

EVALUATION OF NOISE LEVELS FROM VARIOUS SOURCES WITHIN ZARIA
METROPOLIS, KADUNA STATE, NIGERIA

By

Ikenna Ignatius GEORGE, B. ENG (FUT, OWERRI) 2006
MSc/Eng/47955/12-13

DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL ENGINEERING,
FACULTY OF ENGINEERING
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA

DECEMBER, 2016

EVALUATION OF NOISE LEVELS FROM VARIOUS SOURCES WITHIN ZARIA
METROPOLIS, KADUNA STATE, NIGERIA

By

Ikenna Ignatius GEORGE, B. ENG (FUT, OWERRI) 2006
MSc/Eng/47955/12-13

A DISSERTATION SUBMITTED TO THE SCHOOL OF POST GRADUATE STUDIES,
AHMADU BELLO UNIVERSITY, ZARIA,
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF
MASTER DEGREE IN WATER RESOURCES AND ENVIRONMENTAL ENGINEERING
DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL ENGINEERING,
FACULTY OF ENGINEERING
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA

DECEMBER, 2016

DECLARATION

I declare that the work in this dissertation entitled “EVALUATION OF NOISE LEVELS FROM VARIOUS SOURCES WITHIN ZARIA METROPOLIS KADUNA, STATE, NIGERIA” has been performed by me in the Department of Water Resources and Environmental Engineering. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other Institution.

Ikenna Ignatius GEORGE
(M.Sc/Eng/47955/12-13)

Signature

Date

CERTIFICATION

This dissertation entitled “EVALUATION OF NOISE LEVELS FROM VARIOUS SOURCES WITHIN ZARIA METROPOLIS KADUNA STATE, NIGERIA” by Ikenna Ignatius GEORGE, meets the regulations governing the award of the degree of Master in Water Resources and Environmental Engineering of the Ahmadu Bello University, and is approved for its’ contribution to knowledge and literary presentation.

Dr (Mrs) F. B Ibrahim
Chairman Supervisory Committee

Signature

Date

Dr S. B Igboro
Member, Supervisory Committee

Signature

Date

Prof. A. Ismail
Head of Department

Signature

Date

Prof. K. Bala
Dean, School of Postgraduate Studies

Signature

Date

ACKNOWLEDGEMENT

Many Thanks to Almighty God whom through Grace saw me through this work to this point. Beside God, is Dr (Mrs). F. B Ibrahim and Dr S. B Igboro who stood my me to critically supervise all I was doing, gave me direction just to ensure I do the right thing.

I cannot fail to appreciate Prof. C. A Okuofu for his technical assistance, he stood by me from day one we started brainstorming on the best approach.

I appreciate Mr Patrick Ojeah for his sacrifices in sending the noise equipment used from United States of America.

Finally, this appreciation will not be complete without mentioning the pillar of my strength, (My wife, Mrs Atinuke George). I do appreciate her effort and love in taking care of the children even in my late coming back from class during the course of this study.

ABSTRACT

In recent times, noise has been recognized as a major source of pollution in many urban and semi-urban settlements. This study identified the various sources of noise, compared noise levels in various parts of the study area with recommended standards and determined the geo-physical characteristic of noise generated in Zaria metropolis. A noise meter extech model 407750 was used for the noise measurements. A traffic count was conducted in areas where noise levels are high and the possible effects was also determined. The reconnaissance survey carried out shows classification into Transportation and other noise sources and generation in the study area. Other results obtained showed that noise levels at day (L_D) from various sources (Kwangila, PZ and Kofan Doka), areas were 100.79dB (A), 99.77dB (A) and 94.46dB (A) respectively. These measurements were all above the WHO standard limit of 75dB (A). The mean noise level at night (L_N) relatively falls within the standard limit. The study revealed that the commercial, industrial, and transportation noises of the metropolis exceeded the 24 hour WHO noise level quality standard of 65dB (A). The study however showed that the metropolis mean noise level of day and night (L_{DN}) is within the NESREA standards especially in the institutions and schools 45dB (A), residential 54.59 dB (A), industrial 73.78 dB (A), hotels 55.6 dB (A) and religious areas 50.49 dB (A). The average day-night noise level (L_{DN}) obtained is an indication that the noise level of Zaria metropolis is on the average when compared to NESREA standards. The perception of the residents on possible effects of noise to human health revealed that majority of the respondents which constitute 56.3%, 58.2% and 60.6% agreed that noise causes headache, loss of sleep and stress respectively, compared to their counterparts who disagree were 2.8%, 7.5% and 12.5% in that order. Based on these findings, it is recommended that the areas where noise levels are relatively high, planting of trees amongst others should be explored to mitigate the high noise levels.

TABLE OF CONTENTS

COVER PAGE	i
TITLE PAGE.....	iii
DECLARATION	iv
CERTIFICATION	v
ACKNOWLEDGEMENT	vi
ABSTRACT.....	vii
TABLE OF CONTENTS.....	viii
LIST OF TABLE	xii
LIST OF FIGURES	xiii
LISTS OF PLATES	xiv
LIST OF APPENDICES.....	xv
LISTS OF ABBREVIATIONS	xvi
CHAPTER ONE	1
INTRODUCTION	1
1. 1 Preamble	1
1.2 Statement of Research Problem.....	4
1.3 Aim and Objectives	5
1.4 Justification	5
1.5 Scope of the Study	6
1.6. Limitation of the Study	6

CHAPTER TWO	6
LITERATURE REVIEW	6
2.1 Noise Pollution	6
2.2 Global Overview of Noise Pollution Incidences	8
2.3 Fundamentals of Noise	11
2.4 Causes and Sources of Noise Pollution	16
2.5. Effect of Noise Pollution	20
2.5.1 Auditory Effects.....	21
2.5.3 Cardiovascular effects.....	23
2.5.4 Stress.....	24
2.5.5 Annoyance	24
2.5.6 Other Effects of Noise	26
2.6 Noise Pollution Control	27
2.6.1 World Health Organization (WHO)'s Regulations on Noise	28
2.6.2 Noise Reduction Legislation in Nigeria.....	33
CHAPTER THREE	36
MATERIALS AND METHODS.....	36
3.1 Materials	36
3.1.1 Equipment and Field Materials.....	36
3.2 Method.....	37

3.2.1 Reconnaissance Survey.....	37
3.2.2 Noise Level Measurement	38
3.2.3 Measured Equivalent Noise Level (LD, LN, LDN).	38
3.2.4 Spatial Distribution Analysis of Noise Level.	39
3.3 Study Area	39
3.4 Selected Sample Points Areas.....	42
3.5 Determination of Traffic Count	43
3.6 Administration of Questionnaire	43
CHAPTER FOUR.....	44
RESULTS AND DISCUSSIONS.....	44
4.1 Introduction.....	44
4.2 Sources of Noise Generation within Zaria Metropolis.	44
4.3 Variable Geophysical Factors in the Study Area.....	46
4.4 Noise Levels Obtained and Comparison with Standard	47
4.4.2 Noise from Residential Areas	49
4.4.3 Noise from Industrial Areas.....	50
4.4.4 Noise from Educational Areas	51
4.4.5 Noise from Hotel Areas	52
4.5 Noise Generated from Transportation within the Metropolis.....	53
4.5.2 Noise from Aviation Areas	53

4.5.3 Noise from Traffic Areas	54
4.5.4 Noise from Religious Areas.....	55
4.5.5 Noise from Control Area	56
4.6 Volume of Traffic in High Noise Level Areas	56
4.6.1 Volume Composition of In and Out Flow Route Kofan Doka.....	56
4.6.2 Volume Composition of in and out flow Route in Wusasa Axis.....	57
4.7 Spatial Distribution of Noise Generated within the Metropolis.	58
4.7.1 Spatial Pattern of Noise Sample Points within the Metropolis.....	58
4.8 Respondents Perception of Possible Health Effects of Noise Level in the Study Area	
4.8.1 Respondents Knowledge of Noise Pollution (Kwangila, PZ and Kofan Doka).....	62
4.8.2 Respondents Perception on Sources of Noise Generation.....	62
4.8.3 Respondents Perception of Health Effects of Noise	63
CHAPTER FIVE	65
CONCLUSIONS AND RECOMMENDATIONS	65
5.1 Conclusions.....	65
5.3 Recommendation	66
REFERENCE.....	68

LIST OF TABLE

Table	Title	Pages
2.1	Guideline values for community noise in specific environments	33
2.2	Workplace Noise Exposure Limits for Nigeria	37
4.1	Classification of Noise Generation Sources within the Metropolis	45
4.2	Noise Generated from Transportation within the Metropolis	46
4.3	Geo-physical survey of the Study Area	48
4.4	Noise Generation from Commercial Areas	49
4.5	Noise Generation from Residential Areas	51
4.6	Noise Generation from Industrial Areas	52
4.7	Noise Generation from Educational Areas	53
4.8	Noise Generation from Hotel Areas	54
4.9	Noise Generation from Transportation within the Metropolis	55
4.10	Noise Level Obtained from Traffic Areas in Respect to Traffic Count	56
4.11	Noise from Religious Areas	57
4.12	Noise from Control Areas	57
4.13	Respondents Knowledge of Noise Pollution	63
4.14	Respondents Perception of Noise Generation	64
4.15	Respondents Perception on Possible Effects of Noise	65

LIST OF FIGURES

Figure	Title	Pages
3.1	Map of Kaduna State Showing Zaria metropolis	42
4.2	Aerial view of Selected Sample Points in the Study Area	61
4.3	Spatial Distribution of Noise Level within Zaria Metropolis	62

LISTS OF PLATES

Plate		Page
I	Showing Residential Area for LeqM	81
II	Showing Kwangila Measuring Point for LeqE	81
III	Showing MTD Measuring Point for LeqM	82
IV	Showing MTD Measuring Point for LeqA	82
V	Showing MTD Measuring Point for Leq E	83
VI	Showing PZ Cluster Point and Measuring Point LeqM	83
VII	Showing PZ Measuring Point LeqA	84
VIII	Showing Generator Noise Source	84
IX	Showing Commercial Business Area	85
X	Showing Commercial Business Area for Leq A	85
XI	Showing LeqNight Measuring Point	86
XII	Showing LeqNight Measuring Point	86
XIII	Showing LeqNight Measuring Point	87
XIV	Showing LeqNight Measuring Point	87
XV	Showing Leq Measuring Point for Control	88

LIST OF APPENDICES

Appendix		Page
I:	2006 Census Population Distribution by LGA in Kaduna State	77
II:	Weather History Graph obtained within the period of study	78
III:	Structured Questionnaire on possible effects of Noise	79
IV:	Internal Traffic Count: Volume composition of both in and out Flow route, Kofan Doka	81
V:	Internal Traffic Count: Volume composition of both in and out Flow route, Wusasa	82
VI:	Internal Traffic Count: Volume composition of both in and out Flow route, Kwangila Corridor	83
VII:	Plates	84

LISTS OF ABBREVIATIONS

Abbreviations

LAeq	The A-weighted equivalent sound pressure level
LAeqM	The equivalent sound pressure for the morning measurement
LAeqA	The equivalent sound pressure level for the afternoon measurement
LAeqE	The equivalent sound pressure level for the evening measurement
LAeqN	The equivalent sound pressure level for the night measurement
L _D	Day time noise level
L _N	Night time noise level
L _{DN}	Day/Night noise level
NESREA	National Environmental Standards, Regulations and Enforcement Agency
NCAT	Nigerian College of Aviation Technology
Hz	Hertz
L _{max}	Highest Noise Level for the Day

CHAPTER ONE

INTRODUCTION

1. 1 Preamble

Noise may be defined as any sound that is undesired by the recipient. Noise is often referred to as unwanted sound, and is typically characterized by the intensity, frequency, periodicity and duration of the sound. Noise is also an acoustic, electric or electronic signal consisting of a random mixture of wavelengths (λ) (Filippi, 1998). Noise pollution being a byproduct of modern developments in technology is a major constraint on the quality of life in urban settlements. Population explosion and increasing human activities give rise to noise pollution in many cities and urban areas of the world. In most urban areas, according to Mansouri, *et al* (2006), noise pollution is a result of unplanned settlements and is perceived as the least contaminant among all the environmental pollutants.

An important factor for the quality of life in any metropolis is related to the noise levels to which the population is exposed. Several factors interfere with the amount of noise pollution throughout the metropolis. The challenge thus, is the quantification of the noise effects on the population growth in terms of economic, social development and population increase tendency towards noise generation. Noise is a growing health threat, and if left unchecked, could result to hazardous conditions (Adejobi, 2012).

The growth in noise pollution is unsustainable because it involves direct, as well as cumulative, adverse health effects. Due to the ignorance as a factor on human nature, little or no attention is paid to noise pollution in Nigeria. It is on this note, that this study examines the environmental noise levels of Zaria metropolis, one of the ancient towns in northern Nigeria.

In Nigeria, the problem of noise pollution is widespread. A study on environmental noise pollution in Nigerian urban centers found that increase in population, commercial activities and road traffic volume, increase the level of noise generation. Other concomitant noises have been noted to be severe in rapidly expanding cities, towns and regions in Nigeria as observed in the South Eastern States (Onuu, 1992). Noise exposure is not a new phenomenon. Records show that even in medieval times, carriages and horseback riding were banned during the night in some cities in Europe, in order to prevent sleep disturbance (World Health Organization, 2000).

In addition, noise pollution is recognized as a major problem for the quality of life in major urban centre's of the world. Because of the increase in the number of cars and industrialization, noise pollution has also increased. Noise in cities, especially along main arteries, has reached up disturbing levels. Existing evidence indicating that noise pollution may have negative impacts on human health, depending on its duration and volume. The effects of noise on human health and comfort are divided into four categories; physical effects, such as hearing defects; physiological effects, such as increased blood pressure, irregularity of heart rhythms and ulcers; psychological effects, such as disorders, sleeplessness and going to sleep late, irritability and stress; and finally effects on work performance, such as reduction of productivity and misunderstanding what is heard, (Marius et al., 2005).

Noise does not only have harmful effects but sometimes it is very useful. Some of the examples of its usefulness includes:

- i) Study of Heart Beats: Noise produced by the heart beats is very useful to diagnose the person's health accordingly.

- ii) Masking Effects: Sometimes, it is necessary that nobody should hear the conversation between the two persons. For this, masking effect is used. e.g. in the doctor's chamber, doctor wants that nobody should hear his conversation with the patient so he uses masking effect by putting a more noisy exhaust fan which makes noise outside the room.
- iii) Music and Entertainments: the effect energy produced from sounds in a coordinated frequency and amplitude transform unto hear pleasurable (music). This however, translates to entertainment depending on the circumstances.

Fundamentally, sound is produced as result of some mechanical disturbance creating pressure variations in an environment such as air or water, or in fact any elastic medium which can transmit a pressure wave. To be able to hear the sound there must always be air or other elastic medium at the ear. The magnitude of the pressure variations (The amplitude of the pressure oscillation) is proportional to the loudness of the sound. The number of pressure cycle's per-second determines whether we hear a sound of high pitch or of low pitch, the higher the frequency the higher the pitch.

If a device, which can detect small pressure variations (microphone), is placed in the sound field, it will produce an electric signal proportional to the sound pressure. The unit of sound pressure is Pa (Pascal= N/m^2).The range of audible sound pressure variations is very wide ranging from $2 \times 10^{-5} Pa = 20 \mu Pa$, which is threshold of hearing (Pt) to approximately 100 Pa, the threshold of pain (Pp). The ratio between the threshold of hearing and the threshold of pain is 5000 000: 1 equivalent to 134 dB is logarithmic ratio which defines the sound pressure level L as follows: $L = 20 \times \log_{10} p/pref$.

The growth in noise pollution is unsustainable because it involves direct, as well as cumulative, adverse health effects. Due to the ignorance on human nature due to the fact that there exist a close nexus between noise pollution and sustainable city, little or no attention is

paid to noise pollution in Nigeria. It is on this note, that this study examines the environmental noise levels of Zaria metropolis, one of the ancient towns in northern Nigeria.

1.2 Statement of Research Problem

Noise is increasingly a cause of concern in the environment especially in urban areas that are growing in industrialization and transportation activities (Oyedepo *et al.*, 2009). As the demand for air, rail and road transport continues to grow, more people are being exposed to noise from transport and other sources. In Nigeria, the problem of noise pollution is wide spread. A study on noise pollution in Nigerian urban centers found that increase in population, commercial activities and road traffic volume increases the level of noise generation and other concomitant noises have been noted to be severe in rapidly expanding towns and cities and regions in Nigeria such as the South Eastern States (Onuu, 1992). Exposure to Noise is not a new phenomenon, records show that even in medieval era, carriages and horseback riding were banned during night in some cities in Europe in order to prevent sleep disturbance (WHO, 2000). An important factor of life quality in a densely populated area/region is proportional to the noise levels to which the population is exposed to, in terms of economic/commercial activities, social development and population, increases noise generation. Also the connectivity of transport network and traffic density could result to an increase in noise volume generated as observed by Ozer, *et al.*, (2009). Some of the major health effects of noise include hypertension, ischemic heart disease, changes in the immune system and birth defects as observed by Passchier-Vermeer and Passchier, (2000).

In Zaria today, with the rehabilitation and revitalization of the railways, the concern is expected to increase especially the aerodrome of NCAT that is being upgraded. Therefore, exposure to transportation noise will increasingly become an important environmental issue. The direct impact of noise on the human ear is well established and accepted. The effect

result from the noise being a general stressor and so induces conditions like sleep disturbance, mental ill health, physiological dysfunction, distorted speech and poor cognitive performance especially in children.

In search of literature for this study within Zaria metropolis, research has not been conducted on the noise level generated by commercial, residential, industrial and transport activities especially among other sources which this study tends to unravel.

1.3 Aim and Objectives

1.3.1 Aim of the Study

The aim of this study is to evaluate noise level from various sources within Zaria Metropolis, Kaduna State, Nigeria.

1.3.2 Objectives of the Study

The objectives of the study are to;

- i. identify various sources of noise generation in Zaria metropolis Kaduna State, Nigeria.
- ii. determine the Geo-physical characteristics of the study area.
- iii. determine the level of noise generation and traffic volume in areas where noise levels are high within the metropolis and compare with NESREA and WHO standards.
- iv. examine spatial pattern of noise generation in the metropolis.
- v. Describe people's perception of possible effects of noise on human health.

1.4 Justification

The world indeed is changing especially on the rate of urbanization and industrialization; the outcome of this study will thus make a great impact in devising means of putting in place

control measures for noise pollution and environmental sustainability in Zaria metropolis. The need to develop understanding, not only of the magnitude of the effects of noise and exposure-effects relationship in order to trigger interventions and policy; but also to consider the mechanisms of the effects such as the role of annoyance, adaptation, habituation, acclimation and coping strategies in non-auditory impacts of noise (Okuofu, 2014). The findings of this study when published and publicized will help the people to be aware of the level of noise pollution in the metropolis the major characteristic contributions of noise pollution to the environment and reduction measures appropriate

1.5 Scope of the Study

The scope of this study covers Zaria Metropolis. Within the limit of the scope, various noise levels from industrial, commercial, educational/institutional, residential, recreational and religious areas and a control area at Angwan Fulani will be sourced and evaluated.

1.6. Limitation of the Study

Every research has one limitation or the other; certainly, the greatest limitation for this study was lack of sophisticated equipment's, finance and duration/period of the assessment/analysis and possible means of being in all the sample points/fields the same time.

CHAPTER TWO

LITERATURE REVIEW

2.1 Noise Pollution

Noise pollution, being a product of urbanization and industrialization, is now recognized as a major problem in urban areas with many adverse effects (Nathaniel, 2007; Pathak, Tripathi and Mishra, 2008). Noise pollution is one of the major environmental pollutants that have direct effects on human performance (Kryter, 1985). The survival and healthy existence of

man depend largely on the enabling environment where he resides, as disruption in the conducive environment may lead to dysfunction in his health status (Passchier-Vermeer and Passchier, 2000). According to Oyedepo and Saadu (2010) the most important factors raising noise pollution in urban areas are vehicular traffic, railway and air traffic. On the other hand, Amrah, Al-Omari and Sharabi (2006) estimated that vehicular traffic contributes to about 55% of the total urban noise. This is attributable to the substantial growth in the number of vehicles, expansion of road network, industrialization and urbanization.

In other words, noise is derived from the Latin word “nausea” implying ‘unwanted sound’ or ‘sound that is loud, unpleasant or unexpected (Singh and Davar, 2004). Sound is usually measured in decibel. Decibel is a standard of measurement of sound of which whisper measures 20db while a noise in a quiet office measures 40db, the normal conversation measures 60db and a level of sound above 80db is referred to as noise (Miglani, 2010). Noise is considered as pollution because of the noxious and unwanted sound that it emits into the environment. It is also seen as a significant environmental problem in rapidly developing built-up cities. This is further asserted by Oyedepo (2012) who submitted that noise pollution in Nigeria cities is relatively high when compared to recommended levels by World Health Organization.

Traffic noise on the other hand is probably the most rigorous and pervasive type of noise pollution (Ohrstrom and Skanberg, 2004). Traffic noise has become a serious problem in recent times because of inadequate urban planning of the city in the past. Homes, schools, offices, hospitals, commercial business centres, and other structures are routinely built close to the main roads of the municipality without buffer zones or adequate sound proofing. The problem has been compounded by increases in traffic volumes (two wheelers, heavy motor vehicles, and other vehicles) far beyond the expectations of our early urban planners. This

alarming increase in the volume of traffic is actually inversely related to the degradation of the environment (Ouis, 2001). Noise pollution is one of the major environmental pollutants that are encountered in daily life and has direct effects on human performance.

2.2 Global Overview of Noise Pollution Incidences

Much of the information available on noise pollution come from researches conducted in Europe, America, Sweden, India and Japan. The levels of environmental noise vary for a substantial part of the world population, especially in areas with a dense population and dense transportation networks. It is estimated that in the European Union during daytime approximately 77 million people (22% of the total EU population in 1994) are exposed to transportation noise levels exceeding 65 dB, a level that many countries consider to be unacceptable (Miedema, 2007).

Environmental noise, like other forms of pollution, has wide-ranging adverse health, social, and economic effects. Numerous studies on the adverse health effects of noise, many of recent vintage, have been published for a comprehensive overview, see Miedema (2007) and Goines and Hagles (2007). It has been found that noise interferes with behavior, including communication and concentrated activity, or desired states, such as relaxation and sleep. Noise exposure can lead to acute stress responses and/or chronic stress, and can even lead to cardio-vascular and mental health disturbances. In terms of urban planning, noise has been found to interfere with home values and the cost of building and operating new construction. In Germany- based post-occupancy surveys, the acoustic environment, specifically the lack of adequate speech privacy and control of noise levels, has been a major complaint with respect to the ability to carry out work tasks (Jansen, 1992). A study conducted in Holland (Nijland *et al.*, 2007) suggested that noise-sensitive people are less satisfied with their living environment and are more willing to move than others. Another study investigating the

combined effects of noise and temperature on human thermal comfort and task performance found that thermal comfort was affected by noise levels, while ratings of building or office noise were not affected by the ambient temperature (Tiller *et al.*, 2010).

In a related study involving 4.6 million persons above the age of 30 years in Switzerland, (Huss *et al.*, 2010) revealed that exposure to aircraft noise caused myocardial infarction resulting in death. There was a dose-response relationship for the level of and duration of exposure to the noise. No association of the more than 15,000 mortalities was found with air pollution (particulate matter) or socio-economic status of the municipality. The other disease, studied (circulatory diseases, cerebrovascular disease, stroke and lung cancer) did not have any association with aircraft noise.

Being able to cope with daily noise is important for human well-being and health. The effects of environmental noise depend on acoustical characteristics of the noise (e.g., loudness, time pattern), and on aspects of the noise situation that may involve cognitive processing, such as expectations regarding the future development of the noise exposure (whether will it get better or worse), lack of short-term predictability, and a feeling of lack of control over the source of the noise. People differ in their appraisal of noise situations and in their coping style (Cohen and Weinstein, 1981). However, environmental noise is not only a personal matter, but also a societal problem that is beyond the control of most individuals. Unfortunately, noise is still considered a relatively minor form of pollution and public awareness on its negative effects is lower than for air pollution which is sufficiently short to permit detection and display of transient (rapidly changing) noise in a way resembling the human perception of sound.

In Alberta, Canada, measurements of the A-weighted impulse response setting sound level measurement and the A-weighted slow-response setting sound level are taken. If the

difference is 10 dBA or less, the impulsive sound is not deemed significant (AEUB, 1999). The maximum penalty for impulsiveness varies from country to country, and both subjective (based on the type of source, using a list enumerating noise sources such as hammering, explosives, etc.) and objective methods are used to determine the penalty. In Colorado and Denmark, a 5 dB penalty is added for impulsive noise, while in France a penalty of 3, 5 or 10 dB is assessed, depending on the duration of the impulsive noise (Bruel and Kjaer, 2000).

Whereas, in Nigeria, the problem of noise pollution is wide spread, several studies report that noise level in metropolitan cities exceeds specified standard limits. A study by Ugwuanyi et al, (2004) conducted in Makurdi, Nigeria found that the noise pollution level in the city was about 3 dB (A) to 10 dB (A) above the recommended upper limit of 82 dB (A). Anomohanran *et al.*, (2008) also found that the peak noise level at road junction in Abraka, south-south Nigeria to be 100 dB (A). This noise level is higher than the recommended level of 60 dB (A) for commercial and residential areas. Ighoroje *et al.*, (2004) investigated the level of noise pollution in selected industrial locations in Benin City, Nigeria and found that most industrial areas within the city, produces noise above the recommended standards.

On the other hand, irrespective of the noise sources, annoyance is the most reported problem caused by exposure to transport noise and certain factors determine the annoyance response of individuals. These factors are either acoustic factors or non-acoustic factors. The acoustic, factors include: noise source, exposure level, and time of day of exposure, Non-acoustic factors include: the extent of the interference experienced, ability to cope, expectations, fear associated with the source of the noise, individual noise sensitivity, anger and beliefs about whether or not the noise can be reduced by those responsible (Okuofu, 2014).

Although a few Nigerian studies as earlier mentioned above as carried out in the areas like that of traffic and other concomitant noises have been noted to be severe in rapidly expanding

cities and towns and regions in Nigeria such studies in Ilorin by Oyedepo and Saadu, (2010b); Kupolati, *et al.*, (2010); and Akure by Fadairo (2013). This is mostly attributed to poor transportation decisions and poor urban planning and management of these cities etc. However, studies like that of Omubo-Pepple *et al.*, (2010) are available, the study focused on the general noise pollution problems in the Port-Harcourt metropolis and not necessarily transportation noise. According to Clark and Stanfeld, (2007), “noise is a main cause of environmental annoyance and it negatively affects the quality of life of a large proportion of the population”. In addition, health and cognitive effects although modest, may be of importance given the number of people increasingly been exposed to environmental noise and the chronic nature of exposure.

Additionally, Midema and Vos (1998) found that aircraft noise produces greater annoyance responses than road traffic noise at the same level of exposure. Most outdoor noise worldwide comes from sources like construction and transportation systems. The transportation noise sources include motor vehicles, aircraft, and railways. Road traffic noise is a function of traffic volume, composition, speed, road characteristics (surface and gradient) (Okuofu, 2014).

Moreso, in Zaria metropolis, not much work has been done in the metropolis. However, the essence of this work will unfold the level of noise generation within Zaria and compared with NESREA and the world health organization noise level standard within the Zaria metropolis and thus identify and examine the extents of noise level generation in the metropolis.

2.3 Fundamentals of Noise

Noise is generally considered to be unwanted sound. Sound is what we hear when our ears are exposed to small pressure fluctuations in the air. There are many ways in which pressure fluctuations are generated, but typically they are caused by vibrating movement of a solid

object. Also, impulsive noise as defined by Breul *et al.*, (2000) is brief and abrupt noise, and its startling effect causes greater annoyance than would be expected from a simple measurement of sound pressure level. Impulsive sounds, such as gun shots, hammer blows, explosions of fireworks or other blasts, are sounds that significantly exceed the background sound pressure level for a very short duration. Typically each impulse lasts less than one second. Measurements with a sound meter set to 'Fast' response do not accurately represent impulsive sounds. To cope with this, a third time constant called I (for impulse) has been developed. The time constant of I is 35 milliseconds.

Noise can be described in terms of three variables:

- Amplitude (loud or soft)
- Frequency (pitch) and
- Time Pattern (variability).

Amplitude: Loudness of a sound depends on the amplitude of the fluctuations above and below atmospheric pressure associated with a particular sound wave. The mean value of the alternating positive and negative pressure fluctuations is the static atmospheric pressure, not a useful descriptor of sound. However, the effective magnitude of the sound pressure in a sound wave can be expressed by the “root-mean-square” (rms) of the oscillating pressure measured in Pascals, a unit named after Blaise Pascal a 17th century French mathematician. In calculation of the ‘rms’, the values of sound pressure are squared to make them all positive and time-averaged to smooth out variations. The ‘rms’ pressure is the square root of this time-averaged value. The quietest sound that can be heard by most humans, the “threshold of hearing,” is a sound pressure of about 20 microPascals, and the loudest sounds typically found in our environment range up to 20 million microPascals. Because of the difficulty in dealing with such an extreme range of numbers, acousticians use a compressed scale based

on logarithms of the ratios of the sound energy contained in the wave related to the square of sound pressures instead of the sound pressures themselves, resulting in the “sound pressure level” in decibels (dB). The ‘B’ in dB is always capitalized because the unit is named after Alexander Graham Bell, a leading 19th century innovator in communication. Sound pressure level (L_p) is defined as: $L_p = 10 \log_{10} (p_{rms}^2 / p_{ref}^2) = 20 \log_{10} (p_{rms} / p_{ref})$ dB, where $p_{ref} = 20$ microPascals. Inserting the range of sound pressure values mentioned above results in the threshold of hearing at 20 microPascals at 0 dB and a typical loudest sound of 20 million microPascals is 120 dB (Leventhal, G. 2003).

Frequency: Sound is a fluctuation of air pressure. The number of times the fluctuation occurs in one second is called its frequency. A large proportion of low-frequency components in noise may increase considerably the adverse effects on health. Low frequency noise can disturb rest and sleep even at low sound levels. Low frequency noise does not have a consistent definition, but it is commonly defined as noise that has a frequency between 20 and 100 - 150 Hz. Noise at levels below 20 Hz is referred to as infrasound (Bruel and Kjaer, 2000). Depending on the actual conditions, many types of noise can be regarded as low frequency noise. Low frequency noise and infrasound are produced by machinery, both rotational and reciprocating, and all forms of transport and turbulence. Typical sources include pumps, compressors, diesel engines, aircraft and fans. Also, Combustion turbines are capable of producing high levels of low frequency noise. This noise is generated by the exhaust gas. Meanwhile, the firing rate of many diesel engines is usually below 100 Hz, so road traffic noise can be regarded as low frequency. Similar considerations can be made for engines or compressors in industries or co-production plants. Burners can emit broadband low frequency flame roar.

Bruel and Kjaer, (2000), assertion in a study of the magnitude and impact analysis of road traffic noise pollution in Bangladesh shows that, low frequency noise can be noise vibration from traffic and industries, totally or partly transmitted through the ground as vibration and reradiated from the floor of the walls in the dwelling.

Low frequency noise creates a large potential for community annoyance. It is most often experienced inside of homes and buildings where resonance amplifies the sound. It is a general observation that indoor noise is perceived as more "low-frequency-like" than the same noise heard out of doors (Poulsen *et al.*, 2002).

In acoustics, frequency is quantified in cycles per second, or Hertz (abbreviated, Hz), named after Heinrich Hertz, a famous 19th century German physicist. Some sounds, like whistles, are associated with a single frequency; this type of sound is called a "pure tone." Most often, however, noise is made up of many frequencies, all blended together in a spectrum. Human hearing covers the frequency range of 20 Hz to 20,000 Hz. If the spectrum is dominated by many low frequency components, the noise will have a characteristic like the rumble of thunder. Low frequencies are associated with long wavelengths of sound. Conversely, high frequencies are the result of short wavelengths. The way in which frequency and wavelength of sound waves are related is the speed of sound. The relationship is: $f\lambda = c$, where
f = frequency in cycles per second (Hz)

λ = wavelength in feet, and

c = speed of sound in feet per second.

The speed of sound in air varies with temperature, but at standard conditions is approximately 1000 feet per second. Therefore, according to the equation, a frequency of 1000 Hz has a

wavelength of 1 foot and a frequency of 50 Hz has a wavelength of 20 feet. The scale of these waves explains in part the reason humans perceive sounds of 1000 Hz better than those of 50 Hz – the wavelengths are similar to the size of the receiver's head. Waves of 20 feet in length at 50 Hz are house-sized, which is why low-frequency sounds, such as those from idling locomotives, are not deterred by walls and windows of a home. These sounds transmit indoors with relatively little reduction in strength Olayinka *et al.*, (2008).

Time Pattern/Noise-Exposure Analogy for Leq and L_{DN}: The one-hour noise time history in the middle frame of the figure is analogous to one hour of rainfall, that is, the total accumulation of rain over this one-hour period. Note that every rain shower increases the one-hour accumulation. Also, note that heavier showers increase the amount more than do lighter ones, and longer showers increase the amount more than shorter ones. The same is true for noise, every transit event increases the one-hour noise exposure, loud events increase the noise exposure more than do quieter ones, and events that stretch out longer in time increase the noise exposure more than shorter ones.

Unfortunately, the word "average" leaves many people with the impression that the maximum levels which attract their attention are being devalued or ignored. They are not just as all the rains that fall in the rain gauge in one hour counts toward the total, all sounds are included in the one-hour noise exposure that underlies Leq and in the 24-hour noise exposure that underlies L_{DN}. None of the noise is being ignored, even though the Leq and L_{DN} are often numerically lower than many maximum A-weighted Sound Levels. Noise exposure includes all transit events, all noise levels that occur during their time periods without exception. Every added event, even the quiet ones, will increase the noise exposure, and therefore increase Leq and L_{DN}.

Neither the L_{eq} nor the L_{DN} is an "average" in the normal sense of the word, where introduction of a quiet event would pull down the average. Furthermore, similar to the effect of rainfall in watering a field or garden, scientific evidence strongly indicates that total noise exposure is the truest measure of noise impact.

Computing transit noise impact on the basis of the highest L_{max} of the day, for example, as "loudest L_{max} equals 90 dBA?" If that were done, then there would be no difference in noise impact between a main trunk line and a suburban branch line; one pass by per day would be no better than 100 per day, if the loudest level remained unchanged. Clearly such a reduction in number-of-pass by is a true benefit, so it should reduce the numerical measure of impact. It does with L_{eq} and L_{DN} , but not with L_{max} . In addition, if assessments were made just on the loudest pass by, then one pass by at 90 dBA would be worse than 100 pass by at 89 dBA. Clearly this is not true. Both L_{eq} and L_{DN} increase with the number of pass by, while L_{max} does not. Both the L_{eq} and the L_{DN} combine the number of pass by with each pass by L_{max} and duration, all into a cumulative noise exposure, with mathematics that make sense from an annoyance point of view. L_{eq} and L_{DN} mathematics produce results that correlate well with independent tests of noise annoyance from all types of noise sources.

2.4 Causes and Sources of Noise Pollution

Noise pollution emanates from various sources and the impacts on humans and the environment differs significantly by their sources. Noise may be generated according to daily activities. The source may be domestic (utensils, cutleries, cutting and peeling etc.), due to natural causes (water movement e.g. water falls, tides, birds/animal sound, wind movement, commercial activities (advertisements, automobiles, aircraft, machinery etc.), individual activities (boilers, generators, drilling machines, pumps, motors and pneumatic equipment). etc. Most outdoor noise worldwide comes from sources like construction and transportation

systems. The transportation noise sources include motor vehicles, aircraft, and railways. Also, poor planning may give rise to noise pollution in urban areas especially in those residential areas located close to or adjacent to industrial establishments. Other sources of noise include burglar alarms, fireworks, factories, loudspeakers, radios, music systems and other electronic gadgets (Okuofu, 2014).

The most significant source is from transportation, particularly traffic noise. Highway noise emanates from three sources: (a) the engine, (b) the exhaust, and (c) the friction vehicle of the tyres on the road. Once typical highway speeds are reached, the predominant noise from light trucks and cars is from the tire/road interaction. Heavy trucks produce a high volume of noise from all three sources even at low speeds (Chepesiuk, 2005). The level of road traffic noise depends on three factors:

- i. The volume of traffic,
- ii. The speed at which the traffic moves, and
- iii. The number of vehicles in the flow of traffic.

Generally, heavier traffic volumes, higher speeds, and greater numbers of trucks increase the loudness of traffic noise. Vehicle noise as a result of defective mufflers or other faulty equipment on the vehicle can also intensify increase the combination of the noises produced by the engine, exhaust, and tyres; resulting in the particular noise level of traffic. Any conditions (such as a steep incline) that cause the heavy laboring of a motor vehicle engine will also increase traffic noise levels. In addition, there are other more complicated factors that affect traffic noise levels. For example, the further a person moves away a main road, the more likely there will be a reduction in the traffic noise levels. In this case, the terrain, vegetation, and natural and human-made obstacles will dampen the noise effect from the road. Traffic noise is not usually a serious problem for people who live more than 160m from

heavily traveled freeways Chepesiuk (2005).

2.4.1 Transportation Noise Sources

Traffic noise is probably the most rigorous and pervasive type of noise pollution (Ohrstrom and Skanberg, 2004). A survey by Stephenson *et al.*, (2008) in London, confirmed that traffic was the main source of noise in Central London, and details are given of two experiments on measuring the noise contributions made by different types of vehicle. Their assertions were that solely lorries and buses contribute to high noise levels as a function of gradients and speed. The findings show that an urban motorway have a major influence on the noise environment of the future and with respect to traffic volume and distance from the motorways as to control through planning to mitigate the effect of traffic noise on the environment is paramount, with special reference to the use of barriers.

Traffic noise has become a serious problem nowadays because of inadequate urban planning of the city in the past. Homes, schools, offices, hospitals, commercial business centers, and other structures are routinely built close to the main roads of the municipality without buffer zones or adequate sound proofing. The problem has been compounded by increases in traffic volumes (two wheelers, heavy motor vehicles, and other vehicles) far beyond the expectations of our early urban planners. This alarming increase in the volume of traffic is actually inversely related to the degradation of the environment (Ouis, 2001). Noise pollution is one of the major environmental pollutants that are encountered in daily life and has direct effects on human performance.

In a different study of present day traffic noise survey in Nigeria, Omu, (2000) described road side surveys of the noise emitted by freely flowing traffic on sites ranging from motorways to urban roads as the assertions provide an indication of present day traffic noise

conditions against which future comparisons may be made and also show how basic variables such as traffic density, speed and composition, and distance from roadside affect the observed patterns of noise.

Traffic noise needs to be described in physical terms such that measurements or predictions of noise exposure in these units are effectively measurements or predictions of nuisance. Such units are developed by the means of social surveys, and typical survey techniques are briefly described of the three current proposals: Wilson proposals, traffic noise index and mean energy level. The Wilson proposals fail the requirements of a physical unit intended to be the basis of traffic noise control because of the lack of demonstrated correlation of noise levels with nuisance. Both traffic noise index and mean energy level have been shown to correlate well with nuisance but nevertheless the formulations of these two units are, in some respects, conflicting.

2.4.2 Environmental Noise Sources

Noise is defined as unwanted sound (Schmidt, 2005) Ambient noise or environmental noise is unwanted or harmful outdoor sounds created by human activities, including noise emitted through means of transport (e.g. road traffic, air traffic) and noise from sites of industrial activity (Goines and Hagler, 2007).

Environmental noise pollution is a threat to the health and well-being of human-kind. It is more severe and widespread than ever before, and it will continue to increase in magnitude and severity on account of present societal trends namely population growth and urbanization. Its severity will intensify, in relation with the increase in the use of progressively more powerful, varied, and highly mobile sources of noise. Noise levels will also continue to rise with sustained growth in highway, rail, and air traffic, the major sources

of environmental noise (Schell *et al.*, 2006).

Environmental noise pollution is not an entirely new phenomenon, but rather a problem that has grown gradually with time. Although environmental noise is primarily an urban problem, the noise of machines that humankind insists on building is increasingly bringing noise pollution to the few remaining wild sanctuaries in the world. Environmental noise pollution may not pose the threat of immediate destruction that nuclear war does, but one should bear in mind that the effects are the same and just as lasting (Dooley, 2002).

Escape from human-induced sound is markedly more difficult today than a century ago, and within another half-century it may be all but impossible. One might well ask how humankind arrived at the present state of affairs. Several causative factors would seem to be responsible (Schell *et al.*, 2006). Perhaps most important has been the consistent submission to technology and the ever-increasing construction of high-density developments, the reason being that for each and every development:

- i. There is an increase in the number of motor vehicles.
- ii. Noise, unlike air and water pollution, cannot be visually determined and leaves no visible record of its presence.
- iii. Noise is inherently a technical problem which the ordinary citizen has great difficulty in understanding. While humankind does not understand the complex make-up of noise pollution, it is nevertheless obvious that noise is a form of pollution that's demands remedial action by government (Schell *et al.*, 2006).

2.5. Effect of Noise Pollution

A study by Rosenlund *et al.*, (2001), has demonstrated an increase prevalence of high blood pressure with people exposed to aircraft noise. The study was carried out from people within

the ages of 18 and 80 years and effects were greatest among the elderly. Another study by Jarup *et al.*, (2008) also revealed a relationship of daily traffic noise and night time aircraft noise and an increase in blood pressure.

Noise has become a very important “stress factor” in the environment of man. It has many effects on exposed population. It can have a number of undesirable effects depending upon its intensity, frequency, duration and time of the day when it occurs. The various effects of noise pollution on human beings are classified as auditory effects (directly affecting ear & hearing ability) and non-auditory effects (affecting other physiological process). Similarly, noise can show various detrimental effects on other living organisms like plants and animals.

2.5.1 Auditory Effects

The most acute and immediate effect of noise pollution is impairing of hearing which may cause auditory fatigue and may even finally lead to deafness. Auditory fatigue occurs when exposed to noise levels of 90 dB or above. In metro cities, most of the shopkeepers, cobblers, fruit sellers complain tinnitus in ear. For instance, Donatelle, (2002) reported that high level noise will result into hearing loss. Also evidences abound that constant noise exposure can damage sensitive structures in the ear. Noise-induced hearing loss, the second to age induced hearing loss results from damage of the hair cells of the cochlea in the inner ear arising from continuous exposure to recreational and occupational noise (Focus, 2002). Blasts and other intense or explosive sounds can rupture the eardrum or cause immediate damage to the structures of the middle and inner ear, while, hearing loss due to prolonged noise exposure is generally associated with destruction of the hair cells of the inner ear (Olaosun *et al.*, 2009).

Furthermore, deafness occurs when exposed to loud noise. The workers working in the noisy workplace environment may suffer from Noise Induced Hearing Loss (NIHL). Hearing loss

may be temporary or permanent. Prolonged exposure to high noise levels leads to permanent deafness.

Also, the mechanism of hearing loss arises from trauma to stereo cilia of the cochlea, the principal fluid filled structure of the inner ear. The pinna, combined with the middle ear amplifies sound pressure levels by a factor of twenty, so that extremely high sound pressure levels arrive in the cochlea, even from moderate atmospheric sound stimuli. Exposure to high levels of noise have differing effects within a given population, and the involvement of reactive oxygen species suggests possible avenues to treat or prevent damage to hearing and related cellular structures.

The elevated sound levels cause trauma to cochlear structure in the inner ear, which gives rise to irreversible hearing loss. A very loud sound in a particular frequency range can damage the cochlea's hair cells that respond to that range thereby reducing the ear's ability to hear those frequencies in the future. However, loud noise in any frequency range has deleterious effects across the entire range of human hearing. The outer ear (visible portion of the human ear) combined with the middle ear amplifies sound levels by a factor of 20 when sound reaches the inner ear.

Hearing loss is somewhat inevitable with age. Though older males exposed to significant occupational noise demonstrate significantly reduced hearing sensitivity than their non-exposed peers, differences in hearing sensitivity decrease with time and the two groups are indistinguishable by age 79. Women exposed to occupational noise do not differ from their peers in hearing sensitivity, though they do hear well than their non-exposed male counterparts. Due to loud music and a generally noisy environment, young people in the United States have a rate of impaired hearing 2.5 times greater than their parents and 25

grandparents, with an estimated 50 million individuals with impaired hearing estimated in 2050.

2.5.2 Non-auditory Effects

Non-auditory effects are also alarming, because of the fact that they also cause severe diseases. It includes interference with speech communication, annoyance leading to ill-temper, mental disturbance and violent behavior. It also causes loss of working efficiency due to physiological disorder. Physiological disorders associated with noise include increase heart rate, increase in blood pressure, and change in skin temperature and blood circulation, Cardio-vascular diseases, and change in levels of hormones. In females, the chances of miscarriage and congenital birth defects are more in noisy environment ([http://en.wikipedia.org/wiki/health effect from noise](http://en.wikipedia.org/wiki/health_effect_from_noise)).

2.5.3 Cardiovascular effects

Noise has been associated with important cardiovascular health problems. In 1999, the World Health Organization concluded that the available evidence suggested a weak association between long-term noise exposure above 67-70 dB (A) and hypertension.

High noise level was discovered to cause stress and high blood pressure which is the leading cause of health problems (Mead, 2007). Studies have revealed a significant relationship between daily traffic noise and night time aircraft noise and an increase in blood pressure (Jarup *et al.*, 2008) and association between road traffic noise and self-reported doctor diagnosed hypertension (Bluhm, Berglind, Nordling and Rosenlund, 2007).

Fairly typical roadway noise levels are sufficient to constrict arterial blood flow and lead to elevated blood pressure; in this case, it appears that a certain fraction of the population is more susceptible to vasoconstriction. This may result because annoyance from the sound causes elevated adrenaline levels trigger a narrowing of the blood vessels (vasoconstriction),

or independently through medical stress reactions. Other effects of high noise levels are increased frequency of headaches, fatigue, stomach ulcers and vertigo.

2.5.4 Stress

For instance, children from noisy areas have been found to have heightened sympathetic arousal indicated by increased levels of stress related hormones, likewise, those working in noisy office environments have also been found to be less cognitively motivated, and to have higher stress levels (Holmes, 1995). Research commissioned by Rockwool, a UK insulation manufacturer, revealed that in the UK one third (33%) of victims of domestic disturbances claim loud parties have left them unable to sleep or made them stressed in the last two years, whereas, almost one in ten (9%) of those affected by domestic disturbances claim it has left them continually disturbed and stressed. Over 1.8 26 million people claim noisy neighbours have made their life a misery and they cannot enjoy their own homes. The impact of noise on health is potentially a significant problem across the UK given over 17.5 million Britons (38%) have been disturbed by the inhabitants of neighboring properties in the last two years. For almost one in ten (7%) Britons this is a regular occurrence.

2.5.5 Annoyance

Annoyance arising from traffic noise may be associated with the disturbance that goes with noise. Studies on traffic and aircraft noise have shown that noise level have been associated with annoyance in a close-response relationship and fear of the noise source and sensitivity to noise were both found to strongly affect the annoyance from noise (Miedema and Vos, 1999). Because some stressful effects depend on qualities of the sound other than its absolute decibel value, the annoyance associated with sound may need to be considered with regard

to health effects. For example, noise from airports is typically perceived as more disturbing than noise from traffic of equal volume. Annoyance effects of noise are minimally affected by demographics, but fear of the noise source and sensitivity to noise both strongly affect the 'annoyance' of a noise. Even sound levels as low as 40 dB(A) (about as loud as a refrigerator or library) can generate noise complaints and the lower threshold for noise producing sleep disturbance is 45 dB(A) or lower.

Other factors that affect the 'annoyance level' of sound include beliefs about noise prevention and the importance of the noise source, and annoyance at the cause (i.e. non-noise related factors) of the noise. For instance, in an office setting, audible telephone conversations and discussions between co-workers were considered to be irritating, depending upon the contents of the conversations. Many of the interpretations of the level of annoyance and the relationship between noise levels and resulting health symptoms could be influenced by the quality of interpersonal relationships at the workplace, as well as the stress level generated by the work itself. Evidence regarding the impact of long-term noise versus recent changes in ongoing noise is equivocal on its impact on annoyance.

When young children are exposed to speech interference levels of noise on a regular basis (the actual volume of which varies depending on distance and loudness of the speaker), they may develop speech or reading difficulties, because auditory processing functions are compromised. Children continue to develop their speech perception abilities until they reach their teenage years. Evidence has shown that when children learn in noisier classrooms, they have a more difficult time understanding speech than those who learn in quieter settings. In a study conducted by Cornell University in 1993, children exposed to noise in learning environments experienced trouble with word discrimination as well as various cognitive developmental delays. For instance, writing and learning impairment known as dysgraphia

is commonly associated with environmental stressors in the classroom. The effect of high noise levels on small children has been known to cause physical health damages as well. Children from noisy residences often possess a heart rate that is significantly higher (by 2 beats/min on average) than in children from quieter residences.

Furthermore, studies have shown that neighborhood noise (consisting of noise from neighboring apartments, as well as noise within one's own apartment or home) can cause significant irritation and noise stress within people, due to the great deal of time people spend within their residences. This can result in an increased risk of depression and psychological disorders, migraines, and even emotional stress.

In the workplace, noise pollution is generally a problem once the noise level is greater than 55 dB (A). Selected studies show that approximately 35 to 40% of workers in office settings find noise levels from 55 to 60 dB (A) to be extremely irritating. In fact, the noise standard in Germany for mentally stressful tasks is set at 55 dB (A). However, if the noise is source is continuous, the threshold level for tolerable noise levels amongst office workers actually becomes lower than 55 dB (A).

One important effect of noise is to make a person's speech less easy to hear. The human brain automatically compensates the production of speech for background noise in a process called the Lombard effect in which it becomes louder with more distinct syllables. But this cannot fully remove the problems of communication intelligibility made in noise.

2.5.6 Other Effects of Noise

- a) Noise may prevent many animal species from approaching or crossing road corridors because they are afraid. As a result, road corridors become barriers to regular wildlife travel routes, effectively rendering roadside habitat areas inaccessible to some species. Such disturbance

reduces the success of these species and contributes to ecological alteration. For instance, birds that rely on hearing to locate prey are seriously disadvantaged by anthropogenic noise. Also, birds in a city need to call longer and louder than their country counterparts.

- b) Noise disturbs feeding and breeding patterns of some animals and has been identified as a contributing factor of the extinction of some species.
- c) Aircraft noise and sonic booms have been implicated as a cause of lowered reproduction in a variety of animals.
- d) Military sonar has been responsible for the deaths of possibly thousands of dolphins and whales.
- e) In dairy cows, excessive noise reduces feed consumption, milk yield, and rate of milk release.
- f) Intense noise can affect growth of chickens and egg production. Noise has also been showing to have a detrimental effect on the growth of some plants too.

2.6 Noise Pollution Control

Noise control has been presented as a significant challenge to people. As it is indeed a serious environmental problem. In ancient Rome, there were rules governing the noise emitted from the iron wheels of wagons, causing the inhabitants of the city to suffer disturbed sleep patterns and annoyance. In Medieval Europe, horse- drawn carriages and horseback riding were not allowed in certain cities at night to ensure that the city dwellers could enjoy a peaceful night sleep. However, the noise problems of the past are incomparable to those of modern society. A massive number of motor cars are constantly travelling through our cities and the countryside, while heavily- laden trucks with diesel engines, which have been ineffectually silenced for engine and exhaust noise, weave about in our cities day and night (Schwela *et al.*, 1999).

In contrast to other pollution control measures, the control of environmental noise has been

hampered by insufficient knowledge of its effects on humans. The effects of noise on people in developing countries are just as widespread as those in developed countries and the long-term effects are the same. Even though noise pollution control is perceived as an extravagance, with the result that it has not been placed on the priority list of developed countries, exposure to harmful noise levels is often greater in developing countries, on account of ineffectual planning and the poor construction of buildings (Schmidt, 2005).

Hearing is vital for communication. It also produces reflexes and emotions (Tripathi, 1994). Human behaviour is strongly influenced by sounds; the complete absence of sound can be a terrifying experience. Experiments in sound-proofed rooms have proved that complete silence can lead to serious psychological effects on individuals. In short, the human race needs noise (Tripathi, 1994). But what is the optimum noise level for humans? The type of sound is a very important factor and in addition it is important to know that the effect varies with individuals (Miyaya, 1997). Hence, across the world, various regulations are put in place to minimize noise pollutions, out of which Nigeria is not left out.

2.6.1 World Health Organization (WHO)'s Regulations on Noise

Noise is an underestimated threat that can cause a number of short- and long-term health problems, such as for example sleep disturbance, cardiovascular effects, poorer work and school performance, hearing impairment, etc. Noise has emerged as a leading environmental nuisance and the public complains about excessive noise more and more often.

Hence, World Health Organization (2011) stipulated the following guidelines for community noise recommendation of less than 30 A-weighted decibels (dB(A)) in bedrooms during the night for a sleep of good quality and less than 35 dB(A) in classrooms to allow good teaching and learning conditions. As well as guidelines for night noise recommend less than 40 dB of

annual average (night) outside of bedrooms to prevent adverse health effects from night noise.

On the basis of the vulnerable groups to noise pollution, Children and chronically ill elderly are more sensitive to noise disturbances. This is because, children spend more time in bed than adults, and they are more exposed to night noise. Shift workers are at increased risk because their sleep structure is under stress. In addition, the less affluent who cannot afford to live in quiet residential areas or have adequately insulated homes, are likely to suffer disproportionately.

Nuisance at night can lead to an increase in medical visits and spending on sleeping pills, which affects families' budgets and countries' health expenditure. The gap between rich and poor is likely to increase if governments fail to address noise pollution.

As outlined by WHO (2011) report, impairment of early childhood development and education caused by noise may have lifelong effects on academic achievement and health. Studies and statistics on the effects of chronic exposure to aircraft noise on children have found:

- consistent evidence that noise exposure harms cognitive performance;
- Moderate evidence of effects on blood pressure and catecholamine hormone secretion.

Environmental noise is a threat to public health, having negative effects on human health and well-being. Health effects of exposure to night-time noise, examine dose–effect relations, and presents interim and ultimate guideline values for exposure. The guidelines were peer-reviewed and discussed to reach a consensus among the experts and stakeholders. This offers guidance to policy-makers in reducing the effects of night-time noise, thus helping to improve the health of the people.

In the same vein, World Health Organizations (2011) report also outlined the standards (Table 2.1) for community noise (also called environmental noise, residential noise or domestic noise) is defined as noise emitted from all sources, except noise at the industrial workplace. Main sources of community noise include road, rail and air traffic, industries, construction and public work, and the neighborhood. Typical neighborhood noise comes from premises and installations related to the catering trade (restaurant, cafeterias, discotheques, etc.); from live or recorded music; from sporting events including motor sports; from playgrounds and car parks; and from domestic animals such as barking dogs. The main indoor sources are ventilation systems, office machines, home appliances and neighbors. Although many countries have regulations on community noise from road, rail and air traffic, and from construction and industrial plants, few have regulations on neighborhood noise. This is probably due to the lack of methods to define and measure it, and to the difficulty of controlling it. In developed countries, too, monitoring of compliance with, and enforcement of, noise regulations are weak for lower levels of urban noise that correspond to occupationally controlled levels (>85 dB LAeq,8h). Recommended guideline values based on the health effects of noise, other than occupationally-induced effects, are often not taken into account.

WHO recommends that the highest permissible level of noise exposure in the workplace is 85 dB up to a maximum of eight hours per day. Many patrons of nightclubs, bars and sporting events are often exposed to even higher levels of sound, and were therefore advised to considerably reduce the duration of exposure. For example, exposure to noise levels of 100 dB, which is typical in such venues, is safe for no more than 15 minutes.

Teenagers and young people can better protect their hearing by keeping the volume down on personal audio devices, wearing earplugs when visiting noisy venues, and using carefully fitted, and, if possible, noise-cancelling earphones/headphones.

Table 2.1 Guideline values for community noise in specific environments.

Specific environment	Critical health effect(s)	LAeq[dB]	Time base(hrs)	LAmast [dB]
Outdoor living area	Serious annoyance, daytime and evening	55	16	-
	Moderate annoyance, daytime and evening	50	16	-
Dwelling, indoors	Speech intelligibility and moderate annoyance, daytime and evening	35	16	-
Inside bedrooms		30	8	45
Outside bedrooms	Sleep disturbance, night-time			
	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	-
Pre-school bedrooms, indoors	Sleep disturbance	30	sleeping-time	45
School, outdoor playground	Annoyance (external source)	55	during play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time	30	8	40
	Sleep disturbance, daytime and evenings	30	16	-
Hospitals, treatment rooms, indoors	Interference with rest and recovery	1		
Industrial, commercial	Hearing impairment	70	24	110
shopping and traffic areas, indoors and outdoors				
Ceremonies, festivals & entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music through headphones/Earphones	Hearing impairment (free-field value)	85	1	110
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults)	-	-	140
	Hearing impairment (children)	-	-	120
Outdoors in parkland and conservation areas	Disruption of tranquility	3		

Source: Curled from WHO (2011).

Governments also have a role to play by developing and enforcing strict legislation on recreational noise, and by raising awareness of the risks of hearing loss through public information campaigns. Parents, teachers and physicians can educate young people about safe listening, while managers of entertainment venues can respect the safe noise levels set by their respective venues, use sound limiters, and offer earplugs and “chill out” rooms to

patrons. Manufacturers can design personal audio devices with safety features and display information about safe listening on products and packaging.

2.6.2 Noise Reduction Legislation in Nigeria

Prior to the Nigeria independent in 1960, Nigerian environment protection efforts had been through the colonialists. The colonial economics development policies and plans contained little or no stringent rules to conserve the natural resources or to limit pollutions. The major laws on pollution then were included in the Criminal Code and Public Health act of 1958 with section 246 aimed at controlling spread of diseases slaughtering of animals and disposal of night soil and refuse. The formative years of institutional environmental regulation were absent due to non-existence of clear scientific method of waste management. The 1970 Oil pollution attracted some considerable attentions from the public⁵⁵ that revolted against destruction of their farmland and marine animal by the oil exploration and its spillage.

Federal Government in 1988 established the Federal Environmental Protection Agency (FEPA), as a result, State Environmental Protection Agencies and Local Government Environmental Protection Agencies was set up in all the states of the Federation. Nigeria has specific legislations on noise pollution with different statutory provisions that touches on noise pollution in some ways. The Federal Environmental Protection Agency Act represents a major legislative intervention in the control of noise pollution delta area protested against ecological problems resulting from oil spillage as well as government neglects in alleviating their problems.

The concern of most African countries which was their major preoccupation of government for many years has been basically the provision of basic amenities health, road, education etc. However the past efforts on environment particularly in Nigeria in pre and post-colonial

era is the protection and conservation important natural resources as shown from these laws, Oil Pipeline Act 1956, Forestry act 1958, Destruction of Mosquito Act 1958, Public Health Act 1958, Mineral Act 1990, Fishery Act 1990.

Lagos plan action of 1980 and also reinforce the emergence of the Federal Environmental Protection Agency (FEPA) now Federal Ministry of Environment with effect from September, 1999 Decree 58 of 1988 in Nigeria. However in 2007, the National Assembly enacted a law creating the National Environmental Standards and Regulations Enforcement Agency (Establishment) Act (NESREA). For instance the law provides that:

- 1) The Agency shall, on the commencement of this Act, in consultation with appropriate authorities:
 - a). Identify major noise sources, noise criteria and noise control technology; and
 - b). Make regulations on noise, emission, control, abatement, as may be necessary to preserve and maintain public health and welfare.
- 2) The Agency shall enforce compliance with existing regulations and recommend programs to control noise originating from industrial commercial, domestic, sports, recreational, transportation or other similar activities.

The Nigerian Constitution outlines provision for state to protect and improve the environment; however the section of the law is not justiciable. The combined effect of section 33 (1) of the same constitution which states that every person has a right to life and no one shall be deprived intentionally of his life read in conjunction with the provision of section 20 as well as section 24 of the African charter an Human a People's Rights can be relied upon by Nigerian to enforce violation of their right to peaceful environmental rather than relying solely in Section 20 of the Constitution. Nigeria, some countries made the right to peaceful environment a constitutional.

The statutory intervention on the issue of noise pollution in Nigeria can be considered from the Common Law perspective. The common law intervention is through the actionable tort of nuisance. Generally, the tort of nuisance can be explained as the unlawful interference with a person's use or enjoyment of his property by another person. It can manifest in the form of noise, vibration, smoke, fume, smell, pollution, flooding, fire etc. Through a court action for nuisance, an aggrieved person can obtain damages for injury suffered from the offensive noise and also injunction to stop any further emission of such noise.

The principle in this case recognizes the inevitability of some discomfort arising from noise in that interfere with healthy enjoyment of environment and the right of individual against the discomfort. However, there is the need to discourage noise that is offensive to the point of materially interfering with the ordinary physical comfort of human existence.

Most human rights treaties were drafted and adopted before environmental protection became a matter of international concern. It was not until 1960s however that federal government officially recognized noise as pollutant and began to support noise research and regulation. The federal laws against noise pollution included the National Environmental Policy Act of 1969, the Noise Pollution and Abatement Act 1970 and Noise Control Act 1972 which emanated from the Environmental Protection Agency (EPA, 1999).

Table 2.2: Workplace Noise Exposure Limits for Nigeria

Duration Day, Hour	Permissible Exposure Limit dB (A)
8	90
6	92

4	95
3	97
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Source: Curled from FEPA (1989)

According to the Federal Environmental Protection Agency Decree of 1989 (No. 58) industrial or workplace noise arises from occupational exposure of workers to noise from industrial machines or exposure of neighborhood population to noise from factories nearby which could result to hearing loss and other pathological changes in the affected population. Given the above, the law recommended that daily noise exposure for workers should not exceed 90 decibels, dB (A) daily for an 8-hour working period in Table 2.2.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

3.1.1 Equipment and Field Materials.

The following equipment's were used in carrying out the work;

- 1 Noise Meter:** The measurement of the sound level was carried out using Extech models 407750 noise meter which meets the Standard of ANSI and IEC type 2 integrated sound level meter.
- 2 Tripod:** A soligor photo tripod (LG-30) was used to mount the noise meter at varying noise sample areas.
- 3 Global Positioning System (GPS Germin 76cxs):** This was used to take the coordinates of the sites in terms of longitude and latitude. The elevation of the sites above sea level was also measured.
- 4 Software;** ARK GIS VERSION 10.1
- 5 IBM SPSS STATISTICS software, version 21:** The data were analyzed through descriptive statistics in the form of tables using this software.
- 6 Samsung Galaxy X5 Camera:** This was used to take snapshots of the various sample fields in order to see the characteristics of the sites.
- 7 Digital Anemometer (Model Gm816):** The instrument was used to measure the geophysical characteristics of the study area.
- 8 Spot Star Weather Station:** A handheld instrument with thermometer resolution of 0.1°C and ranges from -10°C to 60°C.

3.2 Method

3.2.1 Reconnaissance Survey.

Before taking measurement on noise level, a reconnaissance survey was conducted for a period of Two (2) weeks (May 11 to May 25, 2015). This was done to observe and explore the human and socio-economic activities dominant in the study area which generates noise. During the survey, various sampling points were identified and a GPS was used to take the

coordinates as well as determine the appropriate techniques to be employed in data collections and analysis. This exercise enabled the researcher to familiarize himself with the study area.

3.2.2 Noise Level Measurement

In carrying out the noise level measurements, 10 locations were selected, each divided into four points except the control point which were carefully selected for this study. This instrument (Extech model 407750) was mounted in a tripod at a height of 1.5 m above the ground for all the locations. Measurement was taken with the antenna pointing to the sound source and was set at the A-weighting network and the equivalent noise level (L_{eq}). Noise level was obtained at the designated sample points, and recorded for the three levels of observation with the noise meter. The readings were recorded in decibel.

In order to determine the noise generation level at any point, the noise level was carried out in all the measuring locations at four different times of the day which are: 7.30-8.30am, 12.00-1.00pm, 5.00-6.00pm and 10.00-11.00pm. The instrument was set at fast/slow mode to run continuously for one hour. This is because it is the recommended method from NESREA to obtain noise level pollution and the instrument follows all the fluctuations. The period of noise level measurement was extended enough for two weeks, so that the values obtained can represent the reality of noise pollution level.

3.2.3 Measured Equivalent Noise Level (L_D , L_N , L_{DN}).

The measured equivalent noise level where used as input data in the calculation of the day time noise level (L_D), the night time noise (L_N) and the day-night time noise level (L_{DN}). These calculations were computed using equations 1, 2 and 3 as adopted by Anomohanran, (2010).

$$L_D = 10 \log \left\{ \frac{1}{2} \left[\left(10^{\frac{LAeqM}{10}} \right) + \left(10^{\frac{LAeqA}{10}} \right) \right] \right\} \quad (1)$$

$$L_N = 10 \log \left\{ \frac{1}{2} \left[\left(10^{\frac{LAeqE}{10}} \right) + \left(10^{\frac{LAeqN}{10}} \right) \right] \right\} \quad (2)$$

Thereafter, the results obtained from equations 1 and 2, were further computed into equation 3 to determine the day-night noise level (L_{DN}) of Zaria metropolis. This was carried out by using equation 3

$$L_{DN} = 10 \log \left\{ \frac{1}{24} \left[\left(15 * 10^{\frac{LD}{10}} \right) + \left(9 * 10^{\frac{LN+10}{10}} \right) \right] \right\} \quad (3)$$

3.2.4 Spatial Distribution Analysis of Noise Level.

The Google earth image was downloaded and stored in JPEG format, the image was zoomed to the lowest level (scale 1:200) to ease identification of sample points and locations in the areas where a database was developed and used in entering the coordinates and associated information of the selected control sample points within the study area. The saved image from the Google earth was imported into the GIS environment and the selected controlled points were used to examine the spatial distribution with each point registered individually. However, some modifications were made on the tie (coordinates) to ensure a good match with the ties on the existing map where the spatial variation of the noise level obtained were super imposed to determine the core area in the metropolis where noise levels is high.

3.3 Study Area

Zaria is a major city in Kaduna State in Northern Nigeria, as well as being a Local Government Area. Its geographical coordinates are 11° 4' 0" North, 7° 42' 0" East and its original name (with diacritics) is Zaria, formerly known as Zazzau (Figure 3.1). The Census population of Zaria, 406,990 and Sabon Gari Local Government Area, 291,173 people (NPC 2006) as shown in Appendix I. Zaria, initially known as Zazau, was also the capital of the

Hausa kingdom of Zazzau. However, human settlement predates the rise of Zazzau, as the region, like some of its neighbors, had a history of sedentary Hausa settlement, with institutional but pre-capitalist market exchange and farming.

The old part of the city, known as Birnin Zaria or Zaria-City, was originally surrounded by walls, which now have been mostly removed. In the old city and the adjacent Tudun Wada neighborhood people typically reside in traditional adobe compounds. These two neighborhoods are predominately occupied by the indigenous Hausa. The neighborhoods of Samaru and Sabon Gari are predominately occupied by Nigerians of southern origin, such as the Ibo. The largest market place is in Sabon Gari. Other more recent neighborhoods include: Danmagaji/Wusasa, PZ, Kongo, GRA-Zaria, Graceland, Hanwa, Bassawa, Lowcost, Kofan-Gayan and Shikka.

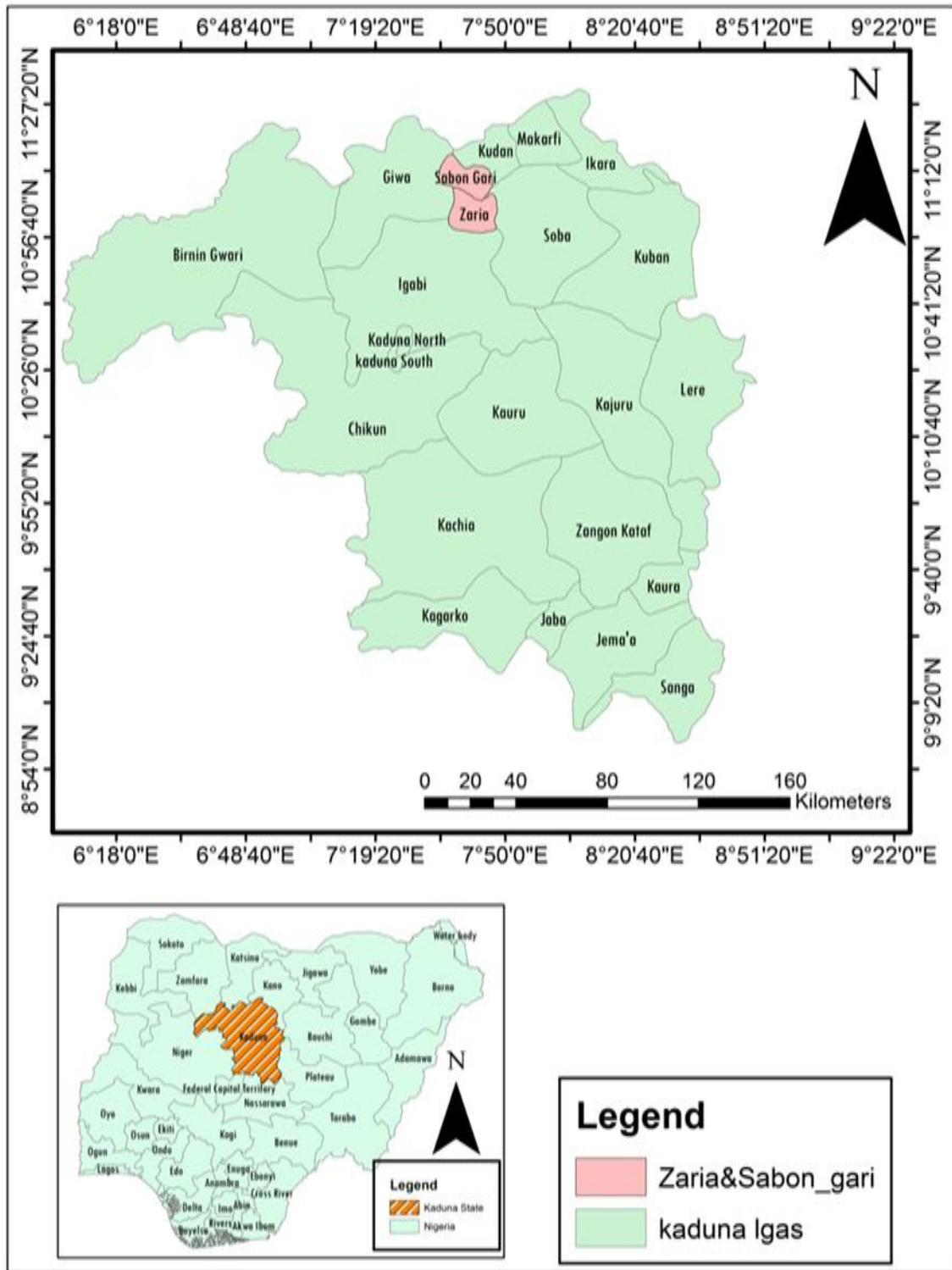


Fig 3.1: Map of Kaduna State Showing Zaria.

3.4 Selected Sample Points Areas

The selected study areas were subdivided into various points within the area for a wider data outsourcing. Plate I-XV shows the characteristics of the sample points in the study area.

- I. **Sabon Gari LGA:** This is the most populated area in the metropolis with 2006 national population figure of over 260,000 people (NPC, 2006), with the largest marketplace within the metropolis. The area comprises of market and residential areas.
- II. **Residential Area:** Residential areas within Zaria metropolis are sparsely distributed within the metropolis. These areas include, GRA, Gaskiya, Ungwan Fulani, Palladan, Graceland, Tudun wada, Zaria City, Danmagaji, Wusasa, Kongo, Samaru and Sabon-Gari.
- III. **Industrial Area:** The metropolis has varying industrial activities in the areas of bakery, Sunseed oil mill, Printing Press, British American Tobacco and welding workshops.
- IV. **Transportation Area;** there are several modes of transport in the metropolis that constitutes noise. These are noise from aviation industry (NCAT), rail and road traffic consisting of Lorries, cars, buses, motorbike and tricycles.
- V. **Institution:** This includes Ahmadu Bello University, Christ school, Nuhu Bamalli Polytechnic, Nigerian Institute of Transport Technology, (NITT), and ITN Islamic center.
- VI. **Hotel areas:** Teejay Palace, Zaria hotel, Immaculate guest, Aifaas and Jim Harrison were the hotel areas selected for investigation
- VII. **Religious Areas.** The survey identified two major religions practice in the metropolis, Christianity (Redeemed church Pz and Anwan GRA, Winners church in Dogarawa and Palladan, Catholic Church Muchia and Wusasa) and Islam (Mosque at Randa Kano, Park Road, Palladan, Tudun wada and Gaskiya).
- VIII. **Control Area:** The Ungwan Fulani area of the metropolis is a developing residential area, its characteristics drive made it chosen as a control for other noise generation sources in the

metropolis due to its location being over 500meters away from major road and and low noise level being a developing area and far from industries.

Also From a reconnaissance survey carried out, various sources of noise generation were obtained and illustrated using a cartographic map in evaluating spatial distributions of noise levels within the metropolis.

The use of geographic information system (GIS) and wind gauge was explored to obtain the coordinates and wind speed of the study areas.

3.5 Determination of Traffic Count

During the reconnaissance survey, the selected routes that had high traffic volume where mark out for traffic counts, from 7am to 6pm for period of one week, to know the traffic flow in areas where noise level are high and compare the relationship of level of noise generation to volume of traffic.

3.6 Administration of Questionnaire

This was carried out through administration of a structure questionnaire to persons living/ staying in areas where noise level generation is very high.

A total of 314 copies of a set of questionnaires were administered in a systematic random pattern for the purpose of this study. The data where analyzed through descriptive statistic in the form of tables using IBM SPSS STATISTICS software, version 21.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, the results obtained are presented in Table 4.1 – 4.14 and Figure 4.1- 4.3 in respect of noise sources, noise generations, volume of traffic, spatial distribution and possible health effects on human in areas recorded high noise level generation within the metropolis.

4.2 Sources of Noise Generation within Zaria Metropolis.

Noise generation within Zaria metropolis was classified into class A and B (Table 4.1) representing noise generated from transportation activities and other activities. During the reconnaissance survey, classifications in Tables 4.1 were obtained, but the specific sources of noise are presented in Table 4.2. The noise level obtained show that the highest noise generation was from transportation activities, (aircraft with 120dB followed by noise from the rail transportation 106 dB (A)).

Table 4.1: Classification of Noise Generation Sources within the Metropolis

Classes	Sources
Class A	Transportation Aircraft Noise Railway Noise Automobiles Noise
Class B	Others Industrial Noise Domestic Appliances Noise Religious Social and Entertainment Functions Noise from Commercial Activities (Market, Shopping Mall, Complex)

Source: Field Survey, 2015.

This is in line with Adejobi, (2012), in the study of spatio temporal analysis of noise pollution levels in Lagos State, as well as those of Ugwuanyi, *et al.*, (2004), and Oyedepo, *et al.*, (2010). The results obtained in Table 4.2 shows the main source of noise generation from

class A and B as stated in Table 4.1 to noise sources related activities, aircraft with 120dB and followed by noise from the rail transportation. However, the noise generated from class B had the highest of 80dB (A) from generators. This is in line with studies on environmental noise pollution in Nigerian urban centers which found that increase in population, commercial activities and road traffic volume, increases the level of noise generation and other concomitant noises has been noted to be severe in rapidly expanding cities and towns and regions in Nigeria such works are those of Onuu, (1992), Ugwuanyi *et al.*, (2004) and Oyedepo *et al.*, (2010b).

Table 4.2: Noise Generated from Transportation within the Metropolis

Noise Sources	Noise Generated (dBA)	Measuring Distance (meters)
Aircraft	92-120	20
	64-73	20
Rail	78-95	3
	76- 89	3
	82-106	3
Heavy Goods Vehicles	72-84	3
	62- 86	3
	50-72	3
	64-93	3
(Vehicles)	45- 78	3
	54-65	3
	47-75	3
	45-80	3
Motorcycles/tricycles	72-98	3
	48-62	3
	60-80	3

Source; Field Survey, 2015

The study revealed that transportation is one of the major noise sources within the metropolis and having aircraft, rail system and road/traffic nuisance commuters in class A contribute to noise generation within the axis. Aircraft noise (from engine thrust and fan) generates 106 ± 3 and 69 ± 3 decibels respectively at a distance of 20meters. The period of noise level

measurement was extended through a span of four weeks, so that the values obtained can represent the reality of noise pollution level.

The locomotive train that passes through Zaria generates 87 ± 3 decibels from its engine, 83 ± 3 decibels from its rolling stocks from a 3meter distance. 78 ± 3 , 74 ± 3 , 61 ± 3 , 61 ± 3 , and 79 ± 3 decibels of noise from heavy goods vehicles are from engine, exhaust, tire and horn respectively, at 3meters distance. Cars were found to generate 62 ± 3 , 62 ± 3 , 70 ± 3 , 60 ± 3 , 61 ± 3 and 63 ± 3 decibels of noise from engine, exhaust, tire and horn respectively at a distance of 3 meters. This is in agreement with Oyedepo and Saadu, (2009) in a study carried on traffic noise out in the city of Ilorin.

4.3 Variable Geophysical Factors in the Study Area

The geophysical factors of the study areas were taken into consideration in order to meet all conditions of the measurements. The wind speed obtained from NIMET via internet in Appendix II showed that within the period of study, the highest recorded was 15.0m/h, This affirms the result obtained from Table 4.3 having the highest wind speed of 22m/h as obtained within Diamond Bank axis of PZ. Other results obtained show within the limit of NIMET records of between 0.00m/h to 12.5m/h. These variable factors indicate a suitable condition to carry out the survey as obtained in Table 4.3. The temperature was within the range of 24°C to 29°C which shows a normal and conducive environment. The elevation shows Samaru area with 680m above sea level and lowest elevation of 632m (park road). The latitudes obtained in the range of 7.654701° to 7.734865°

Table 4.3: Geo-physical survey of the Study Area

Measuring Areas	Longitude (°)	Latitude (°)	Elevation(m)	Wind Speed (Km/H)
Tudun Wada	7.731349	11.10172	638	0.5
Sabo Central Market	7.730657	11.12356	636	0.1
Danmagaji	7.729275	11.11425	639	0.0
Samaru	7.721668	11.15948	680	4.2
Park Road	7.734865	11.12037	632	7.5
Diamond Bank Pz	7.720185	11.1044	640	12.0
Ungwan Fulani	7.716064	11.1561	674	2.5
Sunseed oil mill	7.701436	11.12073	637	11.4
GRA	7.711682	11.11107	643	0.5
British American Tobacco	7.718524	11.12636	649	0.4
Rail way office	7.722857	11.10798	640	0.7
Aviation	7.687462	11.13629	668	0.8
Christ School Emanto	7.699549	11.13586	658	12.5
Dogarawa	7.718562	11.13285	646	10.5
Kwangila Fly Over	7.703735	11.12988	662	0.6
Wusasa	7.679813	11.07743	674	0.4
Kofan Doka	7.709926	11.07835	644	12.2
NITT	7.683309	11.14604	676	0.8
ABU	7.654701	11.15043	672	11.5

Source: Field Survey, 2015.

4.4 Noise Levels Obtained and Comparison with Standard

The noise levels were obtained from various measuring points and presented in Table 4.4 to Table 4.12.

4.4.1: Noise from Commercial Areas.

The commercial areas comprises of the markets (Sabon Gari, Tundun wada, Danmagaji, Samaru and Dogarawa) areas and business (PZ, Diamond Bank, Samaru north gate, PZ

Conoil, Park Road and Tudun wada roundabout) areas within the metropolis. The mean noise level generation for day and night was 59.41decibel as shown on Table 3. The results of noise level show that Sabon gari market has the highest market noise level (71.07) decibel. Tudun wada/Agoro had noise level of 59decibel, Danmagaji market 61decibel, Samaru market 57decibel and Dogarawa market 64decibel. These noise levels are in excess of the NESREA standards of 55decibels especially from the business areas. However, the World Health Organization standards for commercial areas is 65decibel, in comparison, excess of noise level at 71 decibel were generated from Sabo Gari market and all the business areas could partly be attributed to the use of generators in the market, ambient noise from motorcycles and cars/buses.

Table 4.4: Noise Generation from Commercial Areas

(Standard: Who, 65. Nesrea,55)

MARKET AREAS	LD dB(A)	LN dB (A)	LDN dB (A)
Sabon Gari Market	71.73	64.99	71.07
Tundun Wada	60.59	51.03	58.55
Danmagaji Market	63.13	33.59	61.12
Samaru Market	57.59	42.12	52.71
Dogorawa Fruits Market	65	53.03	53.6
Mean Value	63.61	48.95	59.41
Commercial Bussiness Areas	LD dB(A)	LN dB (A)	LDN dB (A)
Pz/Diamond Bank	81.46	72.99	82.59
Samaru North Gate	73.46	70.99	77.85
Pz/Conoil	89.32	84.99	92.35
Park Road	70.96	79.99	85.82
Tudun Wada Roundabout	63.8	74.99	80.79
Mean Value	75.8	76.79	83.88

Source: Field Survey, 2015.

The excess of the noise level could be recovered over the time for the persons affected during the L_D (Day) that exceed WHO and NESREA standards. The survey reveals that the commercial areas of the city like the PZ area is characterized by high noise exposure level with 75.8 dB (A), 76.79 dB (A), and 83.88 dB (A) in respect of L_D , L_N and L_{DN} respectively. The daytime noise level was 81 dB (A), the night-time noise level L_N was found to be 43 dB

(A). The day–night time highest noise level L_{DN} was recorded as 92.35 dB (A), the L_{DN} in the range of 77.85–92.35 dB (A), and the average noise pollution level fell in the range of 75.8–83.88 dB (A).

4.4.2 Noise from Residential Areas

The residential areas selected for study area were GRA, Graceland, Sabon Gari, Ungwan Fulani and Wusasa. The obtained noise levels in these areas, showed that not all the areas exceeded NESREA and WHO recommended noise level of 55 and 65 decibels. Only Sabon Gari and Wusasa slightly exceeded the NESREA and WHO noise level standard of 55 and 65 decibels (L_{DN}) with 59.39 and 61.80 for wusasa and Sabon Gari respectively. Some of the residential areas had major roads and highways that pass through them (Wusasa, Grace land and partly GRA) which lead to increase average noise levels of 51.54-54.59 dB (A) or more every day as shown on Table 4.5.

Table 4.5: Noise Generation from Residential Areas
(STANDARD: WHO, 65. NESREA, 55)

Residential Areas	L_D dB(A)	L_N dB (A)	L_{DN} dB (A)
G R A	44.45	45	51.34
Wusasa/Gaskiya	58.04	50.99	59.39
Sabon Gari	57.23	54.99	61.8

Ungwan Fulani, Palladan	53.85	37.02	52.32
Graceland	44.12	41.1	48.09
Mean Value	51.54	45.82	54.59

Source: Field Survey, 2015.

According to WHO average acceptable noise level expected for healthy hearing on people is 60-dB (A) in which, above this noise level can result in temporary hearing impairment while noise level of 100-dB (A) can cause permanent impairment. The noise levels of residential areas in Zaria metropolis are similar to those reported for other urban areas around Nigeria exceeding the recommended noise level standards such as in most cities in Nigeria and the World, (Oyedepo *et al*, 2010a, Omubo-pepple, *et al*, 2010, Anmohanran *et al* 2008, Huss *et al*, 2010.).

4.4.3 Noise from Industrial Areas

San Yogurt, British American Tobacco, Sunseed oil mill, Bakery (Arewa, Bitmas), selected mechanic/welder workshops and printing press were industrial sites investigated in the study area. Table 4.6 shows result generations from industrial activities in Zaria metropolis.

Table 4.6 Noise Generation from Industrial Areas
(STANDARD: WHO, 65. NESREA,75)

Industrial Areas	L _D dB(A)	L _N dB (A)	L _{DN} dB (A)
SAN YOGURT	69.16	64	71.64
BRITISH AMERICAN TOBACCO	83.2	80.99	87.79
SUNSEED OIL MILL	76.1	64.99	75.72

BAKERIES	66.96	64.99	71.74
MECHANICS/WELDERS	75.34	71.09	78.42
PRINTING PRESS	54.45	49.99	57.39
Mean Value	70.88	66.01	73.78

Source: Field Survey, 2015.

The result obtained show on the average that measurement were higher than the WHO standards of 65 dB (A) but lower than NESREA standard of 75 dB (A). The mean value L_D was 70.88dB (A), L_N 66.01 dB (A) and L_{DN} , 73.78 dB (A). These areas of the metropolis surveyed were characterized by moderate noise level which could be as a result of roads passing through. These average noise levels of 70.88-73.78 dB (A) or more every day which on the average, is within the acceptable good health limit of NESREA standards. In line with this result, Ighoroje *et al.*, (2004), carried out survey in industrial areas of Benin City with noise level exceeding 90 dB (A). This wasn't same with the mean noise level generation in Zaria from industries being 73.78 dB (A). This result could be trace to the shutdown of British American Tobacco. Most of these industries in Zaria winded up result as a result of security traits amongst other factors.

4.4.4 Noise from Educational Areas

Schools and institutions are some of the major land uses that dominate Zaria. The result on Table 4.7 revealed that the noise generation from institutions and schools in Zaria metropolis are within the WHO noise level standards of 45 dB (A) on the average. NESREA noise level standards of 35 dB (A) where exceeded with Nuhu Bamalli Polytechnic, Gaskiya recorded 51.78 dB (A) for L_D followed by 50.22 dB (A), Faculty of Engineering lecture theatre for L_D which were over 45 ± 5 dB (A), ITN Islamic center, Zango recorded 53.64 dB (A) and 48.3 dB (A) for L_D and L_N respectively.

Table 4.7: Noise Generation from Educational Areas

Institutions/Schools (STANDARD: WHO, 45. NESREA,35)	L_D dB(A)	L_N dB (A)	L_{DN} dB (A)
Primary & Secondary	52.51	22.02	47.52
Nigerian Institute of Transport Technology	43.51	25.01	41.82
Ahmadu Bello University/Faculty Of Engr.	50.22	24.99	48.26
Federal College of Education/Kongo	40.18	44.99	50.96
ITN Islamic Center, Zango	53.64	48.3	53.6
Nuhu Bamalli Polytechnic, Gaskiya	51.78	32.01	50.01
Mean Value	48.64	32.89	48.86

Source: Field Survey, 2015.

The average noise level obtained from the institutions within Zaria metropolis were higher than the permissible limit set by NESREA L_D. However, the L_N fall within the Standard set by NESREA of 35 dB (A). The mean value L_{DN} justifies the recovery period of exposure at L_N with an average of 29.80 dB (A) over the L_D having an average of 47.71 dB (A).

4.4.5 Noise from Hotel Areas

The hotel includes; Teejay Palace Hotel, Zaria hotel, Emmaculate Guest Inn, Aifaas Hotel and Jim Harrison Hotel. The mean noise level recorded showed that Emmaculate Guest Inn with 48.79 dB (A), Jim Harrison with 42.44 dB (A) fall within NESREA noise level limits of 55decibel of all the hotels studied. Zaria Hotel had 70.92 dB (A) signifying the highest noise level obtained from the survey, which is followed by Aifaas hotel and Teejah hotel with L_{DN} of 58.76 dB (A), 57.1 dB (A), respectively as shown on Table 4.8.

Table 4.8: Noise Generation from Hotel Areas (STANDARD: NESREA,55)

HOTELS	LD dB(A)	L N dB (A)	LDN dB (A)
Teejay Hotel	48.29	50.99	57.1
Zaria Hotel	59.3	64.99	70.92
Emmaculata	31.96	42.99	48.79
Aifaas Guest In	39.63	52.99	58.76
Jim Harrison Hotels	42.05	33.02	42.44

Mean Value	44.25	49	55.6
------------	-------	----	------

Source: Field Survey, 2015.

The result obtained also show that only Zaria hotel (70.92dB (A)) exceeded WHO recommended noise level of L_{DN} of 65 dB (A) on the average record of 55.60 dB (A). Hotels in the metropolis are mostly located close to major and minor roads within the metropolis. The noise is emanating from traffic ambient noise. This finding is similar to those reported for other urban areas around Nigeria by Oyedepo *et al* (2010), Onuu, *et al*, (1992) and outside Nigeria such as Greece and India.

4.5 Noise Generated from Transportation within the Metropolis

4.5.1 Noise from Railway Areas

The noise from railway was 87.09 dB (A) for L_D , while L_N was 76.75 dB (A) and 90.56dB (A) was obtained for L_{DN} signifying the mean noise levels obtained as shown on Table 4.9. The results shows that the areas where the rail activities take place are mainly commercial areas, the railway crossing area of PZ showed the highest recorded noise level of 100.79 dB(A) at L_{DN} . This could be attributed to rail crossing and other commercial activities within the area.

4.5.2 Noise from Aviation Areas

The only airdrome area in Zaria to obtain noise level from aircraft is Nigerian College of Aviation Technology, NCAT. Mean noise levels obtained showed that L_D is 65.09 dB (A), L_N is 56.40 dB (A) and L_{DN} is 68.55 dB (A). The noise level was measured at various points within the aviation routes. Result showed that the noise generated are within the 90 dB (A) recommended noise level for air crafts (WHO, 2000), The noise level recorded as day and night average also suggest possible adverse impact on people working or living around the

aircraft route which is above 65 dB (A) recommended noise level for threshold of hearing within a period Saadu and Oyedepo, (2008).

Table 4.9: Noise Generated from Transportation within the Metropolis

Transportation /Rail	L_D dB(A)	L_N dB (A)	L_{DN} dB (A)
Mean	87.09	66.32	90.56
Transportation/ Aircraft	L_D dB(A)	L_N dB (A)	L_{DN} dB (A)
Mean	65.1	56.4	68.55
Transportation/Traffic	L_D dB(A)	L_N dB (A)	L_{DN} dB (A)
Mean	83.1	85.22	92.09

Source: Field Survey, 2015.

4.5.3 Noise from Traffic Areas

The World Health Organization (2000) documented the potential effects of environmental noise on health. The overall conclusion is that cardiovascular ill-health are associated with long-term exposure to L_{DN} 24h values in the range of 65-70 dB or more, for both air and road traffic noise. A study carried out by Omokore, (2010) in ascertaining the environmental audit of the Zaria- Sokoto- Kaduna interchange at Kwangila, Zaria reviewed that the noise level generated was 83.77 dB(A). Kwangila is a commercial area as well as high traffic density area. One of the most important characteristics of a traffic stream is its volume of over 96,033 as shown on Appendix iv, v and vi which can be defined as the number of vehicles passing through a section of a road in a unit time usually one hour.

Table 4.10: Noise Level Obtained from Traffic Areas and Respect to Traffic Count

Area	Total Traffic Counts/wk	Mean Noise Level dB(A)
Kofan Doka	23,350	78.20
Wusasa	18,617	58.30
Kwangila	96,033	100.06

Source: Field Survey, 2015.

The mean noise level obtained for L_D is 83.1 dB (A), L_N is 85 dB (A) and L_{DN} is 92.09 dB (A) all exceeded. Tricycles/two-wheel motorcycles are major contributors to the high noise level (Jacob *et al.*, 2013) as obtained in Gusau in a study on evaluation and analysis of noise levels at high- Traffic locations. In the same vein, Anomohanran, (2010) in a study on environmental noise pollution in Abuja recorded the range of 73.2 dB(A) to 83.6 dB(A) which are still above the limits.

4.5.4 Noise from Religious Areas

The study area has diverse two major religions, namely Christianity and Islam.

Table 4.11: Noise from Religious Areas

RELIGIOUS AREA	LD dB(A)	LN dB (A)	LDN dB (A)
CHURCH	53	21	51.98
MOSQUE	52.01	21	49.99
MEAN	52.51	21	50.49

Source: Field Survey, 2015.

The result obtained shows that both religions do not generate noises exceeding the stated standards of 55 dB (A). However, at some instances, both religions emit a high level of noise. The results revealed that the mean L_{DN} for the church was 51.98 dB (A) while the noise generation from mosque was 49.99 dB (A).

4.5.5 Noise from Control Area

WHO, (2000), recommended for every level of noise generation in order to control the health impact on human. The Ungwan Fulani area of the metropolis was chosen as a control for other noise generation sources in the metropolis. The results showed that the L_D was 17 dB (A), L_N were 23 dB (A) and L_{DN} 14 dB (A). The result as shown on Table 4.12 signifies a tolerable and normal noise level which is within the recommended minimum threshold of hearing.

Table 4.12: Noise from Control Area

Control	L_D dB(A)	L_N dB (A)	L_{DN} dB (A)
Ungwan Fulani Extension	17	23	14

4.6 Volume of Traffic in High Noise Level Areas

Traffic volumes taken are from in and out flow route of Kofan Doka, Kwangila and Wusasa areas of the metropolis. This volume and composition of traffic from the location with high noise levels in the study area was counted.

4.6.1 Volume Composition of In and Out Flow Route Kofan Doka

Result obtained as summarized in Appendix IV reveals the traffic count in the study area for a period of one week. A total of 23,350 vehicles passed through Kofa Doka roundabout per week which represents the total of both inflow and out flow of vehicles in the study area.

Motorcycles have the highest with 7,641 which represent 32.72%, cars with 58,111 vehicles represents 24.87%, mini buses with 5308 which represents 22.73%, tricycles with 2,898 vehicles which represent 12.41%, Pick-up with 721 vehicles which represent 3.09%, trailers with 391 vehicles which represent 1.68%, taxi with 53 vehicles which represent 0.23%, midi buses with 332 vehicles which represent 1.42%, and lorry/ truck with 166 vehicles which represent 0.71%.

4.6.2 Volume Composition of in and out flow Route in Wusasa Axis.

In Appendix V, the result revealed the traffic flow of vehicles in Wusasa area for the period of one week. Wusasa is located at the outskirts of the metropolis. The area has a high traffic density due to its position leading to so many states and the major entry and exit corridor in and out of vehicles in Zaria.

As revealed in Appendix V shows that a total of 18,612 vehicles passed through Wusasa area weekly, the count further reviewed that 3278, 2803, 2514, 2801, 2890, 2312 and 2014 for Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday respectively translating to vehicle volume per day which represents the total of both inflow and out flow of vehicles in the study area. Cars have the highest record of 6,940 which represent 37.29%, taxis with 125 vehicles which represent 0.67%, Tricycles with 2046 vehicles which represent 10.99%, Pick-up with 396 vehicles which represent 2.10%, Trailers with 391 vehicles which represent 2.10%, mini buses with 990 vehicles which represent 5.32%, big buses with 275 vehicles which represent 1.48%, Midi buses with 877 vehicles which represent 4.71%, and lorry/ truck with 311 vehicles which represent 1.67%.

4.6.3 Volume Composition of In and Out Flow Traffic, Kwangila Corridor Axis

Appendix VI shows the various vehicles counted at the Kwangila area which is within the study area which is at the exit and midst of traffic flows in the metropolis. The area is a major corridor leading to several states of northern Nigeria. The traffic volume for both in and out-flow of vehicles in kwangila corridor axis were tabulated, The appendix vi shows that a total of 96.033 vehicles passed through Kwangila corridor axis on a weekly basis which represents the total of both inflow and out flow of vehicles for the period of one week. Motorcycles have the total number of 12,395 which represent 12.91%, cars with 78,716 vehicles which represent 81.97%, tricycles with 1,361 vehicles which represent 1.42%, pick-up with 440 vehicles which represent 0.46%, trailers are 945 which represent 0.98%, mini buses with 645 vehicles which represent 0.67%, taxi with 79 which represent 0.08%, midi buses with 88 vehicles which represent 0.09%, and lorry/ truck with 496 vehicles which represent 0.52%.

4.7 Spatial Distribution of Noise Generated within the Metropolis.

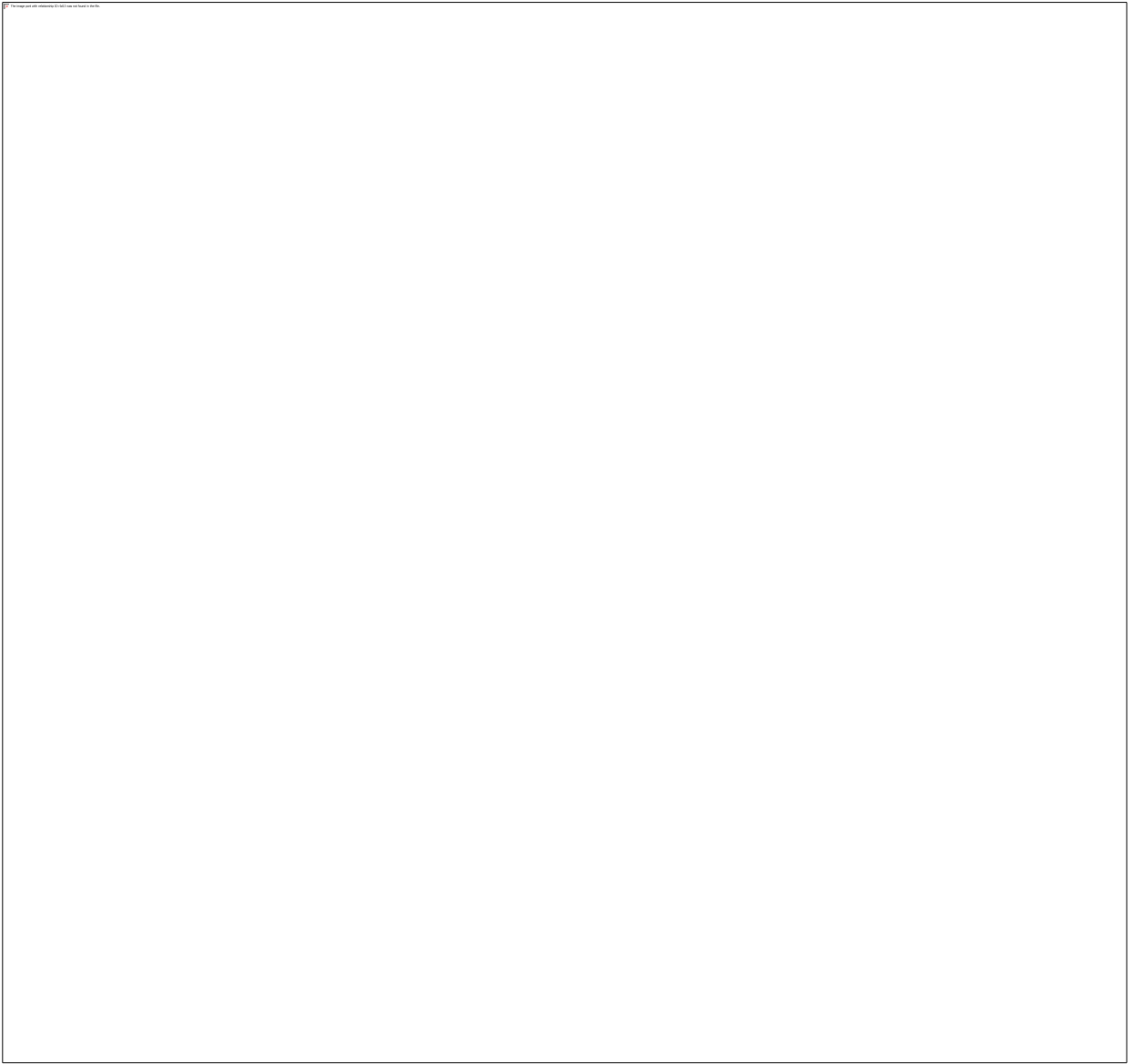
4.7.1 Spatial Pattern of Noise Sample Points within the Metropolis

Noise is invariably one of the environmental pollutions generated. The parts in which this pollution is identified in the map with red dots shows the points where these noise levels are relatively high. Results obtained from measuring points shows that the rail crossing around PZ areas has the highest noise level of 100.79 dB (A), Kwangila has 100.06 dB (A) and aircraft noise with 94.46 dB (A) which were measured from 3m, 3m and 20m respectively.

The activities around the PZ area and the rail horn especially when the train is passing dissipate a high level noise which in turn contributes to the ambient noise in the PZ area. So many factor that contribute to this ambient noise includes the commercial activities, traffic congestion, conversation/interactions of persons transacting business, motorcycles and tricycles, various generator sets from individual shops around, drivers and conductors

shouting for passengers and among others (Stephenson *et al.*,2008, Kupolati, *et al.*, 2010, Fadairo, 2013, Anomohanran *et al.*, 2010 and Omubo-pepple *et al.*, 2010).

Kwangila area shows from Figure 5 a high noise level as indicated with the red round dots. This area is found during the period of study to be a nodal area, commercial area comprising motor-park and retail traders by few meters away from the road. All these activities contribute invariably to the level of noise obtained. The traffic noise can thus be subdivided into various sources namely; noise from heavy duty goods, cars, motorcycles, tricycles and the state of the road, which can be a function of traffic volume, composition, speed, road characteristics (surface and gradient), in line with Okuofu, (2014). According to Clark and Stanfeld, (2007), noise causes annoyance and negatively affects quality of life. Based on this assertion, it is most likely that people living around this area will have these adverse impacts which of cause this work's scope could not cover.



Source: Qirck Bird Image of Zaria. (2015).

Figure 4.2: Aerial view of Selected Sample Points in the Study Area.

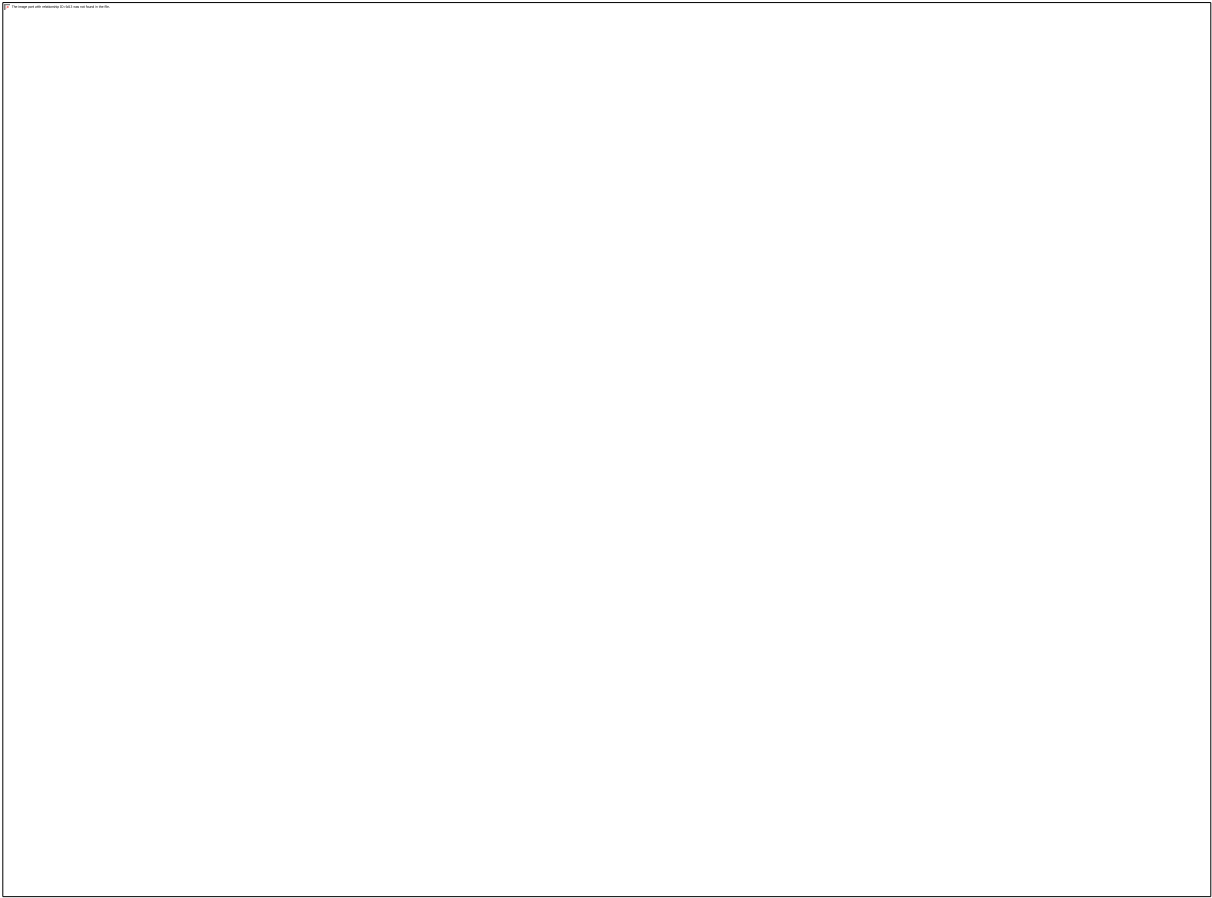


Fig 4.3: Spatial Distribution of Noise Level within Zaria Metropolis

The noise of an aircraft depends on the type of propulsion system. Tampico (TB20) used by NCAT has turboprop and turbojet engines each have special noise characteristics, as do propellers and helicopter rotors. (Rosenlund *et al.*, 2001) assertion in a survey of Aircraft noise and certification based on noise level has shown that people generally find the noise from jet engines much more annoying than that from propeller engines and helicopter rotors, because high Frequency sounds, which people are generally less tolerant of, make up a greater proportion of the noise spectrum of jet engines than of propeller driven engines and helicopter rotors.

The noise generated from this area gives the people living around enough recovery time since the aircraft operation is not all day long. However, this noise contributes to the ambient noise around the metropolis during the day as the aircraft do not fly above 3,100 feet's above the ground level.

Finally, the spatial explanation of noise levels within the metropolis focused around the center or usually called the built-up areas than the isolated areas of the metropolis in regards to various land use acts.

4.8 Respondents Perception of Possible Health Effects of Noise Level in the Study

Area

4.8.1 Respondents Knowledge of Noise Pollution (Kwangila, PZ and Kofan Doka)

The result obtained from the structured questionnaire reviewed that over 96.3% had knowledge of noise pollution while 3.8% of people administered questionnaires do not have knowledge of noise pollution (Table 4.13).

Table 4.13: Respondents Knowledge of Noise Pollution

Knowledge	Frequency	Per cent	Valid per cent
YES	308	96.3	96.3
NO	12	3.8	3.8
Total	320	100.0	100.0

Source: Field Survey, 2015

4.8.2 Respondents Perception on Sources of Noise Generation.

Perceptions of people within the areas where noise levels are high in the three areas, revealed that more than 73.8% strongly agreed that traffic generated a high level of noise. The

industrial activities had 37.5% of the opinion of respondents agreeing to industrial sources of noise. Household source (41.3% of strongly agree), Generator (55.6% of strongly agree), Train (34.7% of respondents undecided) and religious (church/mosque) noise sources representing 51.60% of agreed opinion of the respondents (Table 4.14).

Table 4.14: Respondents Perception of Noise Generation

Sources		Strongly Agreed (1)	Agreed (2)	Undecided (3)	Disagreed (4)	Strongly Disagreed (5)	No Response	Mode	TOTAL
Traffic	Frequency	236	54	0	12	0	18		320
	%	73.8	16.9	0	3.8	0	5.6	SA	100
Industrial	Frequency	87	120	30	35	0	48		320
	%	27.2	37.5	9.4	10.9	0	15	A	100
Household	Frequency	132	125	22	11	0	30		320
	%	41.3	39.1	6.9	3.4	0	9.4	A	100
Generator set	Frequency	178	106	6	6	0	24		320
	%	55.6	33.1	1.9	1.9	0	7.5	SA	100
Train	Frequency	24	115	111	29	0	41		320
	%	7.5	35.9	34.7	9.1	0	12.8	UD	100
Church/Mosque	Frequency	60	165	29	30	0	36		320
	%	18.80	51.60	9.10	9.40	0	11.30	A	100

Field Survey, 2015

Key: SA=Strongly Agreed, A= Agreed, U= Undecided, D = Disagree, SD = Strongly Disagree

4.8.3 Respondents Perception of Health Effects of Noise

The possible effects selected include noise effect to disturbance/General disturbance, headache, hypertension, loss of sleep and stress. From the presentation in Table 4.15, of the respondents that constitute 56.3%, 58.2% and 60.6% agreed that noise causes headache, loss of sleep and stress respectively, compared to their counterparts who disagreed accounted for 2.8%, 7.5% and 12.5% in that order.

The respondent has indecision on the noise possible effects regarding hypertension and perhaps not in agreement that noise could have effects on disturbance (55.9%) as shown on Table 4.15.

Table 4.15: Respondents Perception on Possible Health Effects of Noise

Sources		S A	A	U	D	S D	Mode	TOTAL
No disturbance	Freq	7	14	67	119	6		213
	%	3.3	6.6	31.5	55.9	2.8	D	100
General Disturbance (Irritation)	Freq	28	104	57	24	0	A	213
	%	13.1	48.8	26.8	11.3	0		100
Headache	Freq	75	120	12	6	0	A	213
	%	35.2	56.3	5.6	2.8	0		100
Hypertension	Freq	18	48	112	35	0		213
	%	8.5	22.5	52.6	16.4	0	U	100
Loss of sleep/insomnia	Freq	22	124	51	16	0		213
	%	10.3	58.2	23.9	7.5	0	A	100
Stress	Freq	45	129	13	26	0	A	213
	%	21.1	60.6	6.1	12.2	0		100

Source: Field Survey, 2015.

Finally, there are health effects on Human being generated from noise as revealed from the perception of the respondents as most correspondents attested to health challenges such as headache (56.3%), sleep disturbance/insomnia (58.28%) and stress (60.6%) as the effects from noise exposure in study area.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The conclusion deduced within from the limit of this thesis has that;

- Zaria metropolis has varying sources of noise generations which are mainly from Transportation, residential, industrial amongst other land use activities. The noise generated from transportation activities puts at risk the lives of people living or having things to do along the noise sources. The noise ranges from rail 90.56 dB (A), aircraft 68.55 dB (A) and traffic 92.09 dB (A).
- The physical characteristics survey, revealed that the study area as a good topology and weather. Results show the range of wind speed of 0.0m/s to 12.5m/s.
- Zaria metropolis has an average noise level at L_{DN} Commercial (market 59.41 decibel, business area 83.88 decibel), residential 54.59 decibel, industrial 73.78 decibel, hotel 55.6 decibel, transportation; rail 90.56decibel, aircraft 68.55 decibel, traffic 92.09 decibel, religions 50.49 decibel, educational areas 48.86 decibel and Control 14 decibel.
- The volume of traffic with the corresponding noise levels revealed that traffic is one of the major noise sources within the metropolis. From the survey, the highest L_{DN} is within the PZ axis with noise level of 100.79dB (A) followed by kwangila area with L_{DN} of 100.06dB (A) amongst all other classifications and noise levels standards exceeded the WHO and NESREA. The average day-night noise level obtained is an indication that the noise level of Zaria is on the average level.
- Spatial distribution of noise within the metropolis clustered around the center or usually called the built-up areas than the isolated areas of the metropolis. The noise

sources mainly are from high dense populated areas that are termed either the originating points or destination points and major traffic junctions within metropolis.

- The possible health effect of noise in the study areas especially where noise levels are relatively high, revealed that 60.0% agreed of noise effect to stress, 58.2% (sleep) agreed, 52.6 % (hypertension), 56.3% (headache) and 48.8% (general disturbance).

5.3 Recommendation

Based on these findings, the author therefore recommends the following immediate sustainable measures;

- In areas where noise levels were identified to be high, planting of trees should be explored to mitigate the high noise levels. Also identified noise generation sources, like industries and areas where rail track passes, installation of noise barriers (fence) should be implored as measures to protect people living close to these noise generation sources.
- Comparing noise measured with NESREA noise standard limit were challenging as a result of no specific document that contained admissible noise standard limit for all areas. NESREA on behalf of the Federal Government of Nigeria should properly compile all noise standard limits in a handbook as a guideline.
- Further and detail studies should be carried out regularly within the metropolis in order to advocate planning policies and curtail any possible adverse health effects on people.
- The identified areas like Kwangila, whose daily activities confine them to high noise level within and outside the study area should make sure they have at least 10 hours of recovery time. This could be achieved through dissemination of noise effect on

Health to the people through awareness campaign by NESREA and Kaduna State environmental board.

- The government should implore policies and strategies that will reduce traffic congestion especially in the areas where they are common within the metropolis like in Kwangila, Kofan Doka and PZ areas where by use of signs post mounted at prohibition points.

REFERENCE

- Adejobi, O.S (2012). Spatio-Temporal Analysis of Noise Pollution Levels in Lagos State: Oshodi- Agege Route Experience. *European Journal of Globalization and Development Research*, 5(1): 266-286.
- Alberta Energy and Utilities Board (AEUB). (1999). Noise Control Directive User Guide, Guide 38. <http://www.eub.gov.ab.ca>.
- Amrah, A., Al-Omari A. and Sharabi, R. (2006). Evaluation of Traffic Noise Pollution in Amman, *Jordan. Environ Monit Assess*;120:499–525. doi: 10.1007/s10661-005-9077-5.
- Anomohanran .O, Iwegbue C.M.A, Oghenerhoro I.O and Egbai, I.J.C. (2010). Investigation of Environmental Noise Pollution Level of World Journal of Environmental Engineering 15 Abraka in Delta State, Nigeria. *Trends in Applied Sciences Research* 3 (4): 292-297.
- Bluhm,L. G., Berglind, N., Nordling, E. and Rosenlund, M. (2007). Road Traffic Noise and Hypertension. *Occupational and Environmental Medicine*. 64(2),122-126.
- Bruel, M. and Kjaer, T. S. (2000). Environmental Noise Handbook. http://www.macavsat.org/pdf_files/misc_reports/bk.pdf.
- Chepesiuk, R. (2005). The Effects of Living in a Noisy World. *Environmental Health Perspectives*, 113, 1-4.
- Clark, C. and StanfeLD, S.A. (2007): The Effect of Transportation Noise on Health and Cognitive Development: A Review of Recent Evidence. *International Journal of Comparative Psychology*. 20: 145-158.
- Cohen, S., and Weinstein, N. (1981). Non auditory Effects of Noise on Behavior and Health. *Journal of Social Issues*. 37: 36–70.
- Donatelle, R.J. (2002). Access to Health. 7thed. New York. Benjamin Cummings Publishers.
- Dooley, E.E. (2002). Noise Hurts Boys and Girls, The Beat, *Occupational and Environmental Medicine*, Vol. 1, 1.
- EPA, New South Wales, (1999). *Environmental Criteria for Road Traffic Noise*. Chatswood Publisher, pp.25-26.
- Fadairo, G. (2013). Urban centres air pollution: Case study of Akure, Nigeria, *British Journal of Arts and Social Sciences*. 14(11):125-132.
- FEPA (1989). *National Policy on the Environment*. Federal Environmental Protection Agency, Lagos, Nigeria.
- Filippi, P. (Ed)(1998). Acoustics; Basic Physics, theory and methods. *Academic press* (1994 in French)

- Focus, F. (2002). A Handbook on Environmental Health Perspectives, *Environmental Health press, India*. 110, 3-4.
- Goines, L., and Hagler, L., (2007). Noise Pollution: a modern plague. *South Med Journal*, **3**, 287-94.
- Holmes, H. (1995). Building Healthy Communities for Children: The Transportation Link, *Environmental Health Perspectives*, 103, 1-3.
- http://en.wikipedia.org/wiki/health_effect_from_noise. Accessed on 9/04/2015 at 3:00pm.
- Huss, A., Spoerri, A., Egger, M. and Roosli, M. (2010). Aircraft Noise, Air Pollution and Mortality from Myocardial Infarction. *Epidemiology* 21 (6): 829-836
- Ighoroje A.D.A, Marchie. C and Nwobodo E.D. (2004). Noise Induced Hearing Impairment as an Occupational Risk Factor among Nigerian Traders, Nigeria. *J. of Physiological Sciences* 9(1-2), 14- 19.
- Jacob O, E, and Edwin A, U. (2013); Evaluation and Analysis of Noise Level at High-Traffic Locations in Gusau, Nigeria. *Asia Pacific Journal of Multidisciplinary Research*. Pg 67
- Jansen, G (1992). Noise Effects on Human. VGB (German). 72 (1), 60.
- Jarup, L., Babisch, W., Houthuijs, D., Pershagen, G., Katsouyanni, K., Cadum, E., Dudley, M., Savigny, P., Seiffert, I., Swart, W., Breugelmans, O., Bluhm, G., Selander, J., Haralabidis, A., Dimakopoulou, K., Sourtzi, P., Velonakis, M. & Vigna-Taglianti, F. (2008). Hypertension and Exposure to Noise Near Airports: the HYENA Study. *Environmental Health Perspectives*, 116(3), 329-333.
- Kryter, K.D. (1985). *The Effects of Noise on Man*. 2nd Edition. Orlando, FL: Academic Press.
- Kupolati, W.K. Coker, A.O. and Ogunbor, J.E. (2010). Highway traffic noise level in developing nations: A case study of University of Ibadan, Ibadan, Nigeria, OIDA. *International Journal of Sustainable development*, 2(4): 86-94.
- Mansouri, N. Pourmahabadian, M. and Ghasenkhani, T. (2006). Road traffic noise in downtown area of Tehran. *Iran, J. Environ, Health Sci*. 3(4): 267-272.
- Marius A, Tijunelis M. D, Fitzsullivan B. A, Sean O, Henderson M. D, (2005). Noise in the ED. *American. Journal of Emergency Medicine*. 23(3): 332-335.
- Mead, M.N. (2007). Noise Pollution: The sound behind Heart Effects. *Environmental Health Perspectives*. *Environews*, 115(11), 536-537.
- Miedema, H. (2007). Annoyance Caused by Environmental Noise: Elements for Evidence-Based Noise Policies. *Journal of Social Issues*. 63 (1): 41-57.

- Miedema, H.M.E. and Vos, H. (1999). Demographic and attitudinal factors that modify annoyance from transportation noise. *Journal of the Acoustical Society of America*, 105(6), 3336–3344.
- Miedema, H. M. and Vos, H. (1998). Exposure Response Relationships for Transportation Noise. *Journal of Acoustical Society of America* 104(6), 3432-345.
- Miglani, D.G (2010). Noise Pollution: Sources, Effects and control http://depssa.ignou.ac.in/wiki/index.php/Noise_Pollution
- Miyaya, F. (1997). Guidelines for an Urban Noise Ordinance, Rosario, Argentina, 10-18.
- Nathaniel, M.M. (2007). Noise Pollution: the Sound behind Heart Effects. *Environ Health Perspect*; 115(11):A536–7.
- Nigerian Population Census, (NPC) (2006). Population Census of Nigeria. FGN.
- Nijland, H., Hartemink, S., van Kamp I., and van Wee, B. (2007). The Influence of Sensitivity for Road Traffic Noise on Residential Location: Does it trigger a Process of Spatial Selection? *Journal of Acoustical Society of America*, 122 (3): 1595-1601.
- Ohrström, E and Skånberg, A. (2004). Sleep disturbances from road traffic and ventilation noise-laboratory and field experiments. *Journal of Sound and Vibration*, 271(1&2), 279–296.
- Okuofu, C. A. (2014). Impact of Transportation Noise on Health and the Environment. An Unpublished Seminar paper presented at the Nigerian Institute of Transport Technology, Zaria.
- Olaosun, A.O., Ogundiran, O. and Tobih, J.E. (2009). Health Hazards of Noise: A Review Article. *Research Journal of Medical Sciences*, 3(3), 115-122.
- Olayinka, O. S, Abdullahi., (2008). A Statistical Analysis of the Day-time and Night-time noise levels in Ilorin metropolis, Nigeria. *Trends in Applied Sciences Research*. 3(3). 253- 266.
- Omokore, S. I., (2010). The Environmental Audit of the Zaria- Sokoto-Kano-Kaduna interchange at Kwangila, Zaria. *Being an Unpublished Thesis*. Alhmadu Bello University, Zaria.
- Omubo-Pepple, *et al.*, (2010). Noise pollution in port Harcourt Metropolis. *Environmental Res. Journal*. 6(4); 259-271, 2012.
- Omoo M. U, (2000). Road traffic noise in Nigeria : Measurement, Analysis and Evaluation of Nuisance. *Journal of Sound and Vibration*, 233(30), p. 391-405.
- Onuu, M. U. (1992). *Measurements and Analysis of Road Traffic Noise and its Impacts in Parts of South/sastern Nigeria*. Ph.D. Thesis, University of Calabar, calabar, Cross River State, Nigeria.

- Ouis, D. (2001). Annoyance from Road Traffic Noise: A Review. *Journal of Environmental Psychology*, 21(1), 101-120.
- Oyedepo, O.S. and A. A. Saadu, 2009. A comparative study of Noise Pollution Levels in some selected areas in Ilorin metropolis, Nigeria. *Environ. Monit. Assess.*, 158: 155-167.
- Oyedepo, O.S. and Saadu, A.A. (2010). Evaluation and Analysis of Noise levels in Ilorin Metropolis, Nigeria. *Environ Monit Assess.*;160:563–77. doi: 10.1007/s10661-008-0719-2
- Oyedepo, O.S. and Saadu, A.A, (2010b). Evaluation and Analysis of Noise Level in Ilorin Metropolis, Nigeria. *Environ. Monit. Assess.*, 160;563-577.
- Oyedepo, S.O. (2012): Noise Pollution in Urban Areas: The Neglected Dimensions. *Environmental Research Journal*, 6l(4), 259-271.
- Ozer. S, Yilmaz. H, Yesil. M, Yesil. P., (2009). Evaluation of Noise Pollution Caused by Vehicles in the City of Tokat, Turkey. *Sci., Res. Essay.*, 4(10): 1205-1212.
- Passchier-Vermeer, W. and Passchier W.F., (2000). Noise Exposure and Public Health. *Environ Health perspective* 108 (1), 123-131.
- Pathak, V. Tripathi, B.D and Mishra, V.K. (2008). Evaluation of Traffic Noise Pollution and Attitudes of Exposed Individuals in Working Place. *Atmos Environ*;42(16):3892–8. doi: 10.1016/j.atmosenv.2007.12.070.
- Poulsen, T. and Rysgaard, F. (2002). *Laboratory Evaluation of Annoyance of Low Frequency Noise*. Prepared for Danish Environmental Protection Agency Working Report. 56-61.
- Rosenlund, M, Berglind, N, Jarup, L, Bluhm, G. (2001); Increased Prevalence of Hypertension in a Population Exposed to Aircraft Noise. *Occupation Environmental Medicine*. 58:769-773.
- Schell, L.M., M.V. Gallo, M. Denham and J. Ravenscroft (2006). Effects of Pollution on Human Growth and Development, *Journal of Physiological Anthropology*, 25,103-112.
- Schmidt C.W. (2005). Noise that Annoys: Regulating Unwanted Sound. *Environmental Health Perspectives*, 113, 1-3.
- Schwela, D. and O.Zali (1999). *Urban Traffic Pollution*. Routledge, USA and Canada, 10-49.
- Singh, N. and Davar, S.C. (2004). Noise Pollution- Sources, Effects and Control. *Journal of Human Ecology*. 16(3), 181-187.
- Stephenson, R. J., Vulkan, G.H. (2008). Traffic noise. *Journal of Sound and Vibration*.7 (2), p 247-262.

Tiller, D., Wang, L., Musser, A., and Radik, M. (2010). Combined Effects of Noise and Temperature on Human Comfort and Performance. *ASHRAE Transactions*, 116 (2): 522-540.

Tripathi, P. (1994). Noise and its Effects, <http://www.bhoraskar.com>. Accessed on 06/02/2015 at 4:31pm.

Ugwuanyi J.U, Ahemen.I and Agbendeh A.A. (2004). Assessment of Environmental Noise Pollution in Markurdi Metropolis, Nigerial, *J. Pure Appl. Sci.* 6(2), 134-138.

WHO, Occupational and community noise, WHO Publication, WHO-OHS (2011). *Guidelines for Community Noise*. Available at: <http://www.who.int/docstore/peh/noise/guidelines2.html>

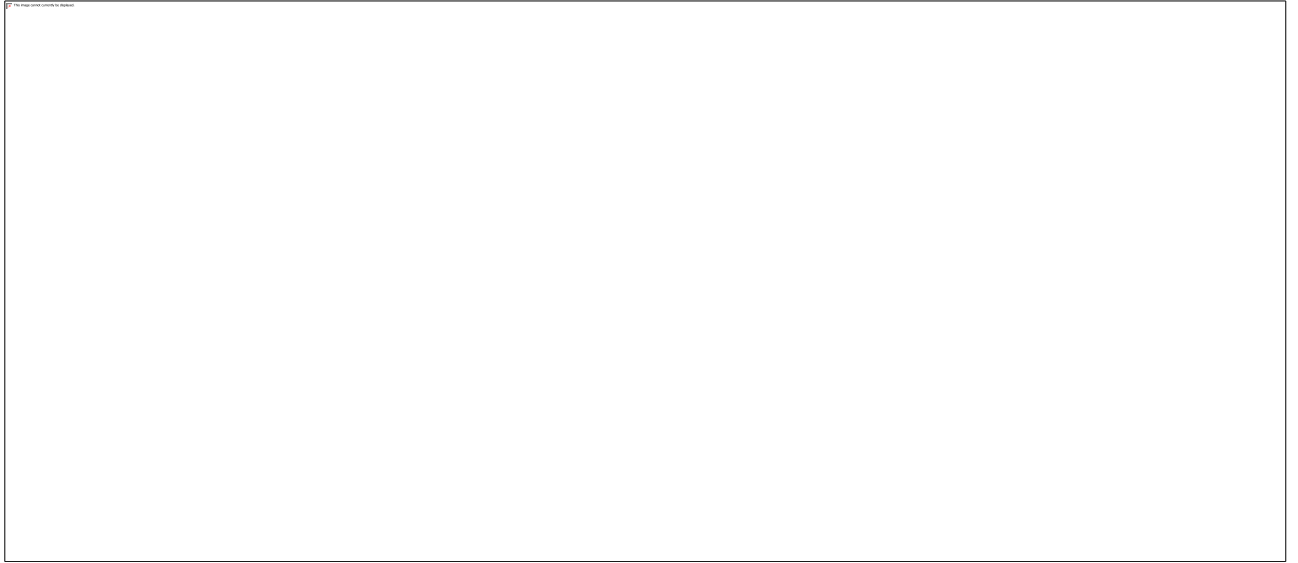
World Health Organization WHO (2000) Guidelines for Community Noise Geneva.

APPENDIX I



Source: National Population Commission.

**APPENDIX II:
Weather History Graph Obtained within the period of Study**



Source: NIMET, July 2015.

APPENDIX III:

**DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL ENGINEERING,
FACULTY OF ENGINEERING, AHMADU BELLO UNIVERSITY, ABU ZARIA**

George, Ikenna Ignatius is a Postgraduate student in the Department of Water Resources and Environmental Engineering A.B.U. Zaria is collecting data on the effects of noise within Zaria metropolis. We would be grateful if you could spare some time to answer a few questions.

Location:

Age : (0-10) (11-20) (21- 35) (36- 60) (61 - Above)

Sex: Male() Female: ()

Educational Background: Primary Education()Secondary Education()Higher Education ()Not Literate()

- 1 Do you know what noise pollution is? (if no, describe to the respondent what it means)
- 1 = yes
- 2 = no
- 3 = do not know

- 2 How long have you lived in Zaria? (in years)
- 0-10 b) 11-20 c) 21- 35 d) 36- 60 e) 61 – Above

- 3 Do you experience any kind of noise in your daily activities
- 1 = yes
- 2 = no

- 3a If Yes, is it within the following sources, rate the degree of the noise level effects from agree to disagree.

Sources	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
---------	----------------	-------	-----------	----------	-------------------

Traffic

Industrial

Household

Generator

3b

Train

Church/Mosque

Others

If others, mention them.....

- 4 Does any particular noise affect you on a daily basis?

1 = yes

2 = no

- 4a If If yes, Source of that noise.....

- 5 If you were to rate the degree of the effects of noise level from strongly agreed to strongly disagreed, what would you give?

Effects of Noise	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
No disturbance					
General Disturbance(Irritation)					
Headache					
Hypertension					
Loss of sleep/insomnia					
Stress					
Others (.....)					

APPENDIX IV:**Internal Traffic Count: Volume Composition of both in and out flow Route, Kofan Doka**

Days	Cars	Taxis	Mini buses	Midi buses	Big buses	Pick-up	Trailers	Lorry-trucks	Motor cycles	Tricycles	Total
Mon	815	8	1228	3	-	53	12	31	1247	354	3751
Tues	671	2	1238	-	4	35	21	29	986	249	3235
Wed	900	18	601	58	2	104	8	18	1015	653	3395
Thur	935	13	725	69	4	72	17	15	1073	670	3593
Fri	1590	4	861	124	2	215	311	34	1270	416	4827
Sat	890	-	440	36	12	213	16	33	1140	250	2140
Sun	900	8	215	42	5	29	6	6	910	306	1519
Total	5811	53	5308	332	29	721	391	166	7641	2898	23350
%	24.87	0.23	22.73	1.42	0.12	3.09	1.68	0.71	32.72	12.41	100

APPENDIX V:**Internal Traffic Count: Volume Composition of both in and out flow Route, Wusasa Axis.**

Days	Cars	Taxis	Mini buses	Midi buses	Big buses	Pick-up	Trailers	Lorry and Trucks	Motor cycle	Tricycle	Total
Monday	1245	15	146	183	31	78	54	43	1008	475	3278
Tuesday	1141	21	93	171	47	39	65	32	958	236	2803
Wednesday	984	19	181	163	32	46	43	28	775	243	2514
Thursday	965	17	172	178	43	66	75	58	910	317	2801
Friday	1005	33	186	79	54	72	64	69	986	342	2890
Saturday	836	14	125	48	37	50	51	43	864	244	2312
Sunday	764	6	87	55	31	45	39	38	760	189	2014
Total	6940	125	990	877	275	396	391	311	6261	2046	18612
%	37.29	0.67	5.32	4.71	1.48	2.13	2.10	1.67	33.64	10.99	100

APPENDIX VI:

Internal Traffic Count: Volume Composition of both in and out flow Route, Kwangila Corridor Axis

Days	Cars	Taxis	Mini buses	Midi buses	Big buses	Pick-up	Trailers	Lorry-trucks	Motor cycles	Tricycles	Total
Mon	16240	12	119	19	134	57	133	110	1870	145	13917
Tue	12138	17	115	13	146	89	160	76	1930	107	14791
Wed	10370	14	76	11	154	67	132	101	1755	137	12817
Thur	10370	2	78	21	129	91	144	65	1840	115	12855
Fri	11318	23	61	14	66	54	128	36	1615	287	18524
Sat	8615	4	84	8	121	49	118	71	1835	360	11265
Sun	9665	7	112	2	118	33	130	37	1550	210	11864
Total	78716	79	645	88	868	440	945	496	12395	1361	96033
%	81.97	0.08	0.67	0.09	0.9	0.46	0.98	0.52	12.91	1.42	100

APPENDIX VII: Plates

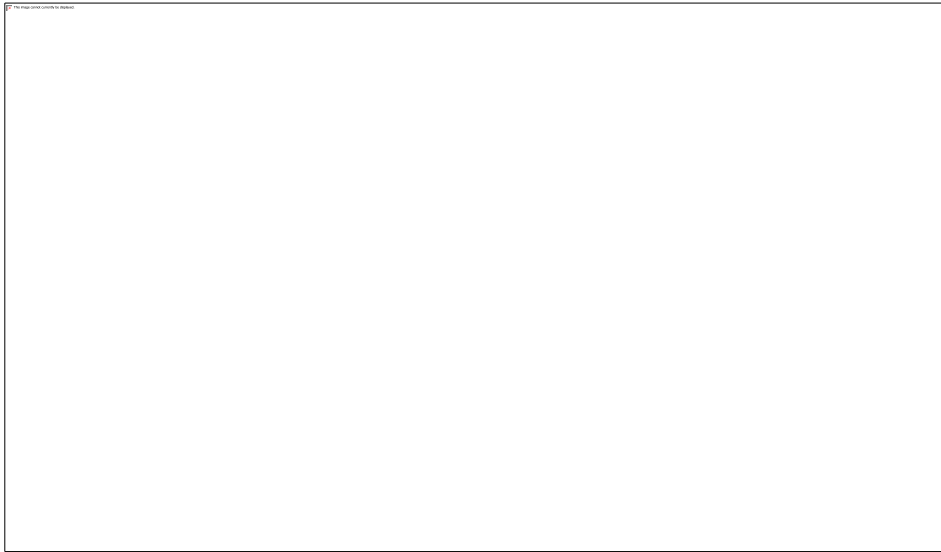


Plate I: Showing Residential Area for Leq

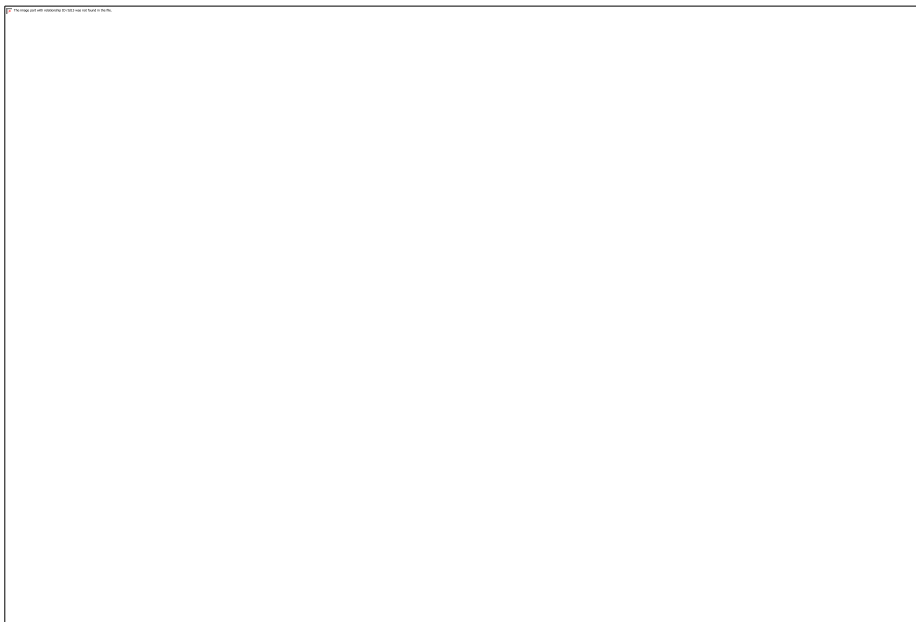


Plate II: Showing Kwangila Measuring Point for Leq.

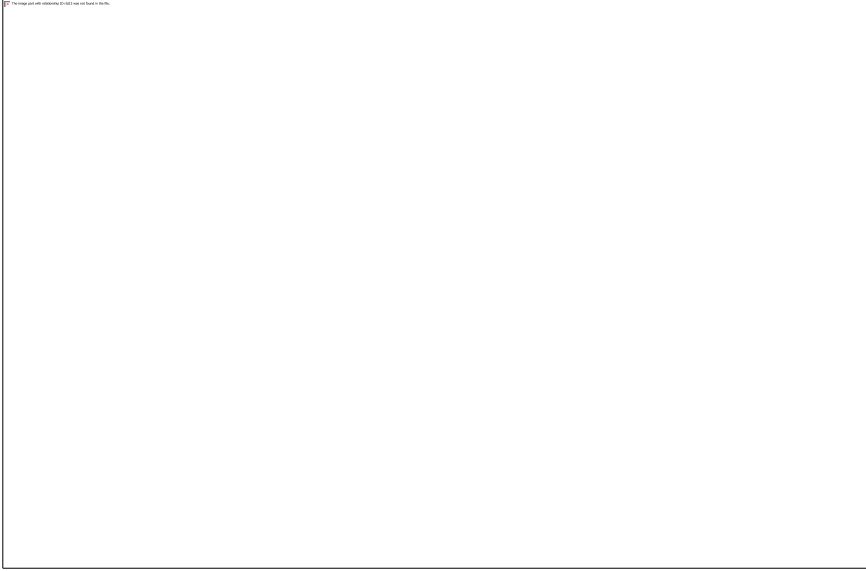


Plate III: Showing MTD Measuring Point for LeqM

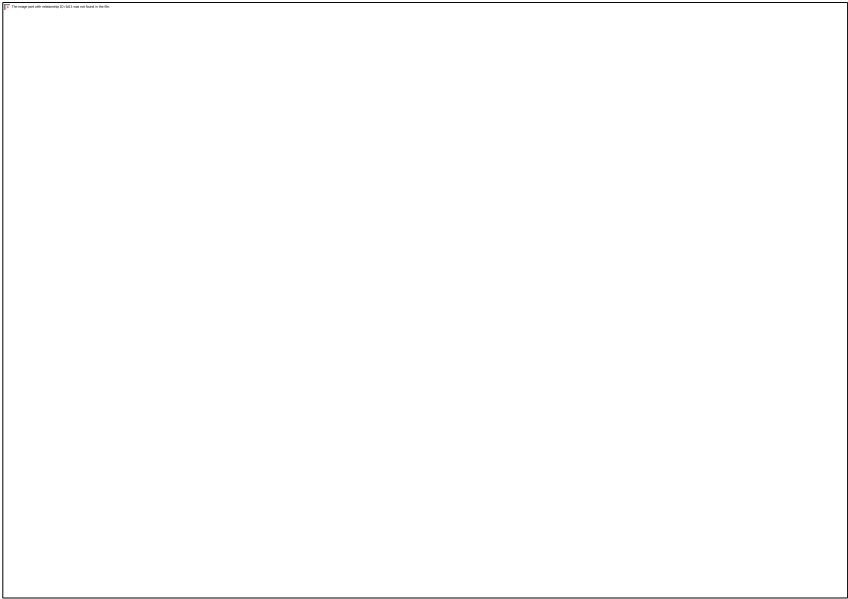


Plate IV: Showing MTD Measuring Point for LeqA

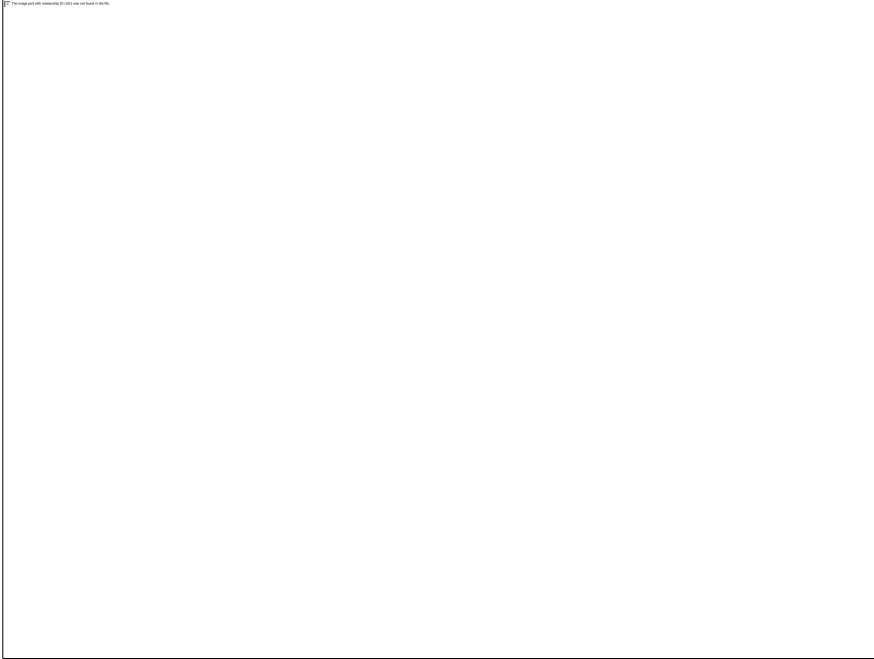


Plate V: Showing MTD Measuring Point for Leq E

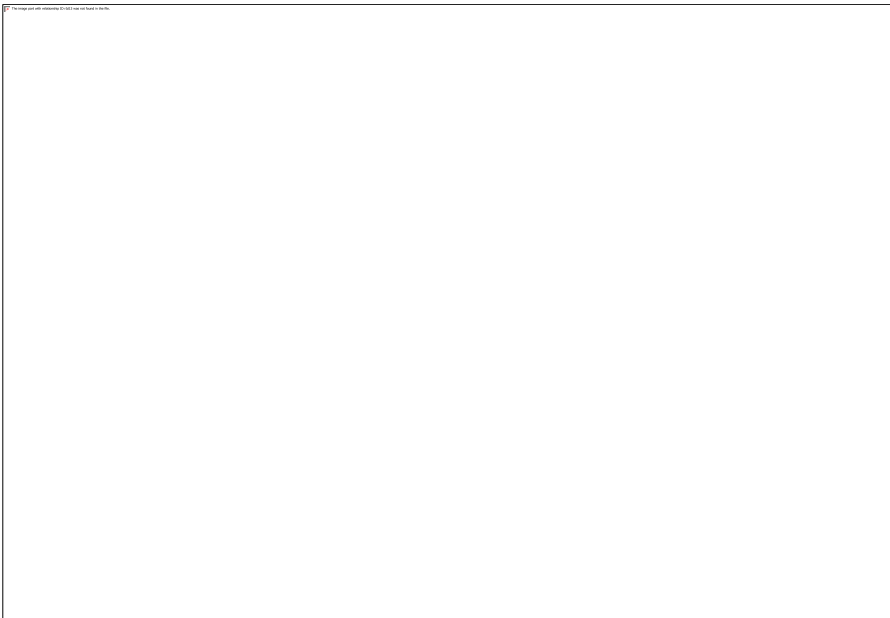


Plate VI: Showing PZ Cluster Point and Measuring Point Leq



Plate VII: Showing PZ Measuring Point LeqA

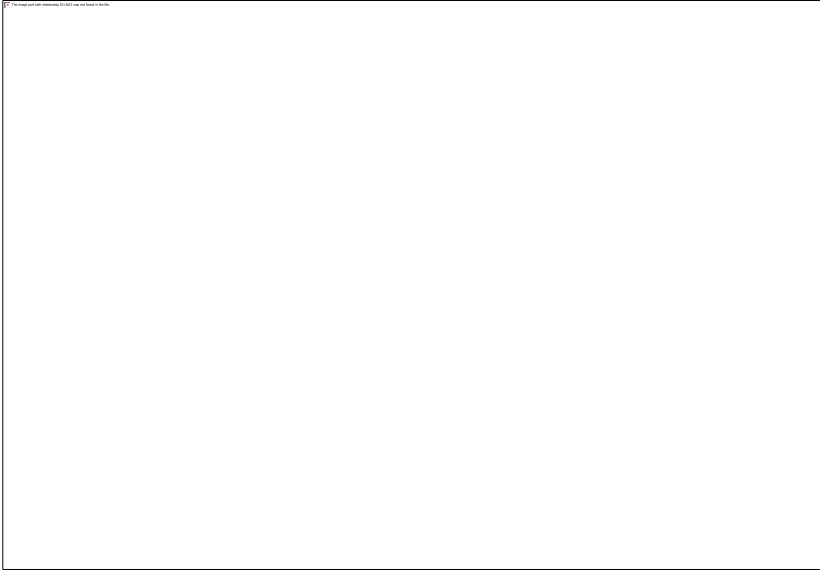


Plate VIII: Showing Generator Noise Source



Plate IX: Showing Commercial Business Area



Plate X: Showing Commercial Business Area for Leq A



Plate XI: Showing Leq Night Measuring Point.

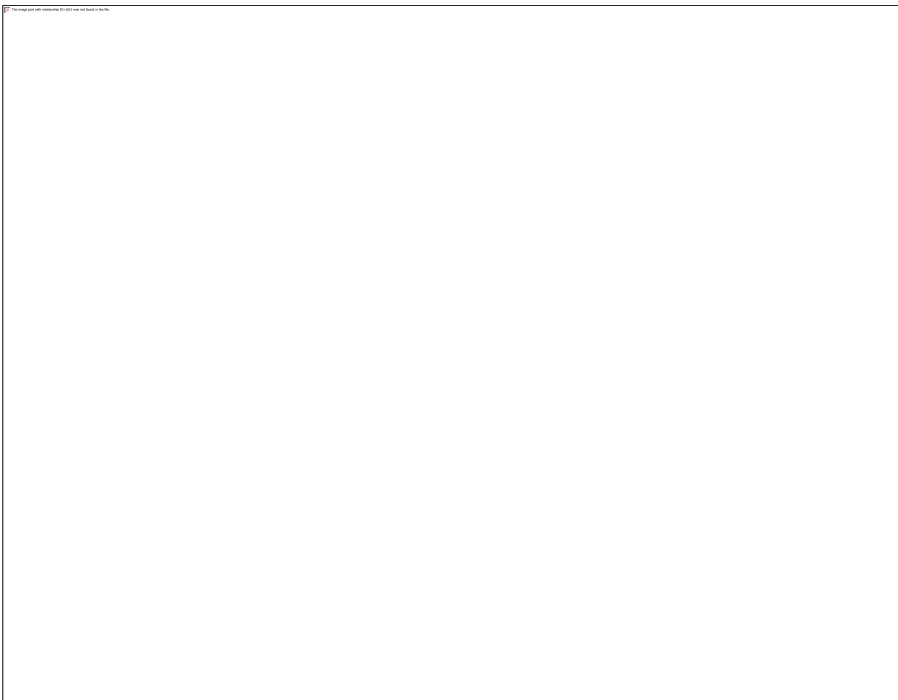


Plate XII: Showing Leq Night Measuring Point.



Plate XIII: Showing Leq Night Measuring Point.

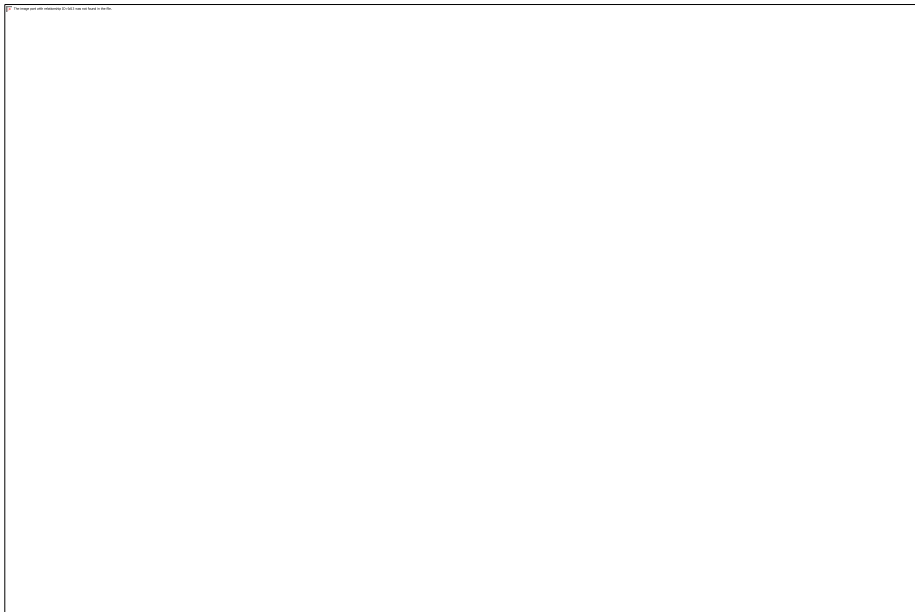


Plate XIV: Showing Leq Night Measuring Point.



Plate XV: Showing Control Point Area for Leq.