INVESTIGATION OF ENVIRONMENTAL NOISE POLLUTION IN SELECTED LOCATIONS IN SABON -GARI LOCAL GOVERNMENT AREA OF KADUNA STATE

BY

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN WATER RESOURCES AND ENVIRONMENTAL ENGINEERING

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DECLARATION

I declare that the work in this dissertation entitled INVESTIGATION OF ENVIRONMENTAL NOISE POLLUTION IN SELECTED LOCATIONS IN SABON -GARI LOCAL GOVERNMENT AREA OF KADUNA STATE has been performed by me in the department of WATER AND ENVIRONMENTAL ENGINEERING, under the supervision of Prof S.B. Igboro and Dr. B.S. Sani. The information derived from the literature has been duly acknowledged in the text and a list of references is provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

ABRAHAM APEH IDOKO ________________ ______________

Signature Date

CERTIFICATION

This dissertation entitled INVESTIGATION OF ENVIRONMENTAL NOISE POLLUTION IN SELECTED LOCATIONS IN SABON -GARI LOCAL GOVERNMENT AREA OF KADUNA STATE by ABRAHAM APEH IDOKO meets the regulation governing the award of the degree of MASTER OF SCIENCE in WATER RESOURCES AND ENVIRONMENTAL ENGINEERING of the Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

Prof S.B. Igboro Chairman, Supervisory Committee	________________ Signature	________________ Date
Dr. B.S. Sani Member, Supervisory Committee	________________ Signature	________________ Date
Prof M.A. Ajibike Head of Department	________________ Signature	________________ Date
Prof Sani.A. Abdullahi Dean, School of Postgraduate Studies	________________ Signature	________________ Date

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ABSTRACT

Environmental noise pollution is an indicator of environmental degradation and its impacts in the sub-urban areas on the sustainability of life is an emerging concern. This has spurred this study on investigation of environmental noise pollution in 54 purposeful selected study points in Sabon Gari Local Government Area of Kaduna state. The noise measurement was carried out in commercial areas, selected busy streets, major intersections, and mixed residential areas. Extech Noise meter model 407750 for sound measurement and Geographical Information System (inverse distance weighted) were used for the spatial interpolation. The population was estimated and three hundred and eighty-five structured questionnaires were estimated and administered by purposeful random sampling. About 358 questionnaires were retrieved. SPSS and Excel statistical software were used for the analysis. The L_{DAY} (L_D), $L_{Evening}$ (L_E), L_{Nigth} (L_N) and (L_{DEN}) were compared with WHO and NESREA specification respectively. For the L_D, 100 % of all the surveyed sites exceeded the WHO standard and 94.4 % exceeded the NESREA standard which range from 67.6 dB (A) at Ijaw Street to 93 dB (A) at Kwangila intersection site one. For the L_E, 100 % of the surveyed sites exceeded the WHO specifications and 90.7 % exceeded the NESREA specifications which range from 67.8 dB (A) at Hanwa residential area to 92.7 dB (A) at Kwangila site three. for the Lnight, 100 % of the surveyed sites exceeded the WHO standard and 83.3 % of the sites exceeded the NESREA specifications ranging from 63.3 dB (A) Dogorawa residential area to 92.1 dB (A) at Kwangila intersection site one. for the L_{DEN}, all the surveyed sites exceeded the WHO specifications and 83.3 % of the sites exceeded the NESREA specifications which range from 73.1 dB (A) at Hanwa/ Graceland residential areas to 98.0 dB (A) at Kwangila site (1). The L_{10} range from 68.1 dB (A) at Graceland residential to 95.1 dB (A). The L_{90} range from 43.8 dB (A) at Graceland residential areas to 81.6 at Kwangila intersection site one. The Traffic Noise Index (TNI) range from 57.8 dB (A) at Hanwa/Pensioners residential area to 122.1 dB (A) at park road about 96.3 % of the surveyed sites exceeded the 74 dB (A) compared standard. The Noise pollution level (L_{NP}) range from 78.1 dB (A) at Hanwa MTN generator to 123.0 dB (A) at Aminu Road and exceeded the compared standard of 72 dB (A) in all the sites. There was a significant difference between L_D and $L_{N,}$ L_E and L_N, L_{10} and $L_{90,}$ TNI and L_{NP} as $P< 0.05$ exception of L_D and L_E where $P>0.05$ with the confident level of 95 %. On the perception responses, about 90.2 % representing 323 of the respondents have awareness on various aspect of environmental noise. There was a significant response on the sources of noise and their severity as traffic noise, generator and commercial activities were ranked in descending order of severity using the Likert scale. There was a significant awareness of the various effects of noise pollution as hearing impairment, annoyance, stress, distraction and aggressiveness were ranked in descending order based on the Likert scale. About 61.7 % representing 221 of the respondents complained about environmental noise. About 72.2 % representing 258 of the respondents had done nothing in mitigating noise. About 91.1 % representing 326 of the respondents want the government to take more proactive actions in mitigating and punishing those who indiscriminately degrade the environments with noise pollution. The noise Index, Parameters, and Percentiles were exceeded in most of the surveyed sites. Therefore, a determined effort by concerned government agencies, non-government, institutions, well-wishers in creating necessary awareness to the expose population, planting of trees with large foliage, constant environmental sound monitoring, strategic urban planning, and wearing safety wears would serve as a deserving mitigating measure.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF APPENDICES

LISTS OF ABBREVIATIONS

ABUMG	Ahmadu Bello University Main Gate
ADS	Afegbu Daraka Samaru,
Ag	Agwangodo,
AR	Aminu Road,
ATC	Albabello Trading company
BPZ	Bank Junction Peterson Zochonis,
BS	British Standard
CR	Cemetery Road,
CR	Chikaji Roads
CS	Club Street
dB (A)	Decibel A weighted Frequency
TNI	Traffic Noise Index
L_{NP}/LNP	Noise Pollution Level
NC	Noise Climate
L_D/LD	Noise Equivalent during the day time
$L_{E\,/}$LE	Noise equivalent level during the evening time intervals
$L_{N\,/}$LN	Noise Equivalent level during the night time intervals
L_{DEN}/LDEN	Noise equivalent level for surveyed site.
D	Dogorawa,
DBH	Dasa Block Hyindogo,
DI	Daily Iya
DPR	Department of Petroleum Resources
ECND	European community Noise Directive
EEA	European Environmental Agency (USA)
EPA	Environmental Protection Agency (Europe)
EU	European Union
FP	Farangida Paladan,
FCT	Federal Capital Territory
FEPA	Federal Environmental Protection Agency
G	Gwado,
Ga	Galadima,
HY	Hyinda-Yaro
GL	Graceland,
GM	Grand Mean
GRA	Government Reservation Area,
H	Hanwa
ICU	Intensive Care Unit
IGCB(N)	Interdepartmental Group on Costs and Benefits Noise
IL	Iya Line
IS	Ijaw Street,
ISO	International Organization for Standardization
KPQ	Kips pure water Agwangodo,
KR	Kings Road,
Kw	Kwangila
LA Max	Level of (A) Weighted Scale Maximum
LAeqT	A Weighted equivalent at a giving Time
LDEN/L_{DEN}	The Equivalent Average for day, Evening and Night
LGA	Local Government Area

LS	Lagos Street
MBS	Munchi Block Samaru,
MLTP	Manchester Line Peterson Zochonis,
MTD	
MU	Muchia,
NAE	National Academy of Engineering
NESREA	National Environmental Regulation Standard and Enforcement Agency
NIHL	Noise Industrial hearing lost
NIOSH	National Institute of occupation Safety and Healthy
NPC	National Population Commission
PGL	Perishable Goods Line
PQH	Pensionaries Quarters Hyindogo,
PR	Park Road,
RKR	Randan Kano Road,
SEL	Sound Energy Level
SL	Saraki Line
TPZ	Tecno Peterson Zachonis,
UFP	Umar Faruk Plaza
WHO	World Health organization
WM	Weekly Mean
YS	Yoruba Street,

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Developed and developing countries have experienced exponential economic advancement in every facet with its attendant environmental consequences such as water pollution, air pollution, and noise pollution. It has been shown to facilitate the degradation of the ecosystem and diminished environmental quality which threatens the sustainability of life if the consistent and proactive decision is not taking to curb the menace (Yuan *et al*, 2019; Jarosińska *et al*., 2018; George *et al*., 2016; Okuofo, 2014; European Environmental Agency (EEA), 2014; Matin *et al*., 2006; Directive 2002/49/EC). Findings by Ibikwe, *et al*., (2016); Hsu, *et al.*, (2012) and European Environmental Policy (EEP), (2008) have considered noise as unacceptable and infuriating sound. It is a consequence of various anthropogenic activities which result in adverse environmental health challenges. Florence Nightingale in 1859 in her observation acknowledged noise as a notable health hazard when she wrote 'that noise is the most gratuitous cruel cruelty of care which can be inflicted on either the sick or the well' (Yuan *et al* 2019; WHO, 2011; George, 2016; Onuu, 2014; Okwudili *et al*., 2021; Hsu *et al*., 2012; Ibikwe *et al*., 2016, Directive 2002/49/EC)

The exponential increase in the number of vehicles, musical instruments, Mega and small-scale industries, urbanization, transportation, hawkers, high amplified music sound, discotheques, private electric-generating plants, grinding machines, population explosion, and other human activities have been identified as the sources of noise pollution in the ecosystem (Lee *et al* 2015; Boateng *et al*., 2018; Okuofu 2014; Lee and Lin, 2007; Singh and Deepak, 2013; Ghanbari *et al*., 2011; Nwaka 2005; Anomohanran and Iserhien, 2016). In 2014, it was estimated that about 125 million people were affected by noise levels greater than 55 dB L_{DEN} (day, evening-night level) (EEA, 2014)

The degree of noise problem is enormous. According to the European Union, approximately 40 % of the inhabitants are unprotected from road traffic noise by means of an equivalent sound pressure level surpassing 55 dB (A) daylight, and about 20 % are unprotected to levels surpassing 65 dB (A) (Liwi and Zaborowski, 20017; Directive 2002/49/EC; Berglund *et al*., 1999; WHO, 2-11-2012). Considering all the exposure to transportation noise together around half of the European Union inhabitants are predictable to live in neighbourhoods that do not guarantee acoustical relief to the populaces. About 30 % are unprotected at night to equivalent sound pressure levels surpassing 55 dB(A) which remain upsetting to sleep. The effect of noise pollution is a significant and severe problem in several cities of developing countries. Data collected alongside densely travelled roads and mixed residential areas have equivalent sound diurnal pressure levels of 75 dB (A) to 80 dB (A) (Basner and McGuire, 2018; Jarosi *et al*., 2018; WHO, 2005; Czyzewski *et al*., 2004; Berglunde *et al*., 1999)

The World Health Organization, other concerned researchers have reported several adverse environmental health associated with noise pollution on homo-Sapiens. Such as hearing impairment, interference with spoken communication, sleep disturbance, productivity, alter efficiency, concentration, hypertension, tinnitus, aggressiveness, cardiovascular disturbances, facilitate in mental health disorder, stress, presbycusis, cognitive deterioration, impaired task performance, negative social behaviours, and annoyance. (Fenech and Rodger, 2019; WHO, 2011, Liwi & Zaborowski, 2017; Luzzi *et al*., 2016; Ononugbo *et al*.,2017; Abbaspour *et al*., 2006; Anomoharan *et al*, 2016;

(EEP, 2008; Directive 2002/49/EC; Jarosińska *et al*., 2018; No. D, (2013); Singhal *et al*., 2009)

The adverse consequences of noise are obvious as it encompasses direct and cumulative impact in environmental health which is of enormous concern to environmental engineers and public health. This necessitates in a need of carrying out research on environmental noise related research in urban and peri-urban area. As inadequate research and legislative enforcement have not been given due attention to address these pertinent concerns of noise pollution in Africa and especially in Nigeria. It is on this hypothesis, that spur this study on the investigation of environmental noise pollution in selected areas in Sabon- Gari LGA of Kaduna State Nigeria.

1.2 Statement of the Problem

The exponential growth in human population, urbanization, industrialization, economic growth, and climate change, is triggering the world environment to become increasingly noisy. This has resulted in diverse environmental and health challenges. This has spurred the urgent need for detailed studies of environmental noise pollution and distinct noise spatial mapping of the study location. Previous findings have affirmed globally, especially in developing countries of insufficient, inconsistent noise data to carry out necessary proactive decisions in monitoring, mitigation, and control of noise pollution (Owen, 2019**;** Ononugbo *et al*., 2017; Orban*, et al*., 2016; WHO,2012; Hammer*, et al*., 2014; Directive 2002/49/EC; Folkeson *et al., 2010, Ge*Geraldin *et al*., 2016; Okuofu, 2014; George, *et al*., 2016).

There is a demand to expand the understanding, not only on the magnitude of the impact of the noise but exposure effects such as annoyance, adaptation, coping strategies to trigger interventions and policy to mitigate the consequences of its impact in Sabon-Gari LGA in Kaduna State. Developed and developing countries need to categorize tractable study sites and scenarios to collect sufficient replication of noise data to understand the response to variation between locations and situations through the sequence of time with populations exceeding 100000 inhabitants (Directive 2002/49/EC ; Hammer, *et al*., 2014; King *et al*., 2016; Akpan, 2015; Gyanfi *et al*., 2016; WHO, 2011, King, 2016).

Though the Nigeria Federal Environmental Protection Agency has been in existence since and 1988 metamorphosized into the Federal Ministry of Environment, where the National Environmental Standard Regulation and Enforcement an Agency (NESREA) as agency was carved out in 2007 to provide strategic guidelines and policy implementation, not much has been done to address the challenges of noise pollution in Nigeria. As such there are few or poorly enforced noise-pollution control laws in many parts of the country as a result of inadequate data (Ighoroje, *et al.*, 2004)

This has led to this study on the investigation of environmental noise pollution status in selected locations in Sabon-Gari LGA.

1.3 Aim and Objectives

The goal of this study is to investigate the temporal and spatial variation of noise levels in Sabon-Gari Local Government Area of Kaduna State, Nigeria

I. To identify the various sources of noise at each selected study location

II. To determine the noise index (L_{DEN}), percentiles (L_{10}, L_{50}, L_{90}), and noise parameters (TNI, L_{NP}, NC).

III. Compare the measured noise appraisal index, parameters with WHO, NESREA, and (SSS) Standard.

IV. To produce the spatial noise mapping of the study area.

V. Perception evaluation of the effects of noise from people living around the study area

1.4 Justification of the Study

In recent times, many governments, nongovernment and individuals have given commendable attention to water, land, and air pollution. As plausible as that could be, not much consistent research has been carried out in respect to noise pollution in developing countries despite its multi- environmental health implication. To consider the effects of noise pollution such as annoyance, tinnitus, adaptation, and coping strategies, there is a need for a better understanding of the magnitude and spread of noise within the environment (Goines and Hagler, 2007; George, *et al*., 2016; Directive 2002/49/EC; Guerra *et al*.,2005). Furthermore, data on spatial noise level and its mapping is essential for effective management of the environment (Dreger et. al., 2019; Guski *et al*., 2017; Majidi and Khosralli, 2016; WHO, 2011)

However, it has been asserted that people in developing countries do not pay significant attention to the seriousness of noise pollution and its dangerous environmental consequences. This is however not the case with other countries of the world where necessary actionable legislation has been promulgated to regulate and to punish offenders appropriately (Guski *et al*., 2017: Anomhanran, *et al*., 2013; Oyedepo, 2012; Abumere, *et al.,* 1999). Therefore, obtaining vital data from the field will facilitate the monitoring of noise levels, provide a better understanding and subsequent effective sustainable management of such hazards as posed by high levels of noise.

In comparison to sundry other environmental challenges, noise pollution continues to grow exponentially and it is attended by the growing number of complaints from individuals unprotected to noise. The increase in environmental noise pollution encompasses adverse health effects, direct, and cumulative. It unpleasantly affects the economy, socio-cultural, aesthetic of the environment, present and future generation

(Jarup *et al*., 2008; Jarosi *et al*., 2018; Berglund *et al*., 1999; Jamir, 2014, WHO, 2011; No, D. (2013).

The outcome of this finding in Sabon-Gari LGA in Kaduna State Nigeria will elucidate the sources, characteristics as well as diurnal temporal and spatial variations of noise levels.

1.5 Scope of the Study

The study is aimed to investigate the diurnal environmental noise pollution for the temporal scope for morning time intervals, evening time intervals and night time intervals in Sabon-Gari LGA in Kaduna state in the categorized area such as mixed residential areas with commercial and light industries, selected Roads/streets, selected road intersections, and commercial areas across eight developmental wards.

1.6 Limitation of the Study

Inabilities to have access to several dosimeters that are recommended for sound measurements such as in the industrial areas, private and public cars. Noise level measurement will be carried out for shorter durations for each of the 54 selected locations due to security challenges and inaccessibility to some areas. It becomes impossible for a continuous reading to be taken throughout the day for a complete year. The study will not account for noise generated in silence zones, development of predicting model, simulation, Noise inside a means of transport, and aircraft noise, traffic count, industrial noise, and Indoor noise. Seasonal variations were not considered in the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Noise is virtually everywhere. It has gradually become the main burden on the quality of life globally. Noise pollution is well-defined as a type of air pollution that is a perceptible unwanted, unpleasant sound that poses a significant threat to a person's (Basner and Mcguire, 2018; Goins and Hagler, 2007; British Noise Regulation, 2015; Juraga *et al*., 2015, Regelova and Kellerrova, 1997). In all languages of the world, noise at all times is considered an unwelcome visitor in any society. The Hausa language is known as Surutu, the Igbo language is known as Mbotu and the Yoruba language is known as ARIWO. Noise is a powerful indicator of environmental degradation and one of the most important factors for the determination of the sustainability of quality of life in the ecosystems (Farooqi et al., 2020; Dube *et al*., 2008; George et al., 2016; Cavanaugh and Tocci, 1998). The noise burden of disease was estimated to be equivalent to 1.7 million in western Europe. Disability-adjusted life years (DALYs) (Brown and Van, 2017). The WHO estimations that 250 million people have a hearing loss and two-third of these people lived in developing countries (Ugbebor *et al.*, 2017)

2.2 Sound and Noise

Sound is very important and vital for the continual existence of life. It is a form of energy, it is heard when it is emitted by vibrating bodies such as water, air, and metals. It is a type of state of motion when reaching the ear, the prompt sensation of hearing through the nervous system. The noise generally consists of three inter-related elements - the source, the receiver, and the transmission path (Padeepz, 2021; Brown and Van, 2017; Vogel *et al*.,2011). The transmission path is usually the atmosphere through which sound is propagated but can include structural materials of any building containing the receiver. Discrimination and differentiation between sound and noise also depend upon the habit and interest of the person or species receiving it. When the ambient conditions and impact of the sound generated during daily activities is beyond the various recommended standard, it becomes a great threat to the existence of life (Padeepz, 2021; Brown and Van, 2017; Yuan, *et al*., 2019; Singh and Davar, 2004)

2.2.1 Sound loudness

Sound loudness is related to the magnitude of the amplitude and is interconnected to frequency. Exposure to sound loudness can vary from the persons whose ear can distinguish the threshold of hearing to the individuals that surpass a threshold of pain**.** The acoustic burden for a smooth simple harmonic sound wave moving in positive x-direction is represented by equation 2.1

$$P\ (x,\ t) = a_{max} *[\sin\ (2\ ft - kʎ)] \quad 2.1$$

where: -

a_{max} = the amplitude of the acoustic pressure wave,

ʎ = stands for the wavelength,

f= frequency and

t = is the time or period

Acoustic instruments, such as a sound level meter is an instrument used to measure the root-mean-square (RMS) pressure, which is proportionate to the amplitude. There is a relationship that exists between the pressure wave amplitude and the root mean square pressure and this is given in equations 2 (Arcadio and Gregoria, 2002)

$$R=\sqrt{\frac{L_{Aeqn}}{10}} \quad 2.2$$

where: -

R= Root mean pleasure

L=Equivalent A-weighted noise level over a giving period

2.2.2 Characteristics of sound

Sound characteristics are essentially waved characteristics. The various parameters used to define sounds are as follows: period, frequency, wavelength, speed, and amplitude. When sound waves are regular, periodic, of long duration, they produce a pleasing effect and such sound is referred to as musical sound. Sound needs a certain intermission of time to travel from one destination to another destination in a medium and with a velocity that is smaller than that of the velocity of the light (Padeepz, 2021). The velocity of sound is maximum in solids, which have higher bulk modules and least in gases on the contrary when the sound waves are non-periodic, irregular, and of short duration, they produce a displeasing effect and such a sound is referred to as noise (Padeepz, 2021).

2.2.2.1 *Classification of Sound*

I. Sound waves having frequencies that are below 20 Hz are referred to as Infrasonic (inaudible)

II. Sound waves possessing frequencies that are above 20000 Hz are referred to as Ultrasonic (inaudible)

III. Sound waves having frequencies of 20 Hz to 20,000 Hz are termed audible sounds (Padeepz, 2021; Aspuru *et al*., 2010)

2.2.3 The Advantages of environmental sound

Despite the adverse consequences of noise pollution, there are advantages of sounds for a healthy environment such as:

I. Masking effects prevent others to hear the conversation between two people. It is applicable in the doctor's Chamber when the doctor wants his or her conversation with his or her patient to be private. E.g., sound exhaust fan which increases the level of indoor sounds. To ensure the conversation is not heard by other patients.

II. Music and entertainments; the outcome or the impact of the energy from sounds in a regulated frequency and amplitude. Its transformation is pleasant to the human ear (George *et al*., 2016; Okuofo, 2014)

2.3 Noise Pollution

Noise pollution is the release of excessive sound that could be uncomfortable, hazardous to the public health and can lead to the degradation of the ecosystem Babish *et al*., 2005; Nigeria Noise Standard regulation (2009). Noise pollution is one of the major environmental pollutants that have direct effects on human performance (Cavanaugh and Tocci, 1998; Breinbauer *et al*., 2012;). The survival and healthy existence of man is a function that depends largely on conducive, enabling, and sustainability of the ecosystems. As a result, any disruption in the conducive environment may lead to dysfunction in health status. Otukong, (2002) and Singh *et al*., (2010) found out that anthropogenic activities such as Urbanization, civilization, industrialization, and increase in density of traffic either from roads, railway and aviation industries are the causative agents of noise pollution**.** The noise that poses threat to the human body is those with high pitch, high amplitude, poorest tone, and longest duration (Ononugbo *et al*., 2017; Nelson *et al*., 2005; Boyd *et al*., 2013; Bartaluci, *et al*., 2015, Babiscu *et al*., 2005).

'Noise is well-thought-out as pollution because of its detrimental effects on the quality of life. Oyedepo and Saadu *et al*. (2010) and Onyango *et al*. (2015), declared that noise pollution in Nigerian cities is comparatively high when compared to recommended levels by World Health Organization. The most rigorous and pervasive type of noise pollution that has been a predominant source of annoyance is traffic noise (Orban *et al.*, 2016; Öhrström and Skånberg, 2004). Noise and especially environmental noise have become a serious problem confronting the world today which is a result of inadequate planning of urban and sub-cities in the past. Homes, schools, offices, hospitals, commercial business centres, and other commercial buildings were routinely built close to the sources without buffer zones or adequate soundproofing (Pal and Bhattacharya, 2012). The problem has been compounded by increases in traffic volumes (two-wheelers, heavy motor vehicles, and tricycles) far beyond the expectations of our early urban planners. The alarming increase in the use of generators by house-holds and small-scale industries, the upsurge in the volume of a different form of fairly used (tokunbo) mobility systems such as big trucks, cars, tricycles, and motorcycles without meeting noise specifications are consequently the direct predominant and determinant causes of the escalation of environmental noise pollution. These have led to diverse environmental impacts on man, animals, and aquatic animals (George *et al.*, 2016; Qutube *et al.*, 2009; Pal and Bhattacharya 2012; Singh and Dev, 2013.)

2.3.1 Types of noise

Noise is the consequence of homo sapiens, animal, and natural disaster activities. When evaluating its influence on human well-being it is categorized either as occupational noise (i.e., noise in the workplace), or as environmental noise, which comprises noise in all other sceneries, whether at the community, residential, or domestic level (e.g., traffic, playgrounds, sports, music) (WHO, 2011- 2012; Amedofu, 2017; Padeepz, 2021). There are two discrete types of noise, they are: indoor noise and the outdoor Noise

2.3.2 Indoor noise

It is the type of noise created in adjacent rooms or in the same room where the noise is noticed. The sources of indoor noises are moving people, crying of babies, playing of radios, banging of doors, traffic on staircases, movement of furniture, a conversation of the occupants, operation of cisterns as in water closets, electric fern, and noise from a type writer, etc.

2.3.3 Outdoor noises

These are noises that are produced from various outdoor activities.

2.3.3.1 *Occupational noise*

Noise is upstretched parallel with industrial growth and technological developments. Currently, many people in the world are unprotected from erratic or continuous dangerous sound levels greater than 85 dB (A) in their work surroundings. On the global scale, the main cause of Noise-induced hearing loss (NIHL) in adults is occupational noise (Nelson and Nelson, 2005). It has been observed that this is currently increasing in developing countries. Several workers comprising those involved in heavy industry, coal, gas processing industry, cement plants, forge hammering, factories, ore mining, commercial, workers at refineries, construction, sawmill, and workers at stationary machine operators are at risk of occupational NIHL. A study in Brazil observed in metalwork corporation, indicated cases of NIHL was about 5.9 % (Wallingford**,** 1987; Harvie-Clarl *et al*., 2019; Gerges, 2004; Nelson *et al*., 2005; Haliza *et al*., 2018; Ighoroje *et al*., 2004; Hurtley, 2009; Anomohanran, 2013). In a different study on 384 workers in an oil refinery in Taiwan, the researchers revealed that those workers who had been unprotected from the noise for more than 15 years had increased hearing threshold shifts at high frequencies. (Guerra *et al*., 2005). As NIHL is an irremediable prevalent work-interrelated hearing handicap in adults, the paramount approach is prevention through identification of noise production sources and levels to establish standard rules and regulations (Wallingford**,** 1987; Fritschi *et al*., 2011; Geraldin *et al*., 2016, Alonso *et al*., 2020).

2.3.3.2 *Environmental noise*

Environmental noise is the noise emitted from all sources except within the industrial workplace. Environmental noise is generated in and around the environment (Schumer, 2001). Noise in the communities in which people live and work is steadily increasing in magnitude and severity (Cavanaugh and Tocci, 1998). One of the major contributors to outdoor noise is traffic noise. The intensity and the nature of noise produced by traffic depend on the type of traffic. Several other sources such as the blaring of loudspeakers and sirens, shouting of hawkers, and religious activities produce different levels and tones of noise to the environment (Fritschi *et al*., 2011; Pal and Bhattacharya, 2012 Azkorra *et al*., 2015).

2.4 Measurement of Environmental Noise

The response and the sensitivity of the human ear to sound depend both on the sound frequency (Hertz) and the sound pressure (decibels). The range of hearing by a healthy young person is 20-20,000 Hz (Berglund and Lindvall., 1995; Padeepz, 2021). There is individual variability in the sensitivity to different frequencies. Sensitivity to high sound frequencies decreases with age with noise exposure. Noise exposure at one time can occur from various sources, therefore the average sound pressure level over a specific period is usually measured (Hopkins, 2015; Horoux and Verbeek, 2018).

Accounting for the perception of the human ear to loudness, a spectral sensitivity factor is used for incorporating a weighting network (simply an electrical circuitry). The noise meter is electronically structured in approximating sound from the environment to the human response. Finding from diverse studies had concluded that the noise meter is efficient and effective in recording sounds as close as to the human ear in capability and it is called the A-weighting scale. The “A-weighting.” correlates well with the subjective response of the human auditory system, and is expressed in decibels, in A-Scale (dBA). It is simple and convenient to deploy for environmental assessment (Hopkins *et al*.,20015; No, D. (2013); Guski *et al*., 20017; EEP, 2009; Directive 2002/49/EC; Berglund and Lindvall, 1995).

Measurement of noise is carried out by noise level meters, at locations where people work, commercial areas, generated traffic areas, and mixed residence areas. The sound level meter that meets the ISO standard is recommended for the investigation of an environmental noise assessment. While Noise dosimeter is the best recommended equipment for assessing individual noise exposure in the industrial environment, which is worn by all the participants that are predisposed to noise. This has the advantage over noise level meter, of capturing the average noise exposure even while moving around the industrial environment. (Churcher and King, 1936; WHO, 2012; Directive 2002/49/EC; NESREA, 2007).

2.4.1 Noise descriptors

Noise descriptors are used to designate the time-varying nature of noise. Several noise descriptors are used to interpret the measured decibel values. These noise parameters include the following.

2.4.1.1 *The equivalent continuous noise level*

The equivalent continuous noise level in a given time is referred to as a continuous sound equivalent pressure level i.e., is the level of sound pressure that is putatively constant encompassing the same energy as the authentic sound whose level may fluctuate over the measured period. It is applicable in the measurement of the level of continuing sounds such as road traffic noise, industrial noises, mixed residential areas, and noise from ventilation systems in buildings. When there are distinct events to the noise such as with aircraft or railway noise, measures of different events should be evaluated (using, for example, LAmax) in addition to LAeq, T measurements. Which is used to describe fluctuating noise levels. It is a constant noise level that expends the same amount of energy as the fluctuating noise level over the same period (Fritschi *et al*., 2011; Directive 2002/49/EC; Martin *et al*., 2006; WHO, 2012; Wallingford**,** 1987**;** Bartalucci *et al*., 2016). Collective environmental effects on the well-being of noise from diverse sources are a necessity. Several acoustical environments comprise sounds originating from more than one source, i.e., there are diverse sources of noise, and some mixtures of effects are common. For example, noise might affect speech in the daylight and generate sleep disorders at night. These circumstances undoubtedly spread over to suburban areas severely polluted with noise. Consequently, the overall adverse well-being load of noise must be measured over 24 hours, and all the cautionary principles for sustainable investigations be applied (Directive 2002/49/EC; EEP, 2008; Borchgrevink, 2003; Alonso *et al*., 2020; Azkorra *et al*., 2015; Basner and McGuire, 2018).

2.4.1.2 *Noise pollution level (L_{NP})*

It is a noise parameter that is used to describe community noise. It employs equivalent continuous sound level (LAeq) and the magnitude of the time fluctuations in noise level. It also gives the vacillations from the average background noise and takes into consideration the variations in the sound signal. It, therefore, serves as a better indicator for environmental pollution for physiological and psychological effects of noise pollution (Scholes *et al*. 1971; Oyedepo and Saadu, 2010; Ma *et al*, 2006).

$L_{NP} = Leq + K\sigma$

Or

$L_{NP=} Leq + a\ (L10 – L90)$ 2. 3

where: -

K= is a constant

σ = is the standard deviation of the sound level during the same period.

L_{Aeq}= Sound Level equivalent over a giving period It was recommended that a = 1.0 and K= 2.56 (Scholes *et al*., 1971; Ma *et al*, 2006).

L_{10}: It is the level of sound that is surpassed by 10% throughout the measuring time in dB (A). $L_{50:}$ It is the level of sound which are surpassed by 50 % during the time of measurement in dB (A) or it is the statistical median of sets of measured sound levels.

L_{90}: It is the sound level that is surpassed by 90 % all through the measurement time (Ma *et al*., 2006, Oyedepo, 2012; Scholes *et al*., 1971**).**

2.4.1.3 *Traffic noise index*

The traffic noise index (TNI) is used to determine the amount of variability in observed acoustic levels in a study location. It is used to improve the correlation between noise measurements and subjective responses to noise sounds. This is also expressed in dB (A). The parameters try to make an allowance for the noise inconsistency with L_{10} and $L_{90.}$ As it has been confirmed that fluctuating noise is more severe to the recipients (Scholes *et al*., 1971; Ma *et al*., 2006)

$TNI = 4 \times (L10 – L90) + (L90 – 30)$ 2.4

2.4.1.4 *Noise climate*

Noise climate (NC) is the range over which the sound levels are fluctuating in an interval of time and is given by the relation

Noise Climate (NC) = (L10– L90) 2.5

(Scholes *et al.*, 1971; Ma *et al.,* 2006)

2.4.1.5 *The compared standard for noise parameters (LNP and TNI)*

Scholes and Sargent recommended a standard of 72 dB (A) Noise pollution Level and 74 dB (A) for Traffic noise index standard (Scholes *et al*., 1971, Ma *et al.*, 2006).

Table 2.1**:** Summary of Environmental Noise Indicators

Indicator	**Defined in**	**Use**	Descriptions
LAeq, T	BS7445 to 1:2003	This is used as the general the descriptor of environmental sound exposure	It is referred to as continuous sound equivalent pressure level, i.e. is the level of sound pressure that is putatively constant encompassing the same energy as the authentic sound whose level may fluctuate over the measurement period
LA90	BS7445 to 1:2003	Is used as an indicator of the stable background sound level	It is the sound level exceeded for 90 % of the measurement period. Generally, it is referred to as the steady background sound level
LA10	BS7445 to 1:2003	Used for the determination of eligibility of insulation grants for traffic noise	It is the sound level exceeded 10% of the measurement period. This is an indicator of the higher levels occurring during the measurement period.

LDAY LEVENING LNIGHT	The European directive 2002/49/EC of Environmental Noise Regulations	Noise mapping	Day, evening and night levels. These are alike to LAeq, T for the succeeding periods: Day 07:00 to 19:00 Evening 19:00 to23:00 Night – 23:00to07:00Though, they are extensive-term averages, i.e., determined over all the day/ evening/ night periods of the year.
LADEN	The European directive 2002/49/EC	Noise mapping	The day-evening-night level: this is comparable to the LAeq, 24-hour, but sound taking place during the evening is specified a 'penalty' of 5 dB and that going on during the night is penalized by 10 dB

(Directive 2002/49/EC**; British Standard (BS) 8233. 2015**)

2.5 Selected Global Overview of Noise Pollution

Environmental noise pollution continues to pose a significant threat to human health and the quality of life for millions of people worldwide. Noise pollution has long been recognized as affecting the quality of life and well-being. Over past decades it has been increasingly recognized as an important environmental and public health issue. According to a recent WHO report on the burden of disease from environmental noise, at least 1 million healthy lives are lost every year in western Europe due to health effects arising from noise exposure. The WHO and other researchers categorize noise as being the second-worst environmental cause of ill health, behind water-borne diseases and ultra-fine particulate matter (PM2.5) air pollution (ETC, 2018; WHO, 2011-2012; Hurtley, 2009; Bartalucci *et al*., 2015; Majidi and Khosravi, 2016; Basner and McGuire, 2018; Hatamzadi *et al*., 2018, Folkeson *et al*., 2010)

2.5.1 Environmental noise context in selected European countries

In western European countries about 1.70 million people experience various effects of noise pollution (Houthijis *et al*., 2018; Fritsci *et al*., 2018; 2011; Clark and Pavnovic *et* *al.,* 2**;** Directive 2002/49/EC; Hurtley, 2009; Dub *et al*., 2008; Boyd *et al*., 2013). Necessary action to reduce environmental noise has a lower priority than other environmental problems such as air and water pollution. There is an urgent, clear need for the management of environmental noise on a national and local scale. Recognizing this as a prime issue, the European Commission adopted the European Noise (Van Kenpen *et al*., 2018; Guski *et al*., 2017; Luzzi *et al*., 20016; Directive 2002/49/EC; EEP, 2008; EEA, 2014). The EU's 7th EPA 'Living well, within the limits of our planet' EU, (2013) highlighted that the majority of Europeans living in major urban areas are exposed to high levels of noise which have adverse health effects on the environment and health.

2.5.2 In the United State of America (USA)

Noise, or unwanted sound, is one of the most common environmental exposures in the United States. Primary sources of noise in the United States include road and rail traffic, air transportation, and occupational and industrial activities (Hanner *et al*., 2014). In addition, individual-level exposures include amplified music, recreational activities (including concerts and sporting events), and firearms. Personal music player usage appears to be common among adolescents (Kim *et al*., 2009; Vogel *et al*., 2011) and may involve potentially harmful sound levels (US. Office of noise abatement, 1974; Breinbauer *et al.*, 2012). Data on the prevalence of noise exposures in the United States are outdated and inadequate. The latest national surveys of community and occupational noise exposures occurred in the early 1980s (Wallingford, 1987). The U.S. Environmental Protection Agency endorsed a DNL of 55 dB as the “level mandatory for the protection of health and well-being with a satisfactory margin of care.

In New York City noise is consistently the number one quality of life issue, and authorities there received more than 40,000 noise complaints in 2012 (Hammer *et al*., 2014). Very few communities appear to consider the health risks of noise in their policy-making (Network for Public Health Law (Geraldin, *et al*., 2016; Bartalucci *et al*., 2015). Although the health effects of environmental noise pollution have been explored over many decades, and the body of evidence linking noise to various health effects, not much has been done to address its environmental hazards (Goines and Hagler 2007; Passchier-Vermeer and Passchier, 2000). In most developed countries such as European countries, the United State of America, Canada, Brazil, Argentina, Canada, and China, there is strict regulation mandatory to clearly in script noise level on products to disclose the level of noise emitted from products capable of adversely affecting the public health and to promote and inform consumers' choices (Hammer *et al*., 2014; Berglund *et al*., 1999, Gilchrist, 2003; Ghanbari *et al*., 2011).

2.5.3 In the Federal republic of China

Noise pollution is a consequence of the negative externality of human activities such as construction activities, especially earthwork, commercial, industrial, and transportation industries. People respond differently to noise pollution; however, when noise levels reach a certain threshold people tend to be affected negatively (Lee and Lin, 2007; Lee *et al*., 2015). Sheng and Levine investigated a total of 5197 worksites from different types of occupational environments (e.g., textile industry, production of construction materials) in 30 counties across China. They discovered the worksites with noise pollution measured above 90 dB(A) were 43% in aggregate. Those above 95 dB(A) were 23 % of the total. The compliance rate for noise pollution was only 33 % (Zhi *et al*. 2000). In China, 42.1% of environmental complaints are associated with acoustic pollution, 25.6 % of which are attributed to construction noise. They asserted that noise is becoming a more serious problem as a result of urbanization and industrialization (Kim *et al*., 2009; Kwon *et al*., 2016; Gilchrist *et al*., 2003; Gegeraldin *et al*., 2016).

For noise control to be successfully implemented in practice, governments must not only implement a strict regulatory system but also develop economic, social, and environmental criteria that make such investments worthwhile (Kwon *et al.*, 2016; Boyd and Khalfan, 2013; Ma, 2020).

2.5.4 Environmental noise in selected African countries perspective

Many findings asserted that in Africa that noise pollution also arises from loudspeakers from religious institutions such as churches and mosques, bells are rung incessantly by peddlers, hawkers, and other salesmen to advertise their wares. Highly amplified music from record shops, private electricity-generating plants, light industries, heavy industries, constructions, and grinding machines also contribute immensely to environmental noise pollution. The noise from these sources irritates, and can in extreme cases lead to environmental health problem. Cairo in Egypt was rated the second highest noisiest city, only behind Guangzhou, Paris Delhi, China, and Beijing (Okwudili *et al*., 2021; Nasaar, 2013; Anomohanran and Iserhien, 2016; Yorkor *et al*., 2017; Nwaka, 2005; Boateng *et al*., 2004; Metagi, 2002; Samagwa *et al.*, 2009). The few studies conducted in Africa, affirmed that there is an escalation of noise pollution both in urban and suburban areas (Dancan *et al*., 2015; Matagi, 2012; Anomoharan *et al*., 2004; Oyedepo, 2012; Omubo-pepple *et al.*, 2010; Ismail, 2009). Noise evaluation in Kenya was above the recommended (Wawa and Mulaku, 2015). They suggested a need for consistent research regarding environmental noise pollution in other cities on the continent. In Ghana, it was affirmed that there are inadequate data on noise pollution levels and few studies conducted on the evaluation of noise pollution exceeded the recommended threshold and made suggestions for further findings (Gyamfi *et al*., 2016; Amedofu *et al*., 2002). Samagwa *et al*. (2009) investigated noise pollution in Morogoro Municipality, Tanzania, East Africa, the noise level exceeded the required sound level in most the survey sites.

2.5.4.1 *Environmental noise pollution in Nigeria perspectives.*

A study conducted by Federal Capital Territory (FCT) Abuja showed that the day, night, and the L_{DN} time mean average equivalent noise exceeded the compared standard in the day and was relatively below the Nigeria standard and WHO specification (Ibekwe *et al*., 2016; Anomohanran, 2013). A similar study carried out in Ilorin Nigeria also confirmed that population explosion and industrialization were the major sources of noise pollution and suggested the need for findings regarding environmental noise indicators in another state of the federation (Oyedepo *et al.*, 2012). 'The world has identified noise pollution as one of the major threats threatening the world today. Okwudili *et al*. (2021), in Owere Metropolis, the noise exceeded in most of site surveyed. However, countries do not pay important attention to the significance of noise pollution and its dangerous environmental consequences. This is however not the case with other countries of the world where necessary actions have been put in place to control and regulate this threat' (Ononugbo *et al.*, 2017; Abumere *et al.*, 1999). Izeogu, (1989) asserted that there is a need for instituting an operational enforcement program that requires a firm commitment on the part of the government and stable leadership in enforcing strict compliance. Most cities in Nigeria are predisposed to the effects of urban and Peri-urban noise predominantly from vehicles and associated traffic activities (Ugbebor, 2017, Ugwuanyi *et al*., 2004, Izeogu, 1989; Oyedepo, 2012; Ibekwe *et al*., 2016). Okwudili *et al*. (2021); Akintoye *et al*. (2014) and Saadu *et al*. (1998) acknowledged that most metropolitan cities of the southwestern region of Nigeria are susceptible to high noise indices; consequently, residents are vulnerable to hearing, audibility, and other related health challenges due to the intensity of the urban transport, commercial, light industries activities and other associated human activities. George *et al*. (2016) asserted that noise levels in most selected areas in the Zaria metropolis were beyond the WHO and NESREA specification and reaffirmed a need for consistent evaluation of noise levels in Peri-Urban areas and especially in other urban cities in Nigeria. In a study conducted by Akintuyi *et al*. (2014) in Bariga Lagos, the cumulative noise index for the area revealed that the incidence of noise pollution level is high with probable consequences on the residents of the surveyed area. The minimum exposure index of 70.39–79.24 dB(A) is well dispersed within publics with low traffic movement and a high built-up area. They asserted that the Ministry of Environment at the Federal and State level need to collaborate in other to conduct a metropolitan noise assessment study. Reaffirmed that such study will yield a comprehensive noise pollution level and regulations standard for effective sustainable environmental development in Lagos, other states to the identified land uses and proffer mitigation where noise level exceeded the recommended standard (Akintuyi *et al*., 2014).

2.6 Impact Arising from Exposure to Environmental Noise.

Numerous adverse environmental and health impacts, both direct and indirect, have been linked to exposure to persistent exposure to noise pollution. Night-time effects can differ significantly from daytime impacts (Ising and Krupa, 2004, Directive 2002/49/EC; Hatamzadi *et al*., 20018). The WHO reported an adverse onset health effect in humans exposed to noise levels at night above 40 dB (Dreger *et al.,* 2019; Smith *et al.,* 2016; WHO, 2005-12). According to experts from the European Union, around 20 % of the European Union population suffer terrible effects of noise levels exposure which can have a long-term impact on their health. Disability-adjusted life-years (DALYs) lost due to environmental noise was estimated to be 61 000 for heart diseases, 45 000 for cognitive impairment, and 22 000 for tinnitus (Fritchi, 2011; WHO, 2011; Dube *et al*., 2008; Boyd *et al*., 2013).

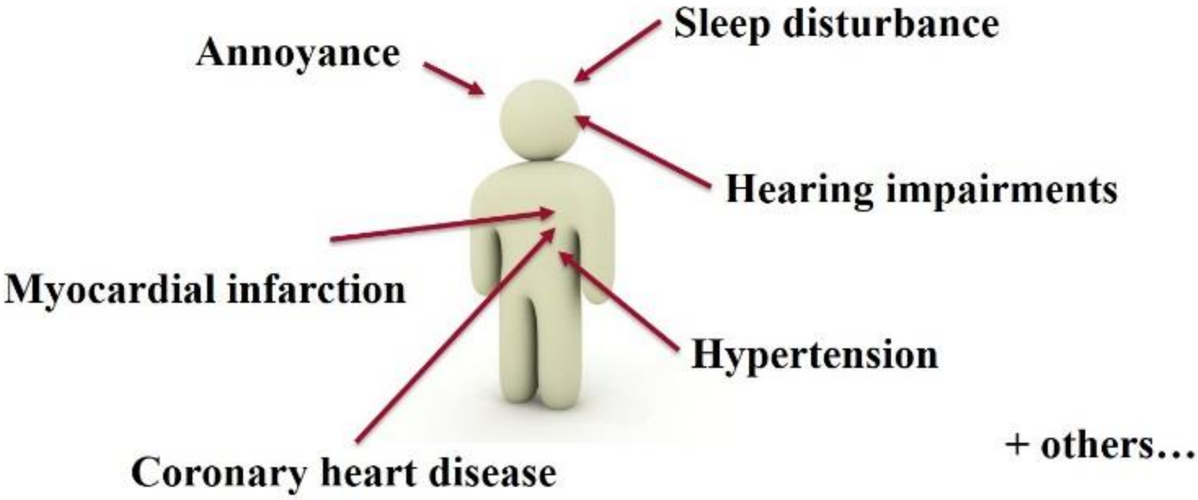


Figure 2.1: The Various Impact of Noise on Homo Sapiens (Interdepartmental Group of Cost and Benefits IDCB, 2010)

2.6.1 Annoyance, sleep disturbance, and cognitive effects

It has been confirmed that noise exposure is responsible for cognitive impairment, annoyance, distortion of sleep disturbance, and alterations to the depth of sleep. Other primary physiological effects induced by noise during sleep include increased high blood pressure, increased heart rate, vasoconstriction, changes in respiration, and increased body movements. As listed in Figure 2.1. It has been affirmed that annoyance and deprivation of sleep can precipitate a decrease in effectiveness, productivity and might lead to mental deterioration. The disorders may also be auditory or extra-auditory (WHO, 2012; Directive 2002/49/EC; Oyedepo, 2012; Moura-de-Sousa, *et al*, 2002; Czyzewsk and Kotus, 2004; Basner *et al*., 2018; Lybojev *et al*., 2014). In 2014, it was estimated that around 20 million adults in Europe were annoyed and 8 million suffer sleep disturbance respectively. In Europe, it is estimated that DALYs lost due to environmental noise are around 903 000 in Europe for sleep disturbance and 654 000 for annoyance (EEA, 2014)

2.6.2 Mental health effect

There is an exact casual relationship that exists between the noise and mental illness that remains ill-defined, and it may well be that noise is just one of many factors affecting mental health. The WHO in their findings alluded that environmental noise intensifies the development of the latent mental disorder. Several symptoms were enumerated which include anxiety, stress, nervousness, nausea, headaches, instability, argumentativeness, sexual impotency, and mood changes (King and Murphy, 2016; WHO, 2011-2012; Oyedepo *et al.,* 2012; Murphy and King, 2010).

2.6.3 Adverse health effect of noise in the recovery of patients

Incessant noise experienced throughout the day by ICU patients contributes to elevated stress and annoyance (Berglund, *et al.*, 1999; WHO, 2005). These lead to emotional reaction patients which consequently necessitated into increasing heart rate, blood pressure, and muscle tension (Overman-Dube *et al*., 2008; Korka, *et al*., 2015; Directive E.N, 2002). In this elevated state, patients are not able to rest, which contributes to delirium and delay the healing of wounds. It is an essential and critical part and elongates the healing process of patients (Farooqi *et al.,* 2020; Rafi *et al.,* 2014; Qutub *et al*., 2009).

2.6.4 Noise-induced hearing impairment

Impairment in hearing has been defined as an escalation in the threshold of normal hearing (Frinschi, 2011; Berglund *et al*., 1999). The person affected is unable to apprehend speech in day-to-day life. Hearing impairment is predominantly noise-induced in the frequency range of 3,000-6,000 Hz, with amplified exposure and at lower frequencies. Noise-induced hearing loss has been scientifically proven as an adverse health impact of environmental noise (Borchgreuink, 2003; Boyd *et al*., 2013). In the temporary hearing loss, the hearing threshold is elevated temporarily and identified as a temporary threshold shift. Through chronic exposure, a permanent threshold shift occurs. In this case, hearing loss becomes permanent due to irreversible damage to the sensory cells of the cochlea. Noise-induced hearing loss usually first affects the hearing threshold at high frequencies above the range of speech sensitivity at around 4 kHz. Hence, it is often not noticed till it becomes severe (Sorensen *et al*., 2013; Jamir *et al*., 2014; Breubauer *et al*., 2012).

2.6.5 Cardiovascular effects

Cardiovascular effects which are the consequences of frequent exposure to excessive noise pollution have been comprehensively considered in occupational settings as well as at municipal levels. It has been established that persistent contact with environmental and industrial noise (at sound levels of 60-85 dB(A) can facilitate a threat to cardiovascular disease (Babisch *et al*., 2005; Stansfeld *et al.*, 2009). The consequences of Noise-induced cardiovascular effects include occurrence of hypertension, higher blood pressure level, irregularities in the electrocardiogram, myocardial infarction (MI), blood viscosity, increased ingestion of cardiovascular prescriptions, more rapid pulse rate, anomalies of heartbeat, and slower repossession of vascular constriction (Vogel *et al*., 2011; Van *et al*., 2017; Singhal *et al*., 2009; Babisch, *et al*., 2005; Pal, 2012; Jarup *et al*., 2008; Smit *et al*., 2016, Stansfeld *et al*, 2009; Van *et al*., 2015)

2.6.6 The adverse impact of noise on children

Environmental noise and industrial noise affect the intellectual prowess of people and most importantly on children who are predisposed to it. These special effects are specific to the nature of work and the thoughtfulness of the individual, but a necessity to be accounted for. Children, in particular, may present symptoms such as concentration and memorization difficulties, reading deficiency, and reduced sound judgment capabilities (Prasher, 2009; Vogel., *et al*., 2011; Directive 2002/49/EC; WHO, 2012; Fritschi *et al*., 2011)

2.6.7 Environmental impact of noise on animals

Environmental noise is not only harmful to humans: it also affects animals. Some animals are extremely sensitive to sound. It has the capabilities to distort their communications, mate for new offspring, lead their confusions and hunt for their daily meal. Such a behaviour change has been observed in avian species, Cows, and Wales. Noise levels have been measured on 55 sites in 14 National Parks in the United States: it turns out that more than half of these sites are exposed to audible noise that might be injurious to animals (Barber *et al*, 2010).

2.6.8 Other environmental consequences of noise pollution

Theakston and Sangeeta asserted that noise exceeding 80 dB (A) and 100 dB (A) could result in the development of arterial hypertension and lead to infertility (Fritschi, *et al*, 2011; Singha *et al*,2009). Noise has been observed as a stimulator of stressor, according to the general stress model, it can provoke a typical stress response and hyperactivity of the sympathetic autonomic nervous system (WHO, 2012; Borenbauer *et al*, 2012; Houthuijs *et al*., 2018; Jarup *et al*., 2018; Van *et al*., 2017; Van *et al*.,2015). These have been observed to facilitate an increase in blood pressure, increased heart rate, and high levels of glucocorticoid cortisol (Ising, *et al*, 2004). It has been confirmed that both excess stress hormones, reduction in sleep quality and duration may lead to a higher risk for type 2 diabetes (Sorenson, *et al*,2013). In a study conducted by Orban, *et al*., (2016), it was established that long-term exposure to road traffic noise may increase the risk of depressive symptoms. They further unfolded that 25–30% frequent high depressive symptoms were observed in participants exposed to road traffic noise levels greater than 55 dB(A). Hence, noise triggers the release of stress hormones that can adversely distress health (Prasher, 2009).

2.7 World Health Organization Noise Standard for Different Categories of Anthropogenic Activities.

The impact of noise has continually been an imperative environmental problem to humanity. The Ministers and representatives of Member States in the WHO European region requested the World Health Organization (WHO) to develop updated guidelines on environmental noise and called upon all stakeholders to reduce children's exposure to noise, including that from personal electronic devices. The WHO Environmental Noise Guidelines as present in appendix II provided evidence-based policy guidance and recommended standards for difference categorization based on the types of anthropologic activities on the environment. When these standards are exceeded, it has consequential health on the predisposed populations as discussed earlier (Jarosińska *et al*., 2018; WHO, 2012; Fritschi *et al*, 2011; Merchan *et al*., 2014; Directive 2002/49/EC)

2.8 Environmental Legislation and Noise Regulation in Nigeria

Before the dumping of toxic waste in Koko village, in Delta State, in 1987, Nigeria was ill -Prepared to efficiently manage the serious environmental crisis, as there was no institutional arrangement for environmental protection and enforcement of environmental laws and regulations in the country. The Koko toxic waste incident, awaken the Federal Government to quickly promulgate the Harmful Waste Decree 42 of 1988, which facilitated the establishment of the Federal Environmental Protection Agency (FEPA) through Decree 58 of 1988 and amended in 1992. The Federal

Environmental Protection Agency (FEPA) was then charged with overall responsibility for efficient environmental management and protection. FEPA Nigeria became the first African country to establish a national institutional mechanism for the protection and sustainability of the environment (Suleiman, 2019; George *et al*.,2016; Okuofu, 2014)

In the best interest of Nigerians, the Federal Government, Merged FEPA and other relevant Departments in other Ministries to become the Federal Ministry of Environment in 1999. Unfortunately, there was no enabling law on the enforcement. This necessitated a gap in the effective enforcement of environmental laws, standards, and regulations in the countries in addressing pertinent environmental challenges confronting Nigeria. In promulgating a solution to this pertinent national environmental issue, the Federal government in line with section 20 of the 1999 constitution of the Federal Republic of Nigeria Established the National Environmental Standards Regulations and Enforcement Agency (NESREA) on the 31st July 2007 as an Agency of the Federal Ministry of Environment. (Suleiman, 2019; George *et al*.,2016; NESREA, 2007)

2.8.1 The National Environmental (Noise Standard and Control) regulation, 2009

The aim of this regulation under the auspices of NESREA is to ensure the conservation, maintenance of a healthy environment for all Nigerians for their psychological and physiological comfortability. To ensure productivity and active life in every facet, regulating and monitoring noise levels is a necessity. They are entrusted with proposing the maximum acceptable noise levels in Nigeria, providing necessary measures for the control of noise and for mitigating actions for the reduction of noise (Suleiman, 2019; NESREA, 2009; Ladan, 2012).

2.8.2 Enforcement of Nigeria national permissible noise levels

The regulation provides a noise permit, anyone who violates this regulation is fined and punished with the following:

(a) The individual that commits such an offense and shall be legally responsible for a fine of five thousand naira for every day the offense exists. If charged to court and convicted such a person would be answerable to a fine not beyond fifty thousand naira (50000.00) or in a correction centre for a term not beyond one year**.**

(b) If this sub-regulation is violated by a corporate body, if found guilty shall be liable to a fine not beyond fifty thousand and an additional fine of hundred thousand naira only for every day the offense exists. (National Environmental (Noise Standards and Control) Regulations,2009). However, not much has been done for its effective implementation (NESREA, 2009).

CHAPTER THREE

MATERIALS AND METHODS

This chapter presents a detailed description of materials used and procedures of how acquired data were acquired, analysed and presented

3.1 Study Area

Sabon-Gari Local Government was created in 1991 and is one of the Local Government Area in Zaria metropolitan city in Kaduna State, Nigeria**.** It has an area of 263km^3 and a density of 1,495/ km^3. Its geographical coordinates are 11.1231^0-degree North (N), 7.7322^0-degree East (E) as in figure 3.1 From the National population commission (NPC) of 1992, Sabon -Gari Local Government Area population was 224,067 and the population increased to 291358 from the national census conducted in 2006 (NPC, 2006). The LGA has a typical tropical continental climate and the landscape is principally plane with a mean elevation of 670m overhead the mean sea level.

There are several high institutions in Sabon-Gari LGA such as Ahmadu Bello University, National Institute of Transport Technology, Leather research institute, and several others. The predominant commercial market is Sabon-Gari market, Samaru Market, Dogarawa Market, Lemu market, the major roads, and streets are Sokoto Road, Kano Road, Chikaji Road, Muchia road, Lagos streets, and Ijaw streets. It also consists of dense residential areas such as Dogarawa, Muchia, Samaru, Graceland, Aguangodo, Hanwa, and GRA with mixed anthropogenic activities. Other areas that attract high human activities are Kwangila, Emanto Junction, MTD, and Peterson Zachonis (PZ) respectively.

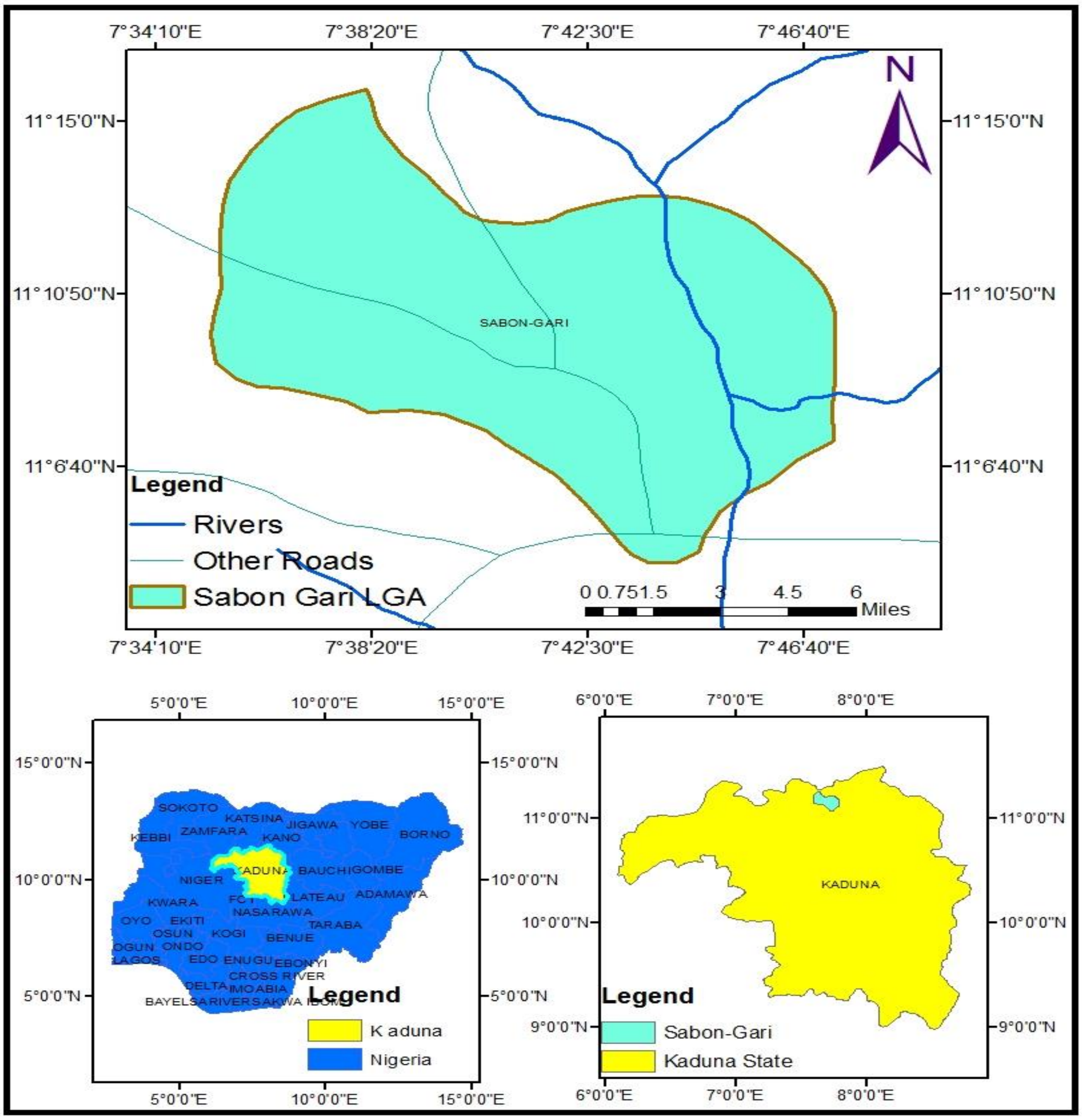


Figure 3.1: Th Map of the Study Location Showing the Map of Nigeria and the Map of Kaduna State.

3.2 Equipment Materials

i. Noise Meter: Extech models with a manufacturing code of 407750 noise meter which satisfied the international standard of ANSI and IEC Type 2 integrated sound level meter was used for the measurement of the sound level.
ii. Tripod Stand**:** The noise meter was mounted on an LG-30 solicitor for measuring the noise level
iii. Global Positioning System (GPS Germin 76exs) was used for taking the coordinates (Latitude and Longitude and of the sites for sampling points.
iv. ArcGIS Version 10.5 software for spatial mapping of the noise level of Sabon-Gari LGA
v. IBM SPS Statistics Software, Version 25: For statistical analysis of data
vi. MICROSOFT Package version 2019
vii. Techno Android WH3: was deployed for the photographs of the fieldwork for visual characteristics
viii. Google Earth Pro 2019 was used for the identification of various sites and obtaining their respective elevations.

3.3 Categorizations of sampling points location:

Sabon-Gari local government was divided into eleven wards administrative structure for efficient administration. The sampling point was randomly and purposefully selected from eight wards, after the renaissance survey for the noise level investigations and purposeful estimation of population and easy questionnaires administration.

i. **Markets**. Three markets, namely Samaru, fruits, and Sabon- Gari market were purposefully identified and selected for the noise level evaluation. The Samaru market operated daily and weekly. The noise levels were monitored at three different locations, Iya line, Saraki line, and Perishable goods line each Friday for three consecutive weeks for the weekly market day. While for daily market Iya line was investigated once. Similarly, for the fruit market at Dogarawa, one study point was selected for assessment. Sabon-Gari market which is the biggest market in Sabon-Gari LGA, three study locations were identified which are Aminu line, Dogo- layi, and Provision/ Drugs line were purposely identified and selected for noise level assessment. The noise evaluation was carried out each day for each study location for three consecutive days.

ii. **Major Intersection**. Five intersections, which consist of Kwangila, Bank Junction PZ, MTD, Emanto, and ABU main gate were selected for noise level assessment. The Kwangila intersection was segmented into three study sites, Kwangila 1 to 3. The Bank Junction PZ was also segmented into two study sites, Bank Junction 1 and 2. ABU main gate was segmented into two study sites ABU 1 and 2. While Emanto and MTD a single study site was selected this was as a result of the nature of anthropogenic activities. The difference in sample size was based on the extent of the degrees of the anthropogenic activities in the study location.

iii. **Major Roads and Streets**. After a reconnaissance survey, major roads and streets were identified and divided into two study sites. Site A and B respectively. Site one consists of the following; Chikaji road, Park Road, Aminu road, Randan Kano road, Kings Road, Lagos Street, club, Yoruba, and cemetery streets respectively. For site two consists of Grace Land Road, Paladam, Leather research road, Saraki street, Dogo-the street, and Naibi street.

iv. **Mixed residential,** (commercial and light traffic activities). Ten study sites, which consist of the following' GRA, Dogarawa, Gwado, Hanwa, Agwangodo, muchia, Ijaw, Hayin-dodo, Afegbu Daraka, Galadima were identified and selected for noise assessment.

v. **Mixed residential:** (domestic, Light industry, commerce, and light traffic activities). Six study sites were purposefully identified and selected for noise assessment. The site consists of the following; Dasa block, Kip’s water, Muncha block, Faringida (Metalwork), Pensioners quarter (MTN mast), and Hanwa (MTN mast).

vi. **Light Industry (Sawmill);** This is the biggest sawmill in the LGA. A study point was identified and selected for noise assessment.

3.3.1 Reconnaissance survey for the identification of sample points and noise sources.

After one week of reconnaissance survey, fifty-four locations were purposefully selected based on the anthropogenic activities at each study location.

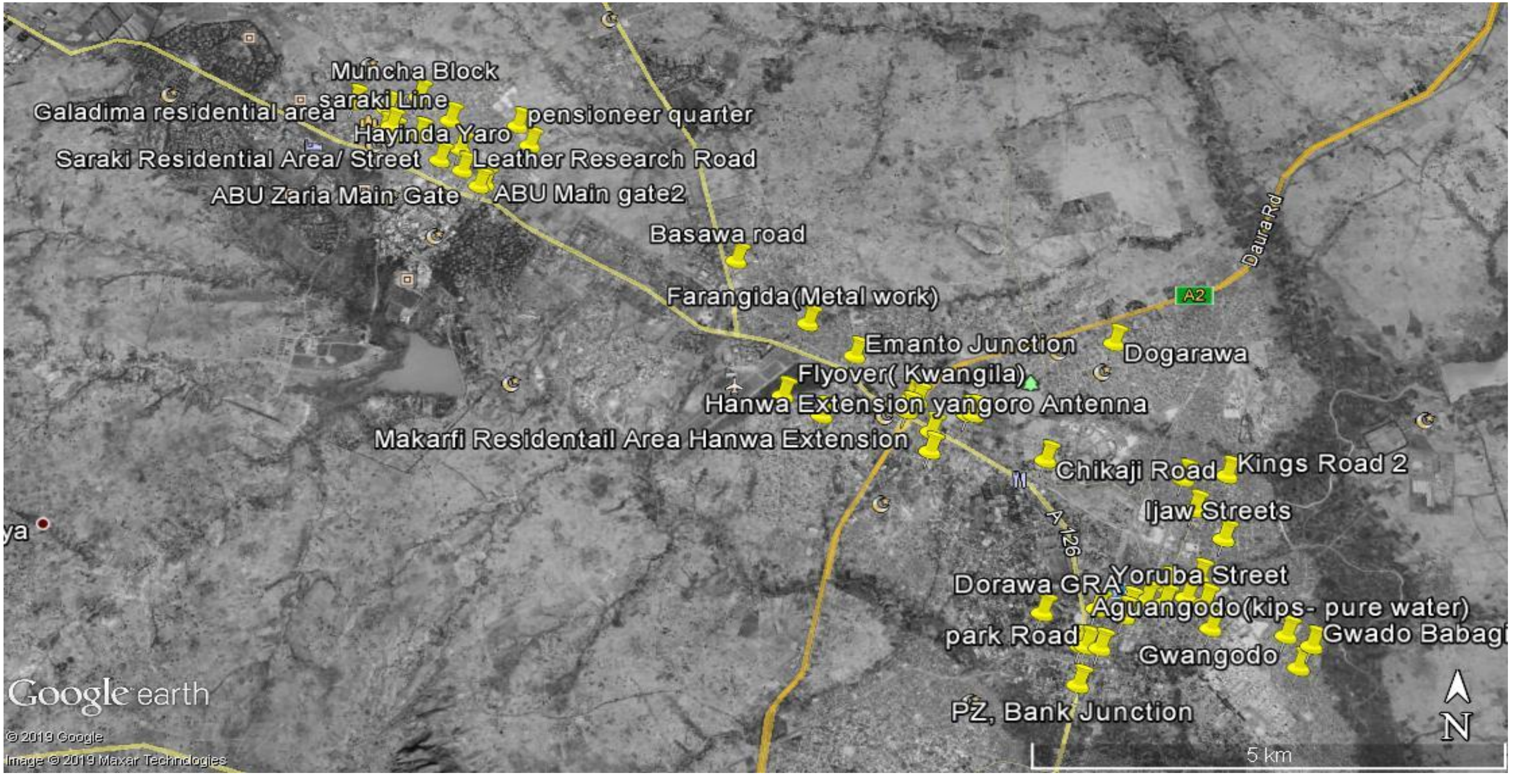


Plate I: Selected Sampling Points in the Study Location

The sampling points were purposefully selected based on various categorization and anthropogenic activities of the surveyed sites.

3.4 Method of Investigation the of Noise Pollution

3.4.1 Assessment of noise levels

Two methods were deployed for obtaining data, objective investigation and subjective investigation.

3.4.2 Experimental flow chart for objective and subjective data

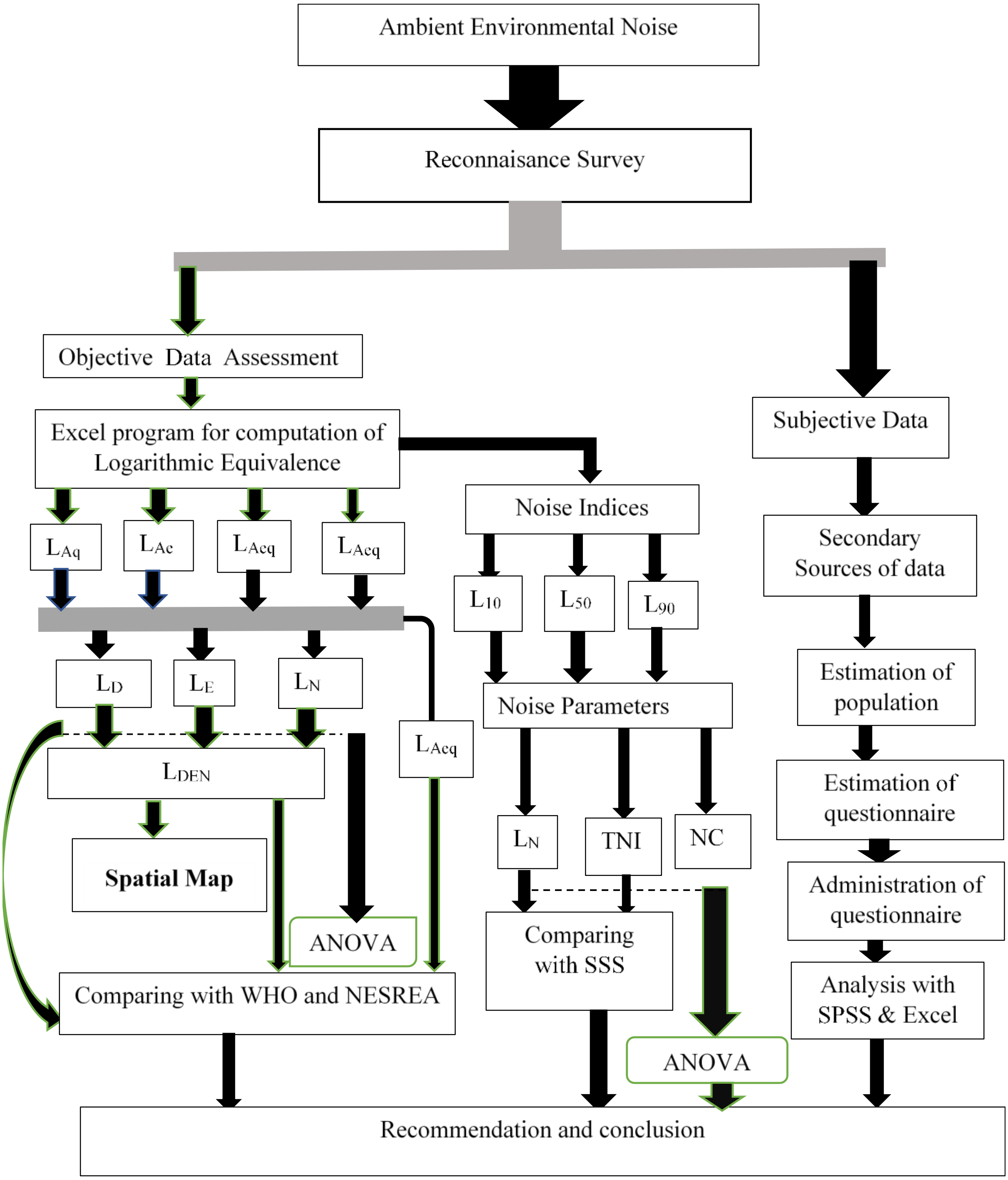


Figure 3.2: Experimental Flow Chart

3.4.3 Reconnaissance survey

The reconnaissance survey was carried out for one week from 24th to 28th August 2019.

The survey was carried out for physical observation and to explore the anthropogenic activities and socio-economic activities dominant in the study area which are potential sources of noise generations. Sampling points were identified and a Global Positioning System (GPS Germin 76 ex) was used for taking the coordinates (Latitude, and Longitude of all the sampling points. This provided the opportunity for familiarization with the study area.

3.4.4 Description of the method for objective data collection

The noise level measurement was carried out from 5th September to 16th December, 2019. The procedures adopted were according to Jarosińska *et al*., 2018; Ismail, (2016); George *et al*., (2016); Flindell and Walker, (2004); Evans, (2007); Dowson and Jiggins, (2001). Extech model 407750, a noise meter which satisfied the international standard of ANSI and IEC Type 2 integrated sound level meter was used for the measurement of the sound level. It was automatically calibrated to 94 dB (A), to ensure accuracy. Measuring ranged within 0 to 130 dB (A) Basic accuracy, ±1.5 dB (A). The noise meter was mounted horizontally on the LG-30 solicitor Tripod stand at angle 90^{o} for measuring the noise level in a still positioned a least 1 to 3.5m from any acoustically reflection surface other than the ground and 1.5m above the ground. The data were collected at major streets/ roads, mixed residential areas (commercial and light industries), markets, business areas, plazas, and selected major intersections. For each sampling location, A-weighted instantaneous sound pressure was measured over 60 minutes at 30 second intervals. The noise level was carried out in all the fifty-four (54) selected locations at four different times of the day, morning (7.30-8.30AM), afternoon (1.0-2.00 PM), evening (5:00-6:00 P.M), and night (10:00-11.00 P.M) as presented in Figure 3.2. Techno Android WH3**:** was deployed for the photographs of the fieldwork for visual characteristics. Google Earth Pro 2019 was used for the identification of various sites for visual views of all the surveyed sites. IBM SPS Statistics Software, Version 22 statical evaluations and Microsoft Package version 2019 for computation of various noise indicators, parameters, and percentiles as presented systematically in Figure 3.2 and equations 3.1 to 3.5. All the sources of noise within each study location were identified and recorded.

3.5 Computation of Noise Descriptor

Noise descriptors are used to designate the time-varying nature of noise. Several noise descriptors are used to interpret the measured decibel values.

3.5.1 The A-weighted equivalent sound pressure level, (LAeq,)

The LAeq, (T) which is the logarithmic computed average energy equivalent level of the A-weighted sound was used for computation of (L_D) which was the average day time noise level using equation 3.3, for L_E which was the evening average night time noise level using equation 3.4 and for (L_N) which was the average night-time noise Level using equation 3.5. For the (L_{DEN}) which was the summation of the daytime noise (L_D), evening time noise (L_E), and night average sound level (L_N) was present in Figure 3.2 was computed using equation 3.6. The addition of 5 dB (A) and 10 dB (A) penalty for evening and night noise interval was a a result of variation of diurnal effects of noise (Directive 2002/49/EC; WHO, 2011). Microsoft Excel version, 2019 was used for the analysis.

3.5.1.1 *Governing Equations for Computing Noise Pollution Index*

i. A Weighted Equivalent Noise level L_{Aeq}

$$\mathbf{L_{eqA} = 10log_{10}}[\frac{\mathbf{1}}{\boldsymbol{N}}\sum_{i=1}^{i=n} 10\left(\frac{n}{10}\right)] \qquad 3.1$$

Where N =The total number of samples measured at each study location and each study time

L_{ni}, L_{n2}, and L_{n3} …L_{n1} is the noise level in dB (A) of the sample recorded at every 30 seconds. Equation 3.2 is used for calculating noise equivalent (L_{aeq}) value for each hour at each study location for Morning, Afternoon, evening, and night equivalent respectively.

$$L_{AEQN} = 10\log\frac{1}{N}(10^{\frac{L_{n1}}{10}} + 10^{\frac{L_{n2}}{10}} - - - - - 10^{\frac{L_n}{10}}) \quad 3.2$$

ii . **L_D** is the daytime noise level

$$L_D = 10log_{10}\{\frac{1}{3}[(10^{\frac{L_{AEQm}}{10}}) + (10^{\frac{L_{AeqA}}{10}}) + (10^{\frac{L_{AeqE}}{10}} +]\} \quad 3.3$$

iii. **L_E** is the evening time noise level

$$L_E = 10log_{10}\{\frac{1}{2}[(10^{\frac{L_{AEQA}}{10}}) + (10^{\frac{L_{AEQE}}{10}})]\} \quad 3.4$$

(Oyedepo and Saadu, 2010; Anomohanran, 2013)

iv **L_N** Night Time Noise Level

$$L_N = 10log_{10}\{\frac{1}{2}[(10^{\frac{L_{AEQE}}{10}} + (10^{\frac{L_{AEQN}}{10}})\} \quad 3.5$$

(Oyedepo and Saadu, 2010; Anomohanran, 2013)

V. Summation of daytime L_D, evening time L_E, and night time noise level L_N

$$L_{DEN} = 10\log\frac{1}{24}[12*10^{\frac{L_{day}}{10}} + 4*10^{\frac{l_{EV}+5}{10}} + 8*10^{\frac{L_{Night}+10}{10}}] \quad 3.6$$

(Directive 2002/49/EC)

Where $L_{\mathbf{(A)EqM}}$,= Morning noise equivalent level

$L_{(A)Eq}A$= Afternoon noise equivalent level,

$L_{(A)}$ Eqe= Evening Equivalent level

and $L_{(A)EqN=}$ Night equivalent level

For all the data lodged in the morning, afternoon, evening, and night for each of the study locations using equation (3.2) respectively.

In this evaluation, it was implicit that measurements for diurnal noise time were carried out according to the L_{DEN} calculation phases, specifically twelve (12) hours-day, four (4) hours-evening, and eight (8) hours-night (EEC, 2014; Directive 2002/49/EC; Ismail, 2016; British Noise Regulation, 2015). As detailed in Figure 3.2 in the experimental flow chart.

3.3.3 Computation of noise percentile (L_{10}, L_{50}, and L_{90})

The exceedance percentile was computed as follows.

$L_{10,}$ =were obtained using 10 percentiles of the longed noise level for one hour using Microsoft Excel, version, 2019).

$L_{50=}$were obtained using 50 percentiles of the longed noise level for an hour using Microsoft excel version, 2019.

L_{90}=were obtained using 90 percentiles of the longed noise level for one hour, using Microsoft excel version, 2019. As in figure 3.2 in the experimental flow chart.

3.3.4 Equations for the computation of noise parameters

3.3.4.1 Noise Pollution Index ($L_{PN/}$)

L_{PN} is the total noise pollution level in a study location. It is used to describe the community noise or sound level. It entails the engagements of equivalents continuous energy sound level L_{Aeq} and the magnitude of the time of variation in noise energy level.

It was evaluated using Microsoft Excel, 2019. As in Figure 3.2 in the experimental flow chart

$L_{NP} = LAeq + (L_{10} – L_{90})$

or

$L_{NP} = Leg + K\sigma$ 3.7

(Schole *et al.*, 1971; Ma, G *et al.*, 2006; Oyedepo and Saadu, 2010)

3.3.4.2 Traffic Noise Index (TNI)

TNI which is the traffic noise index is deployed for the determination of the amount of variability in the observed sound level in a described community. It is one of the essential keys for the estimation of annoyance in response to noise pollution in a study location. It was evaluated using Microsoft Excel, 2019.

$TNI= 4*(L_{10}-L_{90}) +(L_{90}-30)$ 3.8

(Schole *et al.*, 1971; Ma, G *et al.*, 2006; Oyedepo and Saadu, 2010)

3.4.5 Noise Climate (NC)

Noise climate (NC) is the range over which the sound levels is fluctuating in an interval of time as in Figure 3.2 and is computed by the equation below:

Noise Climate (NC) = $(L_{10}– L_{90})$ 3.9

(Schole *et al.*, 1971; Ma, G *et al.*, 2006; Oyedepo and Saadu, 2010)

3.6 Development of Spatial Noise Map of Sabon-Gari LGA

Noise level data were entered into Microsoft Excel and saved as CSV (comma delimited). The saved data was then imported into the ArcGIS environment using add

XY data, the environment was prepared through steps such as processing of the environmental extent, cell size, and output coordinate system. Analysis was performed using Inverse Distance Weighted (IDW) interpolation technique**.** The shapefile of Sabon-Gari LGA was also imported into the ArcGIS 10.5 version environment. IDW was used instead of other interpolation techniques such as Kriging because it is assumed that in IDW the nearer a sample point is to the cell whose value is to be estimated, the more closely the cell's value will resemble the sample point's value (Setianto and Triandini, 2013; Apung and Tamia, 2013).

3.7 Method of Subjective Investigation of Environmental Noise Level

Designed questionnaires were administered to gather data based on social demography, environmental noise awareness, awareness of the effect of noise pollution, personal effects of noise pollution during exposure, government and personal responsibility in mitigating noise pollution. The number of questionnaires where determine by estimated using the population of the 2006 census to estimate the 2019 population of Sabon-Gari LGA using equation 3.10. Equation 3.12 was used for estimating 385 questionnaires for the eight (8) selected wards. The questionnaires were administered by random purposeful selection across each of the eight selected wards in Sabon-Gari LGA. IBM SPSS statistic software and Excel were used for the analysis of the data.

$P_N = P1e^{rt}$

3.10

The r= is the annual percentage of the population increase for 2019 and is given as 3.2%. the estimated population ($P_{N.}$).

P1= Is the known population

The t = is the time interval between 2006 to 2019.

$P_{N=}$ is the unknown population of 2019.

$$S = \frac{X^2 NP(1-P)}{d^2(n-1) + x^2\, p(1-P)} \quad 3.12$$

S =is the required sample size,

X = is the table value of the chi-square size for 1 degree of freedom at the desired confidence value and is given as 3.841,

The d= is the degree of accuracy, which is expressed as 0.05,

P= is the population proportion and for a maximum sample is given as 0.5. The summation of eight (8) selected wards was used to estimate the population of 2019 (Bressane *et al*, 2016, Gerges, 2004, Krejcie and Morgan's, 1970).

3.8 Statistical Analysis for One-Way ANOVA For the Objective Data.

In carrying out the ANOVA test, L_{DEN} noise level was used to compare all the selected commercial areas, major intersections, mixed residential area (comprises of commercial and light traffic) mixed residential area (commercial, light Industries, and light traffic), and one major light industry (Sawmill).

The null hypothesis state that there is no mean difference between the diurnal noise Index (L_D, L_E and, L_N) of the same study sites and of different categories of site. Is applicable for the noise parameters (TNI and L_{NP}), and Noise percentiles (L_{10} and L_{90}) in appendix IV to IX of different categories of the 54 selected surveyed sites respectively when $p > 0.05$, then the result is rejected. Otherwise, there is a mean significant difference when $p < 0.05$ at a confidence level of 95%.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter gives a comprehensive analysis of the detail of the data obtained from the fifty-four (54) Surveyed sites, graphical representation, comparing of the result with standard and related research as well as statistical analysis are presented in Figure 4. 1 to Figure 4.41 and Table 4.1 to 4.23.

4.2 Sources of Noise in all the Categorised Study Locations.

The major sources of noise were Traffic activities, commercial activities, light industries, generators, and domestic noise. The density of these sources varies from one study site to the other. Major intersection, selected roads/streets were characterized with high traffic, generator, and commercial activities such as hawking. Mixed residential areas were characterized by light commercial activities, generators, light vehicular activities, and light industrial activities as the major sources of noise. While commercial areas were categorized by commercial activities, light traffic, and light industrial activities**.**

4.3 Diurnal Noise Level, Percentiles and Parameters for Lemu Market

4.3.1 Analysis of diurnal variation of noise Index at Lemu market, comparing WHO and NESRE standard.

The logarithmic average for L_{Aeq} investigated and evaluated for $L_{D,}$ $L_{E,}$ $L_{N,}$ and LDEN for the morning, afternoon, evening, night. They were compared with WHO, NESREA standard as in figure 4.1 and were expressed in a location with maximum level to the minimum noise level

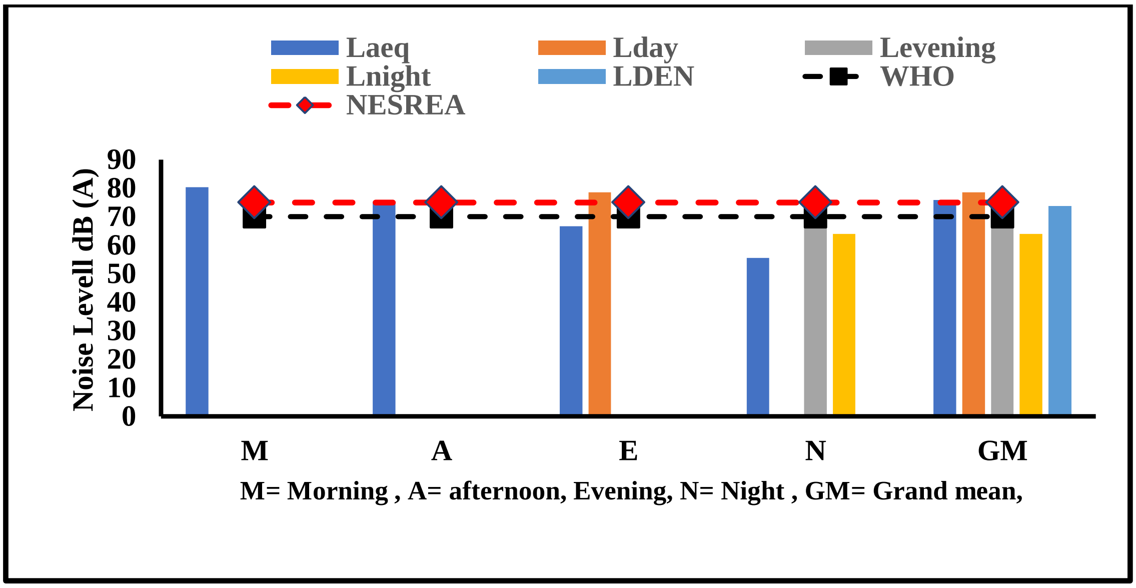


Figure 4.1: The Logarithmic Average of Noise Index at Lemu Market (Fruit Market)

In Figure 4.1 the logarithmic equivalent noise level (LAeq) for the morning, the afternoon was 80.4 dB (A), 75.3 dB (A), it exceeded the WHO and NESREA standard. The evening sound level of 66.7 dB (A) and night level of 55.6 dB (A) were within the WHO and NESREA standards. The logarithmic average equivalent for the L_D and the L_E values evaluated for the market were 78.6 dB (A) and 72.7 dB (A) exceeded WHO standard while 64 dB (A) for the night reading was within the WHO standard. The noise level for the time intervals (L_D) exceeded the NESREA Standard while the logarithmic average for the L_E and L_N were within the standard respectively. The $L_{DEN,}$ the value of 73.7 dB (A), exceeded WHO standard while it was within the NESREA as in Figure 4.1 respectively.

4.3.1.1 *Analysis of percentile at Lemu market*

The logarithmic average of noise percentiles (L_{10}, L_{50}, and L_{90}) were computed at Lemu market, morning, evening, afternoon, night and were expressed from maximum value to minimum value in Figure 4.2.

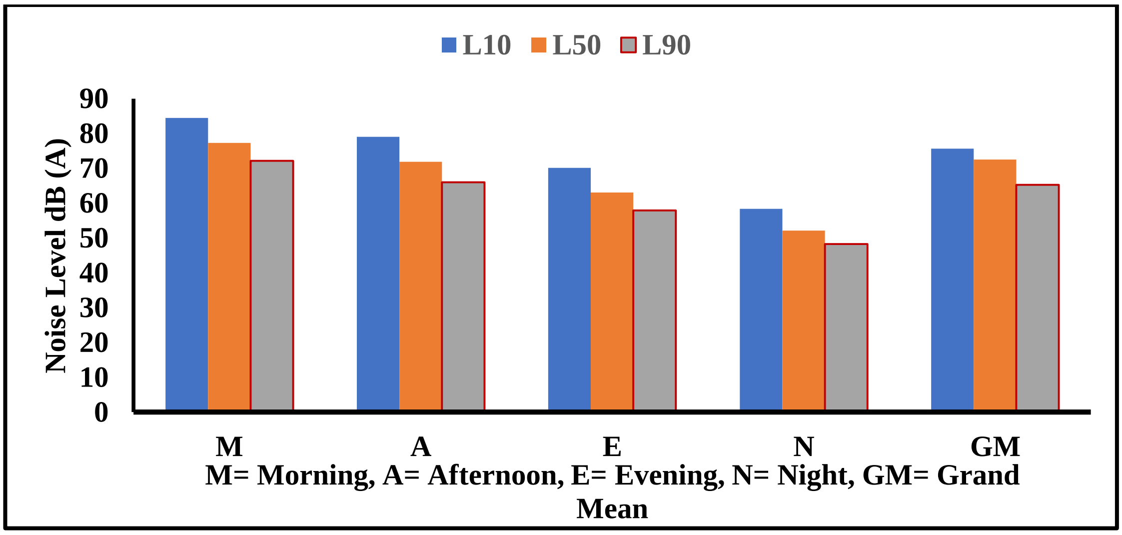


Figure 4.2: The logarithmic mean for Noise Percentile for Lemu Market

The L_{10} values range from the maximum value of 85.5 dB (A) in the morning to a minimum noise value of 58.4 dB (A) at night time as in figure 4.2. The L_{90} ranged from the maximum value of 72.2 dB(A) in the morning to the minimum value of 48.3 dB (A) in the night. The L_{90} logarithmic mean average of the background noise was 65.3 dB (A). The L_{50} values ranged from the maximum value of 77.3 dB (A) in the morning to a minimum value of 52.1 dB (A) in the nighttime intervals as in Figure 4.1 respectively.

4.3.1.2 *Analysis and comparing of noise parameters with Scholes and Sargent standard (SSS)*

The logarithmic average for noise parameters TNI, LNP, and NC for Lemu market were evaluated for M, A, E, N and compared with Scholes, Sargent standard (SSS) as in Figure 4.3 and were expressed from maximum to minimum values.

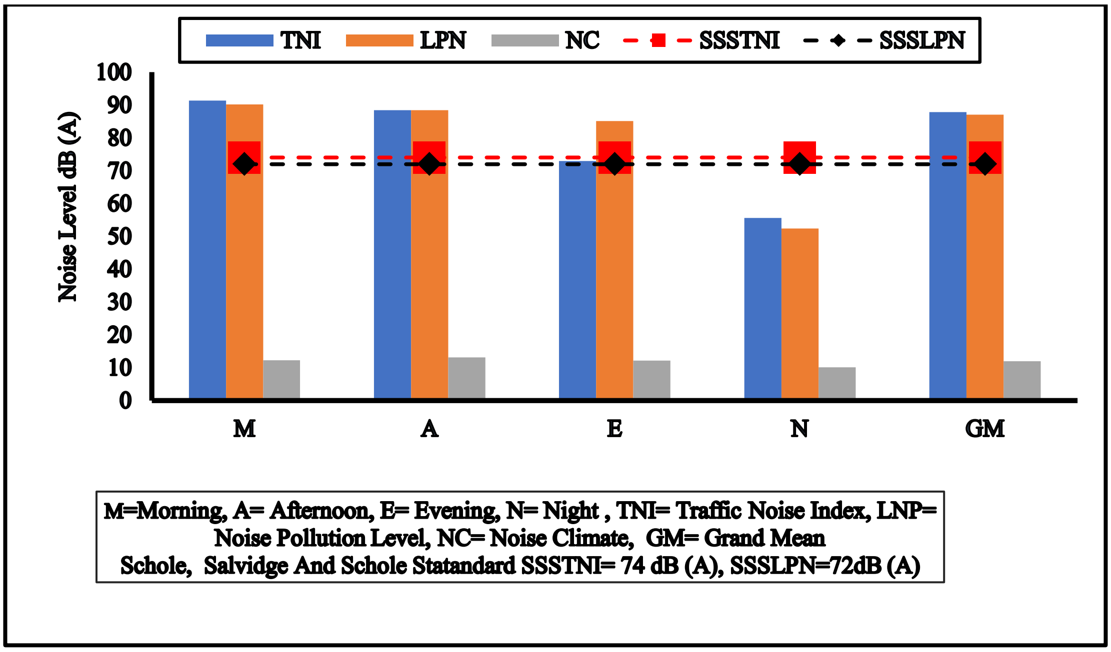


Figure 4.3: The Logarithmic Noise Parameters compared with Scholes, Salvidge, and Sargent (SSS) Standard for Lemu Market

The Traffic noise index (TNI) value of 91.3 dB (A) for morning and 88.4 dB (A) for the afternoon, exceeded the compared standard as in Figure 4.3. While 72.9 dB (A) for the L_E and 55.6 dB (A) for the L_N period were within the School, Salvidge, and Sargent (SSS) standard. The noise pollution index (L_{PN}) for the morning, afternoon, the evening was 90.2 dB (A), 88.4 dB (A), 72.9 dB (A), and mean value of 87.1 dB (A) exceeded compared standard while 52.4 dB (A) for the night time was within the compared standard as in figure 4.3. The noise climate (NC) ranged from 13.1 dB (A) to 10.1 dB (A) and a logarithmic mean of 12.1 dB (A).

The evaluated noise in Figure 4.1 to Figure 4.3 the logarithmic average of LDEN indicator and parameters were above the WHO, while it was within NESREA standard. The noise parameter exceeded the Scholes, Salvidge, and Sargent (SSS) standard. The recipients of the exceedance noise level could be predisposed to several effects of environmental noise pollution such as headache, annoyance, tinnitus, and information distortion which were necessitated by various sources such as commercial activities and light traffic. In a study conducted by Okwudili *et al*., 2021; Owen (2019); Akpan *et al*., (2018); Ononugbo *et al*., (2017); Oyedepo *et al*., (2012a); Anmohanran *et al*, (2016); WHO (2011); Stansfield *et al*., (2009). They asserted that noise in several places of human activities in the environment exceeded recommendation standards and when people are exposed to it for the long period it could result in several effects of noise consequences.

4.2.1.3 *Single-factor ANOVA for Lemu Market*

As present in Table 4.61 P >0.05), therefore, there was no significant difference between sound levels between $L_{Day,}$ $L_{Evening,}$ and L_{Night} with WHO and NESREA standards. The sound level in the Lemu market was within the compared standard. This was a result of diurnal variation of less routine commercial activities on this surveyed site.

Table 4.1: Single Factor ANOVA of Noise index for Lemu (Fruit Market)

Source of Variation	SS	df	MS	F	P-value	F crit	R NSf
Between Groups	67.17	2	33.58	0.57	0.58	4.26	
Within Groups	527.69	9	58.63				
Total	594.87	11					

SS= Sum of square, df= degrees of freedom, F= F-ratio, MS= mean square, p= probability, R= Remarks, NSf= Not Significant,

4.3.2 Analysis of diurnal noise index, percentiles, parameter at Samaru market, comparing with WHO, NESREA, Scholes, Salvidge, and Sergent (SSS) standard.

4.3.2.1 *Analysis of Diurnal variations of noise levels at Samaru market comparing with WHO and NESREA standard.*

The logarithmic average for L_{Aeq} was evaluated for computation of $L_{D,}$ $L_{E,}$ $L_{N,}$ and L_{DEN} for Iya, Saraki, and Perishable goods line. They were compared with WHO, NESREA standard as given in Figure: 4.4 and were expressed from maximum level to minimize noise level

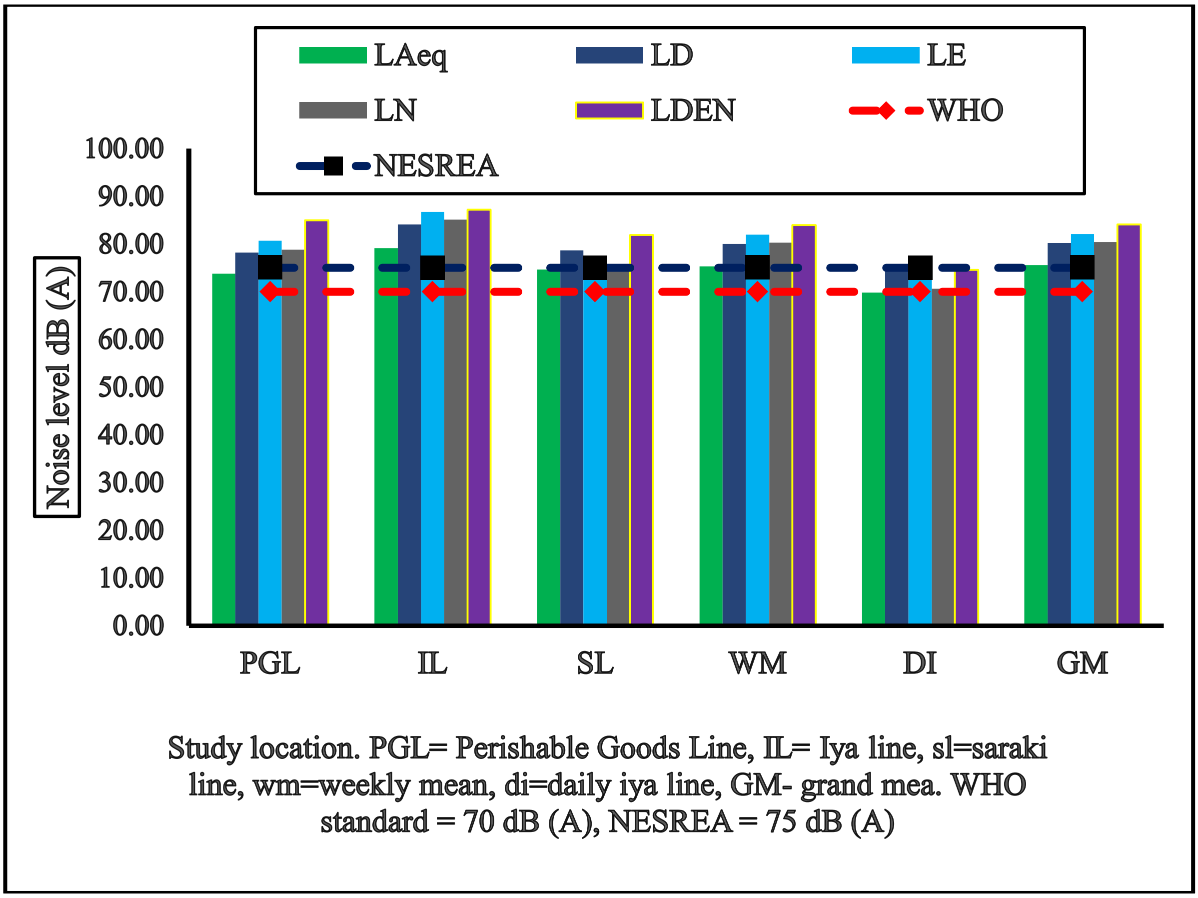


Figure 4.4: The Diurnal Logarithmic Mean for Noise Index for Samaru Market

For the weekly market, the average logarithmic mean noise level L_{Aeq} ranges between the maximum value of 79.2 dB (A) at the Iya line to the minimum value of 73.8 dB (A) at the Perishable goods line with the mean of 75.6 dB (A). It exceeded the WHO while within the NESREA standard as given in Figure 4.4. For the daily market L_{Aeq} of 64 dB (A) was below the compared standard. For the $L_{D,}$ range with the maximum value of 84.1 dB (A) at the Iya line to the minimum value of 78.2 dB (A) at the perishable good line and it exceeded the WHO and NESREA standard ass in figure 4.4. For the daily market, the L_D value was 73.7 dB (A) which exceeded the WHO while within the NESREA standard. The L_E range between the maximum value of 86.7 dB (A) at the lya line to a minimum value of 76.4 dB (A) at the perishable goods line and it exceeded the

WHO and NESREA standard as in Figure 4.1. For daily market days, the L_E value of 74.3 dB (A), exceeded the WHO while within the NESREA standard. For $L_{N,}$ range between the maximum value of 85.1 dB (A) to a minimum value of 74.5 dB (A). It exceeded WHO and NESREA standards. For the daily market $L_{N,}$ the value of 70.6 dB (A) was approximately equal to the WHO specification but within the NESREA specification. The weekly L_{DEN}, range between the maximum value of 87.2 dB (A) at the Iya line to the minimum value of 81.9 dB (A) at the Saraki line and it exceeded the WHO and NESREA standards respectively. For the daily market, the L_{DEN} value of 73.7 dB (A) exceeded the WHO standard and was within the NESREA standard. The L_{DEN} mean for weekly and daily market days with 84.1 dB (A) value exceeded the WHO and NESREA standard respectively as given in Figure 4.4.

4.3.2.2 *Noise percentiles analysis For Samaru market*

The logarithmic average of noise percentiles ($L_{10,}$ $L_{50,}$ and L_{90}) were computed for each location for both weekly and daily Samaru market for the three studied locations, Iya, Saraki, and Perishable goods line and were expressed in forms of locations with maximum value to the minimum value as in Figure 4.5

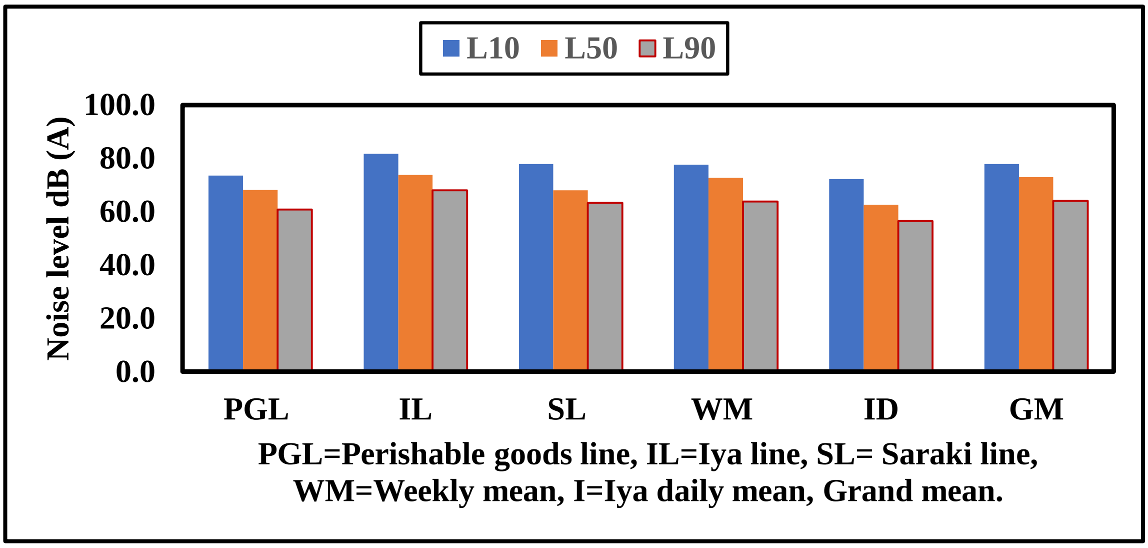
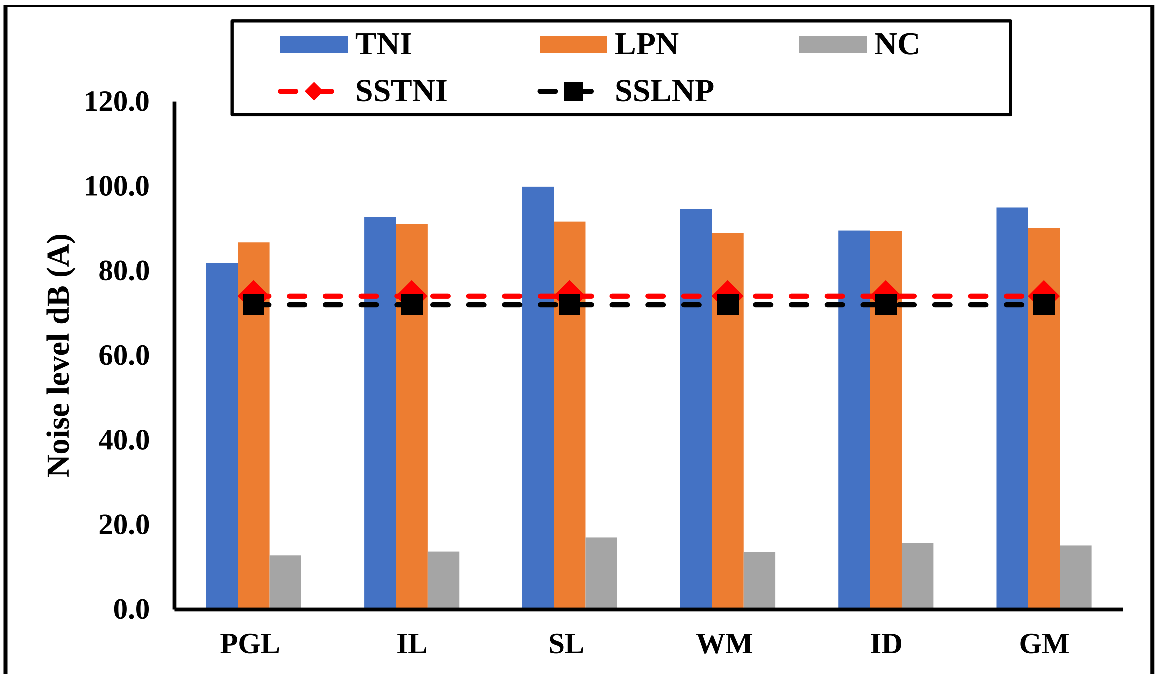


Figure 4.5:The Diurnal Logarithmic Mean for Percentile Noise Level for Samaru Market

The weekly daily market L_{10}, range from the maximum value of 81.7 dB (A) at the Iya line to a minimum value of 73.6 dB (A) at the Saraki line as in Figure 4.5. The logarithmic mean for a weekly market for Samaru market was 77.6 dB (A). For the daily market, the L_{10} value was 72.3 dB (A). The logarithmic mean for L_{10} both weekly and daily market was 77.9 dB (A). For the weekly days market L_{50}, range between a maximum value of 73.8 dB (A) at Iya line to a minimum value of 68.1 dB (A) at Saraki line and Perishable goods line while the logarithmic weakly mean value of was 72.7 dB (A). The L_{50} for daily market value was 62.7 dB (A). The logarithmic mean for the weekly market and daily market days was 72.9 dB (A). For the weekly days market L_{90}, range between the maximum value of 68 dB (A) at the Iya line to a minimum value of 56.6 dB (A) at the perishable goods line while the logarithmic mean value was 63.8 dB (A). For the daily market, the L_{90} value was 56.5 dB (A). The logarithmic mean for the weekly and daily market was 64.0 dB (A) as in Figure 4.5

4.3.2.3 *Analysis and comparison of noise parameters of Samaru market with SSS*

The logarithmic average for noise parameters TNI, L_{NP}, and NC for Lemu market were evaluated for the selected study locations and compared with Scholes, Sargent standard (SSS) as in Figure 4.6 and expressed from maximum to minimum values respectively.



PGL=perishable Goods Line, Il=Iya Line, Sl=Saraki line, WM=Weekly Mean, ID= Iya Daily , Gm=grand Mean, SSSTPI= 74 dB (A), SSLPN= 72dB (A)

Figure 4.6: Diurnal Logarithmic mean for Noise Parameters for Samaru Market Compared With SSS.

The traffic noise index (TNI) for figure 4.6 for the weekly market range between 99.9 dB (A) maximum value at Saraki line to 81.9 dB (A) minimum value at perishable goods line respectively, while the mean for a weekly market value of 94.7 dB (A) exceeded the compared standard. About (89.5) dB (A) was the daily market noise level which exceeded the compared standard as in Figure 4.6. The mean value of 95 dB (A) for daily and weekly markets exceeded the compared standard as present in Figure 4.6. The noise pollution level (L_{NP}) ranges from the maximum value of 91.9 dB (A) at the Saraki line to a minimum value of 86.8dB(A) at the perishable goods line which exceeded the compared standard as present in Figure 4.6. The mean value of the weekly market was about 89 dB (A), which exceeded the compared standard. The L_{NP} for the daily market was 83.5 dB (A), which exceeded the compared standard in figure 4.6. The L_{NP} mean for the daily market and the weekly market was 90.1 dB (A), which exceeded the compared standard as in Figure 4.6. The average noise climate for the weekly market ranges between the maximum value of 17 dB (A) at the Saraki line to a minimum value of 12.8dB(A) at the Perishable goods line. NC for the daily market was 15.7 at the Iya line while the Noise climate logarithmic mean for the Samaru market was 15.1 dB (A). Oyedepo *et al*., (2012) conducted the study and he computed for noise climate, there were variations in magnitude in his findings in comparison to the findings in this study.

All the evaluated noise index and parameters as in Figure 4.4 to Figure 4.6 exceeded the compared threshold. This could suggest that traders could be predisposed to the various effects of environmental noise pollution such as distortion of sleep, hearing impairment, tinnitus, headache, and aggressiveness as suggested by related studies when sound level exceeded the established threshold (WHO, 2011-2013; Directive 2002/49/EC; Debasish *et al*., 2012; Oyedepo *et al* 2012; Scholes *et all*., 1971; Ma *et al*, 2006)

4.3.2.4 *Single Factor ANOVA for Samaru Market*

Table 4.2 accounted for the single factor ANOVA analysis of diurnal noise pollution level, L_D, $L_{E,}$ and LN of three study sites for the weekly market and daily market Samaru Market. From the outcome of the analysis, the ($F(3,8) = 3.18$, $p<0.05$). Therefore, the null hypothesis was rejected. There was a significant difference between the noise pollution level for the diurnal noise index at different locations between a weekly and daily market with the WHO and NESREA standards. The variation of population, commercial activities, and other human activities in different selected surveyed sites were the sources of noise at the time of this survey in the Samaru market and responsible for the significant difference.

Table 4.2: Single Factor ANOVA For Samaru Market

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	*R*
Between Groups	372.1821	6	62.03	3.18	0.02	2.57	
Within Groups	409.2375	21	19.49				SF
Total	781.4196	27					

SS= Sum of square, df= degrees of freedom, F= Factor-ratio, MS= mean square, p=probability, f= factor critical, R=Remaks, SF= Significance.

4.3.3 Analysis of diurnal variations for noise index, Percentiles, parameters in Sabon-Gari Market; comparing with WHO, NESREA and SSS standard

The logarithmic average for L_{Aeq} was evaluated for $L_{D,}$ $L_{E,}$ $L_{N,}$ and LDEN for all the selected locations in Sabon-Gari Market. They were compared with WHO, NESREA standard as in Figure 4.7 and were expressed in a location with maximum level to the minimum noise level

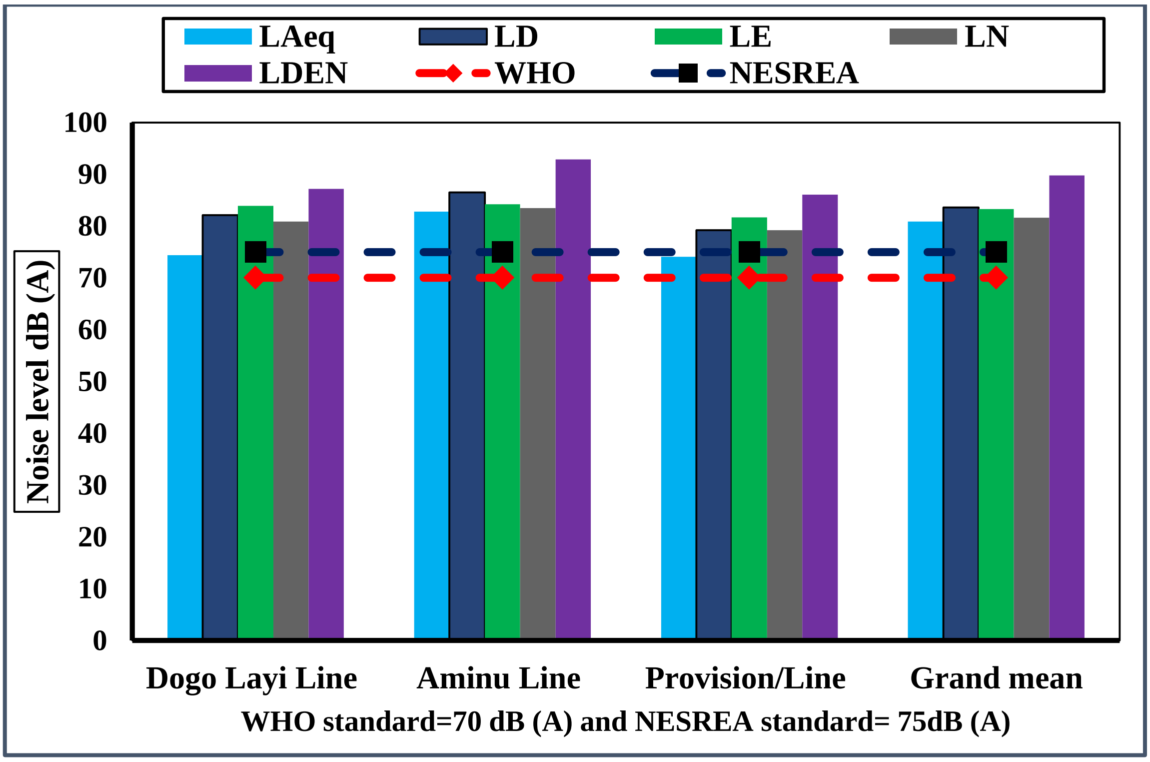


Figure 4.7: Diurnal Logarithmic mean for Noise Index Compared with WHO and NESREA Standard for Sabon-Gari Market.

For the logarithmic equivalent (LAeq) range between the maximum value of 82.8 dB(A) at Aminu line to a minimum value of 74.4 dB(A) at provision line with the mean value of 80.1 dB (A). It exceeded WHO and NESREA standards at the Aminu line and within the NESREA standard at provision line as in Figure 4.7. The L_D range between the maximum value of 86.5 dB (A) at Aminu Line to a minimum value of 79.2 dB (A) at Provision line and with the mean value of 83.6 dB (A) surpassed the compared standard as present in Figure 4.7. The L_E ranged between the maximum value of 84.2 dB(A) at the Aminu line to 81.7 dB(A) at the Provision line with the logarithmic mean value of 84.2 dB (A) exceeded the compared standard as in Figure 4.7. The L_N, ranges between the maximum value of 83.5 dB (A) at the Aminu line to the minimum value of 79.2 dB (A) at the provision line and with the logarithmic mean value of 81.9 dB (A) exceeded the WHO and NESREA recommended standard as in Figure 4.7. For the L_{DEN} logarithmic noise equivalent, range between the maximum value of 92.9 dB (A) at Aminu line to a minimum value of 87.2 dB (A) at the provision line. It exceeded the WHO and NESREA standards respectively as in Figure: 4.7.

4.3.3.1 *Analysis of percentile noise level at Sabon-Gari Market.*

The logarithmic average of noise percentiles (L_{10}, L_{50}, and L_{90}) was computed at Aminu line, Provision line, and Dogolayi lines were expressed from maximum to minimum value in Figure: 4.8

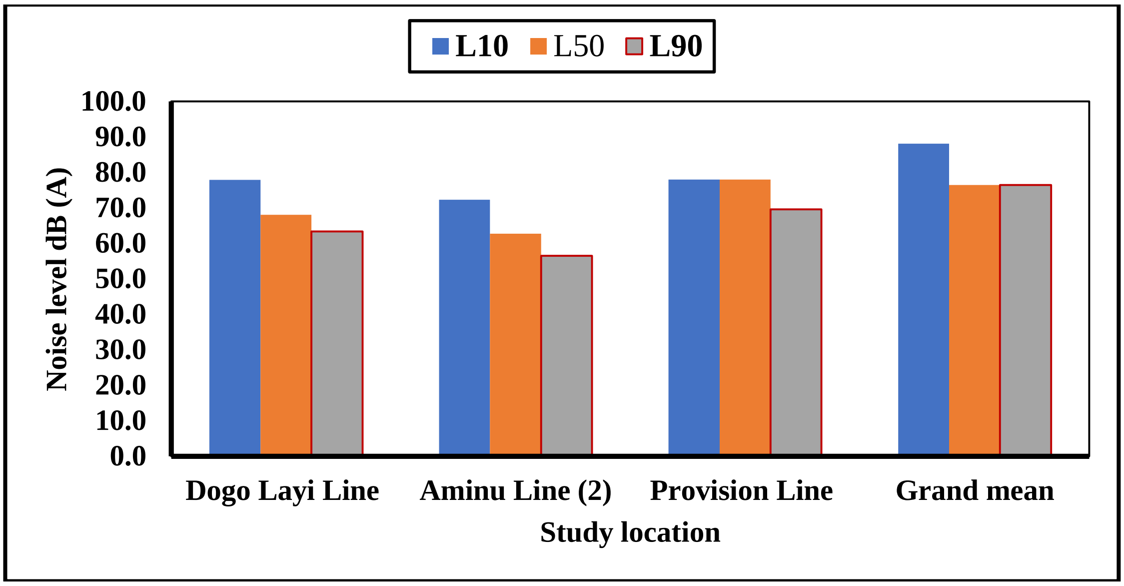


Figure 4.8: The diurnal Logarithmic mean for Noise percentiles for Sabon-Gari Market

For the L_{10} range between the maximum 88.1 dB (A) Aminu line to a minimum value of 74.2 dB (A) at provision line and with the logarithmic mean noise level of 83.9 dB (A) as in 4.8. The L_{50} ranges from the maximum value of 78.0 dB (A) at the provision line to a minimum value of 68.1 dB (A) at the Dogolayi line with a logarithmic of 76.5 dB (A) for Sabon-gari LGA. L_{90} range between the maximum value of 70.1 dB (A) at Aminu line to a minimum value of 64.5 dB (A) at provision line with the mean value of 72.7 dB (A) at the time of this finding in Figure:4.8

4.3.3.2 *Analysis and comparisons of noise parameters of Sabon-Gari market with SS standard*

The logarithmic average for noise parameters TNI, L_{NP}, and NC for Sabon-Gari was evaluated for the selected study locations and compared with Scholes, Salvidge and Sargent (SSS) standard as in Figure:4.9 and expressed from maximum values to minimum values respectively.

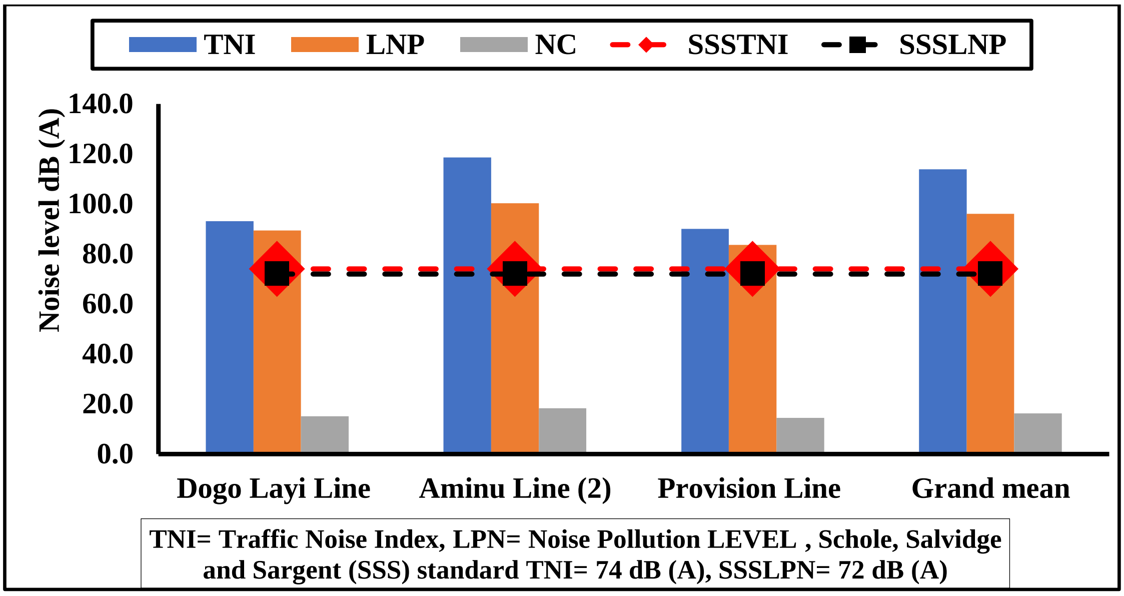


Figure 4.9 The diurnal logarithmic mean for Noise Parameters Compared with SSS standard at Sabon-Gari Market

The TNI range between the maximum value of 118.6 dB (A) at Aminu Line to a minimum value of 90.1 dB (A) at Provision line, and with the logarithmic mean of 113.8 dB (A) exceeded the compared standard as in Figure 4.9. For the L_{NP} range between the maximum value of 100.3 dB (A) at Aminu line to the minimum value of 83.6 dB (A) minimum at Provision line with the logarithmic mean of L_{NP} of 95.9 dB (A) exceeded the compared standard as present in Figure 4.9. The noise climate (NC) ranges between the maximum value of 18.3 dB (A) at the Aminu line to a minimum value of 14.4 dB (A) at the provision line with the mean value of 16.3 dB (A) in Figure:4.9.

In the analysis of Figure 4.7 to Figure 4.9, all the indicators and parameters exceeded the compared standard. This could suggest that the exposed population could be predisposed to adverse effects of environmental pollution such as annoyance, impaired hearing, tinnitus, cardiovascular effects, distorted sleep, and intuitiveness. These were affirmed by related studies by Clark and Pavnovic, (2018); Dancan *et al*., (2015); Debasish *et al*., (2012); Oyedepo *et al* (2012); Metcalfe (2013); Scholes *et al*., (1971);

Ma *et al*, (2006); Anmohanran *et al*, (2016). These resulted from the sources of noise such as commercial activities, vehicular activities, hawking, light industries, and generators.

4.3.3.3 *Single Factor ANOVA at Sabon-Gari Market*

As presented in Table 3 the single factor ANOVA analysis of noise pollution level, $L_{D,}$ $L_{E,}$ and $L_{N.}$ The (F (3,8) =13.43, p<0.05). Therefore, the null hypothesis was rejected and there was a significant difference between the noise pollution level of the different noise indicators at different locations between a weekly and daily market with the WHO and NESREA standard. This was as a result of variation of noise from commercial activities, and other anthropogenic activities within the Sabon-Gari market.

Table 4.3: Single Factor ANOVA For Noise Indicators for Samaru Market with WHO and NESREA Standard

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	***Re***
Between Groups	697.67	6	116.28	13.43	4.24E-05	2.85	sf
Within Groups	121.20	14	8.66				
Total	818.86	20					

SS= Sum of square, df= degrees of freedom, F= Factor-ratio, MS= mean square, p=probability, f= factor critical, Re= Significant

4.3.4 Diurnal Variation of noise index, Parameters for Busy Commercial area; comparing with WHO, NESREA AND SSS standard

The logarithmic average for L_{Aeq} was investigated and evaluated for $L_{D,}$ $L_{E,}$ $L_{N,}$ and LDEN for all the selected busy commercial areas. They were compared with WHO, NESREA standard as in figure 4.10 and were expressed from maximum level to minimum level.

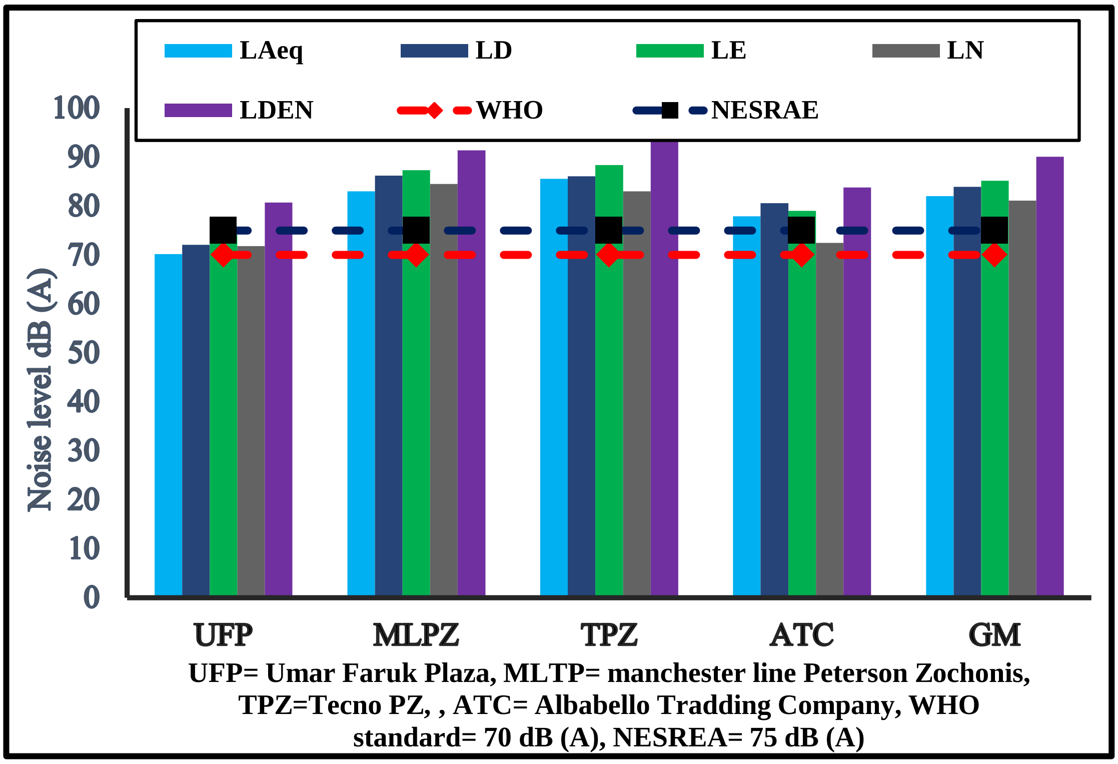


Figure 4.10: Diurnal Logarithmic mean of Noise Index for the Busy Commercial areas.

As present in Figure 4.10, the L_{Aeq} range between the maximum value of 85.6 dB (A) at Techno PZ to a minimum value of 70.2 dB (A) at Umar Faruk Plaza with the logarithmic mean value of 82.6 dB (A) and it exceeded the WHO and NESREA standards. For the L_D range between the maximum value 86.2 dB (A) at Manchester Line PZ to 72.1 dB (A) value of at Umar Faruk Plaza which exceeded the WHO and NESREA standard at Manchester but withing NESREA standard at Umar Faruk Plaza as in Figure 4.10. The L_E range from a maximum value of 88.4 dB (A) at Techno PZ to a minimum value of 74.1 dB (A) at Umar Faruk Plaza while with a mean value of 85.2 dB (A). It exceeded WHO in all the four sites but NESREA standards in three study sites represented 75% as in Figure 4.10. The L_N range between the maximum value of 84.5 dB (A) at Manchester line PZ to a minimum value of 71.8 dB (A) at Umar Faruk Plaza with the mean value of 81.1 dB (A). It exceeded the WHO standard in all the four surveyed sites, while above the NESREA standard at three sites representing 75%. For the L_{DEN} range between the maximum value of 93.5 dB (A) at Techno PZ to the minimum value of 80.7 dB (A) at Umar Faruk with the logarithmic mean value of 90.1 dB (A) which exceeded WHO and NESREA standard as present in Figure 4.10 respectively

4.3.4.1 *Noise level percentiles for selected commercial areas in Sabon-Gari LGA*

The logarithmic average of noise percentiles ($L_{10,}$ $L_{50,}$ and L_{90}) was evaluated at Umar Faruk Plaza, Manchester lines PZ, Tecno PZ, and Albabello Trading company lines were expressed in forms of surveyed sites with maximum value to the minimum value as in figure: 4.11.

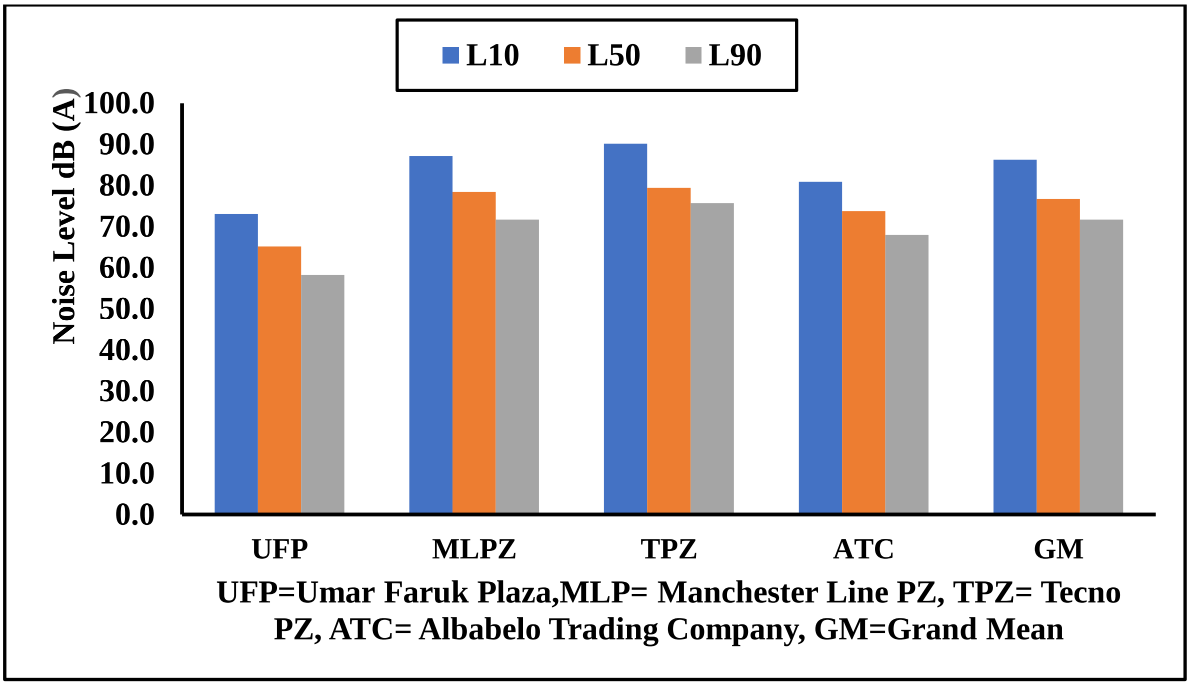


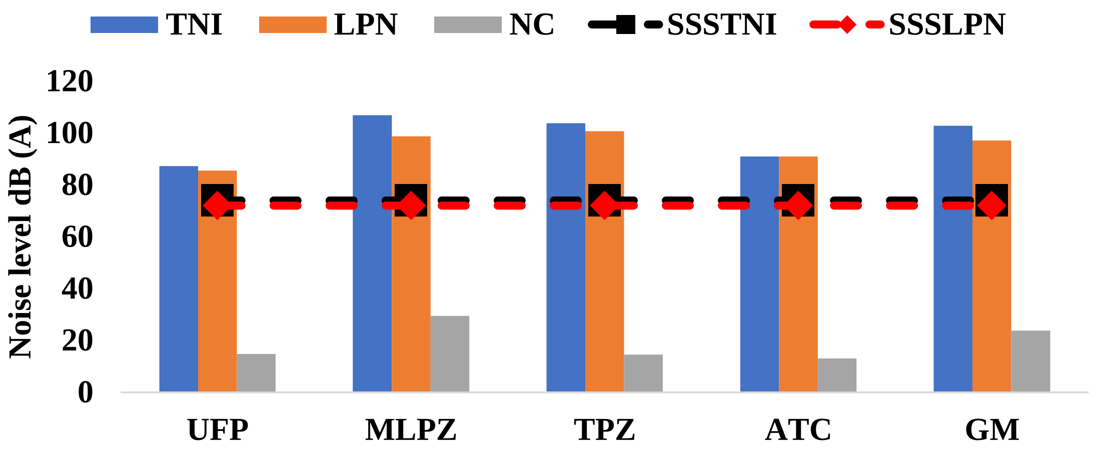
Figure 4.11: Diurnal Logarithmic men for Noise Percentiles for Busy Commercial Areas

For the L_{10} range between the maximum value of 90.2 dB (A) at Techno PZ to the minimum value of 73 dB (A) at Umar Faruk with the logarithmic mean value of 86.3 dB (A) as in Figure 4.11. For the L_{50} range between the maximum value of 79.5 dB (A) at Techno PZ to the minimum value of 65.2 dB (A) at Umar Faruk Plaza with the mean value of 79.5 dB (A). For the L_{90} range between the maximum value of 75.7 dB (A) at

Techno PZ to the minimum value of 58.3 dB (A) at Umar Faruk Plaza and with the mean value of 71.7 dB (A), as in Figure: 4.11.

4.3.4.2 *Analysis and comparison of noise parameters for Commercial busy areas of Sabon- Gari with SSS*

The logarithmic average for noise parameters TNI, LNP, and NC for selected busy commercial areas were evaluated for the selected study locations and compared with Scholes, Salvidge and Sargent (SSS) standard as in Figure: 4.12 and were from the maximum value to minimum values respectively.



TNI= Traffic Noise Index, LPN= Noise Pollution Level, UFP= Umar Faruk Plaza, MLPZ=manchester line PZ, TPZ= Techno PZ, ATC=AL-Babelo trading company, GM=GRAND Mean, SSSTNI= 74dB (A), SSSLNP= 72 dB (A)

Figure 4.12: Diurnal Logarithmic mean for Noise Parameters and Compared with SSS standard for Busy Commercial Areas

The Traffic noise index range between the maximum value of 106.9 dB (A) at Manchester line PZ to the minimum value of 87.3 dB (A) at Umar Faruk Plaza and with the logarithmic mean of 102.8 dB (A), exceeded the compared standard in figure 4.12**.** The Noise Pollution Level (L_{NP}) range between the maximum value of 100.7 dB (A) at the Manchester line to the minimum value of 85.5 dB (A) at Umar Faruk Plaza and with the logarithmic grand mean of 97.1 dB (A), it exceeded the compared standard as in Figure 4.12. The Noise climate range from the maximum value of 20 dB (A) at the

Manchester line to the minimum value of 13 dB (A) at the Umar Faruk Plaza and the mean of noise climate was 23.8 dB (A).

In the analysis of Figure 4.10 to Figure 4.12 the computed noise indicators and parameters exceeded the compared WHO, NESREA, and SSS standards respectively. The exposed population could be predisposed to the effects of noise pollution such as Annoyance, aggressiveness, sleep disorder, tinnitus, hearing impairment, and deterioration of cognitive prowess as detailed by related studies conducted by Ising et at., (2004); Kim MG *et al*., (2009); Oyedepo *et al*., (2012); Lee *et al*., (2015); Hatamzadi *et al*., (2018), Scholes *et al*., (1971); Ma *et al*, (2006); Ljubojev *et al*., (2014)

4.3.5 Single Factor ANOVA for Diurnal noise index for busy commercial areas

As presented in Table 8 for one-way ANOVA of statistical analysis of noise level $L_{D,}$ $L_{E,}$ and L_N of four busy business areas. The (f (6,21) =3.18, p<0.05), therefore, the null hypothesis was rejected. There was a significant difference between the noise pollution index at different study locations of the selected busy business areas with the WHO and NESREA standards. This was necessitated by the variety of human activities and their respective sources of noise, such as commercial activities, generators, and light traffic activities at the different selected business areas in the study locations.

Table 4.4: A Single Factor ANOVA Analysis for Busy Commercial Areas, with WHO Standard and NESREA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	*Re*
Between Groups	372.18	6	62.03	3.18	0.02	2.57	sf
Within Groups	409.24	21	19.49				
Total	781.42	27					

SS= Sum of square, df= degrees of freedom, f= Factor-ratio, MS= mean square, p=probability, f= factor critical, sf= significant

4.4 Diurnal Noise Index, Percentiles, Parameters of Selected Intersections Comparing with WHO, NESREA, and Schole, Salvidge and Sargent (SSS) standard.

4.4.1 Analysis of diurnal variation of noise index, comparing with WHO and NESREA standard.

The logarithmic average for L_{Aeq} was evaluated for $L_{D,}$ $L_{E,}$ $L_{N,}$ and LDEN for all the selected intersections. They were compared with WHO, NESREA standard as in Figure 4.13: and it was expressed in a location with maximum level to the minimum noise level.

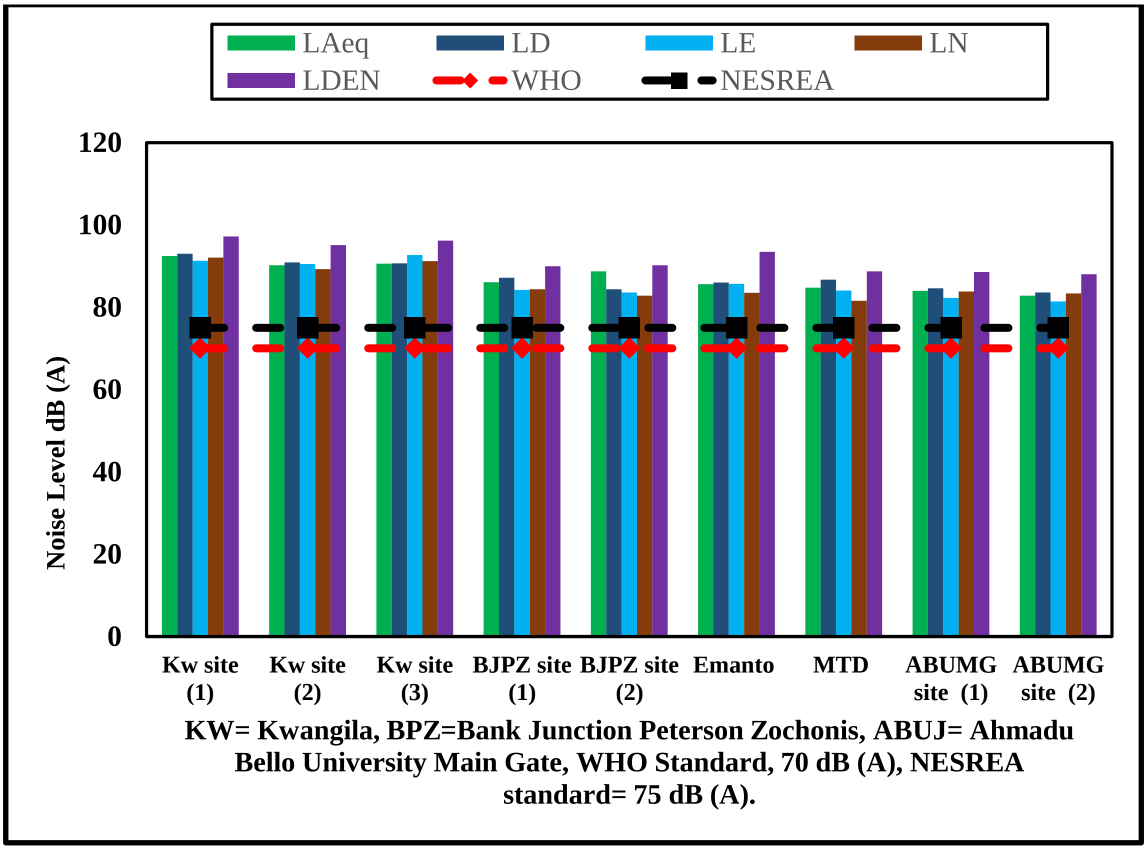


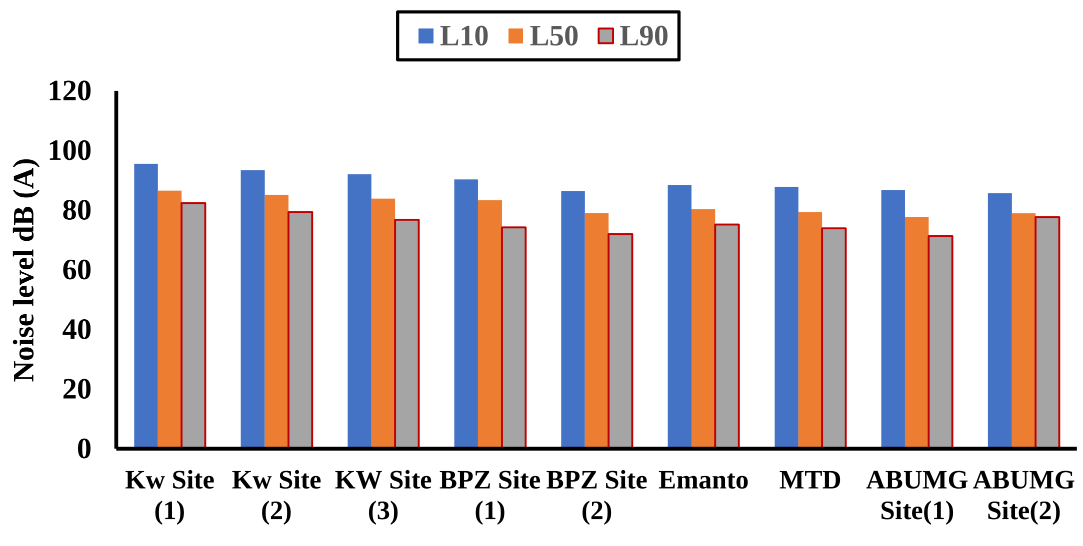
Figure 4.13: The Diurnal Logarithmic Mean for Noise Index for Selected Road Intersections.

Figure 4.13, the LAeq range between the maximum value of 92.5 dB(A) at kwangila site (1) to the minimum value of 82.8 dB (A) at the ABU main gate site (2) and exceeded the WHO and NESREA standards as in Figure 4.13. The L_D ranges between the maximum value of 93.0dB (A) at Kwangila at the site (1) to the minimum value of 83.6 dB (A) at ABU main gate site (2) intersection and it exceeded the WHO and

NESREA specifications respectively as in Figure 4.13. The $L_{E,}$ range between the maximum value of 92.7 dB (A) at kwangila site (1) to the minimum value of 84.1 dB(A) at Emanto intersection and it exceeded the WHO and NESREA standards. The $L_{N,}$ ranges between the maximum value of 92.1 dB(A) at Kwngilar site (1) to the minimum value of 81.6 dB(A) at MTD intersection and it exceeded the compared standard as in Figure 4.13. The maximum L_{DEN} range between 97.2 dB (A) at Kwangila site (1) to the minimum value of 88.0dB (A) at ABU main gate site (2) and it exceeded the WHO standard and NESREA Standard respectively as in figure 4.13.

4.4.2 Noise level percentile for selected streets and roads in Sabon-Gari LGA

The logarithmic average of noise percentiles ($L_{10,}$ $L_{50,}$ and L_{90}) were computed at Kw site (1) to Kw site (3), BPZ site (1), BPZ site (2), Emanto, MTD, ABUMA site (1) and ABUMG site (2) were evaluated and expressed from maximum value to minimum value as present in Figure: 4:14.



KW= Kwangila, BPZ= Bank Peterson Zochonis, ABUMG= Ahmadu Bello University Main Gate .

Figure 4.14: The Diurnal Logarithmic Mean for Noise Percentile Noise Level at Selected Road Intersections in Sabon-Gari LGA

The maximum L_{10}, ranges between the maximum value at 95.5 dB (A) at kwangila (1) to the minimum value of 85.7 dB (A) at ABU main gate site (2) as in Figure 4.14. The L_{50} ranges between the maximum value of 86.5 dB (A) at Kwangila site (1) to the minimum value of 77.7 dB (A) at Ahmadu Bello university's main gate site (1). L_{90} range between the maximum noise level 82.3 dB (A) at Kwangila to the minimum value of 72 dB (A) minimum at bank intersection PZ as in Figure 4.14

4.4.3 Analysis of noise parameters for selected intersections and comparing with SSS standard

The logarithmic average for noise parameters TNI, LNP, and NC for selected intersections evaluated and compared with Scholes, Salvidge, and Sargent (SSS) standard as present in Figure: 4.15 and were expressed from maximum to minimum values respectively.

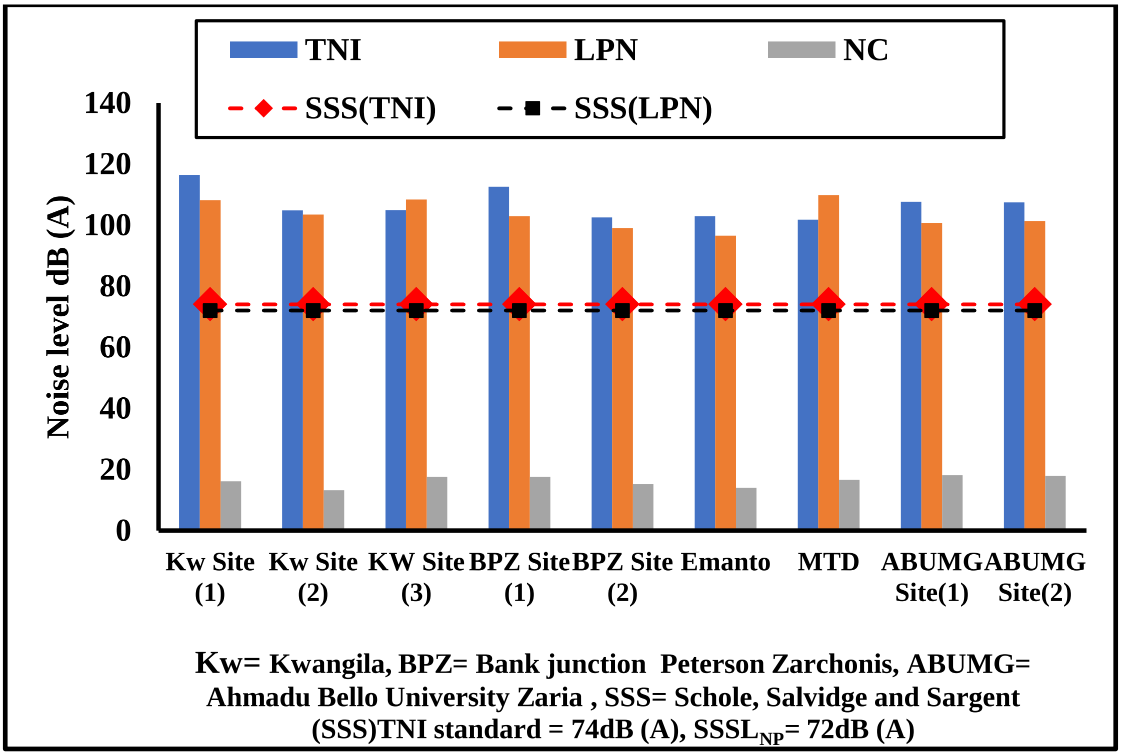


Figure 4.15: The Diurnal Logarithmic Mean Noise Parameters for Selected Road Intersection in Sabon-Gari LGA

Figure 4.15, the TNI range between the maximum value of 116.4dB (A) at Kwangila site (1) to the minimum value of 101.7 dB (A) at MTD intersection. Noise pollution levels (L_{NP}) range between the maximum value of 108.3 dB (A) at Kwangila site (3) to the minimum value of 96.5dB (A) at Emanto intersections. The TNI and the L_{NP} exceeded the compared standard in Figure 4.15 respectively. The Noise climate (NC) ranged between the maximum value of 18 dB (A) at ABU main gate (1) to the minimum value of 13 dB at (A) at Kwangila (2) as in Figure 4.15

In the analysis of figure 4.13 to Figure 4.15, the sound level exceeded all the compared standards which could result in annoyance, hearing impairment, stress, and cardiovascular effects on the merchants and travellers. Related studies had asserted that if sound level exceeded compared standard it results in noise into various noise effects (Okwudili et al., 2021; WHO, 2011; Ma *et al*., 2006, Majidi *et al*.,2016, McDonald *et al*., (2016), Metcalfe (2013), Oyedepo *et al* (2010), Moller (2007), Omubo-Pepple *et al*., (2010). This noise pollution was the result of diverse anthropogenic activities and sources of noise hooting from vehicles, generators, and commercial activities.

4.4.4 Single Factor ANOVA for Noise index for the selected road Intersections

The single-factor ANOVA of nine selected intersections, the null hypothesis was rejected as the ($F(2,9) = 237.01$, $p<0.05$). There was a significant difference between the noise pollution indix at different locations with the WHO and NESREA standards. This was as a result of the differences in anthropogenic activities and sources of noise as enumerated in previous discussions.

Table 4.4: Single Factor ANOVA For Noise Index for selected Intersection, with NESREA and WHO Standard

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	***Re***

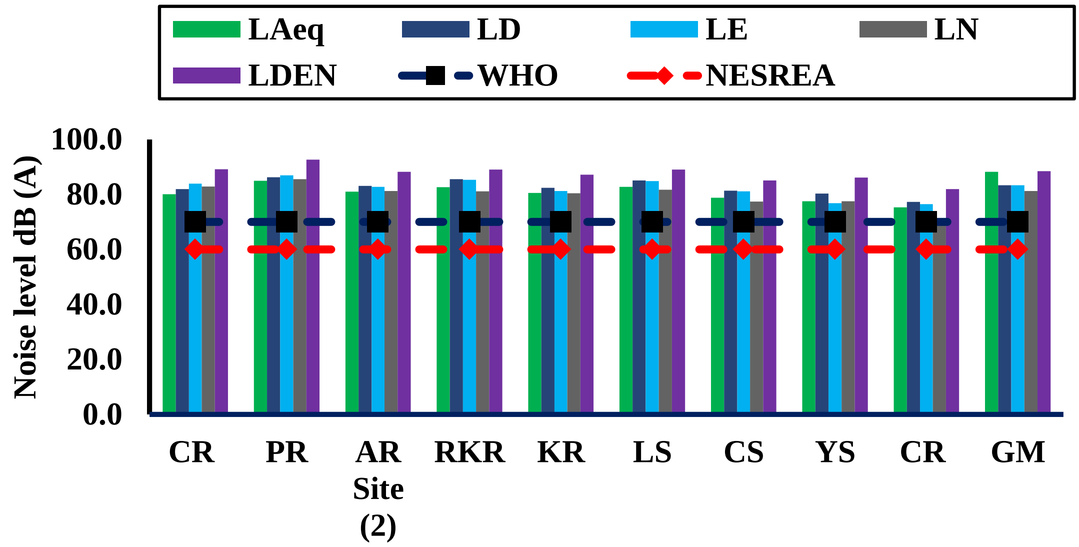
Between Groups	2284.30	2	1142.15	237.01	3.89E-15	3.47	sf
Within Groups	101.20	21	4.82				
Total	2385.5	23					

SS= Sum of square, df= degrees of freedom, F= F-ratio, MS= mean square, p=probability, f= f critical, Re= Remarks, sf= Significant

4.5 Diurnal Noise Index, Percentiles, Parameters for Streets/ Road group (A) Comparing with WHO, NESREA, and SSS standard.

4.5.1 Diurnal noise variation indicators for streets/road, compared with WHO and NESREA standard.

The logarithmic average for L_{Aeq} was evaluated and computed for $L_{D,}$ $L_{E,}$ $L_{N,}$ and LDEN for all the streets/roads. They were compared with WHO, NESREA standard as in fig: 4.16, and they were expressed in a location with maximum level to the minimum noise level.



Selected studied location. CR= Chikaji Road, PR= Park Road, AR= Aminu Road, RKR= Randan Kano Road, KR=Kings Road, LS=Lagos Street, CS= Club Street, YS= Yoruba Street, CR=Cemetery Road, WHO standard =70 dB (A), NESREA standard= 60 dB (A)

Figure 4.16: The Diurnal Logarithmic Mean for selected Streets/Roads

In Figure 4.16 the L_{Aeq} range between the maximum value of 85.0 dB (A) at park road to the minimum value of 75.3 dB(A) at cemetery street with the logarithmic mean value of 82 dB (A). It exceeded the WHO and NESREA standards. For the logarithmic $L_{D,}$ the noise level raged between the maximum value of 86.3 dB (A) maximum at Park Road to the minimum value of 77.3 dB(A) at Cemetery Road with a logarithmic mean of the roads/Streets value of 83.9 dB (A). It exceeded WHO the NESREA standard in all the surveyed sites as in Figure 4.16. For the L_E, range between the maximum value of 86.9dB (A) at Park Road to the minimum value of 76.5 dB (A) at Cemetery Road and the mean of 85.2 dB (A) which exceeded WHO and NESREA standard in all the surveyed sites respectively as in Figure 4.16. For the logarithmic $L_{N,}$ range between the maximum value 86.9 dB (A) at Park Road to the minimum value of 69.7 dB (A) at Cemetery Road, the logarithmic mean value of 81.1 dB (A) exceeded the compared standard. The L_{DEN} range between the maximum value of 92.6 dB (A) at Park Road to the minimum value of 81.9 dB (A) at cemetery road. It exceeded the WHO and NESREA standards. The logarithmic mean for LDEN value of 88.5 dB (A) exceeded the compared standard as in Figure: 4.16 respectively.

4.5.1.1 *Sound percentiles for selected streets and roads in Sabon-Gari LGA*

The logarithmic average of noise percentiles ($L_{10,}$ $L_{50,}$ and L_{90}) were evaluated at **CR, PR, AR, RKR, KR, LS, CS, YS, CR, GM** and were expressed in forms of location with maximum value to the minimum value in figure 4.17

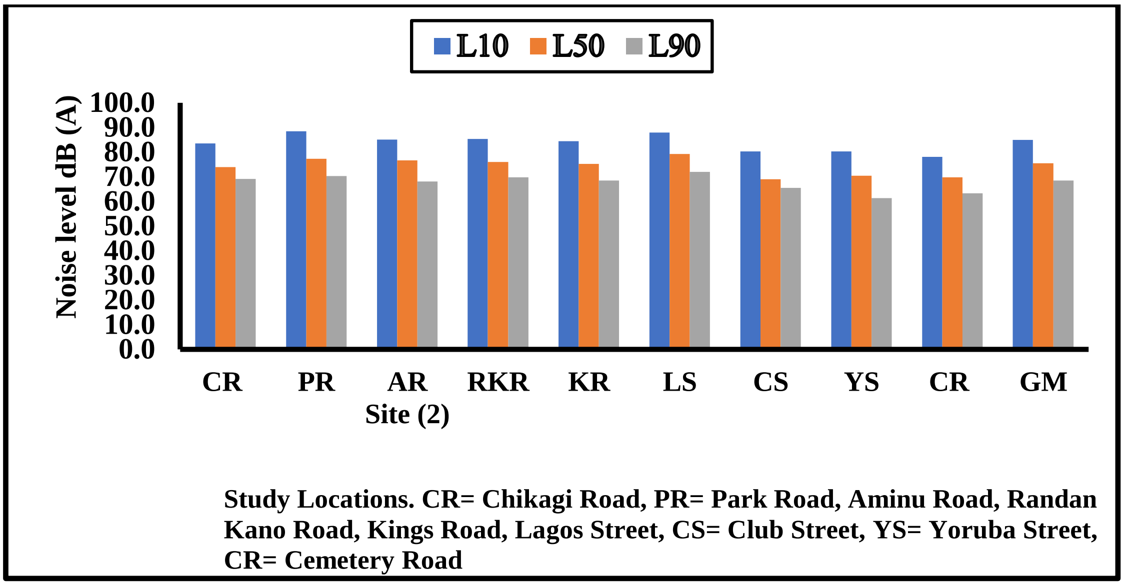
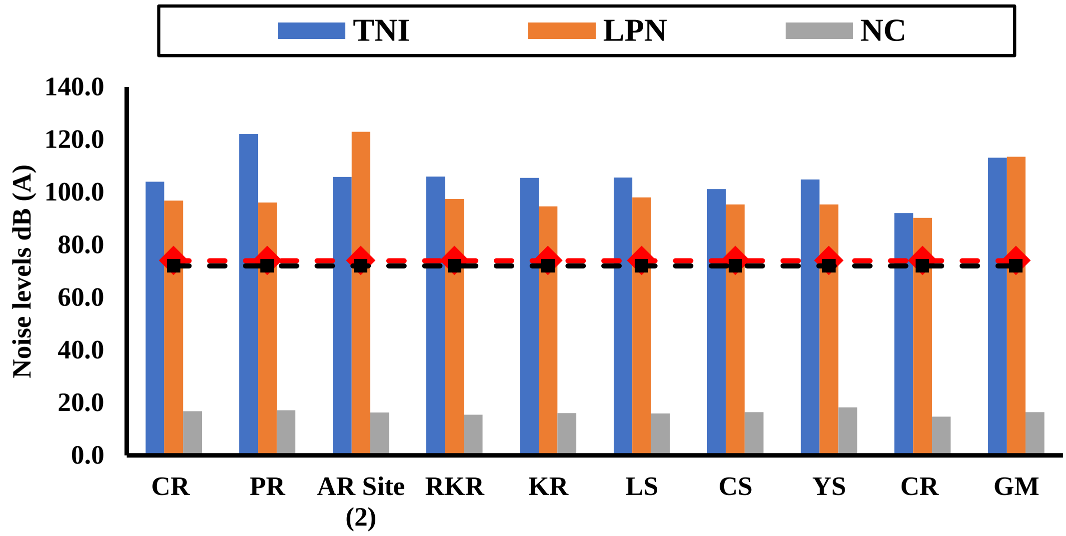


Figure 4.17:The Diurnal Logarithmic Mean for Percentiles Noise Level for Selected Streets/Roads Group (A) In Sabon-Gari LGA

Figure 4.17, the L_{10} range between the maximum value of 87.9 dB(A) at Lagos Street to the minimum value of 78 dB(A) at cemetery street with the mean value of 84.9 dB (A). The L_{50} ranges between the maximum value of 79.2 dB (A) at Lagos Street (1) to the minimum value of 69 at (1) at club street with a logarithmic mean of 75.4 dB (A). The L_{90} range between the maximum value of 72. dB (A) at Lagos Street to the minimum values of 61.4 dB(A) at Yoruba street. The outcome was in line with the findings of Oyedepo *et al*, (2010), though varies in magnitude.

4.5.1.2 *Analysis of diurnal noise parameters of selected streets and Roads compering with SSS.*

The logarithmic average for noise parameters TNI, $L_{NP,}$ and NC for the selected roads and streets were evaluated and compared with Scholes, Sargent, and Salvidge (SSS) standard as in figure: 4.17 and expressed in from maximum to minimum values respectively.



Study location. CR= Chikargi Road, PR=Park Road, RKR= Randan Kano Road, KR= Kings Road, LR= Lagos Road, CS= Club Street, YS= Yoruba Street. sssTNI= 74dB (A), SSSLNP=72dB (A)

Figure 4.18: The Diurnal Logarithmic Mean Noise Parameters for Roads and Streets Groups (A) in Sabon-Gari LGA

Figure 4.18, the TNI range between the maximum value of 122.1 dB (A) at park road to the minimum value of 92.1 dB (A) at Cemetery Street with the mean value of was 113.1 dB (A). The L_{NP} range from the maximum value of 123 dB (A) at Aminu road to the minimum value of 90.2 dB(A) at Cemetery Road with the mean of 113.5 dB(A). The TNI and L_{NP} of the surveyed sites exceeded the compared standard as in Figure 4.18. The Noise Climate range between the maximum value of 18.3 dB (A) at Yoruba street to the minimum value of 14.7 dB (A) at cemetery street and with the logarithmic mean of 16.4 dB (A) as in Figure: 4.18

The analysis of figure 4.16 to Figure 4.18 noise indicators and parameters in all the surveyed sites exceeded the compared standard for the selected major streets/roads in Sabon-Gari LGA. This could suggest the exposed population are predisposed to the effect of noise such as annoyance, headache, sleep disturbance, cardiovascular diseases, reduce concentration, and increase in stress as affirmed by the study conducted by Okwudili et al., 2021; WHO, 2011; Anmohanran, 2010; Oyedepo *et al*, 2010; Hanner *et* *al*.,204; George *et al*.,2015). This was as a result of the variation of various sources and anthropogenic activities such as traffic activities, street hawking, generators, and light industries.

4.5.2 Analysis of diurnal variation's noise level for selected streets groups (B); comparing with WHO, NESREA, and SSS standard

The logarithmic average for L_{Aeq} was evaluated and computed for L_{D}, L_{E}, L_{N}, and L_{DEN} for the selected streets/roads group (B). They were compared with WHO, NESREA standard as in Figure: 4.19 and were expressed from maximum level to minimize noise level.

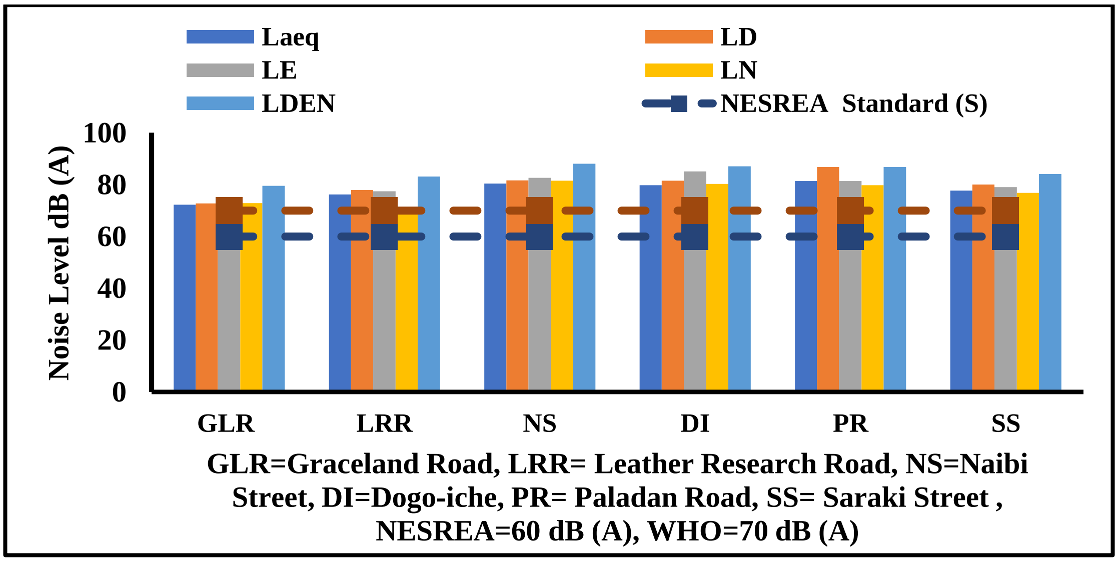


Figure 4.19: The Diurnal Logarithmic Average for Noise Index for Major Roads and Streets in Sabon-Gari LGA

Figure 4.19, the LAeq range between 81.4 dB(A) maximum value at Paladan road to minimum values of 71.3 dB(A) at Graceland Road exceeded WHO and NESREA standard respectfully. The L_{D}, range from the maximum value of 86.9 dB(A) at Palladan road to the minimum value of 72.8 dB(A) at Grace land road and exceeded the WHO and NESREA standard as in Figure 4.19. The L_{E} range between the maximum value of 85.1 dB(A) at Dogo-Iche street to the minimum value of 74.3 dB (A) at Grace land road and it's exceeded the NESREA and WHO standard as in Figure 4.19. The L_N range between the maximum values of 81.5 dB(A) at Naibi street Samaru to the minimum value of 72.9 dB(A) at Grace land street. It exceeded the WHO and NESREA standards as present in Figure 4.19 respectively. The $L_{DEN,}$ range between the maximum value of 88.1 dB (A) at Naibi street to the minimum value of 79.5 dB(A) at Graceland Road and exceeded the WHO and NESREA compared standard respectively as in figure 4.19.

4.5.2.1 *Noise percentile for streets/ roads group (B) of Sabon-Gari LGA*

The logarithmic average of noise percentiles ($L_{10,}$ $L_{50,}$ and L_{90}), were evaluated at Graceland site (2), Leather research road, Saraki street, Dogo-iche street, Paladan road, and Naibi street and were expressed from maximum value to minimum value in the Figure: 4.21

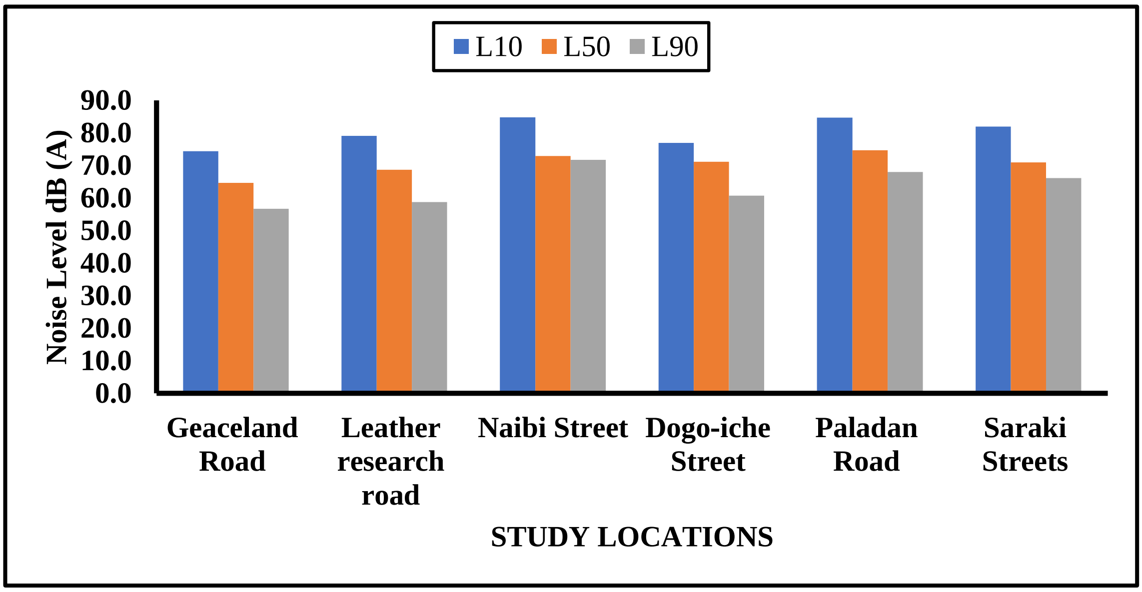
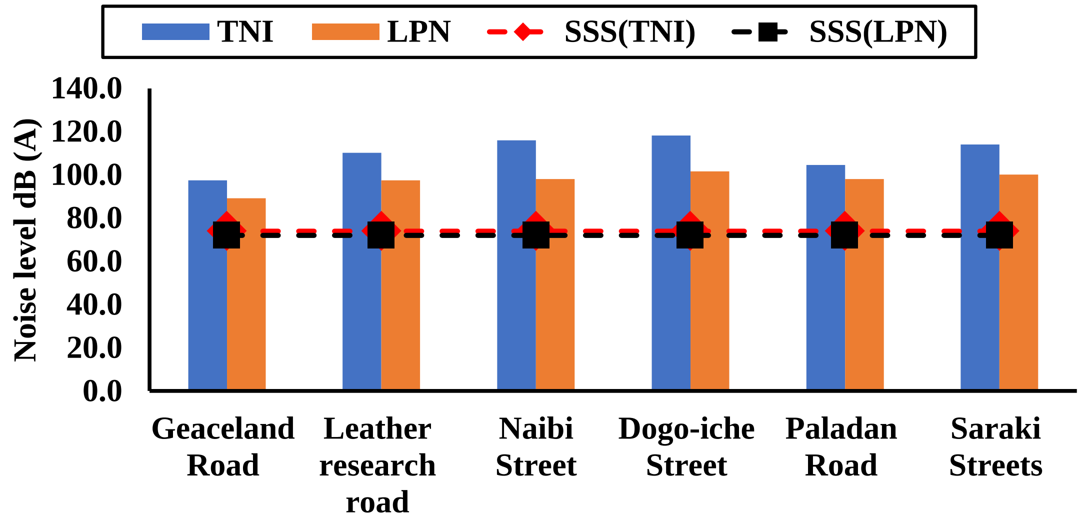


Figure 4.20:Diurnal Logarithmic Mean for Percentile Noise Level for Selected Roads and Streets Group (B) In Sabon-Gari LGA

The $L_{10,}$ range between the maximum values of 84.8 dB(A) at Naibi street to the minimum value of 74.4 dB(A), while 81.8 dB (A) was the logarithmic mean value in Figure: 4.20**.** The L_{50} ranges between the maximum value of 74.7dB (A) at Palladan road to the minimum value of 64.6 at (1) at club street. The $L_{90,}$ ranges between the maximum value of 71.7 dB (A) at Naibi-street to the minimum value of 56.7 dB (A), at Grace land road. The logarithmic mean value was 66.6 dB (A) as in Figure: 4.20

4.5.2.2 *Analysis of noise parameters for streets/roads groups (B) compared with SSS*

The logarithmic average for noise parameters TNI, LNP, and NC for the selected roads and streets group (B) were evaluated and compared with Scholes, Salvidge, and Sargent (SSS) standard as in Figure: 4.21 and expressed from maximum to minimum values respectively.



TNI= Traffin Noise Index, LPN= Noise pollution Level, SSS=Scholes, Salvige and Salgent statandar, SSS(TNI)= 74 dB (A), SSSLPN= 72 dB(A)

Figure 4.21: Diurnal Logarithmic mean for Noise Parameters for Roads and Streets Groups (B) in Sabon-Gari LGA

The TNI, range between the maximum value of 118.3 dB (A) at Dogo-iche to the minimum value of 97.5 dB (A) at Grace land and exceeded the compared standard as present in Figure 4.21. The $L_{NP,}$ ranges between the maximum value of 101.7 dB(A) at Dogo-iche to the minimum value of 89.2dB(A) at Graceland (RA) and it exceeded the compared standard as in Figure 4.21. The Noise climate range between the maximum value of 21.9 dB (A) at DogoIche to the minimum of 15.5 dB(A) at Grace land in Figure: 4.21

From the analysis of Figure 4.19 to 4.21 all the study locations in the selected streets/roads in the group (A) exceeded the compared standard which could suggest the exposed population were predisposed to the effect of noise such as annoyance, stress, distortion of information, sleep disturbance and cognitive prowess as enumerated by the study conducted by WHO, (2012) in European's countries, Anmohanran *et al*, (2013); in Federal Capital Territory, Abuja, Nigeria Oyedepo *et al* in Ilorin Nigeria, Kwon *et al*., (2016) in China. Sources of noise and other human activities such as domestic activities, commercial activities, traffic activities, and light industrial activities were responsible for the variations in the magnitude of the compared standard in the different surveyed sites.

4.5.3 Single Factor ANOVA for major roads and streets.

Table 4.6 presented the single factor ANOVA of the diurnal index of the two classified streets. The $p<0.05$, therefore, there was a significant difference between noise pollution levels between the selected roads/ streets in sites A and B with the WHO and NESREA standards. The differences were a result of the concentration of population and other anthropogenic activities in the different roads/streets in Sabon-Gari LGA of Kaduna State

Table 4.5: Single Factor ANOVA Of Major Streets/Roads for Noise Indicators with WHO and NESREA Standard

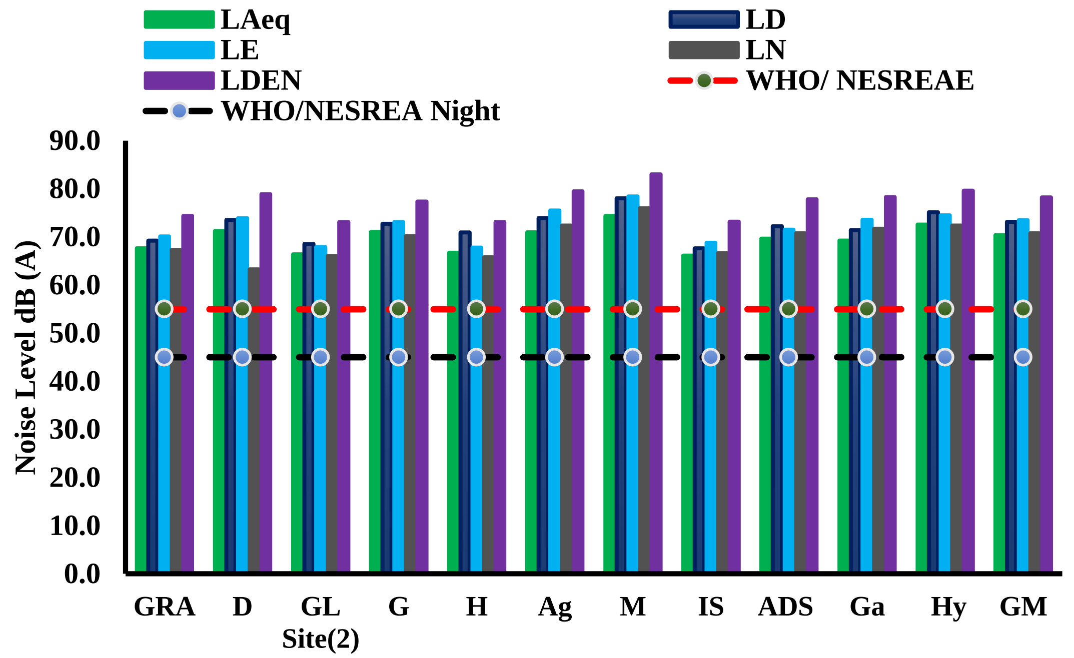
Source of Variation	*SS*	*df*	*MS*	*FCal*	*P-value*	*F crit*	***Re***
Between Groups	2181.98	3	727.32	176.36	1.5E-14	3.098	sf
Within Groups	82.48	20	4.12				
Total	2264.46	23					

SS= Sum of square, df= degrees of freedom, F= F-ratio, MS= mean square, p=probability, f= f critical, Re= Remarks, sf= Significant

4.6 The Logarithmic Diurnal Mean of Noise Index, Percentile and Parameters for Mixed Residential with Commercial Areas.

4.6.1 Analysis of diurnal variations of noise levels of mixed residential with commercial with WHO and NESREA standard

The logarithmic average for L_{Aeq} was evaluated and computed for L_D, L_E, L_N, and LDEN for all the mixed residential with commercial areas. They were compared with WHO, NESREA standard in the Figure: 4.22 and were expressed from maximum level to minimize noise level.



GRA= Government Reservation Area (RA), D= Dogorawa (RA), GL= Graceland (RA),H=Hanwa (RA), Ag= Agwangodo (RA), M=Muchia (RA), IS= Ijaw street (RA), Afegbu Darak Samaru (RA), Ga= Galadima (RA), HY=Hyinda-Yaro. WHO/NESREA day Time =55 dB (A), WH0/ NESREA=45

Figure 4.22: The Diurnal Logarithmic Mean for Noise Index for Mixed Residential with Business Areas

In figure 4.22 the LAeq, range with the maximum value of 78 dB (A) at Muchia Residential Area (RA) to the minimum value of 67.6 dB(A) at Hyinda-Yaro (RA) with the logarithmic mean value of 70.4 dB (A) exceeded the WHO and NESREA standard respectively. The evaluated L_D, range with the maximum value of 78.4 dB(A) at Muchia (RA) to the minimum value of 67.8 dB (A) at Grace land (RA) and with the logarithmic mean value of 73.1 dB (A) exceeded the WHO and NESREA standard respectively in Figure 4.22. The evaluated L_E, range with the maximum of 78.4 dB (A) at Muchia (RA) to the minimum value of 67.8 dB (A) at Dogorawa, (RA) with the logarithmic mean value of 73.5 dB (A) exceeded the WHO and NESREA standard respectively. $L_{N,}$ range with the maximum value of 76 dB (A) at Muchia to 63.3 dB (A) minimum value at Dogorawa and with the logarithmic grand mean value of 70.8 dB (A) exceeded the WHO and NESREA standard. The evaluated L_{DEN} range with the maximum values 83.0 dB(A) at Muchia to the minimum value of 73.1 dB (A) at Graceland B/Hanwa respectively with the logarithmic grand mean value of 77.5 dB (A) exceeded the compared standard as in figure 4.22.

4.6.2 Sound percentiles for mixed residentials with commercial area in Sabon-Gari LGA

The logarithmic average of noise percentiles ($L_{10,}$ $L_{50,}$ and L_{90}) was evaluated at **GRA, D, GL, G, H, Ag, M, IS, ADS, Ga and HY** and were expressed in forms of location with maximum value to the minimum value in the figure: 4.23

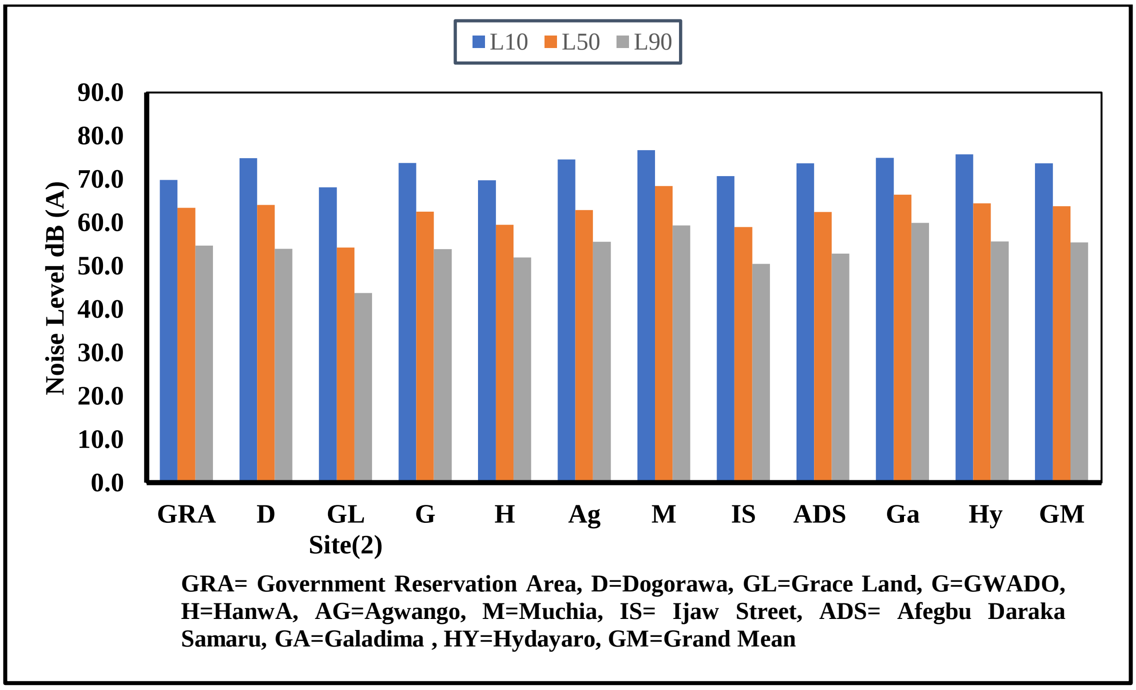
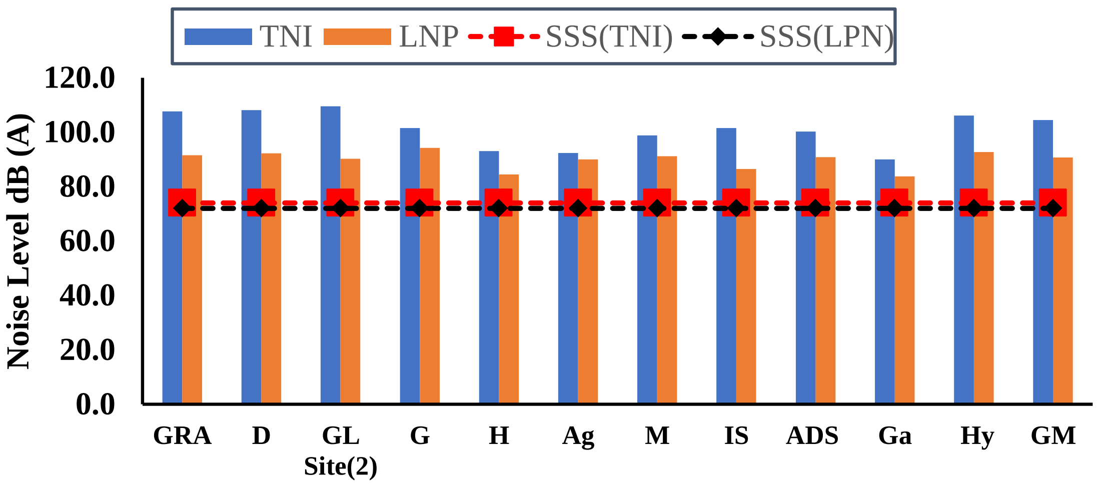


Figure 4.23:Diurnal logarithmic mean for Noise Percentiles for mixed Residentials with Commercials Areas.

The evaluated L_{10} in figure 4.23 ranges between the maximum value of 76.7 dB (A) at Muchia to the minimum value of 68.1 dB(A) at Hyda-Yaro and with the logarithmic mean value of 73.7 dB (A). The L_{50} ranged between the maximum value of 68.4dB (A) at Muchia to the minimum value of 63.8 dB (A) at Graceland site (2) with the grand logarithmic mean of 63.8 dB (A). The $L_{90,}$ range between the maximum value of 59.9 dB (A) at Muchia to the minimum value of 43.8 dB (A) at Graceland(B) with the logarithmic mean value was 55.4 dB (A) as in Figure 4.23.

4.6.3 Analysis of noise parameters at mixed residential with commercial and comparing with SSS standard

The logarithmic average for noise parameters TNI, LNP, and NC for mixed selected residentials areas were evaluated and compared with Scholes, Salvidge, and Sargent (SSS) standard as in figure: 4.24 and expressed in maximum values to minimum values respectively.



GRA= Government Reservation Area, D= Dogorawa Residential Area (RA), GL= Graceland (RA), G=Gwado (RA), H= Hanwa (RA), AG= Agwangodo (RA), M=Muchia (RA), IS= Ijaw Street (RA), ADS= Afegbu Daraka Street (RA), GA= Galadima (RA), HY= Hyindo-dogo (RA), SSSTN

Figure 4.24:Diurnal logarithmic mean for Noise Parameters for Selected Mixed Residential with Commercial Areas in Sabon-Gari LGA

Figure 4.25, the TNI, range between the 109.5 dB (A) maximum at Grace Land to 90.0 dB (A) minimum at Galadima with the logarithmic mean value was 104.4 dB (A) which exceeded the standard in Figure: 4.24. The $L_{NP,}$ ranges between the maximum value of 95.1 dB (A) at Gwado to the minimum value of 83.7 dB (A) at Galadima and with the logarithmic mean value of 90.7 dB (A), exceeded the compared standard as in Figure 4.24. The Noise Climate (NC) ranges between the maximum value of 23.5 dB (A) at Dogorawa to the minimum value of 17.8 dB (A) at Hanwa with the mean of 20.3 dB (A) in Figure: 4.24.

The analysis in Figure 4.22 to Figure 4.24 showed that the noise index and parameters exceeded in surveyed sites in the residential areas with mixed commercial activities with the compared standard, WHO, NESREA, and SSS standard. The exposed population might be predisposed to the various effect of noise pollution. These were affirmed by related findings by Elijah, (2020); Oyedepo and Saadu, (2010); ETC, 2018; Ugbebor and Yorkor, (2015); Ugwaha *et al*., (2016); Brain Bauer *et al*., 2012). In which they affirmed that noise levels in most mixed residential areas exceeded the recommended threshold and the exposed population could be predisposed to its consequences such as annoyance, sleep disturbance, aggressiveness, stress, tinnitus, hearing impairment, and depreciation of intuitiveness. Sources of noise and other human activities light traffic, commercial activities and domestic activities were responsible for the exceedance of the evaluated noise index and parameters.

4.6.4 Single-factor ANOVA for noise Index for mixed residential with commercial areas

As presented in Table 4.7 the null hypothesis was rejected as $P<0.05$. Therefore, there was a significant difference between noise pollution levels in twelve (12) selected residential areas with the WHO and the NESREA standard. The result of the variation was as different activities in the mixed residential and commercial areas in the selected study location in Sabon-Gari LGA of Kaduna State.

Table 4.6: Single-factor ANOVA for Mixed Residential Noise Indicators with WHO and NESREA Standard.

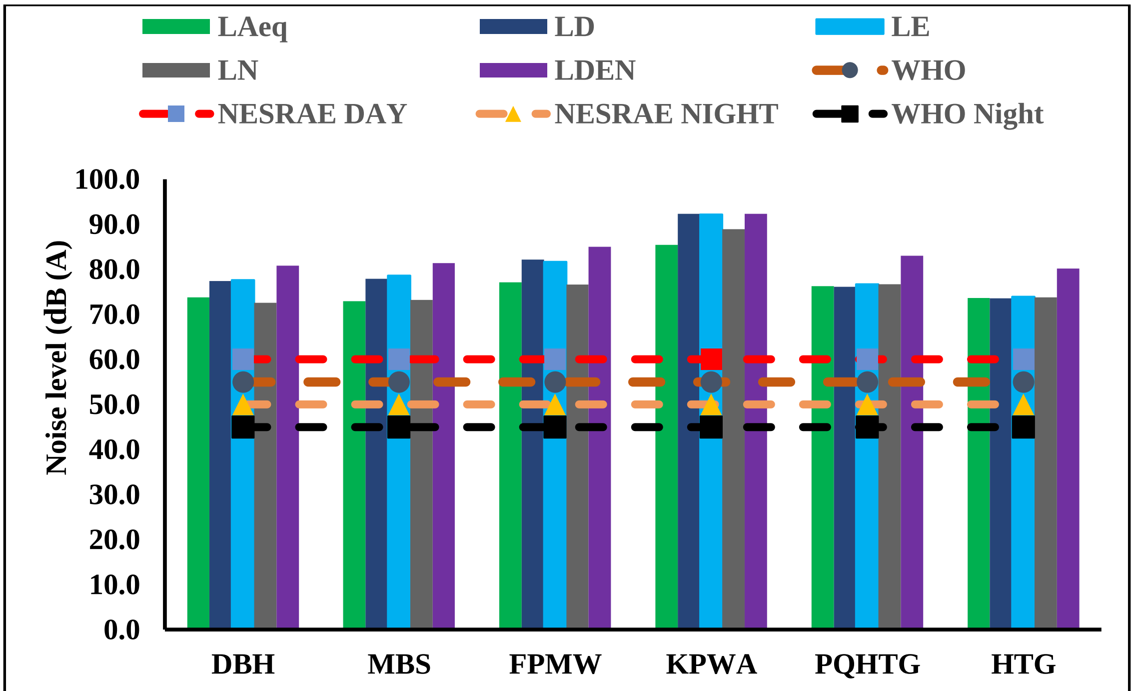
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	*Re*

Between Groups	2690.68	1	2690.67	504.93	1.16E-15	4.35	sf
Within Groups	106.58	20	5.33				
Total	2797.25	21					

SS= Sum of square, df= degrees of freedom, F= F-ratio, MS= mean square, p=probability, f= f critical, Re= Remarks, sf= Significant

4.6.5 Analysis of Diurnal noise index for mixed residential, commercial light industry, comparing with WHO, and NESREA Standard

The logarithmic average for L_{Aeq} was evaluated and computed for $L_{D,}$ $L_{E,}$ $L_{N,}$ and LDEN for all the selected locations. They were compared with WHO, NESREA standard as shown in the figure: 4.25 and were expressed from maximum level to minimize noise level.



DBH= Dasa Block Hyindogo, MBS= Munchi Block Samaru, FPMW= Farangida Paladan Metal Work, KPWA= Kips Pure Water Agwangodo, PQH= Pensionnaire Quarters Hyindogo, H= Hanwa Telecomication Mast. WHO day=55 dB (A), NESREA day=60 dB (A), NESREA

Figure 4.25: Diurnal logarithmic mean for Noise index for Mixed Residential Light Industry And Commercial.

Figure 4.25, the $L_{Aeq,}$ range between the maximum value of 85.5 dB (A) at Kips pure water in Agwangodo to the minimum value of 73 dB (A) at Muncha block and it exceeded the WHO and NESREA standard. The L_D, range between the maximum value of 92.3 dB (A) at kips pure water to the minimum value of 73.6 dB(A) at Hanwa (MTN mast) and exceeded the WHO and NESREA standard as present in Figure 4.25. The $L_{E,}$ range between the maximum value of 92.2 dB (A) at Kips pure water to the minimum value of 73.9 dB (A) at Hanwa (MTN mast) and it exceeded the compared WHO and NESREA standard in figure 4.25. The evaluated $L_{N,}$ range between the maximum value of 88.9 dB(A) at kips pure water to the minimum value of 72.6 dB(A) at Dasa block. It exceeded the WHO and NESREA standards as in Figure 4.25. The $L_{DEN,}$ range between the maximum value of 92.3 dB (A) at kips pure water to the minimum value of 80.2 dB (A) at Hanwa (MTN Mast) and it exceeded WHO and NESREA standard in Figure 4.25 respectively.

4.6.6 Analysis of noise percentiles for mixed residential, commercial and light industry

The logarithmic average of noise percentiles ($L_{10,}$ $L_{50,}$ and L_{90}), were evaluated at DBH, MB, FP, KPQ, PQH, and H were expressed in forms of location with maximum value to the minimum value in the figure: 4.26

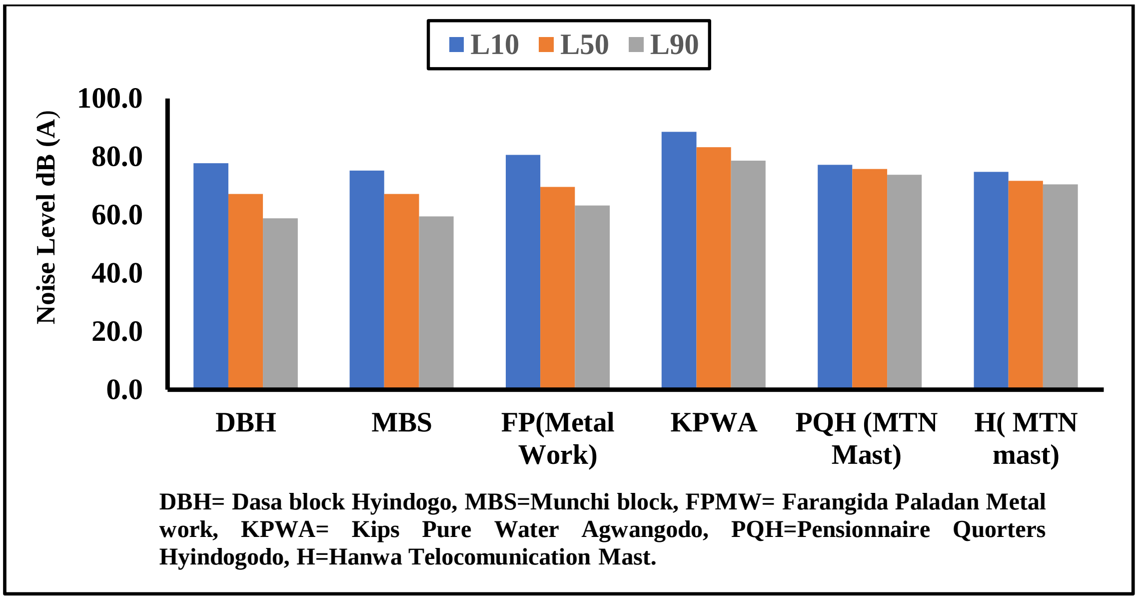


Figure 4.26: Diurnal Logarithmic mean for Noise Percentile for Mixed Residentials with Commercial and Light Industry for Sabon-Gari LGA

Figure 4.26, the L_{10}, ranges between the maximum value of 88.6 dB (A) at Kips pure water to the minimum value of 74.9 dB (A) at Hanwa (MTN mast). The L_{50} ranges between the maximum value of 83.3dB (A) at Kips Pure water to the minimum value of 67.3dB (A) at Muchia block Samaru. The L_{90} ranges from the maximum value of 78.7 dB (A) at Kips water to a minimum value of 58.9 dB (A) at Dasa block as in Figure 4.26.

4.6.6.1 *Analysis of Noise parameters for mixed residentials with, commercial, light industries and comparing with Scoles, Salvidge and Sargent (SSS) standard.*

The logarithmic average for noise parameters TNI, LNP, and NC for mixed selected residentials with light industries was evaluated and compared with (SSS) as in figure: 4.27 and was expressed in maximum to minimum values respectively.

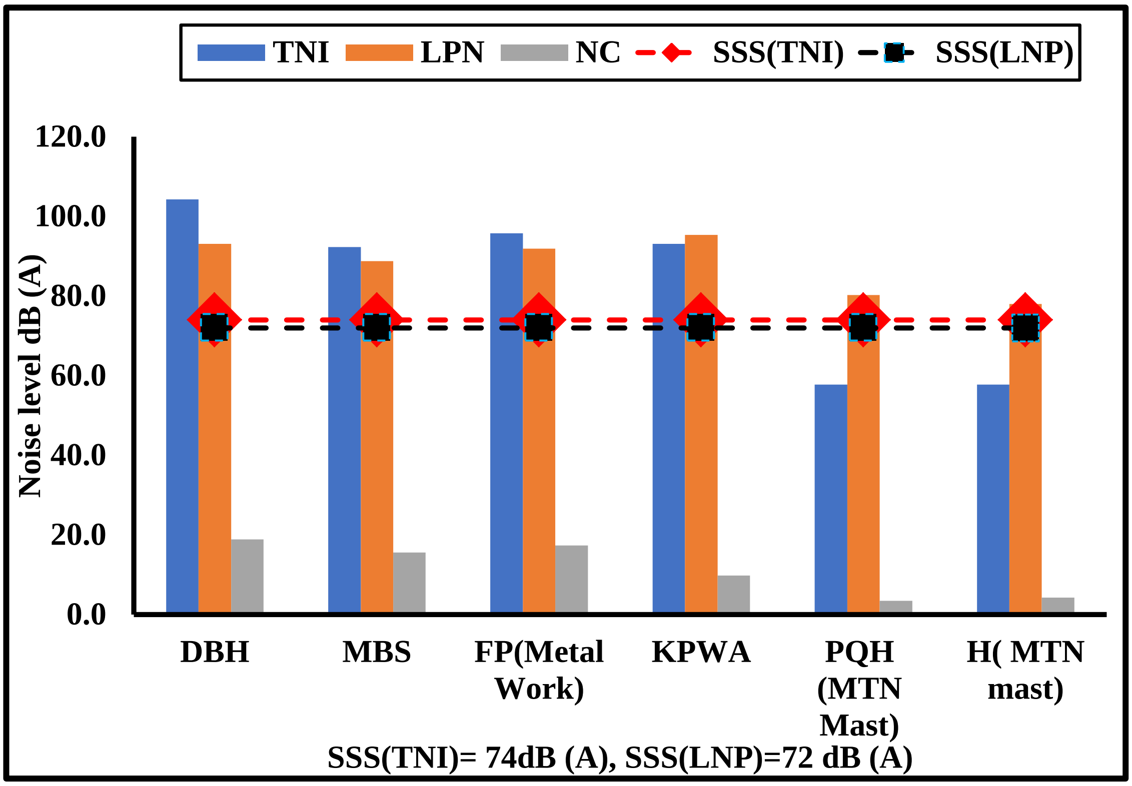


Figure 4.27: Diurnal Logarithmic Mean of Noise Parameters for Mixed Residential Area and Comparing with SSS

Figure 4.27, the L_{NP}, range between the maximum value of 95.4 dB (A) at kips pure water to 78.1 dB (A) minimum value at Hanwa (MTN mast) which exceeded the compared Scholes and Sargent standard (SSS). The TNI range from the maximum value of 104.3 dB (A) at Dasa Block to the minimum value of 87.8 dB (A) at Pensioners quarter /Hanwa MTN mast. These values exceeded SSS as present in Figure 4.27. The noise climate varied with the maximum value of 18 dB (A) at Dasa bock to the minimum value of 3.2 dB (A) at the pensioner quarter in Figure 4.27 respectively.

Figure 4.25 to Figure 4.27, the noise index and parameters exceeded the compared standard WHO, NESREA, and SSS in all the surveyed mixed residential with light industries. The exposed population could be subjected to the effect of noise pollution such as annoyance, distortions of information, and other associated effects of noise pollutions as affirmed by related studies by Elijah, Ugbebor, and Yorkor (2015), Ugwaha *et al* (2016) Hatamizadi *et al* 2018), they asserted that if the recommended standard is exceeded, the exposed population might fill the effect of noise pollution.

4.6.6.2 *Single-factor ANOVA for diurnal noise index for mixed residential with light Industry*

As presented in Table 4.7, $P<0.05$, therefore, there was a significant difference between diurnal noise index in the selected mixed residential area with commercial, light industries with WHO and NESREA standards. It was a result of the diurnal variation in the anthropogenic activities in the mixed residential and commercial areas in the selected study location in Sabon-Gari LGA.

Table 4.7: Single Factor ANOVA for Mixed Residential with Light Industry for Noise Indicators LDEN With WHO AND NESREA Standard

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***	***Re***
Between Groups	2222.5	2	1111.25	153.9	2.79E-09	3.89	sf
Within Groups	86.64	12	7.22				
Total	2309.14	14					

SS= Sum of square, df= degrees of freedom, F= F-ratio, MS= mean square, p=probability, f= f critical, Re= Remarks, sf= Significant

4.7 Diurnal Noise index, Percentiles, And Parameters of Sabon-Gari Sawmill

4.7.1 Analysis of diurnal noise level variations and comparing with WHO and NESREA Standard.

The logarithmic average for L_{Aeq} evaluated and computed for L_{D}, L_{E}, L_{N}, and LDEN/L_{DEN} for the Sawmill. They were compared with WHO, NESREA standard as in figure 4.28 and were expressed from maximum level to minimize noise level.

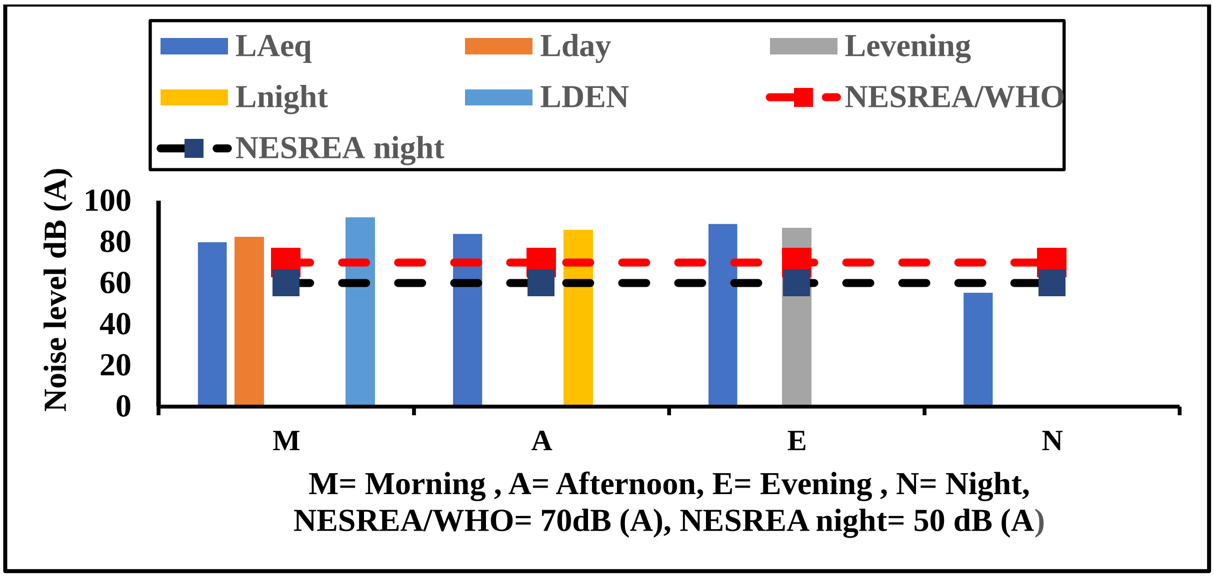


Figure 4.28: The Logarithmic Noise Index for Sabon-Gari Sawmill Compared with WHO and NESREA standard?

As in Figure 4.28, the logarithmic equivalent L_{Aeq}, range with the maximum value of 88.7 dB (A) in the evening to the minimum value of 55.3 dB (A) recorded at night time. It exceeded WHO and NESREA standards in the morning but within the specified standard for the night equivalent average. The L_D, the value of 82.4 dB (A), the L_E, value of 86.9 dB (A), the L_N value of 85.5 dB (A), the L_{DEN} dB (A) of 92 dB (A) exceeded the WHO and NESREA standard as in Table 4.28 respectively

4.6.2: Analysis of noise percentiles (L_{10}, L_{50}, and L_{90}) for Sawmill

The logarithmic average of noise percentiles ($L_{10,}$ $L_{50,}$ and L_{90}) were evaluated at Sawmill at morning, evening, afternoon, night and expressed in forms of locations with maximum value to the minimum value in the figure: 4.29

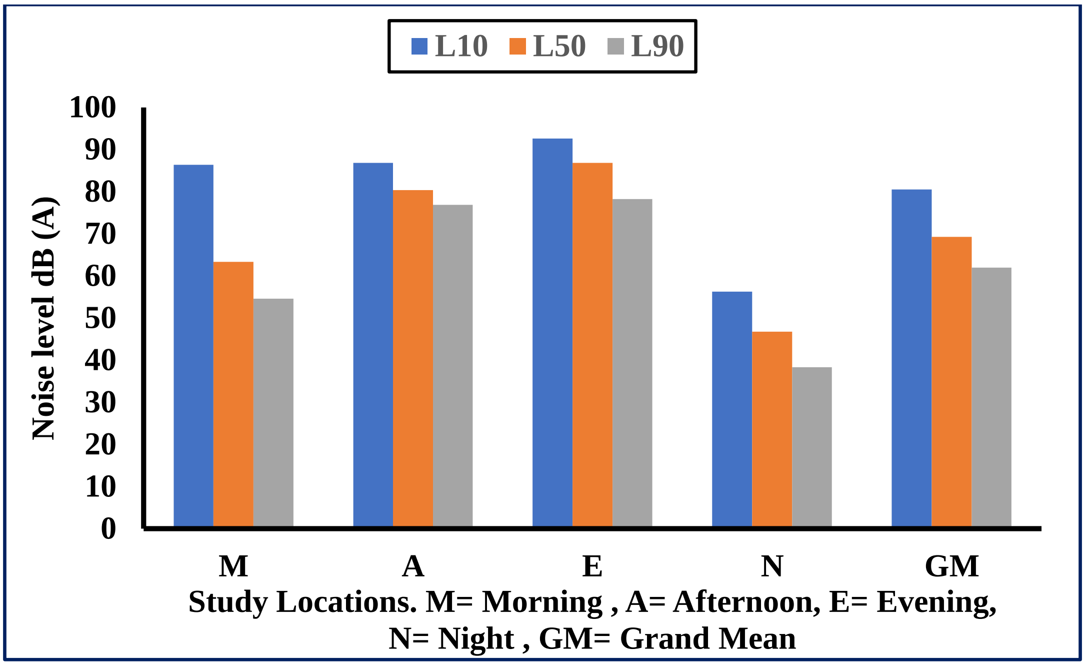


Figure 4.29: The Logarithmic mean for the Percentile of Noise Indicators (L_{10}, L_{50}, and L_{90}) For Sawmill

Figure: 4.50, the $L_{10,}$ ranges between the maximum value of 92.6 dB (A) in the evening to the minimum value of 56.3 dB (A) for the night sound level while the mean value was 80.5 dB (A). The L_{50} ranges from the maximum value of 86.8 dB (A) in the evening to the minimum value of 46.5 dB (A) for the night level while the mean value was 80.5 dB (A). $L_{90,}$ range between the maximum value of 78.2 dB (A) to the minimum value of 38.3 dB (A), evening and night respectively with the logarithmic mean value was 62 dB (A) in Figure: 4.29

4.7.2 Analysis, and comparing sawmill noise parameter with Scholes, Salvidge and Sargent (SSS) Standard

The logarithmic average for noise parameters TNI, LNP, and NC for Lemu market was evaluated for M, A, E, N was compared with (SSS) as in figure:4.30 and were expressed from the maximum value to minimum value.

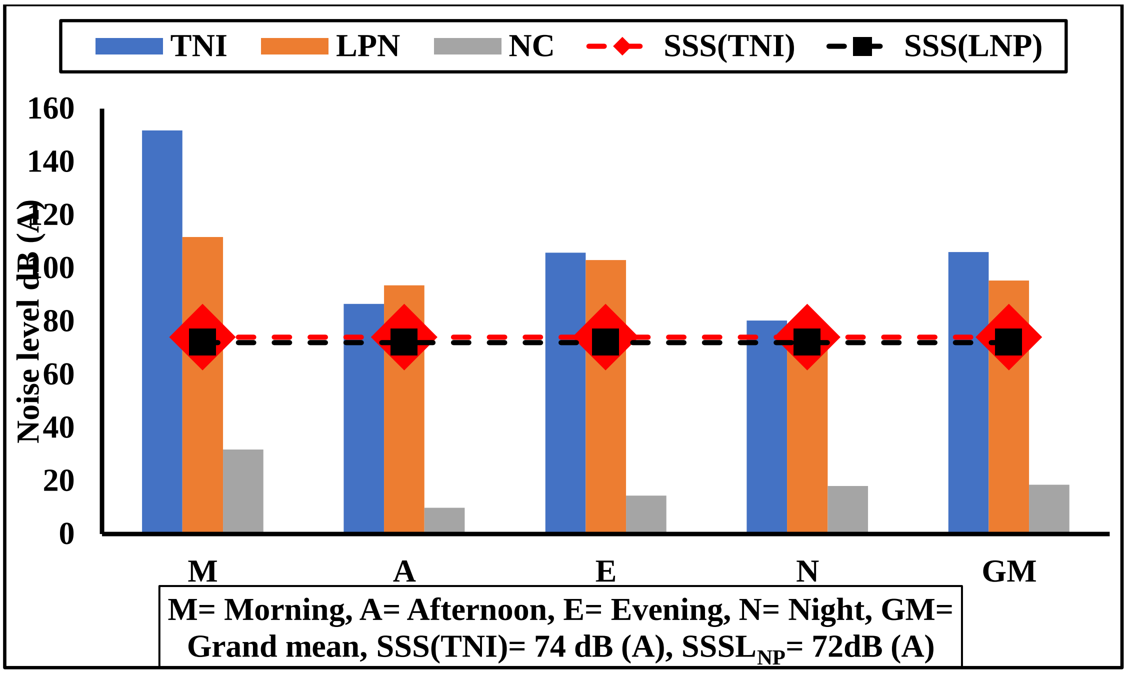


Figure 4.30: The Logarithmic mean for Noise Parameters of Sawmill Compared with SSS

The maximum TNI value of 151.5 dB (A) value for morning equivalent to minimum value of 80 dB (A) at night equivalent with the logarithmic mean value of 106.1 dB (A) exceeded the compared standard as present in Figure 4.30. The L_{NP} maximum value of 111.7 dB (A) at morning equivalent to minimum value of 73.3 dB (A) at equivalent night with the logarithmic mean value of 94.5 dB (A) exceeded the compared standard in Figure 4.30.

As accounted for in Figure 4.48 to Figure 4.51 the level of noise exceeded the compared standard and predisposed exposure could lead to diverse effects of noise pollution such as annoyance, headache, information distortion, Tinnitus, aggressiveness, cardiovascular diseases, and impaired cognitive performance in children and most important presbycusis with time. This is affirmed by a related study conducted by Ugbebor and Yorkor (2015), Ugwaha *et al*, (2016); Mackenzie and David, (2008); Hopkins, 2015). They asserted that if sound level exceeded the recommended threshold, it could result in noise effects noise pollution.

4.7.3 Single-factor ANOVA for noise level for Sabon-Gari Sawmill

In Table 4.8, the null hypothesis was rejected as (f (1,6) =36.26), p<0.05), therefore, there was a significant difference between various noise pollution level indicators between L_{day}, $L_{evening}$, and L_{night} in Sawmill with WHO and NESREA standards.

Table 4.8: Single Factor ANOVA for Noise Indicators for Sawmill with WHO and NESREA Standard.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	*Re*
Between Groups	741.125	1	741.13	36.27	0.00095	5.99	sf
Within Groups	122.61	6	20.44				
Total	863.735	7					

SS= Sum of square, df= degrees of freedom, F= F-ratio, MS= mean square, p=probability, f= f critical, Re= Remarks, sf= Significant

4.8 Single Factor ANOVA For L_D, L_E, L_N, L_{10}, L_{90} TNI and L_{NP} in All the Study Locations

4.8.1 Single Factor ANOVA between L_D and L_E for the 54 surveyed sites

In table 4.9, the null hypothesis was accepted, (F (1,106) =0.16, p>0.05). Therefore, there was no significant difference between L_D and L_E noise level indifference categorized surveyed sites which was due to the differences in the concentrations of the sources of noise.

Table 4.9: Single factor ANOVA between LD and LE

Source of Variation	SS	df	MS	F	P-value	F crit	Re
Between Groups	7.16	1	7.16	0.16	0.68	3.93	
Within Groups	4554.26	106	42.97				
Total	4561.4	107					Nsf

4.8.2 Single Factor ANOVA between L_D and L_N for the 54 Surveyed sites.

In Table 4.10, the null hypothesis was rejected, (F (2,107) = 0.16, (p<0.05). Therefore, there was a significant difference between L_D and L_N of the different surveyed sites which were necessitated by changes in different sources of noise.

Table 4.10: Single factor Between L_N and L_D ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit	Re
Between Groups	274.56	1	274.56	5.54	0.02	3.93	
Within Groups	5249.23	106	49.52				
Total	5523.8	107					sf

SS= Sum of square, df= degrees of freedom, F= F-ratio, MS= mean square, p=probability, f= f critical**,** Re= Remarks, sf= Significant

4.8.3 Single factor ANOVA between L_E and L_N for the 54 surveyed sites.

In Table 4.11 the null hypothesis was rejected, (F (1,107) = 4.17, (p<0.05). Therefore, there was a significant difference between L_E and L_N noise levels in the different surveyed sites which were necessitated by variations in different concentrations of sources of noise.

Table 4.11: Single Factor ANOVA For LE and LN

Source of Variation	SS	df	MS	F	P-value	F crit	Re
Between Groups	193.07	1	193.07	4.17	0.04	3.93	
Within Groups	4912.57	106	46.35				
Total	5105.64	107					sf

SS= Sum of square, df= degrees of freedom, F= F-ratio, MS= mean square, p=probability, f= f critical**,** Re= Remarks, sf= Significant

4.8.4 Single Factor ANOVA between L_D, $L_{E,}$ and L_N for the 54 Surveyed sites

In Table 4.12, the null hypothesis was rejected, (F (2,159) = 3.42, (p<0.05). Therefore, there was a significant difference between L_D, L_E, and L_N noise levels in the different surveyed sites which are necessitated by different sources of noise

Table 4.12: Single Factor ANOVA For LD, LE, and LN

Source of Variation	SS	df	MS	F	P-value	F crit	Re
Between Groups	316.52	2	158.26	3.42	0.04	3.05	
Within Groups	7358.03	159	46.28				
Total	7674.55	161					sf

SS= Sum of square, df= degrees of freedom, F= F-ratio, MS= mean square, p=probability, f= f critical**,** Re= Remarks, sf= Significant

4.8.5 Single Factor ANOVA between L_{10}, and L_{90} for the 54 surveyed sites.

In Table 4.13, the null hypothesis was rejected as (F (1,106) =113.91, ($p<0.05$). Therefore, there was a significant difference between the noise percentiles L_{10} and L_{90} from the different surveyed sites.

Table 4.13: Single Factor ANOVA Between L10 and L90

Source of Variation	SS	df	MS	F	P-value	F crit	Re
Between Groups	6230.96	1	6230.96	113.91	2.11E-18	3.93	
Within Groups	5688.82	106	54.7				
Total	11919.78	107					sf

SS= Sum of square, df= degrees of freedom, F= F-ratio, MS= mean square, p=probability, f= f critical**, Re= Remarks, sf= Significant**

4.8.6 Single factor ANOVA for TNI and L_{NP}/LNP in all the surveyed Sites.

In Table 4. 14, the null hypothesis was rejected, (F (1, 106) =6.83, ($p<0.05$). Therefore, there was a significant difference between the TNI and L_{NP} from the different classified surveyed sites. This finding is at variance from the study conducted by Oyedepo in Ilorin where there was no significant difference TNI and $L_{NP.}$

Table 4.14: Single Factor ANOVA Between Traffic Noise Index and Noise pollution Level

Source of Variation	SS	df	MS	F	P-value	F crit	Re
Between Groups	743.33	1	743.33	6.83	0.01	3.93	
Within Groups	11324.48	106	108.89				
Total	12067.8	107					sf

4.9 Spatial Noise Mapping Sabon- Gari LGA Using Inverse Distance Weighted (IDW)

Table 4.15: the latitude, Longitude from surveyed sites, and LDEN for spatial Noise Mapping

Site	Site Designation	Latitude in degree	Longitude in degree	LDEN dB (A)
Aminu 1	A1	11.107684	7.726494	92.9
Dogolayi	A2	11.108494	7.727371	87.2
Provision L	A3	11.108494	7.727371	86.1
Iya Line	A4	11.1609441	7.64816	87.2
Iya Line Day	A5	11.1609441	7.64816	81.9
Perishable L	A6	11.161063	7.657816	85
Saraki Line	A7	11.1609441	7.64816	74.6
Lemu M	A8	11.127587	7.71006	73.5
Techno PZ	A9	11.102836	7.720348	93.5
Umar F Park	A10	11.106799	7.721505	89.7
AL-Babelo	A11	11.106059	7.72464	83.8
Manchester L	A12	11.10288	7.719845	91.8
Chikaji road	A13	11.122869	7.717172	89.2
Park Road	A14	11.09988	7.72022	92.6
Aminu ROAD	A15	11.107684	7.726494	88.2
Randan Kano R	A16	11.127866	7.709383	89
Kings Road	A17	11.120262	7.72464	87.2
Lagos street	A18	11.10817	7.73042	89.1
Club Street	A19	11.110105	7.731919	85.1
Yoruba Street	A20	11.107414	7.7322308	86.1
Cemetery Street	A21	11.110105	7.731919	81.9
Graceland Road	A22	11.127709	7.694442	79.5
Leather R R	A23	11.15613	7.657349	83.2
Naibi Street	A24	11.160866	7.651023	81.7
Dogo -Iche Street	A25	11.160866	7.651023	87.1
Paladan Road	A26	11.139342	7.686292	86.9
Saraki Street	A27	11.157764	7.65341	84.1

Table 4.16: The longitude, latitude from surveyed sites, and LDEN for spatial Noise Mapping

Site	Site Designation	Latitude	Longitude	LDEN dB (A)
ABU MG 1	A28	11.154814°	7.658766	89.6

ABU MG 2	A29	11.155167^{o}	7.65714	88.4
Emantor	A30	11.135232	7.697965	89.3
Kwangilar 1	A31	11.129188	7.70409	98.3
Kwangilar 2	A32	11.12648	7.703528	97.1
Kwangilar 3	A33	11.128854	7.703495	96.2
MTD	A34	11.122757	7.71537	89.6
PZ Junction 1	A35	11.08882	7.719248	91.6
PZ Junction 2	A36	11.098987	7.7196099	90.2
Dasa Block	A37	11.15782	7.65744	80.4
Mucha Block	A38	11.165704	7.65066	81.4
Faringida	A39	11.1383025	7.693025	85
Kips P W	A40	11.106275	7.734789	92.3
Pensionnair Q	A41	11.162173	7.661575	83
Hanwa (MTN)	A42	11.125992	7.705429	80.2
GRA (Dorawa)	A43	11.106325	7.71639	74.4
Dogorawa	A44	11.136287	7.72442	78.9
Gracelad R	A45	11.129888	7.690425	73.1
Gwado	A46	11.103034	7.742605	77.4
Hanwa R	A47	11.123773	11.123773	73.1
Aguangodo	A48	11.100768	7.741123	79.5
Muchia Block	A49	11.120931	7.731124	83
Hayida Yaro	A50	11.159731	7.663009	73.2
Afegbu Darak S	A51	11.164636	7.63748	77.8
Galadima R	A52	11.164631	7.63748	78.3
Ijaw street	A53	11.114366	7.734735	79.6
Sawmill	A54	11.107264	7.724699	92

4.9.1 Spatial noise mapping Sabon- Gari LGA using Inverse Distance Weighted (IDW)

As accounts for in Table 4.15 to 4.16, the coordinates and logarithmic mean of L_D-L_E - L_N represented as L_{DEN} were used for the spatial map of the noise level of Sabon-Gari LGA of the classified categories in the fifty-four (54) surveyed sites as presented in Figure 4.21

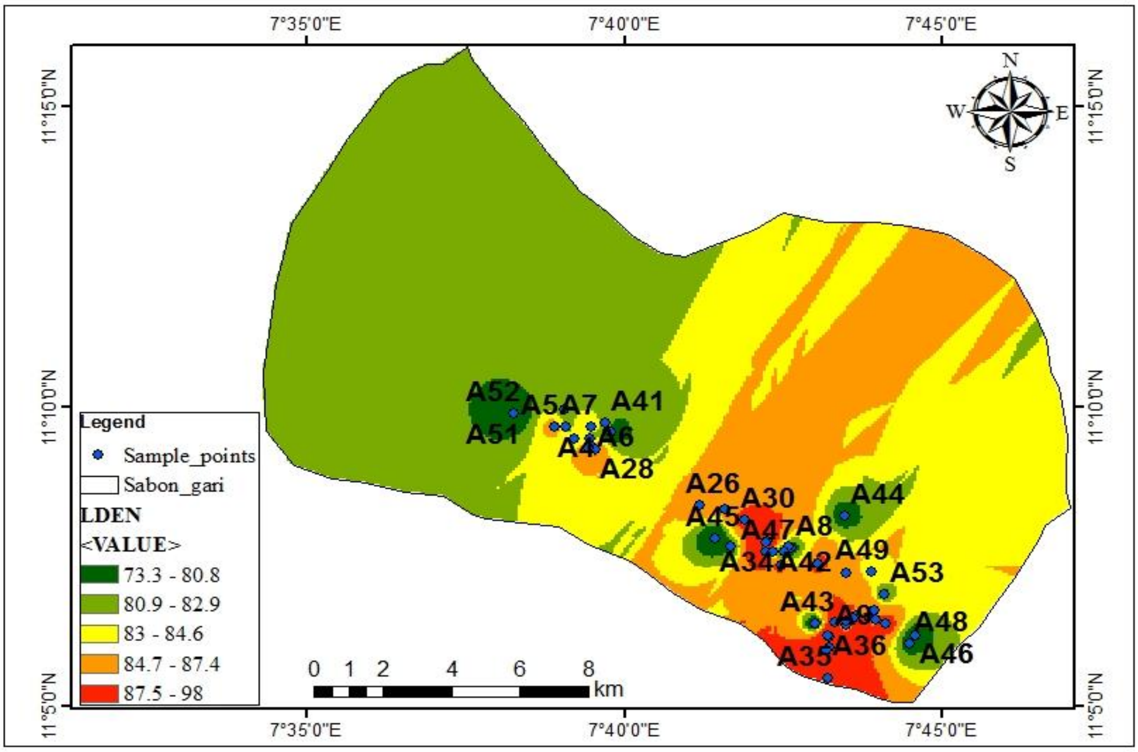


Figure 4.31: Spatial Environmental Noise Map of Sabon-Gari LGA Kaduna State

As accounts for in Figure 4.31, the red color-coding representing the noise level of 87.5 to 98.0 and orange color coding representing noise levels of 84.7 dB (A) to 87.5 dB (A) represent the sites with the most noise level which was as a result of the dense concentration of anthropogenic activities such as commercial activities, generators, discotheques and hawking by loudspeakers. While the light green colour coding of noise level ranging 80.9 dB (A) to 82.9 dB (A), dense green colour coding with a noise level ranging from 73.3 dB (A) to 80.8 dB (A) and yellow colour of 83 dB (A) - 84.6 dB (A) with different range of noise levels where surveyed sites with less concentration of anthropogenic activities as seen in Figure 4.31. The classification was in accordance to WHO, (1999); Directive 2002/49/EC; Cllark and Paunovic, (2018); Oyedepo *et al, 2019.*, Akin *et al*, 2014., Anomohanran *et al*, 2013; Majidi *et al*., 2016). The flashpoints were at kwangila, PZ commercial areas, Bank Junction PZ, MTD, Emanato, Palladan road, ABU main gate intersection, park road, Lagos Street, and king's road at the time of the study. The noise pollution level coding LDEN Showed that the environmental noise pollution exceeded the WHO and NESREA recommendations. It was clear that the noise pollution level of the Sabon-Gari was mostly above the giving threshold and the exposed population might be predisposed to the effects of noise pollution such as presbycusis, annoyance, headache, hearing impairment, tinnitus, and depreciation of metal capability as asserted by Okwiduli et al., 2021; WHO, 2011; Directive 2002/49/EC; The L_{DEN} noise map color code followed the recommendation by Directive 2002/49/EC

4.10 Analysis of Questionnaire on People's Perception of Environmental Noise

Table 4.17: The Estimated Population and Numbers of Questionnaires Administered in Sabon-Gari LGA

WARD	NPC. 2006	Estimated (NPC) 2019	Numbers of Questionnaire/ Ward
JUSHI	45120	68582	84
GABAS	14580	22162	27
CHIKAJI	22815	34679	43
Jama'A	23415	35591	44
Hanwa	24205	36792	45
Dogorawa	22335	33949	42
Muchia	25648	38985	48
Samaru	27550	41876	52
Total	205668	312616	385

4.10.1 Analysis of respondents on the social demography

Figure 4.32 to Figure 4.37 represented the pie charts of the statistical analysis of the social demography of the respondents on their perceptions and awareness of environmental noise pollution in Sabon-Gari LGA of Kaduna state.

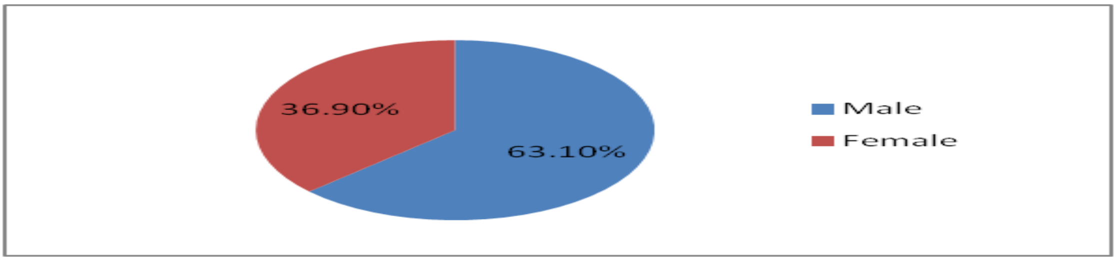


Figure 4.32: Gender Distribution

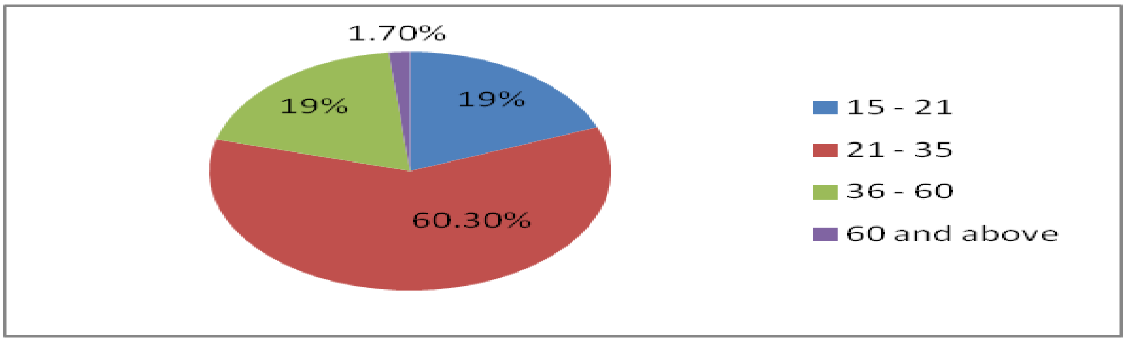


Figure 4.33: Age Distribution

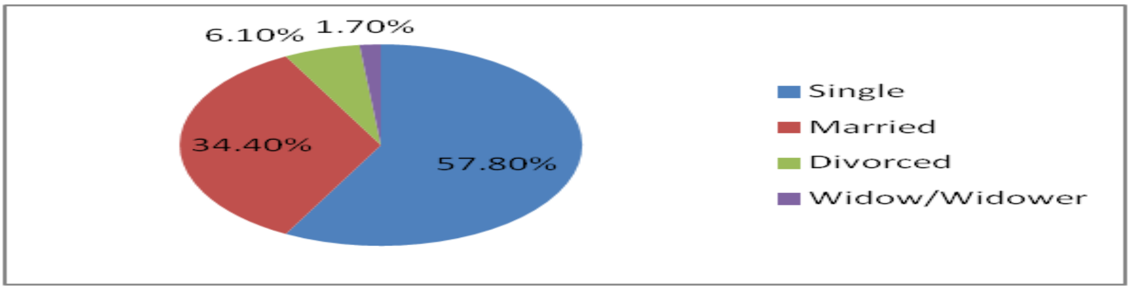


Figure 4.34: Marital Status Distribution

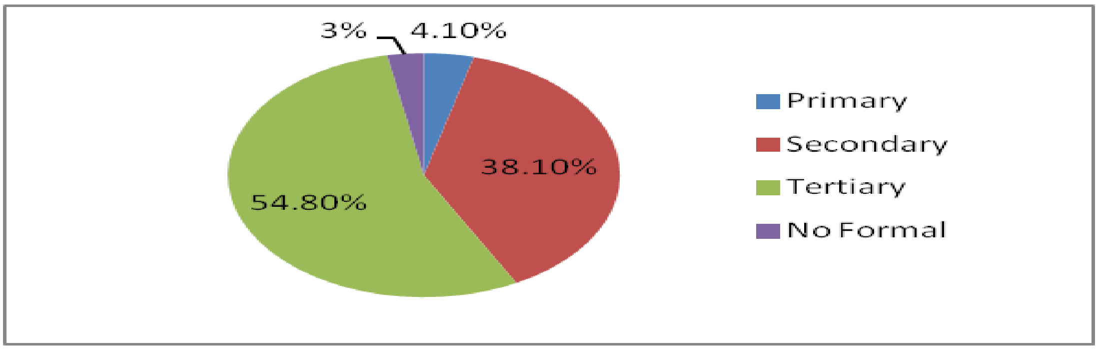


Figure 4.35: Educational Distribution

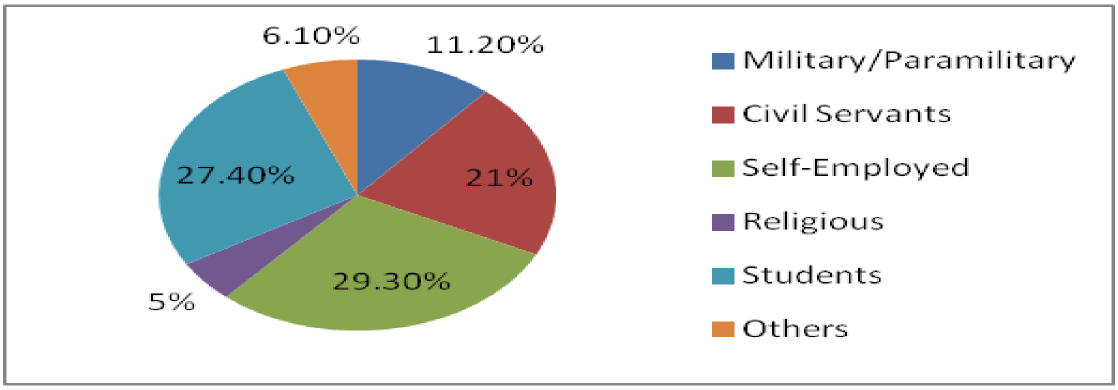


Figure 4.36: Occupational Distribution

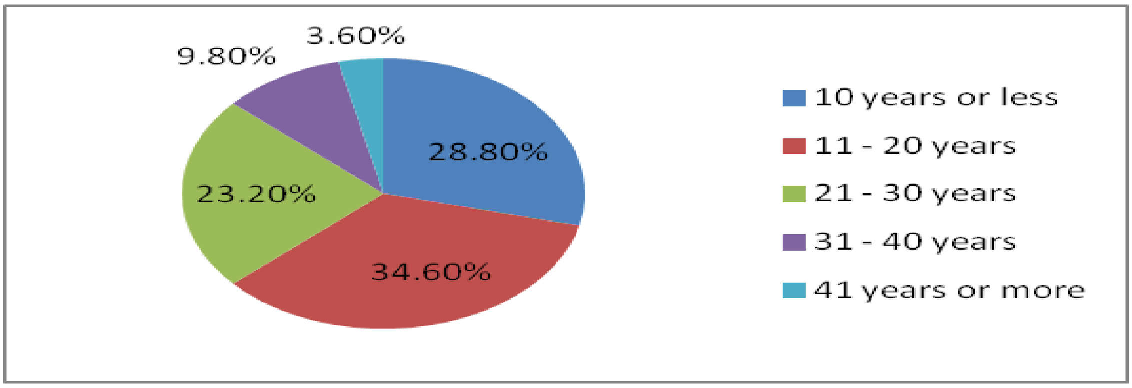


Figure 4.37: Residency Distribution

Figure 4.32 represented the gender variables of the respondents, 226 respondents representing 63.1 % were male and 132 respondents representing 36.9 % were female. Figure 4.33, represented the age distribution of the respondents, 15-18 years of age representing 19 % responded to the sampled population. About 21-35 years of age, of the respondents, representing 60.3 % responded out of the population sampled. While about 36-60 years of age of the respondents representing 19 % responded to the sampled population. About 60 years and above of the respondents representing 1.7 % responded to the population sampled.

Figure 4.34 represented the marital status of the respondents, two hundred and seven (207) representing 57.8 % were single, one twenty-three (123) representing 34.4 % were married, twenty-two (22) representing 6.1 % were divorced and six (6) represented 1.7 % were widow/ widower of the study population**.**

Figure 4.35, represented the academic qualification of the respondents. Fifteen (15) respondents, representing 4.2 % have primary education, one hundred and thirty-nine (139) respondents representing 36.9 % had secondary education, two hundred (200) respondents representing 55.9 % had tertiary education, and while eleven representing 2.1 % had formal education respectively. Figure 4.38, represented the occupational variables of the respondents, forty (40) respondents representing 11.2 % were Military/paramilitary respondents while about 75 respondents representing 20.9 % were civil servants, 105 respondents representing 29.3 % were self-employed, 5 % of the respondents were religious leaders, 98 respondents representing 27.4 % were students and 22 respondents representing 6.1 % were applicants of the studied sample respectively.

Figure 4.37 represented the year of residence of the respondents in the study location, One hundred and three (103) of the respondents representing 28.8 % of the population have been residing in the study location for the last ten (10) years, one hundred and twenty-four (124) of the respondents representing 34.6 % of the sample population have been residing since the last 20 years, eighty-three respondents representing 23.2 % of the sample population have been residing since the last 30 years. Thirty-Five (35) respondents representing 9.8 % of the study population have been living in the study area for the last 31-49 years, thirteen (13) respondents representing 3.6 % of the sample population have been living in the study location for the last 41 years above correspondingly.

4.10.2 Analysis on the awareness of the perception of the impacts of environmental noise in Sabon-Gari LGA

In Figure:4.38 about 326 of the respondents representing 91.1 % knew what was noise population and 32 of the sampled populations representing 8.9 % did not know what was noise population. Three hundred and twenty-one (321) of the respondents representing 89.7 % knew that unplanned urbanization and inadequate awareness were exacerbating noise pollution and 37 of the respondents representing 10.3 % differs. Three hundred and twenty-four (324) respondents representing 90.5 % agreed that noise pollution was increasing, while thirty-four (34) of the respondents representing 9.5 % disagreed that noise pollution was not increasing. Three hundred and seventeen (317) of the respondents representing 88.5 % of the respondents agreed that they were aware of the effects of noise pollutions, while forty-one (41) representing 11.5 % of the respondents were not aware of the effects of noise pollution. Three hundred and twenty-six (326) representing 91.1 % experience noise in their daily activities, while thirty-seven representing 8.9 % agreed that they did not experience noise in their daily activities

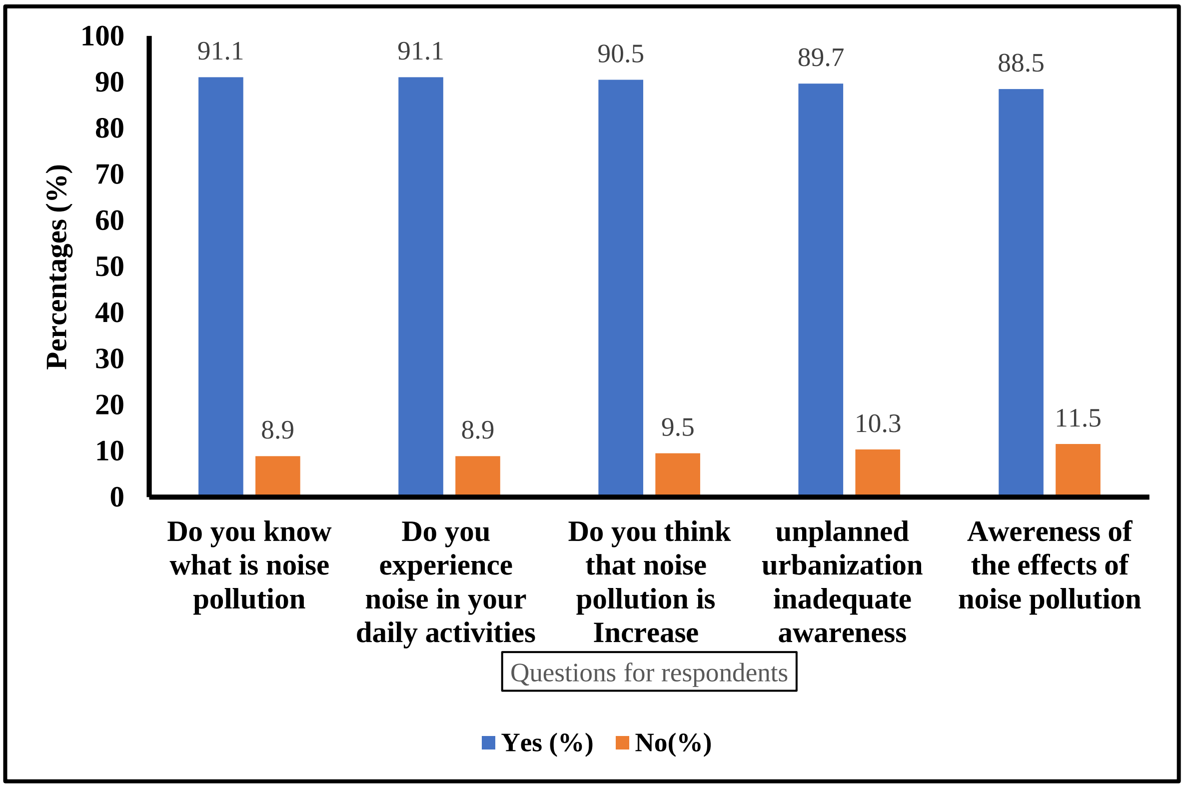


Figure 4.38: Responses on Awareness of Environmental Noise Pollution

4.10.3 Response on the sources and severity of noise pollution by respondents

As accounted for in Table 4.18 on the responses of the respondents on the various sources of noise and their severity. For the residential noise, 58 respondents representing 16.2 % asserted that household noise was highly severe, 65 respondents representing 18.2 % assert that it was severe, 151 respondents representing 42.2 % asserted that household noise was moderate, 40 respondents representing 11.2 % asserted that it was mild and 44 respondents representing 12.3 % asserted that it was very mild.

For the traffic sources of noise, 165 respondents representing 46.1 % asserted that traffic noise was highly severe, 97 respondents representing 27.1 % asserted that it was severe, 53 respondents representing 14.8 % asserted that it was moderate, 19 respondents represented 5.3 % of asserted that it was mild and while 24 respondents representing 6.7 % assert that it is very mild. For the Light industry, 121 respondents representing 33.9 % of the respondents asserted that it was highly severe, 80 respondents representing 22.3 % assert that was severe, 72 respondents representing 20.1 % of the asserted that it was moderate, 46 respondents representing 12.8 % asserted that it was mild and 36 respondents representing 10.9 % asserted that it was very mild.

For construction source of noise, 93 respondents representing 26 % asserted that it was highly severe, 64 respondents representing 19.9 % asserted that it was severe, 80 respondents representing 22.3 % asserted that it was moderate, 60 respondents representing 16.8 % assert that it was mild and while 61 respondents representing 17.0 % asserted that it was very mild. For the generator sources of noise, 154 respondents representing 43 % asserted that it was highly severe, 109 respondents representing 30.4% assert that it was severe, 49 respondents representing 13.7 % respondents, responded that it was moderate, 22 respondents representing 6.1 % asserted that it was mild, 24 respondents representing 6.7 % asserted that it was very mild. For the commercial sources of noise, 111 respondents representing 31.0 % assert that it was very severe, 107 respondents representing 29.9 % asserted that it was severe, 78 respondents representing 20.3 % asserted that it was moderate, 37 respondents representing 9.6 % asserted that was mild and while 25 respondents representing 6.5% assert it was highly severe correspondingly.

In general, as presented in Table 4.17, the mean standard deviation of 3.00 was less than the grand or cumulative mean of 3.601. Therefore, there was a high identification of the various sources of noise as traffic noise, generator, commercial, light industries, construction, and residential were identified as the major prevalent sources and their severity in descending order respectively within the study sample population.

The result of the one-way ANOVA in Table 4.19, the $p< 0.05$, therefore, there was a significant difference between the various sources of noise and their severity in the investigated population of Sabon-Gari LGA of Kaduna state. In a related study by Okwudili *et al.*, (2021), in Owere mwtropolis, Olorutoba *et al* (2012) in Ibadan metropolitan town, Anomohanran, (2016) in Agbo in Delta state Nigeria and Rajiv *et al* (2019) on Indian roads, in their findings traffic noise and other sources of noise were identified as the most predominant sources of noise pollution as affirmed by this study,

Table 4.18: Perception Analysis for Different Sources of Environmental Noise and Their Severity

Noise Source	HS	S	M	MI	VM	Total	Mean	STD	RA	RE
Residential	58 (16.2%)	65 (18.2%)	151 (42.2%)	40 (11.2%)	44 (12.3%)	358 (100.1%)	3.15	1.19	6	SF
Traffic	165 (46.1%)	97 (27.1%)	53 (14.8%)	19 (5.3%)	34 (6.7%)	368 (100.0%)	4.01	1.20	1	SF
Light Industry	121 (33.9%)	80 (22.3%)	72 (20.1%)	46 (12.8%)	39 (10.9%)	358 (100.0%)	3.55	1.36	4	SF
Construction	93 26.0%	64 (19.9%)	80 (22.3%)	60 (16.8%)	61 (17.0%)	358 (102.0%)	3.19	1.43	5	SF
Generator	154 (43.0%)	109 (30.4%)	49 (13.7%)	22 (6.1%)	24 (6.7%)	358 (99.0%)	3.97	1.19	2	SF
Commercial	111 (31.0%)	107 (29.9%)	78 (20.3%)	37 (9.6%)	25 (6.5%)	358 (97.3%)	3.68	1.21	3	SF
Grand Cumulative Mean							3.61			
Standard Decision Mean							3.00			

HS = Highly Severe (5), S = Severe (4), M =Moderate (3), MI = Mild (2), VM = Very mild (1), STD = Standard Deviation, RA = Rank, RE= Remarks,

Table 4.19: Single Factor ANOVA on Noise sources and their severity

Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	28148.20	4	7037.05	9.39	8.93E-05	2.76
Within Groups	18739.67	25	749.59			
Total	46887.87	29				

SS = Sum of square, df = degree of freedom, MS = mean of square, F = F ratio

4.10.4 Respondents' responses on the awareness of effects of noise pollution.

Table:4.20 accounted for the outcome of the statistical analysis of the respondents on the awareness of the various effects of environmental noise. On stress effects resulting from noise exposure about 150, 140 respondents representing 41.9 %, 39.1 % agreed and strongly agreed that they were aware that noise pollution led to stress, while, 32, 26, 10 respondents representing 8.9 %, 7.3 %, 2.8 % were undecided, disagreed and strongly disagreed of noise stress effect. On the awareness of annoyance due to the effects of noise,171,130, representing 47.7 %, 36.3 % of the respondents strongly agreed and agree, while 32, 16, and 10 represented 8.9 %, 4.5 %, 2.5 % of the respondents were undecided, disagreed and strongly disagreed.

On the responses of the awareness of the respondents on the effects of noise on hearing impairment, 140, 160 representing 39.1 % and 45 % agreed and strongly agreed, while 28, 12, 17 representing 7.8 %, 3.4 %, 4.7 % were undecided, disagreed and strongly disagreed. On the risk of accidents on the effects of noise, 131, 126 representing 36.6 %, 35.2 % respondents agreed and strongly agreed, while 23,62, 16 representing 6.4 %, 17.3 %, 4.5 % of the respondents were undecided, disagreed, and strongly disagreed. On the impairment of efficiency and productivity,153 and 95 representing 42.7 % and 26.5 % respondents agreed and strongly disagreed. While 53, 28, and 27 represented 14.8 %, 7.8 %, and 7.5 % of the respondents were undecided, disagreed, and strongly disagreed. For the effects of noise on the facilitation of mental illness, 141 and 97 represented 39.4% and 27.1 % of respondents agreed and strongly agreed. While 67, 28 and representing 25 %, 18.7 %, 7.8 %, and 7 % respondents were undecided, disagreed, and strongly disagreed. On the effects of noise on distraction, aggressiveness, and restlessness, 133 and 152 represented 37.2 % and 42.5 % of respondents and strongly agreed. While 31, 23, and 19 represented 8.7 %, 6.4 %, and 5.3 % of respondents were undecided, disagreed, and strongly disagreed. Using the Likert scale, the cumulative mean was greater than the decision mean, therefore there was a significant awareness of various effects of environmental noise as hearing impairment, Annoyance, stress, distraction, aggressiveness, information distortion, impaired efficiency, and mental depreciation were ranked in descending order.

Table 4.21, represented the single factor ANOVA on the awareness on the various effects of noise by the respondents, as the $p < 0.05$, therefore, there was a significant identification of the awareness on the various effects of noise pollution in the sampled populations of Sabon-gari LGA of Kaduna state. Some of the findings by Oyedepo and Saadu 2010) in a conducted in Ilorin metropolises asserted to the findings in this study.

Table 4.20: Awareness of Effects of Environmental Noise Pollution in Sabon-Gari- LGA

Effects of Noise Pollution	SA	A	UN	D	SD	Total	Mean	STD	RA	RE
Stress	140 (39.1%	150 (41.9%	32 (8.9%)	26 (7.3%	10 (2.8%	358 (100.0%	4.070	1.01	3	SF
Annoyance	171 (47.3%	130 (36.3%	32 (8.9%)	16 (4.5%	9 (2.5%	358 (99.5%)	4.220	0.96	2	SF
Hearing Impairment	161 (45.0%	140 (39.1%	28 (7.8%)	12 (3.4%	17 (4.7%	358 (100.0%	4.240	1.84	1	SF
Risk of accident	126 (35.2%	131 (36.6%	62 (17.3%	23 (6.4%	16 (4.5%	358 (100.0%	3.916	1.08	6	SF
Information Distortion	122 (34.1%	164 (45.8%	39 (10.9%	14 (3.9%	19 (5.3%	358 (100.0%	3.994	1.04	5	SF
Impaired Efficiency and Productivity	95 (26.5%	153 (42.7%	55 (15.3%	28 (7.8%	27 (7.5%	358 (99.8%)	3.729	1.15	8	SF
Facilitate Mental Illness	97 (27.1%	141 (39.4%	67 (18.7%	28 (7.8%	25 (6.9%	358 (99.9%)	3.858	2.94	7	SF
Distraction, Aggressiveness and Restlessness	152 (42.5%	133 (37.2%	31 (8.6%)	23 (6.4%	19 (5.3%	358 (100.0%)	4.050	1.12	4	SF
Grand Cumulative Mean							4.011			
Standard Decision Mean							3.000			

SA = Strongly Agree (5), A= Agree (4), UN = Undecided (3), D = Disagree (2), SD = Strongly Disagree (1), STD = Standard Deviation, RA = Rank, RE= Remarks,

Table 4.21: Single Factor ANOVA for the Effects of Noise Pollution by the Respondents

Source of Variation	SS	df	MS	F	P-value	F critical	Remarks
Between Groups	91569.38	3	30523.13	99.88	4.61E-15	2.95	SF
Within Groups	8556.5	28	305.5893				
Total	100125.9	31					

SS= Sum of square, df= degrees of freedom, F= Factor-ratio, MS= mean square, p=probability, f= factor critical, Sf= Significance.

4.10.5 Reactions to noise pollution by the respondents during exposure

Table 4.22 presented the percentage and the Likert scale evaluation of personal reactions to noise exposure by the respondents. On responses to annoyance, about 152 of the respondents representing 42.5 % responded to highly annoyance, 125 respondents representing 34.9 %, asserted to severe annoyance, 52 respondents representing 15.5 %, asserted to moderate annoyance, 14 respondents representing 3.9% asserted mild annoyance, 15 respondents representing 4.2 % asserted to very mild annoyance during exposure respectively. About one hundred and thirty-two (132), 130, 60 and 22 respondents representing 36.9 %, 36.3 %, 16.8 %, 6.1 %, and 3.9% asserted that aggressiveness and distraction during noise exposure were severe, moderate, mild, and very mild during exposure. About one hundred and eighty-four (184), 96, 48, 17 and 13 respondents representing 51.5 %, 26.8 %, 16.8 %, 4.7%, and 3.6% asserted that sleep disturbance during noise exposure was highly severe, severe, moderate, mild, and very mild during exposure respectively.

About one-hundred and seven (117),118, 69,32, and 22 respondents representing 32.7 %, 33 %, 19.3 %, 8.9 %, and 6. 1% asserted that information distortion, was highly severe, severe, moderate, mild, and very mild during noise exposure. One- hundred and six (106), 109, 79, 48, and 44 of the respondents representing 29.6 %, 33.4 %, 22.1 %, 13.4 %, and 12.3 % of the respondents asserted that hearing impairment was highly severe, severe, moderate, mild and very mild during noise exposure. About 96, 109, 61, 48, and 44 of the respondents representing 26.8 %, 30.4 %, 17 %, 13 %, and 12.3 % asserted that ringing in the ear (tinnitus) was highly severe, severe, moderate, mild, and very mild during exposure to noise pollution. About 135, 112, 61, 33, and 17 of the respondents representing 37.7 %, 31.3 %, 17 %, 9.2 %, and 4.7 % of the population sampled asserted that headache during exposure was highly severe, severe, moderate, mild, and very mild respectively.

About 104, 115, 67, 39, and 33 of the respondents representing 29.1 %, 32.1 %, 18.7 %, 10.9 %, and 9.2 % of the population sample asserted that stress during exposure was highly severe, severe, moderate, mild, and very mild during exposure as represented in table 4.26. The computed decision mean was less than the grand/cumulative which was obvious that the respondents experienced the effects of noise during exposure. While Sleep disturbance, annoyance, aggressiveness, headache, stress, and hearing impairment were ranked in severity in descending order during exposure by the respondents Using the Likert Scale.

Table 4.23 accounted for the single factor ANOVA of the personal effects during exposure, showed that $p< 0.05$, there was a significant difference in the various effects of noise pollution during exposure by the respondents in the studied population of Sabon-Gari LGA of Kaduna state. The outcome of these findings reaffirmed to a related study conducted by Oyedepo (2010) in Ilorin, Olorutoba *et al* (2012) in Ibadan metropolitan town, and Oyenike (2016), in the Ille-Efe Southwestern state of Nigeria, were their various responses by the respondents on the effects of perception of noise pollution exposure.

Table 4.22: Perception of Effects of Personal Response and Reactions During Noise Exposure

Personal Reactions	HS	S	M	MI	VM	Total	Mean	STD	RA	**RE**
Annoyance	152 (42.5%)	125 (35.0%)	52 (14.5%)	14 (3.9%)	15 (4.2%)	358 (100.1%)	4.08	1.05	2	SF
Aggressiveness	132 (36.9%)	130 (36.3%)	60 (16.8%)	22 (6.1%)	14 (3.9%)	358 (100.0%)	4.07	2.42	3	SF
Sleep Disturbance	184 (51.4%)	96 (26.8%)	48 (13.5%)	17 (7.5%)	13 (3.6%)	358 (102.8%)	4.18	1.06	1	SF
Distortion of Information	117 (32.7%)	118 (33.0%)	69 (19.3%)	32 (8.9%)	22 (6.1%)	358 (100.0%)	3.77	1.18	6	SF
Hearing Impairment	106 (29.6%)	119 (33.2%)	79 (22.1%)	27 (7.5%)	27 (7.5%)	358 (99.9%)	3.70	1.19	7	SF
Ringing in the Ears	96 (26.8%)	109 (30.4%)	61 (17.0%)	48 (13.4%)	44 (12.3%)	358 (99.9%)	3.46	1.24	8	SF
Headache	135 (37.7%)	112 (31.3%)	61 (17.0%)	33 (9.2%)	17 (4.7%)	358 (99.9%)	3.88	1.16	4	SF
Stress	104 (29.1%)	115 (32.1%)	67 (19.0%)	39 (11.0%)	33 (9.2%)	358 (100.4%)	3.61	1.26	5	SF
Grand Cumulative Mean							3.84			
Standard Decision Mean							3.00			

HS = Highly Severe (5), S = Severe (4), M =Moderate (3), MI = Mild (2), VM = Very mild (1), STD = Standard Deviation, RA = Rank, RE= Remarks,

Table 4.23: Single Factor ANOVA During Exposure by The Respondents.

Source of Variation	**SS**	df	MS	F	P-value	F critical	Remark
Between Groups	58434.53	4	14608.63	44.86	4.68E-11	2.76	Sf
Within Groups	8140.667	25	325.6267				
Total	66575.2	29					

SS= Sum of square, df= degrees of freedom, F= Factor-ratio, MS= mean square, p=probability, f= factor critical, SF= Significance.

4.10.6 Analysis of respondents on the knowledge perception of personal and government responsibility on environmental noise pollution.

As presents in figure 4.39, about two hundred and twenty-one (221) of respondents representing 61.7% people of the sample population the respondents complained about environmental noise pollution, while 137 representing 38.3 % of the respondents do not complain during noise exposure. On the third-party complaints, 260 of the respondents representing 72.6 %, did receive complaints from the third party on noise pollution, while 98 of the respondents represented 27.4 % do not. On the assessments of the government agency responsible for the regulation of environmental noise pollution, 44 representing 12.3 % of the respondents are aware, while 314 representing 87.7 % of the respondents did not know any government agency that was responsible for monitoring noise pollution.

On personal mitigation of environmental noise pollution by the respondents as in Figure 4.39, about 99 representing 27.7 % of the respondents asserted, while 259 representing 87.7 % were unconcerned about taking any mitigating measures. About 54 representing 15.1 % of the respondents asserted that the government had done enough in the mitigation of environmental noise pollution, 304 representing 84.9% affirmed that the government had not done enough in proffering mitigating measures to noise pollution. On taking more proactive and strategic action in mitigating noise pollution by government, about 329 representing 91.9 % of the respondent asserted to it, while 29 representing 8.1 % of the respondents disagreed. The study conducted by Olorutoba *et al.*, (2012) on the perceived health of Urban noise pollution in Ibadan metropolitan city reaffirmed the responses of the respondents in this study.

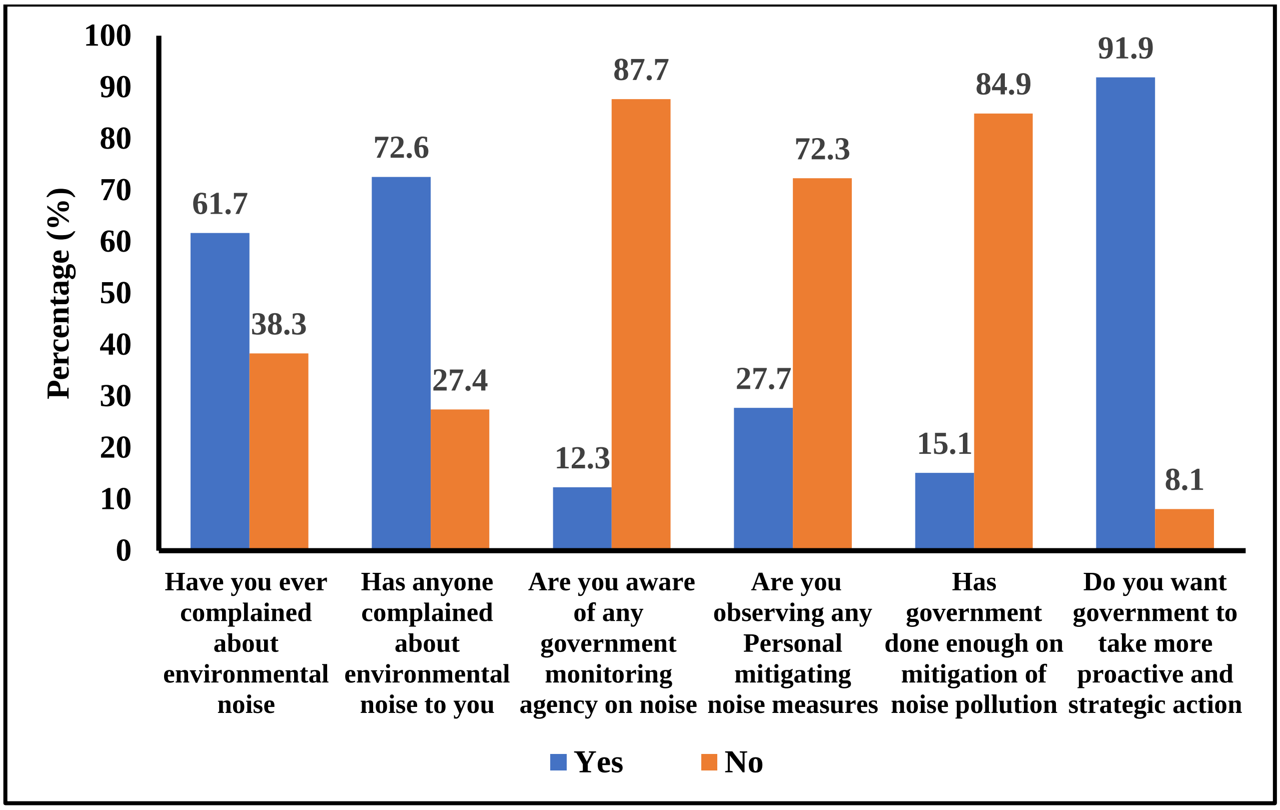


Figure 4.39: The Responses of Personal Awareness and Government Responsibility by the Respondents

4.10.7 : Analysis of respondents on actions taken during exposures to environmental noise.

Figure 4.40 represented the outcome of personal action taken during environmental noise pollution by the respondents. About 146 respondents representing 40.8 % asserted that they endured noise. About 35 respondents representing 9.8 % asserted that they reported to the police. About 74 respondents representing 20.7 % of the sample population asserted that they confronted the sources to turn down the noise. About 103 respondents representing 28.8 % asserted that they left the place of the sources of noise.

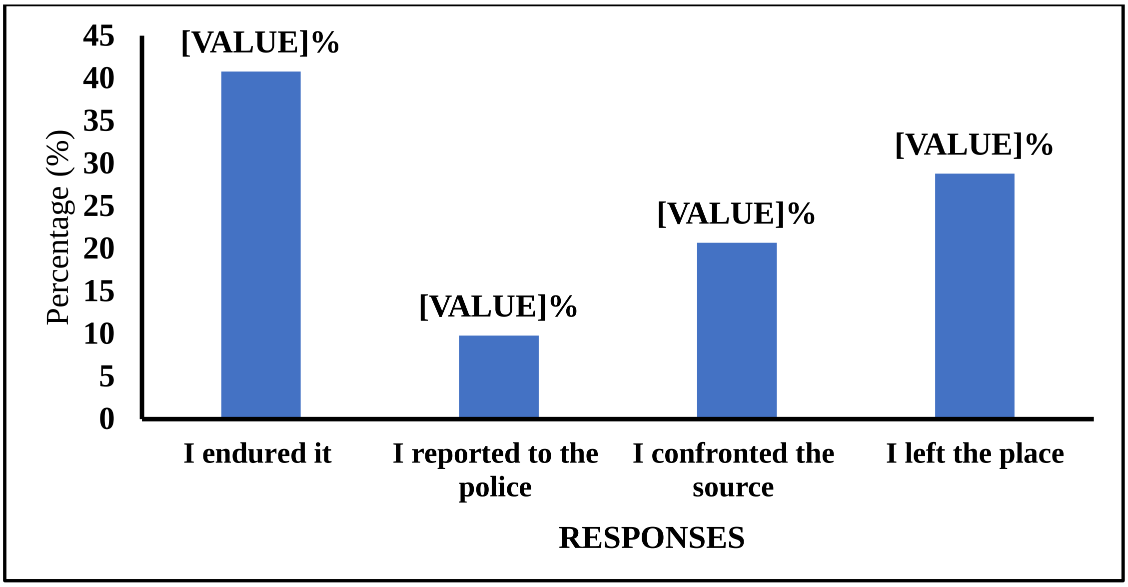


Figure 4.40: Responses of the Respondents on Actions Taking During Noise Exposure

4.10.8 : Analysis of respondents on knowledge on awareness of environmental noise monitoring agency

As presented in Figure 4.41: about 12, 15, 7 respondents representing 3.6 %, 4.2 %, and 2 % identify NESREA, KEPA, and others respectively as agencies responsible for monitoring noise in Kaduna State and Nigeria. While about 323 representing 90.2 % of the respondents were ignorant of the environmental agency responsible for monitoring noise pollution in the surveyed sites.

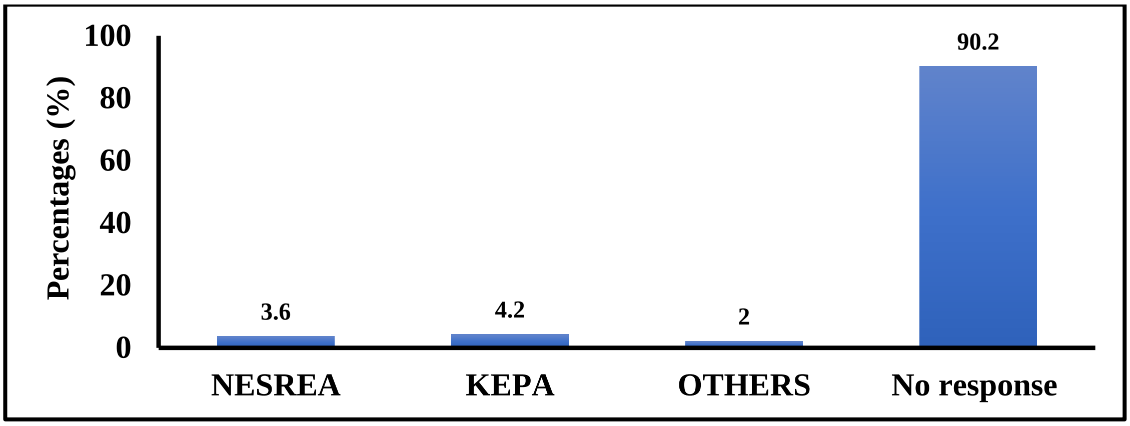


Figure 4.41: Respondents Responses on the Various Environmental Monitoring Agency

CHAPTER FIVE
5.0 CONCLUSION AND RECOMMENDATION

This chapter presents conclusions of the study on the investigation of environmental noise pollution in fifty-four (54) surveyed sites in Sabon-Gari Local Government Area of Kaduna State.

5.1 CONCLUSION

1. The major sources of noise observed during reconnaissance surveys and measurements were generators, the hooting of vehicles, tricycles, sirens, motorcycles, hawking, discotheques, domestic noise, and light industries in the neighborhood. This was also confirmed from the subjective assessment from the responses of the respondents.
2. The L_{DEN} for major daily markets range from 89.8 dB(A) to 73.7 dB(A). For busy commercial areas, the L_{DEN} ranges from 93.5 dB(A) to 80.7 dB(A), for major selected road junctions, the $L_{DEN,}$ range from 97.2 dB(A) to 88.0 dB(A). For selected roads/streets, the L_{DEN} range from 92.6 dB(A) to 79.5 dB(A). For mixed residential areas with commercial activities, the L_{DEN} ranges from 83.0 dB(A) to 73.1 dB(A). For mixed residential areas with light industrial activities the L_{DEN} range from 92.3 dB(A) to 80.8 dB(A). The L_{DEN} exceeded the WHO standard in all the surveyed sites while about 96.3% of the surveyed sites exceeded the NESREA standard as presented in appendix II and III.
3. For selected market the L_{10} range from 83.9 dB(A) to 72.3 dB(A), for busy commercial areas it ranges from 90.2 dB(A) to 73 dB(A). For selected roads intersection the L_{10} from 95.5dB(A) to 85.7 dB(A). For selected roads/streets the L_{10}, it ranges from 88.5dB(A) to 74.4dB (A). For mixed residential areas with commercial activities, it ranges from 75.1 dB(A) to 68.1dB(A). For mixed

residential areas with light industrial activities, the L_{10}, ranges from 86.6dB(A) to 75.2 dB(A).

4. For the $L_{90,}$ for the surveyed market, it ranges from 70.3 dB(A). to56.5 dB(A) for busy commercial areas L_{90} ranges from 79.5 dB(A) to 58.3 dB(A). For road intersections, the $L_{90,}$ range from 82.3 dB(A) to 71.3 dB(A). For selected roads/streets the L_{90}, range from 72 dB(A) to 56.7 dB (A). For selected Mixed residential areas with commercial activities, it ranges from 59.9 dB(A) to 43.3dB(A). For mixed residential areas with light commercial activities the L_{90}, range from 78.7 dB(A) to 58.9dB(A).
5. For Traffic Noise index for the selected market ranges from 114 dB(A) to 87.2 dB(A). For busy commercial areas, it ranges from 106.9 dB(A) to 87.3 dB(A). For selected road intersections it ranges from 116.4dB(A) to 101.5dB(A). For selected roads/streets it ranges from 122.1 dB(A) to 92.1dB(A). For mixed residential with commercial activities, it ranges from 109.5 dB(A) to 90 dB(A). For mixed residential with light industrial activities, it ranges from 104.3 dB(A) to 57.8 dB(A). It exceeded the TNI standard as presented in appendix I in the 98.1% of the surveyed sites.
6. The Noise pollution level (L_{NP}) for surveyed market range from 95 dB(A) to 87.1 dB(A). For busy commercial areas, it ranges from 100.7 dB(A) to 85.5 dB(A). For the surveyed intersections, it ranges from 108.1dB(A) to 96.5 dB(A). For the selected roads/streets it ranges from 123.0 dB(A) to 89.2dB(A). For mixed residential areas with mixed commercial activities, it ranges from 94.1B(A) to f 83.7 dB(A). For mixed residential areas with light industrial activities from 95.4 dB(A) to 80.3 dB(A) at pensioner's quarter. L_{NP} in all the

categorized study sites exceeded the compared standard as presented in appendix I.

7. There was a statistical significance difference between L_D and L_N, L_E and L_N, L_D, L_E and L_N in all the categories groups, of the diurnal noise index, as P<0.05 exception of Lemu market L_D and L_N., where the P>0.05. There was a significant difference between L_{10} and L_{90} in all the surveyed sites as the P< 0.05. There were significant differences between TNI and L_{NP} as P<0.05 at the confidence level of 95% respectively.
8. For the spatial map, the red, yellow, and orange color codding were survey sites with high noise levels ranging from 98.0 dB(A) to 83.0 dB(A) such survey sites were at Kwngila intersections, PZ junctions, Park Road, Muchia road and some commercial areas, Kings roads, and Lagos streets. The green color codding were survey sites ranging from 82.9 dB(A) to73.3 dB(A) such sites were commercial areas, GRA, Muchia residential areas, Daraka residential area, Agwangodo, Gwado, Hanwa, and Graceland respectively.
9. The Average mean of 323 respondents representing 90.2% agreed that they had relevant awareness regarding what is noise pollution, while 36 respondents representing 9.8% were of the contrary views. On the sources of noises and their severity showed that there was a significant identification of the various sources of noise and their severity. As traffic, generator, commercial and noise from light industries, were ranked the highest in descending order based on the percentage cumulative mean by the respondents using the Likert scale. Annoyance, stress, distraction, aggressiveness, restlessness, and information distortions were ranked the highest in descending. About 91.1% of the

respondents want governments to take more proactive and strategic decisions in mitigating noise pollution while 8.1% disagreed.

5.2 Recommendations

1. There is a need for Urban and Suburban planning to be strategized to give priorities to efficient transportation planning, construction, siting of commercial, roads/streets, and residential areas, by complying with the state or national standard specification in the study location.
2. The importance of efficient maintenance of silencers, and vehicle suspensions to decrease rolling stocks and silencer noise will facilitate the mitigation of traffic noise in both Urban and Sub-Urban areas.
3. There is also a need for an effective and consistent public campaign through the deliberate utilization of social media, electronic, advertisement, stickers, using Nigeria local languages on the general public, on the diverse environmental health effects of noise pollution in the Urban and Sub-Urban areas in Nigeria.
4. Installation of noise barrier where noise pollution has been well-known to be above the recommended threshold.
5. A campaign by concerned individuals on the planting of trees with dense foliage is essential for noise mitigation. As it has been established that trees with dense foliage are very effective in absorbing the environmental acoustic noise. Enforcement of soundproofing of generators in commercial areas and residential areas should be emphasized as an urgent necessity and a deliberate emphasis on the importance of ear protective devices by recipients would serve as a mitigation to the effect of environmental noise pollution.
6. Further studies should be carried out on the investigation of noise pollution in other Urban and Sub-Urban areas in Nigeria.

7. Further studies should be carried out on the development of a traffic predicting Model with an audiometric test on the area having high noise levels.

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APPENDICES

Appendix I: Schole *et al*, 1971 Compared Standard for Noise Parameters.

Standard	Value (dB (A))
Noise Pollution Level (LNP)	72
Traffic Noise Index (TNI)	74

Source (Scholes *et al*, 1971, Ma *et al*, 2006)

Appendix II: Selected NESREA Noise Specification for Nigeria

S/N	FACILITY	Maximum Permissible noise limit dB (A) (Leq)	
		Day	Night
A	Any building used as hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning.	45	35
B	Residential buildings	50	35
C	Mixed residential (with some commercial and entertainment)	55	45
D	Residential + industry or small-scale production + commerce	65	59
E	industrials outside perimeter fence	70	60
F	Commercial Areas	75	50

Day - 6:00am - 10:00Pm, Night - 10:00pm-6:00am, were the timeframe takes into Consideration for human activities.

Appendix III: WHO Environmental Noise Specification

Specific environment	Critical health effect(s)	LAeq	Time base [hours]	Amax fast
Outdoor living area	Serious annoyance, daytime and evenin o	55	16	
	Moderate annoyance, daytime and evening	50	16	
Dwelling, indoors	Speech intelligibility & moderate annoyance, daytime & evening	35	16	
Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms pre-schools, Indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	
Pre-school bedrooms, indoor	Sleep disturbance	30	sleeping time	45
School, playground outdoor	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			
Industrial, commercial shopping and traffic areas, indoors and outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music and other sounds 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 conservations areas	Disruption of tranquillity			

World Health Organization Noise Standard adapted from Guidelines for Community Noise (WHO).1999). *Above this LAeq and period of exposure and the critical health effects.

Appendix IV: Multifaceted Noise Indicators of Fruit Market

Location	LAeq	L10	L50	L90	TNI	LPN	NC	Lday	LE	LN	LDEN
Morning	**80.4**	**845**	**77.3**	**72.2**	**91.4**	**90.2**	**12.3**	**78.6**			**73.7**
Afternoon	**75.3**	**79.1**	**71.9**	**66**	**88.4**	**88.4**	**13.1**				
Evening	**66.7**	**70.1**	**63.1**	**57.9**	**72.9**	**85.1**	**12.2**		**72.7**		
Night	**55.6**	**58.4**	**52.1**	**48.3**	**55.6**	**52.4**	**10.1**			**64**	
Mean	**75.9**	**75.7**	**72.5**	**65.3**	**87.1**	**87.2**	**12**	**78.6**	**72.7**	**64**	**73.7**

Appendix V: Multifaceted Noise Indicators of Selected Commercial

Locations	LAeq	L10	L50	L90	TNI	LPN	LD	LE	LN
Perishable G	73.8	73.6	68.1	60.8	81.9	86.8	78.2	80.7	78.8
IYA LINE	79.2	81.7	73.8	68.0	92.8	91.0	84.1	86.7	85.1
Saraki Line	74.6	77.9	68.1	63.4	99.9	91.6	78.7	76.4	74.5
Daily Iya	69.8	72.3	62.7	56.5	89.5	89.4	73.7	74.3	70.6
Dogo Layi Line	74.4	78.0	74.2	69.6	93.2	89.4	82.1	83.9	80.9
Aminu Line	82.8	88.1	76.5	70.3	118.6	100.3	86.5	86.0	83.5
Provison/Drug	74.1	74.2	70.1	64.5	90.1	83.6	79.2	81.7	79.2
Fruit Market	69.5	73.0	66.1	61.1	77.1	79.0	78.6	72.9	64.0
Faruk Plaza	70.2	73.0	65.2	58.3	87.3	85.5	72.1	74.1	71.8
Techno PZ	85.6	90.2	79.5	75.7	103.8	100.7	86.1	88.4	83.0
Manchester line	83.0	87.2	78.4	71.7	106.9	98.7	86.2	87.3	84.5

Appendix VI: Multifaceted Noise Indicators of Major Selected Intersection

Locations	LAeq	L10	L50	L90	TNI	LPN	LD	LE	LN
Albabello T.C	77.9	80.9	73.8	68.0	94.8	90.9	80.6	79.0	72.5
Kwangillar 1	92.5	95.1	85.5	81.6	106.5	106.6	93.0	91.3	92.1
Kwangillar 2	90.2	92.1	84.9	79.3	100.7	102.6	90.9	90.5	89.3
Kwangillar 3	90.6	91.0	83.7	76.7	103.4	107.5	90.7	92.7	91.2
PZ POINT 1	86.1	88.1	79.8	70.9	109.6	102.2	87.2	84.2	84.4
PZ POINT 2	88.7	85.8	77.7	70.6	101.1	98.3	84.4	83.6	82.8
Emanto	85.6	87.1	79.8	74.2	95.6	92.9	86.0	85.7	82.8
MTD	84.8	87.9	78.8	72.2	100.0	103.5	86.7	84.1	81.6
ABU POINT 1	84.0	86.5	76.6	69.9	106.3	100.0	84.6	82.2	83.8
ABU POINT 2	81.5	83.9	76.5	70.3	107.2	99.8	83.8	81.4	83.4

Appendix VII: Multifaceted Noise Indicator of Selected Major Streets

Locations	LAeq	L10	L50	L90	TNI	LPN	LD	LE	LN
Chikaji Roads	80.1	83.5	73.9	69.1	104.0	96.9	81.9	83.9	82.9
Park Road	85.0	88.5	77.3	70.2	122.1	96.1	86.3	86.9	85.5
Aminu Road 2	81.1	85.1	76.6	68.1	105.9	123.0	83.1	82.8	81.2
Randan Kanu	82.6	85.3	76.0	69.7	105.9	97.4	85.6	85.3	81.1
KINGS ROAD	80.6	84.5	75.2	68.5	105.5	94.7	82.4	81.3	80.4
Lagos Street	82.7	87.9	79.2	72.0	105.6	98.1	85.1	84.8	81.7
Club Street	78.8	80.3	69.0	65.4	101.2	95.3	81.4	81.1	77.4
Yoruba	77.5	80.3	70.5	61.4	104.8	95.4	80.3	76.8	77.5
Cemetery	75.3	78.0	69.7	63.3	92.1	90.2	77.3	76.5	69.7
Geaceland Road	71.3	74.4	64.6	56.7	97.5	89.2	72.8	74.3	72.9
Leather Research	76.2	79.1	68.7	58.7	110.2	97.5	77.9	77.5	71.4
Naibi Street	80.4	84.8	72.9	71.7	116.0	98.0	81.7	82.7	81.5
Dogo-iche Street	79.8	76.9	71.2	60.8	118.3	101.7	81.5	85.1	80.3
Paladan Road	81.4	84.7	74.7	68.0	104.6	98.1	86.9	81.4	79.8
Saraki Streets	77.7	82.0	70.9	66.2	114.0	114.0	100.2	80.0	79.1

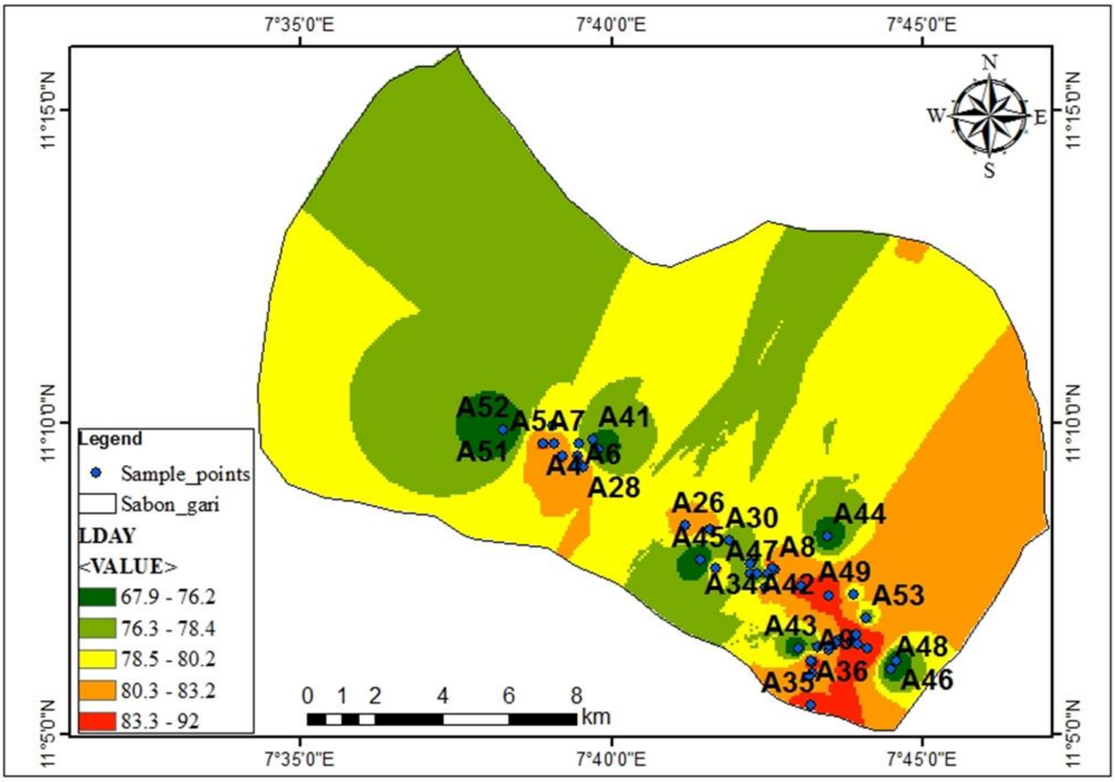
Appendix VIII: Multifaceted Noise Indicators of Selected Mixed Residential Areas

Locations	LAeq	L10	L50	L90	TNI	LPN	LD	LE	LN
GRA	67.7	69.9	63.4	54.7	107.6	91.5	69.2	70.1	67.3
DOGORAWA	71.3	74.9	64.1	53.9	108.1	92.2	73.5	73.9	63.3
Graceland B	66.4	68.1	54.3	43.8	109.5	90.2	68.5	67.9	66.1
Gwado	71.1	73.7	62.6	53.9	101.5	94.1	72.7	73.1	70.2
Hanwa	66.8	69.7	59.5	52.0	93.0	84.4	70.9	67.8	65.8
Agwangodo	71.0	74.6	62.9	55.6	92.3	90.0	73.9	75.5	72.4
Muchia	74.4	76.7	68.4	59.4	98.8	91.1	78.0	78.4	76.0
Ijaw Street	66.2	70.7	59.0	50.5	101.5	86.4	67.6	68.8	66.7
Afegbu Daraka	69.7	73.7	62.5	52.9	100.2	90.5	72.2	71.5	70.8
Galadima	69.3	74.9	66.4	59.9	90	83.7	71.4	73.6	71.7
Dasa Block H	73.8	77.8	67.3	58.9	104.3	93.1	77.4	77.6	72.6
Muncha Block	72.9	75.2	67.2	59.5	92.3	88.8	77.9	78.6	73.2
Farangida MW	77.1	80.6	69.6	63.3	95.8	91.9	82.2	81.7	76.6
Kips (Pure water)	85.5	88.6	83.3	78.7	93.1	95.4	92.3	92.2	88.9
Sawmill	76.9	80.5	69.3	62	106.1	95.4	82.4	86.9	85.7
Pensionnairs Q	76.3	77.3	75.8	73.8	57.8	80.3	76.1	76.7	76.7
Hanwa	73.7	74.9	71.8	70.6	57.8	78.1	73.6	73.9	73.8

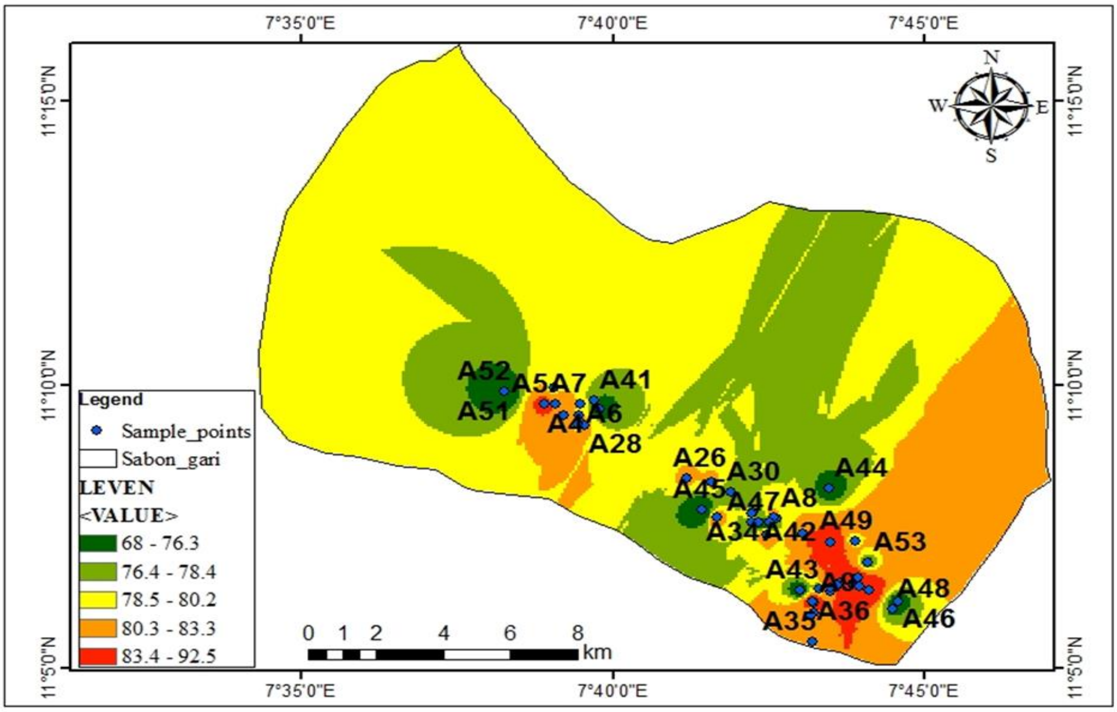
Appendix IX: Multifaceted Noise Indicators of Sawmill

Locations	LAeq	L10	L50	L90	TNI	LPN	LD	LE	LN	NC	LDEN
Morning	79.9	86.4	63.3	54.6	151.8	111.7	82.4			32.8	92
Afternoon	83.9	86.8	80.4	76.9	86.5	93.5				9.9	
Evening	88.7	92.6	86.8	78.2	105.8	103.1		86.9		14.4	
Night	55.3	56.3	46.8	38.3	80.3	73.3			85.7	18.0	
Grand mean	76.9	80.5	69.3	62	106.1	95.4	82.4	86.9	85.7	18.5	92

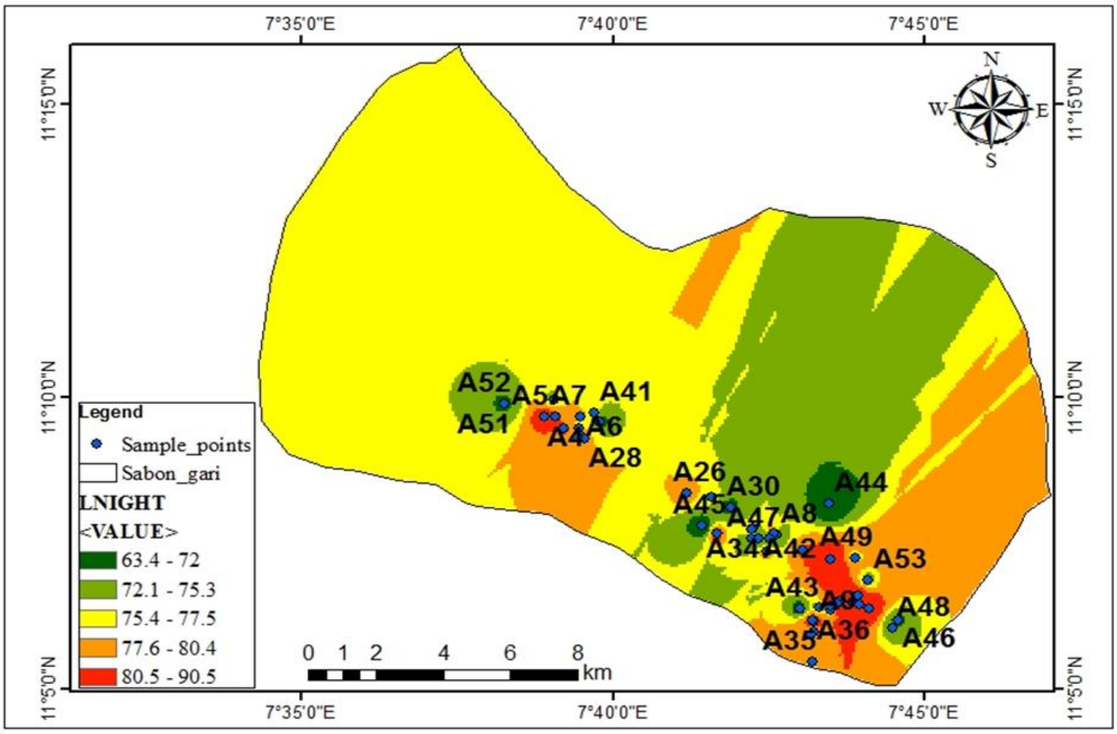
Appendix X: Spatial Noise Map for LDAY for Sabon-Gary LGA of Kaduna State



Appendix XI: Spatial Noise Map for Levening for Sabon- Gari LGA of Kaduna State



Appendix XII: Spatial Noise Map for Lnight for Sabon- Gari LGA of Kaduna State:



Appendix XIII: Perception Response on the Effects of Environmental Noise Pollution.

Dear Respondent.

QUESTIONNAIRE FOR THE INVESTIGATION OF SPATIAL ENVIRONMENTAL NOISE POLLUTION

It will be a privilege to have your views in this research. The questionnaire is design to investigate awareness, perceptions and Effects of noise pollution in the Environment. It is Important to let you know that this questionnaire is for academic purposes only and a confidential treatment of the information is well assured.

SECTION A: SOCIO DEMOGRAPHIC	
S/N	BIO-DATA
1	Gender Male ☐ Female ☐
2	Age Bracket: 15-20 ☐ 21-35 ☐ 36 – 60 ☐ 61 – Above ☐
3	How long have you lived in Sabon-Gari LGA (In Years) 0-10 ☐ 11-20 ☐ 21-30 ☐ 31-40 ☐ 40 and above ☐
4	Marital status: Single ☐ Married ☐ Divorced ☐ Widowed/Widower ☐
5	Highest level of qualification. Primary School ☐ Secondary School ☐ Tertiary ☐ No formal Education ☐
6	Occupation: Military/Paramilitary ☐ civil servant ☐ Self Employed ☐ Religious Leader ☐ Students ☐ Applicant ☐

SECTION B

1	QUESTIONS ON ENVIRONMENTAL NOISE AWARENESS
a	Do know what is noise pollution: Yes ☐ No ☐
b	Are you aware about the effects of noise pollution: Yes ☐ No ☐
c	Do think that unplanned urbanization and lack of awareness is increasing noise pollution: Yes ☐ No ☐
d	Do you experience any kind of noise in your daily activities and do you think it is increasing: yes ☐ No ☐
e	If yes to question Id, indicate the sources of noise and rate the degree of the effects of noise level, where, HS= Highly Severe, S= Severe, M= Moderate, Mi= Mild, VM= Very mild.

S/N	Facilitators	HS	S	M	Mi	VM
f	Household noise					
g	Religious activities					
h	Traffic noise (vehicles, Motor cycles, tricycles, train and Air craft)					
i	Industrial noise /Small Industries e.g., grounding machine, welding, Sawmill and Block industry etc.					
k	Construction noise					
l	Generator					
m	Commercial activities (market activities)					

SECTION 1B						
1B	QUESTION RELATED TO THE EFFECTS OF NOISE POLLUTIO N					
Question and descriptions of respondent	Do you know that noise pollution can lead to any of the following where; SÁ=Strongly Agreed; A= Agree; Un=undecided; D= Disagree; SD= Strongly disagree)					
S/NO	Facilitators	SA	A	Un	D	Sd
A	Stress					
B	Annoyance					
C	Hearing Impairment					
D	information distortion					
E	Impaired efficiency and productivity					
f	Facilitate mental Illness					
g	Distraction and aggressiveness					

SECTION C						
2	QUESTIONS ON THE PERSONAL EXPERIENCE OF THE EFFECTS OF NOISE POLLUTION					
Questions and descriptions of responses	Rate how you have felted the effects of noise pollution during exposure. Where HS= Highly Severe; S= Severe; M= Moderate; Mi, =Mild; VM= Very Mild					
A	Facilitators	HS	S	M	MI	VM
B	Annoyance and irritation					
C	Aggressiveness and distraction					
D	Sleep disturbance					
E	Distortion of Information					
F	Hearing Impairment					
G	Ringing in your ear [Tinnitus]					
H	Headache					
I	Stress					

SECTION C. QUESTIONS ON GOVERNMENT AND PERSONAL RESPONSABILITIES

$1_{A..}$ Have you ever complained about the effects of Noise in your environment before before.

Yes ☐ No ☐

$2_{.}$ Has anyone complained about the effects of environmental noise pollution to you before?

Yes ☐ No ☐

3. If yes to 1_{A} and $2_{B.}$ How do you handle the situations, thick appropriately?

I endured it ☐ I reported to the police ☐ I left the place ☐ I confronted source to turn down the noise ☐

4A. Do you know any Government regulation agency responsible for monitoring of noise pollution in Nigeria?

Yes ☐ No ☐

4B. If the response to 14A is Yes, state the agency……………………………………

5A. Are you taking any action in preventing noise pollution? Yes ☐ NO ☐

5B. If the response to 5A is yes, state any of your action ……………………………

6. Do you think that the government has done enough to provide solution to Environmental noise pollution in kaduna state and Nigeria at large.

Yes ☐ No ☐

7. Wound you like Government to take more strategic and proactive actions in mitigating and punishing those who indiscriminately generate noise pollution in the environment?

Yes ☐ No ☐

Appendix XIV: Social Demography on effect of Perception of Environmental Noise

Variables	Facilitator	Frequency	Percentage
Gender	Male	226	63.1 (%)
	Female	132	36.9 (%)
Age	15-20	68	19 (%)
	21-35	216	60.3 (%)
	36-60	68	19 (%)
	60 -above	6	1.7 (%)
Years of resident	0-10	103	28.8 (%)
	10-20	124	34.6 (%)
	21-30	83	23.2 (%)
	31-40	35	9.8 (%)
	41-above	13	3.6 (%)
Marital Status	Single	207	57.8 (%)
	Married	123	34.4 (%)
	Divorced	22	6.1 (%)
	Widow/Widower	6	1.7 (%)
Education	Primary School	15	4.2 (%)
	Secondary	139	36.9 (%)
	Tertiary	200	55.9 (%)
	No formal education	11	2.1 (%)
Occupation	Military/Paramilitary	40	11.2 (%)
	Civil servant	75	20.9 (%)
	Self Employed	105	29.3 (%)
	Religious leader	18	5 (%)
	Students	98	27.4 (%)
	Applicant	22	6.1 (%)

Appendix XV: Respondents on Awareness of Environmental Noise Pollution

	Frequency	Frequency
Question	Yes	No
Do you know what is noise pollution	326	32
unplanned urbanization inadequate awareness	321	37
Increase in noise level	324	34
Awareness of the effects of noise pollution	317	41
Do you experience noise in your daily activities	326	32

Appendix XVI: Personal and Government Responsibility on Noise Pollution

Question	Facilitators	
	Yes	No
Noise effect complaints	221 (61.7%)	137 (38.3%)
Third party noise effect complaints	260 (72.6%)	98 (27.4%)
Awareness of government monitoring agency	44 (12.3%)	314 (87.7%)
Personal mitigating noise measures	99 (27.7%)	259 (72.3%)
On whether the government has done enough on mitigation of noise pollution?	54 (15.1%)	304 (84.9)
On taking more proactive and strategic action by government	329 (91.9%)	29 (8.1%)

Appendix XVI: Respondents' Approach During Exposure to Noise Pollution

Respondents	Frequency	Percentage
I endured it	146	40.8
I reported to the police	35	9.8
I confronted the source to turn down the noise	74	20.7
I left the place	103	28.8

Total	358	100

Appendix XVII: Respones on Agency for Monitoring Environmental Noise

S/N	Respondent	Frequency	%
1	NESREA	12	3.6
2	KEPA	15	4.2
3	Others	7	2
4	No response	323	90.2
Total		358	100

Appendix XVIII: Data Collections at ABU Main Gate During the Afternoon (LeqA)

Appendix XIX: Data Collection at ABU Main Gate at Night Reading. (Leqn)

Appendix XX: Data Collection at Club Street in the Morning Period (LeqM)

Appendix XXI: Data Collection at Kwangila During the Night Period (LeqN)

Appendix XXII: Data Collection at Kwangila During the Morning Period (Leqm)

Appendix XXIII: Data Collection at Kwangila During the Afternoon Period (LeqA)

Appendix XXIV: Data Collection at Lemu Market at Afternoon Period. (LEqA)

Appendix XXV: Data collections at Tecno PZ During the Evening Period (LeqE)

Appendix XXVI: Data Collection at Park Road During the Night Period (LeqN)

Appendix XXVII: Data Collection at Al-Babello Trading Company in the Morning Periode

Appendix XXVIII: Data Collection at Mixed Residential Area Daraka Samaru