ENVIRONMENTAL EFFECTS OF ELECTRIC POWER GENERATING SETS IN GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS VILLAGE, LOKOJA, NIGERIA

BY

OKEME, Muktari
MTech/SET/2017/6894

A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF TECHNOLOGY (MTech) IN URBAN AND REGIONAL PLANNING (ENVIRONMENTAL IMPACT ASSESSMENT)

SEPTEMBER, 2021

ABSTRACT

Nigeria today is referred to as the country with the highest consumers of electric power generating sets globally despite her rich energy sources. Estimate has shown that more than 60 million Nigerians make use of electric power generating sets of varying sizes and capacities mostly in commercial areas. However, these generating sets while in operation produce gaseous emissions and high sound level which pose serious health risk to not only the users but to individuals in the surrounding environment. This research therefore used ATP 901A sound meter, MSA Altair 5X Multi gas detector, PCE-RCM 05 and MSA Altair pro single gas detector to monitor the decibel level, accumulation of carbon monoxide (CO), Sulphur dioxide (SO_2) and Particulate matter ($PM_{2.5}$) in and around the GSM Villages in Lokoja.Results of the above measured gases at Ganaja, kpata and Cantonment GSM Villages showed that $PM_{2.5}$(262µg/m^3), CO (14.4 µg/m^3) and SO_2 (0.15ppm) at Ganaja and $PM_{2.5}$ (258µg/m^3), CO (18.6 µg/m^3) and SO_2 (0.16ppm) atKpata and cantonment all exceeded the Federal Ministry of Environment's standard of 250 µg/m^3($PM_{2.5}$), 11.4 µg/m^3 (CO) and 0.1ppm (SO_2).Decibel level of noise at Ganaja GSM Village (90.8 dBA), Kpata and Cantonment (102.4dBA) were also higher than the Federal Ministry of Environment's (FMEnv) and WHO permissible limits of 55dBA and 70dBA during the day.This study therefore concludes that the incessant use of electric generating sets remain a problem that cannot be overlooked considering the multiplicity of its effects on the workers and residents of the study area.**It was therefore recommended that regulatory agencies in the state should see to the enforcement of Polluter Pays Principle at the three locations under study so as to allow the polluters pay for the damages or harm they inflict on the environment via their activities during power outage**.

TABLE OF CONTENTS

Content **Page**

CHAPTER TWO

CHAPTER THREE

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

LIST OF PLATES

LIST OF APPENDICES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Many towns and cities in Nigeria today are linked to the national power grid for their electricity supply but unfortunately, the epileptic supply from the grid has compelled residents to seek for other means of generating electricity (Sambo *et al.,* 2009). In view of this, there is a general shift of residents to off-grid sources of power supply which include the use of power generating sets of varying models, capacities and sizes. This development therefore has made the country to be running generator economy (Ahmad and Abubakar, 2012). Globally, Nigeria has been tagged as the country with the highest concentration of power generating sets despite her abundant energy sources and as a result, more than 60 million Nigerians use generating sets to provide energy for their domestic and commercial activities (BBC Africa, 2013).

The rate at which electric power generating sets are being imported over the years is therefore continually on the increase as the number of generating sets in Nigeria is estimated at about 60 million (Okoro, 2014). Varying sizes of these generating sets are being massively used in offices, business premises, homes, schools, religious centres, cinemas, industries and other generator inclined places (Adeyemo, 2012). The uses are however more in commercial centres or malls where multiple units run at the same time as a necessity for businesses to function. Electric power generating sets are capable of emitting noise and gaseous substances that can negatively influence the composition of the atmosphere or environmental quality (Ibitoye and Adenikinju, 2007; Yesufu *et al*. 2013; Azodo, 2014). Noise is often seen as a type of environmental pollution that can affect people both physiologically and psychologically and more importantly, interfere with basic activities such as rest, study, sleep, and communication. Sound pollution has been recognized in recent years as one of the problems hampering the quality of life across the globe (Hunashal and Patil, 2012). Awofeso (2010) observed that sound pollution that emanates from domestic generating sets usually surpass those produced by buses, trucks and workplaces. These generators according to him, cause more harm to human environment, due to their closeness to homes or residential buildings.

The advent of GSM technology brought with it the need for repairs and sales of handsets of different types and models in Nigeria. This development necessitated the creation of Ganaja, Kpata and Cantonment GSM Villages in Lokoja, Kogi state. The commercial nature of these GSM Villages coupled with the intermittent power supply in the state compelled the shop owners in the villages to look for other means of generating electricity. To this extent, power generating sets of varying sizes and capacities are being used by the workers to foster their business activities during power outage.

Numerous researchers such as Hammer *et al.* (2014), Liu *et al.* (2014), Otutu (2011), Akin (2016) have established that subsequent exposure to noise and gaseous pollutants from these power generating sets can be detrimental to human health and may sometimes lead to death. It is therefore significant to assess the level of risk posed by these power generating sets on the ambient environment of the study area. Hence the need to carry out this study.

1.2 Statement of Research Problem

The massive failure of the old National Electric Power Authority (NEPA), and its underperforming descendant, the Power Holding Company of Nigeria (PHCN), has left almost all Nigerians with no choice but to invest in electric power generating sets. Owning a portable electric power generating set therefore is not only essential, but a norm in Nigeria (Akin, 2016). The power supply problem in our nation today has therefore made the use of generators an issue of a growing concern since electricity generating plants which are meant to serve as power alternative or back up source during power failure, are fast becoming major means of power generation in homes and commercially designated areas (Ibitoye and Adenikinju, 2007; Yesufu *et al*. 2013; Azodo, 2014).

In addition, there are no positive sides to the sounds produced by generators because it has neither rhythm, sequence nor pattern. It is therefore more or less not possible for any running quality generator not to produce sound at all except it is switched off (Azodo and Adejuyigbe, 2013). Diesel generators have the capacity to produce 88 decibel of sound, while gas or petrol powered generators can produce above 95decibel and sound higher than 85 decibel is physically painful (Alam, 2013).The effects associated with the usage of these generators by residents impacts greatly on human health and the environment at large and this has stimulated great concerns amongst environmentalists and other players in the built environment (Obadote, 2009).

Apart from sound pollution, electric power generating sets contribute greatly to the emission of greenhouse gases which is also a threat to public health (Komolafe *et al.*, 2014). Contemporarily, the problem of climate change due to the release of carbon iv oxide (CO_2) and some gaseous substances in air has become a problem of global concern (Yang *et al*., 2008) and carbon emissions from automobiles and generators are the major contributors to this sad phenomenon (Wang *et al*., 2016).

This similar trend is no exception in the three GSM Villages in Lokoja because the problem of noise and air pollution in the GSM villages Lokoja suddenly become evident as soon as there is power outage or when power supply is epileptic and cannot power their appliances. In this regards, multiple generating sets of different kinds and sizes begin to run at the same time in order to sustain their businesses. There are therefore probable chances that the people in and around the village stand the risk of being affected by the noise and gases emanating from the exhaust of these power generating sets

1.3 Research Questions

1. Are the various land uses in the study area compatible?
2. What are the operational activities in the study area?
3. How does the workers and residents perceive the impact of GSM Village activities on their environment?
4. How does the sound and gaseous emission from the electric power generating sets affect the workers and residents of the study area?

1.4 Aim and Objectives of the Study

1.4.1 Aim of the study

The aim of this research is to assess the environmental effects of sound and gaseous emissions from electric power generating sets on the air quality of GSM Village Lokoja and its surrounding environment through the following objectives. To:

1.4.2 Objectives of the study

1. examine the various land use compatibility in the study area
2. assess the operational system and power usage in the GSM Villages
3. examine workers and residents perception of the GSM Village activities on their environment
4. Assess the decibel level, concentration of particulate matter, carbon monoxide and sulphur dioxide in the study area.

1.5 Scope of the Study

The scope of this research covers the three GSM Villages at Ganaja Junction, Cantonment and Kpata all in Lokoja Local Government Area of Kogi State. The activity scope is to assess the extent of environmental pollution at the three GSM Villages through careful examination of the sound and concentration of pollutants being emitted by the generating sets of different sizes and capacities at the villages. In a bid to assess the extent of pollution in the study area, readings of sound and gaseous emission were taken at 300 meters radius and the results obtained were compared with established national and international standards. This makes it possible for planning recommendations to be proffered.

1.6 Justification

According to ECN (2009), More than 60 million Nigerians depend on power generating sets and past studies carried out on sound from these generating sets by (Omubo *et al.*, (2010), Otutu (2011), Oguntoke *et al.* (2012), Yesufu and Ana (2013) and a host of others have revealed that health efafects such as impaired task performance, cardiovascular diseases, annoyance, negative social behaviour, sleep disturbances, interference with spoken communication and tinnitus (impairment) are all associated with sound from power generating sets (Azodo *et al.,* 2013).

On the other hand, previus studies on emissions associated with portable electric power generating sets showed that cancer, headache, respiratory and cardiovascular diseases are directly linked to the pollutants being emitted by generating sets. Ahmad and Abubakar (2012) also found out that the accompanied air pollution from these generating sets cause grave health complications that are tied to the duration or range of exposure to the amount of fumes discharged by these generating sets. He highlighted health challenges such as irritation of the respiratory systems, cancer, eye irritation, birth defects and toxic poisoning as some of the health problems caused by pollutants from generator sets.

In GSM Village Lokoja, virtually all shop owners have generating sets and these generators run on either diesel or petrol to power their appliances thereby resulting in environmental pollution (i.e. sound and air pollution). Currently, little effort has been made to tackle the problems of sound and gaseous emission at the three locations under study. The benefit of this research work therefore is to educate the inhabitants of Lokoja on the effects of electric power generating sets on their health and the environment at large with a view to providing practical recommendations on the way forward.

1.7 The Study Area

1.7.1 Geographical location

Lokoja is one of the 21 Local Governments of Kogi state and it is situated between Longitudes: 8^0 20′ 00″– 7^0 55′ 00″E and Latitudes: 6^0 15′ 00″- 7^0 5′ 00″ N of with an area coverage of 3179.7189 square kilometres as indicated in Figure 1.1. Lokoja as a capital of

Kogi state is blessed with various institutions like the Federal Medical Centre (FMC), specialist hospital Lokoja, Stella Obasanjo Library, Kogi State Polytechnic and Prince Abubakar Audu University formerly known as Kogi State University (Joseph, 2015).

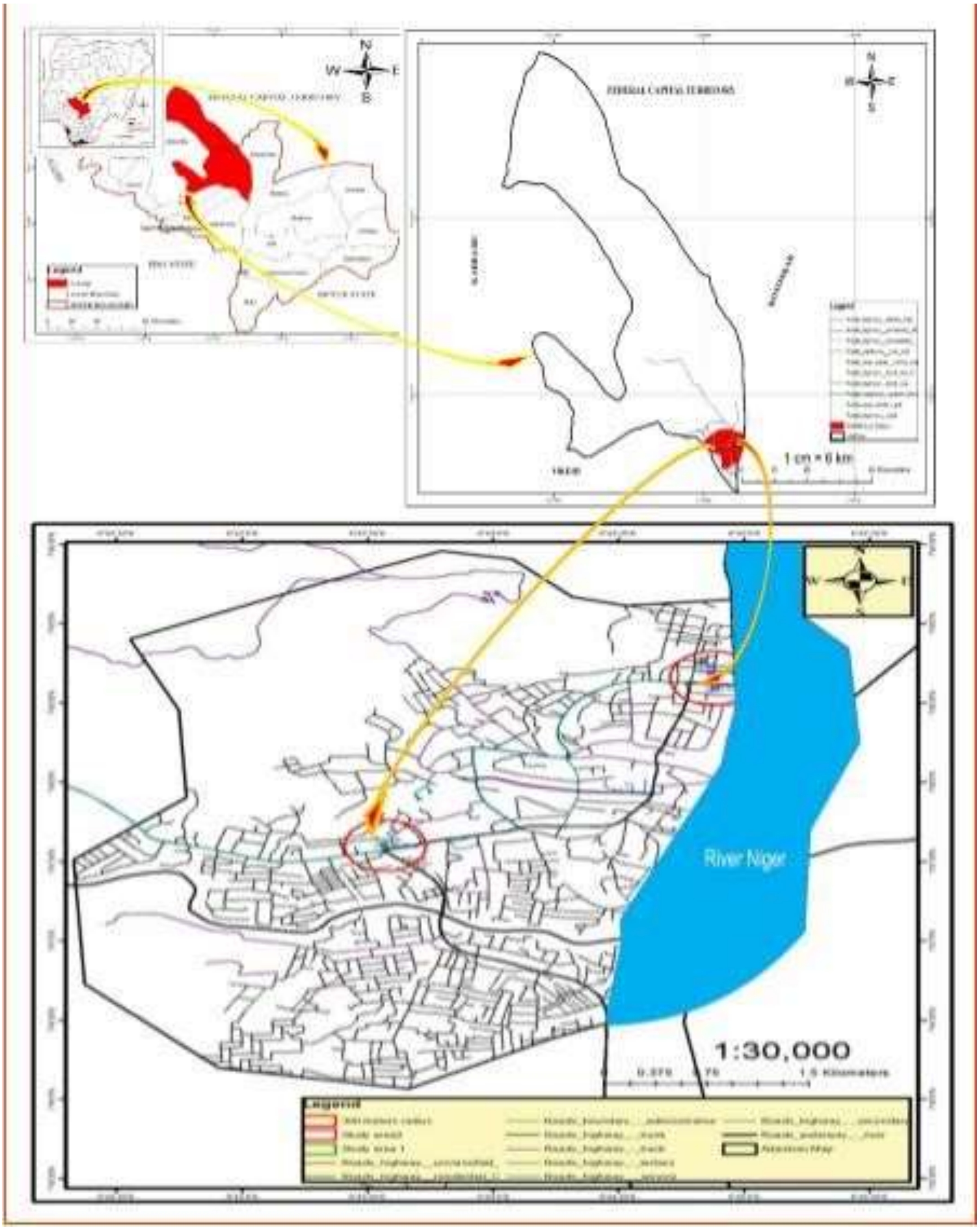


Figure 1.1: Map of Kogi State Nigeria showing the study area
Source: Kogi State Ministry of Lands and Housing (2019)

1.7.2 Climate and weather of Lokoja

Lokoja is characterized by two seasons (wet and dry) with an annual rainfall of 1016 mm and 1524 mm. Greater percentage of the rain drops between May to October and at the peak in September, while the summer season starts from November to April. The temperature of the study area ranges from 27.7^{o}C - 33.94^{0}C (Ifatimehin *et al.*, 2009). The study area records its maximum temperature around March to April while the lowest temperature comes around December and January. The influence of Northeast Trade Wind brings harmattan wind (dry season) while the Southwest Humid wind brings rainfall (wet season). The average wind speed varies between 3.0 to 4.6 Knots within the months of June/July and the average wind speed within the months of December/January is between 1.5 to 3.7 Knots (Siji, 2015).

The wind as identified earlier moves in north- eastern (NE) and south western (SW) axis of the study area. Pollutants from the generating sets in the study area are therefore blown towards the above mentioned directions thereby putting people along this axis at a disadvantaged position. This is due to the negative effects of the pollutants from the power generating sets in the village would be felt more by them. However, people living along the north-west (NW) and south-east (SE) parts of the village also get to share in the negative impacts especially when the pollutants collide due to some natural occurrences like the storm and time of the season thereby resulting in haphazard or random movements in the atmosphere.

1.7.3 Historical background of the study area

As far back as 1830, the Lander Brothers discovered the Niger River which became the principal route that ushered people, goods and services into the interior parts of the city.

The city later became the favourite spot for the European explorers, administrators, missionaries and merchants due to its strategic location. The fact that different classes of persons became interested in the town led to the setting up of a homestead by Dr. Baikie which led to the erection of a consulate building in 1865 and eventually transformed to be the capital of the Northern Province in 1900. Lokoja as the midpoint of River Niger and Benue has attracted both local and foreign tourist and this makes the town to experience rapid development and growth. However, after the coming together of the two regions (Northern and Southern) the country (Nigeria) was then formed. Lokoja became the administrative centre because of its recognition as the capital of the British Colonial Government. (Kogi State Ministry of Information, 2011).

There are many historic towns and cities in Nigeria and Lokoja happens to be one of them but became a metropolitan city since before the independence. The city is known for sheltering other smaller ethnic groups in the country and it as well serves as the central business district (CBD)/capital of Kogi state. The early migrants that settled in the study area were Bassa-Nge people in (1831) and the Oworo people in the early 1970 after which different ethnic groups sprang up (Akamisoko2002). Lokoja is cosmopolitan in nature and as a result, it is made up of numerous ethnic groups such as the Oworos, Bassa-Nges, Hausa, Egbira, Nupe, Kakanda, Kupa and Egan. Others are Yoruba, Igala, Igbo, Tiv. But the original settlers of the town are Oworos. Siji (2015)

1.7.4 Relief and geology

The geography of Lokoja is very unique due to the undulating nature of it terrain. The study area is blessed with many valleys positioned at the western poles, river bank of river Niger to the western, high plateau to the north and Patti ridge to the east with an altitude of 45-

450 above sea level (Alabi and Enete, 2012). The abundance of Patti ridge and water body in Lokoja has shaped the nature and pattern of settlements to a linear form. Equally the nature has also modified consequence of climate change on the environment through the Patti ridge, water body and vegetal cover that are in abundance in Lokoja, these natural resources serve as carbon sink for temperature regulation in both day and night (Alabi, 2009). The study area is drained by three major rivers 'River Niger, River Meme and River Ero' (Siji, 2015). The relief or terrain has the capacity of influencing how far sound can travel. Elevated parts of the earth like hills and mountains affect sound dispersion of an area because they sometimes act as buffers unlike a flat land.

1.7.5 Population and economic activities

Kogi state was established by the then military head of state in August 1991. Today as a result of urbanization and population influx into the city (Lokoja). The population of Lokoja that was formerly 77,516 in 1991 has tremendously increased to 196,643 (2006 population census). Subsequently, the land use arrangement of the area was modified as a result of rapid development and uniqueness of the meeting point of river Niger and river Benue which eventually turned the city to a trade centre for fishing and other agricultural activities.

The political history of Lokoja can be traced as far back as 18^{th} century, during the then British colonial period and exploration by Williams Balfour Balkie in 1860. Long before now, Lokoja is a significant commercial settlement that is made up of unconventional Africans, migrant and indigenous people that were fortified to move down from the top of the mount Patti. Although, Lokoja was changed from a transportation business centre to a feasible marketable heart for foreign investors in the1860's. In 1841, the ruler of the Igala kingdom ‘Attah of Igala yielded the ancient town of Lokoja to the British. This eventually earned him (Attah of Igala) a favour to be selected to the first British Delegation that ranged from 1860-1869 and later, the Military head office of Sir George. These achievements earned Lokoja a big name ahead of other cities and this in turn made the city to attract people more than any other cities in the region ‘(melting pot for a collection of diverse ethnic groups)’.

In 1904 however, the military headquarters status of Lokoja was taken/moved to Zungeru and this development led to a serious decline in Lokoja’s fame. This development however was short-lived owing to the fact that the coming together of Northern and southern region into one country (Nigeria) in 1914 restored back its status. As the capital, it became a suitable managerial town for the British government. However, the capital and many things were shifted away from Lokoja with the coming of Lord F. Lugard as the first Governor General of Nigeria in 1914.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Green House Gas Theory

The greenhouse theory was initiated by a scientist known as Fourier as far back as 1827 when he related the effect of the atmosphere to the heating of an enclosed space below a pane of glass (Jones and Sellers, 1990). In his theory, the earth's atmosphere was likened to the glass of a hot house or a box covered with a pane of glass. According to Fourier, the house becomes warm /hot when solar rays from the sun pass through the glass into the house and the interior parts of the house afterwards partly absorbs and partly reflects the incoming solar rays (Allmendinger, 2017**).**

Similarly, incoming ultraviolet radiations from the sun easily penetrates the walls of the greenhouse gases because of the intensity of the radiation. These radiations are partly absorbed and partly reflected by the soft and hard surfaces of the earth. However, the reflected radiations (Weaker infrared) find it difficult to pass through the glass walls of the greenhouse gases rather they are trapped and re-radiated in different directions. Some of these re-radiated rays find their way back to the earth surface making it warmer (Marc, 2015).

In reality, the greenhouse theory is based on the fact that many gaseous substances in the air permit more solar rays from the sun to pass through them down to the surface of the earth compared to the volume of radiant infrared energy that the atmosphere allows to escape back up to space. This therefore implies that the more the concentration of greenhouse gases in the atmosphere the fewer infrared energy that can escape back to space. Thus, having more greenhouse gasses equally intensifies the earth's surface temperature (Schneider, 1989).See Figure 2.1 for an illustration of greenhouse effect as presented by US EPA.

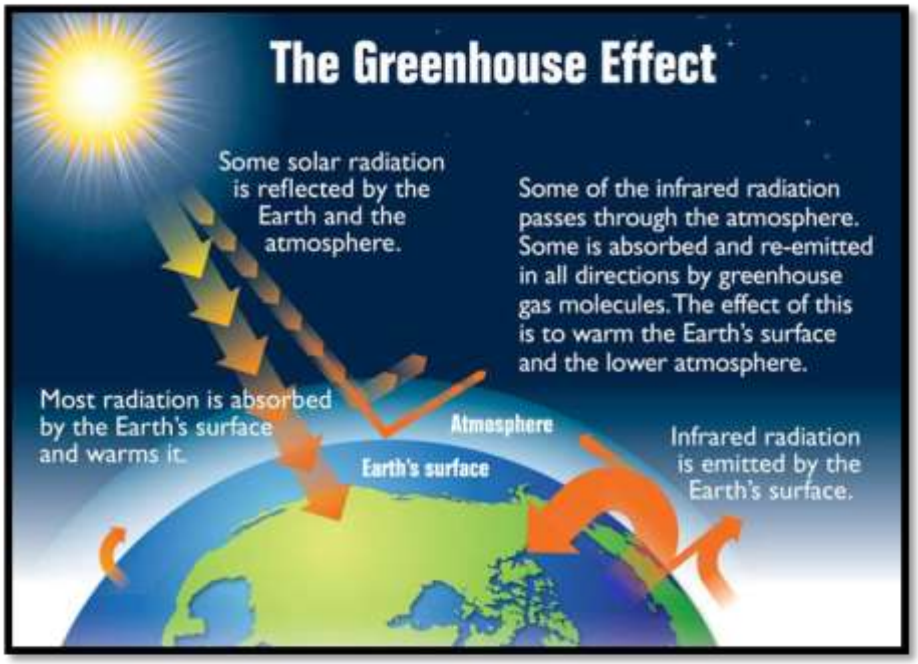


Figure 2.1: Greenhouse effect
Source: (US EPA 2012)

Invariably, the more the greenhouse gasses (methane carbon dioxide, nitrous oxide, chlorofluorocarbons, tropospheric ozone to mention but a few) in the atmosphere through the burning of fossil fuel, the less the likelihood for reflected thermal radiation to escape into space thereby subjecting the earth to more heat (Marc, 2015).

The emission of greenhouse gases is a function of the global population, economic, technological, and social trends (UNFCCC, 2001; IPCC, 2006 and UNFCCC, 2014) and the total CO_2 emissions from energy systems can be expressed by a formula termed "the population multiplier" (Ehrlich and Holdren, 1971). The formula is expressed as:

Total CO_2 emission =

$$\frac{CO_2\ emission}{Technology} \times \frac{Technology}{Capita} \times Total\ population\ size$$

The first expression signifies engineering effects, the second stands for standard of living and the third represents demography.

The limitation of the greenhouse theory is the fact that the atmosphere was treated or characterised solely as a static object. The earth itself that was represented by a box is made up of mountains, land, sea surfaces, free flow of air and other variables that induce different climatic zones. Operating average values therefore does not give room for a logical conclusion about the fluctuation of the weather and enhanced temperature elevations in certain areas or regions of the earth (Allmendinger, 2017). The greenhouse gas theory is therefore more or less an experimental theory.

2.1.1 The Polluter pay principle and physical harm

The Polluter Pay Principle (PPP) gained prominence after being recognized by the Organisation for Economic Co-operation and Development Recommendation of May 26th 1972 (OECD, 1972). Historically, the idea of Polluter Pay Principle for environmental harm was enshrined in both Western and Eastern traditions (Luppi *et al*., 2012).

The principle states that National Authorities should endeavour the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should in principle, bear the cost of pollution. It is therefore built on the fact that polluters are made to pay for the damages or harm they inflict on the environment thereby forcing them (polluters) to take all the costs of their actions into consideration (UNEP, 1992).

Harm is often done to the climate when noxious gasses such as CO_2, NO_2, CH_4, SO_2, are emitted into the atmosphere/space. The harmed climate afterwards results into sea level rise, increase storm frequency or intensity, species extinction, loss of agricultural productivity, diseases, changes in rainfall pattern and drought. This harm as a result of a changed climate is termed physical harm. To this extent, the definition of harm broadly covers environmental quality, health, sensory offences and damage to property.

This principle is however in line with Pigouvian tax theory that was initiated in 1920 to aid in fixing carbon tax at a level that assumes the right charges of environmental damages so that the real cost of environmental pollution would be revealed by the prices. Most times, the polluter pays principle comes in the form of a tax gathered by the government levied per unit of pollution emitted into the air or water (Pigou, 1920).

As a policy instrument for controlling pollution, a tax on emissions will theoretically moderate pollution, as firms or individuals will reduce emissions in order to avoid paying the tax. Under a range of market conditions, standard economists assume that pollution tax will generally be more cost-effective at reducing pollution than regulations. There are however challenges in measuring the cost of harms connected to greenhouse gasses as evident in Pigouvian tax theory due to the difficulties in apportioning the cost of damages associated with GHG emissions. To this extent, many countries have followed the approach, in which the tax is set at a rate that influences taxpayers 'behaviour (UNEP 2009). Researchers like Gardiner *et.al.* (2010), Meyer (2012), Eric Neumayer (2000), Botzen, *et. al.* (2008) and Caney (2005) all agreed to versions of the above claim.

In the 90s, an Indian philosopher Kautiliya in his research in the field of economics recommended different levels of economic fines for inflicting harm on the environment depending on the level of damage caused. For instance, he would recommend charges for urinating or defecating on holy grounds, places meant for water, temples and royal places (Kautiliya, 1986).

2.1.2 Applications of polluter pays principle

From Kautiliya's view, one could easily tell that the idea or application of Polluter Pays Principle to help solve the problems of pollution in the native settings was conceived long time ago even though there were no such global common problems as we have them today. Progressively, it became useful as an economic tool in making domestic polices since it allows for the allocation of costs of pollution, prevention and control. (Smets, 1990; Gaines, 1991).

Canadian government today has placed a compulsory charge on the activities that contributes to the release of greenhouse gasses especially the combustion of diesel fuel in the country so that her citizens will be forced to limit emissions in the future. Currently, there is a voluntary market for offsetting CO_2 emissions in Canada that ranges from $6-$11 per tonne of CO_2 emitted. He further buttressed that there is a general consensus that the price of emissions must rise to at least $200 /t CO_2e in order to achieve the desired goal of reducing the effects of Green House Gases globally. A target price of $250 /tonne CO_2 by the year 2025 has been recommended by the Canadian Government.

Also in the United States of America, Yale and Mason Universities conducted a poll which revealed that 61% of her citizens agreed that producers of fossil fuel should made to pay the hidden costs of the industry so that the money realized can be invested in the treatment of citizens affected by air pollution related sicknesses emanating from the activities of the industries (Nesbit, 2012).

The application of Polluter Pays Principle in India is however different from the practices in other parts of the world. In India, the Government takes responsibility or assumes direct liability by paying compensation to victims and later allows the original polluters to pay for damages through a process called subrogation (Faure *et al.*, 2010). Similarly, governments of countries like Chile, South Africa, Taiwan, and Kenya, adopted Polluter pays principle (PPP) via judicial, legislative and constitutional reforms. Mitigation of harms is therefore normally done through the government to ensure victims are compensated when polluters cannot be identified.

2.2 Environmental Pollution

Environmental pollution has been perceived as one of the problems bedevilling the world today and the fact that it keeps rising each year and causing serious and lasting damages to the earth and human health makes it more worrisome (Godson and Chikare, 2016). The manipulation of the ecosystem or environment through the use of technology by man to meet their needs often results in environmental pollution (Godson and Chikare, 2016). Contemporarily, it has become a thing of serious concern that threatens the survival of mankind. The foods we consume, the air we breathe, the water we drink, the damages in global ecosystems, disappearance of plant and animal species, the lack of natural resources and the earth being threatened by biochemical processes are all inclined to environmental pollution (Madaleno, 2018).

To this extent, Environmental pollution is defined as the build-up and accumulation of toxic heavy metals in the air, water, and land that reduces the ability of the contaminated sites to support life (Pushpanathan and Rajendhran, 2014). Environmental pollution therefore poses different consequences on the environment through different mediums like air, water, noise, soil, thermal and radiation (Khan and Ghouri, 2011).

2.2.1 Air pollution

Air pollution is one of the notable environmental problems that is threatening the existence of life today and it has recently increased the rates of mortality and morbidity worldwide (Abam and Unwachukwu, 2009). WHO (1999) defined air pollution as substances put in by the activities of mankind in concentration sufficient to cause harmful effects to health, properties, crop yield, or to interfere with the enjoyment of property (Mukherjee, 2002 in Akindayo, 2016).

Atmospheric pollution is a situation in which certain substances made up of gases such as sulphur dioxide, nitrogen oxides, carbon monoxides, hydrocarbons, particulate matters like smoke, dust, fumes, aerosols as well as radioactive materials are existent in such concentrations that may produce unwanted effects on man and the ecosystem (Al-Salem and Bouhamrah, 2006 as cited in Chizoruo *et al.*, 2017). The natural or artificial substances that makes the environment unfit for humans, plants and animals are referred to as pollutants.

The speedy rise in urban population, increase in industrialization, escalating demands for energy and motor vehicles have all aggravated the level of pollution facing the world today (Harendra, 2012). Air pollution has lots of negative effects on human health and has been considered a major problem for the global community (Franchini *et al.*, 2016). The World

Health Organisation (WHO) opined that, over seven million deaths in 2012 was caused by ambient air pollution representing over 10% of all caused deaths and more than doubling previous estimates.

Contaminants, pollutants or hazardous substances associated with air pollution are majorly carbon dioxide (CO_2), heavy metals, ground-level ozone (O_3), particulate matter (PM_2/ PM_{10}), benzene (C6H6), nitrogen dioxide (NO_2), carbon monoxide (CO) and sulphur dioxide (SO_2) (EPHA, 2009). More so, air pollution normally results in ill health and death and it is usually from natural or man-made sources. The man-made pollution sources are mainly; congested roads, poor environmental regulations, aged and poor maintenance of vehicles, automobiles, less efficient technology of production, industries, home cleaning agents, heating, burning of solid fuels for cooking, tobacco smoke, insecticides and power generation. The natural sources on the other hand, include incinerators and waste disposals, forest and agricultural fires (European Public Health Alliance, 2009).

2.2.2 Sound pollution

Noise is generally defined as an unwanted sound that can reduce productivity, interfere with communication and may sometimes result in permanent hearing loss in high exposures (Michael and Mark, 2009). It has been perceived as an important harmful physical factor being faced by developed and developing countries today especially in work environment (Fiedler and Zannin, 2015). Generally, sound pollution is regarded as one of the notable environmental contaminants that has direct impacts on humans (Debasish and Debasish, 2012).

According to Patrick (2013), noise has many health effects which makes it worrisome. These effects however can cause the loss of hearing (tinnitus), high blood pressure, stress, sleep disorder, distraction affecting productivity, irritability and in general reduction in the quality of life (Goines and Hagler, (2007) as cited in Patrick and Babatope, 2013). Prolonged contact to less intense but harmful sounds can gradually lead to undetected weakening of hearing ability. According to Mbamali *et al.* (2012), noise readings beyond WHO threshold of 70 to 75 decibel are accompanied by heightened emotions and behaviour and increases blood pressure. Such intensities of sound can result to hearing disorder (tinnitus) as well as disagreements amongst neighbours. See figure 2.2

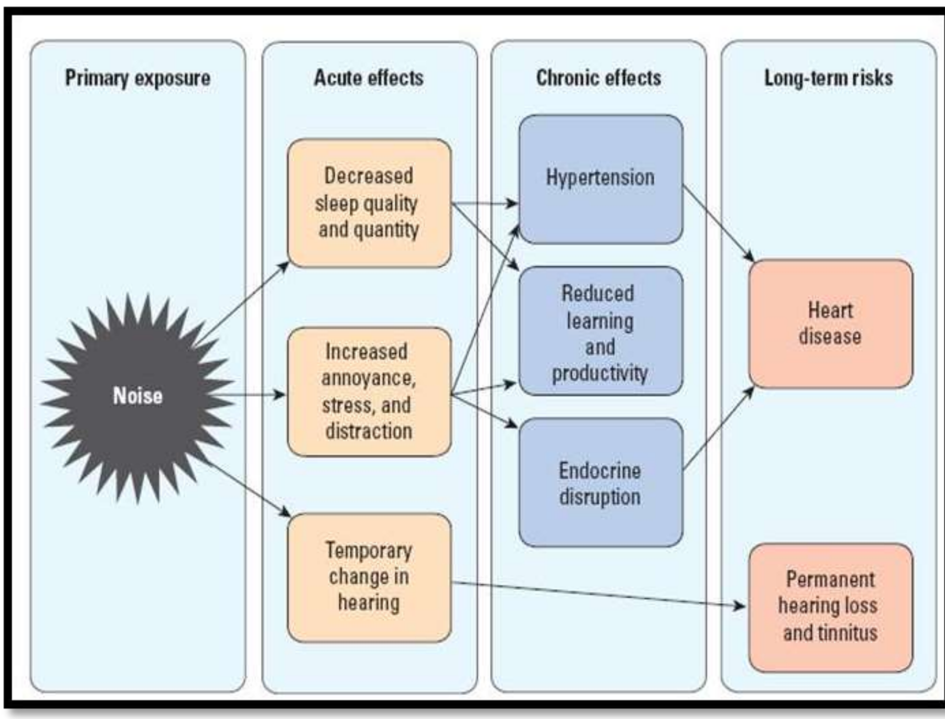


Figure 2.2: Effects of noise pollution on human health
Source: (Hammer *et al*., 2014)

Domestic sources of urban noise entail a range of individual household and family activities that transcends into audible noise that extends beyond the confines of the household. Some of these activities include leisure music and news from radios and television sets, the usage of power generating sets, grinding mills of private and commercial outfits and other domestic noise inclined sources like backing and howling of poorly trained dogs, bleating of goats, and mewing of cats especially in silent nights (Fadairo, 2013).

2.2.3 Water pollution

One other implication of excessive pollution, with obvious impact on human health, is water pollution (Haseena *et al.*, 2017)**.** Water pollution occurs when unwanted materials enter into water, changes its quality and makes it harmful to the environment and human health (Alrumman *et al.*, 2016). Water is apparently a significant natural resource used for drinking and other developmental uses in the environment (Bibi *et al.*, 2016). Unfortunately, drinking water in a number of countries does not mostly meet WHO standards (Khan *et al.*, 2013) and about 3.1% deaths happen as a result of unhygienic and poor quality water (Pawari and Gawande, 2015).

Major sources of water pollution stems from industrialization, discharge of domestic waste, radioactive waste, population growth, excessive use of pesticides, fertilizers and leakage from water tanks, urbanization and weak management systems (Haseena *et al.*, 2017). According to World Health Organisation WHO (1999), one sixth of the global population approximately 1.1 billion of the world’s population do not have access to portable water and 2.4 billion people lack basic sanitation (EPHA, 2009). Some water pollution effects are felt or recognized instantly, while others manifest over time. It could be for months or years as the case may be (Ashraf *et al.,* 2010).

In fact, the leading cause of human death across the globe today has been linked to water pollution. Moreover, our oceans, drinking water, lakes and rivers are being polluted day in day out there by making it a global concern (Scipeeps, 2009).

2.3 Modern Instruments for Measuring Air Pollution

2.3.1 Wöhler CDL 210

The Wohler CO_2-logger is an instrument that measures CO_2 level in part per million (PPM), air temperature in degree/ farinhide (^{O}C or ^{O}F) and humidity in Percentage (%). It is very useful in the evaluation and monitoring of the interior climate in living spaces and in commercial premises. See plate I. The meter also has an audible alarm to warn or notify the user when CO_2 concentration exceeds the limits. The instrument beeps once CO_2 concentration of the environment under study is high and a fan icon is displayed on its screen to show that CO_2 concentration has exceeded its limit or threshold. See Plate II.

Plate I:Wöhler CDL 210
Source (Wallner, 2015)

Plate II: Fan icon indicating high concentration of CO_2
Source: (Wallner, 2015)

2.3.2 EGA4 combustion analyser and MSA altair 5X multi-gas detector

The EGA4 Combustion Analyser is an instrument that measures carbon monoxide CO_2, Nitrogen oxide NO_2 and Sulphuric acid SO_2. The measured and calculated pollutants are often displayed on LCD alphanumeric screen of size 40 by 56 mm with an automatic backlight device for easy readings especially under poor light condition. The instrument uses electochemical cells to measure the above mentioned toxic gases in the atmosphere.

Just like the Wohler CO_2-logger, it gives acoustic and visual alarm once the set limits are exceeded. See plate III

The Version SW 1.27.06.50 of MSA Altair 5X Multi gas Detector on the other hand is a portable hand held device used to monitor atmospheric gases. It is made up of four maximum sensors capable of displaying readings for five separate gases like CO, H_2S, Oxygen and 2 combustible gases including Pentane See plate III and IV.

Plate III: EGA4 Combustion Analyser
Source: (Adefeso *et al.,* 2012)

Plate IV: MSA Altair 5X Multi-gas Detector
Source (Chuks, 2019)

2.4 Modern Instruments for Measuring Noise Pollution

2.4.1 Type 2 model IEC 651 and GM 1352 digital sound level meters

Type 2 model of IEC 651 sound level meter is an instrument designed to meet the requirements of different noise/sound inclined environments. Some of its external features are a measuring range between 35 – 100 dB for low and 65 – 130 dB for high, a screen that displays the sound pressure level, response and maximum “hold” switch button to set the meter to either the slow or fast mode and the reset button, used to reset level indicator.

The GM 1352 Digital Sound Level Meter on the other hand is a hand held sound recording instrument that fits comfortably in the palm with a measuring range of 30 to130dBA and a 0.1dBA resolution respectively. The instrument has a maximum (Max), minimum (Min), and hold sound level tracking buttons with large backlit LCD that displays large visible numbers. See plates V and VI respectively.

Plate V: Type 2 Model IEC 651 Sound Meter Source: (Azodo *et al*., 2016)

Plate VI: GM 1352 Digital sound meter Source: (Oseji, 2011)

2.4.2 Amprobe SM-20 sound meter

The Amprobe SM-20 sound meter is an instrument that measures sound pressure levels (SPL) in a noisy environment. It is also useful in acoustic analysis especially when it involves taking readings to ensure compliance with set standards and health safety codes. The instrument is designed to have the ‘A weighting and C’ weighting measurement settings. The 'A' weighting functions where the ambient noise is low or moderate for example an office while the 'C' weighting is meant to take readings where the background noise is loud such as machine shops. The meter also offers a choice of two response speeds i.e. (the fast 125-millisecond response and the slow 1-second response setting). The fast 125-millisecond response measures the average sound level in environments with steady ambient sound, while the slow 1-second response setting measures peak noise levels in environments with fluctuating ambient sound. See plate vii.

Plate VII: SM-20 Sound Meter
Source: (Hill and Lavela, 2015)

2.5 Air and Noise Pollution Guidelines/Standards

2.5.1 World Health Organisation

According to World Health Organisation 1999 guideline, values for outdoor noise levels in residential, institutional and educational areas for day time (i.e. 7am – 10pm) is 55 dBA while that of the night which ranges from 10pm-7am is set at 45 dBA. Limits for industrial and commercial areas is set at 70 dBA for both day and night as shown in Table 2.1.

Table 2.1: WHO noise limit guidelines (dBA)

Receptor	**Day time**	**Night time**
	(07:00 – 22:00)	(22:00 – 07:00)
Residential **Institutional** **Educational**	55	45
Industrial **Commercial**	70	70

Source: World Bank/IFC General EHS Guideline 2007.

2.5.2 Federal ministry of environment (FMEnv)

Limits for particulate matters, sulphur dioxides, non-methane hydrocarbons, carbon monoxide, nitrogen dioxide and photochemical oxidants are respectively given by Federal Ministry of Environment as shown in Table 2.2

Table 2.2: Nigerian ambient air quality standards

Pollutants	Limits
Particulates Matter	250 $\mu g/m^3$
SO_2	0.1PPM
Non-methane Hydrocarbons	160 $\mu g/m^3$)
Carbon monoxide	10 ppm/ (11.4 $\mu g/m^3$)
Nitrogen oxides (Nitrogen dioxide)	0.04 -0.06 ppm
Photochemical oxidant	0.06 ppm

Source: FMENV, 2008

Table 2.3 represents the noise exposure limits as given by Federal Environmental Protection Agency and Federal Ministry of Environment in Nigeria.

Tale 2.3: Noise exposure limits in Nigeria (FMENV)

Duration per day (hr)	Possible exposure limits (dBA)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Source: Oyedepo and Saadatu, 2010

2.5.3 **NESREA (**National Environmental Standards and Regulations Enforcement Agency)

The hours of the day according to NESREA spans from 6.00a.m to 10.00p.m while that of the night ranges from 10.00p.m to 6.00a.m. The organisation has placed a permissible noise limit on the general environment with emphasis on the above mentioned periods of the day. See Table 2.4.

Table 2.4: Maximum permissible noise levels for the general environment

	Column 1	Column 2	
	Facility	**Maximum Permissible noise limits dBA**	
		Day: 6 a.m-10 p.m.	Night: 10 p.m.- 6 a.m.
A	Any building used as hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning, conference rooms, public library, environmental or recreational sites,	45	35
B	Residential buildings	50	35
C	Mixed residential (with some commercial and entertainment)	55	45
D	Residential + industry or small scale production + commerce	60	50
E	industrial (outside perimeter fence)	70	60

Source: NESREA (Noise Standards and Control) Regulations 2009.

2.6 Review of Related Case Studies

2.6.1 Case studies in other continents

Hammer *et al.* (2014), conducted a research on environmental noise pollution in the United States and how to develop an effective public health response. According to the researchers, millions of American Citizens are faced with lots of serious health problems including heart diseases and hearing losses resulting from noise pollution. Their research was aimed at describing some severe health problems that are noise induced. Extrapolations and estimates were made from numerous published works on exposure to highly prevalent noise sources. In 2013 they estimated that over 24 hours, 104 million individuals were exposed to an annual equivalent continuous average level of >70 dBA and were at risk of being affected by tinnitus. The researchers equally asserted that cardiovascular diseases and other noise inclined illnesses may affect tens of millions more. They therefore recommended that substantial public health benefits can be attained by integrating interventions that decrease environmental noise levels and exposures into the federal public health agenda of the United States.

Liu *et al.* (2012) also looked at the link between housing nearness to fuel fired plants and rate of hospitalization for respiratory diseases in the United States of America. The study was aimed at determining whether living close to a fossil fuel powered plant increases the possibility of hospitalization for respiratory diseases. The researchers used the hospitalization data for 1993 to 2008 obtained from New York State Department of Health, in relation to data on individuals living close to fuel-fired power plants. Through this data, they were able to estimate the number of people hospitalized for acute Respiratory

Infections (ARI), asthma and Chronic Obstructive Pulmonary Diseases (COPD). Their research however revealed 11%, 15% and 17% increase in the estimated rate of asthma, Acute Respiratory Infection and Chronic Obstructive Pulmonary Diseases respectively.

Similarly, Jade (2011) carried out a research in Ontario Canada by relating the environmental effects of diesel generated electricity with hybrid diesel-wind electricity for off-grid first nation communities in Ontario. His study revealed that Hybrid diesel-wind energy is a viable energy alternative for off-grid electricity production in seven first Nation communities in Ontario. According to him, the use of diesel fuel combustion engines bring about the increase in the cost of diesel fuel and at the same time increases the substantial environmental impacts associated with diesel fuel combustion. Through the use of Gabi software, the researcher compared the environmental impacts of the proposed hybrid diesel-wind system to the conventional diesel engines/systems and the result showed that hybrid diesel-wind can effectively moderate the total environmental effect produced by off grid diesel electric generating sets.

Bari and Kindzierski (2017), investigated the ambient concentrations, sources and potential human health risk of hazardous air pollutants (HAPs) / air toxics in the City of Edmonton (Canada) over a period of five years (i.e.2009-2013). They argued that the average concentrations of individual HAPs in the atmosphere in addition to volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and trace metals ranged from 0.04 to 1.73 mg/m3, 0.01 to 0.54 mg/m3, and 0.05 to 3.58 ng/m3 respectively. A cooperation of hazardous and non-hazardous threat of air pollutants were also compared with the level of risks endorsed by regulatory bodies. The use of positive matrix factorization aided the researchers in identifying six air toxics sources with road traffic contributing majorly to total HAPs (4.33 mg/m3, 42%), followed by background or secondary organic aerosol (SOA) (1.92 mg/m3, 25%) and burning of fossil fuel (0.92 mg/m3, 11%). In other words, local traffic was recognized as the main activity heightening the amount of HAPs as compared to background/SOA and fossil fuel burning especially on event days that aggravates air pollution. The researchers were also able to establish that the Hazardous risk values of traffic, background/SOA and metals industry emissions were above the United States Environmental Protection Agency's (USEPA) acceptable level. According to them, their findings would offer useful preliminary information on the current ambient air toxics levels, dominant sources and their potential risk to public health in the study area as well as support policy makers in the development of appropriate control strategies if need be.

Various studies have been undertaken in developing nations regarding noise and air pollution. In India, air pollution dispersion modelling for diesel generators was carried out at Jamie University Campus, New Delhi by (Brajmohan *et al*., 2018). The study was aimed at assessing the contribution of pollutants from diesel generators running at Jamia Millia Islamia University Campus. Industrial Source Complex Short Term (ISCST3) air dispersion model was used to stimulate air quality for a period of 24 hours taking into consideration the concentration of pollutants like SO_2 (Sulphur), NO_2 (Nitrogen), PM_{10} (Particulate Matter)and CO_2 (Carbon monoxide). Readings from the ISCST3 instrument were respectively given as Sulphur (SO_2) 58.4 μgm^3, Nitrogen (NO_2) 176.50 μgm^3, Particulate Matter (PM_{10}) 11.33 μgm^3 and carbon (CO_2) 57.02 μgm^3. After comparison with the National Ambient Air Quality Standards (NAAQS 2009), it became apparent that apart from particulate matter, quantities of the other mentioned toxic substances in the air were found to be below permissible standard. The researchers therefore recommended that proper environmental management plan in conjunction with mitigation measures such as water sprinklers and planting of trees around the industrial areas can reduce and at the same time protect the environment. They further recommended that instead of using forty generator sets of 8650KVA capacity, it would be better to install four generator sets with 250KVA capacity. This way, the concentration of the pollutants would be reduced by almost half of the former particulate matter (PM10) value.

Majumder (2018) evaluated the perception, knowledge, attitude and practices of traffic policemen in Bangladesh towards the physiological and psychological health effects of noise pollution they are exposed to. The researcher carried out a questionnaire survey which he purposely administered to 110 selected traffic policemen in Dhaka Metropolitan Police area. Findings revealed that 40.9% of the respondents fall between the age brackets of 20-24. A self-assessment of hearing ability of the policemen showed that 11.8% of the respondents sensed their ability to hear was lower than average, while 15.5% of the respondents however specified they often strain their ears and most times, miss portions of their conversations with someone on the phone. Similarly, 25.5% of the respondents reported similar case while having a conversation with people or someone in a noisy environment. 33.6% re-counted that while viewing television they regularly keep the sound louder to enable them hear properly. 08.2% of them have problems of inner ear disorder or Vertigo. They recommended that, awareness through education on the effects of noise pollution is most important for the traffic policemen.

Liu *et al*. (2018), equally studied the effects of air pollution in Beijing, China. According to the researchers, increase in economic and social development has contributed greatly to the air pollution and its resultant effect in China. Using the information obtained from the data base of China Health and Retirement Longitudinal Study (CHARLS), they were able to establish a hierarchical linear model combining pollution, socioeconomic and psychosocial variables to examine the effects of air pollution on public health in China. They argued that the relationship between health and its determinants varied greatly between Eastern and Central/Western China. More so, long term marriage, better life satisfaction, higher income and education were extensively connected to improved health status amongst Chinese as a result, and regional healthcare resources were positively tied to the health of residents. They further established that the interval of acceptable air quality was very important for enhancing public health and therefor recommended that emphasis should be on yet to come policies that will target mainly on how to increase the duration of good air quality while managing air pollution by regulating or lessening serious air pollution.

Rasheed *et al*. (2013), measured and analysed the air quality of Islamabad, Pakistan. The ambient air quality pollutants at Islamabad, Pakistan were categorised by the researchers from 2007-2011. The recorded result of the annual and hourly concentration of $PM_{2.5}$ and Nitrogen showed that the concentrations of the two pollutants were above the permissible limits stipulated by Pakistan's National Environmental Quality Standards (NEQS). They ascribed the major reason why the concentration of nitrogen was high in the study area to transportation. However, the average concentration of O_3 per hour also exceeded the NEQS especially during the summer with the exception of SO_2 and CO_2 which were always within the limits. It was also deduced that, the seasonal profile of O_3 concentration recorded the highest for photochemical production of O_3, while out of the four seasons, the winter has the minimum concentration of O_3

Back-trajectory analysis was then carried out by the researchers using the Hybrid-Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model, which was developed by the US National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL). Through this model, they discovered that for the period of summer months, significant source areas of trajectories reaching Islamabad were located at eastern Afghanistan and western India. While the source regions in the Indian states of Gujarat, Rajasthan, and Punjab (i.e., southeast of Islamabad) have high concentration of industries and mechanized farming that are sources of particulate and gaseous emissions. According to the researchers, their study would play a vital role for regulatory bodies as it will aid greatly in the conduction of monitoring and plan mitigation measures in order to improve the air quality of the city. Moreover, their data set would be of immense value to the urban, regional and global air quality modelling community.

In another research, Iqbal and Lodhi (2014), evaluated the average willingness to pay and be rewarded for the adverse health effects caused by noise from electric generating sets running outside marriage halls in Pakistan. According to the researchers, the electricity shortage in Pakistan has led the country to seek for other means of generating electricity hence the use of electric power generating sets which became a great phenomenon in the country. The noise pollution from the extensive use of generators has therefore disrupted the peace of many parts of the country. Their study was centred primarily on two residential areas of Lahore (Iqbal Town and Model Town) and two other Commercial areas (liberty market and hall road) situated within the city.

The contingent valuation survey method was employed in the course of the research. Questionnaires were filled by residents at the residential locations and shopkeepers from commercial locations. The results obtained from the use of regression model showed that the average willingness to be compensated for noise pollution from generating sets was greater than the average willingness to pay. Related results were gathered at the other hand as the average willingness to be compensated exceeded average willingness to pay if externality was internalized.

2.6.2 Case studies in other parts of Africa

Essandoh and Armah (2011), undertook a research titled determination of ambient noise levels in the main commercial areas of Cape Coast, Ghana. The aim of their study was to measure sound and obtain the perceptions of residents in selected neighbourhoods in the central commercial areas of Cape Coast, Ghana. Through the use of questionnaire, Global Positioning System (GPS) and sound level meter, they were able to establish that the level of sound pollution (LNP) at low-income residential areas stood at 58-68 dBA while that of high-income residential areas scored 53-72 dBA. In the same vein, they discovered that the range of traffic noise index TNI at low-income (high density) residential areas was in the space of 34-107 dBA, and that of high income density (low density) residential areas was within the range of 27-65 dBA. The latter according to their study simply portrays the disparity between the residents in the high density residential areas and the low density residential areas. More so, the calculated Mean Square Ratio (MSR) for level of noise pollution (LNP) at 90% confidence level was 65.02 while the tabulated value was 2.36. Correspondingly, the calculated MSR at the same confidence level for traffic noise index (TNI) was 6.23 while the tabulated value remained at 2.36.

Because the two calculated Mean Square Ratio (MSR) values were higher than the tabulated value, there was a significant difference ($p<0.05$) in the pollution level of noise and Traffic Noise Index (TNI) in the locations. They therefore established that if noise pollution in the study area is left unchecked by the regulatory authorities, it can lead to serious health risk to the residents. They further opined that discomfort and irritation resulting from toxic gasses can immensely reduce productivity in both private and public sectors.

Egondi *et al.* (2013), examined community perceptions of air pollution and its related health risks in Nairobi Slums. The aim of their research was to establish associations between perceived pollution and health risk perception among slum residents. A cross-sectional study of 5,317 individuals between the age of 35 years and above was conducted in two slums of Nairobi and association of perceived score and individual characteristics were then assessed through the use of linear regression model. Their study showed that the average perception level of air pollution level at Viwandani was higher amongst the residents as compared to those at Korogocho. Also the perceived health risk was positively associated with the perception of air pollution level. The researchers recommended the need for the creation of awareness programme on the sources of air pollution and their resultant health risks.

2.6.3 Case studies in Nigeria

In most community surveys, vibrations are normally seen as a complement to high sound and are observed to be a vital element in determining annoyance. Symptoms reported amongst industrial workers frequently exposed to noise and vibration includes nausea, headaches, anxiety and changes in mood (Yesufu, 2012).

Against this backdrop, Jibiri *et al.* (2015) carried out a research on noise and vibration that emanates from machines in Ibadan Metropolis (generators inclusive). He perceived the noise and vibration produced by generators as physical disturbances that can be harmful to humans if the body is exposed to them on a regular basis for a long period of time. His research therefore was aimed at assessing the Health effects of Noise and levels of vibration at the main Business Complexes and Markets in Ibadan Metropolis, Nigeria.

The researcher argued that there is much prevalence in the utilization of generating sets amongst generator users in the study area, thus, subjecting them to both vibration and noise induced health effects. According to him, these effects or damages done to human body lessens or diminishes with as one moves away from the generating sets due to damping effect. In order to arrest the problems of these effects on human body, he considered a Whole Body Vibration (WBV) and Hand-Arm Vibration (HAV). WBV occurs when the whole body is exposed to vibration either through contacts with the buttocks or feet and this can lead to low back pain and discomfort; whereas HAV refers to a situation where the hand/arm is exposed to vibration through contact, which can cause muscle aches and pains.

The researcher arrived at the above conclusion through the use of a calibrated vibration meter and a sound level meter as well as a semi-structured interviewer administered questionnaire to gather or collect data on users' perception of vibration, auditory and non-auditory health effects that are tied to exposure to vibration and noise.

He recommended that users of power generating sets should take safety measures such as wearing proper hearing protection devices (such as ear muffs, and formable ear plugs) to shield their ears from noise. He also recommended that workers should employ the use of anti-vibration hand gloves, rubber Mats and thick rubber sole shoes so as to reduce the vibration effects on humans. He also suggested the need for occupational health safety management to be carried out to avert serious health effects associated with generator usage. In order to improve users' awareness, there is the need to educate them on the effects of generator usage on their health i.e. (risk of noise to the ears; whole Body Vibration (WBV) and Hand Armed Vibration (HAV).

In another study, Olamijulo *et al.* (2016), undertook a study aimed at assessing the level of noise exposure to portable generators and its effects on human health. He chose the Faculty of Public Health at the University of Ibadan (UI), Oladele Ajose building, Nigeria as his study area because of the level of commercial activities and incessant usage of power generating sets in the area. He discussed that due to the erratic power supply in Nigeria coupled with increase in number of commercial outfits, there has been an increase in the usage of portable generators in institutional settings. The noise level was measured at six sample locations at Oladele Ajose building of UI by the researchers. They were able to obtain the much needed information in the study area via a semi structured questionnaire administered to staff and students. Also, with the aid of a calibrated AEMC sound meter, the average indoor and outdoor decibel level of 60.26±8.45dB and 58.15±4.53dB were respectively obtained by the researcher from the six sampled locations. The obtained result of 0.26±8.45dB and 58.15±4.53dB was found to exceed the World Health Organisation (WHO) guideline limits of 35dB and 55dB.

Having established that the occupants of Oladele Ajose Building are vulnerable to noise from electric power generating sets at levels above WHO permissible standard, he put forward the necessity for design of appropriate containment means that would help reduce the menace associated with the use of these generating sets. He further suggested that, substitute sources of energy like solar power, wind mill, hydro and biogas should be adopted to reduce the high demand of generating set to mitigate the impact on the environment.

Yesufu *et al*. (2013), based his study on the assessment of the Knowledge and Perception of noise health hazards that are related to generators in commercial district of Ibadan. A total number of 515 users were sampled within Agbowo and Ajibode Connunity with each accounting for 304 and 211 generating sets respectively. Information on perception and knowledge as well as socio demographic characteristics of the people were gathered through a pretested interviewer administered questionnaire. Majority of the respondents at Agbowo i.e. 82.9% and 86.7% at Ajibode commercial areas attested to the fact that the noise generated by the various generators in the study area can cause tinnitus but were not aware of the limit or set standard that can be detrimental to their health. The percentage of respondents with negative perception of noise at Agbowo stood at 51.3% while the proportion of residents with same perception (negative perception of noise) at Ajibode area recorded 82% respectively ($p<0.05$). Fewer respondents however, saw noise induced hearing impairment as a severe health problem compared to other health challenges. In the same vein, 80% of the respondents at Agbowo and 26% at Ajibode agreed that their workplaces are noisy ($p<0.05$) as a result, only 11.5% and 6.6% desired to change occupation. Data collected were fed into Microsoft Excel and then managed and analysed with the aid of Statistical Package for Social Sciences (SPSS) version 15. Analysis of the data was done with the aid of descriptive statistics, Chi-square test and logistic regression at 5% level of statistical significance. The researcher concluded by recommending that awareness programmes on the menace associated with the use of electric power generating sets should be intensified. He equally advocated on the need for access to steady power supply

Adenife & Samuel (2013), also carried out a similar study on the impacts of sound pollution from generating sets on inhabitants of Obantoko community, Nigeria. Their study however showed that electrical energy holds a top grade spot as far as energy hierarchy is concerned in Nigeria. This is because electrical energy has numerous uses at homes and other related places. A 43-item questionnaire was used to examine the health associated impacts of noise on residents of the study area. Considering the sex and age groups of residents, a total of 262 persons were sampled. Their findings revealed however that Obantoko residents are constantly exposed to generator noise thereby hampering the health status of the residents. Some of these health effects being experienced by the residents are tinnitus, adverse social behaviour and annoyance, impaired task performance, cardiovascular disturbances, sleep disturbances and interference with spoken communication. In response to the adverse effects of noise observed, the researchers emphasised on the need for urgent attention to be paid to Obantoko residence. It was submitted therefore that owners of power generating sets should implore the use of insulation made of strong materials with substantial mass and rigidity alongside acoustic building barriers to reduce the effect of noise pollution.

In another study, Oguntoke *et al.* (2012), assessed the noise emission from vibrator block factories and their diesel power plants (leister) as well as their impacts on the wellbeing of Abeokuta residents, Nigeria. Ten (10) random vibrator concrete block (VCB) factories and 10 residential areas were randomly selected at Odeda LGA of Abeokuta metropolis

Nigeria. In total, twenty (20) workers and twenty (20) residents were sampled. Daily noise dose (D) and the Time Weighted Average (TWA-8) of the exposed factory workers were calculated using the formula published by the U.S. Department of Health and Human Services which put allowable limit of daily noise dose (D) value at 100dBA. According to the U.S Department, any figure exceeding this becomes unsafe. On this basis measurements were taken at the selected factories. Apart from Kammy factory which stood at 100 dBA, all other factories were above the allowable limit. Ogo- Oluwa was 115dBA), Toluwalase (108) dBA and Jotas (108dBA). The effects of this phenomena on the workers' health consist of hearing disorder such as ringing ear (tinnitus) being experienced by (90%), impaired hearing (70%), speech interference (90%), stress to workers and residents (100% and 90%), headache (80 and85%), dizziness 90% and 75%). With the aid of linear regression model, attempt was made to predict the minimum buffer between Vibrator Concrete Block (VCB) and the nearest building.

The study recommended urgent intervention for sound control in VCB factory locations. Asides mandatory wearing of hearing protection, recommendations were also made to start up programmes that will create environmental awareness and educate VCB workers on the prevailing dangers associated with the usage of power plants. Also, appropriate agencies should see to the enforcement of 80m minimum buffer between VCB factories and the nearest residential house and VCB factories should be zoned out of residential areas in the long run.

Omubo-Pepple *et al*. (2010) studied the sources and effects of noise pollution in Port Harcourt Metropolis. In the course of their study, it was revealed that the major sources of noise pollution as given by a notable percentage of the inhabitants are from generators, road traffic, loudspeakers mainly from religious centres and social activity inclined places. This was achieved by personally interviewing more than two hundred (200) residents that cuts across different age groups, sex, geography, educational levels, and income levels across the residents of the study area. The researchers were able to establish that noise brings about direct and cumulative adverse effects that leads to health impairment and degradation of residential, social, working, and learning environments with corresponding real (economic) and intangible (well-being) losses. Their study also revealed that the numerous effects of noise include mental health and cardiovascular problems, negative social behaviours, annoyance, interference with communication, sleeplessness, reduction in efficiency, and obstacle to teaching and learning. The research however suggested Public education and awareness through government and NGO"s as the best method to tackle this menace**.**

Similarly, Otutu (2011) undertook a study on noise pollution inside the second Campus of Delta State University, Abraka. He made use of a type 2 model 1EC651 decibel meter to measure noise from generating sets situated at twenty two (22) different locations within the campus. The Noise measurements were however taken from 8.00am (during working hours) and from 4.30 pm (after working hours) respectively. Before the average and percentages were calculated, the noise recorded from each of the 22 locations were taken four times each at a period or interval of ten minutes. The results obtained showed that there is an average noise level of 87dBA on campus two (2) and it is mostly produced by the generators at the business centres due to frequent power outage.

In addition, noise from portable generators being used by offices during power outage and the voices of students and staff contribute greatly to the noise experienced in the environment. The study showed that academic work in terms of reading and learning, annoyance, task performance, sleep and conversations are all linked to noise pollution from these generator sets. A comparison of the outcome of his research (87 Dba average noise on campus 2) was compared with the exposure limits of 90dBA as recommended by both WHO and the Federal Environmental Protection Agency (FEPA). The result however prompted the researcher into making a recommendation for an urgent employment of control strategies in the study area by proposing that, Government should ensure the increase in the effectiveness of the services of Power Holding Company of Nigeria PLC (PHCN) as it will reduce the need for private power plants. Also, efforts should be made to have a centrally located generating set that will serve departmental offices, Faculties, Administrative and Bursary blocks as this according to the researcher will go a long way to reducing the noise from varying generating sets.

He also suggested that, business centres should be situated away from school premises, ear protector devices should be provided for students and workers whenever they are close to the noise sources and finally, national code of practice should be provided by the occupational health and safety commission in order to to effectively manage noise pollution in work places.

There are lots of research works on air pollution and its resultant effects on man and his environment. One of such works was carried out by Akin (2016). He looked at the environmental brutality of electric power generator usage in Ogbomoso, Nigeria. The researcher argued that the lack of electric power supply in Nigeria has led to the voluntary acquisition of generating sets by nearly every household and firms in Nigeria. This according to him is evident in the direct and indirect consequences of generator usage on the local and global environment. His research was therefore aimed at analysing the environmental consequences of electric power generator usage in relation to climate change. The study relied on primary and secondary data as well as the use of an online carbon footprint calculator to estimate the carbon and carbon dioxide emission from sampled generators.

However, the carbon footprint recorded in his study area scored very high as the daily annual carbon footprint mean stood at 0.455 while the mean annual footprint point of carbon for only generator usages and other household components scored 172.3 which was almost attaining 180 points. This high score indicates therefore that on the average in Nigeria, our lifestyle of constant use of electric power generating sets would require four earth sizes to be adequately sustainable. The researcher went further to suggest distance and green buffers as antidotes to the problems of electric generator use.

In another research, Adefeso *et al.* (2012), undertook a study on the environmental impacts of portable power generating sets on indoor air quality. According to their study, the increase in power demand and low generation capacity of the country has automatically increased the demands for alternative sources of electricity in homes and offices in Nigeria. The conventional means of generating off-grid power in Nigeria is via portable generators which contributes greatly to the release carbon mono oxide (CO).

Their research was predicated on determining the emission factors of carbon mono oxide (CO) from gasoline-powered portable generators (PPG), evaluate the effects of the CO influx on indoor air quality and to identify appropriate ways of maintaining the ambient concentrations below acceptable limit. Outdoor-indoor exchange of CO concentration was also determined by modelling a number of situations of portable generators that runs outdoor using simulation tool kit for Indoor Air Quality and Inhalation Exposure (IAQX) model. The source of carbon mono oxide (CO) concentration from Portable Power Generators was measured using EGA4 combustion analyser. Comparison with 10ppm standard was obtained and the result was found to be very high at 24.289 x 103 mg/m. The obtained CO emission factors were 2.2366 x103 kg/m3 of fuel consumed and 9.5411 x 106 kg/hr. of activity. The outcome therefore proved exchange of high air rate gives room for fast decay of CO concentrations while low air exchange rates contributes greatly to the accumulation of CO indoor. They recommended that a PPG should be stationed at least 10 meters away from the building.

Oguntoke and Adeyemi (2016) appraised the effect of generating sets emissions on air quality and human health in selected areas of Abeokuta city, Nigeria. According to their research, the unreliability of electricity from the grid has led to the utilization of varying models, sizes and capacities of portable electric generating sets in Nigeria. A total of eight (8) pollutants precisely methane, nitrogen dioxide, sulphur oxides, particulate matter (PM1, PM3), carbon monoxide, carbon dioxide and hydrogen sulphide were examined via portable samplers. Generator operators and nearby residents were given copies of questionnaire to fill in order to acquire substantial information.

The capacities of the sampled generating sets fall between 1 to 25KVA and concentrations of PM1 (4.7–219.2 mg/m3), PM3 (7.8–251.6 mg/m3), carbon dioxide (4.5–10.9%), carbon monoxide (141.1–4167.0 ppm), NOx (4.0–85.7 ppm), sulphur oxides (3.5–65.6 ppm) and hydrogen sulphide (0.0–0.7 ppm) were highest at generator sites. The distance of sample sites to generator locations accounted for 14–66% variation of pollutants levels. Ailments frequently suffered by the exposed residents included nasal congestion (66%), cough (33%), and headache (24%) and fever (12%). The study recommended that a well-articulated policy that will control the quality of generating sets, educate the citizenry on emission standards and mode of generator use is urgently required in Nigeria in order to curb the current environmental degradation and health concerns that are linked to impact of pollution from generators.

Ogunbayo (2016), also carried out a research on retrospective study of effects of air pollution on human health. His focus was based on how to identify air pollutants that are of health importance to humans, find their negative impacts on human health, and conduct retrospective studies to find out if there is a correlation between exposure to environmental air pollutants and hospital visits. According to him environmental air pollution poses a serious challenge to human health and the effects mostly result in cancer, respiratory and cardiovascular diseases. He was able to establish the latter by collecting and analysing hospital case files of 229 patients from 1st February 2016, to 22nd March 2016. The data collected include hospital file number, sex, diagnosis, comorbidity, month of the last hospital visit, positive family history of the diseases, occupation, working in environment with toxic substances, exposure to toxic substances at workplace, smoking, years of smoking, and number of packets of cigarette per day. All of these information were obtained in accordance with the ethical committee of the hospitals.

The Pearson correlation coefficients shows the relationship between the exposures to environmental air pollutants against over-all hospital visit was found to be 0.99 which shows a strong correlation. Also the P value of 0.004 ($p<0.05$) also showed that exposure to environmental air pollutant has a significant effect on the total hospital visits due to symptoms of illness at the confident interval of 95%. The findings justified that exposure to air pollution truly has serious effects on human health.

2.7 Summary of Reviewed Case Studies

One of the major concerns threatening the existence of life today is the rapid increase of greenhouse gasses. Exposure to these gasses has led to several environmental and public health concerns. In view of these, lots of studies have been undertaken in the area of noise and air pollution with reference to their impacts on health and the general environment. In the developed nations, renewable energy sources such as solar, photovoltaic (PV), wind, hydroelectric, geothermal and biomass are often used in place of non-renewable energy sources like the consumption of fossil fuels, coal and natural gases. These nations are however not completely free from the use of conventional power generating sets that make use of fossil fuels. Studies have equally shown that the major pollutants across the globe that pose serious danger to human health and the general environment are particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen oxides (NO_2), carbon mono oxide (CO), ozone (O_3) and sulphur dioxide (SO_2). Continuous exposure to these pollutants can be detrimental to human health and may sometimes result to death.

Reviews have also shown that the effects of power generator usage are more in the developing nations because of the persistent lack of electricity supply and consistent use of electric power generators of varying sizes and capacities. Through the use of decibel meters and air emission measuring instruments, the impacts of these generator sets on the environment were measured and comparisons with international and national standards were made. In the same vein, different relevant models in relation to air and noise studies were employed by the researchers to enable them predict and ascertain the actual damage or harm being inflicted on the environment by these generators.

2.8 Gap in Literature

From the above reviewed literatures, several studies have been undertaken to expound the effects of noise and various atmospheric pollutants on the environment. Most of these studies however looked at the effects of these pollutants on their immediate environment with little consideration for terrain impacts. This study therefore seeks to employ the Kriging spatial interpolation method to show the dispersion of noise, carbon monoxide (CO), particulate matter ($PM_{2.5}$) and sulphur dioxide (SO_2) emission within 300 metres radius.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

Research methodology is the basic plan that guides the collection and analysis phase of research. This chapter therefore discuss issues such as research design, sources and methods of data collection, sample frame (population) and sample size of the study, techniques of sampling as well as methods of data analysis and presentation.

3.1 Research Design

This research employs the use of qualitative and quantitative data. Qualitative data were sourced for using structured questionnaire and interview guide. Quantitative aspect of the data acquired include the use of a hand held GPS, MSA Altair 5X multi-gas detector, MSA Altair pro single gas detector, PCE-RCM 05 Air Quality meter and ATP 901A Sound Level Meter.

Table 3.1: Methods of data analysis and data presentations

S/N	OBJECTIVES	DATA REQUIRED	SOURCE OF DATA	METHOD OF DATA ANALYSIS	METHOD OF DATA PRESENTATION
1.	Examine the various land use compatibility in the study area.	-Various land uses -compatibility of the various uses.	Satellite imagery and observation(Discreet and participatory observations)	- Digitization - Land use colour	Tables and Maps
2.	Assess the operational system and power usage in the study area.	- Sources of power supply. - Data on generator sets, models and capacities(KVA)	Primary and Secondary sources. Questionnaire	Descriptive Statistics (SPSS)	Tables
3.	Examine workers and residents perception of the GSM Village activities on their environment.	-Noise and gaseous emission from the generating sets	Questionnaire	Descriptive Statistics (SPSS)	Tables
4.	Assess the decibel level, concentration CO, SO_2 and $PM_{2.5}$ in the study area.	-Noise from generator sets -Gaseous emissions(CO, SO_2 and $PM_{2.5}$)	-Garmin 60 handheld GPS. - 901A sound level - Altair 5x multi gas meter, PCE-RCM 05 meter and MSA Altair pro gas Detector	Ordinary Kriging spatial interpolation model.	Tables and maps

Source: Author's Field Survey (2019)

3.2 Sources of Data

The much needed information for this study were obtained via primary and secondary data. The primary data includes names of the GSM Villages, time of arrival, closing time, number of shops, effects of generator sets on the environment, noise and gaseous emission readings were all sourced primarily while Secondary data were obtained from Journals, text books World Health Organisation (WHO), Federal Ministry of Environment (FME) and National Environmental Standard and Regulation Agency (NESRA) permissible standard for noise and gaseous emission as well as the extraction of study area imageries from Google earth.

3.2.1 Primary data collection

Primary data refers to the first hand data/information collected by the researcher from the field or area under study. These data were gathered through the structured questionnaire, interview guide and observations (discreet and participatory). Data on emission and noise from loud speakers and generator sets were obtained using AMS Altair 5x Multi gas Detector and ATP 901A Sound level meter.

3.2.2 Secondary data

Secondary data for this research were obtained via Satellite imageries downloaded using Terra incognita software in order to have a clearer image of the study area. Data on land use compatibility were sourced from Google earth imagery and digitized in order to identify the various land uses in the study area.

Data on power usage in the study area were collected from Abuja Electricity Distribution Company (AEDC) branch office situated at wharf Road Lokoja-Kogi State. Data on permissible noise level and emission were obtained from NESREA, Federal Ministry of

Environment and World Health Organisation (WHO) Guidelines. Other materials relevant to this study were sourced from the University Library, Journals and Internet.

3.3 Instruments for Data Collection

The data for this study were collected using structured questionnaire, hand held GPS, android phone (pouvoire 3 air), interview guide, ATP 901A Sound Meter, MSA Altair Multi Gas Detector, PCE-RCM 05 Air quality meter and Altair pro single gas detector.

3.3.1 Structured questionnaire

A mixture of opened and closed ended questionnaires were used to acquire the needed information for this study.

3.3.2. Hand held GPS and pouvoire 3 air android phone

Plate VIII shows Germin 60 Geographical Positioning System device that was used to locate and record sample points at Ganaja, Kpata and Cantonment GSM Villages. The camera of Pouvoire 3 air Android phone was used to snap the three GSM Villages and the generating sets in the study area. See plate IX.

Plate VIII Garmin 60 GPS
Source: NESREA (2019)

Plate IX Pouvoire 3 air Android phone
Source: Author's (2019)

3.3.3 ATP 901A sound meter, MSA altair multi gas detector, PCE-RCM 05 air quality meter and altair pro single gas detector

ATP 901A Sound Meter was used to take and record noise readings at the different sample locations in the study area while MSA Altair 5X Multi gas Detector, PCE-RCM 05 and MSA Altair pro single gas detector are portable hand held devices that were used to monitor carbon monoxide (CO), sulphur(SO_2) and particulate matter ($PM_{2.5}$) in the study area.. MSA Altair 5X Multi gas Detector has a maximum of four sensors which can display readings for carbon monoxide (CO), Hydrogen Sulphide (H_2S), Oxygen and 2 combustible gases including Pentane. PCE-RCM 05 Air quality meter measures $PM_{2.5}$, Humidity and temperature while MSA Altair pro single gas detector measures only sulphur dioxide acid. See plate X, XI, XII and XIII.

Plate X: ATP 901A Sound Meter
Source: NESREA (2019)

Plate XI: MSA Altair Multi Gas Detector
Source: Chuks (2019)

Plate XII: PCE-RCM 05 Air quality meter
Source: FMEnV (2020)

Plate XIII: MSA Altair pro single gas detector
Source: FMEnV (2020)

3.4 Research Population

According to the National population Census (NPC) of 2006, the population figure of Lokoja is 195,261 but the study is limited to the three GSM Villages with each having a buffer of 300m. For this reason, the population of this study was determined by counting the buildings within the 300m service radius of the three GSM Villages at Ganaja Area, Cantonment and Kpata respectively and the building count was done with the aid of Google Earth imagery. The two GSM Villages at Kapta and Cantonment however overlapped each other due to their proximately (see figure 3.1) and as a result, the central place between the two locations was determined using Walter Crystaller's Central Place Theory and a three hundred meter service radius was used to represent the area coverage for the two locations as shown in appendix H. The population of the two locations was therefore obtained by merging the two GSM villages in order to avoid counting one building twice.

Figure 3.1: Satellite imagery showing locations of the three GSM Villages at Lokoja
Source: Google Earth Satellite Imagery (2019)

The total numbers of buildings obtained at the three locations of the study areas were 256 for Ganaja while Kpata and Cantonment totalled 502. Multiplying each of the figures obtained by the national household size of 6 gave 1,536 for Ganaja, while Kpata and Cantonment stood at 3,012. The addition of the figures obtained from the three locations earlier mentioned equalled 4,548 which formed the sample frame for this study. Figure 2.4 shows the location of the three GSM Villages and their buffers.

3.4.1 Sampling size

Sample size is simply referred to as a part of the population under study that is chosen for a survey or experiment. The sample size for this study was determined using Krejcie and Morgan tabulation approach (2006) as shown in appendix F. Adopting 95% confidence level and 5.0% margin error from the above table the sample population of 4,548 falls between 346 population size. In order to make provision for error that may arise in the process, 10% of the sample size i.e. 34.6 was added to the initial sample size figure thereby making the sample size 380.6. The sample size for this study therefore is approximately 381.

The number of questionnaires administered at Ganaja GSM Village was obtained by dividing the sample population figure of Ganaja 1,536 by the total population size of the three GSM Villages (4,548) and multiplied by sample size (381) as shown

$$\frac{1,536}{4,548} \times 381 = 129$$

In the same vein, the total number of questionnaires administered at Kpata and Cantonment, were obtained by dividing the sample population of Cantonment and Kpata

(3,012) by the total population size of the three villages (4,548) and multiplied by the sample size (393) as shown

$\frac{3,012}{4,548} \times 381 = 252$

The total number of questionnaires administered at Ganaja, Kpata and Cantonment equalled 381 with Ganaja accounting for 129 while Cantonment and Kpata equalled 252.

3.4.2 Sampling technique

The study area was delineated into clusters using the street pattern and Random Sampling method was adopted during the administration of questionnaires. The number of administered questionnaires in the study areas were determined with respect to the density of each of the clusters. There are six defined clusters in Ganaja and five at Kpata and Cantonment, see table 3.2 and 3.3 respectively.

Table 3.2: Distribution of questionnaire amongst the clusters in Ganaja

S/N	clusters	Population Per cluster	Number of questionnaires administered per cluster
1.	A	204	17
2.	B	340	28
3.	C	196	17
4.	D	296	25
5.	E	186	16
6.	F	314	26
Total		1,536	129

Source: Author's Field work (2019)

Table 3.3 Distribution of questionnaire amongst the clusters in Kpata and Cantonment

S/N	clusters	Population Per cluster	Number of questionnaires administered per cluster
1.	A	632	53
2.	B	348	29
3.	C	584	49
4.	D	628	53
5.	E	820	68
	Total	**3,012**	**252**

Source: Author's Field work (2019)

3.5 Noise and Gaseous Emission Sample Locations

With the aid of a handheld GPS and the acquired Google Earth Images of the study area, sample locations were established by moving ten points North, West, South and East (four cardinal points). Readings were taken at an interval of 30 meters following the direction of the four cardinal points i.e. 30m, 60m, 90m, 120m, 150m, 180m, 210m, 240m, 270m, and 300m to the North, West, South and Eastern axis of the study area in order to examine the extent of noise and concentrations of carbon monoxide, sulphur dioxide and particulate matter 2.5 in the villages and their surrounding environment. Figure 3.2 and 3.3 shows the sample location points at Ganaja, Kpata and Cantonment respectively.

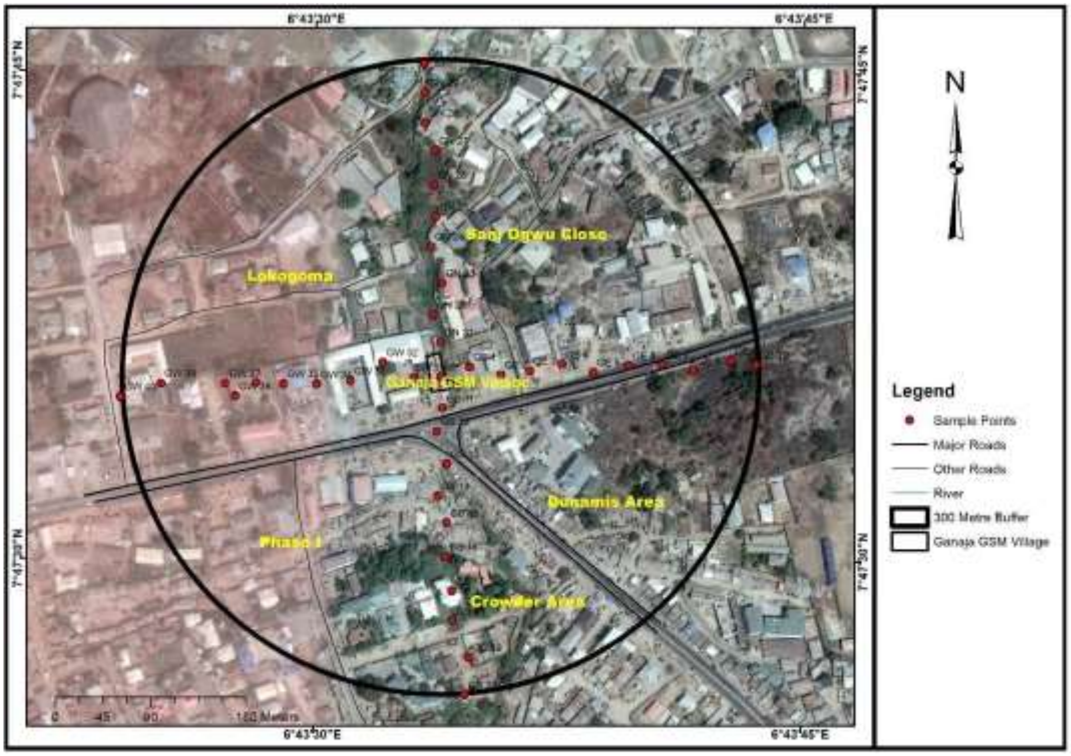


Figure 3.2: Ganaja Village Sample Locations
Source: Author's Field Survey (2019)

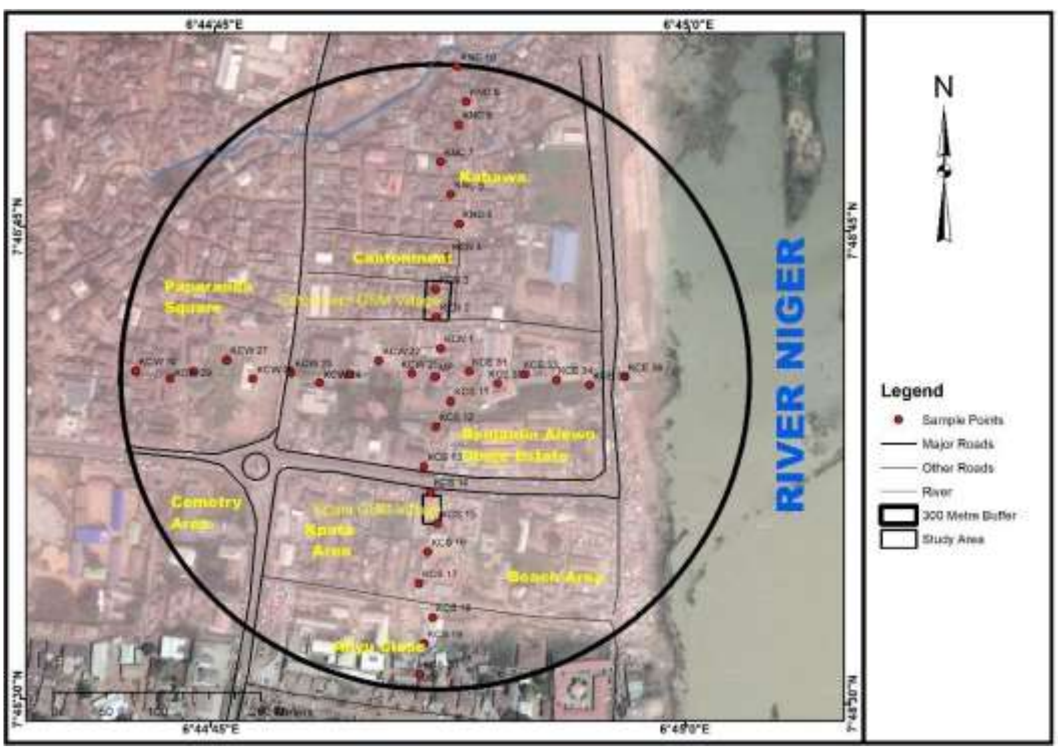


Figure 3.3: Kpata and Cantonment GSM Village Sample Locations
Source: Author's Field Survey (2019)

3.6 Methods of Data Analysis

The data collected were analysed using Statistical Package for Social Sciences (SPSS), on-screen image interpretation Kriging model symbology (ArcGIS) software. Comparative analysis was also used to show comparisons of noise and air quality levels with regulatory bodies like WHO, FMEnv and NESREA.

3.7 Methods of Data Presentation

Maps, tables and plates were used to show results of readings/measurements obtained from the field.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Land Use Compatibility in the Study Area

This section identifies and examines the existing land uses in Ganaja, Kpata and Cantonment areas. Table 4.1 shows that residential land use covers about 72.3% of the total land uses in Ganaja area. This is followed by commercial land use which accounts for about 24.2% of the total area while the rest of the uses are mixed and public uses with each occupying 2.3%, and 1.2% respectively

Table 4.1: Various land uses in Ganaja

Land Uses	Number of Buildings	Area Coverage (m^2)	Percentage (%)
Residential	185	83,250	72.3
Commercial	62	55,800	24.2
Mixed Use	6	5,400	2.3
Public	3	3,850	1.2
Total	**256**	**148,300**	**100**

The study also revealed in Table 4.2 that residential land use covers about 82.1% of the total land uses in Kpata and Cantonment areas. This is followed by commercial land use which accounts for about 12.7% of the total area while the rest of the land uses are dominated by mixed and public uses with each taking about 4.4% and 0.8% respectively.

Table 4.2: Various land uses in Kpata and Cantonment

Land Uses	Number of Buildings	Area Coverage (m^2)	Percentage (%)
Residential	412	309,000	82.1
Commercial	64	62,400	12.7
Mixed Use	22	19,800	4.4
Public	4	12,450	0.8
Total	**502**	**403,650**	**100**

Figure 4.1 and 4.2 shows the graphical representation of the digitized building foot prints and land use map of Ganaja area with colour red, yellow, dark brown and light brown representing commercial, public, residential and mixed uses respectively.

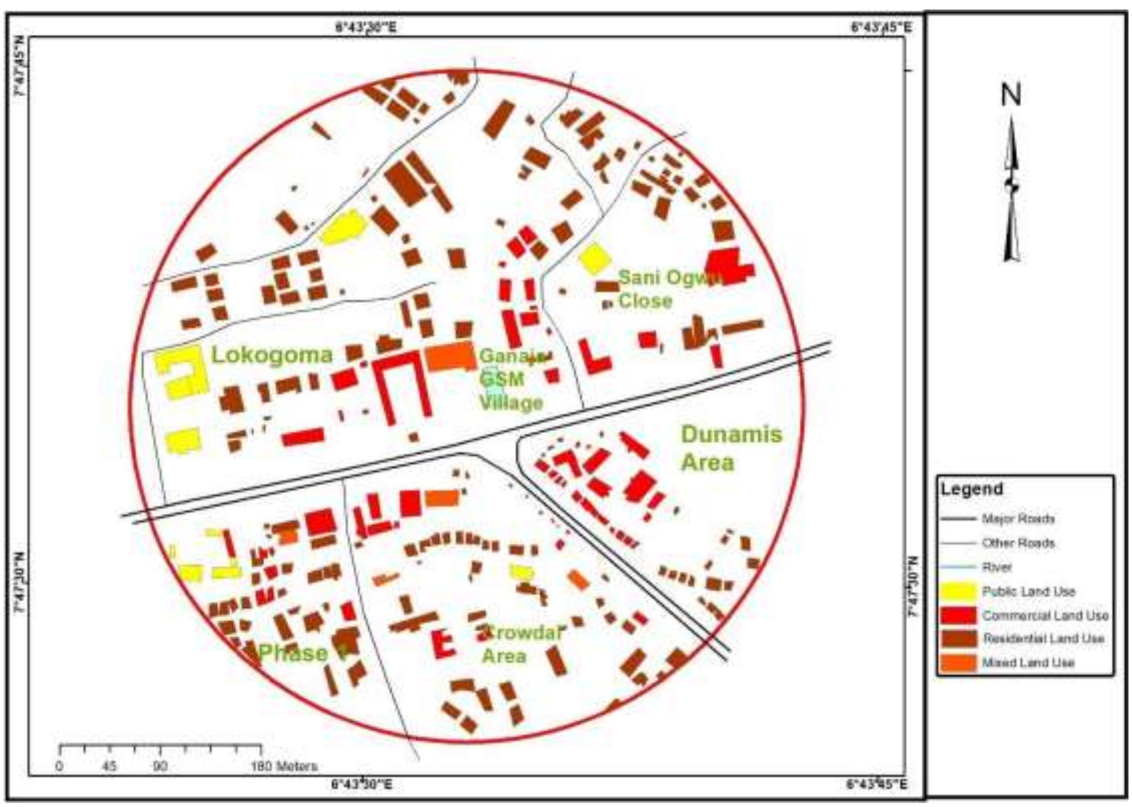


Figure 4.1 Digitized building footprints at Ganaja area
Source: Author’s Field Survey (2019)

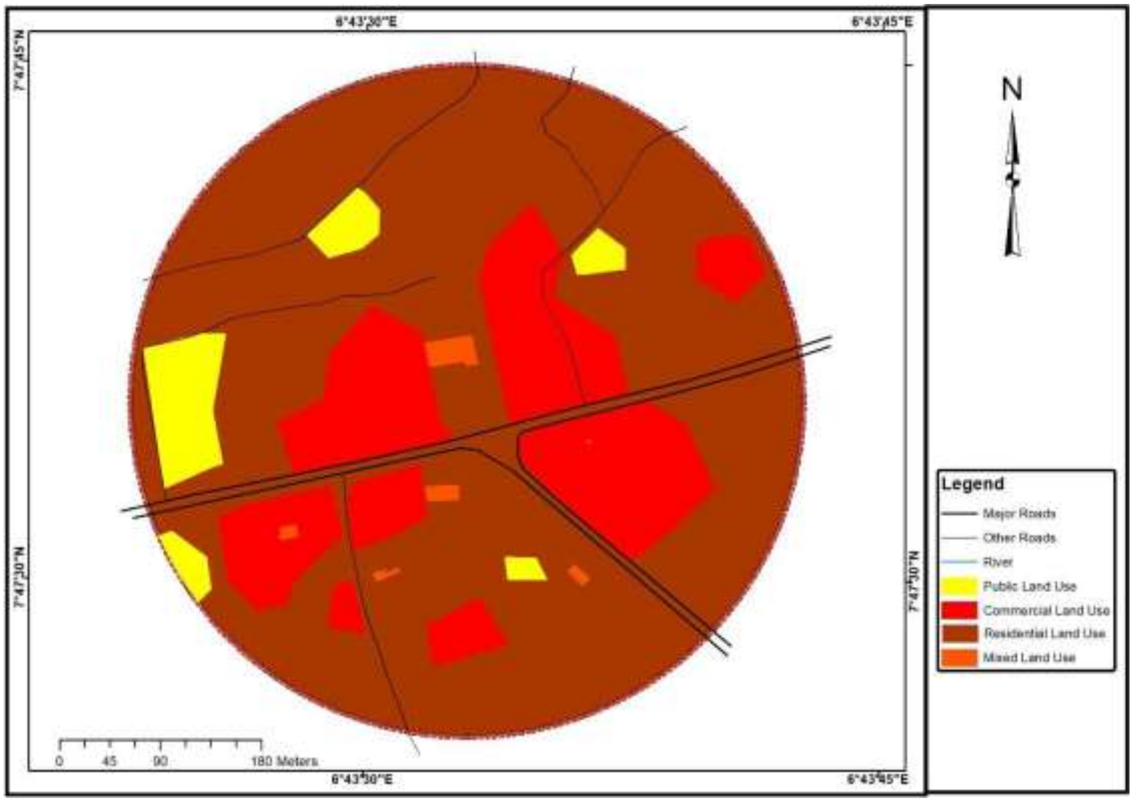


Figure 4.2: Land Uses in Ganaja Area
Source: Author's Field Survey (2019)

Four (4) land uses were identified in these areas and they include commercial, mixed, public and residential uses. Commercial land uses are represented by red while mixed, public and residential uses are represented by light brown, yellow and dark brown respectively. Figure 4.3 and 4.4 represents the digitized building footprints and land use map of Kpata and Cantonment GSM Villages.

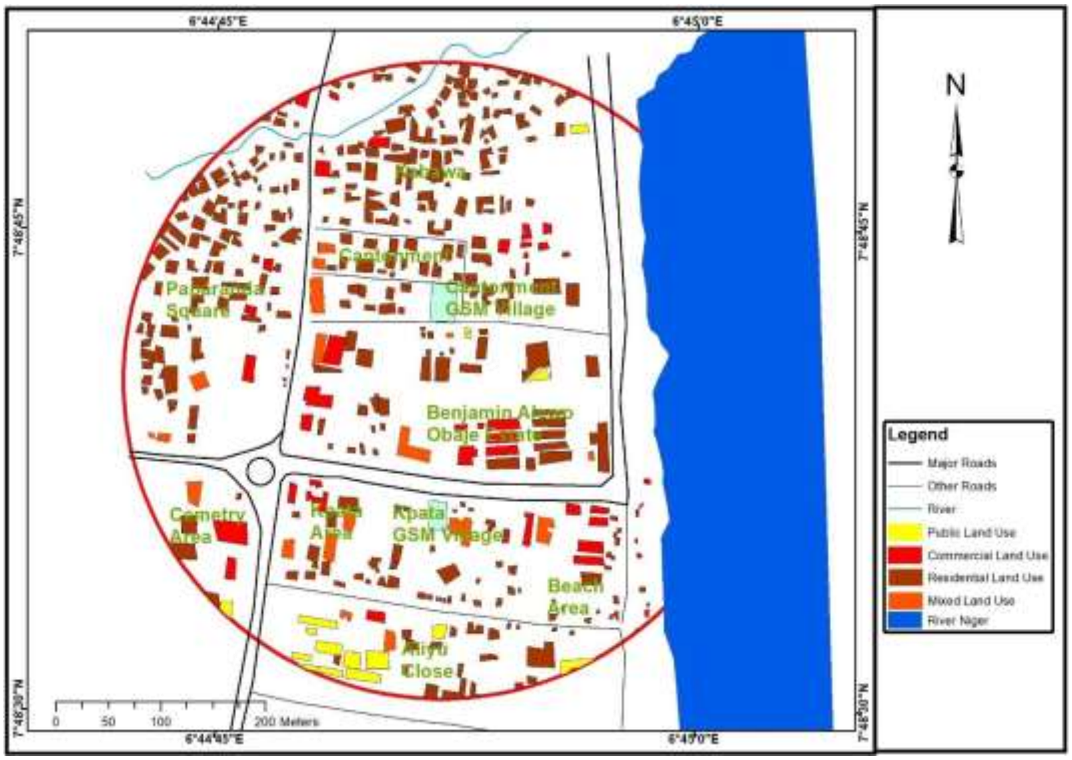


Figure 4.3: Digitized Building Footprints at Kpata and Cantonment
Source: Author's field survey (2019)

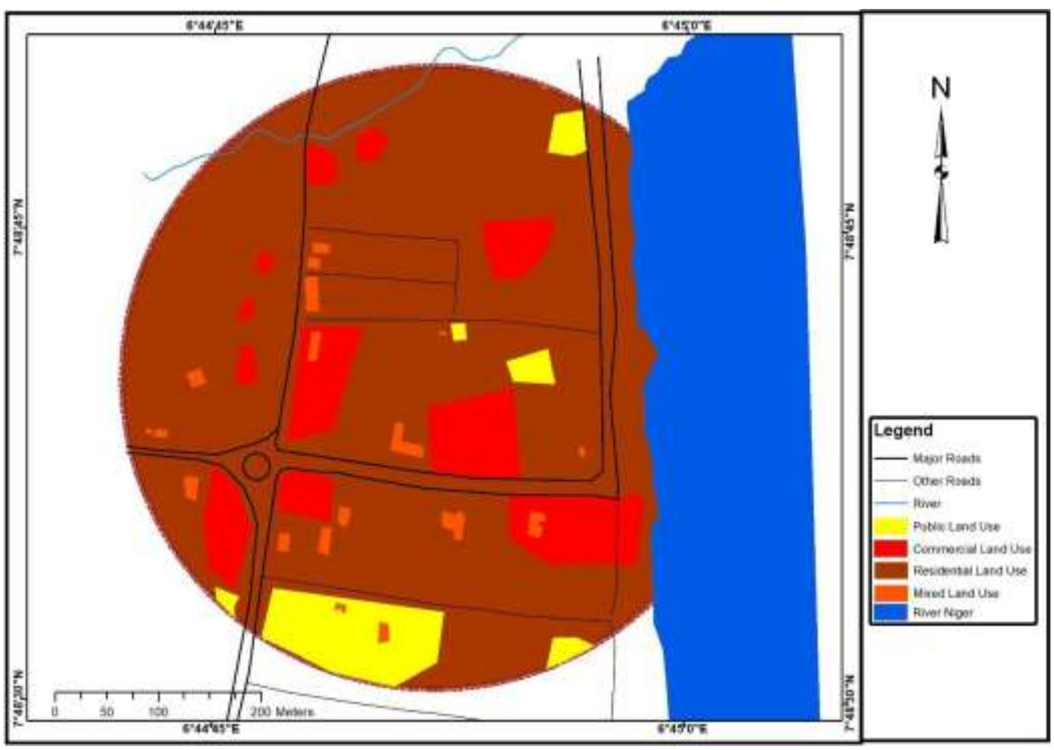


Figure 4.4: Land Uses in Kpata and Cantonment
Source: Author's field survey (2019)

The various uses as revealed in the digitized images of the study area has shown that commercial uses interfere greatly with residential units. This implies that little or no reference was made to predetermine planning standards as setbacks were not duly observed especially at Kpata and Cantonment. Consequently, the problems of pollution emanating from the study area tends to be more pronounced on the residents living close to the study area.

The decibel level of sound in a mixed land use area (i.e. Residential, Commercial and Entertainment) as stipulated by the National Environmental Standards and Regulations Enforcement Agency (NESREA), World Health Organisation (WHO) and Federal Ministry of Environment (FME) must not exceed 55db, 70db and 55db respectively during the day. However the decibel levels recorded during power outage in Ganaja at 30 metres and 90m towards the southern part of the study area scored 90.4 and 82.6db which were far above the values obtained from other commercial out fits in the study area.

Findings also revealed that, the decibel level of noise at Kpata and Cantonment area during power outage were above these stipulated limits of 92.4 db was recorded as far as 90m away towards the southern part of the GSM Village. In the same vein, the concentration of all the gaseous parameters measured in and around the GSM Villages were found to be more in the atmosphere during power outage compared to when there is electricity supply in the study area. This development has therefore shown that the GSM Villages contribute greatly to the noise and concentration of measured pollutants in the study area.

4.2 Operational System and Power Usage in the GSM Villages

The activities of the study area comprise of the repairs and sales of handsets, sales of phone accessories, bluetooth device, airtime, phone swaps, sales of laptops, tablets and other internet enabled devices, It as well covers the operational time (resumption and closing time of workers), utilisation of electricity to power phone repair tools and other gadgets such as soldering iron, wall fan, ceiling fan, energy saving bulbs, phone chargers and hot air blower. Ganaja, Kpata and Cantonment GSM Villages consist of 58, 80 and 180 shops respectively. Findings however revealed that work at the GSM Villages starts by 7am and closes by 6pm daily with the exception of Sundays. Findings also showed that the study area makes use of power from the national grid from 6am to 11am as at the time the research was conducted. Invariably, the workers enjoy supply from the grid for 4 hours since work normally resumes by 7am daily.

Majority of the respondents at Ganaja (64.3%), Kpata (70.1%) and Cantonment (66.5%) commence work within the period of 8-8:59 am. Despite the difference in location, workers resume at the same time in the GSM Villages, and this means that most of the generating sets at the time of commencement of work will be off owing to the fact that there is electricity supply in the village. This implies that noise and gaseous emissions from the power generating sets is experienced for 7 hours or thereabout starting from 11am-6pm as indicated in Table 4.3.

Table 4.3 Operational Time

Ganaja			Kpata			Cantonment		
Time	**workers**	**%**	**Time**	**workers**	**%**	**Time**	**workers**	**%**
7-7:59am	17	30.4	**7-7:59am**	18	23.4	**7-7:59am**	47	26.7
8:8:59am	36	64.3	**8-8:59am**	54	70.1	**8-8:59am**	117	66.5
9:9:59am	3	5.4	**9-9:59am**	5	6.5	**9-9:59am**	12	6.8
Total	**56**	**100%**	**Total**	**77**	**100%**	**Total**	**176**	**100%**

4.3 Categories of Power Generating Sets in the Study Area

Table 4.4 shows the types, models and capacities of the electric power generating sets used in the study area. The findings revealed that the workers at the three GSM Villages use Tiger, Firman, Elopaq, Honda, Tigmax, Senwei and Thermocool products to sustain their businesses during power outage. 41% of the shop owners use firman products at Ganaja GSM Village with Firman 1.1, 1.5, 1.8 and 2.2KVA accounting for 14.3%, 8.9%, 10.7% and 7.1% respectively. This is followed closely by tiger (26.8%) and Elopaq (21.4%) products at Ganaja GSM Village with Tiger TG 950, TG 2700, TG 3700 and EPN 4000 taking 8.9%, 5.4%, 7.1% and 5.4% respectively. In the same vein, majority of the shop owners at Kpata (41.5%) use firman while 31.2% and 13% use Tiger and Elopaq products. The rest are Honda (6.5%) and Tigmax (7.8) Unlike Ganaja and Kpata, majority of the workers at Cantonment 42%, 29.5% and 16.5% employ the use of Tiger, Firman and Elopaq products to sustain their businesses during power outage. This implies that majority of the pollution (gaseous and sound) experienced in the study area stems mainly from Firman, Tiger and Elopaq products of power generating sets.

Table 4.4 Categories of power generating sets in the study area

	Ganaja				Kpata				Cantonment		
KVA	**Model**	Freq.	Decibel	**KVA**	**Model**	Freq.	Decibel	**KVA**	**Model**	Freq.	Decibel
Tiger 0.7	**TG 950**	5	84.6	**Tiger 0.7**	**TG 950**	11	100.4	**Tiger 0.7**	**TG 950**	32	109.2
Tiger 2	**TG 2700**	3	70.8	**Tiger 2**	**TG 2700**	6	78.8	**Tiger 2**	**TG 2700**	18	101.4
Tiger 2.5	**TG 3700**	4	74.2	**Tiger 2.5**	**TG 3700**	3	58.2	**Tiger 2.5**	**TG 3700**	14	98.2
Tiger 2.5	**EPN 4000**	3	68.4	**Tiger 2.5**	**EPN 4000**	4	60.4	**Tiger 2.5**	**EPN 4000**	10	86.5
Thermo cool 2.5	**TEC 2500**	4	76.2	**Tigmax1.8**	**TH6800D**	6	72.6	**Thermo cool 2.5**	**TEC 2500**	8	78.8
Senwei 1.8	**ECO 2020S**	2	65.8	**Honda 2**	GX 160	5	70.4	**Honda 2**	GX 160	7	74
Elepaq 1.3	**SV3200**	5	78.5	**Elepaq 1.3**	**SV3200**	7	82.2	**Tigmax1.8**	**TH6800D**	6	68.2
Elepaq 3.5	**EC5800CX**	5	82.7	**Elepaq 3.5**	**EC5800CX**	2	68.5	**Elepaq 1.3**	**SV3200**	16	104.2
Elepaq 4.5	**SV 7200 E2**	2	66.2	**Elepaq 4.5**	**SV 7200 E2**	1	65.2	**Elepaq 3.5**	**EC5800CX**	10	88.4
Firman 1.1	**SPG 1800**	8	102.8	**Firman 1.1**	**SPG 1800**	10	98.4	**Elepaq 4.5**	**SV 7200 E2**	3	68
Firman 1.5	**SPG 1800**	5	85.6	**Firman 1.5**	**SPG 1800**	12	102.8	**Firman 1.1**	**SPG 1800**	14	92.3
Firman 1.8	**SPG 2200**	6	79.8	**Firman 1.8**	**SPG 2200**	8	79.2	**Firman 1.5**	**SPG 1800**	20	106
Firman 2.2	**SPG 2900**	4	72.4	**Firman 2.2**	**SPG 2900**	2	62.8	**Firman 1.8**	**SPG 2200**	18	96.2
Total		56	100	**Total**		77	100	**Total**		176	100

4.4 Perceived Effects of Generator usage by workers of the GSM Villages

Findings revealed that the workers perception of the activities in the GSM Villages varies across the three locations under study. Table 4.5 shows that 32.1%, 26% and 29% of the workers at Ganaja, Kpata and Cantonment GSM Village complained of headache during operation while 21.4% (Ganaja), 20.8% (Kpata) and 25% (Cantonment) experience restlessness during operation. In the same vein, 42.9%, of the workers at Ganaja, 46.8% (Kpata) and 40% (Cantonment) respectively experience annoyance while low percentage of the workers i.e. 3.6 % (Ganaja), 6.5% (Kpata) and 6.3% (Cantonment) experience itchy eyes and running nose.

Table 4.5: Worker's perception of GSM village activities

Worker's perception of Ganaja GSM Village		Worker's perception of Kpata GSM Village		Worker's perception of Cantonement GSM Village		
Ailments	**Workers**	**%**	**workers**	**%**	**workers**	**%**
Headache	18	32.1	20	26	51	29
Restlessness	12	21.4	16	20.8	44	25
Annoyance	24	42.9	36	46.8	70	40
Itchy eyes and running nose	2	3.6	5	6.5	11	6.3
Total	**56**	**100.0**	**77**	**100**	**176**	**100**

4.5 Perceived Effects of Generator usage by residents outside the GSM Villages

Table 4.6 revealed that 43.5% of the respondents in Ganaja area and 40.7% at Kpata and Cantonment area are affected by sound pollution emanating from the electric power generating sets in the village while 4% of the respondents in Ganaja and 6.1% of respondents at Kpata and Cantonment are affected by the gasses from the generating sets.

The residents of these GSM Villages are therefore more concerned with the sound pollution from the generating sets than the toxic gasses.

Table 4.6 Residents perception of GSM village activities

	Perceived effects at Ganaja GSM Village		Perceived effects at kpata and cantonment GSM Village	
Pollutants	**Respondents**	**%**	**Respondents**	**%**
Noise	54	43.5	101	40.7
Toxic Gasses	5	4.0	15	6.1
No effect	65	52.5	132	53.2
Total	124	100	248	100.0

4.6 Health Opinion Survey

Table 4.7 shows that 14.5% of the respondents in Ganaja area experience headache due to the unwanted noise from the GSM Village, 16.1% reported sleeplessness while the generating sets are working, 20.2% complained of being annoyed as a result of noise, 2.4% experience itchy eyes and running nose resulting from the gasses being inhaled while 46.8% are not affected by the noise and gaseous emission emanating from the village.

The study shows that 17.7% of the respondents at Kpata and Cantonment suffers from headache due to the sound from the generating sets, 15.3% complained of not being able to sleep, 25% are annoyed by the sound pollution emanating from the electric power generating sets in the GSM Village, 2.5% of the respondents reported that they are affected by the gasses from the generating sets while 39.5% said they are not affected by the activities in the village.

Table 4.7 Health opinion survey of GSM village activities on the residents of Ganaja, Kpata and Cantonment

	Perceived Effects of GSM Village activities on Ganaja Residents		perceived effects of GSM Village activities on Kpata and Cantonment Residents	
Ailments	Frequency	%	Frequency	%
Headache	18	14.5	44	17.7
Sleeplessness	20	16.1	38	15.3
Annoyance	25	20.2	62	25.0
Itchy eyes and running nose	3	2.4	6	2.5
No effect	58	46.8	98	39.5
Total	124	100.0	248	100.0

4.7 Concentration of Measured Air Pollutants in the Study Area

Table 4.8 shows the coordinates of sample locations, decibel level, concentrations of Particulate Matter 2.5, carbon monoxide and sulphur dioxide at Ganaja GSM Village. The first readings were taken at the midpoint (MP) of the study area and the result showed that all of the above mentioned gasses including noise were above permissible limit as compared to FMEvns reference standard with $PM_{2.5}$ recording 262 µg/m3, while CO, SO_2 and noise recorded 14.4, 0.15ppm, and 90.8dB. Subsequent readings also revealed that, $PM_{2.5}$ (250µg/m3), CO (11.4ppm), SO_2 (0.11ppm) and decibel level (70.2dB) were all high at 150m east, 240m south, 270m north and 240m west respectively. The high concentrations of $PM_{2.5}$, carbon monoxide and Sulphur dioxide that were recorded far away from the village, could be attributed to wind direction and other fossil fuel burning related activities in the study area.

The decibel level of sound at Kpata and Cantonment GSM Village (102.4) however surpassed that of Ganaja Village by 11.6db. This could be as a result of the large number of generating sets at Kpata and Cantonment compared to Ganaja GSM Village.

Table 4.8 shows the various sample locations, coordinates and readings of $PM_{2.5}$, CO and SO_2 in Ganaja area

Sample Codes	Interval	Easting	Northing	$PM_{2.5}$	CO	SO_2	Noise Level (dBA)
MP	0	6.726152	7.793234	262	14.4	0.15	90.8
G.N1	30	6.726152	7.793529	188	12.4	0.08	74.2
G.N2	60	6.726085	7.793766	255	9.6	0.12	54.6
G.N3	90	6.726161	7.794033	156	2	0	68
G.N4	120	6.726066	7.794347	84	4.8	0.1	70.5
G.N5	150	6.726104	7.794604	38	0	0.01	32.4
G.N6	180	6.726085	7.794871	12	18	0.05	18.2
G.N7	210	6.726095	7.795166	0	0	0	25
G.N8	240	6.726009	7.795404	87	10.4	0.09	20.4
G.N9	270	6.726009	7.795661	0	8.6	0.11	35.2
G.N10	300	6.726000	7.795908	10	4.2	0	24.0
G.S1	30	6.726171	7.792967	258	11.8	0.12	90.4
G.S2	60	6.726123	7.792767	260	8.6	0.04	70.8
G.S3	90	6.726209	7.792491	230	11.5	0.11	82.6
G.S4	120	6.726133	7.792215	250	4.6	0.1	54.6
G.S5	150	6.726209	7.791987	100	0	0.07	68.2
G.S6	180	6.726199	7.791701	180	2.4	0.05	45.2
G.S7	210	6.726257	7.791406	0	8.2	0.1	58.3
G.S8	240	6.726266	7.791149	112	11.4	0	70.4
G.S9	270	6.726409	7.790835	86	6.8	0.02	28.6
G.S10	300	6.726371	7.790521	0	0	0.01	32.2
G.W1	30	6.725924	7.793224	198	11.2	0.12	86.4
G.W 2	60	6.725657	7.793357	252	9.1	0.04	78.2
G.W 3	90	6.725381	7.793196	128	10.6	0.11	56.4
G.W 4	120	6.725096	7.793167	250	11.8	0.1	70.5
G.W 5	150	6.724810	7.793167	108	8.2	0	48.2
G.W 6	180	6.724581	7.793176	72	0	0.1	62.4
G.W 7	210	6.724315	7.793167	28	11.4	0.08	36.2
G.W 8	240	6.724401	7.793062	0	6.8	0.05	70.2
G.W 9	270	6.723763	7.793167	58	0	0.07	42
G.W 10	300	6.723420	7.793053	0	4.2	0	28.2
G.E 1	30	6.726399	7.793319	254	12.2	0.11	74.6
G.E 2	60	6.726668	7.793253	189	6.4	0.08	82.4
G.E 3	90	6.726913	7.793291	204	0	0.1	70.8
G.E 4	120	6.727189	7.793348	178	11.5	0	68.4
G.E 5	150	6.727456	7.793281	250	9.4	0.04	70
G.E 6	180	6.727761	7.793338	182	11.4	0.09	30.6
G.E 7	210	6.728046	7.793348	135	0	0.1	48.4
G.E 8	240	6.728313	7.793300	68	2.4	0.01	35.2
G.E 9	270	6.728636	7.793386	0	5.8	0	40.4
G.E 10	300	6.728846	7.793348	28	4.6	0.1	30.4
(FMEnv's standard				250 (μg/m^3)	11.4 μg/m^3)	0.1 (PPM)	70 (Db)

Figure 4.5 shows the kriging spatial concentration of $PM_{2.5}$ at Ganaja GSM Village .The results showed that $PM_{2.5}$ is concentrated within 120m radius with the highest reading recorded at the midpoint (262 µg/m^3) of the study area. Substantial concentration of the gas was also recorded at 150m towards the eastern part of Ganaja GSM Village. This could be as a result of external sources such as automobiles from the main road and other fossil fuel inclined activities around the study area. The results were presented in stretch colours where red yellow and green represents higher, minimum and lower concentrations respectively.

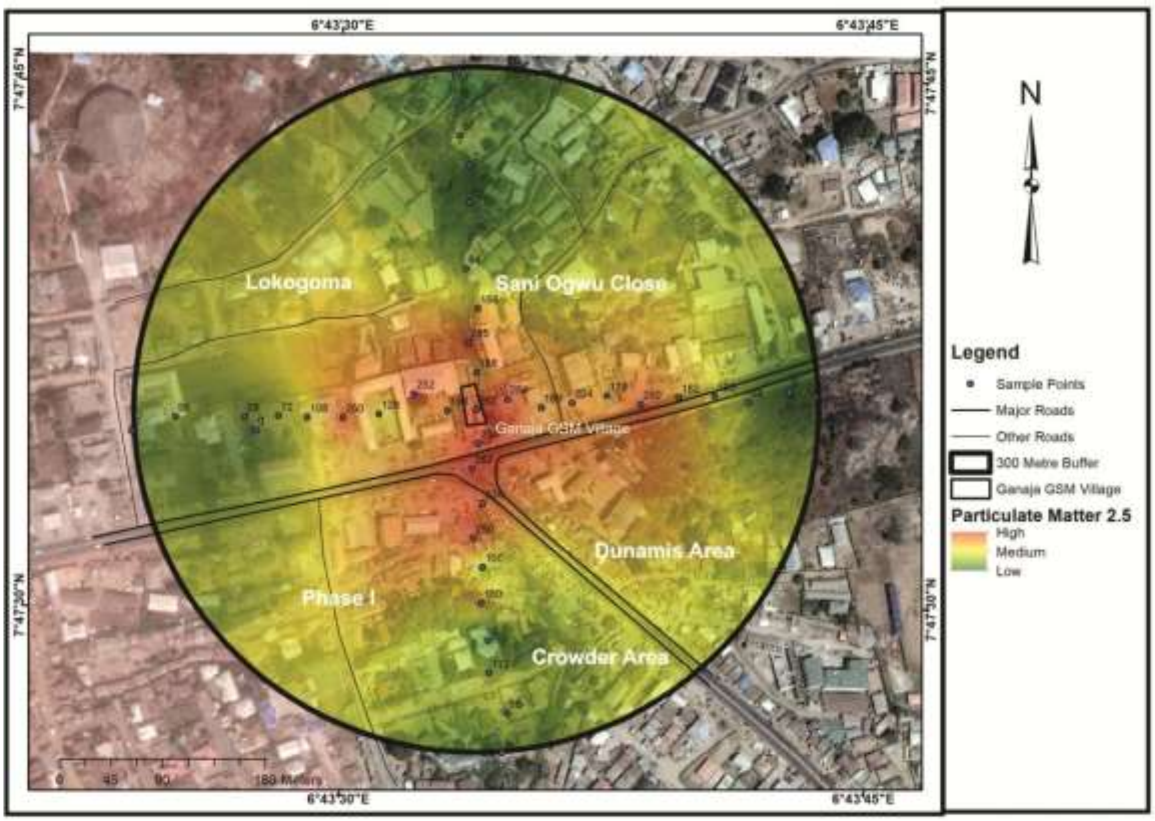


Figure 4.5: Kriging spatial interpolation of $PM_{2.5}$ at Ganaja GSM Village
Source: Author's field survey (2019)

The highest value of carbon monoxide (CO) recorded at the midpoint of the study area was 14.4 ppm. The gas also scored 11.4ppm at 240m towards the southern part of the study area. This implies that residents at 240m away from the study area may be affected by the activities being carried out in the GSM Village as well. Figure 4.6 shows the spatial concentration of carbon monoxide (CO) at Ganaja GSM Village in stretch colours.

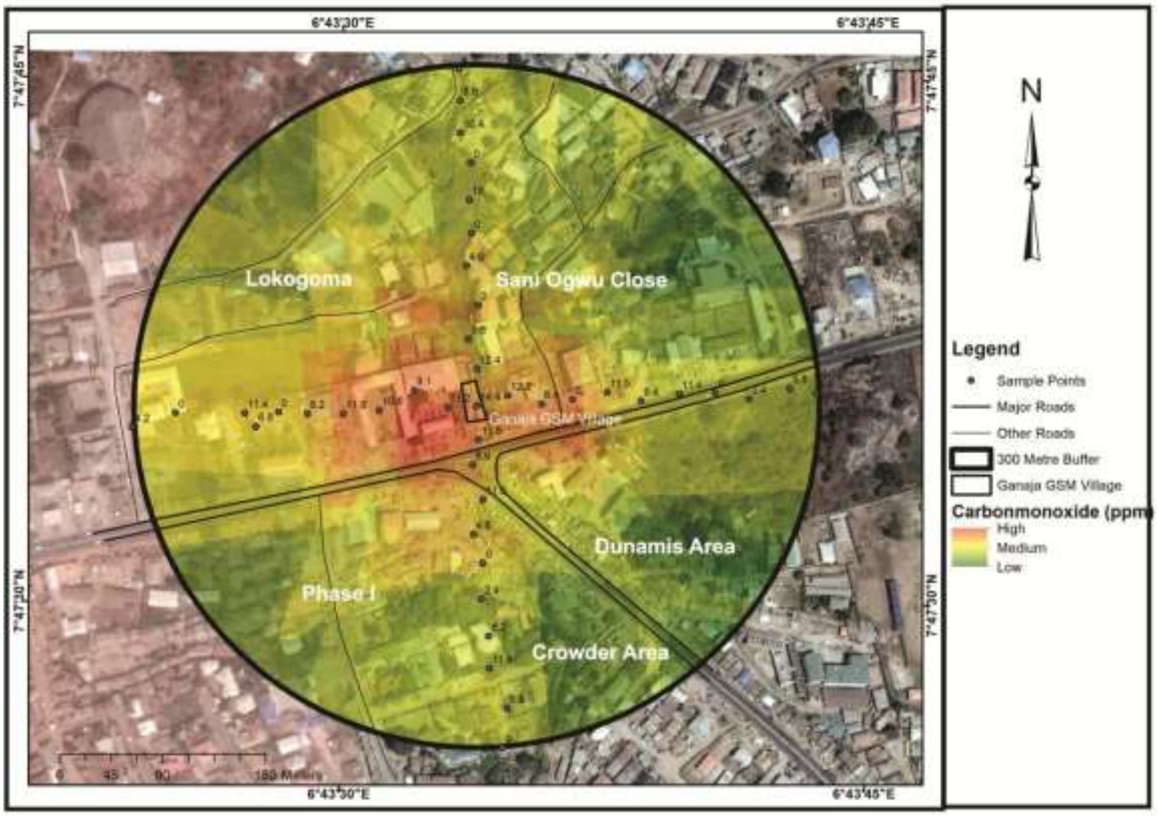


Figure 4.6: Kriging spatial interpolation of CO at Ganaja GSM Village
Source: Author's field survey (2019)

Figure 4.7 depicts the spatial concentration of sulphur dioxide (SO_2) at Ganaja GSM Village. The gas recorded 0.15ppm at the Midpoint of the GSM Village and this was closely followed by 0.11ppm at 270m towards the western part of the study area.

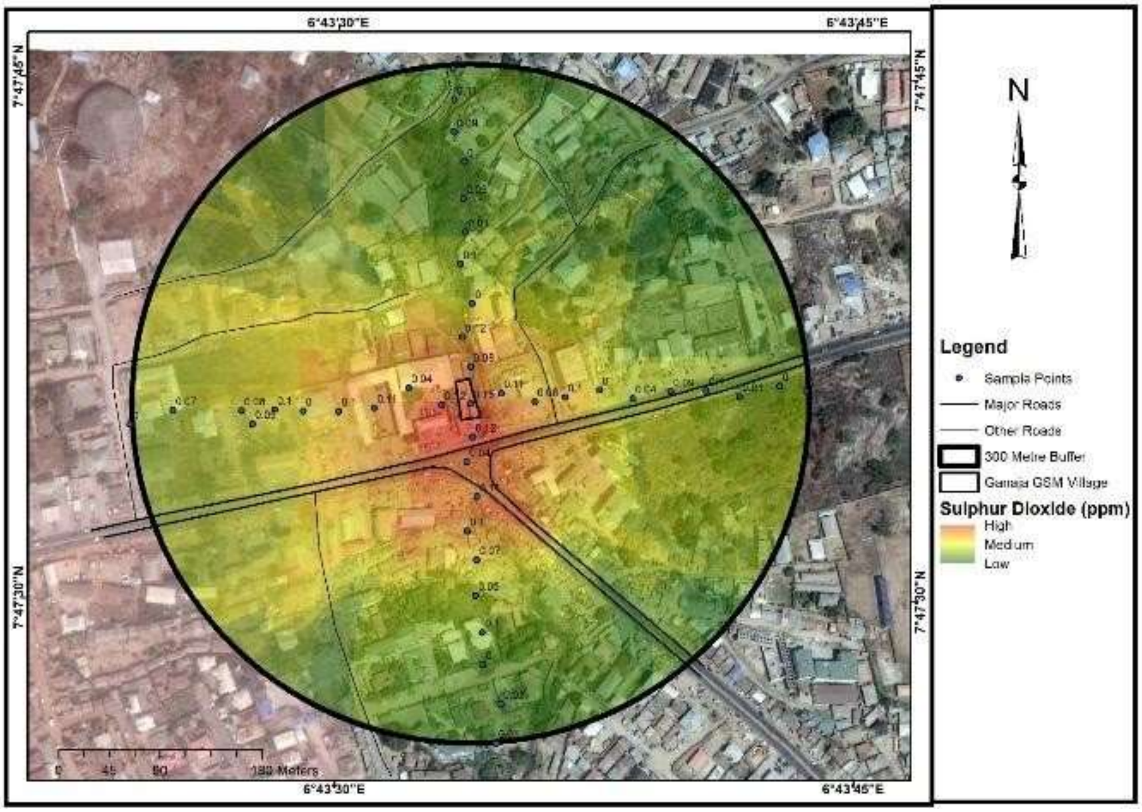


Figure 4.7: Kriging spatial interpolation of SO_2 at Ganaja GSM Village
Source: Author's field survey (2019)

Figure 4.8 represents the Kriging Spatial interpolation of noise pollution at Ganaja GSM Village. The results revealed that at 30m south, the noise level recorded was 90.4 dB which was the highest reading documented for noise outside the village during power outage. This was closely followed by 86.4db at 30m away towards the southern part of the study area. Other readings at 120m north, 240m south and 240m west all exceeded the permissible limit of Federal Ministry of Environment's reference standard as each recorded, 70.5, 70.4 and 70.2dB respectively.

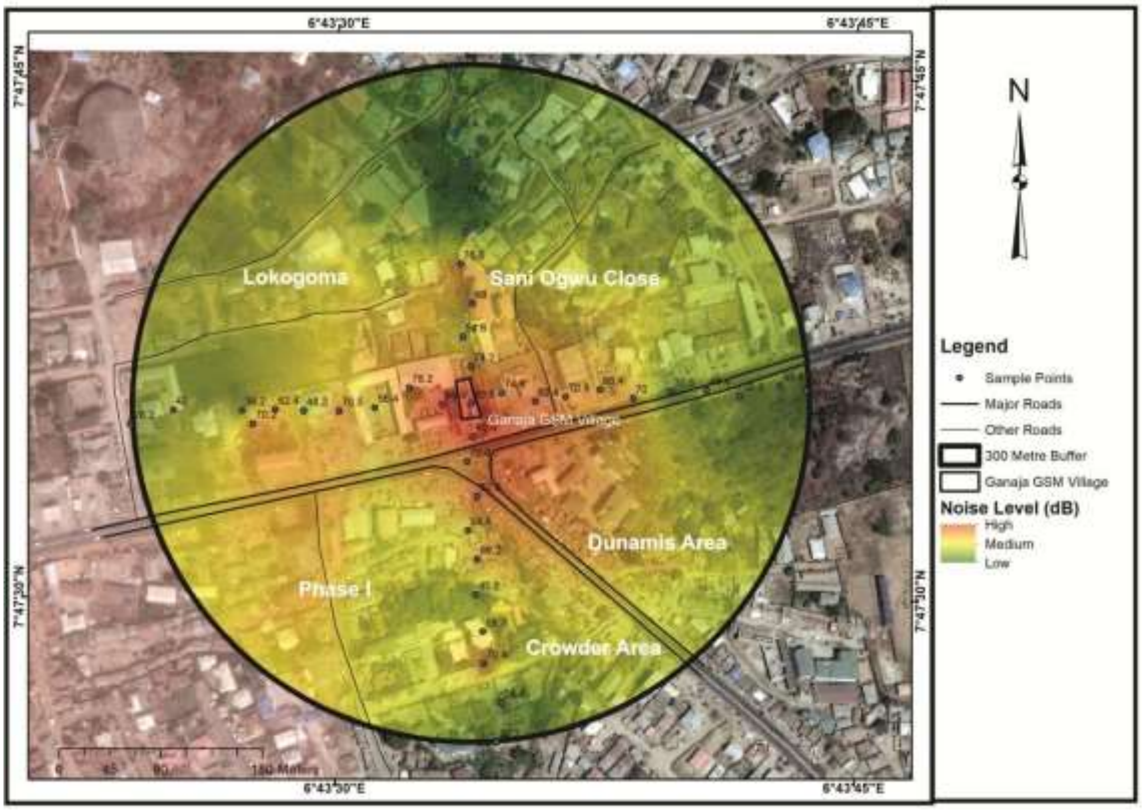


Figure 4.8: Kriging spatial interpolation of Noise at Ganaja GSM Village and its environment
Source: Author's field survey (2019)

4.8 Air Quality Assessment in Ganaja

Table 4.9 shows the comparison between the measured parameters at Ganaja area and the acceptable limits set by World Health Organisation (WHO) and Federal Ministry of Environment (FMEnv's). The positive (+) and negative (-) signs represents parameters that are above and within the acceptable limits of the above mentioned regulatory bodies. The results showed that all the readings taken inside Ganaja GSM Village were above the acceptable limits of WHO and FME. Results also showed that $PM_{2.5}$ scored high in Ganaja as most of the readings recorded surpassed WHO acceptable limits.

Table 4.9. Summary of ambient air quality assessment in Ganaja

Sample codes	Interval (m)	PM2.5 (µg/m^3)	WHO	FME	CO (µg/m^3)	WHO	FME	SO2 (µg/m^3)	WHO	FME	Noise (Db)	WHO	FME
MP	0	262	+	+	14.4	+	+	150	+	+	90.8	+	+
G.N1	30	188	+	-	12.4	+	+	80	-	-	74.2	+	+
G.N2	60	255	+	+	9.6	-	-	120	+	+	54.6	-	-
G.N3	90	156	+	-	2	-	-	0	-	-	68	-	+
G.N4	120	84	+	-	4.8	-	-	100	+	-	70.5	+	+
G.N5	150	38	-	-	0	-	-	10	-	-	32.4	-	-
G.N6	180	12	-	-	18	+	+	50	-	-	18.2	-	-
G.N7	210	0	-	-	0	-	-	0	-	-	25	-	-
G.N8	240	87	+	-	10.4	+	-	90	+	-	20.4	-	-
G.N9	270	0	-	-	8.6	-	-	110	+	+	35.2	-	-
G.N10	300	10	-	-	4.2	-	-	0	-	-	24.0	-	-
G.S1	30	258	+	+	11.8	+	+	120	+	+	90.4	+	+
G.S2	60	260	+	+	8.6	-	-	40	-	-	70.8	+	+
G.S3	90	230	+	+	11.5	+	+	110	+	+	82.6	+	+
G.S4	120	250	+	-	4.6	-	-	100	+	-	54.6	-	-
G.S5	150	100	+	-	0	-	-	70	-	-	68.2	-	+
G.S6	180	180	+	-	2.4	-	-	50	-	-	45.2	-	-
G.S7	210	0	-	-	8.2	-	-	100	+	-	58.3	-	+
G.S8	240	112	+	-	11.4	+	+	0	-	-	70.4	+	+
G.S9	270	86	+	-	6.8	-	-	20	-	-	28.6	-	-
G.S10	300	0	-	-	0	-	-	10	-	-	32.2	-	-
G.W1	30	198	+	-	11.2	+	-	120	+	+	86.4	+	+
G.W2	60	252	+	+	9.1	-	-	40	-	-	78.2	+	+
G.W3	90	128	+	-	10.6	+	-	110	+	+	56.4	-	+
G.W4	120	250	+	-	11.8	+	+	100	+	-	70.5	+	+
G.W5	150	108	+	-	8.2	-	-	0	-	-	48.2	-	-
G.W6	180	72	+	-	0	-	-	100	+	-	62.4	-	+
G.W7	210	28	-	-	11.4	+	-	80	-	-	36.2	-	-
G.W8	240	0	-	-	6.8	-	-	50	-	-	70.2	+	+
G.W9	270	58	+	-	0	-	-	70	-	-	42	-	-
GW10	300	0	-	-	4.2	-	-	0	-	-	28.2	-	-
G.E1	30	254	+	+	12.2	+	+	110	+	+	74.6	+	+
G.E2	60	189	+	-	6.4	-	-	80	-	-	82.4	+	+
G.E3	90	204	+	-	0	-	-	100	+	-	70.8	+	+
G.E4	120	178	+	-	11.5	+	+	0	-	-	68.4	-	+
G.E5	150	250	+	-	9.4	-	-	40	-	-	70	-	+
G.E6	180	182	+	-	11.4	+	-	90	+	-	30.6	-	-
G.E7	210	135	+	-	0	-	-	100	+	-	48.4	-	-
G.E8	240	68	+	-	2.4	-	-	10	-	-	35.2	-	-
G.E9	270	0	-	-	5.8	-	-	0	-	-	40.4	-	-
G.E10	300	28	-	-	4.6	-	-	100	+	-	30.4	-	-
FMEn		**250 µg/m^3**			**11.4 µg/m^3**			**100 µg/m^3**			**55Db**		
WHO		**50 µg/m^3**			**10 µg/m^3**			**80 µg/m^3**			**70dB**		

Key: (+) shows that the concentration is above the permissible limit.
(-) shows that the concentration is within the permissible limit

Table 4.10 shows the coordinates of sample locations, decibel level, concentrations of Particulate Matter 2.5, carbon monoxide and sulphur dioxide at Kpata and Cantonment GSM Villages. The Midpoint (MP) readings for the above mentioned gasses in the study area were 242 $\mu g/m^3$, 11.2ppm and 0.1ppm respectively all of which were below the permissible level stipulated by FMENvs with the exception of SO_2 that is within permissible limit. The highest values of the above parameters were recorded at 90m towards the northern part of the study area as each scored 278 $\mu g/m^3$, 18.6ppm and 0.16ppm respectively.

Subsequent readings however revealed that $PM_{2.5}$ at 120m south, CO at 270m west and SO_2 at 90m north all scored 258 $\mu g/m^3$, 11.5ppm and 0.15ppm respectively. The results of these gasses at these locations were still higher than the FMENvs permissible limit but was attributed to wind and other external sources that makes use of fossil fuel to function.

Table 4.10 shows the various sample locations, coordinates and readings of $PM_{2.5}$, CO and SO_2 at Kpata and Cantonment GSM Villages

Sample Codes	Interval	Easting	Northing	PM2.5	CO	SO_2	Noise Level (dB)
MP	0	6.7478622	7.8111942	242	11.2	0.1	102.4
KC.N1	30	6.747909	7.811445	252	11.4	0.08	50.6
KC.N2	60	6.747871	7.811724	234	8.2	0.1	70.2
KC.N3	90	6.747862	7.811966	278	18.6	0.16	90.4
KC.N4	120	6.747974	7.812255	250	12.4	0.1	78.6
KN.C5	150	6.748067	7.812543	145	10.4	0.1	48.2
KN.C6	180	6.747993	7.812804	180	2.4	0.04	52.4
KN.C7	210	6.747899	7.813092	98	0	0	34.8
KN.C8	240	6.748058	7.813418	48	4.8	0.06	25.4
KN.C9	270	6.748123	7.813622	0	0	0	42.8
KN.C10	300	6.748039	7.813929	32	6.2	0.02	30
KC.S1	30	6.748002	7.810980	184	11.5	0.1	62.8
KC.S2	60	6.747871	7.810757	138	8.6	0.01	70
KC.S3	90	6.747769	7.810403	244	14.2	0.11	92.4
KC.S4	120	6.747825	7.810180	258	9.4	0.1	82.2
KC.S5	150	6.747890	7.809901	108	11.4	0.04	70.8
KC.S6	180	6.747806	7.809650	84	10.8	0	52.1
KC.S7	210	6.747732	7.809371	0	4.2	0.08	62.4
KC.S8	240	6.747853	7.809073	242	0	0	50.8
KC.S9	270	6.747778	7.808840	0	6.4	0.02	34.6
KC.S10	300	6.747741	7.808571	12	0	0.1	42.4
KC.W1	30	6.747658	7.811222	238	6.4	0.08	59.2
KC.W2	60	6.747369	7.811334	198	10.8	0.11	70.4
KC.W3	90	6.747109	7.811213	252	12.4	0.15	80.6
KC.W4	120	6.746848	7.811138	264	11.6	0.07	78.4
KC.W5	150	6.746597	7.811222	144	8.4	0	65.5
KC.W6	180	6.746262	7.811166	88.2	6.4	0.05	48.4
KC.W7	210	6.746029	7.811334	46.2	7.6	0.1	35.2
KC.W8	240	6.745741	7.811231	64.8	11.4	0	42.6
KC.W9	270	6.745536	7.811166	0	0	0.02	30.4
KC.W10	300	6.745229	7.811231	20.2	4.6	0	42.2
KC.E1	30	6.748160	7.811241	86	8.6	0.1	58.2
KC.E2	60	6.748411	7.811138	142	14.2	0.14	74.4
KC.E3	90	6.748653	7.811222	252	11.2	0.1	86.8
KC.E4	120	6.748932	7.811176	258	7.6	0.09	70.9
KC.E5	150	6.749220	7.811129	184	4.8	0	64.2
KC.E6	180	6.749528	7.811203	20	0	0.02	54.8
KC.E7	210	6.749797	7.811324	0	2.1	0	35.2
FMEnv's standard				**250 (μg/m^3)**	**11.4 (μg/m^3)**	**0.1 (Ppm)**	**70 (dB)**

The results of Particulate matter 2.5 recorded at Kpata and Cantonment GSM Villages showed that the gas exceeded the FMEVns value of 250 **μg/m3** at 120m towards the southern and western locations of the study area as the gas scored 258 and 268 **μg/**m^3 at the above mentioned locations of the study area. The results were represented in stretch colours with red showing regions with high values, yellow indicating areas within permissible level and green representing locations with low concentration of PM 2.5 respectively as shown in figure 4.9.

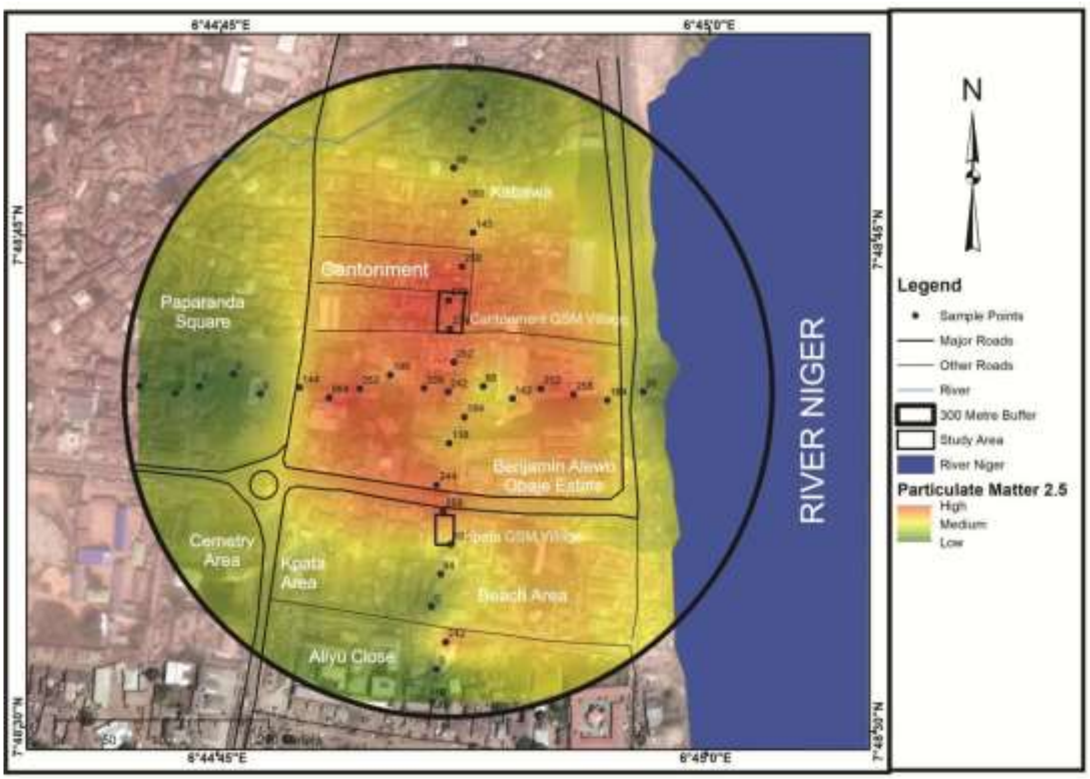


Figure 4.9: Kriging spatial interpolation of $PM_{2.5}$, at Kpata and Cantonment Area
Source: Author's field survey (2019)

Figure 4.10 represents the Kriging spatial interpolation of carbon monoxide (CO) at Kpata and Cantonment. The result showed that, the values of CO at 120m north, 150m south and 240m west were all high as each of the gasses scored 12.4, 11.4 and 11.4 ppm respectively. All the results were represented in stretch colours with red showing regions with high values, yellow indicating areas within permissible level and green representing locations with low concentration of Carbon monoxide respectively.

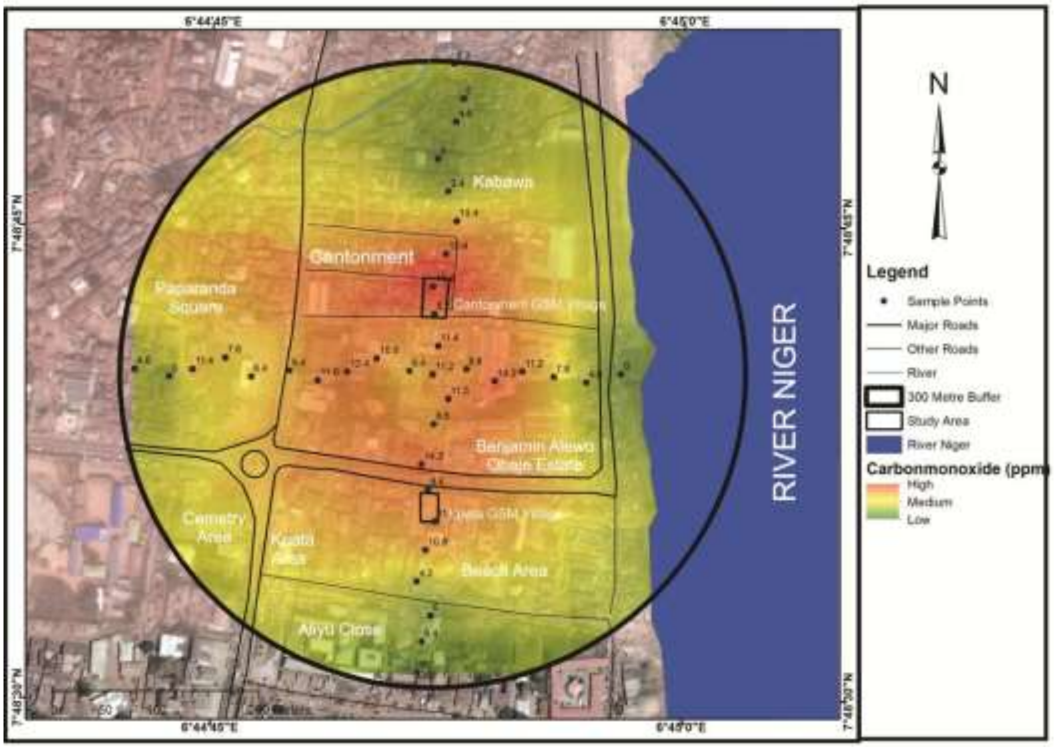


Figure 4.10: Kriging spatial interpolation of CO at Kpata and Cantonment Area
Source: Author's field survey (2019)

Figure 4.11 represents the Kriging spatial interpolation of sulphur dioxide (SO_2) at Kpata and Cantonment GSM Villages. The results obtained were equally represented in stretch colours with colour red depicting regions with high values, yellow showing areas within permissible level and green representing locations with low concentration of SO_2 respectively.

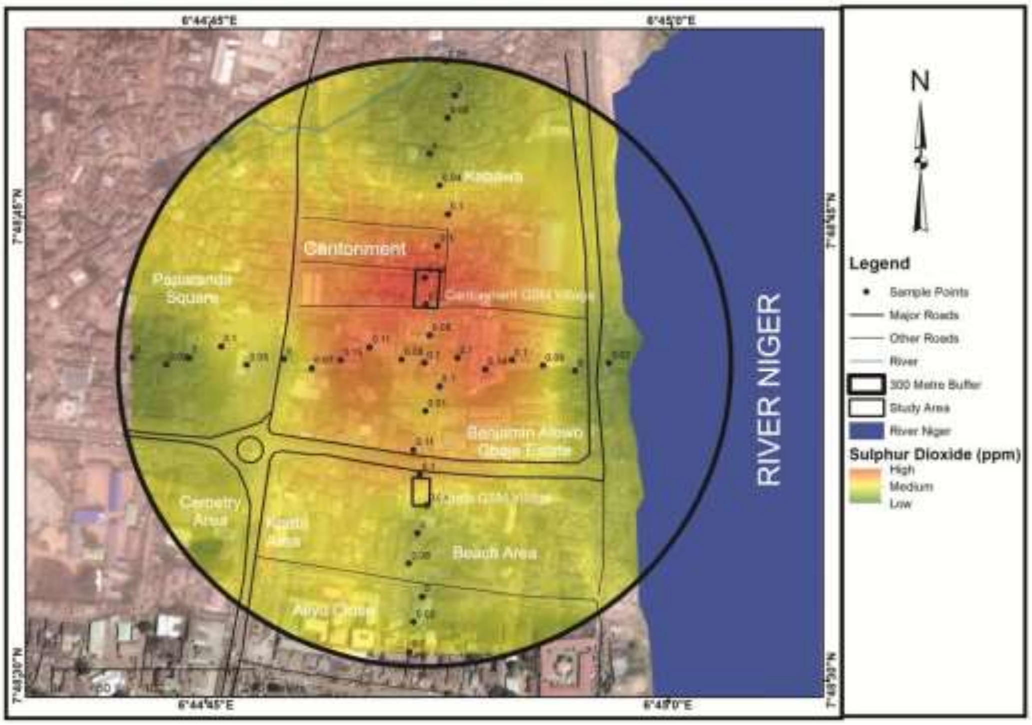


Figure 4.11: Kriging spatial interpolation of SO_2 at Kpata and Cantonment Area
Source: Author's field survey (2019)

Figure 4.10 represents the Kriging Spatial interpolation of noise pollution in Ganaja, Kpata and Cantonment GSM Villages. The result revealed that at 90m south, the noise level recorded was 92.4 dB which was the highest reading documented for noise in the village during power outage and this was closely followed by 90.4db at 30m away towards the northern part of the study area. Other readings at 120m east, 150m south, 90m west and 60m north all exceeded the permissible limit of Federal Ministry of Environment's reference standard as each recorded 70.9, 70.8, 80.6 and 70.2 respectively. Like the gases, wind also plays a vital role in the dispersion of sound pollution emanating from power generating sets and speakers in the GSM Villages.

Though there are other external sources that generate sound in the study area, result showed that the noise being generated at the village surpassed every other noise inclined sources in Kpata and Cantonment.

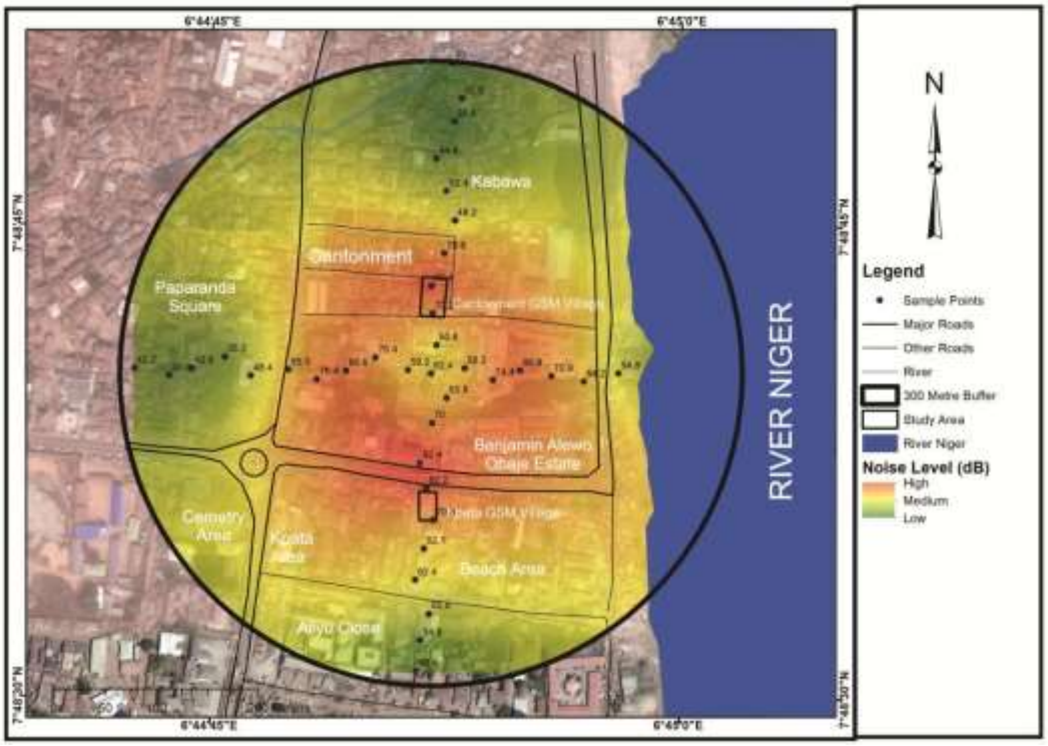


Figure 4.12 spatial interpolation of noise concentration at Kpata and Cantonment GSM Villages. Source: Author's Field Survey (2019)

4.9 Air Quality Assessment of Kpata and Cantonment

Table 4.8 shows the comparison between the field measurements at Kpata and Cantonment area with the acceptable limits of World Health Organisation (WHO) and Federal Ministry of Environment (FMEnv's). The positive (+) and negative (-) signs represents parameters that are above and within the acceptable limits of the above mentioned regulatory bodies. The results showed that all the readings taken inside Kpata and Cantonment were above the acceptable limits, just like the results recorded at Ganaja. Although the results recorded at Kpata and cantonment were higher than that of Ganaja GSM Village. This could be attributed to the fact that there are more generating sets at kpata and cantonment compared to Ganaja GSM Villge. The decibel level recorded at the midpoint of Kpata and Cantonment was 102.4db which happens to be the highest in the study area. This was closely followed by 92.4db towards the southern part of Kpata and Cantonment.

Table 4.11. Summary of ambient air quality assessment in Kpata and Cantonment

Sample Codes	Interval (m)	$PM_{2.5}$ (μg/m³)	WHO	FME	CO (μg/m³)	WHO	FME	SO_2 (μg/m³)	WHO	FME	Noise (Db)	WHO	FME
MP	0	242	+	-	11.2	+	-	100	+	-	102.4	+	+
KC.N1	30	252	+	+	11.4	+	-	80	-	-	50.6	-	-
KC.N2	60	234	+	-	8.2	-	-	100	+	-	70.2	+	+
KC.N3	90	278	+	+	18.6	+	+	160	+	+	90.4	+	+
KC.N4	120	250	+	-	12.4	+	+	100	+	-	78.6	+	+
KN.C5	150	145	+	-	10.4	+	-	100	+	-	48.2	-	-
KN.C6	180	180	+	-	2.4	-	-	40	-	-	52.4	-	-
KN.C7	210	98	+	-	0	-	-	0	-	-	34.8	-	-
KN.C8	240	48	-	-	4.8	-	-	60	-	-	25.4	-	-
KN.C9	270	0	-	-	0	-	-	0	-	-	42.8	-	-
KN.C10	300	32	-	-	6.2	-	-	20	-	-	30	-	-
KC.S1	30	184	+	-	11.5	+	+	100	+	-	62.8	-	+
KC.S2	60	138	+	-	8.6	-	-	10	-	-	70	-	+
KC.S3	90	244	+	-	14.2	+	+	110	+	+	92.4	+	+
KC.S4	120	258	+	+	9.4	-	-	100	+	-	82.2	+	+
KC.S5	150	108	+	-	11.4	+	-	40	-	-	70.8	+	+
KC.S6	180	84	+	-	10.8	+	-	0	-	-	52.1	-	-
KC.S7	210	0	-	-	4.2	-	-	80	-	-	62.4	-	+
KC.S8	240	242	+	-	0	-	-	0	-	-	50.8	-	-
KC.S9	270	0	-	-	6.4	-	-	20	-	-	34.6	-	-
KC.S10	300	12	-	-	0	-	-	100	+	-	42.4	-	-
KC.W1	30	238	+	-	6.4	-	-	80	-	-	59.2	-	+
KC.W2	60	198	+	-	10.8	+	-	110	+	+	70.4	+	+
KC.W3	90	252	+	+	12.4	+	+	150	+	+	80.6	+	+
KC.W4	120	264	+	+	11.6	+	+	70	-	-	78.4	+	+
KC.W5	150	144	+	-	8.4	-	-	0	-	-	65.5	-	+
KC.W6	180	88.2	+	-	6.4	-	-	50	-	-	48.4	-	-
KC.W7	210	46.2	-	-	7.6	-	-	100	+	-	35.2	-	-
KC.W8	240	64.8	+	-	11.4	+	-	0	-	-	42.6	-	-
KC.W9	270	0	-	-	0	-	-	20	-	-	30.4	-	-
KCW10	300	20.2	+	-	4.6	-	-	0	-	-	42.2	-	-
KC.E1	30	86	+	-	8.6	-	-	100	+	-	58.2	-	+
KC.E2	60	142	+	-	14.2	+	+	140	+	+	74.4	+	+
KC.E3	90	252	+	+	11.2	+	-	100	+	-	86.8	+	+
KC.E4	120	258	+	+	7.6	-	-	90	+	-	70.9	+	+
KC.E5	150	184	+	-	4.8	-	-	0	-	-	64.2	-	+
KC.E6	180	20	-	-	0	-	-	20	-	-	54.8	-	-
KC.E7	210	0	-	-	2.1	-	-	0	-	-	35.2	-	-
FMEnv		**250 μg/m³**			**11.4 μg/m³**			**100 μg/m³**			**55dB**		
WHO		**50 μg/m³**			**10 μg/m³**			**80 μg/m³**			**70dB**		

Key: (+) signifies concentration is above acceptable limit.
(-) signifies concentration is within the permissible limit

4.10 Summary of Findings

The study revealed that the residential and commercial uses are in proximity and as a result, commercial uses interfere greatly with residential units. There is therefore a case of uncoordinated land uses as setbacks are not duly observed. Little or no reference was made to predetermine planning standards in the study area especially at Kpata and Cantonment. Consequently, the problems of pollution emanating from the study area tends to be more pronounced on the residents living close to the study area.

Findings have also shown that Ganaja, Kpata and Cantonment area of Lokoja utilise power from the national grid for six hours (that is. 5 -11 Am) as at the time the research was conducted. That is to say that the GSM Villages make use of power from the grid for only 4 hours daily since majority of the workers normally resume work by 7am. This implies that the generating sets in the GSM Villages may likely be on from 11am to 6pm daily. In other words, the noise and gaseous emissions from these power generating sets will be experienced by workers and residents living close to the villages for 7 hours.

Decibel level of noise at Ganaja GSM Village (90.8), Kpata and Cantonment (102.4) all exceeded the Federal Ministry of Environment's permissible limits of 55db during the day and WHO limit of 70dB. Studies have shown that exposure to noise levels further than the World Health Organisation's permissible limit of 70 to 75db for a long period of time, may likely lead to abnormal fatal development, heart disease, instantaneous hearing impairment (Tinnitus), high blood pressure and endocrine disruption.

Findings have equally showed that majority of the residents and workers of the GSM Villages are mostly concerned with the noise generated from the off grid sources thereby giving less attention to the gaseous parameters. Results of measured gases however showed that SO_2, $PM_{2.5}$ and CO all scored high at the villages and were all above the permissible limit set by World Health Organisation and Federal Ministry of Environment.

The low perception of workers and residents as regards the gaseous pollutants does not mean these gaseous parameters are not harmful rather it is an indication that workers and residents of the locations under study are not aware of the negative effects of these gasses on their health.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Noise and gaseous emissions from electric power generating sets has been regarded as one of the major concerns threatening the existence of life today. This study revealed that electricity generating sets contributes greatly to the environmental pollution experienced in and around the study area as 32.2%, 45.2%, 31.4% and 4.9% of the respondents complained of headache, annoyance, sleeplessness, itchy eyes and running nose respectively. Though findings also revealed that respondents still experience high noise and gaseous emissions as far as 270m away from the study area, it was attributed to the wind and other external sources that require the use of fossil fuel to function. This study therefore concludes that the incessant use of fossil fuel electricity generating sets remain a problem that cannot be overlooked in the study area considering the multiplicity of its effects on the workers and residents of the study area. The study therefore proffer some recommendations in a bid to mitigate the menace associated with the use of electric power generating sets in the study area.

5.2 Recommendations

The result of findings from this study revealed that sound pollution, concentrations of particulate matter, carbon monoxide and sulphur dioxide were higher at close proximity compared to other locations of the study area. Continuous exposure to pollutants emanating from these generating sets can be detrimental to human health and may sometimes lead to death. It is therefore recommended that:

1. Awareness programme should be organised by regulatory bodies to educate workers and residents of the study area on the dangers associated with the use of electric power generating sets.
2. Additional planting of trees around the study area should be encouraged as they have the ability to trap gaseous emissions emanating from burnt fossil fuels.
3. Government should increase the effectiveness of the services of Abuja Electricity Distribution Company of Nigeria (AEDC) so as to reduce the need for private power plants if not totally discouraged.
4. Installing a cleaner, efficient and less hazardous alternative power source will go a long way to solving the problems of gaseous emissions and incessant noise pollution in the study area. Having a central solar system to power the villages may be expensive and space consuming, it is therefore cost effective for shop owners to install a 1KVA solar system each to power their appliances.
5. Shop owners are encouraged to use a significantly low noise (sound proof) central generator with large impedance composite muffler as backup power alternative.
6. Import restrictions should be placed on certain types of generating sets by the government especially poor or low quality ones. Emphasis should therefore be laid on quality (i.e. functionality and efficiency) rather than quantity and quick sales for money.
7. The polluter pays principle should be adopted in GSM Village so as to allow the polluters pay for the damages or harm they inflict on the environment via their activities during power outage. Regulatory agencies in the state should see to the enforcement of this principle at the three locations under study.

8. Finally, there is the need for a comprehensive environmental audit to be conducted in the GSM Villages to forestall the potential environmental hazards emanating from the Generating sets.

REFERENCES

Abam, F.I. & Unwachukwu, C.O. (2009). Vehicular emissions and Air quality standards in Nigeria. *Eur. J. Sci. Res*., 34(18), 550-560

Adefeso, I., Sonibare, J., Akeredolu, F. & Rabiu, A. (2012). Environmental Impact of Portable Power Generator on Indoor Air Quality. *International Conference on Environment, Energy and Biotechnology* IPCBEE, 33(8), 89-96

Adenife, P.A. & Samuel B.A. (2013). Examination of noise pollution from generators on the Residents of Obantoko, Ogun State Nigeria. *Asian Journal of Engineering, Science and Technology, 3, 31 – 41*.

Adeyemo, A. (2012). 60 million Nigerians spend n1.6trillion on generators annually. http://www.bellanaija.com

Ahmad, M.T. & Abubakar, H. (2012). Economic Implications of the use of generators as alternative source of energy in Kano metropolis, Nigeria. *International Journal of Research in Commerce, Economics and Management*, 2 (2), 28-33.

Akamisoko, D. (2002). *Samuel Ajayi Crowther in the Lokoja Area*. Sefer Books, Ibadan.

Akin, A.O. (2016). False Adaptive Resilience: The Environmental Brutality of Electric Power Generator use in Ogbomoso, Nigeria. *World Environmen*t, 6(3) 71-78 DOI: 10.592320160603.01

Akindele, A. & Adejumobi, D.O. (2017), "Domestic electric power generator usage and Residents' livability milieu in Ogbomosho, Nigeria*", Environmental Management and Sustainable Development*, 6(1), 91-104.

Alabi, M.O. & Enete, I.C (2012). Using multi-criteria decision model and GIS to determine land suitability for development purposes in Lokoja, Kogi State, Nigeria. *Journal of Environmental Management and Safety*, www.cepajournal.com

Alabi, M.O. (2009). *Urban sprawl, pattern and measurement in Lokoja, Nigeria*. Theoretical and Empirical Researches in Urban Management, 13 (4), 158-154

Alam P. A., (2013). Impact of Solid Waste on Health and Environment. Special Issue of *International Journal of Sustainable Development and Green Economics*, 2(1), 165-168

Allmendinger T. (2017**).** The Refutation of the Climate Greenhouse Theory and a Proposal for a Hopeful Alternative. *Environmental Pollution Climate Change* 1-23

Alrumman, S.A, El-kott, A.F, Kehsk, M.A. (2016) Water pollution: Source and treatment. *American journal of Environmental Engineering*, 6(3), 88-98.

Al-Salem, S.M. & Bouhamrah W.S., (2006). Ambient concentrations of benzene and other VOC's at typical industrial sites in Kuwait and their cancer risk assessment. *Res. J. Chem. Environ., Journal, 10, 42-46*

Ashraf, M.A., Maah, M.J., Yusoff, I. & Mehmood, K. (2010). Effects of Polluted ATSDR – Agency for Toxic Substances and Disease Registry. Health effects of hydrogen sulphide.www.eoearth.org/view/article/*153395.Available*online:http://www.usnews.com/news/blogs/at-the-edge/2012/05/07/poll-says America ready

Awofeso N. (2010). Generator diesel exhaust: a major hazard to health and the environment in Nigeria. *Am J Respir Critical Care Med.,* 183: 1437.

Azodo, A.P, Adejuyigbe, S.B. (2013). Examination of noise pollution from generators on the residents of Obantoko, Ogun State, Nigeria. *Asian J. Eng. Sci. Technol.,* 3(1), 31- 41.

Azodo, A.P. (2014). Electric power supply, main source and backing: A survey of residential utilization features. *Int. J. Res. Stud. Manage. ,* 3(2), 87-102.

Azodo, A.P., Omokaro, I., Mezue, T.C & Owoeye, F.T (2016). Pollution Evaluation and Analysis of Environmental Noise from Petrol Fuelled Portable Power Generators Used In Commercial Areas. *Journal of Experimental Research,* 6(1*)*

Bari, M.A., Kindzierski, W.B. (2017). Concentrations, sources and human health risk of inhalation exposure to aiAwosur toxics in Edmonton, Canada. *School of Public Health,University of Alberta*, 3-57 South Academic Building, 11405-87 Avenue, Edmonton, Alberta.T6G 1C9 Canada http://dx.doi.org/10.1016/j.chemosphere.2016.12.157 0045-6535

Bibi, S., Khan, R.L. and Nazir, R. (2016). Heavy metals in drinking water of Lakki Marwat District, KPK, Pakistan. *World applied sciences journal,* 15-19.

Botzen, W.J., Gowdy, J.M., and van den Bergh, Jeroen C. J. M. 2008. "Cumulative CO_2

Brajmohan, Masood, A. and Ahmed, K (2018). Air Pollution Dispersion Modelling for Diesel Generators at Jamia University Campus, New Delhi, India. *International Journal of Advance Research and Innovation.*

British Broadcasting Corporation- Africa (2013). *Shame: More than 60 Million People own Generators in Nigeria*.

Caney, S. (2005*). Cosmopolitan Justice, Responsibility, and Global Climate Change.* Leiden

Chizoruo, F.O., Iheanyichukwu O.A., Chukwuemeka N. P. and Ikechukwu, A.J. (2017). Ambient Air Quality Assessment of Orlu, Southeastern, Nigeria. *Journal of Applied Sciences*. DOI 10.3923/jas.2017.441.457

Debasish, P. and Debasish, B. (2012). *Effect of Road Traffic Noise Pollution on Human Work Efficiency in Government Offices, Private Organisations, and Commercial Business Centres in Agartala City Using Fuzzy Expert System*: A Case Study. Advances in Fuzzy Systems http://dx.doi.org/10.1155/2012/828593

Egondi T., Kyobutungi C., Muindi N.K., Oti S., Vijver S.,Ettarh R., and Rocklöv J. (2013). Time-Series analysis of weather and mortality patterns in Nairobi's informal settlements. *Int. J. Environ. Res. Public Health* 10, 4851-4868; doi: 10.3390/ijerph10104851

Ehrlich, P. R. and Holdren, J. P. (1971). Emissions Shifting International Responsibilities for Climate Debt." *Climate Policy*, 8, 569–76.

Energy Commission of Nigeria (2009). *60 Million Nigerians now Own Power Generators*. Adopted from Vanguard Newspaper, 26th January

United States Environmental Protection Agency (2009). Air pollutants in *Guide to Environmental Issues*, Doc .No. 520/B-94-01, United States Environmental Protection Agency, Washington, DC., USA

Essandoh, P.K and Armah, F.A. (2011). Determination of Ambient noise levels in the main Commercial Area of Cape Coast, Ghana. *Research Journal of Environmental and Earth Sciences, 3(6): 637-644, 2011Essential Readings. New York:* Oxford University Press.

European Public Health Alliance (2009). Air, Water Pollution and Health Effects.

Fadairo, G. (2013). Urban Centres Noise Pollution: Case Study of Akure, Nigeria. *British Journal of Arts and Social Sciences, ISSN: 2046-9578, Vol.14 No. II.*

Faure, Michael, Morag Goodwin, & Franziska Weber (2010). "Bucking the Kuznets curve:Designing effective environmental regulation in developing countries." Virginia *Journal of International* Law, 51 95–156.

Fiedler, P.E.K., Zannin, P.H.T (2015). Evaluation of noise pollution in urban traffic hubs, Noise maps and measurements. *Environ. Impact Assess Rev*; 51:1-9.for-hard-choice-on-fossil-Fuels-climate.

FMEnv (2008). – Federal Ministry of Environment Guidelines and Standards for Environmental Pollution Control in Nigeria, Lagos, Nigeria, 1991.

Fourier, M. (1827). Mémoire sur les températures du globe terrestre et des espaces planétaires. Mémoires de l'Académie Royale des Sciences de l'institutde France 7:569-604.

Franchini, M., Mengoli, C., Cruciani, M., Bonfanti, C. & Mannucci, P.M. (2016). Association between particulate air pollution and venous thromboembolism: A systematic literature review. *Eur. J. Intern. Med.*, 27, 10–13.

Gaines, S.E. (1991). "The polluter pays principle: From economic equity to environmental ethos. *Texan International Law Journal*, 26 463.

Gardiner, Stephen, Caney, Simon, Jamieson, Dale, & Shue, Henry (2010). *Climate Ethics:*

Godson-ibeji, C.C & Chikaire, J.U (2016). Consequences of Environmental Pollution on Agricultural Productivity in Developing Countries: A Case study of Nigeria *International Journal of Agricultural and Food Research* [IJAFR] ISSN 1929-0969 5 (3), 112

Goines L. & Hagler L. (2007). Noise pollution: *A modern plague, Southern Medical Journal, 100(3), 287–294.*

Hammer, M.S., Swinburn T.K. & Neitzel, R.L. (2014). Environmental noise pollution in the United States: developing an effective public health response. Environ Health Perspective 122:115 119**;** http://dx.doi.org/10.1289/ehp.1307272_Hopeful Alternative .*Environ Pollut Climate Change*, 1-123.

Harendra, K. (2012): Quality of life in relation to environmental pollution. Advances in Asian Social Science, 1, 72-75.

Haseena M., Malik M.F., Javed A., Arshad S., Asif N., Zulfiqar S. and Hanif J. (2017**).** Environmental Risk Assessment and Remediation. *Allied Journals Academic*, 1, (3). DOI**:** 10.4066/2529-8046.100020

Health & Safety Executive UK. (2012). Diesel engine exhaust emissions. *www.hse.gov.uk/pubns/indg286.pdf*

Hill, J.N, & Lavela, S.L (2015). Noise Levels in Patient Rooms and at Nursing Stations at T Here VA medical Centres. *Health Environmental and Research Journal*, DOI 10.1177/19375867155192635

Hunashal, R.B. & Patil, Y.B (2012). Assessment of noise pollution indices in the city of Kolhapur, India. *Procedia Soc Behav Sci*; 37:448-57.

Ibitoye, F.I & Adenikinju, A. (2007). *Future Demand for Electricity in Nigeria*. Appl. Energy. 84; (5): 492-504.

Ifatimehin, O.O., Musa, S. D. & Adeyemi, J.O. (2009): An analysis of the changing land use and its impact on the environment of Anyigba town, Nigeria. *Journal of Sustainable Development in Africa*, 10, (4) 357-364

Intergovernmental Pannel on Climate Change (2007). Working Group I. The physical science basis: how do human Activities contribute to climate change and how do they compare with natural influences. *www.ipcc.ch/* publications and data/ar4/wg1/en/faq-2-1.html (accessed 9 October 2014).

Jade, S. (2011). Comparing the Environmental Impact of Diesel Generated Electricity with Hybrid diesel –wind Electricity for off grid first Nation Communities in Ontario, Canada. *Master Thesis Submitted to the Department of Environmental and Applied Science and Management, University of Plymouth, UK*

Iqbal, Z. & Lodhi, S. (2014). Noise Pollution Caused by Electric Generators and Firing outside Marriage Halls in Lahore: A Sensitivity analysis using contingent valuation. *International Journal of Research in Applied, Natural and Social Sciences, 2, (11), 159-168*

Ismail, A.S., Abdullah, A.M. & Samah M.A.A. (2017). Environmetric study on air quality Pattern for assessment in Northern region of Peninsular Malaysia. *J. Environ. Sci*. Technol., 10: 186-196

Jibiri, N. N., Olaluwoye, M. O. & Ayinmode B. O. (2015). Assessment of Health Effects of Noise and Vibration Levels at Major Business Complexes and Markets in Ibadan Metropolis, Nigeria. *Journal of Health Science,* 5(4): 69-75 DOI: 10.5923/j.health.20150504.02

Jones, M.D.H. & Sellers, H.A. (1990). History of the Greenhouse Effect, Prog. *Phys. Geog. 14,* no. 1, p. 5 *Journal of International Law 18: 747–75.*

Kan, H. (2009): Environment and health in China: Challenges and opportunities. Environmental Health Perspectives, 117:530-531.

Khan, M.A., Ghouri, A.M. (2011). Environmental Pollution: Its effects on life and its remedies. *Journal of arts, science and commerce*, 2(2):276-85.

Khan, N., Hussain, S.T & Saboor, A. (2013). Physiochemical investigation of the drinkingwater sources from Mardan, Khyber Pakhtunkhwa, Pakistan. International journal of physical sciences, 8(33) 61-71.

Kogi State Ministry of Information (2011): official Gazette.

Komolafe, A. A., Adegboyega, S. A., Anifowose, A.Y., Akinluyi,F.O.,& Awoniran, D.A. (2014). Air Pollution and Climate Change in Lagos, Nigeria.

Liu, W., Xu, Z., & Yang, T. (2018). Health Effects of Air Pollution in China. *International Journal Environment Research and Public Health, 15, 14-71*

Liu, X., Lessner, L., & Carpenter, D. O. (2012): Association between Residential Proximity to Fuel-Fired Power Plants and Hospitalization Rate for Respiratory Diseases

Luppi, B., Francesco P., & Shruti R. (2012). The rise and fall of the polluter-pays principle in developing countries. *International Review of Law and Economics*, 32 135–44.

Madaleno, M., (2018). Environmental Pollution, Waste Generation and Human Health. *Biomed Sci &Tech Res* 8(4) - 2018. BJSTR MS.ID.001671. DOI: 10.26717/ BJSTR.2018.08.001671.

Majumder, A.K, (2018) Noise Induced Hearing Quality Assessments of Traffic Police Personnel in Dhaka City. *Journal of Environment Pollution and Human Health*, 6, (4) 121-125. Doi: 10.12691/jephh-6-4-1

Marc, L. (2015). *What is the greenhouse effect*? *http://www.livescience.com/37743* greenhouse-effect.html, Accessed 23 May 2015

Mbamali, I., Stanley, A.M., Zubairu, I.K. (2012). Environmental hazards of fossil fuel generators for electricity supply to buildings in Nigeria. *Canadian Journal on Electrical and Electronics Engineering*, 3(10).

Meyer, L.H. (2012). "Why Historical Emissions Should Count." *Chicago Journal of Health Development*

Michael R. & Mark A.W.A., (2009). *How does Background Noise affect our Concentration*? Seton Hill University, Greensburg.

Mukherjee A. (2002). Perpesctives of the Silent Majority: Air Pollution, Livelihood and Food Security. Hampshire: *Ashgate Publishing Company.*

National Environmental Standards and Regulations Enforcement Agency 2009

National Population Census (NPC), 2006.

Nesbit, Jeff. "Poll says America Ready for Hard Choice on Fossil Fuels, Climate" (2012). Available online:http://www.usnews.com/news/blogs/at-the-edge/2012/05/07/poll-says americaready-for-hard-choice-on-fossil-fuels-climate

NFPA–National Fire Protection Association (2014). Portable generators. www.nfpa.org/safety-information/for-consumers/causes/portable-generators.Nigeria. *Indoor and Built Environment* 1(6) 1–13. DOI: 10.1177/1420326X16629818 ibe.sagepub.com

Obadote, D.J. (2009). *Energy Crisis in Nigeria*. Rasheen Publisher, Lagos, Nigeria, pp. 37 51.

Organisation for Economic Co-operation and Development (1992). *The Polluter-Pays Principle:* OECD Analyses and Recommendations.

Ogunbayo, A. O. (2016*). Retrospective study of effects of air pollution on human health*. Bachelor's Thesis Degree Programme in Environmental Engineering (Environmental Management)

Oguntoke, O., & Adeyemi, A. (2016). Degradation of urban environment and human Health by emissions from fossil-fuel combusting electricity generators in Abeokuta metropolis

Oguntoke, O., Odeshi, T.A. & Annegarnnh,. J. *(2012).* Assessment of Noise Emitted by Vibrator-Block Factories and the Impact on Human Health and Urban Environment in Nigeria *International Journal of Applied Environmental Sciences* ISSN 0973-6077 7, 57-68

Okoro, R.C. (2014). Survey & analysis of noise by generating plants in some parts of the University of Calabar, Calabar, and Cross River state Nigeria. *Int. J. Res. Agric. Food Sci*., 1(3), 8-15.

Olamijulo J.O., Ana, G. R.,Morakinyo, O. M. (2016). Noise from Portable Electric Power Generators in an Institutional Setting: A Neglected Risk Factor. *International Journal of Environmental Monitoring and Analysis*, 4,(4) Doi: 10.11648/j.ijema.20160404.11

Omubo-Pepple, V.B., M.A. Briggs-Kamara, & Tamunobereton-ari I. (2010). Noise Pollution in Port Harcourt Metropolis: Sources, Effects, and Control. *Pacific Journal of Science and Technology*, 11(2), 592-600.

Oseji J.O. (2011). Investigation of environmental noise within campus 2, Delta state University, Abraka. Nigeria. *Int. J. Recent Res. Appl. Stud.*, 6(2), 223- 229.

Otutu, O. J. (2011). Investigation of Environmental Noise within Campus 2, Delta State University, Abraka, Nigeria. www.arpapress.com/Volumes/Vol6Issue2/IJRRAS 6 (2), 14

Oyedepo, O.S.; Saadu, A.A. (2010) Evaluation and Analysis of Noise Levels in Ilorin Metropolis, Nigeria. *Environ. Monit. Assess*, 160, 563–577.

Patrick, A.A & Babatope A.S (2013). Examination of Noise Pollution from Generators on the Residents of Obantoko, Ogun State, Nigeria. *Asian Journal of Engineering, Sciences &Technology*, *3*(1) 31-41

Pawari, M.J, Gawande, S. (2015). Ground water pollution & its consequence. International *journal of engineering research and general science*, 3(4), 773-76.

Pigou , A.C. (1920) The Economics of Welfare, London: Macmillan

Principle 16 of United Nations Environment Programme (1992).Coleman, Hershovitz, and Mendlow.

Pushpanathan, M., & Rajendhran, J.(2014). *Microbial Biodegradation and Bio remediation*

Rasheed, A., Aneja, V. P., Aiyyer A., & Rafique U. (2013). Measurements and analysis of air quality in Islamabad, Pakistan. *Earth's Future*, 2, 303–314, doi: 10.1002/2013EF000174. Retrieved from http://www.epha.org/r/54.

Sambo, A.S., Garba, B., Zarma, I.H. & Gaji, M.M. (2009). Electricity Generation and the Present Challenges in the Nigerian Power Sector. *A Conference Organized by the Energy Commission of Nigeria*, Abuja. 1-17.

Schneider, S. H. (1989). The greenhouse effect: Science and policy. *Science* 243: 771-81.

Scipeeps, (2009). Effects of Water Pollution. Retrieved from *http://scipeeps.com/effects- of water- pollution*

Shell Nigeria. 90 million Nigerians have smoke-related health problems. (2015). http://leadership.ng/nga/articles/39025/2012/11/02/90millionnigerians have smoke related_ health_problems_shell.html

Siji, J. (2015). *Optimizatyon of Municipal Solid Waste Collection and Disposal for Lokoja, Nigeria.* A Project Report submitted to the School of Postgraduate Studies and the Department of Geography, University of Nigeria, Nsukka

Smets, H. (1994). *The polluter pays principle in the early 1990s*. The Environment after Rio: International Law and Economics. Edited by Luigi Campiglio. London: Graham & Trotman /Martinus Nijhoff

The Corporation Tax (Land Remediation Relief) Order, (2009). No 2037, Explanatory Memorandum.

The International Panel of Climate Change (IPCC). (2006). IPCC guidelines for national greenhouse gas inventories; 2007. Available from: http://www.ipcc

UN-HABITAT (2011); Global Report on Human Settlements, Cities and Climate Change. United Nations Human Settlements Programme. London/Washington DC: Earth scan

United Nations Framework Convention on Climate Change (UNFCCC). (2001). Climate change information KiT. https:// unfccc.int/essential_background/background_publicationshtmlpdf/climate_change_information_kit/items/305.php.

United Nations Framework Convention on Climate Change (UNFCCC). Article1 definitions;2014.Availablefrom:http:/unfccc.int/essential_background/convention/background/items/ 1350.php.

United States Environmental Protection Agency (2012). *The Greenhouse Effect Climate Change Indicators in the United States*. 2nd edition, Washington, DC, USA: US EPA, p.3. EPA 430-R-12-004

Wang M., Braggio Q., Dabney J., Yan B., Miller F., Malik J., Agwale R..V., & Mitchell C. (2016). 'Use of GIS in Maryland Environmental Public Health'. *Electronic Journal of Health Informatics, 6(2)*

World Health Organisation (1997). *Health and Environment in Sustainable Development: five years after the earth* Summit. WHO/EHG/97.12.E, 87. http:// libdoc.who.int/hq//WHO_EHG 97.12eng.

World Health Organisation (2007). Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide, Global update. http://whqlibdoc. who.int/hq/2007/WHO_SDE_PHE_OEH_06.02_eng.pdf.

WNA (2013). *World Nuclear Association*. Environment and health in electricity generation. www.world-nuclear.org/

Wong I.C, N. Y. (2014). *Cancers of the lung, head and neck on the rise*: perspectives on the geno toxicity of air Pollution. PubMed

World Health Organisation. (1999). Guidelines for Community Noise. *http://www.who.int/peh/*

Yang, H., Xu, Z., Fan, M., Gupta, R., Slimane, R.B., Bland, A.E. & Wright, I. (2008). Progress in carbon dioxide separation and capture: A review. *J. Environ. Sci*., 20, 14–27.

Yesufu A. L, Ana G. R. E. (2012). Electric Generator Characteristics, Pattern of Use and Non Auditory Health Effects Experienced by Commercial Workers in Agbowo and Ajibode Areas of Ibadan, Nigeria*. Review of Global Medicine and Healthcare Research; 3 (2), 159-171*.

Yesufu, L.A., Ana, G.R., Umar O.Z. (2013). Knowledge and Perception of Noise Induced Health Hazards Associated with Generator Use in Selected Commercial Areas in Ibadan, Nigeria *International Journal of Collaborative Research on Internal Medicine & Public Health*, 5(9), 581-595.

APPENDICES

APPENDIX A

URBAN AND REGIONAL PLANNING DEPARTMENT

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA NIGER STATE

POSTGRADUATE QUESTIONNAIRE

Questionnaire to assess the impact of power generating sets on the shop owners of GSM Village Lokoja, Kogi State of Nigeria. This survey is strictly for academic purpose and any information obtained will be treated as confidential.

SECTION A: Bio Data

Please thick the appropriate answer

1. Gender

   (a). Male (b) Female

2. Age

   (a).10 and below (b) 11- 20 (c) 21 -30 (d) 31 and above

3. Marital Status

   (a). Single (b). Married (c) Widow (d) Widower (e) Divorced

4. Place of residence

5. Distance from the GSM Village

   (a) 1-50m (b) 51-100m (c) 101-150m (d) 151-200m (e) 201m and above

6. What time do you start operation

   (a). 7a.m – 7:59 am (b). 8a.m – 8:59am (c). 9a.m – 9:59am

7. How long have you been in this business

(a). 1year and below (b). 2 – 3years (c). 4 – 5years (d). 6 years and above

8. How many hours do you operate daily

   (a). 1 - 3 hours (b). 4 - 7 hours (c). 8-12 hours

9. Are you connected to the PHCN line?

   (a). yes (b). No

10. If yes, how many hours do you make use of power from the PHCN per day

    (a).1- 3 hours (b). 4-6 hours (c). 7-9 hours (d). State otherwise

11. What is your major source of power supply

    (a) Solar (b) Battery (c) Electric power Generator (d) PHCN

12. Is there any law in the GSM Village controlling the use of Generating sets

    (a). Yes (b). No

13. If yes, state the law..

    - - - - - - -

14. How many liters of fuel do your generator set consume per day

    (a). 1-2 (b). 3-4 (c). 5 – 6 (d). 7 – 8 (e). 9 and above

15. What is the capacity of your generator set in KVA?

    (a). 1KVA (b). 1.5KVA (c). 2KVA (d). 3.5KVA (e). 4KVA and above

16. What health related problem(s) do you experience as a result of working here

(a). Headache (b). Restlessness (c). Annoyance (d). Itchy eyes and running nose (f). State otherwise

17. Have you had any form of orientation/sensitization regarding the effect of electric power generating sets on human health and the general environment? (a) Yes (b) No

SECTION B

INTERVIEW GUIDE

To the shop owners in GSM Village Lokoja

1. Shop number and location of the GSM Village---
2. When was the GSM Village established?..
3. How many shops are available in the GSM Village?--
4. Is there an approval from the government pertaining to the GSM Village?---------------
5. What time do you normally resume work?------------------------
6. What time do you close for the day?-----------------------------

URBAN AND REGIONAL PLANNING DEPARTMENT

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA NIGER STATE

POSTGRADUATE QUESTIONNAIRE

Questionnaire to assess the impact of power generating sets on the environment of Lokoja area of Kogi State, Nigeria. This survey is strictly for academic purpose and any information obtained will be treated as confidential.

SECTION C: To the Residents of GSM Village

1. Name of street...

   - - - - -

2. How long have you lived here

   -

3. Are you or any member of your family affected by the activities carried out in the GSM Village

   (a). Yes (b) No

4. If yes, what are the effects perceived

   (a). Noise (b) Toxic gasses (c) No effect

5. What are the likely ailments you experience as a result of the activities in the GSM Village

   (a). Headache (b). Sleeplessness (c) Annoyance (d) Itchy eyes and running nose (e) No effects

6. What is the distance of your house to the GSM Village

   (a) 10-50m (b). 51-100m (c). 101-150m (d) 151-200m (e) 201 – 250m (f) 251-300m

7. How often do you patronize the GSM Village

   (a). Daily (b). Once in a week (c) twice in a month (d) once in a year (e) Not at all

8. Do you or your family relation work in the GSM Village

   (a). Yes (b) No

9. If yes state the type of work..

   ----

10. What do you suggest for the management of the GSM Village--------------------------

    ----

Appendix B

Microgram per cubic meter to Part per million Conversion Table

Mg/m^3	PPM	Mg/m^3	PPM
1 mg/m^3 =	0.001 ppm	26 mg/m^3 =	0.026 ppm
2 mg/m^3 =	0.002 ppm	27 mg/m^3 =	0.027 ppm
3 mg/m^3 =	0.003 ppm	28 mg/m^3 =	0.028 ppm
4 mg/m^3 =	0.004 ppm	29 mg/m^3 =	0.029 ppm
5 mg/m^3 =	0.005 ppm	30 mg/m^3 =	0.03 ppm
6 mg/m^3 =	0.006 ppm	31 mg/^{m3} =	0.031 ppm
7 mg/m^3 =	0.007 ppm	32 mg/^{m3} =	0.032 ppm
8 mg/m^3 =	0.008 ppm	33 mg/m^3 =	0.033 ppm
9 mg/m^3 =	0.009 ppm	34 mg/m^3 =	0.034 ppm
10 mg/m^3 =	0.01 ppm	35 mg/m^3 =	0.035 ppm
11 mg/m^3 =	0.011 ppm	36 mg/m^3 =	0.036 ppm
12 mg/m^3 =	0.012 ppm	37 mg/m^3 =	0.037 ppm
13 mg/m^3 =	0.013 ppm	38 mg/m^3 =	0.038 ppm
14 mg/m^3 =	0.014 ppm	39 mg/m^3 =	0.039 ppm
15 mg/m^3 =	0.015 ppm	40 mg/m^3 =	0.04 ppm
16 mg/m^3 =	0.016 ppm	41 mg/m^3 =	0.041 ppm
17 mg/m^3 =	0.017 ppm	42 mg/m^3 =	0.042 ppm
18 mg/m3 =	0.018 ppm	43 mg/m^3 =	0.043 ppm
19 mg/m^3 =	0.019 ppm	44 mg/m^3 =	0.044 ppm
20 mg/m^3 =	0.02 ppm	45 mg/m^3 =	0.045 ppm
21 mg/m3 =	0.021 ppm	46 mg/m3 =	0.046 ppm
22 mg/m3 =	0.022 ppm	47 mg/m3 =	0.047 ppm
23 mg/m3 =	0.023 ppm	48 mg/m3 =	0.048 ppm
24 mg/m3 =	0.024 ppm	49 mg/m3 =	0.049 ppm
25 mg/m3 =	0.025 ppm	50 mg/m3 =	0.05 ppm

APPENDIX C

Part per million Conversions

mg/m3↔kg/L	1 kg/L = 1000000000 mg/m3	Ppm↔lb/yd3	1 lb/yd3 = 593.27642110147 ppm
mg/m3↔g/L	1 g/L = 1000000 mg/m3	ppm↔lb/gal (UK)	1 lb/gal (UK) = 99776.397913856 ppm
mg/m3↔kg/m3	1 kg/m3 = 1000 ppm	Ppm↔lb/ft3	1 lb/ft3 = 16018.46336974 ppm
ppm↔g/m3	1 ppm = 1 g/m3	ppm↔lb/gal (US)	1 lb/gal (US) = 119826.42730074 ppm
pm↔mg/m3	1 ppm = 1000 mg/m3	Ppm↔oz/in3	1 oz/in3 = 1729994.0439319 ppm
ppm↔g/cm3	1 g/cm3 = 1000000 ppm	Ppm↔oz/ft3	1 oz/ft3 = 1001.1539606087 ppm
ppm↔mg/L	1 ppm = 1 mg/L	Ppm↔oz/yd3	1 oz/yd3 = 37.079776318842 ppm
ppm↔mg/mL	1 mg/mL = 1000 ppm	Ppm↔ton/yd3	1 ton/yd3 = 1307873.3978551 ppm
ppm↔mg/tsp	1 mg/tsp = 5000 ppm	Ppm↔lbs/in3	1 lbs/in3 = 27679904.70291 ppm
ppm↔ug/uL	1 ug/uL = 1000000 ppm	ppm↔per	1 per = 10000 ppm
ppm↔pg/uL	1 ppm = 1000 pg/uL	Ppm↔ppb	1 ppm = 1000 ppb
ppm↔ng/uL	1 ppm = 1 ng/uL	Ppm↔ppt	1 ppm = 1000000000 ppt
ppm↔pg/mL	1 ppm = 1000000 pg/mL	Ppm↔slug/ft3	1 slug/ft3 = 515378.81852553 ppm
ppm↔pg/dL	1 ppm = 100000 pg/dL	Ppm↔mg/dL	1 mg/dL = 10 ppm
ppm↔ug/mL	1 ppm = 1 ug/mL	Ppm↔g/dL	1 g/dL = 10000 ppm
ppm↔ug/dL	1 ppm = 100 ug/dL	Ppm↔ng/ml	1 ppm = 1000 ng/ml
ppm↔ug/L	1 ppm = 1000 ug/L	Ppm↔ng/dL	1 ppm = 100000 ng/dL
ppm↔ng/L	1 ppm = 1000000 ng/L		

APPENDIX D

Readings recorded during electricity supply at Ganaja GSM Village

SAMPLE LOCATIONS	INTERVAL	EASTING	NORTHING	$PM_{2.5}$µg/m	CO ppm	SO_2	NOISE LEVEL dB
MP	0	6.726152	7.793234	201	7.4	0.05	68.2
GE 1	30	6.726399	7.793319	212	10.2	0.09	58.4
GE 2	60	6.726668	7.793253	188	11.8	0.09	48.8
GE 3	90	6.726913	7.793291	149	8.4	0	70.1
GE 4	120	6.727189	7.793348	110	5.6	0.1	55.4
GE 5	150	6.727456	7.793281	205	2.4	0.04	39.4
GE 6	180	6.727761	7.793338	98	0	0.09	28.2
GE 7	210	6.728046	7.793348	41	5.2	0.02	52.6
GE 8	240	6.728313	7.793300	0	0	0.11	45.8
GE 9	270	6.728636	7.793386	24	3.6	0	62.4
GE 10	300	6.728846	7.793348	0	0	0.1	38.2
GS 11	30	6.726171	7.792967	196	10.2	0.07	58.2
GS 12	60	6.726123	7.792767	205	8.4	0.1	70.4
GS 13	90	6.726209	7.792491	224	11.6	0.09	62.5
GS 14	120	6.726133	7.792215	252	9.8	0.1	70.6
GS 15	150	6.726209	7.791987	184	5.4	0	54.2
GS 16	180	6.726199	7.791701	89	10.2	0.06	38.4
GS 17	210	6.726257	7.791406	54	11.4	0.1	68.2
GS 18	240	6.726266	7.791149	218	0	0	28.6
GS 19	270	6.726409	7.790835	264	4.1	0.05	32.8
GS 20	300	6.726371	7.790521	0	0	0.12	74.8
GN 21	30	6.726152	7.793529	182	9.4	0.09	54.8
GN 22	60	6.726085	7.793766	86	11.5	0.1	45.4
GN 23	90	6.726161	7.794033	208	9.8	0.02	30.8
GN 24	120	6.726066	7.794347	155	0	0	55.5
GN 25	150	6.726104	7.794604	94	2.6	0.01	33.6
GN 26	180	6.726085	7.794871	206	6.4	0.04	18.4
GN 27	210	6.726095	7.795166	0	11.8	0.1	20.6
GN 28	240	6.726009	7.795404	18	0	0	42.4
GN 29	270	6.726009	7.795661	32	2.9	0.08	68.2
GN 30	300	6.726000	7.795908	0	6.4	0.08	15.5
GW 31	30	6.725924	7.793224	168	8.6	0.1	64.8
GW 32	60	6.725657	7.793357	185	10.4	0.09	52.6
GW 33	90	6.725381	7.793196	268	9.8	0.12	70.5
GW 34	120	6.725096	7.793167	192	11.6	0.04	61.2
GW 35	150	6.724810	7.793167	148	0	0	48.4
GW 36	180	6.724581	7.793176	252	4.8	0.1	35.5

GW 37	210	6.724315	7.793167	211	0	0.06	42.4
GW 38	240	6.724401	7.793062	142	2.9	0	58.2
GW 39	270	6.723763	7.793167	262	0	0.01	32.4
GW 40	300	6.72342	7.793053	102	6.2	0	22.6

APPENDIX E

Readings recorded during electricity supply at Kpata and Cantonment

SAMPLE LOCATIONS	INTERVAL	EASTING	NORTHING	$PM_{2.5\mu g}/m$	CO ppm	SO_2	NOISE LEVEL dB
MP	0	6.7478622	7.8111942	201	9.2	0.06	64.8
KCN 1	30	6.747909	7.811445	196	6.4	0.1	48.6
KCN 2	60	6.747871	7.811724	146	10.2	0	35.5
KCN 3	90	6.747862	7.811966	205	8.6	0.08	70.4
KCN 4	120	6.747974	7.812255	184	11	0	52.4
KNC 5	150	6.748067	7.812543	128	0	0.04	30.5
KNC 6	180	6.747993	7.812804	94	5.2	0.1	72.6
KNC 7	210	6.747899	7.813092	0	5.4	0	58.2
KNC 8	240	6.748058	7.813418	84	0	0.05	40.5
KNC 9	270	6.748123	7.813622	0	2.1	0.1	61.4
KNC 10	300	6.748039	7.813929	0	0	0	38.6
KCS 11	30	6.748002	7.810980	194	6.8	0.08	64.2
KCS 12	60	6.747871	7.810757	202	8.2	0.02	52.6
KCS 13	90	6.747769	7.810403	176	10.4	0.1	70.4
KCS 14	120	6.747825	7.810180	148	7.8	0.01	48.6
KCS 15	150	6.747890	7.809901	94	10.8	0	36.5
KCS 16	180	6.747806	7.809650	102	11.6	0.09	68.4
KCS 17	210	6.747732	7.809371	243	8.1	0.01	74.2
KCS 18	240	6.747853	7.809073	186	4.8	0	35.6
KCS 19	270	6.747778	7.808840	154	0	0.03	42.8
KCS 20	300	6.747741	7.808571	0	3.8	0	66.4
KCW 21	30	6.747658	7.811222	178	10.4	0.1	58.8
KCW 22	60	6.747369	7.811334	206	8.2	0.09	64.2
KCW 23	90	6.747109	7.811213	198	11.2	0.02	48.4
KCW 24	120	6.746848	7.811138	145	9.6	0.1	52.6
KCW 25	150	6.746597	7.811222	248	5.4	0	60.5
KCW 26	180	6.746262	7.811166	212	8.1	0.1	70.8
KCW 27	210	6.746029	7.811334	252	11.6	0.08	58.4
KCW 28	240	6.745741	7.811231	124	5.1	0.04	75.2
KCW 29	270	6.745536	7.811166	82	0	0.1	68.4
KCW 30	300	6.745229	7.811231	0	4.2	0	50.2
KCE 31	30	6.748160	7.811241	224	10.2	0.09	58.4
KCE 32	60	6.748411	7.811138	186	11.6	0.1	66.8
KCE 33	90	6.748653	7.811222	204	8.4	0.1	70.2
KCE 34	120	6.748932	7.811176	76	5.8	0.09	62.4
KCE 35	150	6.749220	7.811129	0	11.4	0.04	71.4
KCE 36	180	6.749528	7.811203	54	6.4	0	52.6

KCE 37	210	6.749797	7.811324	252	4.8	0.1	35.5
KCE 38	240	6.816944	7.811185	148	0	0	42.4
KCE 39	270	6.750337	7.811176	65	2.4	0.02	68.2
KCE 40	300	6.750625	7.811185	0	0	0	56.1

APPENDIX F

WHO Ambient Air Quality Guidelines

Pollutants	Averaging Period	IFC Guideline value ($\mu g/m^3$)
Sulfur dioxide (SO_2)	24-hour 10 minutes	20 500
Nitrogen dioxide (NO_2)	1 Year 1 hour	40 200
Particulate matter (Pm10)	1 year 24 hours	20 50
Particulate matter ($Pm_{2.5}$)	1 year 24 hours	10 20
Ozone (O_3)	8 hourly daily maximum	100

Source: WORLD BANK/IFC General EHS Guidelines 2007

APPENDIX G

Krejice and Morgan Sample Size Table

Population Size	Confidence = 95%				Confidence = 99%			
	Margin of Error				Margin of Error			
	5.0%	3.5%	2.5%	1.0%	5.0%	3.5%	2.5%	1.0%
10	10	10	10	10	10	10	10	10
20	19	20	20	20	19	20	20	20
30	28	29	29	30	29	29	30	30
50	44	47	48	50	47	48	49	50
75	63	69	72	74	67	71	73	75
100	80	89	94	99	87	93	96	99
150	108	126	137	148	122	135	142	149
200	132	160	177	196	154	174	186	198
250	152	190	215	244	182	211	229	246
300	169	217	251	291	207	246	270	295
400	196	265	318	384	250	309	348	391
500	217	306	377	475	285	365	421	485
600	234	340	432	565	315	416	490	579
700	248	370	481	653	341	462	554	672
800	260	396	526	739	363	503	615	763
1000	278	440	606	906	399	575	727	943
1200	291	474	674	1067	427	636	827	1119
1500	306	515	759	1297	460	712	959	1376
2000	322	563	869	1655	498	808	1141	1785
2500	333	597	952	1984	524	879	1288	2173
3500	346	641	1068	2565	558	977	1510	2890
5000	357	678	1176	3288	586	1066	1734	3842
7500	365	710	1275	4211	610	1147	1960	5165
10000	370	727	1332	4899	622	1193	2098	6239
25000	378	760	1448	6939	646	1285	2399	9972
50000	381	772	1491	8056	655	1318	2520	12455
75000	382	776	1506	8514	658	1330	2563	13583
100000	383	778	1513	8762	659	1336	2585	14227
250000	384	782	1527	9248	662	1347	2626	15555
500000	384	783	1532	9423	663	1350	2640	16055
1000000	384	783	1534	9512	663	1352	2647	16317
2500000	384	784	1536	9567	663	1353	2651	16478
10000000	384	784	1536	9594	663	1354	2653	16560
100000000	384	784	1537	9603	663	1354	2654	16584
300000000	384	784	1537	9603	663	1354	2654	16586

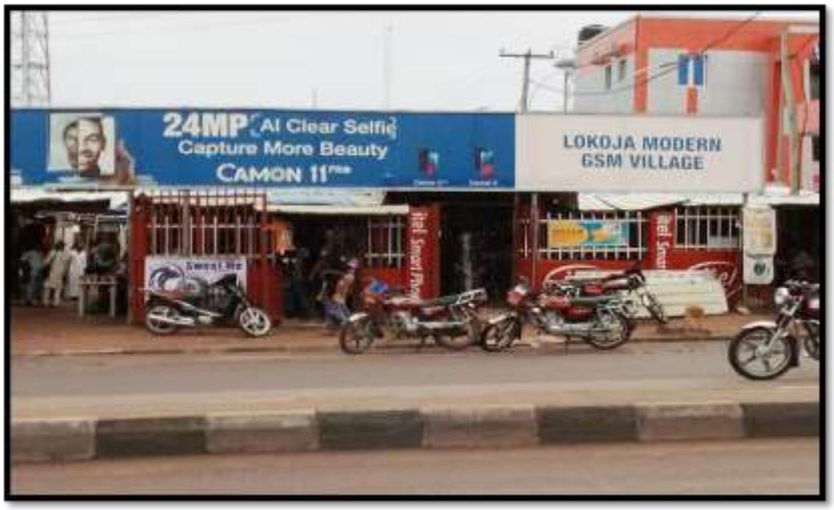
:

APPENDIX H

Ganaja, Kpata and Cantonment GSM Villages

Ganaja GSM Village, Lokoja

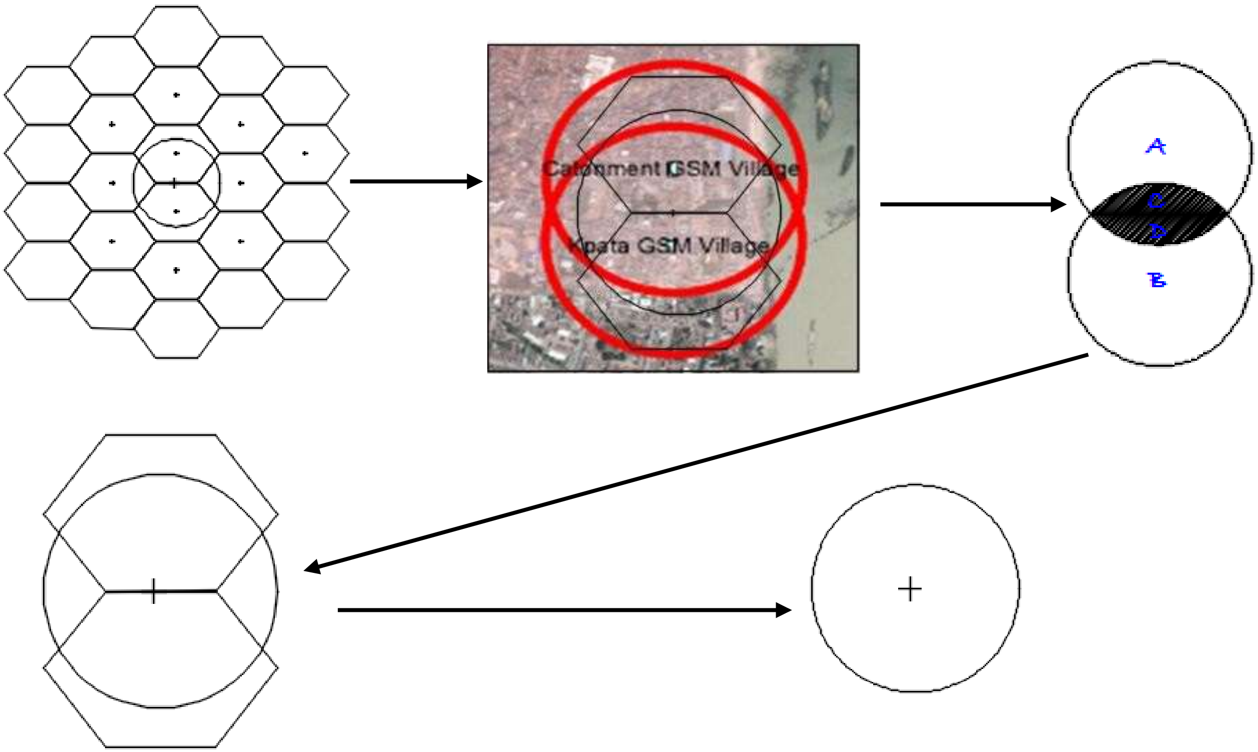
Cantonment GSM Village, Lokoja



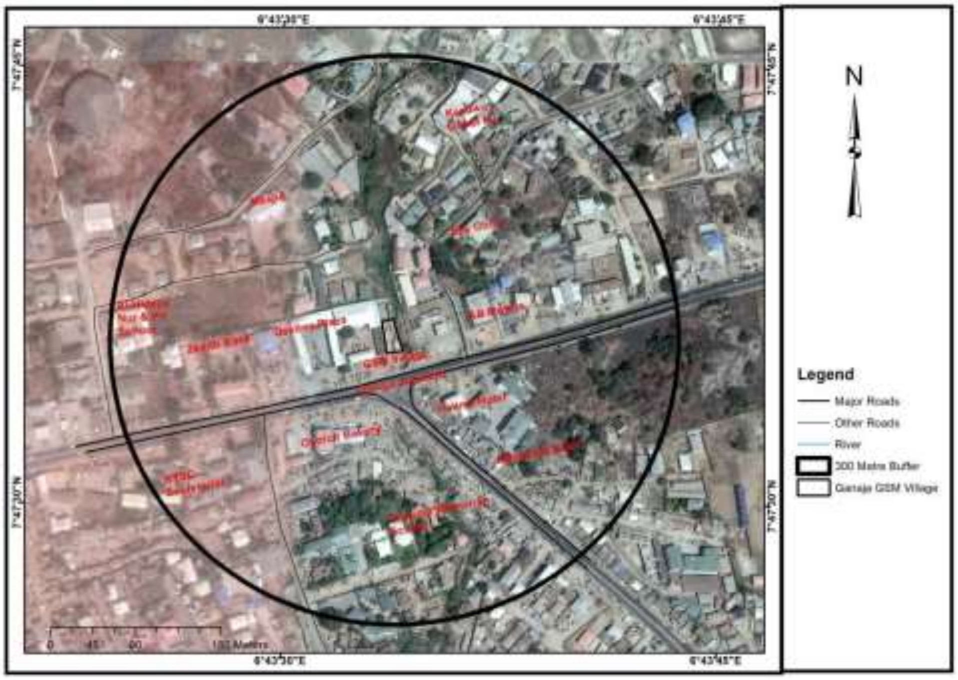
Kpata GSM Village, Lokoja

APPENDIX I

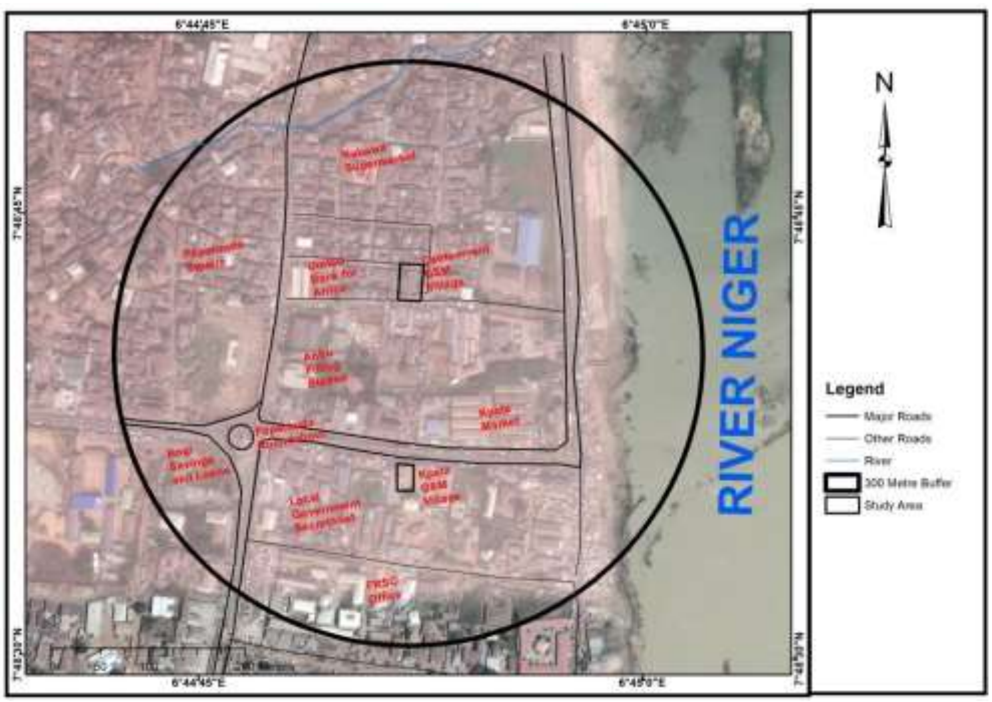
An illustration of Walter Crystaller's Central Place Theory



APPENDIX J



Satellite Imagery of key land uses at Ganaja GSM Village
Source: Author's field survey2019



Satellite Imagery of key land uses at GSM Village Kpata, Cantonment
Source: Author's Field Survey (2019)