ASSESSMENT OF ROAD TRAFFIC NOISE IN MINNA METROPOLIS

BY

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MEng/SIPET/2018/8255

DEPARTMENT OF CIVIL ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF ENGINEERING IN CIVIL ENGINEERING (TRANSPORTATION ENGINEERING)

AUGUST, 2023

DECLARATION

I hereby declare that this thesis titled: **“Assessment of Road Traffic noise in Minna metropolis.”** is a collection of my original research work and has not been presented for any other qualification anywhere. Information from other sources (published and unpublished) has been duly cited and acknowledged.

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Signature & Date

CERTIFICATION

The thesis titled: **“Monitoring and Assessment of Road Traffic noise in Minna metropolis.”** by: **ALFA, Umar** (MEng/SIPET/2018/8255) meets the regulations governing the award of the degree of MEng of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to Almighty Allah (SWT), the eternal and ever sufficient. May His peace and blessings be upon the noble Prophet Muhammad, the key to that which has been closed and the seal to those which have passed (S.A.W). May this blessing extends to his household, his companions and those who have rightly follows his path till the day of accountability. May Allah be pleased with Sheikh Ahmad Tijjani and his vicegerent Sheikh Alhaji Ibrahim Inyass (Radiyallahu Anhuma).

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ABSTRACT

Transportation is one of the important pillars of the nation's economic and overall growth. As transportation is very important, it has its negative impacts on the environment as well as human health. One of its negative impacts is noise pollution. Traffic noise is an important part of urban environment contributing about 55% to the entire urban noise. Road Traffic noise in many cities of the world has become one of the popular research areas among the engineer and scientists. Population increase and the standard of living have led to rise in the number of vehicles on the roads. Apart from increase in new vehicles there is also increment in volume of vehicles becoming old. Old vehicles are the causes for huge noise emitting from outdated/poor standard engines. This is observed especially in case of buses, trucks, auto rickshaws (keke Napep), cars etc. This Study present the assessment of road traffic noise in Minna metropolis. The study was conducted in Kpakungu, Mobil roundabout, and Kure market area in Minna city. The noise levels were measured following standard procedure using calibrated sound level (dB) meter(ExtechSDL600 Sound Level Meter) by keeping the sound level meter on a tripod almost to chest level (1.2m) in order to reduce errors due to reflection of sound from the body of investigator and the instrument was kept at 1m away from the roadside. Traffic count was done in the form of 2 wheelers, 3 wheelers, 4 wheelers, bus, and trucks. The traffic noise level data were analyzed to evaluate noise descriptors in the form of L10, L50, L90, Lnp, TNI, and Noise climate. In this study a mathematical model which requires total vehicle count and percentage of heavy vehicles is taken which is Calixto model for predicting noise levels and then the observed noise levels were compared with calculated/predicted noise levels L_{eq}. For validation of this, a regression analysis was done for all areas and correlation coefficient R_2 was obtained. In the present study correlation coefficient R_2 values for Kpakungu showed the highest correlation of 0.9738 whereas Mobil area also showed the best results of R^2 value of 0.911, and the Kure Market area of shows least correlation coefficient R^2 value of 0.8931. This shows that in all the areas the correlation is very good and the value of "r" also shows good results. From this we can conclude that the Calixto model is good for Nigeria road conditions.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Transportation is the movement of people, goods and services from one location to another. This movement can be achieved through different modes such as: land air and water transportation. Transportation is one of the important pillars of the nation's economic and overall growth. As transportation is very important, it has its negative impacts on the environment as well as human health. One of its negative impacts is noise pollution. Noise is one of the pollutions that have always been an important environmental problem for human. It is characterized as 'undesirable sound', and it is seen as a natural stressor due to the annoyance from human daily activities (Stansfeld and Matheson, 2003). The major form of noise is including transportation, industrial and neighborhood sector. Transportation noise can come from a variety of sources including motorcycles, vehicles, aircraft and rail transport). Road traffic has become an important factor in societal development and economic progress due to increasing number of vehicles (Berglund *et al.,* 2000).

Traffic noise tends to be a dominant noise source in urban and rural environment, which has turned into a developing public concern. Based on the Report of World Health Organization, sound may cause hearing disability, sleep disturbance, performance loss, cardiovascular impacts, and interferences with social behavior which are aggressiveness, protest and helpfulness. Traffic noise has also related to the obstruction in speech communication and annoyance. Another perspective view on the economic consequences of these health impairments are property value. Loss in areas subjected to noise impact can bring down work performance of those influenced by noise (Su, 2009) and medical expenses of improving the condition of health of those influenced by noise. Its adverse effects on health and economy have forced communities to seek solutions to improve quality of life by reducing traffic noise.

1.2 Statement of the Research Problem

Exposure to high levels of noise has negative effects in the short- and long-term. Long term effects include damage to human health: it is possible that repeated exposure to high noise levels at the corridors may result in damage to Commuter's hearing and circulatory systems. As will be discussed in this study's literature review, researchers have shown a conclusive link between hearing loss and exposure to high ambient noise levels, and daily commuters who use stations in noisy highway medians over the course of many years may suffer from hearing loss (WHO 1999). Other studies have linked cardiovascular problems, particularly hypertension, to long-term exposure to high noise levels (Passchier-Vermeer and Wim, 2000; Chepesiuk, 2005). Increased risk of ischemic heart disease has also been found in those who are exposed to elevated noise levels. While research has not specifically studied health problems in transit passengers, the possibility of passengers who use highway-centered stations experiencing long-term health problems is a substantial risk.

In the short-term, the high levels of noise on station to create an unpleasant environment for passengers waiting for their bus or train. Riders have difficulty holding conversations with fellow passengers or on their phones. Research into annoyance caused by noise shows that people exposed to high noise levels have difficulty concentrating, making even silent activities, such as reading, problematic (Garcia, 2001). In addition, the high noise levels can prevent the effective use of loudspeakers in the station to provide information to riders, especially important in emergency situations. Some passengers may find the environment unpleasant enough that they choose not to use these stations, thus reducing ridership on the lines. Because the cost to construct these lines runs to the hundreds of millions of dollars, Metro should be concerned that the unpleasant station environment is deterring potential riders from using the stations and so reducing the value of its investment in these lines.

1.3 Justification of the Study

Owning to the high rate of noise expose to people and commuter's in Minna. Traffic noise tends to be a dominant noise source in urban and rural environment, which has turned into a developing public concern. Based on the Report of World Health Organization, sound may cause hearing disability, sleep disturbance, performance loss, cardiovascular impacts, and interferences with social behavior which are aggressiveness, protest and helpfulness. Traffic noise is also related to the obstruction in speech communication and annoyance

1.4 Aim and Objectives of the Study

The aim of this project is to assess road traffic noise in Minna metropolis. While the objectives are:

i) Measure the hourly traffic volume of two axel load, three axel load and four axel load (light & heavy)

ii) Determine the noise level at transit station and noise parameters(i.e. Traffic Noise Index (TNI), Noise Climate (NC) and Noise Pollution Level (L_{np}) for all the study locations)

iii) Development of a road traffic noise prediction model based on the percentage of heavy vehicles and regression analysis to predict noise equivalent levels (L_{eq}) using Calixto model.

1.5 Scope of the study

This research work is to determine the level of exposure to people/commuters in Kpakungu, Kure market and Mobile area to traffic noise and how it conforms with international and national standard.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Transportation System

Transportation is the movement of people, animals and good from one location to another. The modes of transportation include air, rail, road and water. The field can be divided into infrastructure, vehicles and operation. Transport infrastructure consists of the fixed installation that includes roads, railways, airways, waterways and terminals such as airport, railways, station, bus station and sea port. Vehicles traveling on these networks may include automobile, bicycle, buses, trains and trucks. Transportation is one of the important pillars of the nation's economic and overall growth. As transportation is very important, it has its negative impacts on the environment as well as human health. One of its negative impacts is noise pollution. Noise is the main source of pollution in urban areas and is a part of environmental pollution which interferes with communication and people's health (Agarwal and Swami, 2009; Pathak *et al*., 2008a).

Noise is also considered as an environmental sterner and according to WHO, "Noise is the third most hazardous type of pollution next to air and water pollution" (WHO, 2005). People are mainly affected by noise in three major areas that is; their performance, health and comfort (Miedema and Outshroon, 2001). Hence it becomes imperative to understand the sources and types of noise pollution, monitoring techniques, effects on health and prediction of future noise pollution levels through modeling studies to effectively face noise pollution.

2.1.1 Road Transport in Nigeria

Anyanwu *et al.* (1997) documented that the history of road transport in Nigeria dates back to 1904 when Lord Laggard attempted the construction of a mule road linking Zaria and Zungeru both in the Northern States of Nigeria. The road was later extended from Zaria to Sokoto, Katsina and Maiduguri. However, the road linking Ibadan and Oyo constructed in 1906 is recorded to be the first motorable road ever constructed in Nigeria.

At independence in 1960, the Nigerian landscape was dotted with a skeletal network of trunk roads as well as secondary and feeders roads that exhibited the characteristics which reflected the purpose of their construction. They were narrow and winding, being simply meant to facilitate the evacuation of agricultural produce from the interior to the ports for exports in addition to serving as links between scattered human settlements. In 1925, the central government of Nigeria set up a Road Board.

Walker proposed a skeleton trunk road system to link the major administrative centres in the country. These roads were designed as a frame upon which the network of secondary roads could be built thus enabling the general road system to be considered as a co-coordinated whole-rather as a jigsaw of small disjointed sections. The total length of roads maintained by the government rose soon from 6,160 km (5,875 miles) in to 9,453 km (5,875 miles). Development of Road Transport in Nigeria Drawing upon the account of Anyanwu (1997), the historical development of road transport in 21 Nigeria can be traced to 1940, when Lord Luggard attempted the construction of a mule road Linking Zaria and Zungeru both in the Northern state of Nigeria.

The road was later extended from Zaria to Sokoto, Katsina and Maiduguri. However, the road linking Ibadan and Oyo constructed in 1906 was recorded to be the first motorable road ever constructed in Nigeria. At independence in 1960, the Nigerian landscape was dotted with a skeletal network of trunk roads as well as secondary and feeders roads that exhibited the characteristics which reflected the purpose of their construction. They were narrow and winding, being simply meant to facilitate the evacuation of agricultural produce from the interior to the ports for export in addition to serving as links between scattered settlements thus permitting ease of administration.

The various data published by the Federal Office of Statistics in Nigeria, show that as at 1951, out of the total of 44,414km of road in Nigeria, 1,782km were surfaced, though the roads were lacking in standard designs and were single lane with sharp bends and poor drainage system. By 1980, the total length had increased from 44,414km in 1951 to 114,768km, while tarred roads increased in length from 1782km in 1951 to 28,632km in 1980, and earth/gravel road increased from 4,232km in 1951 to 8,613km in 1980. According to the Central Bank of Nigeria (2003) the estimated total road network length in Nigeria was about 200,000km.

2.1.2 Environmental pollution in Nigeria

Noise and air pollution are two main environmental pollutants in the Nigerian road transportation system. Air pollution comprises Nitrogen, Lead, Hydrocarbons, and Carbon II Oxide emission from the car exhaust pipes. These gases pose a great health hazard to the quality of life led as well as the health of both the community and motorists. The air pollution caused by traffic also has negative effects on the built environment. Metal corrosion and deterioration of coatings, lime, mortar, and construction elements through the action of acidic deposit of NO_x and SO_2 and particulate matter represent some of the current challenges. Complementary, soil contamination with chemical compounds from transport activities contribute to soil erosion, as the pollutants lead to the destruction of existing vegetation and soil organisms. Health implications although transportation system is part and parcel of the contemporary life, WHO (2004) European Region face challenges related to the reduction of environment and health risks as well as meeting the requirements of nations for efficient transportation systems (Krzyzanowski *et al.*, 2005). Air pollution exposes humans to silent killer diseases such as stroke, lung cancer, asthma, chronic and acute respiratory diseases, to mention a few. Unfortunately, approximately 94% of the Nigerians are susceptible to air pollution, including particulate matter (PM). The PM can be suspended in air over an elongated period and travel over long distances, causing a variety of diseases that significantly reduces the life expectancy of the entire population (Kim *et al*., 2015).

2.2 Pollution

An undesirable change in the physical, chemical and biological characteristics of the environment especially air, water and land that may adversely affect human population and the wild life, industrial processes, cultural assets (building and monuments) (National Academy of Sciences, USA 1997)

2.2.1 Type of Pollution

Depending upon the area or the part of environment affected, pollution may be of the following types:

i. Air pollution
ii. Water pollution
iii. Land pollution
iv. Noise pollution

i) Air pollution

It is refers to the release of pollutant into the air which are detrimental to human health and the planet as a whole. According to the world health organization (WHO), each year air pollution is responsible for nearly seven million deaths around the globe. Most air pollution comes from energy and production and burning fossil fuel release gases and chemical into the air. Air pollution in the form of Carbondioxide and methane raises the earth's temperature. Another type of pollution, Smog is then worsened by that increased heat, forming when the weather is warmer and there more ultraviolet radiation. Air pollution can be prevented by transitioning to cleaner fuel and industrial processes. By switching over to renewable energy sources (such as wind and solar power) maximizing fuel efficiency in our gasoline-powered cars and truck with electric version.

ii) Water pollution

Water pollution is the release of substances into bodies of water that make water unsafe for human use and disrupts aquatic ecosystem. Water pollution is one of the most serious environmental problems. Water pollution is caused by a variety of human activities such as industrial, agricultural and domestic. Agricultural runoff laden with excess fertilizers and pesticides, industrial effluents with toxic substances and sewage water with human and animal wastes pollute our water thoroughly. Natural sources of pollution of water are soil erosion, leaching of minerals from rocks and decaying of organic matter. Rivers, lakes, seas, oceans, estuaries and ground water sources may be polluted by point or non-point sources. When pollutants are discharged from a specific location such as a drain pipe carrying industrial effluents discharged directly into water body it represents point source pollution. In contrast non-point sources include discharge of pollutants from diffused sources or from a larger area such as runoff from agricultural fields, grazing lands, construction sites, abandoned mines and pits, roads and streets. In order to prevent water pollution, the following can be adopted (National Academy of Science USA, 1997)

a) Reduce your plastic consumption and recycle plastic
b) Properly dispose of chemical cleaner, oils, and non-biodegradable items to keep them from ending up down the drain

c) Maintain your car so it doesn't leak oil antifreeze or coolant

d) If having a yard, consider landscaping that reduce runoff and avoid applying pesticides and herbicides

iii) Land pollution

Land pollution is the degradation of the earth's surface as a result of human activity. Also, land pollution can be addition of substances which adversely affect the quality of soil or its fertility is known as soil pollution**.** Generally polluted water also pollutes soil. Solid waste is a mixture of plastics, cloth, glass, metal and organic matter, sewage, sewage sludge, building debris, generated from households, commercial and industries establishments add to soil pollution. Fly ash, iron and steel slag, medical and industrial wastes disposed on land are important sources of soil pollution. In addition, fertilizers and pesticides from agricultural use which reach soil as run-off and land filling by municipal waste are growing cause of soil pollution. Acid rain and dry deposition of pollutants on land surface also contribute to soil pollution. In order to prevent land pollution, the following can be adopted (National Academy of Science USA, 1997)

a) Reusing material help to reduce the requirement of harvesting resources

b) Reduce the use of pesticide and fertilizer in agriculture activities

c) Reduce the use of biodegradable material

d) Avoid buying packaged items as they will lead to creating garbage and end up in the landfill site

e) Ensure that you do not litter on the ground and do proper disposal of garbage.

iv) Noise Pollution

Noise pollution can be defined as any disturbing or unwanted noise that interferes of harms human of wildlife. Noise is one of the most pervasive pollutants. A musical clock may be nice to listen during the day, but may be an irritant during sleep at night. Noise by definition is "sound without value" or "any noise that is unwanted by the recipient". Noise in industries such as stone cutting and crushing, steel forgings, loudspeakers, shouting by hawkers selling their wares, movement of heavy transport vehicles, railways and airports leads to irritation and an increased blood pressure, loss of temper, decrease in work efficiency, loss of hearing which may be first temporary but can become permanent in the noise stress continues. It is therefore of utmost importance that excessive noise is controlled. Noise level is measured in terms of decibels (dB). W.H.O. (World Health Organization) has prescribed optimum noise level as 45 dB by day and 35 dB by night and has said that any noise level that is above 80dB is hazardous (Rashid, 2013)

2.3 Sources of noise pollution

Noise pollution is a growing problem. All human activities contribute to noise pollution to varying extent. Sources of noise pollution are many and may be located indoors or outdoors.

i) **Indoor sources** include noise produced by radio, television, generators, electric fans, air coolers, air conditioners, different home appliances, and family conflict. Noise pollution is more in cities due to a higher concentration of population and industries and activities such as transportation. Noise like other pollutants is a byproduct of industrialization, urbanizationand modern civilization (Rashid, 2013)

ii) **Outdoor sources** of noise pollution include indiscriminate use of loudspeakers, industrial activities, automobiles, rail traffic, airplanes and activities such as those at market place, religious, social, and cultural functions, sports and political rallies. In rural areas farm machines, pump sets are main sources of noise pollution. During festivals, marriage and many other occasions, use of fire crackers contribute to noise pollution (Rashid, 2013).

2.4Effects of noise pollution

Noise pollution is highly annoying and irritating. Noise disturbs sleep, causes hypertension (high blood pressure), emotional problems such as aggression, mental depression and annoyance. Noise pollution adversely affects efficiency and performance of individuals (Rashid, 2013)

Prevention and control of noise pollution

Following steps can be taken to control or minimize noise pollution-

i. Road traffic noise can be reduced by better designing and proper maintenance of vehicles.
ii. Noise abatement measures include creating noise mounds, noise attenuation walls and well maintained roads and smooth surfacing of roads.
iii. Retrofitting of locomotives, continuously welded rail track, use of electric locomotive or deployment of quieter rolling stock will reduce noises emanating from trains

2.5 Historical Background of Noise

Noise Pollution is a major source of pollutant of environment these days along with air and water pollution. It is no less harmful than lethal chemicals in our environment. In historical times also, noise was considered as pollutant. Towards the end of the 19th and beginning of the 20th century, noise problems and complaints increased significantly because of urbanization and mechanization in several countries in America and Europe. The problem of noise pollution was taken up over the years both socially and legally. To reduce noise pollution, control measures were introduced. The first noise standards were introduced in the early 50s, various noise standards were introduced in many countries of world and also by International Standard Organization in 60s and 70s. Effective laws on noise control were adopted which became useful in noise abatement at work.

2.6 Environmental Noise Pollution

The harmful external sound or undesired sound created by different activities of humans is known as Environmental Noise. This noise which is a potential threat to the health of humans has been of lesser priority than other kinds of pollution, but it also poses negative effects to the quality of life of individuals in behavioral, physiological and psychological changes. It is getting more and more severe and widespread than ever before, and it continues to increase both in its magnitude and intensity due to rapid rise in population and further development of urbanization. This environmental noise pollution is not a completely new phenomenon but this problem has grown gradually with time. This increase in noise levels is also affecting wild life in addition to humans. So, this environmental noise pollution is poised to become a major threat to humans in the coming years. The gathering of offending sounds is environmental noise to which humans are exposed involuntarily. Motor vehicles, industries, aircraft and entertainment like music at high volumes are prime sources of environmental noise and are generally referred to as Noise Pollution.

Environmental noise is administrated by noise regulations which place utmost recommended levels of sound for specific areas of usage such as educational institutions like schools, hospitals and factories. The level of noise at this location can be determine by weighting filter

The following are responsible for noise pollution according to (Schell *et al.,* 2006).

- **i)** Number of vehicles increasing.
- **ii)** Noise Pollution, unlike air and water pollution, cannot be visually determined and leaves no visible record.
- **iii)** An ordinary citizen doesn’t understand noise problems. Noise is a form of pollution that demands remedial action by government.

2.6.1 Classification of noise pollution based on industrial and non-Industrial sources

Industrial and non-industrial sources are major contributors of noise pollution. The industrial noise constitutes heavy duty machines under operation generating huge noise, while automobiles are the major sources of non-industrial noise pollution. These noise sources can be any of the three type's viz., Line source, point source or area source (Schell *et al.*, 2006).

2.6.1.1 Line source

A line source may be described as a continuous form of radiation, such as pipe carrying turbulent fluid. It is composed of large number of point sources so closely spaced such that the resultant emission may be considered as emanating from a notional line connecting them (Schell *et al*, 2006).

(i) Road traffic noise

Road traffic noise is the most extensive source of noise in all countries and the most widespread cause is annoyance and interference. The intensity of noise is proportional to the number of vehicles at a particular point of time and place. Increase in population accompanied by increase in standards of people has led to rise in the number of vehicles which in turn resulted in escalation of noise pollution. Apart from the density of vehicles, road traffic noise according to (Rashid 2013) depends on following factors:

i) Road conditions

ii) Traffic clearance

iii) Size of the vehicle

iv) Condition of vehicles

v) Speed of vehicles

vi) Common sense

In cities, the major sources of noise pollution are from vehicle engines and exhaust systems. This type of noise is enhanced by tall structures e.g. like buildings and narrow lanes which produce a gap in which traffic noise reverberate. This noise intensity can reach up to much higher value when measured at specific point of time and place. The noise levels vary depending on the speed of the vehicle. For example, though there is rolling noise (noise emitted due to the movement of tires) its effect is predominant only at higher speeds. Beyond a higher critical speed, tire road interaction and aerodynamic noise become the major contributors. The noise from the engine is mainly observed at low speeds. Apart from this, rated load is another factor particularly with respect to the exhaustive system, traffic flow rate, horn, road surfacing, change in engine speed and petrol, diesel or electric power used as fuel, proportion of heavy vehicles, including motor vehicles on road and the road gradient and on the condition of the vehicle etc. The noise level increases in heavy vehicles by 6 dB (A) on a one in eleven gradients compared to a level road due to the increased power applied on a gradient road to maintain the speed levels. According to previous research (Ouis, 2001) in figure 2.1, shows that 73% has pointed that traffic noise are the main source that contributes in urban area.

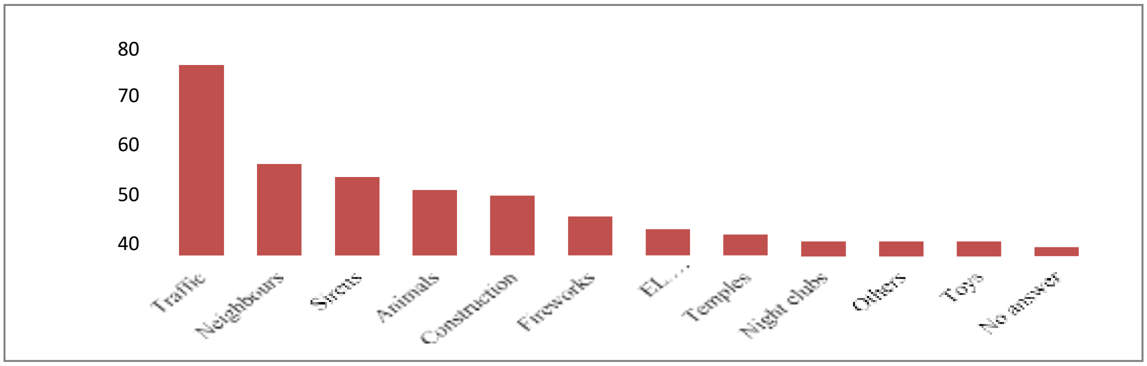

Figure 2.1 The histogram of road traffic noise in an urban setting. (Source: Ouis, 2001).

(ii) Aircraft noise

Noise emitted from the engines of air vehicles is very high. The intensity, especially at airports, is very high when the planes are about to take off or land. Increasing air traffic only results in higher levels of the noise problems. Noise levels from the engine increase with speed as more gases are emitted from the exhaust. The invention of supersonic aircraft increased the speeds tremendously. These airplanes which travel at speeds greater than the speed of sound in air, have added more noise for the plight of persons who live near airports. Breaking of the sound barrier resulted in high speed of the supersonic plane shatters windowpanes, damage walls and buildings. It becomes clear that aircraft noise has some adverse effects on human body (Rashid, 2013).

(iii) Rail traffic noise

Diesel engines and their respective motors, electric traction motors, friction between the rail and the wheel during fast motion, siren, shunting, switching operations in rail yards all produce high levels of noise and can adversely impact neighboring communities and also railroad workers (Rashid, 2013).

2.6.1.2 Point source:

A sound source is said to be a point source, when dimensions are small compared to the distance from the receiver and which radiates equal amount of energy in all directions. Typical point sources are industrial plants, aircraft and individual road vehicles. In urban areas vehicular traffic which is posing various health hazards is considered as major point source (Rashid, 2013).

(i) Construction noise:

Blasts performed during mining, drilling operations, demolitions, construction of high-rise buildings, dams, highways etc., generate huge noise. Movement of bulldozers, loaders, dump trucks, operation of pneumatic hammers, air compressors and pavement breakers are the other factors which contribute to the noise. Though the construction noises are temporary, mining operations pose a serious threat especially to workers and the living community staying near the respective areas (Rashid, 2013).

(ii) Noise in industry

Industrial noise is one of the less common community noise problems. However, the noise levels are significant enough to scale them at a greater level. Rolling mills, grinders, lathes, industrial fans, slicers, industrial hammers, induction heaters, electric generators, pump sets, gantry cranes, compressors and turbines are mainly responsible for noise pollution in industries (Rashid, 2013).

(iii) Residential noise

Several home appliances produce noise. Some of the major sources are exhaust fans; lawn movers, fans, vacuum cleaners, T.V, music systems, coolers, old installations and some kitchen appliances like grinders etc., generate significant amount of noise. It occurs mainly during religious festivals, fairs, marriages or public functions. Loud speakers generate huge noise pollution. In many developing countries, poor urban planning also plays a crucial role. Congested houses, poor parking facilities and regular fights over basic facilities leads to increase of noise pollution, which may disturb the environment of society (Rashid, 2013).

2.6.1.3 Plane source

A plane source can be described as follows: If a piston source is constrained by hard walls to radiate all its power into an elemental tube to produce a plane wave, the tube will contain a quantity of energy numerically equal to the power output of the source. In the ideal situation there will be no attenuation along the tube. Plane sources are very rare and only found in duct systems (Rashid, 2013).

2.7 Traffic Noise Pollution

Traffic noise is an important part of urban environment contributing about 55% to the entire urban noise (Pandya and Dharmadhikari, 2002). Road Traffic noise in many cities of the world has become one of the popular research areas among the environmental scientists. Population increase and the standard of living have led to rise in the number of vehicles on the roads. Apart from increase in new vehicles there is also increment in volume of vehicles becoming old. Old vehicles are the causes for huge noise emitting from outdated/poor standard engines. This is observed especially in case of buses, trucks, keke Napep, cars etc., it has also been observed that diesel vehicles take the major blame for the noise pollution. Recent research clearly demonstrates that road traffic has been the core source of annoyance. Due to congested roads and huge density of population in urban areas the noise levels are increasing everyday leading to a major and potential threat to urban life.

2.7.1 Effects of various factors on traffic noise pollution

Rapid increases in population and developed community anticipation in terms of environmental effects have created the prerequisite to provide environmental impact statement. Prophecy of traffic noise is more complex due to the facts that highways are not flat, straight or free from natural terrain variations (Murlikrishana and Murthy, 1983; Omidvari and Nouri, 2009). The factors like vehicle speed, traffic mix and density and number of lanes are not constant and they affect the density of noise. Therefore in case of traffic noise each of these parameters is taken into consideration. Traffic noise depends on the following factors:

i) Traffic parameters consist of vehicle volume, vehicle mix and average speed
ii) The characteristics of roads constitute pavement width, flow characteristics, gradient and surface finish
iii) Observer characteristics consist of observer distance, element size, shielding and observer relative height.
iv) Road surface and gradient for vehicles traveling on very rough or very smooth pavement, the basic noise level computations are adjusted upward or downward, depending on the case, by 5 dB.

2.7.2 Noise from individual vehicles

The main source of noise is the personal vehicle; the annoyance caused by the accrual of sound of individual vehicles in a traffic flow is called as traffic noise (Birgitta and Lindvall, 1995; Fidell *et al.*, 1995; Berge, 1994; Berry, 1983; Berglund *et al.*, 1975).

Noises from individual vehicles are categorized as follows:

i) Noise from engine and transmission: It depends on the design of the car and particularly on the method of support used for its moving parts. Expensive cars employ an elaborate damping system where the resultant sound wave is damped out and then it cannot be transmitted to the body and surroundings.
ii) Exhaust noise: This is the major cause of noise pollution in vehicles. Engine operation generates huge noise and in order to reduce it, muffler and other components are used in

exhaust system. Muffler reduces the energy of sound by increasing the distance travelled by the sound waves.

iii) Slamming of car doors: In old vehicles this problem is more prevalent because of the lack of rubber lining employed in car doors.

iv) Brake squeal: Brake squeal is particularly noticeable in modern day brakes although drum brakes also exhibit this phenomenon. The reason is that the vibration produced during the application of brakes resonates within the brake structure and is then further magnified by the body of the car.

v) Use of horn: All motor cars are fitted with horns. During busy traffic, these create huge and often unbearable noise pollution.

2.8 Effects of Noise Pollution

According to the report given by the World Health Organization (WHO, 2005) the third most hazardous type of pollution is noise pollution. It is a weightless form of pollution which interferes in day-to-day communication and disrupts our health (Prabhat and Nagarnaik, 2007; Pathak *et al*., 2008b; Agarwal and Swami, 2009).

WHO organized an International Program on Chemical Safety in 1994 and defined adverse effects of noise as, "The change in the morphology and physiology of an organism that results in impairment of functional capacity, or an impairment of capacity to compensate for additional stress, or increases the susceptibility of an organism to the harmful effects of other environmental influences." The effects on the organisms as defined above can be temporary or long lasting. A few of the effects of noise pollution are hearing impairment, disruption of communication, restlessness, sleep disorders and erratic behavior etc. All the above have adverse effects on our day to day life.

2.8.1 Effects of Noise Pollution on Humans

Being healthy does not just imply a disease-free life but also includes the total physical and psychological wellbeing of a person. Noise develops annoyance, irritation and fatigue in humans and it also causes disturbance in work, rest, sleep and communication patterns. Invariably, all these can lead to psychological problems rending the affected person incapable of leading a normal life. Therefore, noise can be rightly called a potential health hazard. The exponential growth in the noise pollution is a direct consequence of the advancement of technology. Duration of sound wave, intensity of wave, frequency of sound wave and the duration of exposure are few of the factors on which the harmful effects of noise pollution depend on.

The impacts of noise pollution on health can be studied in four aspects. They are

i) Physical effects such as, temporary or permanent hearing impairment.
ii) Physiological effects such as, respiratory problems, high BP, sleep apnea.
iii) Psychological effects such as emotional outrage etc.
iv) Performance related effects, such as decrease in one's efficiency (Onder and Kocbeker, 2012).

The affected people may have one or of the above listed effects (Miedem and Outshroon, 2001).

2.8.1.1*Physical effects*

Auditory effects: It includes hearing loss and speech interference, physiological effects include acoustical privacy. The most immediate and intense effect of noise pollution is hearing impairment. A sudden loud noise can cause some hearing loss that may become permanent. According to research, exposure to noise above 90 dB (A) can cause hearing impairment

(Thompson, 1996). Traffic in urban establishments is a major source of noise (Skanberg and Ohrstrom, 2002), with a wide range of effects on humans (Pandya, 2003).

Nelson and Abbott (1987), reported that auditory fatigue is caused by sounds over 90 dB (A) and permanent deafness is caused by sounds over 100 dB (A).

a) **Damage risk criteria:**

   As per Ward *et al.* (1986) the primary effect of noise is increase in hearing threshold. According to Audiometry, a temporary hearing loss is called "Temporary Threshold Shift", since the ear by nature tends to recover when the subject is shifted to peaceful environment. High exposure to noise or exposure in a minor interval may lead to "Noise Induced Permanent Threshold Shift".

b) **Noise induced hearing loss:**

   Detecting any sound in the audible range of frequency is defined as normal hearing. Decrease in the ability to hear as age increases is called "Prebycusis". Hearing sensitivity decreases as the frequencies fall below 100Hz. In addition to Prebycusis, exposure to noise decreased hearing sensitivity. This sort of hearing loss is known as "Noise Induced Hearing Loss". Exposure to noise is hazardous and can cause physical or psychological stress (Peng and Mayorga, 2008).

2.8.1.2 Physiological effects:

Noise Pollution can have complications as serious as of air or water pollution. Psychological, respiratory and BPM of the subject can be affected by it. Millions of industrial workers are at a potential threat of temporary or permanent hearing impairment. Prolonged exposure to noise can lead to chronic hypertensions or heart diseases.

a) Sleep disturbance

Sleep rejuvenates and revitalizes body and its functions. It is absolutely necessary for body to keep functioning. Noise causes disturbance in sleep patterns as it is difficult to sleep soundly in a noisy environment. Berry and Thiessen (1970) observed that frequency of initiation was lower for a spontaneous noise irrespective of its level but was more for the noise from trucks and aircraft flyovers. Lukas and Dobbs (1972) observed that sleep of children and young people less affected than middle or old aged peoples by the noise. Sleep disturbance is due to variations of noise levels from night to night and also reported that free flow of traffic at medium range of noise (47-60 dB (A)), caused an increase in the percentage of deep sleep along with an increase in the number of awakenings. Lukas and Dobbs (1972) observed that women were more sensitive to noise during sleep than men. Chakrabarty *et al*. (1997) conducted interviews of people living in buildings near the traffic junctions. From the subjectively judged sleep quality, it was found that 67.93% of the respondents had sound sleep, 27.15% had slightly disturbed sleep and 40.91% had severely disturbed sleep.

A reduction in the time of repairing sleep causes an increase in cortisol levels on the following day (Vgontzas *et al*., 1999; Ising *et al*., 2004). All studies reported a generalized long-term inability on the part of individuals to adapt to nocturnal noise, which may lead to cornification of cortisol overproduction (Maschke, 2002).

b) Effect of noise on task performance and cardio-vascular system:

Noise can act as a distracting stimulus and may also affect the psychological and clinical health of the individual. Additional strain on body, which is inducing by noise, is fatigue cause either directly or indirectly through hindrance with sleep. It has been reported that symptoms of mental disorder were more common among those who were very irritated by the noise exposure

(Tarnopolsky *et al*., 1978). Continuous exposure to noise causes constriction of blood vessels in humans, which may eventually lead to heart ailments (Lehmann and Tamm, 1956). The effect of pleasant and unpleasant sounds on physiological and biochemical functions of human volunteers. Health outcome deriving from long-term exposure to noise include both cardiovascular and respiratory events, a phenomenon that has been well documented by cohort studies undertaken in recent years (Hart *et al*., 2013).

c) Blood pressure

Noise pollution affects human's peace of mind. In addition to the existing vicissitudes in life, noise pollution further worsens our condition. It elevates blood pressure leading to ailments such as hypertension.

2.8.1.3 Psychological effects (non-auditory)

Behavioral changes are observed in both animals and humans. The undesired sound may cause annoyance. Intolerable agony may result when the source of the sound is not known. Interruption during speech may hamper the flow and efficiency of the speaker. It is also found that noise pollution is responsible for strains and tensions in the muscles. Noise pollution is also known to increase the rate of heartbeat, constriction of blood vessels, muscle constriction leading to nervous breakdown and tension. Fluctuations in arterial blood pressure decrease in heart output, decrease in the capability in distinguishing colors have been reported. Recent studies have shown the relation between noise and non-auditory effects. Common effects of noise pollution are irritability and sleeplessness. This stress may lead to heart diseases too. Noise pollution compromises the quality of life (Meidema and Outshroon, 2001). Repeated exposure to high level noises causes stress on nervous and auditory system (Subramani *et al*., 2012).

a) Annoyance

Annoyance is a feeling of displeasure caused by noise. Capacity of annoyance is dependent on many parameters such as personality, situation, frequency, activity, intensity, spectral characteristics intermittence and time of exposure. As annoyance reactions are also sensitive to social (non-acoustic factor), psychological or economic nature and so there are significant differences in individual response to the same noise. Vehicular movement and industrial noises are responsible for annoyance in urban areas. Annoyance can lead to many physical and psychological problems. In Visakhapatnam, Rao and Rao (1991) carried out a survey on people to elicit information about the effects of noise due to road traffic. They concluded that air horns of motor vehicles were particularly a single major factor contributing highly to noise pollution. Chakrabarty *et al*. (1998) also studied the relationship between the extent of annoyance of people and exposure to traffic noise in the city of Calcutta. Health study was done by (Mohan *et al*., 2000) showed that 30% of the subjects were extremely infuriated with traffic noise and especially people living near a distance of 30 mts distance are much annoyed due to traffic. Studies conducted by (Agarwal *et al.*, 2009) reported that 48.6% of the respondents had problems in sleep disturbance, 46% reported hypertension and 52% of subjects were suffering from regular irritation. Sleep disruption was also reported at night time by many (Goswami *et al*., 2011). Patil *et al*. (2011) reported utmost annoyance of 47% which was more during midday and afternoon, while 50% of subjects reported headache, nervousness and hearing difficulties due to severe noise pollution.

b) Behavioral effects

By lowering the auditory sensitivity of person, noise result in poor attention and concentration. Children studying in schools located at busy junctions show poor performance in studies. Noise can hamper learning abilities. Housewives working in kitchen often get headaches due to noise. Noises from TVs disrupt studies when at home.

d) Mental health

Experiments suggest mild disturbance in mental health such as anxiety, depression etc; but not severe psychiatric disorders.

2.8.1.4 Performance Related Effects

a) Effect of noise on speech communication

Humans can distinguish between different sounds. For example, one can distinguish between a person talking and ringing door bell simultaneously. This phenomenon is called Masking. Masking disrupt with communication, sometimes it is beneficial too.

b) Lack of concentration

Better concentration yields better results. Noise disrupts concentration levels. In cities noise due to vehicular and industrial movements disrupt concentration levels in individuals.

c) Fatigue

People cannot concentrate on their work when exposed to noise pollution. They tend to take extra time to complete an allotted task.

2.8.1.5 Effect of noise on wild life:

High levels of noise adversely affect not only human beings, but also animals. Animals and birds are forced to relocate to other places when exposed to high levels of noise. Many birds for example leave the place if it becomes too noisy and go elsewhere to nest. Migratory birds stopped migrating to noisy places during breeding period. Several birds have been observed to have stopped laying eggs. It was reported by the director of Delhi Zoological Park (Shastri and Trivedi 1988) that the zoo animals, particularly the deer, lions and rhinos, are worst affected by the noise. They become dull and inactive; their health deteriorates and their numbers do not increase. According to him, the psychological and ecological consequences of noise pollution may threaten the very existence of few species. In a survey in Malaysia, it was observed that grizzly bears, musk-oxen and kangaroo rats are falling victims to noise pollution. According to a study conducted by Environmental Protection Agency of Kualalumpur (Malaysia), the kangaroo rats have become more and more vulnerable to their predators - venomous rattlesnakes. The grizzly bears on other hand are said to be moving out of the area of their inhabitation in search of less noisy places. The noise affected their health, food habits and mating behavior.

Selye (1956) conducted extensive studies on the psychological effects of noise on animals. He exposed a group of hares to high levels of noise and observed the classic stress reaction tried viz., (1) Atrophy of thymus gland (2) growth of duodenal ulcers and (3) swelling and staining of the adrenal glands.

2.8.1.6 Effects on non-living things

High intense noise affects non-living thing too, viz., buildings. The crackers are also a major source of noise. Depreciation of the value of property for residential purpose near airports, and other noise prone areas also takes place as the noise generated there frequently interferes with speech and sleep patterns of the residents there. Thus, the effects of noise are of big concern even for non living things.

2.9 Noise Levels in Different Cities of the World

Mohammad *et al*. (2015) studied "Spatial Traffic Noise pollution Assessment – A Case study" GIS (Geographic Information System) is used to assess the traffic noise pollution in Tehran, Iran. Equivalent sound levels L_{eq} were measured for different days and different times of a week for 14 districts and 91 stations were selected and L_{eq} were measured three times in the morning (7:00-9:00 AM.), afternoon (12:00-3:00 PM.) and evening (5:00-8:00 PM.) on Saturday to Wednesday. Basij Highway recorded a high L_{eq} value of 84.2 dB (A) and minimum value of 59.9 dB (A) was recorded at Fajr Hospital. L_{eq} was higher compared to national standard limits at all stations. Use of sound walls on highways and widening of streets were recommended to reduce noise.

Eunice *et al*. (2014) in "Assessment of traffic related noise in three cities in the United States", observe that traffic related noise is a big health worry in developed and in developing countries. Noise measurements were done in Atlanta, Los Angeles and New York City. Ambient noise levels and also vehicle count were measured simultaneously and assessed the relationships between noise and traffic in all three cities in US. The significant variation in ambient noise levels measured in Atlanta (78%), New York City (62%) and Los Angeles (58%) was mainly due to increase in vehicles. Ambient noise levels measured in all three cities were interrelated with traffic data and traffic planning importance and noise related health effects.

Hassan and Alam (2013) studied "Traffic Noise Levels at Different Locations in Dhaka City" reported that noise emission is one of the most important concerns for a mega city like Dhaka. A large civil-structured project is being put into operation in Dhaka, which is well-known as Jatrabari- Gulistan flyover. The main aim for this research was to record and to analyze the noise levels in major intersections located at the study area as well as key locations such as hospital, educational institutions and religious institutions etc. during both day and night times for a week. Average noise level recorded at Jatrabari intersection during construction period was 92.7 dB (A) and 86.6 dB (A) during normal period. Noise indices such as L_{eq}, L_{10}, L_{50} and L_{90} have been predicted from field observations of noise levels. Noise levels were observed to be high above the permissible limits at all study locations.

Gavin *et al*. (2012**)** studied "Noise levels associated with urban land use";two study areas were selected using area geography, land use information, air photography and ground-truthing. The first study area is residential and the second is a mixed area which consists of commercial and institutions and these areas were further divided into six grids and locations were selected randomly. The locations were sampled four times over a 24 hr day. Mixed area showed higher values of noise compared to residential area. Both the areas exceeded higher values when compared to recommended noise levels when compared to WHO guidelines and leads to annoyance and sleep disturbance.

Mohammad *et al*. (2012) studied "Noise Pollution in Urban Environments: a Study in Yazd city, Iran"; in both residential and commercial areas a total of 135 samples were taken and the noise indices in the city was 71.2 ± 4.4, 66.2 ± 3.7 and 60.3 ± 4 for L_{10}, L_{50} and L_{90} respectively. The average equivalent noise levels showed a maximum (L_{max}) value of 74.3 dB (A) and a mean value of 66.7 dB (A). Creating awareness in public through educational programs and technical control for future growth of the city

Cristina and Cristian (2012) studied on "Review of Transport Noise Indicators" A critical analysis of the strengths and weaknesses of noise indicators are provided as well as discussing the framework and suggesting their best use. A classification is proposed supplemented by DPSIR approach (Driving forces, Pressures, States, Impacts and Responses) which assesses the cause-effect relationship between society and environment.

Muhammad *et al*. (2010) studied "Traffic Noise Pollution in Karachi, Pakistan" reported that maximum noise levels recorded from motorcycles and auto rikshaws without silencers and minibuses showed a value of 110 dB(A). The noise levels observed during peak rush hours between 01:00 to 03:00 pm and 05:00 to 07:00 pm showed maximum and was in the range of 110 dB (A) with decrease in value by 5-10 dB (A) during 05:00 to 07:00 pm. M.A Jinnah road (Merewether Tower & opposite K.M.C building) was the area where noise was more. The average noise levels at residential and commercial areas were found to 60 and 95.75 dB (A) respectively. The city of Karachi is facing a huge problem of exceedingly soaring levels of traffic.

Bavani and Ramdzani (2010) studied "Effect of Traffic Noise on Sleep: A Case study in Serdang Raya, Selangor, Malaysia" Field measurement were conducted to find the noise and questionnaire survey was conducted on residents to take their view and opinion on their sleep disturbance. The L_{Aeq} was more than the prescribed limits and contradictorily survey showed that the residents were not affected and got accustomed with these noise levels in their daily life as they were living there for last 19 years. Noise barriers should be constructed from preventing them to get chronic effects.

Ghatass (2009) studied "Assessment and Analysis of Traffic Noise Pollution in Alexandria City, Egypt". In Three main streets of the city (Elgish Street, Horreya Avenue and Circular Highway) in which thirty seven sampling locations were selected for noise measurement. The minimum noise levels were recorded were 58.4, 48.6 and 40.2 dB (A) respectively, while the maximum value was nearly 101 dB (A) at Elgish Street, Horreya Avenue and Circular Highway. The day-evening-night level (L_{DEN}) was used to calculate the annoyance. The average values of DEN and L_{DEN} were more precise if the day and night time is divided into three intervals. The noise levels (indices) L_{10} were 92, 88, 97 dB (A) at Elgish Street, Horreya Avenue and Circular Highway, respectively. The noise levels (indices) L_{90} (background noise) was 67, 62 and 57 dB (A) at the same streets. The noise level at three streets during the day and evening times were high when compared with the permitted limits according to Egyptian Environmental Law 4/94.

2.10 Impact of Various Parameters on Noise Levels

i) Traffic noise index (TNI)

To describe community noise, Traffic Noise Index (TNI) is used. The amount of variability in observed sound levels is taken into consideration by TNI. In order to improve the correlation between traffic noise measurements and subjective response to noise a pursuit is made by TNI and was proposed by (Griffiths and Langdon (1968); Schultz, 1972). In order to estimate the annoyance response due to traffic noise the TNI values were enumerated and the Value of TNI over 74 dB (A) (Scholes and Sergeant, 1971, Ma *et al*., 2006) is defined as the threshold of over criterion and the traffic noise index is defined by

$TNI = 4\,(L10 - L90\,) + L90 - 30\,dB\,(A)\,Where, L10 = 10$ percentile exceeded sound level $L90 = 90$ percentile exceeded sound level

All these are in dB and measured during 24 hours period.

ii) Noise Pollution Level (L_{np})

At times to describe community noise, which employs the equivalent continuous (A-weighted) sound level and the magnitude of the time fluctuations in levels Noise Pollution Level (L_{np}) is used. L_{np} was developed by Robinson in the late 60's (Schultz, 1972) and has a threshold value of 72 dB (A) (Scholes and Sergeant, 1971).

$L_{np} = L_{50} + (L_{10}-L_{90})^2/60 + (L_{10}-L_{90})$

iii) Noise Climate (NC)

Sound levels will be fluctuating over an interval of time and is assessed by the following formula. The range over which the fluctuations occur is known as Noise Climate (NC).

$NC = (L_{10}-L_{90})$

Where, L_{10} = 10 percentile exceeded sound level and L_{90} = 90 percentile exceeded sound level or background noise level which is present due to absence of traffic vehicular movement at the time of record.

iv) Traffic Volume (Q)

The level of noise varies directly proportional to the no. of vehicles on a road. Traffic volume is the total number of vehicles streaming on a road per hour.

v) Percentage of Heavy Vehicles (P)

The volume heavy vehicle consists of buses and trucks is called truck traffic mix ratio and the noise generated by them will be high when compared to light vehicles. It is oblivious that increase in number of heavy vehicles is an important factor for creating annoyance. This is particularly the case in the shift in the range between continuous noise and "just annoying noise events" (Stallen, 1999; Schultz, 1977; Scholes and Sergeant, 1971). Noise levels increase is observed with this ratio.

vi) Speed of Vehicle (V)

The vehicle is traveling within a range of limited speed, the noise produced is independent of speed and depends on the type of vehicle. Vehicle speed is taken as an average speed of all vehicles whose speed ranges between 20-50 km/hr.

vii) Road Conditions

One of the main reasons for increase in traffic noise pollution is condition of roads. Narrow roads, surface of the road and frequent road repair all lead to traffic congestion and thereby increasing noise

2.11 Noise Modeling

Traffic noise prediction models have been built and developed using various approaches. The method most widely adopted generally is classical multiple regression modelling. Till the end of 20^{th} century, much of the research in road traffic noise was focused on highways i.e., uninterrupted traffic flow conditions. Early traffic noise prediction models such as FHWA model and STAMINA are used in the USA and CoRTN in the UK.

Table 2.1 Different Model use around the world to predict noise level

Model Name	Country Name	Input Data
FHWA STAMINA	USA, Japan, Canada, Mexico	Traffic, Speed flow, Road and Environmental data
FHWA TNM VERSION 1.0	USA ,Canada	Traffic type, Flow, Speed, Whether interrupted, Road and Environmental data
CoRTN	UK, Australia, Hong Kong, NewZealand	Constant speed, Grades
STOP AND GO MODEL	Bangkok	Constant speed
RLS 90	Germany	Constant speed, Grades, Quasi intersections, Interruptions
ASJ-1993	Japan	Traffic type, Flow, Speed, Barrier Geometry
ERTC MODEL	Thailand	Traffic type, Flow, Speed and Barrier

2.11.1 Development of the mathematical models:

To predict noise levels in a satisfactory manner, a mathematical model needs to be developed using statistical information.

Mathematical model should be simple.

Data will be obtained easily.

Incorporate correct results according to the subjective insight of the noise.

2.11.2 Different models used in world to predict noise levels

The different noise prediction models used in different countries of the world to find equivalent noise levels (L_{eq}) is shown in the below Table 2.1 Based on the literature review, it is inferred that the building height and open space between arterial roads and buildings have not taken as input variables for traffic noise prediction models.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1. Preamble

The present study entitled "Assessment of Road Traffic noise in Minna Metropolis" was carried out in the city of Minna capital of Niger state, Nigeria. It was designed to assess the equivalent noise levels (L_e) and noise indices such as (L_{10}, L_{50} and L_{90}) for different location in Minna city which include Kpakungu, Mobil and Kure market. The noise produced by the mixed traffic were determined at this location while also determining the categories of the vehicle

3.2. Material required for this Research work

i) Sound level meter

ii) Stop watch

iii) Reflective jacket

3.3. Research Methods

In order to achieved the aims and objective, the following below was adopted

i) Study area Indication

ii) Study Approach

iii) Traffic count/ Observation of traffic

iv) Road traffic noise monitoring

v) Data proceeding

vi) Development of a model for the prediction of noise level

3.4 Study Area Indication

Minna is the capital of Niger State, and it is 162 km from Abuja the Federal Capital of Nigeria. Its climate lies between the Sahel and Guinea Savanna regions (that is the midland region). The dry season occurs between November and March while the rainy season is between April and October, with the peak rainfall in September.

The population in Minna was 60,000 in 1963, when the state was created. The population had increased to 122,031 in 1991 with a growth rate of 2.8%. There has not been a corresponding increase in industrial activities in the town. On the other hand, there has been an increase in the number of vehicles for personal and commercial use in the 39-town spread across Minna. Thus, the road traffic noise is expected to be a major source of pollution in the town

Figure 3.1 Study Area Location

3.5 Study Approach

The study at different areas was done by counting the number of vehicles (2 axle load, 3 axle load, 4 axle load light and heavy vehicles) along with continuous measurement of equivalent noise levels (L_{eq}) generated using calibrated sound level meter to capture the level of noise at different time of the day referencing the volume and type of vehicle at the same time and then predicting the noise levels by a model (Calixto).

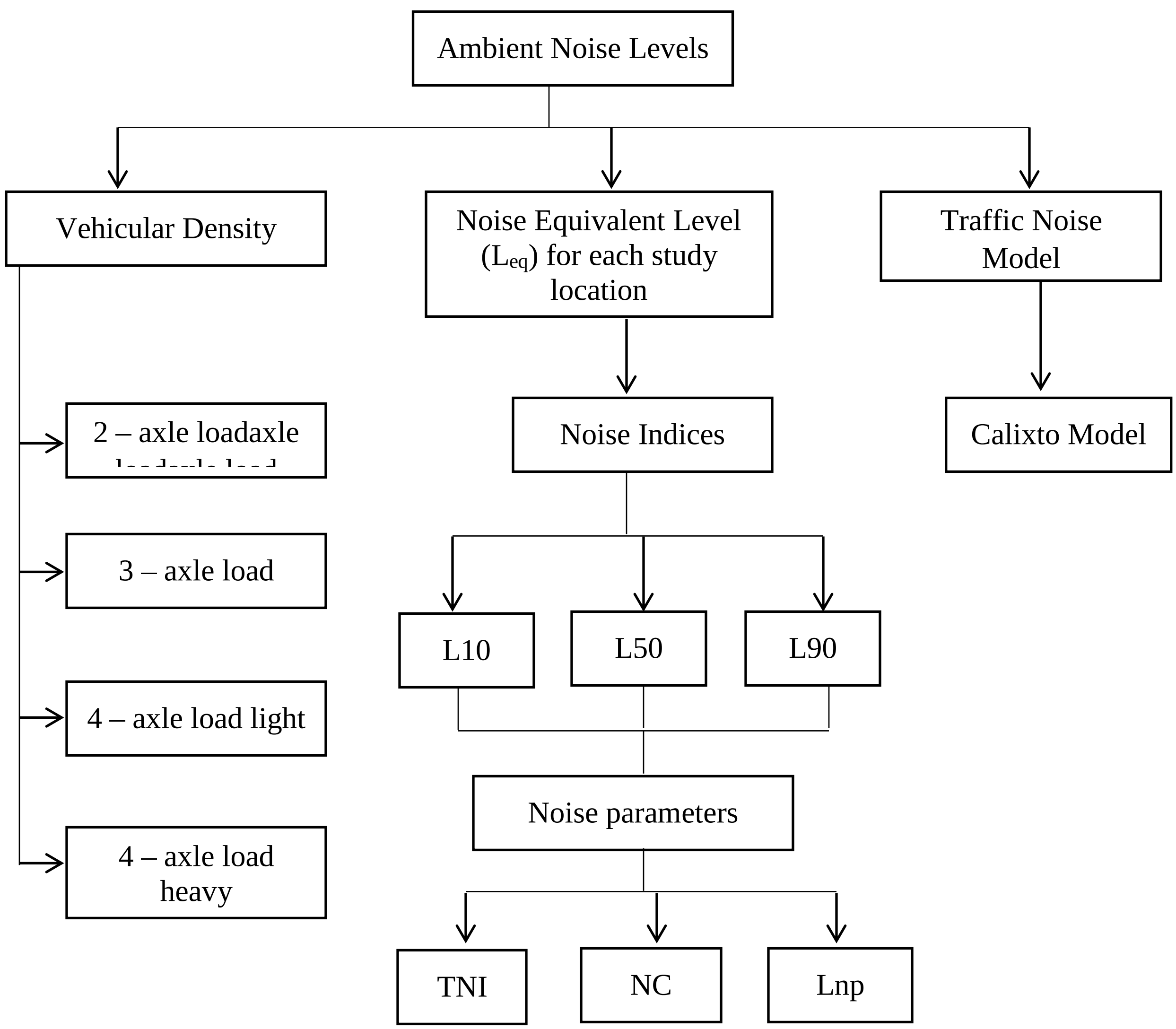

Figure 3.2 Flow chart of the research

3.6 Traffic Count

The volume of traffic at each study location of Kpakungu Mobil and Kure market was carried out within the hours of 7:30AM- 7:30PM for the duration of three (3) week at each location. The traffic count for Kpakungu was conducted from 16th of June 2020 to 7 of July 2020(3week), while that of Mobil and Kure Market were carried out on 5th of April 2021 to 26th of April 2021(3weeks)and 10th of May 2021 – 31 of May 2021(3weeks) respectively. The traffic count was conducted by counting the number of vehicles passing through a particular point on either side of the roadat an interval of every 0ne hour, the traffic volume was evaluated by classifying the vehicle into two axle loads like scooters, motorcycles, three axle loads like kekenapep, four axle load light vehicles like cars and heavy vehicles such as buses and trucks at all study locations. Each vehicle type count was recorded for the day and summary taking at day ends

3.7 Road Traffic Noise Monitoring

The study was conducted in Kpakungu, Mobil roundabout, and Kure market area in Minna city. The traffic noise level at each study location of Kpakungu Mobil and Kure market was carried out within the hours of 7:30AM- 7:30PM for the duration of three (3) week on each location. The traffic Noise for Kpakungu was carried out on 16th of June 2020 to 7 of July 2020(3week), while that of Mobil and Kure Market were carried out on 5th of April 2021 to 26th of April 2021(3week), and 10th of May 2021 – 31 of May 2021(3week), respectively. The noise levels were measured following standard procedure using calibrated sound level (dB) meter (ExtechSDL600 Sound Level Meter) by keeping the sound level meter on a tripod at a height of 1.2m in order to reduce errors due to reflection of sound from the body of investigator and the instrument was kept at 1m away from the roadside

3.7.1 Sampling of sound level meter

Sound level meter is a fundamental requirement for measuring the noise levels. It is designed to estimate the sensitivity level of loudness for the human ear and gives the desired, reproducible measurements for the sound pressure level. To determine the frequency range, spectral weighting of sound, along with the function of time constants, and computation of the equivalent continuous level the sound level meter does more complex work. The block diagram of sound level meter is shown in Figure 3.2 which consists of a micro phone which acts as a transducer to convert the sound into its equivalent electrical signal. The magnitude of the electrical signal is small which comes out of the microphone and then this low electrical signal is amplified by a pre amplifier and output of which is connected to a frequency weighting network "A" or "C" and the output of filter is again amplified and is then given to an microcontroller which has an analog to digital converter which converts the analog signal to digital and then the output is given to a averaging system for data storage facility and then we have display unit which displays the desired noise levels in digital.

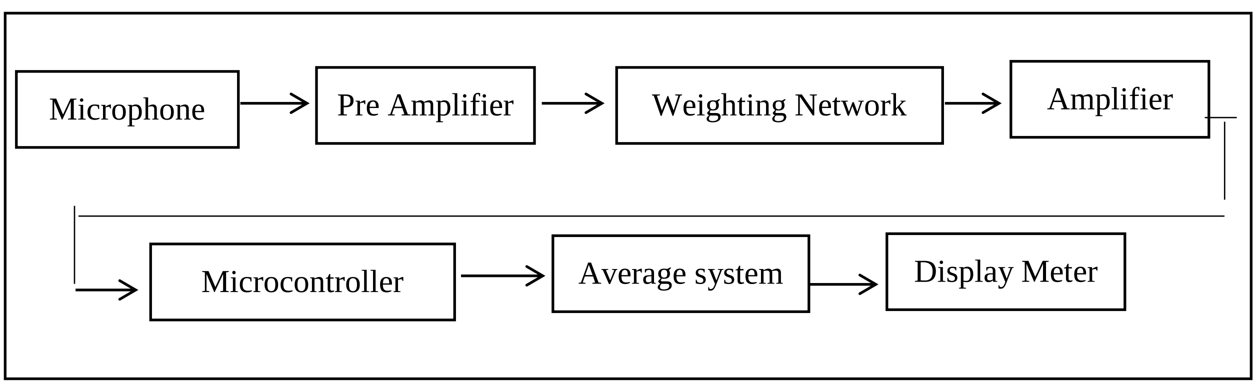

Figure 3.3: Operational diagram of sound level meter

Plate I: Sound Level Meter(SLM)

3.8 Data Processing

3.8.1 Noise descriptors

Noise descriptors such as L_{eq}, L_{10}, L_{50}, L_{90}, TNI (Traffic Noise Index), L_{np} (Noise Pollution Level), NC(Noise Climate), Q (Traffic volume) and P (Percentage of heavy vehicles) are assessed to reveal the amount of noise pollution created due to heavy traffic in these studied locations.

i) Noise index levels

The noise index for Kpakungu, Kure Market and Mobil was accesses by using statistical quantities for a given period of time interval. By means of the percent of time, certain noise levels exceed the time interval it is calculated. The notation for the statistical quantities of noise levels is described below

By integrating sound level meter, hourly L_{eq} values have been computed and measured in dB (A).

The sound level that has been exceeded "X" percent of time in a measurement period is defined in this way.

L_{10}: The levels which exceeded throughout 10% of the measuring time in dB (A), i.e. 10 percentile exceeded sound level (average peak level).

L_{50}: The levels which exceeded for the duration of 50% of the measuring time in dB (A), i.e. 50 percentile or median value of sound level).

L_{90}: The levels which exceeded all through 90% of the measuring time in dB (A), i.e. 90 percentile exceeded sound level (average background level)

ii) Noise level parameter

The noise parameter such as the Traffic Noise Index (TNI), Noise Pollution Level **(**Lnp), and Noise climate (NC) for Kpakungu, Mobil and Kure Market was access by using the following noise index observed. The parameter was accesss using the following equation

$$TNI = 4 (L_{10} - L_{90}) + L_{90} - 30 \text{ dB (A)} \tag{3.1}$$

$$L_{np} = L_{50} + (L_{10} - L_{90})^2/60 + (L_{10} - L_{90}) \tag{3.2}$$

$$NC = (L_{10} - L_{90}) \tag{3.3}$$

Where, L_{10} = 10 percentile exceeded sound level , L_{90} = 90 percentile exceeded sound level and L50= 50 percentile exceeded sound level.

3.9 Development of Model for the Prediction of Noise

A noise prediction model is required for predicting noise levels and helps in planning and design process creating a healthy noise free environment (Brown and Macdonald, 2003). To predict noise levels in a satisfactory a model needs to be developed using statistical information which should be simple and also data should be easily obtained. A statistical model will be developed in which percentage of heavy vehicles play a significant role in increase of road traffic noise. Calixto model is used for road traffic noise in an urban setting (Calixto *et al*., 2003). We calculate a weighting factor (n) which is varying from 4 to 10 gives the weightage of presence of heavy vehicle in road traffic noise emission for Nigeria road conditions in our present study the weighing factor (n) is taken as 10. The validation of the above developed model (Calixto) is then verified for validation by R^2 value and then found appropriate for Indian road conditions. Regression equations were also found between vehicles and observed Leq. A set of regression equations were found between the observed and calculated Leq for all study locations and a value of R^2 was found.

3.9.1 Calixto Model

The total sum of vehicles is always the combination of light vehicles which comprises of motorcycles, scooters, auto rikshaws and cars and heavy vehicles. A heavy vehicle produces more sound when compared to light vehicle when it passes on the road during a certain time interval under speed considerations a model is developed to predict/calculate equivalent noise levels for Nigeria road conditions. Calixto model is best suited model for Indian roads, in this survey, a factor, n, has been considered for such vehicles, so that an equivalent value could have been achieved for the traffic flow, *Q*eq. By considering *Q* as the real hourly vehicle flow, VP as the percentage of heavy vehicles and n as the weighting factor, we get:

$$Qeq = Q\ (1 + n \times VP/100) \qquad (3.4)$$

So, the term 10 log (*Q*eq) will be transformed into

$$10 \log [Q\ (1+n \times VP/100)]. \qquad (3.5)$$

The factor value, *n*, will have to have a certain value that results in the largest correlation coefficients between the noise levels and this factor

$$10\log[Q(1+n \times VP/100)]. \qquad (3.6)$$

By varying the factor from 4 to10, the largest correlation coefficients between Leq and the above term

Mathematically, the curve can be represented by:

$$Y=a*x+k \qquad (3.7)$$

By applying the variables on the straight

line equation, we get:

$$Leq = a*10\log [Q\ (1+n*VP/100)] +k\ (3) \qquad (3.8)$$

Where 'n' is the weighting factor and the values of constants 'a' and 'k' was found after the statistical methods of linear regression

Since heavy vehicle is responsible for stronger noise than a light vehicle, a factor n has been taken into account for such vehicles. In Calixto model by considering Q as real hourly vehicle flow, VP as the percentage of heavy vehicles and n as weighting factor, Q_{eq} is given by following equation

$$Q_{eq}=Q(1+n \times VP/100) \qquad (3.9)$$

And the term $10\log(Q_{eq})$ will be transformed into

$$10\log[Q(1+n\times VP/100)] \quad (3.10)$$

Weighting factor n is calculated by using largest correlation coefficient between observed L_{eq} values given in table 4.9, 4.10 and 4.11and the factor given by equation and foundn = 10.

$$L_{eq}= 10\log[Q(1 + 10 \times VP/100)] \quad (3.11)$$

Using the observed data, a new model with weighting factor n = 10 has been developed by calibrating Calixto model. Microsoft excel spread sheet has been used for estimating the L_{eq} values using equation (3). The estimated L_{eq} values were then compared with observed L_{eq} values to get the regression equation as follows

$$L_{eq}=14\log[Q(1+0.1\times VP)]+12.5976 \quad (3.12)$$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Traffic Count

4.1.1 Traffic count for kpakungu

Presented in Table 4.1 is the summary result of the average daily traffic count conducted at Kpakungu from the 16th of June 2020 – 7 of July 2020, also shown in Figure 4.1 is the graphical representation of the average daily traffic count.

Table 1: Average hourly traffic Volume for Kpakungu

Time(AM - PM)	Motorcycle	Tricycle	Cars,	Bus	HV
7:27:30 -7:57:29	452	211	435	10	45
7:57:29 -8:27:29	500	398	456	20	90
8:27:29- 8:57:29	328	210	302	5	38
8:57:29 -9:27:29	554	380	420	19	52
9:27:29 -9:57:29	550	320	400	10	80
9:57:29 -10:27:29	590	350	550	10	85
10:27:29-10:57:29	535	310	340	10	45
10:57:29-11:27:29	465	301	325	10	40
11:27:29-11:57:29	545	225	375	10	60
11:57:29-12:27::29	600	375	300	30	90
12:27:29-12:57:29	700	400	520	10	65
12:57:29 -13:27:29	650	354	456	8	55
1:27:29 -1:57:29	340	200	300	5	62
1:57:29 -2:27:29	345	210	265	10	80
2:27:29 -2:57:29	300	200	265	8	87
2:57:29 -3:27:29	406	210	365	6	100
3:27:29 -3:57:29	384	210	300	10	45
3:57:29 -4:27:29	400	325	350	9	15
4:27:29 -4:57:27	648	350	420	30	65
4:57:29 -5:27:29	695	350	565	45	70
5:27:29 - 5:57:29	710	585	710	130	90
5:57:29 -6:27:29	612	456	526	10	60
6:27:29 -6:57:29	535	308	450	15	95
6:57:29 -7:27:29	745	458	589	15	89
Total	12589	7696	9984	445	1603

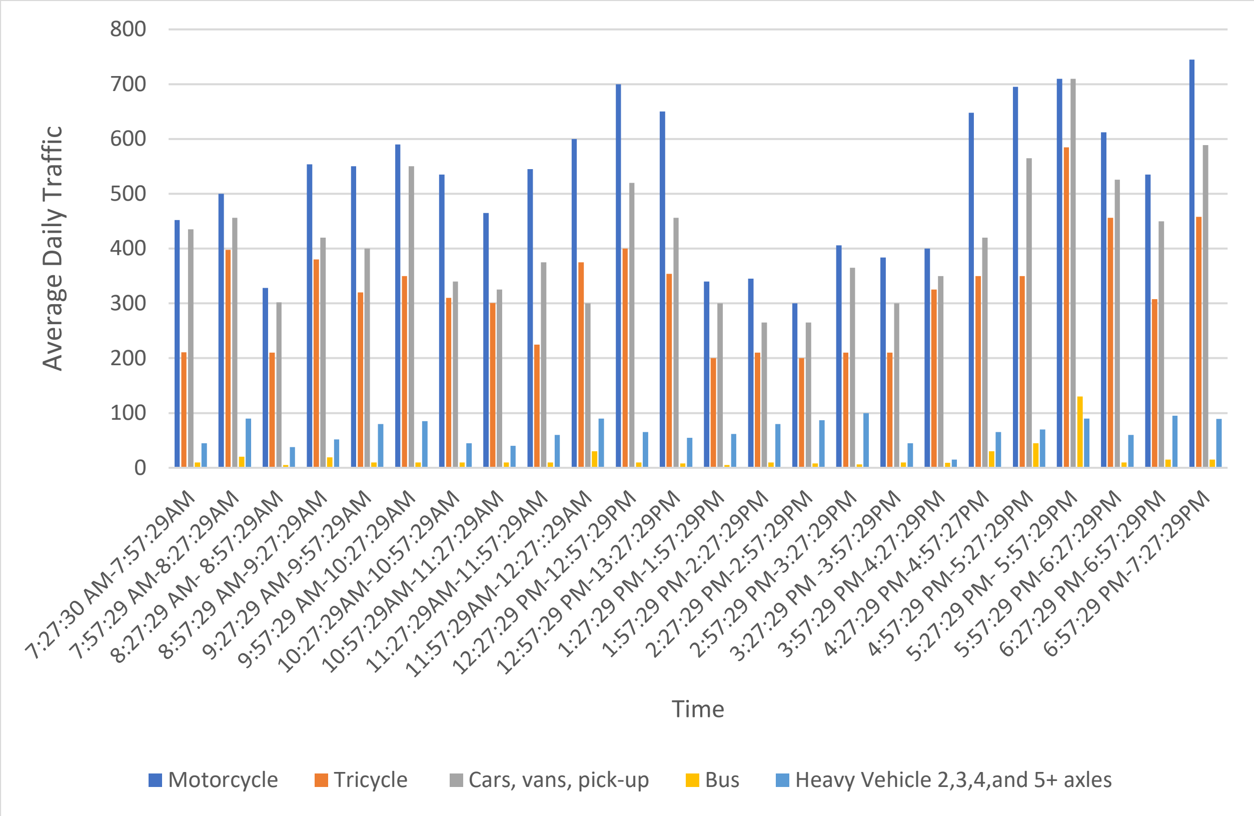

Figure 4.1: Average daily traffic for Kpakungu

It was observed from Table 4.1 and Figure 4.1 that motorcycle has the highest volume of 12,589veh/day in terms of number and is closely followed by car, van and pick up categories of 9,984veh/day, then followed by tricycle, heavy vehicle and bus with their respective value of 7,696veh/day 1,603veh/day and 445veh/hr. It is also observed that the road is congested throughout the day due to the fact that it an interstate road and the volume of vehicle per day exceed the specification for township road which state that the average traffic volume for township single carriageway should not exceed a threshold value ranging between 8,000-10,000veh/day where the percentage of truck traffic exceeds 15 percent.

4.1.2 Traffic count for Kure market

Presented in Table 4.2 is the summary result of the of the average daily traffic count conducted at Kure Market from the 5th of April 2021 – 26th of April 2021, also shown in Figure 4.2 is the graphical representation of the average daily traffic count

Table 4.2: Average daily traffic Volume for Kure Market

Time(AM - PM)	Motorcycle	Tricycle	Cars,	Bus	HV
7:27:30 -7:57:29	410	315	396	13	15
7:57:29 -8:27:29	486	398	456	20	15
8:27:29- 8:57:29	328	210	302	5	12
8:57:29 -9:27:29	455	380	420	19	10
9:27:29 -9:57:29	550	320	400	10	9
9:57:29 -10:27:29	590	350	550	10	11
10:27:29-10:57:29	521	352	514	15	14
10:57:29-11:27:29	570	310	430	21	5
11:27:29-11:57:29	610	300	420	30	14
11:57:29-12:27::29	655	530	630	10	12
12:27:29-12:57:29	640	482	550	20	17
12:57:29 -13:27:29	670	350	580	5	12
1:27:29 -1:57:29	680	375	520	25	20
1:57:29 -2:27:29	710	535	520	25	10
2:27:29 -2:57:29	800	320	610	15	12
2:57:29 -3:27:29	406	210	365	6	19
3:27:29 -3:57:29	384	210	300	10	17
3:57:29 -4:27:29	648	350	420	30	12
4:27:29 -4:57:27	860	400	785	25	12
4:57:29 -5:27:29	605	350	510	30	18
5:27:29 - 5:57:29	980	430	730	28	16
5:57:29 -6:27:29	1033	520	842	34	18
6:27:29 -6:57:29	989	458	689	15	25
6:57:29 -7:27:29	899	512	685	15	14
Total	15479	8967	12624	436	339

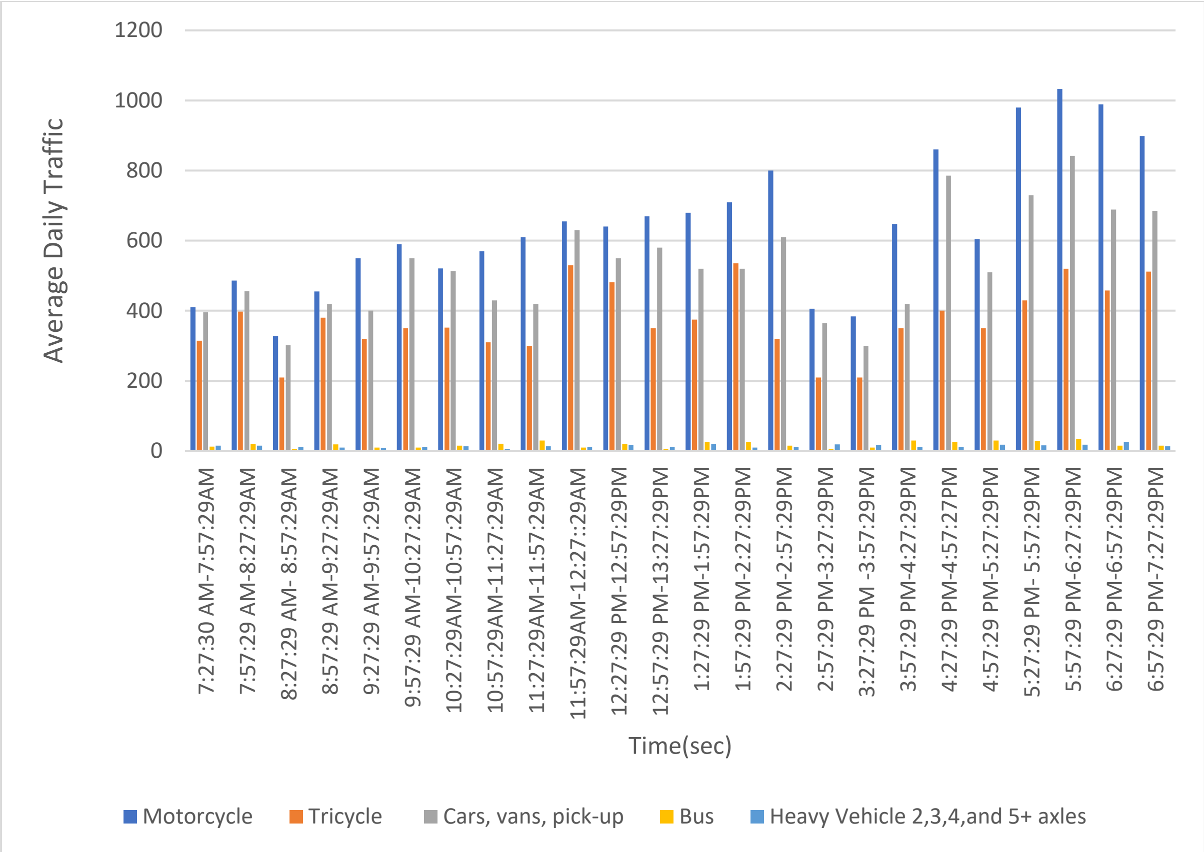

Figure4.2 Average daily traffic for Kure Market

The result of Traffic count for Kure market is presented in Table 4.2. the observed average traffic count volume for 3week count at Kure market from 5th of April 2021 – 26th of April 2021 shows that motorcycles has the highest volume of 15,479veh/day while cars vans and pick up has 12,624veh/day, closely followed by tricycle, bus and heavy vehicle with 8,967veh/day, 4,36veh/day and 339veh/day respectively. Figure 4.3 also shows a defined congestion period at for afternoon and evening. Afternoon traffic congestion period starts from 12:30AM to 3:00PM while Evening congestion period falls within 4:30PM to 7:30PM. The volume of vehicle per day exceed the specification for township road which state that the average traffic volume for township single carriageway should not exceed a threshold value ranging between 8,000-10,000veh/day where the percentage of truck traffic exceeds 15 percent.

4.1.3 Traffic count for Mobil

Presented in Table 4.3 is the summary result of the of the average daily traffic count conducted at Kure Market from the 10th of May 2021 – 31th of May 2021, also shown in Figure 4.3 is the graphical representation of the average daily traffic count

Table 4.3: Average daily traffic volume for Mobil

Time (AM - PM)	Motorcycle	Tricycle	Cars,	Bus	HV
7:27:30 -7:57:29	500	398	456	20	4
7:57:29 -8:27:29	328	210	302	5	7
8:27:29- 8:57:29	555	380	420	19	8
8:57:29 -9:27:29	568	386	489	15	7
9:27:29 -9:57:29	525	300	425	10	10
9:57:29 -10:27:29	600	384	510	10	15
10:27:29-10:57:29	389	250	325	5	8
10:57:29-11:27:29	590	350	450	10	2
11:27:29-11:57:29	585	321	480	7	4
11:57:29-12:27::29	745	458	542	15	8
12:27:29-12:57:29	806	401	650	10	4
12:57:29 -13:27:29	485	281	475	5	8
1:27:29 -1:57:29	590	389	430	6	2
1:57:29 -2:27:29	850	410	540	10	5
2:27:29 -2:57:29	485	281	475	5	7
2:57:29 -3:27:29	590	389	450	6	8
3:27:29 -3:57:29	850	400	540	10	4
3:57:29 -4:27:29	589	350	510	15	4
4:27:29 -4:57:27	650	400	465	15	5
4:57:29 -5:27:29	550	401	500	10	1
5:27:29 - 5:57:29	744	495	682	20	4
5:57:29 -6:27:29	756	308	450	15	5
6:27:29 -6:57:29	854	458	654	15	10
Total	14184	8400	11220	258	140

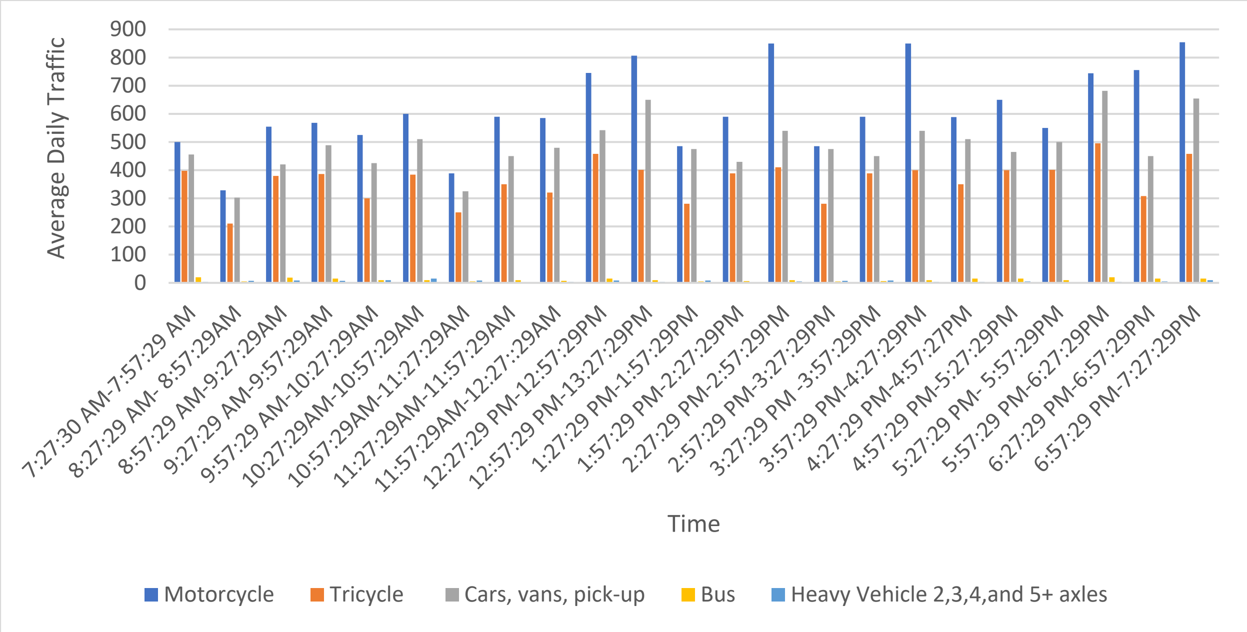

Figure 4.3: Average daily traffic for Mobil

The result of traffic count for Mobil is presented in Table 4.3. the observed average traffic count volume for 3week count at Mobil from10th of May 2021 – 31th of May 2021 shows that motorcycles has the highest volume of 14,184veh/day while cars vans and pick up has 11,220veh/day, closely followed by tricycle, bus and heavy vehicle with 8,400veh/day, 258veh/day and 140veh/day respectively. Figure 4.5 also shows a defined congestion period at for morning and evening. Morning traffic congestion period starts from 7:30AM to 9:00AM while Evening congestion period falls within 4:30PM to 7:30PM. The volume of vehicle per day exceed the specification for township road which state that the average traffic volume for township single carriageway should not exceed a threshold value ranging between 8000-10000veh/day where the percentage of truck traffic exceeds 15percent.

4.2 Average Hourly noise level

4.2.1 Average hourly noise level at Kpakungu

Presented in Figure 4.4 is the graphical representation of the average hourly noise level from the 16th of June 2020 – 7 of July 2020 at Kpakungu.

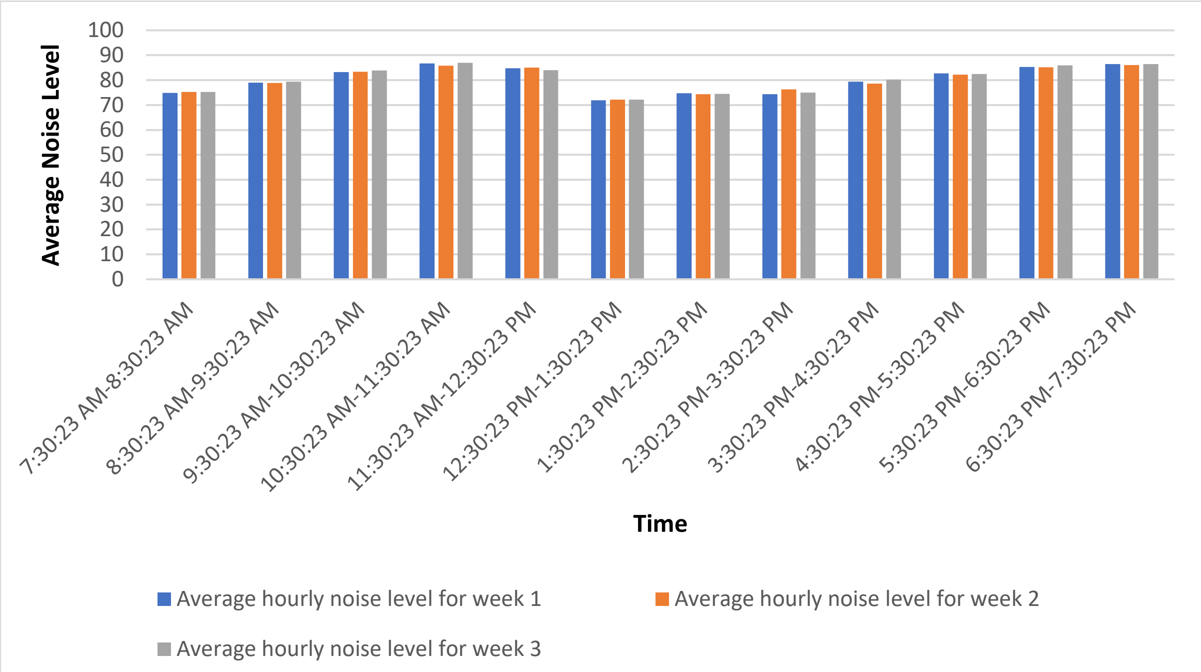

Figure 4.4: Average hourly weekly noise level at Kpakungu

The result of the average hourly noise level for week 1, 2, and 3 at Kpakungu are presented in Figure 4.7. it can be observed that there is a rise in the noise level from the morning period of 8.30 AM to afternoon period of 12.30PM due to the increase in activities such as increase in vehicular movement which lead to increase in horn from vehicle and load Music from vendor, there's also a slight fall in the noise level between the hours of 12.30PM to 4.30PM due to a decrease in the vehicle movement. Then a rise during the evening due to increase in vehicular activities from the commuters coming back from work, school and market

4.2.2 Average hourly noise level at Kure Market

Presented in Figure 4.5 is the graphical representation of the average hourly noise level from the 16th of 5th of April 2021 – 26th of April 2021 at Kure Market.

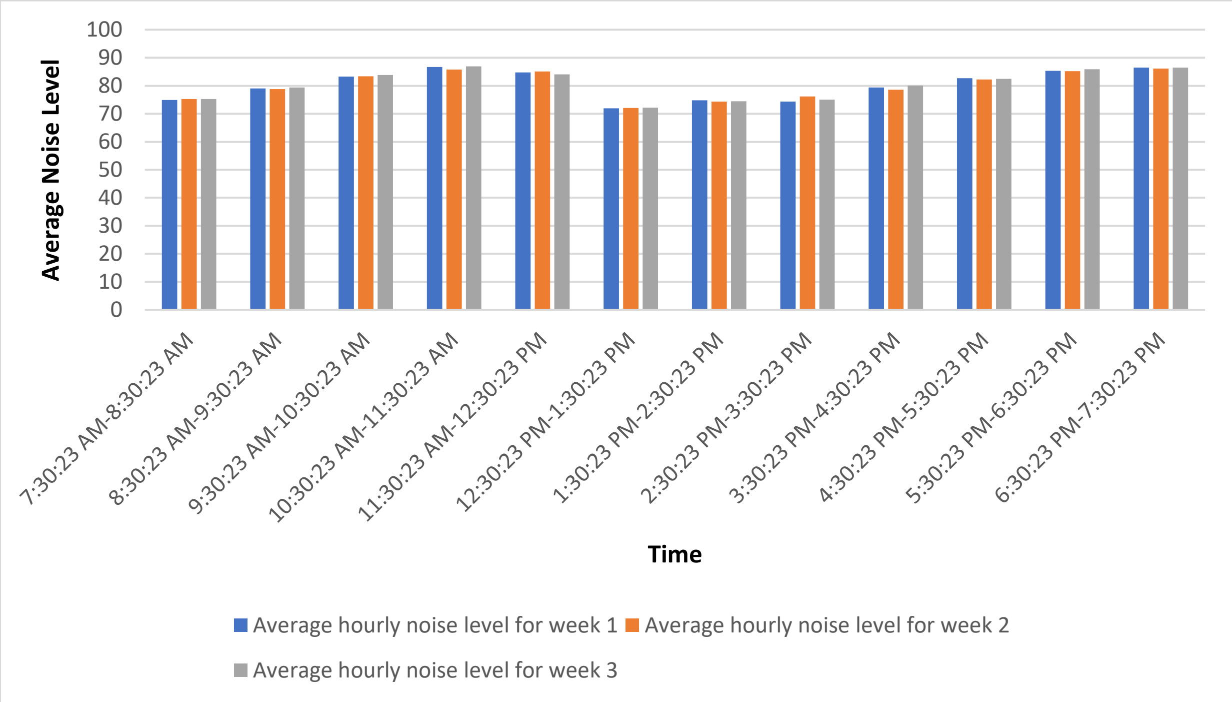

Figure 4.5: Average hourly weekly noise level at Kure Market

The result of the average hourly noise level for week 1, 2, and 3 at Kure market are presented in Figure 4.8. it can be observed that there is a rise in the noise level from the morning period of 8.30AM to afternoon period of 12.30PM due to the increase in activities such as increase in vehicular movement which lead to increase in horn from vehicle and load Music from vendor, there's also a slight fall in the noise level between the hours of 12.30PM to 3.30PM due to a decrease in the vehicle movement. Then a rise during the evening due to increase in vehicular activities from the commuters coming back from work, school and market.

4.2.3 Average hourly noise level at Mobil

Presented in Figure 4.6 is the graphical representation of the average hourly noise level from the May 2021 – 31th of May 2021 at Mobil.

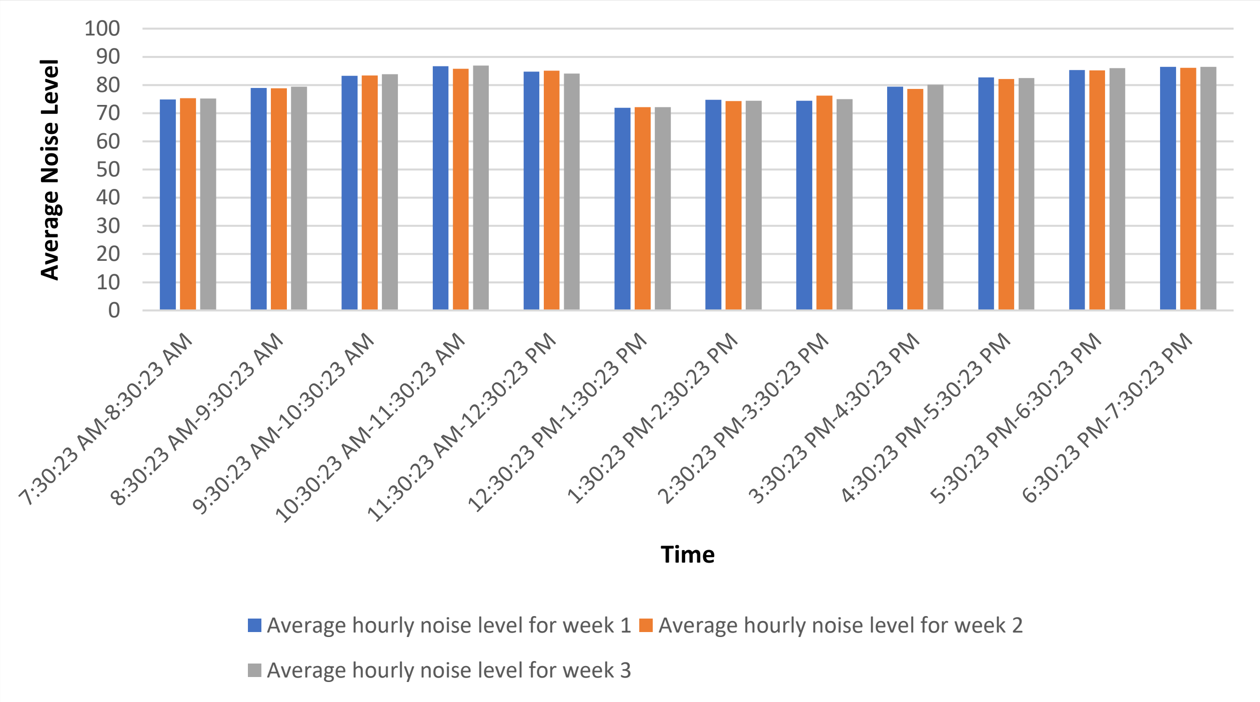

Figure 4.6: Average hourly weekly noise level at Mobil

The result of the average hourly noise level for week 1, 2, and 3 at Mobil are presented in Figure 4.9. it can be observed that there is a rise in the noise level from the morning period of 8.30AM to afternoon period of 12.30PM due to the increase in activities such as increase in vehicular movement which lead to increase in horn from vehicle and load Music from vendor, there's also a slight fall in the noise level between the hours of 12.30PM to 3.30PM due to a decrease in the vehicle movement. Then a rise during the evening due to increase in vehicular activities from the commuters coming back from work, school and market

Table 4.7 Average Hourly Noise level for study location

Time	Average hourly noise level at Kpakungu	Average hourly noise level at Mobil area	Average hourly noise level at kure market
7:30:23 AM-8:30:23 AM	71.32	75.12	71.46
8:30:23 AM-9:30:23 AM	78.42	79.12	76.78
9:30:23 AM-10:30:23 AM	83.49	83.34	80.00
10:30:23 AM-11:30:23 AM	86.79	86.33	82.99
11:30:23AM-12:30:23PM	87.29	84.56	84.56
12:30:23 PM-1:30:23 PM	84.28	72.05	85.75
1:30:23 PM-2:30:23 PM	76.51	74.55	76.89
2:30:23 PM-3:30:23 PM	73.21	75.11	73.11
3:30:23 PM-4:30:23 PM	74.37	79.31	76.32
4:30:23 PM-5:30:23 PM	76.46	82.49	78.49
5:30:23 PM-6:30:23 PM	79.81	85.28	82.61
6:30:23 PM-7:30:23 PM	82.18	86.35	85.68

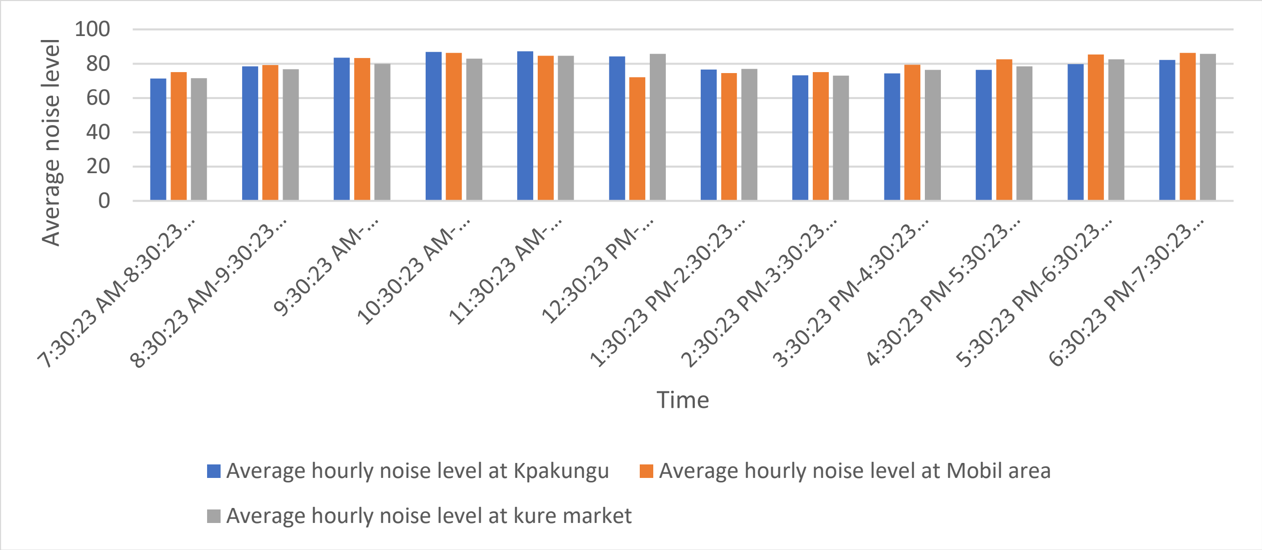

Figure 4.7: Average hourly noise fluctuation level for all the Study location

4.3 Average Noise Levels for Different Study Locations

From Table 4.7For kpakungu area, the minimum value of 71.32 and 73.21 is seen during the 7.30am-8.30am and 2.30am-3.30am respectively due to less activity and maximum value of 87.29 at 11.30-12.30pm due to more activities shouting of vender, horn and increase in the vehicular flow. The minimum value of 72.5 is seen during the 12.30-1.30pm due to lesser activities and maximum value of 86.5 during the 6.30-7.30pm due to increase in vehicular flow and more activities for Mobil area

The area of Kure market shows a minimum of 71.9 and 73.1 during the morning period of 7.30-8.30am and 2.30pm-3.30pm due to less traffic, rain and shouting of vendors and a maximum value of 85.5 during the evening period of 6.30pm-7.30pm due to increase in vehicular flow, which are all above the prescribed permissible ambient noise level standard of the standards as given by the National Environmental Standard and Regulation Enforcement Agency.

4.4 Noise Indices L_{10}, L_{50} And L_{90} At Study Location(S)

Table 4.8 Noise Indices during the Morning, afternoon and evening peak hour for

Study location	Monitoring Time period (Peak hour)	L10	L50	L90	TNI	NC	Lnp
Kpakungu	Morning	87.13	83.49	74.16	95.50	12.97	85.40
	Afternoon	83.43	76.50	73.60	77.30	9.83	99.10
	Evening	81.40	78.13	74.90	79.30	6.50	87.83
Mobil	Morning	85.92	83.70	76.92	88.92	9.00	95.65
roundabout	Afternoon	82.66	75.90	73.26	80.86	9.40	86.77
	Evening	86.04	83.75	80.25	73.40	5.79	90.11
Kure	Morning	84.00	80.00	73.00	85.50	11.0	93.10
market	Afternoon	85.00	76.89	74.16	88.30	11.0	89.90
	Evening	85.00	80.50	76.00	82.00	9.00	90.83

Kpakungu, Mobil roundabout and Kure market

4.4.1Noise indices at Kpakungu

The value of the indices such as L10, L50 and L90 were studies for 12hour at Kpakungu area is shown in Figure 4.11. The value L10 for 12hr shown maximum value 87.13 during the morning followed by 83.4 during the Afternoon and minimum value 81.93 during the evening

The L50 value for 12hr show the same with the minimum during the afternoon and maximum during the morning and evening hours

In the case of the background noise L90 for 12hr show that both morning and afternoon have afternoon have maximum value of 74.16 and 74.9 respectively and a minimum of 73.6 was seen during the afternoon.

4.4.2 Noise indices at kure market

The value of the indices such as L10, L50 and L90 were studies for 12hour at kure market area is shown in Figure 4.11. The value L10 for 12hr shown maximum value 85 during the afternoon followed by 85 during the evening and minimum value 84 during the morning. The L50 value for 12hr show the minimum value 76.89 during the afternoon and maximum value 80 and 80.5 during the morning and evening hours

In the case of the background noise L90 for 12hr show that both afternoon and evening have maximum value of 74.16 and 76 respectively and a minimum of 73 was seen during the morning.

4.4.3 Noise indices at mobil area

The value of the indices such as L10, L50 and L90 were studies for 12hour at Mobil roundabout area is shown in Figure 4.11. The value L10 for 12hr shown maximum value 85.92 during the morning followed by 86.05.4 during the evening and minimum value 82.66 during the afternoon

The L50 value for 12hr show the same with the minimum during the afternoon and maximum during the morning and evening hours

In the case of the background noise L90 for 12hr show that both morning and evening have maximum value of 76.92 and 80.25 respectively and a minimum of 73.26 was seen during the afternoon.

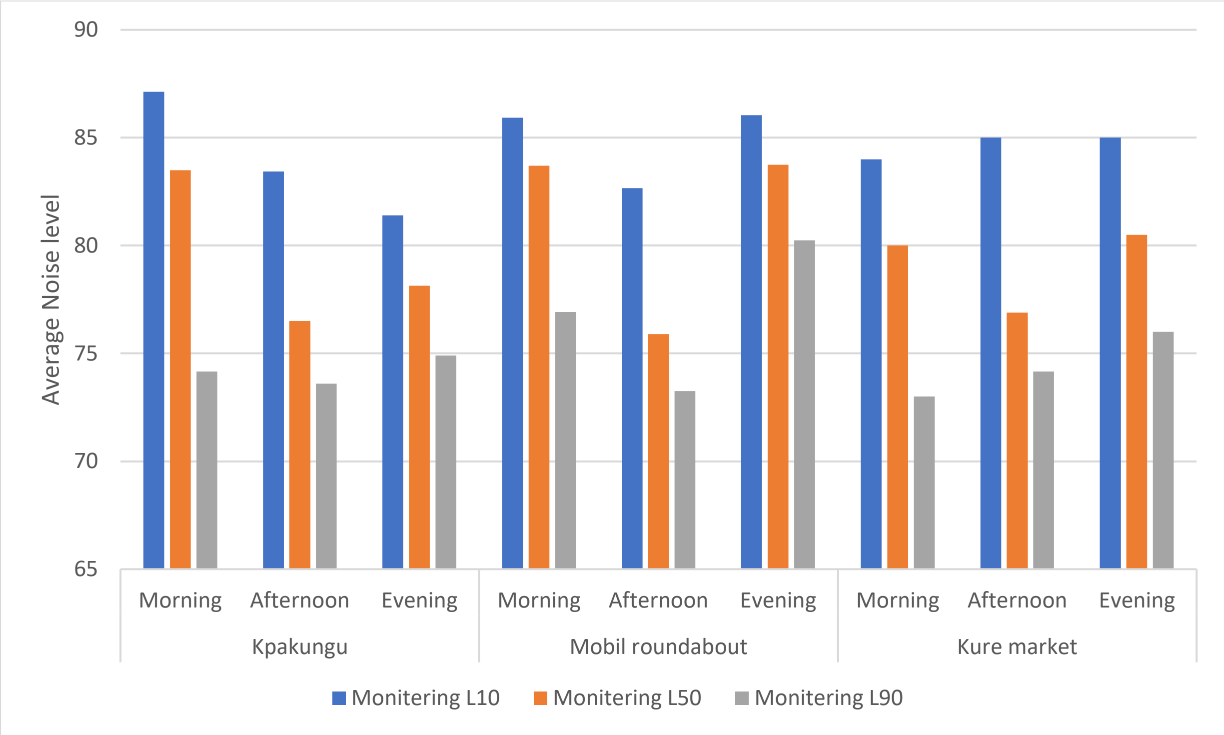

Figure 4.8.Noise indices L10, L50 and L90 variation for all the study area

4.5 Noise Parameters TNI, NC and L_{np} at Study Location(s)

4.5.1 Noise parameter at Kpakungu

The different noise parameters such as TNI, NC and L_{np} at the study location of kpakungu is shown in Figure 4.12. Traffic Noise Index (TNI) is a parameter which indicates the degree of variation in a traffic flow expressed in dB (A) and depends upon the different noise Indices. The TNI showed a minimum value of 77.3 dB (A) during afternoon period and maximum of 95.5dB (A) and 79.3 during the morning and evening period.

The Noise Climate (NC) provides the range over which the sound levels fluctuate in an interval of time and expressed in dB(A) which also depends upon noise indices. The NC varied between 8.35- 12.84 dB.

The Noise Pollution Level (L_{np}) has a threshold value of 72 dB (A) (Scholes and Sargeant, 1971).The L_{np} showed a minimum value of 85.4 dB (A) during morning and maximum value of 99.1 dB (A) and 87.83 dB (A) during the morning and afternoon respectively. From the study it is clear that both TNI and L_{np} showed higher values when compared to the threshold values.

4.5.2 Noise parameter at kure market

The different noise parameters such as TNI, NC and L_{np} at the study location of kure market area is shown in Figure 4.12. Traffic Noise Index (TNI) is a parameter which indicates the degree of variation in a traffic flow expressed in dB (A) and depends upon the different noise Indices. The TNI showed a minimum value of 82.0 dB (A) during evening period and maximum of 85.5dB (A) and 88.3 during the morning and afternoon period. The Noise Climate (NC) provides the range over which the sound levels fluctuate in an interval of time and expressed in dB(A) which also depends upon noise indices. The NC varied between 9.00-11 dB.

The Noise Pollution Level (L_{np}) has a threshold value of 72 dB (A) (Scholes and Sargeant, 1971).The L_{np} showed a minimum value of 89.9 dB (A) during afternoon and maximum value of 93.1 dB (A) and 90.83 dB (A) during the morning and evening respectively. From the study it is clear that both TNI and L_{np} showed higher values when compared to the threshold values.

4.5.3 Noise parameter at mobil area

The different noise parameters such as TNI, NC and L_{np} at the study location of Mobil area is shown in Figure 4.12. Traffic Noise Index (TNI) is a parameter which indicates the degree of variation in a traffic flow expressed in dB (A) and depends upon the different noise Indice. The TNI showed a minimum value of 73.2 dB (A) during evening period and maximum of 88.92 dB (A) and 80.86 during the morning and afternoon period respectively. The Noise Climate (NC) provides the range over which the sound levels fluctuate in an interval of time and expressed in dB(A) which also depends upon noise indices. The NC varied between 5.8-10.0 dB.

The Noise Pollution Level (L_{np}) has a threshold value of 72 dB (A) (Scholes and Sargent, 1971). The L_{np} showed a minimum value of 86.77 dB (A) during the afternoon and maximum value of 95.05 dB (A) and 90.11 dB (A) during the morning and evening respectively. From the study it is clear that both TNI and L_{np} showed higher values when compared to the threshold values.

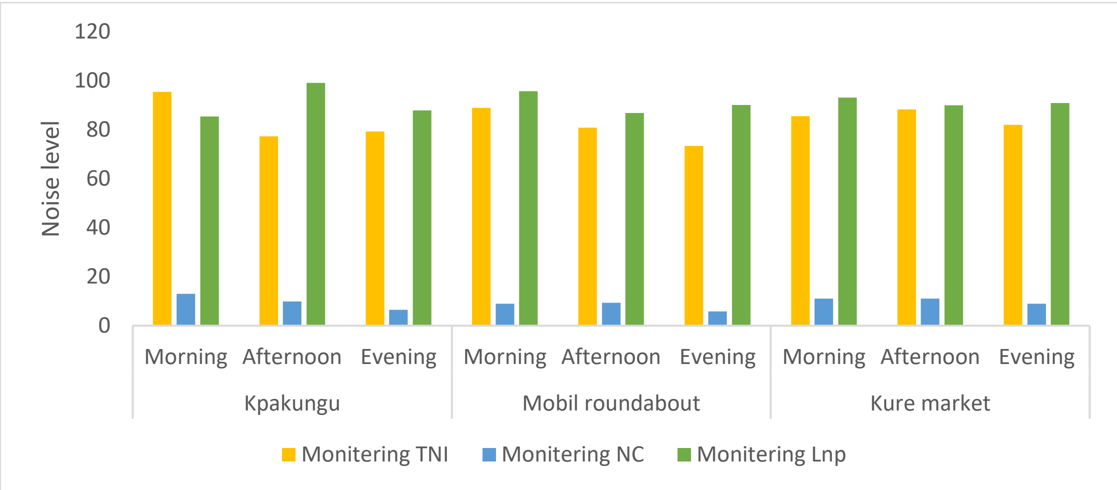

Figure4.9 Noise parameters TNI, NC and Lnp variation for all the study area

4.6 Model Equation Result

4.6.1 Observed noise level vs predicted noise level leq at kpakungu

Table 4.9: Observed and the predicted noise level at Kpakungu

Time	Total No. of Vehicles/hour (Q)(No)	No. of heavy vehicles (HV)(No)	Percentage of Heavy Vehicles (VP)(%)	Observed Noise level(dB)	Predicted noise level(dB)
7:30:23 AM-8:30:23 AM	20838	95	0	71.33	72.73
8:30:23 AM-9:30:23 AM	53423	1286	2	78.42	79.47
9:30:23 AM-10:30:23 AM	58768	6178	11	83.49	83.26
10:30:23 AM-11:30:23 AM	57239	11087	19	86.79	85.86
11:30:23 AM-12:30:23 PM	58936	12123	21	87.29	86.38
12:30:23 PM-1:30:23 PM	58348	9756	17	84.28	84.79
1:30:23 PM-2:30:23 PM	46144	428	1	76.51	77.95
2:30:23 PM-3:30:23 PM	36576	168	0	73.21	75.46
3:30:23 PM-4:30:23 PM	40882	587	1	74.37	76.37
4:30:23 PM-5:30:23 PM	60365	998	2	76.46	80.12
5:30:23 PM-6:30:23 PM	78116	1896	2	79.813	81.22
6:30:23 PM-7:30:23 PM	81016	2267	3	82.18	82.10

Table 4.9 depicted the observed noise level versus the predicted noise level at Kpakungu by using calixto model which is based on percentage of heavy vehicles taken from the total number of vehicles and the weighting factor (n) is taken as 10. It was observed that the value

of the predicted noise is close to the respective observed noise level measured. Such comparison depicted that the model used for the prediction has the applicability to evaluate urban road traffic noise, since it yields reliable result close to that by direct measurement. It was clearing evident that the equivalent noise level Leq for Kpakungun were higher than that of WHO and National environment standard and regulation enforcement agency (NESREA) respectively

4.5.1 Observed Noise level Vs Predicted noise level Leq at Mobil

Table 4.10: Observed and the predicted noise level at Mobil

Time	Total No. of Vehicles/hour (Q)(No)	No. of heavy vehicles (HV)(No)	Percentage of Heavy Vehicles (VP)(%)	Observed Noise level(dB)	Predicted noise level(dB)
7:30:23 AM-8:30:23 AM	53438	105	0	75.20	78.9
8:30:23 AM-9:30:23 AM	59213	1234	2	79.50	80.00
9:30:23 AM-10:30:23 AM	53897	1545	3	83.70	80.00
10:30:23AM-11:30:23 AM	47088	1723	4	86.30	79.00
11:30:23AM-12:30:23 PM	44769	1785	4	84.90	81.00
12:30:23 PM-1:30:23 PM	51484	223	0	72.50	76.00
1:30:23 PM-2:30:23 PM	58034	756	1	74.40	78.00
2:30:23 PM-3:30:23 PM	49437	1475	3	75.90	79.00
3:30:23 PM-4:30:23 PM	57882	1245	2	79.31	79.78
4:30:23 PM-5:30:23 PM	72783	1745	2	82.50	82.01
5:30:23 PM-6:30:23 PM	78116	1875	2	85.12	82.02
6:30:23 PM-7:30:23 PM	80016	2042	3	86.50	83.01

Table 4.10 depicted the observed noise level versus the predicted noise level at Mobil by using calixto model which is based on percentage of heavy vehicles is taken from the total number of vehicles and the weighting factor (n) is taken as 10. It was observed that the value of the predicted noise is close to the respective observed noise level measured. Such comparison depicted that the model used for the prediction has the applicability to evaluate urban road traffic noise, since it yields reliable result close to that by direct measurement. It was clearing evident that the equivalent noise level Leq for Mobil were higher than that of WHO and National environment standard and regulation enforcement agency (NESREA) respectively

4.6.2 Observed noise level vs predicted noise level leq at kure market area

Table 4.11: depicted the observed noise level versus the predicted noise level at Kure Market

Time	Total No. of Vehicles/hour (Q)(No)	No. of heavy vehicles (HV)(No)	Percentage of Heavy Vehicles (VP)(%)	Observed Noise level(dB)	Predicted noise level(dB)
7:30:23 AM-8:30:23AM	45880	60	0	71.90	76.02
8:30:23 AM-9:30:23 AM	41696	824	2	76.10	77.01
9:30:23 AM-10:30:23 AM	35784	1386	4	79.80	78.02
10:30:23 AM-11:30:23 AM	43579	2145	5	82.30	80.12
11:30:23 AM-12:30:23 PM	45168	2948	7	84.60	81.00
12:30:23 PM-1:30:23 PM	38487	5547	14	86.01	82.11
1:30:23 PM-2:30:23 PM	39030	1245	3	77.90	77.80
2:30:23 PM-3:30:23 PM	46526	52	0	73.10	76.00
3:30:23 PM-4:30:23 PM	52498	740	1	76.20	79.00
4:30:23 PM-5:30:23 PM	47228	1452	3	78.80	79.01
5:30:23 PM-6:30:23 PM	50162	3542	7	82.70	81.00
6:30:23 PM-7:30:23 PM	51665	5985	12	85.50	83.01

Show in Table 4.11 is the observed and the predicted noise level at Kure Market area by using calixto model which is based on percentage of heavy vehicles is taken from the total number of vehicles and the weighting factor (n) is taken as 10. It was observed that the value of the predicted noise is close to the respective observed noise level measured. Such comparison depicted that the model used for the prediction has the applicability to evaluate urban road traffic noise, since it yield reliable result close to that by direct measurement. It was clearing evident that the equivalent noise level Leq for Kure Market area were higher than that of WHO and National environment standard and regulation enforcement agency (NESREA) permissible limit of 65db and 72db respectively

4.7 Traffic Noise Model Validation: Variations of Observed L_{eq} vs Calculated L_{eq} for Different Study Locations

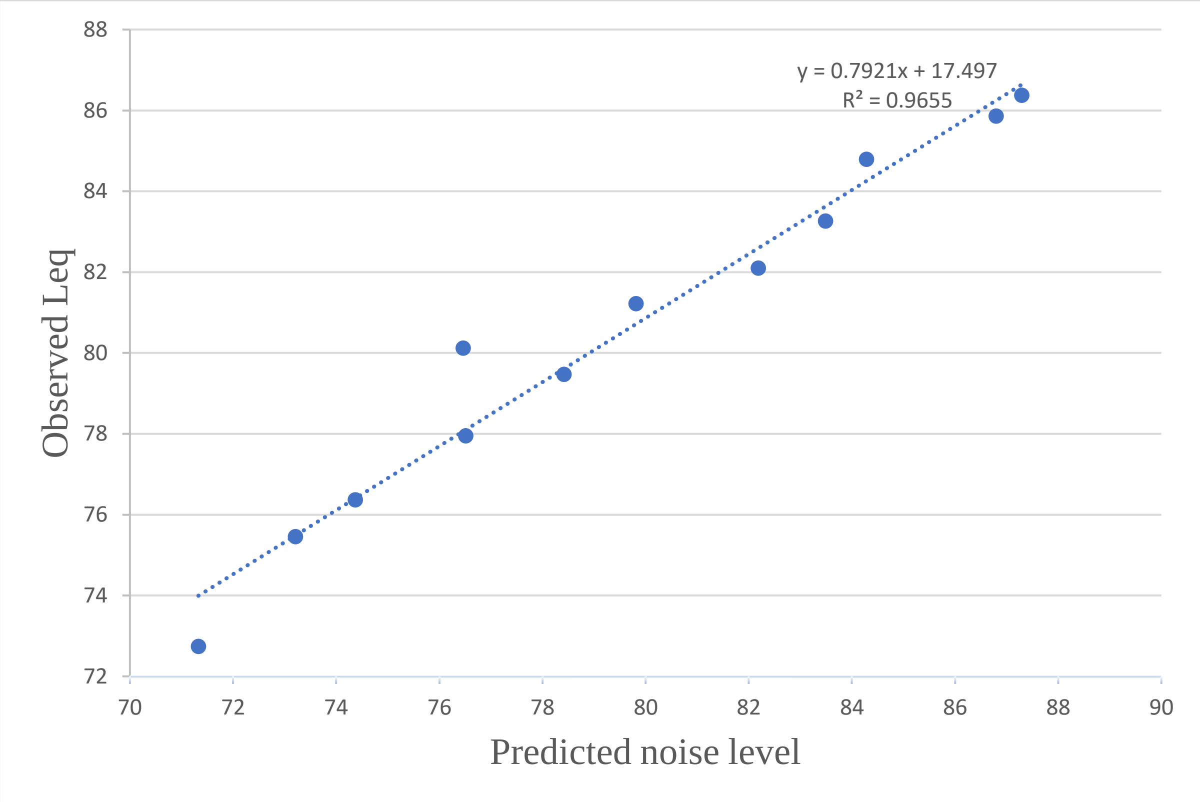

Figure 4.10: Graph of actual noise level versus predicted noise level for kpakungu area

Figure 4.10 show the validation of the new develop urban road traffic noise prediction model given by calixto equation for Kpakungu. Calculated noise level by the equation is then compared to the observed noise level to get the regression equation. Also Figure 4.13 show a strong correlation coefficient was found between the observed noise level and the calculated with a value of $R^2 = 0.9655$

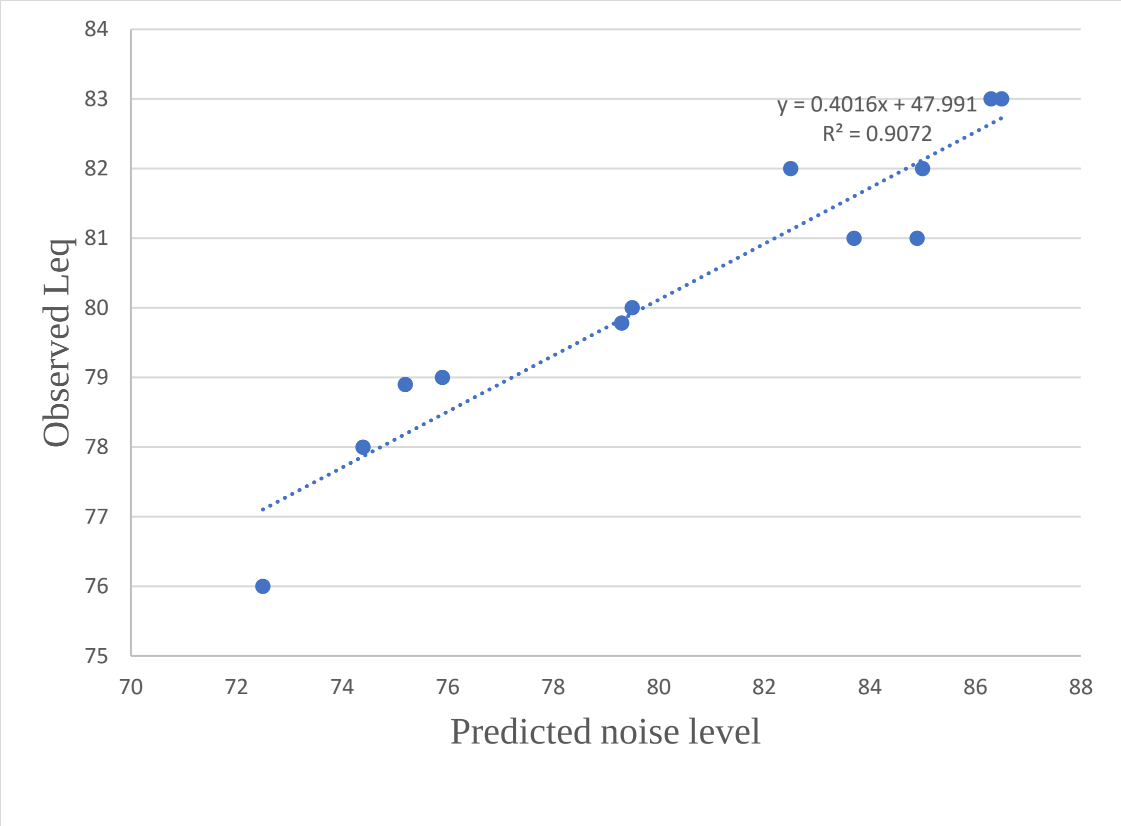

Figure 4.11: Graph of actual noise level versus predicted noise level for mobil area

Figure 4.11show the validation of the new develop urban road traffic noise prediction model given by calixto equation for Mobil. Calculated noise level by the equation is then compared to the observed noise level to get the regression equation. Also Figure 4.14 show a strong correlation coefficient was found between the observed noise level and the calculated with a value of $R^2 = 0.9072$

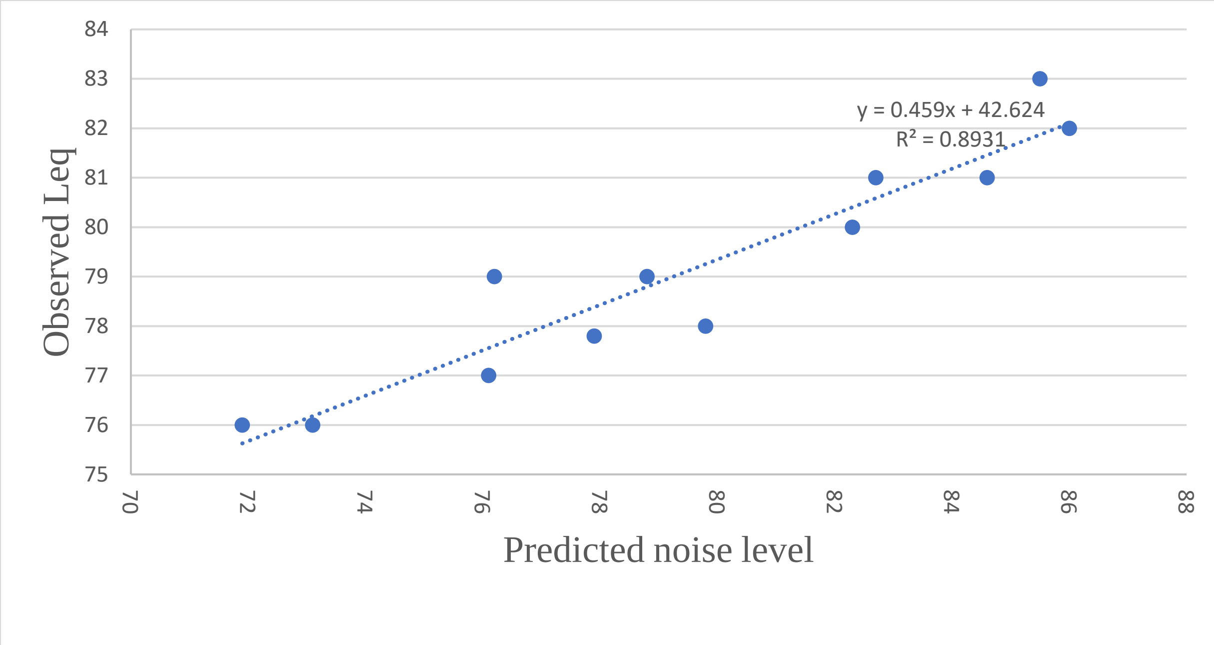

Figure 4.12: Graph of actual noise level versus predicted noise level for kure market

Figure 4.12 shows the validation of the new develop urban road traffic noise prediction model give by calixto equation for Mobil. Calculated noise level by the equation is then compared to the observed noise level to get the regression equation. Also Figure 4.15 show a strong correlation coefficient was found between the observed noise level and the calculated with a value of $R^2 = 0.8931$

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the first objective which is to measure the hourly traffic volume of two axel load, three axel load and axel load for all the study location. It was discovered that Kpakungu road is the most congested route of the entire road networks, closely followed by the Mobil Road then Kure market. The traffic congestion along these routes is most prominent on Mondays, Wednesdays by around 8am - 10am and 4pm - 6pm and on Fridays around 1pm-4pm. Also, a free traffic flow is often experienced on Saturdays and Sundays by 7am which gradually builds into a synchronized flow around the evening time on all the road networks considered. It was also discovered there is no parking space in Kpakungu along Minna–Bida road which is one of the major causes of traffic congestion due to incessant parking of vehicles along the road corridors. Other notable causes include: narrow road width, bad road pavement, indiscriminate parking of cars by the road side, lack of traffic light, reckless driving and commercial viability of the axis.

From the second objective which is to determine the noise level at transit station and the noise parameter (i.e. Traffic Noise Index (TNI), Noise Climate (NC) and Noise Pollution Level (Lnp) for all the study locations) Traffic noise impact (TNI) near to sensitive area has identified. There is a significance evidence of difference noise level produce in different peak and off-peak hour. The noise level, noise pollution level (LNP) and TNI in the areas did not satisfy the road traffic noise limit recommended by WHO and National environment standard and regulation enforcement agency (NESREA). This particular scenario indicated that the increasing noise level can be respectively associated with increase in the number of heavy weight vehicle and some driver behavior such as honk from the vehicles, speed of the vehicles and also their vehicles itself has a turbo engine that can contribute to high noise level.

From the third objective which is to develop a road traffic noise prediction model based on the percentage of heavy vehicles and regression analysis to predict noise equivalent levels (L_{eq}) using Calixto model. A mathematical model which requires total vehicle count and percentage of heavy vehicles is taken which is Calixto model for predicting noise levels and then the observed noise levels were compared with calculated/predicted noise levels Leq. For validation of this a regression analysis was done for all areas and correlation coefficient R2 was obtained. From the result obtain it show that calixto Model is good for Nigeria road.

5.2 Recommendations

The following recommendations are made to reduce these noise levels and thereby creating good environment which further leads to good health.

Plantation of variety trees along the roadside is one easy way which is cost effective Vegetation buffers zones should be created at different places of the city.

1. Awareness programs should be conducted for the people and vehicle drivers regarding the aftermaths or consequences of noise pollution.
2. Road surface gradient (design), road usage and development of adjacent roads are also factors that influence the traffic noise.
3. Making people aware of use of bicycles rather than using vehicles for smaller distances saving fuel as well as making it less pollution and promotion of more ecofriendly vehicles which can reduce noise.
4. Silent zones should be created near the schools and hospitals and should be maintained properly.

5. Restricting heavy vehicle movements in the city during morning hours and separate lanes should be provided for heavy vehicle if they are allowed. Special drives should be done to check the vehicles and overage vehicles should be eliminated which make more noise.
6. The individual can control noise of his vehicle by proper maintenance and fitting a suitable muffler or silencer which can reduce sound. Use of unwanted horns should be avoided and using of honking horns (hydraulic) should be banned as it makes other people travelling restless.
7. The windows of the houses which are nearby road should be double glazing which can reduce the levels up to 20dB.
8. There should be an increase in public mass transport especially during peak hours to avoid usage of individual vehicles which can reduce the traffic and thereby decrease the noise pollution.

5.3 Contributions to Knowledge

This research project on the assessment of road traffic noise in Minna Metropolis makes significant contributions to knowledge and the world. By quantifying the hourly traffic volume of different axle loads, it provides valuable data on the distribution and impact of light of and heavy vehicles on noise levels. The determination of noise parameters such as Traffic Noise Index (TNI), Noise Climate (NC), and Noise Pollution Level (Lnp) at transit stations enhances our understanding of the overall noise environment in the study locations. Additionally, the development of a road traffic noise prediction model based on heavy vehicle percentages and regression analysis offers a practical tool for forecasting noise equivalent levels (Leq). The findings of this research can aid policymakers, urban planners, and researchers in implementing effective noise mitigation strategies, ultimately leading to improved quality of life in urban areas not only in Minna but also in similar context globally.

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APPENDICES

Time	Average hourly noise level for week 1	Average hourly noise level for week 2	Average hourly noise level for week 3
7:30:23 AM-8:30:23 AM	71.5	71.27	71.21
8:30:23 AM-9:30:23 AM	78.00	78.85	78.41
9:30:23 AM-10:30:23 AM	83.25	83.40	83.82
10:30:23 AM-11:30:23 AM	86.70	86.78	86.91
11:30:23 AM-12:30:23 PM	87.80	87.07	87.01
12:30:23 PM-1:30:23 PM	84.60	84.12	84.13
1:30:23 PM-2:30:23 PM	76.77	76.32	76.45
2:30:23 PM-3:30:23 PM	73.40	73.22	73.01
3:30:23 PM-4:30:23 PM	74.36	74.63	74.12
4:30:23 PM-5:30:23 PM	76.72	76.19	76.48
5:30:23 PM-6:30:23 PM	79.30	80.20	79.94
6:30:23 PM-7:30:23 PM	81.00	83.10	82.45

Time	Average hourly noise level for week 1	Average hourly noise level for week 2	Average hourly noise level for week 3
7:30:23 AM-8:30:23 AM	74.90	75.27	75.21
8:30:23 AM-9:30:23 AM	79.00	78.85	79.41
9:30:23 AM-10:30:23 AM	83.25	83.40	83.82
10:30:23 AM-11:30:23 AM	86.70	85.78	86.91
11:30:23 AM-12:30:23 PM	84.80	85.07	84.01
12:30:23 PM-1:30:23 PM	71.90	72.12	72.13
1:30:23 PM-2:30:23 PM	74.77	74.32	74.45
2:30:23 PM-3:30:23 PM	74.40	76.22	75.01
3:30:23 PM-4:30:23 PM	79.36	78.63	80.12
4:30:23 PM-5:30:23 PM	82.72	82.19	82.48
5:30:23 PM-6:30:23 PM	85.30	85.20	85.94
6:30:23 PM-7:30:23 PM	86.50	86.10	86.45