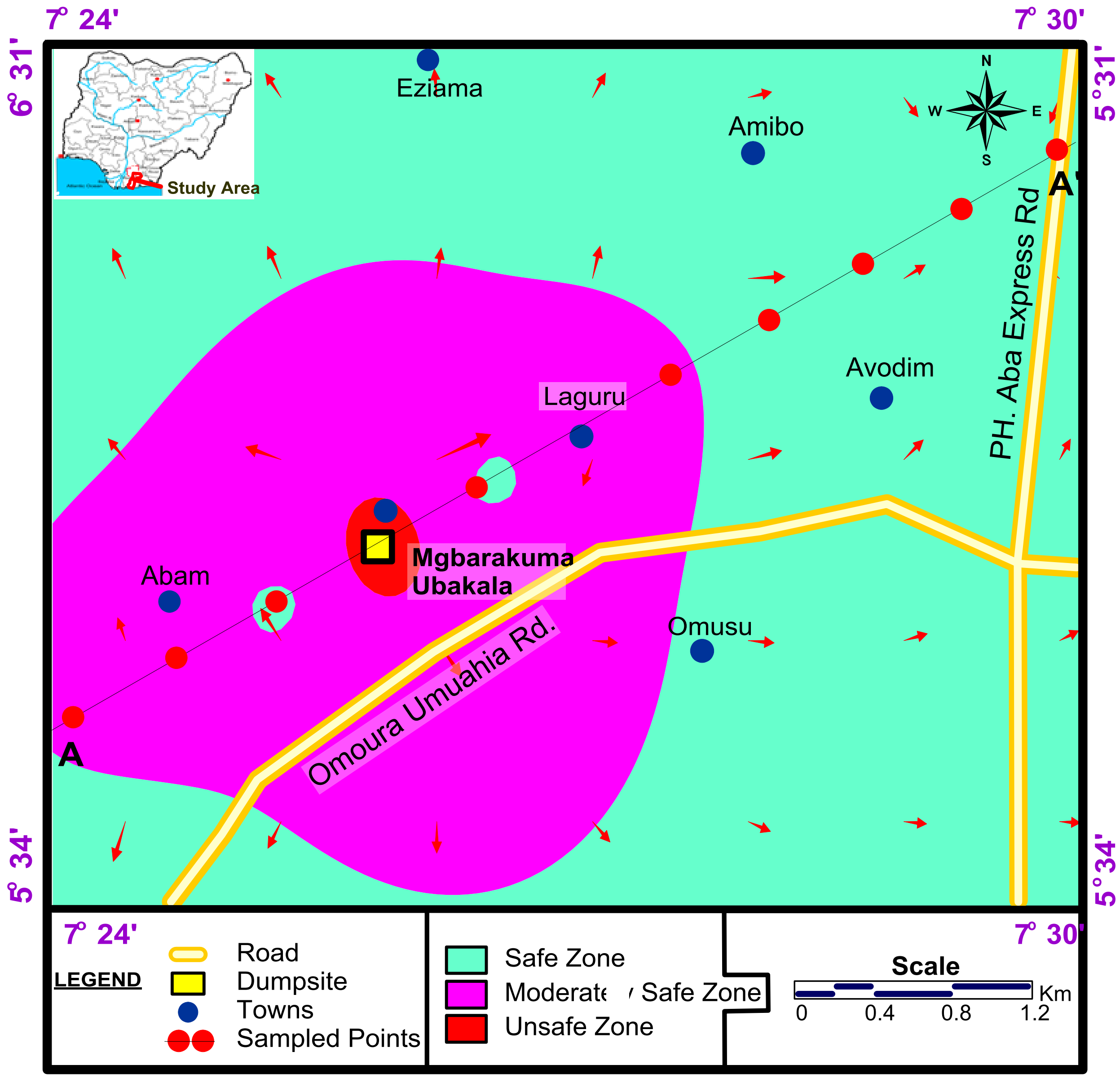

Figure 4.13: Showing Safe, Moderately Safe and Unsafe Zones

4.2.7 Evaluation of Spatial Dispersion Rate

Concentration of gases emitted from the dumpsite disperses and diffuses at varying rate and dilute at different distances. The slope of the linear plots of concentration against distance shown in figures 4.12 (a-f) represents the dispersion rate of the various gases. They are evaluated as follows:

$$\text{Slope (Rate)} = \frac{Final\ Concentration - Initial\ Concentration\ (ppm)}{Final\ Distance - Initial\ Distance\ (km)} \qquad 4.2$$

It therefore follows that SO_2 diffuses at - 1.238 ppm/km, VOC (- 0.971 ppm/km), H_2S (- 0.917 ppm/km), CO (- 0.523 ppm/km), NH_3 (- 3.072 ppm/km), and CH_4 (- 0.057 ppm/km) respectively. Ammonia has the highest rate of diffusion (3.072 ppm/km). This implied that ammonia dilutes faster and does not stay so long in the environment. Methane has the lowest rate of diffusion (0.057 ppm/km) and as a result, does not disperse and dilute so easily. That is, it can stay for so long in the environment.

The rates are shown to be negative because they are decreasing down the distance of dilution. So, the minus sign before is negligible.

Also wind speed and direction seem to be responsible for this concentration variation. The movement or emission of gases from the dumpsite could also be attributed to the three main factors that influence migration of dumpsite gases, diffusion (concentration), pressure and permeability (EPA, US 1995).

4.2.8 **Effects of Air Pollution on the Environment**

Global warming, smog and the depletion of the ozone layer are just a few of the most alarming results of pollution. Air pollution also poses a significant human health risk, causing serious respiratory and other illnesses (EPA, 2009). Human health, agriculture, natural ecosystems, coastal areas and waste generation are examples of climate-sensitive systems. Global temperatures are expected to continue to rise as human activities continue to add carbon dioxide, methane, nitrous oxide, and other greenhouse (or heat-trapping) gases to the atmosphere (IPCC, 2007). Some of the effects of global warming include shrinking of glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of growing seasons, shifts in plant and animal ranges and earlier flowering of trees. In general, agriculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms. Climatic factors that influence agriculture (temperature, rainfall, atmospheric levels of carbon dioxide (CO_2), other greenhouse gases and extreme weather and fire events) are changing and are expected to continue changing due to human activities.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The findings of this study have provided the level of concentration of gases of ambient air pollutants around Ubakala waste dumpsite, the effects of Seasonal variations, and the dispersion of the gases at varying rates.

The high concentration of pollutants recorded at the dumpsites account for the fact that; the Ubakala waste dumpsite is a major source of air pollution around the area.

Dumpsite emissions are due to the release of dumpsite gases by the decomposition of waste on being consumed by bacterial and dumpsite activities such as waste burning, scavenging, plants operations, vehicular movement of transporting and tipping of waste, etc.

This research has also shown that air pollutant concentrations (gases) varies between seasons (dry and wet) with the dry season concentrations significantly higher than the wet season concentrations, which could be due to different conditions such as dumpsite's temperature fluctuation, increase bacterial activity, site operational activities, etc, that leads to increase gas production. While, the low concentration in the wet season could be due to combination of heavy rainfall that scrub down pollutants and, in some cases, a high wind speed off the oceans that significantly improve air quality. Mean concentrations of air pollutants within the dump were found generally higher than the controls, although, not significant different due to high human and natural activities, wind speed and direction. It also revealed that pollutants such as CH_4, H_2S and CO were below standard whereas VOC, SO_2, and NH_3, in the air samples exceeded the permissible limits recommended by the Federal Ministry of Environment and hence pose threat to the environment.

The concentration of gases detected was found to disperse at different rates and decreases to varying points of dilution at different distances. These distances indicate the safest points to which habitation can take place, owing to the fact that; gases can travel up to l.01 km, 2.4 km, and 4.3 km at various rates before dilution from source of emission. The distance of dilution of these gases also depend on some factors such as; the concentration of the gas from the point of emission and other sources of that same gas along its path of dispersion.

It also recorded that Methane (CH_4) as a domestic gas, was emitted at 0.53% of the total emission. Though it is not enough but could be extracted and used as cooking gas.

5.2 Recommendations

On the basis of the present study, it is hereby recommended that;

i. There is need for public enlightenment programmes in Ubakala, to educate the residents on the importance of keeping to a reasonable distance from the dumpsites while siting buildings so as to achieve basic sanitary and hygienic conditions).

ii. Emission of gaseous pollutants (CO, H_2S, NH_3, VOC, CH_4, and SO_2) from dumpsite sites should be controlled through a landfill gas management system based on capping and flares and/ or engines. The operator should employ dust suppression measures such as surface wetting to combat the effect of wind-blow dust. Effective government legislation against uncontrolled dumping of hazardous air pollutants wastes into dumpsite as this will help in controlling the pollution of the surrounding air.

iii. Government should build waste recycling plant so as to recycle the recyclables to reduce the quantity of waste dispose to waste dumps. This will lead to job creation for the unemployed through waste to wealth programmes.

iv. Finally, further research should be carried out to determine the impact of these air pollutants on the life of people living near the dumpsite.

5.3 Contribution to Knowledge

This study provided baseline emission data and dispersion model for both dry and wet seasons in Ubakala open dumpsite. The emission data for dry seasons comprised of temperature, particulate matters (22.60 - 74.93 µg/m^3), H_2S (0 - 4 ppm), VOCs(0.3 - 2 ppm), CO(0.32 -2.8 ppm), NH_3 (0.4 - 4.2 ppm), CH_4 (0.01 - 0.11 ppm) and SO_2 (0.10 - 1.6 ppm). Similarly, in wet season, the mean concentrations of particulate matters, H_2S, VOCs, CO, NH_3 CH_4 and SO_2 ranged from 63.50 - 20 µg/m^3, 0.2 -3.4 ppm, 0.5 - 2.9 ppm, 0 - 2.3 ppm, 0.9 - 8 ppm, 0.01 - 0.07 ppm and 0.09 – 1.05 ppm respectively. The result provided data on the possible recovery of methane for use as cooking gas from the emission.

REFERENCE

Abur, B. T., Oguche, E. E., Duvuna, G. A. (2014). Characterization of Municipal Solid Waste in the Federal Capital Abuja, Nigeria. Global Journal of Science Frontier Research: Environment & Earth Science, 14(2): 1 - 6.

Adedibu, A. A (1985). "Comparative analysis of solid waste composition and generation in two cities of developing nation." The Environmentalist, 5(2): 123 - 127.

Aderinola O. J., Clarke E. O., Olarinmoye O. M., Kusemiju V. and Anatekhai M. A. (2009). Heavy Metals in Surface Water, Sediments, Fish and Perwinkles of Lagos, Lagoon. American-Eurasian J. Agric. & Environ. Sci., 5(5): 609-617.

Aibor M. S. and Olorunda, J. O., (2006). A Technical Handbook of Environmental Health in the 21st Century for Professional Students. Akure: His Mercy Publisher.

Angaye, C.N., and Abowei, F.N., (2017). Review on the Environmental Impacts of Municipal Solid Waste in Nigeria: Challenges and Prospects, Greener Journal of Environment Management and Public Safety, Vol. 6(2), pp.018-033, June.

Agwu, A. and Ozeh, R.N. (2013). Evolution of Ambient Air. Quality of Aba Metropolis, Nigeria. International Journal of Current Research, 5(4):843 - 844.

Akinjare, O. A., Olusegun, O. A, Caleb, A. A, and froham, C.O, (2010). Perception of Disamenity Hazards of Residential Housing Value in Lagos, Nigeria. Far East Journal of Marketing and Management, Vol.]. December, 2011. pp.1.9.

Asian Institute of Technology, (AIT). (2004). *Municipal Solid Waste Management in Asia*. Thailand: Asian Regional Research Program on Environmental Technology (ARRPET), AIT.

Barakat, C., Zhang, S., Siddiqua, A., Dghaim, R. (2015). Air quality and Respiratory Health among Adolescents from the United Arab Emirates. Journal of Environmental and Plublic Health, pp. 1-5.

Barman, S. C., Kumar, N., Singh, R., Kisku, G. C., Khan, A. H., Kidwai, M. M., & Murthy, R. C. (2010). Assessment of urban air pollution and it' s probable health impact, Journal of Environmental Biology, 31: 913–920.

Beede D. N and Bloom, D.E (1995) the economics of municipal solid waste. World bank research observer, 10, 133-150/http//:dx.doi.org/10.1093/wbro/10.2.113

Bower, J. and Mucke H. (1999). Design, Operation and Quality Assurance and Control in a Monitoring System, WHO Regional Publications, European Series.

Carter N.L (2003), Impact of Air Pollutant and Acid Rain. Available at http://www.air-quality.org.uk/15php.

Cernuschi, S., and Giugliano, M., (1996). "Emission and Dispersion Modelling of landfill gas", in Landfilling of Waste: Biogas (eds Christensen, T.H., Cossu, R., and Stegmann, R.,) E & FN Spon, London, ISBN: 0419 19400 2, pp. 2 14-233.

Chen, I. C., Hegde, U., Chang, C.H., and Yang, S. S, (2008). Methane and Carbon Dioxide Emissions from Closed Landfill in Taiwan, Chemosphere 70, pp. 1484-1491

Chima, O. O and Pius B. U (2009). Air Pollution Climatology in Spatial Planning for Sustainable Development in the Niger Delta, Nigeria. Accessed at http://www.fig.net/ pub/fig2009/papers/ts0 1 dlts0 1 d.. ogbautang 3202.pdf

Christensen, T.H., Kjeldsen, P., and Lindardt, B., (1996). Gas Generating Processes in Landfilling Waste: Biogas (eds Christensen, T.H., Cossu, R, and Stegmann, R..,) E and FN Spon, London, ISBN: 0419194002, pp. 214-233

Coils, J. (2002b). Air Pollution. Available at http://en.wikipidia.org/wiki Air.

DEFRA (Department of Environment, Food and Rural Affairs), (2007). The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Volume 1, Available at www.archive. defra.gov.uk/environment/ quality/air/strategy/ document/air-qualitystrategy-vol1.pdf

Eduardo Z. (2006). The Effect of Air Pollution on Plants. University of California, Los Angeles. Retrieved from http://4e.plantphys.netlarticle.php?ch=&id=262

Efel, S.I (2008). Distribution of particulate air pollution in Nigerian cities: implications for human health. Journal of Environmental Health Research. Accessed at http:I/www. cieh.org/jehr/jehr3 .aspx?id= 14688.

Einola, J.K., Kettunen, R.H., and Rintala, J.A., (2007). Responses of Methane Oxidation to Temperature and Water Content in Cover Soil of Boreal Landfill: Soil Biology and Biochemistry 39, pp. 156-1164

Ekwe, A.C., Onu, N.N. and Onuoha K.M., (2006) Estimation of Aquifer Hydraulic Characteristics from Electrical Sounding Data: the case of Middle Imo River Basin Aquifers, Southeastern Nigeria. Journal of Spatial Hydrology. Vol. 6, No.2 Fall 2006.

El-fadel, M., Findikakis, A.N and Leckie, J.O. (1995). Environmental Impacts of Solid Waste Landfilling, *Journal of Environmental Management*.

Ene A., Boşneagă A. and Georgescu L. (2009). Determination of Heavy Metals in Soils using XRF Technique, University of Galati, Faculty of Sciences, Chemistry Department, 111 Domneasca St, 800201 Galati, Romania pp. 815-820.

EPA (Environmental Protection Agency) (2009). Status Report: Advances In Inhalation Dosimetry of Gases and Vapors With Portal of Entry Effects In The Upper Respiratory Tract, Washington DC,EPA/600/R-09/07/072,2009.

EPA (Environmental Protection Agency) (2006). National Emission Inventory (NEI) Trends Report: Average annual emissions. all criteria pollutants. http://www.epa.gov/ttnl/chiefYtrends.

EPA (Environmental Protection Agency) US, (2001). Environmental factsheet EPA 429f 01-030. http://www.epa.gov/olaq/regs/nonroadJproposal 103 0.htm#l

EPA, (1995). US Environmental Protection Agency. Compilation of Air Pollution Emission Factors AP-42, Fifth-42 Addition Vol. 1: Stationary point Area sources. January, 1995

Gurijala, K.R., Sa, P., and Robinson, J.A., (1997). "Statistical Modeling of Methane Production from Landfill Samples", Applied and Environmental Microbiology 63, pp. 3797-3803.

Heather G. (2009). Effects of Air Pollution on Agricultural Crops, Ministry of Agriculture. Food and Rural Affairs. Queen's Printer for Ontario. Accessed at http://www.omafra.gov.on.ca/English/crops/facts/01-015.ht.

Hill, R. D., (2009). Hazardous Waste and Toxic Materials Safe Handling and Disposal, (Fawcett H. H.), New York, John Wiley. Pp. 281-307

HPA (Health Protection Agency) (2009a). Compendium of Chemical Hazards. Methane. Available at http://hpa.org.uk/web/HPAwebFile /I{PAweb_C/128714790726

Ibe F. C., Opara, A. I., Njoku, P. C. and Alinnor, J. I., (2017). Ambient Air Quality Assessment of Orlu, Southeastern, Nigeria. Journal of Applied Sciences, 17: 441-457.

IPPC (2007). *Climate change* 2007: Impacts Adoption and Vulnerability. Contribution of working group 11 to the fourth Assessment Report of the Intergovernmental panel on climate Change (parry, Martin L. Canziainc).

Jean-Paul, R. (2009). The Geography of Transport System, Second Edition. New York: Routledge, pp. 352 ISBN 978-0-415-48324-7

Jung, H., Matsuto, T. and Tanaka, M. (2005). Behaviour of metals in ash melting and gasification - Melting of Municipal Solid Waste (MSW). *Waste Management* 25, pp. 301- 310.

Maurice, C. and Lagerkvist, A., (2003). "LFG emission measurements in cold climatic conditions: seasonal variations and methane emissions mitigation", Cold Regions Science and Technology 36, pp. 37-46. 2008

Momodu, N. S., Dimuna, K. O., Dimuna J. E. (2011). Mitigating the Impact of Solid Wastes in Urban Centres in Nigeria. J Hum Ecol, 34(2): 125 - 133.

Nwosu E. E. and Tamunobiekiri G. P. (2016). Site Selection and Analysis of Solid Waste Dumpsites in Ile-Ife, Nigeria (8363). FIG Working Week 2016 Recovery from Disaster Christchurch, New Zealand, May 2–6, 2016.

Obodai E.A., Boamponsem L.K., Adokoh C.K., Essumang D.K., Villawoe B.O., Aheto D.W. and Debrah J.S. (2011). Concentration of Heavy Metals in two Ghanaian Lagoons. Archive of Applied Science research, 3(3): 177-187.

Odeyemi, A. T (2012). Antibiogram Status of Bacterial Isolates from Air Around Dumpsite of Ekiti State Destitute Centre at Ilokun, Ado-Ekiti, Nigeria. Journal of Microbiology Research, 2(2): 12 - 18.

Onakpohor, A. (2013). Analysis and evaluation of emission from Tombia Road municipal waste dumpsite, Yenogoa, Bayelsa State, Nigeria. Unpubl. MSc thesis.

Rajaganapathy V., Xavier F., Sreekumar D. and Mandal P. K. (2011). Heavy Metal Contamination in Soil, Water and Fodder and their presence in Livestock and Products: A Review. Journal of Environmental Science and Technology,4:234-249.

Rushbrook, P., (2001). Guidance on Minimum Approaches for Improvement to Existing Municipal Waste Dumpsites, WHO Regional Office for Europe, Copenhagen, Denmark.

Sharholy, M., Ahmad, K., Mahmood, G., Trivedi, R.C. (2008). Municipal solid waste management in Indian cities – a review. Waste Management 28(2), 459–467.

Shayley H., McBride M, and Harrison E. (2009). Sources and Impacts of Contaminants in Soils. Cornell Waste Management Institute.pp.1-6.

Shusterman, D. (1992). Critical Review of the Health Significance of Environmental Pollution Arch, Environmental Health 47; 76-87, 1992

Stavrianou W. (2007). The Western Australian Contaminated Sites Act 2003: The Applicability of Risk Assessment as a basis for the Assessment and Management of Site Contamination, www.awu.edu.au pp. 1- 92.

Thermoset Resin Formulators Association (TRFA) (2010) Annual Meeting, Hyatt Regency San Antonia, Tx TRFA (630) 942 – 6596.

Uma, K.O. (1989). Appraisal of the groundwater resources of the Imo River Basin, Nigeria. J. Min. Geol. 25(1&2):305-315.

UNEP, (2006). Environmental Pollution and Impact on Public Health: Implications of the Dandora Municipal Dumping Site in Nairobi, Kenya. Urban Environment Unit. UNEP. Kenya

United State Environmental Protection Agency, (2008). Data Acquisition and Information Management Handbook, Volume II Section 14.

USEPA (United State Environmental Protection Agency), (1991). Air Emission from Municipal Solid Waste Landfills: Background Information for Proposed Standards and Guidelines. EPA 450/3-90-011a

Whiteman A (1982). Nigeria, its Petroleum Geology, Resources and Potentials. 2. Graham and Trotman Publ., London, pp. 234-241.

World Bank. (2003). *An Analysis of Municipal Solid Waste in Kano Metropolis Nigeria. In Aliyu, Baba Nabegu (ed).* (MSc.), University of Science and Technology. Wudil, Kano State.

World Health Organization, (2014) 7 Million Premature Deaths Annually Linked to Air Pollution, World Health Organization, Geneva, Switzerland, http://www.who.int/mediacentre/news/releases/2014/air- pollution/en/.

Worksafe, V. (2005). Industry Standard Contaminated Construction Sites. EPA Victoria, www.worksafe.vic.gov.au, First Edition. pp. 1-28.

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Appendix A1

Table 4.2: Seasonal Variation of Particulate Matter and Gaseous Air Pollutants

		TSP		H_2S		VOC_S		CO		NH_3		CH_4		SO_2	
Station		**(µg/m³)**		Concentration (ppm)											
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
1	Day	68.00	80.24	3.40	4.00	2.90	2.00	2.30	2.80	8.00	4.20	0.070	0.11	1.05	1.60
	Night	59.00	69.62	2.80	3.00	2.60	1.80	1.70	2.20	6.00	3.90	0.050	0.09	0.95	1.40
	Mean	**63.50**	**74.93**	**3.10**	**3.50**	**2.75**	**1.90**	**2.00**	**2.50**	**7.00**	**4.05**	0.06	**0.10**	**1.00**	**1.50**
2	Day	41.00	48.38	2.60	3.20	2.00	1.70	1.60	2.63	5.00	3.60	0.06	**0**.050	0.6	1.40
	Night	39.00	46.02	2.40	2.80	2.00	1.25	1.20	2.31	3.00	3.00	0.04	**0.030**	**0.8**	**1.00**
	Mean	**40.00**	**47.20**	**2.50**	**3.00**	**2.00**	**1.50**	**1.40**	**2.47**	**8.00**	**3.30**	**0.05**	**0.08**	**1.00**	**1.20**
3	Day	25.00	28.75	2.00	3.30	1.10	1.07	1.04	2.57	4.60	2.50	0.05	0.070	**0**.50	1.00
	Night	23.00	26.45	2.00	2.10	1.00	0.95	0.76	2.03	3.40	1.50	0.03	0.050	**0.30**	0.80
	Mean	**24.00**	**27.60**	**2.00**	**2.70**	**1.05**	**1.01**	**0.90**	**2.30**	**4.00**	**2.00**	**0.04**	**0.060**	**0.80**	**0.90**
4	Day	24.00	28.32	1.70	2.20	0.90	0.60	0.68	2.50	4.60	1.00	0.04	**0**.050	0.70	0.80
	Night	21.00	24.78	1.25	2.00	0.70	0.80	0.32	1.20	3.20	1.50	0.02	**0.030**	0.50	0.60
	Mean	**22.50**	**26.55**	**1.50**	**2.10**	**0.80**	**0.70**	**0.50**	**1.85**	**3.90**	**1.25**	**0.03**	**0.040**	**0.60**	**0.70**
5	Day	23.00	25.99	1.22	1.80	0.90	0.80	0.40	1.60	3.20	1.00	0.03	0.036	**0**.50	0.60
	Night	21.00	23.73	1.00	1.40	0.60	0.50	0.20	1.30	2.00	0.60	0.02	0.024	0.30	0.30
	Mean	**22.00**	**24.86**	**1.11**	**1.60**	**0.75**	**0.65**	**0.30**	**1.45**	**2.50**	**0.80**	**0.025**	**0.030**	**0.40**	**0.45**
6	Day	22.00	24.86	0.70	1.2	0.80	0.70	0.11	1.05	3.00	0.70	0.016	0.025	0.25	0.30
	Night	20.00	22.60	0.50	0.80	0.60	0.50	0.09	0.95	1.80	0.90	0.012	0.015	0.15	0.20
	Mean	**21.00**	**23.73**	**0.60**	**1.00**	**0.70**	**0.60**	**0.10**	**1.00**	**2.50**	**0.80**	**0.014**	**0.020**	**0.20**	**0.25**
7	Day	21.00	23.73	0.40	1.00	0.8	0.60	0.00	0.76	1.10	1.04	0.01	0.01	0.11	0.20
	Night	19.00	21.47	0.20	0.00	0.5	0.30	0.00	0.32	0.90	0.40	0.01	0.01	0.09	0.10
	Mean	**20.00**	**22.60**	**0.30**	**0.5**	**0.65**	**0.45**	**0.00**	**0.54**	**1.00**	**0.72**	**0.01**	**0.01**	**0.10**	**0.15**