STUDY OF NOISE LEVES IN THE CITY OF KUMASI

By

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Science

degree in Mechanical Engineering at the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana under the supervision of the undersigned.

All works consulted have been duly acknowledged in the references.

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ABSTRACT

Kumasi is the capital town of Ashanti region and it has been observed that noise pollution is ever increasing. Therefore it is imperative to conduct a research of noise levels at some areas in Kumasi to ascertain its level, whether it conforms to Environmental Protection Agency (EPA) standards. Measurements of daytime noise levels was carried out in three bus terminals, two timber industries, three churches and three funeral gatherings using DT-8852 Precision digital sound level meter. The three bus terminals namely Kwame Nkrumah University Of Science and Technology (KNUST) Junction, Anloga Junction and Kejetia from the research had their daytime noise levels of 78.8 dBA, 72.1 dBA and 78.3 dBA respectively. The two timber industries, company A and company B had their day time noise levels of 84.1 dBA and 82.4 dBA respectively. Day time noise levels from the Church A, Church B and the Church C were 78.3 dBA, 82.8 dBA and 81.4 dBA respectively. Funeral ground 1 recorded the highest noise level of 84 dBA, followed by funeral ground 3 of 83.6dBA then funeral ground 2 of 79.2dBA. The bus terminals, timber industries, churches and funeral gatherings had their day time noise levels exceeding the permissible levels of 70 dBA, 70 dBA, 60 dBA and 65dBA respectively by EPA standards. It is recommended that the public should be made aware of the adverse effects of noise pollution. The Television, radio and newspaper should be used as media to promote campaign on noise levels, its effect and control.

DEDICATION

I dedicate it First and foremost to my Parents, Mr. Samuel Mari Abankwa and Madam Cecilia Okomeng Dedaa. "Your, encouragement, support, prayers and advice have been of immense benefit to me ".

I also dedicate to my beloved, Patricia Essel, for her prayers, caring, encouragement and understanding .

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ACRONYMS

USEPA: United States Environmental Protection Agency

dB: decibels

dBA: A-weighted decibels

WHO: World Health Organization

EPA: Environmental Protection Agency

Hz: Hertz

IEC: International Electro technical Commission

RMS: Root Mean Square

SEL: Sound Exposure Level

SPL: Sound Pressure Level

ISO: International Organization for Standardization

ICAO: International Civil Aviation Organisation

EPA: Environmental Protection Agency

CHAPTER ONE

INTRODUCTION

This chapter discusses the background information, justification, the objective of the research, the scope of research and the structure of report**.**

1.1 Background

Since the advent of the Industrial Revolution, noise has been a significant source of physical and psychological stress (Loeb, 1986). In the 21st century, noise exposures have increased in both duration and intensity as a result of the ubiquitous presence of handheld devices that provide auditory stimulation in the form of speech and music. Noise has broad effects, ranging from interference with cognitive processing (Smith, 1983) to detrimental effects on mental and physical health (Clark, 1984). Understanding the factors that moderate the relationship between noise and human response is therefore crucial to areas of concern that range from general theories of stress to the pragmatic design of occupational noise mitigation strategies.

The general effect of noise on the hearing of workers has been a topic of debate among scientists for a number of years (Jansen, 1992; Johnson, 1991; Alton B., 1990). Regulations limiting noise exposure of industrial workers have been instituted in many places. For example, in the U.S., the Occupational Noise Exposure Regulation states that industrial employers must limit noise exposure of their employees to 90 dBA for one 8-h period (USEPA, 1973; Eleftheriou, 2002).

Exposure to continuous and extensive noise at a level higher than 85 dBA may lead to hearing loss. Continuous hearing loss differs from person to person with the level, frequency and duration of the noise exposed (USEPA, 1974).

Noise-making is a nuisance and more or less an environmental problem, which in a way may make the environment uncomfortable for mankind. Noise is an inevitable part of everyday human life, be it in the city, town or village one is engulfed by noise most of the time. It is therefore logical to accept some degree of noise in the environment. It has been observed that, as the population increases, the level of noise making also increases, however, this should not permit people to make excessive noise to infringe on other people's right and privacy.

1.2 Environmental Protection Agency (EPA), Ghana noise regulation

The Environmental Protection Agency (EPA) is the leading public body for protecting and improving the environment in Ghana. Their job is to make sure that air, land and water are looked after by everyone in today's society, so that tomorrow's generations inherit a cleaner, healthier world. They have more than 30 years of history behind them. They have offices across Ghana working on and carrying out Government policy, inspecting and regulating businesses and reacting when there is an emergency such as a pollution incident. One essential mandate of EPA, Ghana, is to ensure that notices are issued in the form of directives, procedures or warning to such bodies as it may determine for the purpose of controlling the volume, intensity, and quality of noise in the environment (EPA, Act 490, 1994).

1.2.1 EPA guideline for noise making

The Environmental Protection Agency (EPA), the government wing responsible for the prudent management of the environment, has set out guidelines that come with permissible ambient noise for the aforementioned areas. The environmental agency puts permissible ambient noise levels in residential areas at 55 decibels (dB) during the day and 48 dB at night. Permissible noise levels around educational and health facilities was put at 55 dB during the day and 50 dB at night, while the noise level for areas with commercial or light industrial activities was registered as 60 dB and 55 dB during the day and night respectively. The new guidelines also permit 65 dB noise levels during the day and 60 dB during the night for light industrial areas and places of entertainment and public assembly such as churches and mosques. Predominant commercial areas, according to the new guidelines, are allowed 70 dB during the day and 65 dB at night, while the noise level for heavy industrial areas was pegged at 70 dB during the day and night. (Odoi-Larbi, 2012)

1.3 Justification

The recognition of noise as a serious hazard as opposed to nuisance is a recent development and the health effects of the hazardous noise exposure are now considered to be an increasingly important public health problem (WHO, 2001).

Every member of a society needs a form of privacy once in a while. Privacy is a form of human right which no human being can do without. It gives space for one to think considerably about a decision concerning one's life. However, in as much as a sound environment is needed for privacy, the environment in this part of the world does not always make way for privacy to prevail. It has been observed that noise is one of the most common activities in the Ghanaian environment with the cities being the worst affected; it is the notion of many people that the existence of the rule of democracy enables them to behave freely, forgetting that one's freedom ends where another's begins.

Kumasi is the Capital town of Ashanti region and it has been observed that noise pollution is ever increasing. Most business activities in Ashanti region take place in Kumasi and noise will play a major role in affecting business negatively. Therefore it is imperative to conduct a study on noise at Kumasi to ascertain its level, whether it conforms to the EPA standards and come up with suggestions and recommendation to reduce noise.

1.4 Research Objective

The main aim of the study is to investigate the noise levels in the Kumasi metropolis.

1.4.1 Specific Objectives

i. To Identify noisy environments in the city of Kumasi
ii. To measure noise levels at the identified areas in Kumasi;
iii. To determine whether the noise generated in Kumasi metropolis is beyond acceptable limits by EPA standards and make appropriate recommendations.

1.5 Scope of Research

The scope is limited to the use of Sound level meters to measure the sound intensity at the study areas and to draw conclusions by analyzing the results using International and National standards as well as environmental regulations.

1.6 Structure of The Report

Chapter one of the studies consist mainly of the general introduction to the study, its justification, research objectives, scope of research and structure of the report. The subject under discussion sets out the procedure to guide the conduct of the research.

Chapter two is the review of relevant literature on the subject matter. It explores the nature and extent of work done by others on the subject and serves as a foundation for the rest of the study.

Chapter three presents the methodology of the research. It discusses the instruments and tools used and how it was used in the research and the procedures used.

Chapter four presents results of the research as well as a discussion of the results.

Finally, chapter five presents the findings and conclusions of study, and the necessary recommendation that will help curb noise levels in the Kumasi metropolis.

CHAPTER TWO

LITERATURE REVIEW

2.1 Noise: Definition & Fundamentals

Noise is generally defined as unpleasant sounds which disturb the human being physically and physiologically as well as causes environmental pollution by destroying environmental properties (Melnick, 1979). To gain satisfactory understanding of the effects of noise, it would be useful to look briefly at the physical properties of sound.

In physics, sound is a vibration that propagates as a typically audible mechanical wave of pressure and displacement, through a medium such as air or water. Sound is the result of pressure changes in a medium (usually air), caused by vibration or turbulence. The amplitude of these changes is stated in terms of sound level, and the rapidity with which these changes occur is the sound's frequency. Sound level is measured in decibels (abbreviated dB), and sound frequency is stated in terms of cycles per second, currently, hertz (abbreviated Hz). Sound level is a logarithmic rather than a linear measure of the change in pressure with respect to a reference pressure level. A small increase in decibels can represent a large increase in sound energy. Technically, an increase of 20 dB represents a hundredfold increase of sound energy, and an increase of 30 dB represents a thousandfold increase of sound energy (Suter, 1991). The human ear, perceives 1 dB increase as not noticeable, 3 dB increase as barely noticeable, 5 dB increase as clearly noticeable change, 10 dB increase as doubling of loudness and 20 dB increase as quadruple of loudness (Claridge, 2013).

The human ear does not have equal sensitivity to stimuli over the entire frequency and sound pressure ranges (Fletcher & Munson, 1933), the dB scale, therefore, does not entirely equate to what an observer perceives.

Another important aspect is the duration of sounds and the way it is distributed in time. Continuous sounds have little or no variation in time, varying sounds have differing maximum levels over a period of time, intermittent sounds are interspersed with quiet periods, and impulsive sounds are characterized by relatively high sound levels and short durations.

The effects of noise are determined mainly by duration and level of noise, but they are also influenced by the frequency. Long-lasting, high level sounds are the most damaging to hearing and generally the most annoying. High frequency sounds tend to be more hazardous to hearing and more annoying than low frequency sounds. Low frequency sounds appear to be somewhat less damaging to hearing than continuous sounds because of the ear's ability to regenerate during the intervening quiet periods. However, intermittent and impulsive sounds tend to be more annoying because of their unpredictability (Suter, 1991).

2.2 Sources of Noise Pollution

Noise pollution originates from several sources, including street traffic, aircraft, railroads, industry, construction, consumer products, and other sources. In order to better understand noise pollution, it is important to understand where it comes from. Upon doing so, one can then more carefully consider its impacts on humans and more effectively investigate methods for reducing noise and preventing its negative consequences.

2.2.1 Street Traffic

Of all the sources of noise pollution, street traffic is the most prevalent and perhaps the most damaging source of noise pollution. Sharp and Donovan (1979) confirm that "more people are exposed to noise from motor vehicles than any other single source of noise". Though this claim is now over 30 years old, the prevalence of street traffic has certainly grown since then, and thus the impacts of traffic noise are still a major factor in human society.

Noise emitted by street traffic is generated by engines, exhaust systems and tyres interacting with the road. Tyres contribute most predominantly to the noise emitted by automobiles, both in the effects on passengers within a vehicle and in the contribution to roadside noise, especially in American-made cars. The other components of traffic noise are significant contributors nonetheless. Exhaust and engine noise, for example, have been implicated as even more prevalent than tyre noise in some cases, especially in Japanese and European-made cars. Further, noise produced during acceleration can be as much as 20 dB greater than that produced at cruising speed (Burgliarello et al., 1976).

Besides cars, buses and trucks also contribute significantly to traffic noise. Though there are fewer of these vehicles in use than cars, the contribution of buses and trucks to noise pollution is significant nonetheless. One reason for this is that trucks and buses generally use diesel engines, in which ignition occurs at a higher pressure than in gasoline-burning automobile engine, resulting in an increased amount of airborne vibration emission. Additionally, diesel engines tend to be used at or near maximum power more often than passenger cars and light trucks, further contributing to their levels of noise emission (Burgliarello et al., 1976).

The motorcycle are another source of traffic noise, and they present a unique situation. Firstly, unlike cars, trucks, and buses, tyre noise contributes rather insignificantly to the overall amount of noise produced by motorcycles (Sharp and Donovan, 1979). It is the type of engine, acceleration, and other issues that is relevant to the engine system rather than the tires that become more important when considering motorcycles as a source of noise. Secondly, unlike passengers in cars, trucks, and buses, the rider of a motorcycle is not shielded by an enclosed compartment from the noise produced by their vehicle. Thirdly, motorcycles can be particularly noisy; whereas cars generally produce noise levels in the range of 67-75 dB, motorcycle noise generally ranges from 72-83 dB, but can reach levels as high as 120 dB immediately behind the cycle (Burgliarello et al., 1976).

2.2.2 Aircraft

Aircraft noise originates primarily from airplane's propulsion systems and from aerodynamic noise. First, there are three major propulsion systems to consider, the turbojet, the turboprop and the turbofan. In the turbojet engine, air is first compressed, then heated in a combustion chamber, and finally accelerated by expansion through a jet nozzle. This results in the production of three types of noise: noise radiated from the air intake, noise radiated from vibrations of the engine shell, and that from the exhaust noise. Cabin noise in turbo-propeller driver aircraft can cause crew and passenger discomfort. The noise level in the interior of turbopropeller-driven aircraft, which results mainly from the excitation of the fuselage by theunsteady aerodynamic pressure field of the propellers, is typically higher than the noise level in comparable turbofan-powered aircraft. The turbofan engine differs primarily from the turbojet engine in that it utilizes a thrust-producing fan and that it produces a lower exhaust velocity, resulting in a relatively quieter operation for a given total thrust (Raney & Cawthorn, 1979).

The second type of noise that is dominant in aircraft noise is aerodynamic noise, which includes the noise that is produced by the passing of air around the aircraft. Under normal cruising conditions, this type of noise predominates, especially among higher frequencies. However, propulsion noise tends to predominate at the lower takeoff and landing speeds (Raney and Cawthorn, 1979).

In subsonic flight, which is typical for the vast majority of passenger flights, aircraft noise peaks when the aircraft is approximately overhead and then gradually diminishes to the ambient noise level. Additionally, noise that is heard as the aircraft approaches tends to be dominated by higher frequency sound, whereas noise that is heard after the aircraft has passed tends to include more lower-frequency sound (Raney and Cawthorn, 1979). However, this also depends on whether the aircraft is powered by a turbojet engine or a turbofan engine. In a turbojet engine, lower-frequency exhaust noise predominates over the rearward-propagating, higher-frequency noise produced by the air compressor. In the turbofan engine, on the other hand, higher-frequency sound radiating from the internal fans predominates over exhaust noise and propagates both forward and rearward from the aircraft (Bugliarello et al., 1976).

2.2.3 Railroads

Railroads, like street traffic, are a source of surface transportation noise. The majority of noise emitted by trains is produced by the engines and by the interaction of the wheels with the track (Lotz and Kurzweil, 1979). While the former predominates in long-distance railroad systems, the latter is the predominant noise source in urban subway systems (Bugliarello et al., 1976). Other sources of noise in railroad systems include warning signals at crossings, whistles and horns, freight classification yards, and railroad construction and maintenance equipment (Lotz and Kurzweil, 1979).

Noise levels experienced by passengers in trains generally increase by about 10 dB in tunnels, an observation that is particularly relevant to urban subway system patrons. And even in open areas, noise levels from trains decrease as a function of distance less than noise levels from buses do (Bugliarello et al., 1976).

2.2.4 Industry

There are four main categories of industrial activity that are particularly relevant to the study of noise: product fabrication, product assembly, power generation, and processing. Noise is generated in all of these activities, with the majority occurring at the lower end of the frequency spectrum. While people around an industrial facility and the people within it are both affected by industrial noise, it is the workers within the plant that generally bear the brunt of most of it.

Product fabrication, the first category of industrial activity, can be a highly noisy operation. In metal fabrication, the cutting, shearing, pressing, and riveting of metal products can be very noisy. Molding, type of product fabrication, can also be highly noisy with its use of high-pressure air in the operation, pneumatic control, and cooling of molding machinery. Plastic molding has been reported to produce noise at levels greater than 100 dB (Bugliarello et al., 1976).

The second category of industrial activity, product assembly, also produces dangerous noise levels. The activities within this category often produce broad-band noise that includes high levels of higher-frequency noise due to the operation of electric and pneumatic tools, such as grinders and impact wrenches (Bugliarello et al., 1976).

The noise emitted in power generation, the third industrial category, is produced by turbine generators and air compressors, though some noise also derives from devices such as fans and blowers. Processing includes activities such as oil refinery. Major sources of noise in processing are furnaces, heat exchangers, pumps, compressors, and air and steam leaks (Bugliarello et al., 1976).

Miller also discusses industrial noise production, and lists "motor noise, fan noise, transformer noise, aerodynamic noise, hydraulic system noise, impact noise, bearing noise, gear noise, and vibration-induced noise" as examples of noise due to industrial machinery (Miller, 1979b).

2.2.5 Construction

Construction noise is a major source of noise pollution emitted by construction equipment, which Leasure (1979) defines as "that equipment utilized at construction sites for the fabrication, erection, modification, demolition, or removal of any structure or facility, including all related activities such as clearing of land, site preparation, excavation, cleanup, and landscaping". Like industrial equipment, construction equipment produces more noise in the lower end of the frequency spectrum. But unlike industrial equipment, which emits noise that primarily affects workers within a facility, construction equipment is used outdoors, and thus affects many other people besides the workers at the site. Additionally, construction equipment tends to emit noise at lower peak intensities than industrial equipment, with the exception of impact pile drivers and ballast cleaning machines, which can reach peak intensities of over 105 and 120 dB, respectively (Bugliarello et al., 1976; Leasure, 1979).

2.2.6 Funerals

It is a true, some acts of noise-making are done consciously, but the majority is done without negative intent. One of the commonest kinds of noise-making is at funerals. In Ghana funerals are held after the dead has been buried. It is celebrated with the playing of music, mostly from large blaring loudspeakers. In Ghana one needs a permit when one is holding a funeral ceremony at home, for the playing of loud music. Exposure to loud noise makes a person lose the reading, understanding and learning ability. One will also loose the problem solving abilities and may get the short-term memory loss because of the often exposure to the noise (Anonymous, 2009).

2.2.7 Music Vendors

When it comes to music vendors i.e., compact disc /cassette sellers, they can easily be described as the worst culprits. Many young people have turned to the selling of audio and video compact discs (CDs). They have developed a marketing strategy where they mount sound systems together with loud speakers on a vehicle and play the music very loudly to attract customers. Despite the fact that it is against the bye-laws, its prevalence has made it seem a normal thing in society (Anonymous,2009).

2.2.8 Churches

It is suspected that churches during worship may be generating noise above what is permissible. With the increasing number of churches, the degree of noise they generate not just on Sundays but on weekly basis during revivals, crusades may be unbearable to the human ear . Music from churches are loud and could pose a threat to humans.

2.3 Effects of Noise Pollution

Noise has many effects on humans, including hearing loss, non-auditory physiological effects, sleep disruption, annoyance and communication interference.

2.3.1 Noise - Induced Hearing Loss

Exposure to sufficiently intense noise for a long period of time results in damage to the inner ear and thus decreases one's ability to hear. In addition to, a general decrease in the ability to detect sounds, the quality and clarity of auditory perception can be affected, as well. While these effects are often temporary, it is not uncommon for some residual permanent damage to persist for the remainder of the affected person's life (Miller, 1979a).

Whether the effects are temporary or permanent, hearing loss due to noise exposure primarily affects the inner ear, especially when the noise is presented over a significant period of time. Specifically, it is the organ of corti that is most commonly affected (Bugliarello, Alexandre, Barnes, & Wakstein, 1976; Miller, 1979a).

2.3.2 Non-Auditory Physiological Effects

Noise also has other physiological effects. People who complain about environmental stressors are probably also more likely to complain about other aspects of their life, including their health (Ruback et al., 1997).

Non-auditory physiological effects of noise pollution that have been specifically identified thus far include cardiovascular, autonomic, and gastric effects. Further, it appears that noise can exert its non-auditory effects independent of hearing loss.

2.3.3 Effects on Sleep

It is a common knowledge that noise can disturb sleep (that's why we use alarm clocks). In fact, a study published in 1963 by McKennell reported that 40 percent of the London residents who were interviewed had been awakened by aircraft noise at least "occasionally," and since the volume of air traffic has certainly increased substantially since then, it is likely that even more people are affected now.

Sleep disturbance by noise is affected by characteristics of the noise itself. For example, stimulus intensity is related to sleep disturbance, with more intense stimuli awakening people more often. However, disturbance thresholds vary widely among individuals, with some people being disturbed by levels as low as 35 dB and others being able to sleep through 90 dB levels. And a person's threshold depends on the type of stimulus, as well. For example, it appears that most people can sleep through 60 dB of aircraft noise, but only 40 dB of street traffic noise (Bugliarello et al., 1976).

Another factor affecting sleep disturbance is the stage of sleep during which a noise occurs. In general, it requires greater intensity stimuli to awaken people in the deeper stages of sleep, and Rapid eye movement sleep (REM sleep) appears to be particularly easy to disturb (Berry and Thiessen, 1970). However, this can sometimes be avoided by incorporating the stimulus into dreams, which occurs most often in REM sleep.

2.3.4 Annoyance

Annoyance due to noise depends on many factors, including several parameters of the noise itself. For example, louder noises are generally more annoying than quieter noises (e.g. van Dijk, Verbeek, & de Fries, 1987), though two sounds with equal intensity may still result in different levels of annoyance. Patterned sounds appear to be less annoying than sounds that are randomly produced (Bragdon, 1972). Also, noises that are of higher pitch are generally rated as more annoying than that of lower pitch. And finally, annoyance depends on the regularity of the noise. That is, noises that remain constant in pitch (Bragdon, 1972) and intensity (Molino, 1979) are generally rated as less annoying than noises that change in pitch or intensity.

Another factor affecting annoyance appears to be the source of the noise. For example, it appears that noise produced by street traffic is less annoying than equally-intense noise that is produced by aircraft. (Kryter, 1982). As a result, much of the research on noise-induced annoyance has focused on aircraft noise (Abel, 1990; Miller, 1979a).

2.4 Sound Level Meter

A sound level meter or sound meter is an instrument which is used to measure sound pressure level. It is commonly used in noise pollution research for the quantification of different kinds of noise, especially for industrial, environmental and aircraft noise. The reading from a sound level meter however does not correlate well to human-perceived loudness, which is better measured by a loudness meter. The current international standard that specifies sound level meter functionality and performance is the IEC 61672:2003 (Wikipedia, 2013).

2.4.1 Classification

The IEC 61672-1 specifies "three kinds of sound measuring instruments”. (IEC, 2002).

They are the "conventional" sound level meter, the integrating-averaging sound level meter, and the integrating sound level meter. The standard sound level meter can also be called an *exponentially averaging sound level meter* as the AC signal from the microphone is converted to DC by a root-mean-square (RMS) circuit and thus have a time-constant of integration; today referred to as the time-weighting. The output of the RMS circuit is linear in voltage and is passed through a logarithmic circuit to give readout linear in decibels (dB). This is 20 times the base 10 logarithm of the ratio of a given root-mean-square sound pressure to the reference sound pressure. An exponentially averaging sound level meter, gives a snapshot of the current noise level, is of limited use for hearing damage risk measurements; an integrating or integrating-averaging meter is usually mandated. An integrating meter simply integrates—or in other words 'sums'—the frequency-weighted noise to give sound exposure and the metric used is the squared of pressure times time. However, because sound was historically described in decibels, the exposure is most often described in terms of sound exposure level (SEL), the logarithmic conversion of sound exposure into decibels. Sound level meters are divided into two "classes" (previously called "types" in older standards). Sound level meters of the two classes have the same functionality, but different tolerances for error. Class 1 instruments have a wider frequency range and a tighter tolerance than the lower cost Class 2 unit. This applies to both the sound level meter itself as well as the associated calibrator. Most national standards permit the use of "at least a Class 2 instrument". For many measurements, there is little practical point in using a Class 1 unit; these are best employed for research and law enforcement (OSHA, 2013).

2.4.2 Measurement

The IEC 61672-1:2003 mandates the inclusion of an *A*-frequency-weighting filter in all sound level meters, and also describes *C* and *Z* (zero) frequency weightings. The B and *D* frequency-weightings are now old and are no longer described in the standard. In almost all countries, the use of A-frequency-weighting is mandated to be used for the protection of workers against noise-induced deafness. The A-frequency curve was based mainly on the historical equal-loudness contours and while arguably, A-frequency-weighting is no longer the ideal frequency weighting on purely scientific grounds, it is nonetheless the legally required standard for almost all such measurements and has the huge practical advantage that old data can be compared with new measurements. It is because of these reasons that A-frequency-weighting is the only weighting mandated by the international standard, the frequency weightings 'C' and 'Z' being optional fitments. Originally, the A-frequency-weighting was only meant for quiet sounds in the region of 40 dB sound pressure level (SPL), but is now mandated for all levels. C-frequency-weighting however is still used in the measurement of the peak value of a noise in some legislation, but B-frequency-weighting has almost no practical use (ANSI, 2006).

D-frequency-weighting was designed for use in measuring aircraft noise, when non-bypass jets were being measured and after the demise of Concord, these are all military types. For all civil aircraft noise measurements, A-frequency-weighting is used as is mandated by the ISO and ICAO standards.

2.4.3 Standardization

Until 2003 there were separate standards for exponential and linear integrating sound level meters, but since then IEC 61672 has described both types of sound level meters. The classic exponential meter was originally described in IEC 123 for 'industrial' meters followed by IEC 179 for 'precision' meters. Both of these were replaced by IEC 651, later renamed IEC 60651, while the linear integrating meters were initially described by IEC 804, later renamed IEC 60804. Both IEC 60651 and 60804 included four accuracy classes. In IEC 61672 these were reduced to just two accuracy classes 1 and 2. New in the standard IEC 61672 is a minimum 60 dB linear span requirements and *Z*-frequency-weighting, with a general tightening of limit tolerances, as well as the inclusion of measurement uncertainty in the testing regime. This makes it unlikely that a sound level meter designed to the older 60651 and 60804 standards will meet the requirements of IEC 61672: 2003. These 'withdrawn' standards should no longer be used, for any official purchasing requirements, as they have significantly poorer accuracy requirements than IEC 61672.

2.5 Analysis of Noise Levels

Measured noise level can be used in the calculation of the day time noise level and night time noise level. The equations for the calculation are below

$$L_D = 10\log\left[\frac{1}{2}\left[\left(10^{L_{AeqM}/10}\right) + \left(10^{L_{AeqA}/10}\right)\right]\right] \quad (2.1)$$

$$L_N = 10\log\left[\frac{1}{2}\left[\left(10^{L_{AeqE}/10}\right) + \left(10^{L_{AeqN}/10}\right)\right]\right] \quad (2.2)$$

Where

L_{Aeq} = The A-weighted equivalent sound pressure level

$L_{Aeq\,M}$ = The equivalent sound pressure for the morning measurement

L_{AeqA} = The equivalent sound pressure level for the afternoon measurement

L_{AeqE} = The equivalent sound pressure level for the evening measurement

L_{AeqN} = The equivalent sound pressure level for the night measurement

L_D = Day time noise level

L_N = Night time noise level (Olayinka and Abdullahi, 2008)

2.6 Studies on Noise

Study was done to investigate the levels of noise pollution in some hospitals in Taiwan and to study the effects of noise pollution on the physiological and psychological reactions and annoyance response of medical care staff, patients and visitors in these hospitals. An instrument for the measurement of sound level was used and a self-answered survey questionnaire on noise pollution was administered. Results showed that the daily average sound levels measured inside these hospitals during daytime were between 52.6 and 64.6 dB. These are higher than the current daytime environmental noise limit of 50 dB in Taiwan. Most nursing staff members expressed that “talking of visitors or patient’s family members” is the major source of noise inside the wards, whereas “talking of visitors or patient’s family members” and “children playing” are the two major noise sources outside the wards. However, most patients or visitors claimed that “doors opening or closing” and “patients moaning or crying “are the two major sources of noise inside the wards. “Footsteps,” “renovation of hospitals,” “talking of visitors or patient’s family members,” “shouting of nursing staff” and “doors opening or closing” are the five major noise sources outside the wards (Juang et al., 2010).

The problem of noise in the industries around Sivas was studied; and noise measurement and survey studies was carried out at concrete traverse, cement, iron and steel and textile factories located in this region. A questionnaire was completed by 256 workers during this study in order to determine the physical, physiological, and psycho-social impacts of the noise on humans and to specify what kind of measurements have been taken both by the employers and workers for protection from the effects of noise. It was specified, during the surveys, that the noise levels detected in all the industries were much above the 80 dBA that is specified in the regulations.73.83% of the workers in these industries are disturbed from the noise in their workplaces, 60.96% of them have complaints about their nervous situations, 30.96% of these workers are suffering hearing problems although they had not had any periodical hearing tests and they are not using ear protection equipment (Atmaca et al., 2005).

Asamoah-Baidoo (2011) investigated the prevalence of noise induced hearing loss among workers in and around the Kotoka International Airport using the NM 102 noise meter. In his Study, thirty (30) persons were also taken through audiometric and otoscopic examinations, where their hearing acuity was tested to check the effect of exposure to the excessive aircraft noise at the Airport Clinic and Korle-Bu Teaching Hospital respectively. The average noise level at the Kotoka International Airport of 74 dB (A) exceeded the acceptable EPA noise level of 70 dB and the level of noise generated by aircrafts during the day and night also exceeded the standard EPA noise level at 82.66 dBA.

Gupta and Ghatala (2010) focused on the traffic noise assessment and its negative health effect on road side residents. Five different locations were selected along a National Highway of Burdwan having a day time level of 60 to 89.5 dBA. Evaluation of various noise descriptors such as L_{10}, L_{50}, L_{90} Leq, L_{NP} and TNI showed that people of the study area got suffered from slight uncomfortable feeling to a position of noise annoyance. Assessment of health effects among the 52 peoples of 10 families residing in the study areas for long time was conducted through a questionnaire based survey. Responses from the people were collected for analysis and the outcome revealed that 53%, 36%, 40% of people were suffered from headache, anxiety and high blood pressure whereas 36%, 15%, 67% and 61% of people were suffered from hearing disability, cardiovascular diseases, irritability and insomnia respectively. Chi-Square test was conducted among the different physiological and psychological effects and it was found that noise has a significant ($\alpha = 0.05$) effect on hearing loss, sleep disturbances, abnormal heart beat and speech communication problem.

In a study, attempts were made to study the noise level range at different roads of the Mysore city. Traffic behaviour and characteristics at various roads near schools, hospitals, railway tracks, offices and courts using "Sound Level Meter". Then, the maximum value of noise level in decibels was estimated. From the results, sources of noise pollution vary from place to place. it was observed that the sound pressure level was maximum 107dB at Ramanuja road near JSS hospital at 10:00 am. (G.M and B.M, 2010)

The noise levels in various production sections at a cement factory in Tanga, Tanzania were measured. The attitudes of workers towards noise health hazards were assessed. Noise levels were measured using a digital sound level meter at three appropriate locations of the working zone of the workers. Questionnaires were provided to each worker in selected production section and field under close supervision to avoid influence of one's results by other subject. The results showed maximum noise level at the power plant section with 104.82 dBA and minimum noise level of 50 dBA was observed in offices. The maximum and average noise levels measured in most production sections exceeded the allowed limit value of 85 dBA as recommended by Tanzania Bureau of Standards (TBS). Subjective responses indicated that 47.5% of workers are exposure to noise for more than 5 years whereas, 82.5% of workers indicated that there could be health effects caused by the noise from machines (Mndeme and Nkoma, 2012).

The capital city of Nigeria has experienced rapid development and high influx of people with the implication of increased generation of noise. Hence there was the need to evaluate the noise pollution level of the city. Measurement of equivalent noise level was carried out in 35 locations around the city using a CR811C integrated sound level meter. Result showed that the day time mean equivalent noise level of the city ranged from 73.2 dBA to 83.6 dBA. Result also showed that the night time mean equivalent noise level of Abuja city was of good quality as it ranged from 44 dBA to 56.8 dBA. The night time therefore serves as a recovery time for those who are exposed to high noise value during the day. Results further showed that the Central Business District of Abuja has the highest day-night noise value of 82 dBA while the lowest day-night noise level was obtained from Asokoro district with a value of 71 dBA. The average day-night noise level of the City was obtained as 76.4 dBA. It is recommended that those whose daily activities confine them to areas with unhealthy noise level should make sure they have at least 10 hours of recovery time in areas where the sound level is less than 65 dBA (Ochuko Anomohonran, 2013) .

2.6.1 Studies on Noise Effects Related to Age

There have been several recent reports on the potential risk to hearing from various types of social noise exposure. However, there are few population-based data to substantiate a case for concern. During the last 10-20 years, use of personal cassette players (PCPs) has become very much more prevalent, and sound levels in public nightclubs and discotheques are reported to have increased. A study investigated the prevalence and types of significant social noise exposure in a representative population sample of 356 18-25 year olds in Nottingham. Subjects were interviewed in detail about all types of lifetime noise exposure. Noise measurements were also made for both nightclubs and PCPs. 18.8% of young adults had been exposed to significant noise from social activities, compared with 3.5% from occupational noise and 2.9% from gunfire noise. The study concluded that social noise exposure has tripled since the early 1980s in the UK. Most of the present day exposure, measured in terms of sound energy, comes from nightclubs rather than PCPs. Moreover, 66% of subjects attending nightclubs or rock concerts reported temporary effects on their hearing or tinnitus (Carayon et al., 2000).

The objectives in a study were to analyze noise effects on episodic and semantic memory performance in different age groups, and to see whether age interacted with noise in their effects on memory. Data were taken from three separate previous experiments that were performed with the same design, procedure and dependent measures with participants from four age groups (13-14, 18-20, 35-45 and 55-65 years). Participants were randomly assigned to one of three conditions: (a) meaningful irrelevant speech, (b) road traffic noise, and (c) quiet condition. The results showed effects of noise sources on a majority of the dependent measures, both when taken alone and aggregated according to the nature of the material to be memorized. However, the noise effects for episodic memory tasks were stronger than for semantic memory tasks. Further, in the reading comprehension task, cued recall and recognition were more impaired by meaningful irrelevant speech than by road traffic noise. Contrary to predictions, there was no interaction between noise and age group, indicating that the obtained noise effects were not related to the capacity to perform the task. The results from the three experiments taken together throw more light on the relative effects of road traffic noise and meaningful irrelevant speech on memory performance in different age groups (Boman et al., 2005).

2.6.2 Studies on Noise Effects Related to Task Performance

The effects of noise are seldom catastrophic, and are often only transitory, but adverse effects can be cumulative with prolonged or repeated exposure. Although it often causes discomfort and sometimes pain, noise does not cause ears to bleed and noise-induced hearing loss usually takes years to develop. Noise-induced hearing loss can indeed impair the quality of life, through a reduction in the ability to hear important sounds and to communicate with family and friends. Some of the other effects of noise, such as sleep disruption, the masking of speech and television, and the inability to enjoy one's property or leisure time also impair the quality of life. In addition, noise can interfere with the teaching and learning process, disrupt the performance of certain tasks, and increase the incidence of antisocial behavior. (Suter , 1991)

Large numbers of children both in the United States and throughout the economically developing world are chronically exposed to high levels of ambient noise. Although a great deal is known about chronic noise exposures and hearing damage, much less is known about the non-auditory effects of chronic ambient noise exposure on children. To estimate the risk of ambient noise exposure to healthy human development, more information on non-auditory effects such as psycho-physiological functioning, motivation, and cognitive processes is needed. In their article that critically reviews existing research on the non-auditory effects of noise on children, Evans and his team developed several preliminary models of how noise may adversely affect children; and advocates an ecological perspective for a future research agenda (Evans et al., 1993).

In the short term, noise induced arousal, may produce better performance of simple tasks, but cognitive performance deteriorates substantially for more complex tasks (i.e. tasks that require sustained attention to details or to multiple cues; or tasks that demand a large capacity of working memory, such as complex analytical processes). Some of the effects are related to loss in auditory comprehension and language acquisition. Other tasks that are not among the cognitive effects are reading, attention, problem solving and memory. These are the ones that are most strongly affected by noise. The observed effects on motivation, as measured by persistence with a difficult cognitive task, may either be independent or secondary to the aforementioned cognitive impairments. For aircraft noise, the most important effects are interference with rest, recreation and watching of television. This is in contrast to road traffic noise, where sleep disturbance is the predominant effect (Evans, et al., 1997).

Two types of memory deficits have been identified under experimental noise exposure: incidental memory and memory for materials that the observer was not explicitly instructed to focus on during a learning phase. For example, when presenting semantic information to subjects in the presence of noise, recall of the information content was unaffected, but the subjects were significantly less able to recall, for example, in which corner of the slide a word had been located. There is also some evidence that the lack of “helping behavior” that was noted under experimental noise exposure may be related to inattention to incidental cues (Berglund et al., 1999).

Exposure to transport noise disturbs sleep in the laboratory, but generally not in field studies, where adaptation occurs. Noise interferes with complex task performance, modifies social behavior, and causes annoyance. Studies of occupational noise exposure suggest an association with hypertension, whereas community studies show only weak relations between noise and cardiovascular disease. Aircraft and road-traffic noise exposure are associated with psychological symptoms and with the use of psychotropic medication, but not with the onset of clinically defined psychiatric disorders. In carefully controlled studies, noise exposure does not seem to be related to low birth weight or to congenital birth defects. In children, chronic aircraft noise exposure impairs reading comprehension and long-term memory and may be associated with increased blood pressure (Stansfeld, 2000).

2.6.3 Studies on Noise Survey

A survey was developed using noise contours by two procedures namely analytical and graphical. The graphical procedure requires input data: ambient noise level, noise levels generated by individual machines, and the (x, y) coordinates of the machine locations. When drawing the noise contours in work shop floor, a set of mathematical formulae is also developed to estimate the combined noise levels at predetermined locations of the workplace floor. Contour lines are then drawn to connect points having an equal noise level. The analytical nature of the procedure also enables engineers to quickly construct the noise contour map and revise the map when changes occur in noise levels due to a workplace re-layout or an addition of a new noise source. (Nanthavanij et al., 1999)

CHAPTER THREE

METHODOLOGY

3.1 Study Area –Kumasi

Kumasi is the capital city of the Ashanti region and the second biggest city in Ghana, with approximately 2.0 million inhabitants (GSS, 2012). It is situated 250 km northwest of Accra and has a geographical location of 06°41'N latitude and 01°28'W01°28'W longitude. It is located near Lake Bosumtwi, in a Rain Forest region, and is the capital of Asanteman. Kumasi is approximately 480 km north of the Equator and 160 km north of the Gulf of Guinea.

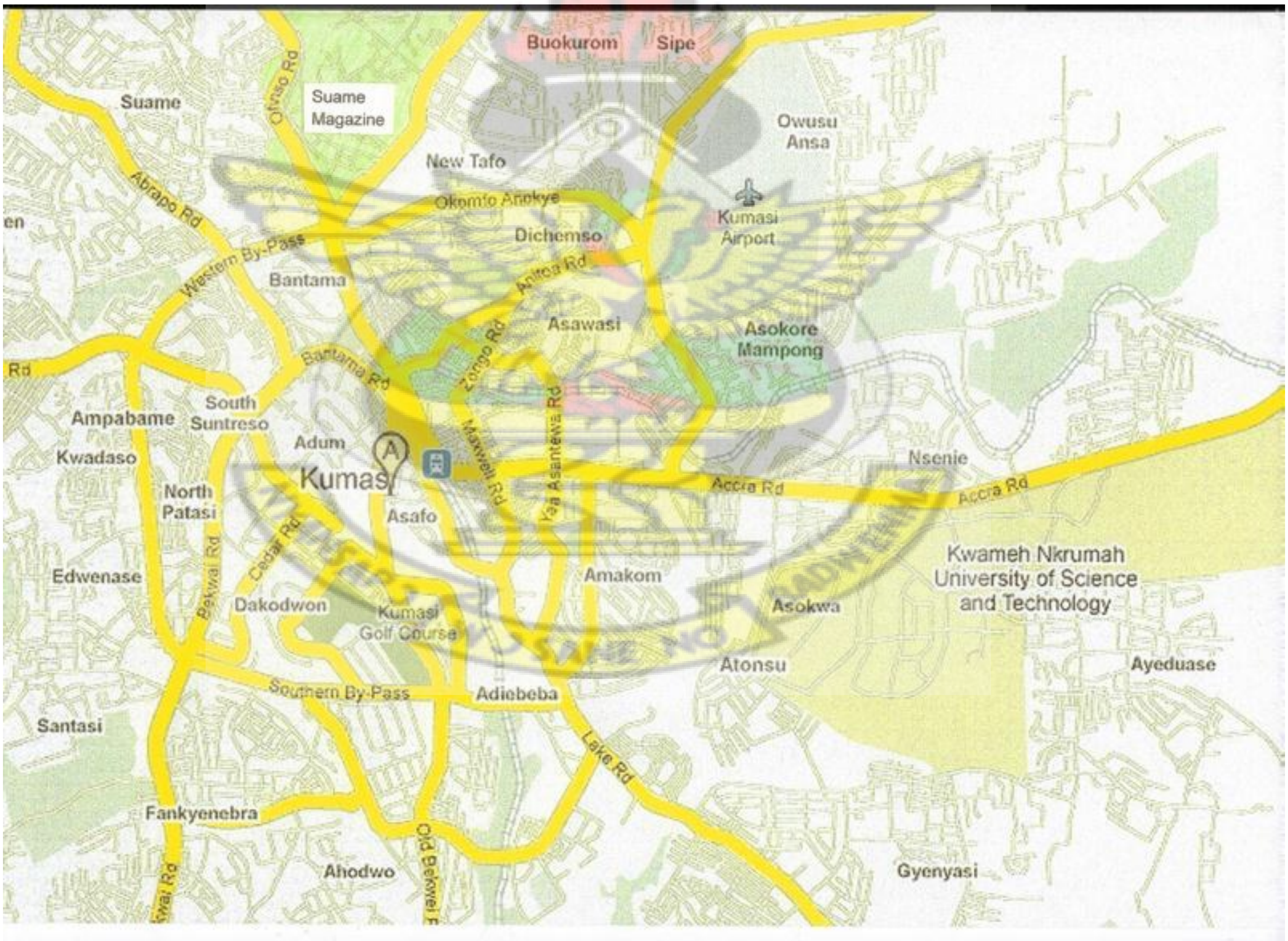

Figure 3. 1: A map of Kumasi (Powell J., 2011)

3.2 Measurement Of Noise Levels

Measurement of noise levels was done in some industry, churches, bus terminals and funeral grounds. Two timber companies, three churches, three bus terminals and three funeral grounds were selected for this study. Noise level was measured in July and August 2013.

In this work, the measurement of noise level was done using a sound level meter which conforms to IEC 61672 standards. The sound level meters manufactured to IEC 61672 standards are the ones internationally accepted for the measurement of noise levels currently. It gives good accuracy requirements.

The Instrumentation for the measurement of noise levels in this study consisted of a DT-8852 Precision digital sound Level meter as shown in Figure 3.2 . (This was manufactured to IEC 61672-1 Type 2,ANSI S1.4 Type2),1/2 inch dielectric condenser microphone and 1/3-octave filter with a frequency range and measuring range of 31.5Hz- 8KHz and 30dB-130dB, respectively.

The instrument was calibrated before taking measurements. In the calibration procedure,the frequency weighting, time weighting and level range were switched to A-weighting, Fast and 50-100dB respectively. The microphone housing was inserted carefully into the ½ inch insertion hole of the calibrator and the switch of the calibrator was turned on. The call potentiometer of the unit was adjusted to display 94.0dB.

This instrument was designed for noise project, quality control, illness prevention & cure and all kinds of environmental sounds measurements. It is applied to the sounds measurement at factory, school, office, traffic access and household, among others.

Noise levels were measured for three working days for each company. The sound level meter was carefully mounted on a tripod at a height of 1.5 metres above the ground for all the two timber companies for consistency with the antenna facing the sound source. The instrument was calibrated to A-weighting for general noise level. The measurement process was carried out for the two timber companies at Kaase industrial area. Measurements were recorded at intervals of 1 second for a period of 1 hour, giving 3600 meter readings per sampling location. The procedure was carried out for the morning, 8:35-9:35 am and afternoon, 11:00 am-12:00 noon.Three appropriate locations were selected for the noise levels measurement at the companies. The digital sound level meter was placed at a distance of 3 meters at from the sound source.

Noise levels measured at the churches were done on three Sundays for a period of one hour. For Church A, it was carried out from 7:51-8:51 am, Church B, 10:00-11:00 am and Church C ,7:30-8:30 am.The sound level meter was mounted on tripod at a height of 1.5 metres from the ground and placed outside the church auditorium. It was placed at a distance of 3 metres from the sound source for measurement.

Noise levels were measured at three funeral events for a period of 1 hour. The noise measurement results were recorded by mounting the sound level meter on a tripod at a height of 1.5 metres from the ground with the antenna facing the noise source. The instrument was held at a distance of 3 metres from the noise source. The funeral grounds were Ayeduase School Park, Ayigya Park and Kotei School Park

Noise levels were also measured at three bus terminals namely KNUST bus terminal, Anloga bus terminal and the Kejetia bus terminal . The sound level meter was positioned at a height of 1.5 metres above the ground. The instrument was held at a distance of 3 metres from the noise source. This measurement process was carried out for three locations at each Bus Terminal at two different times of the day which were: 8.35-9.35 am and 11.00-12.00 noon for nine working days.

Figure 3. 2: DT-8852 Sound level meter.

3.3 Data Collection And Analysis

After measurements of the noise levels, the sound level meter was connected to a computer to retrieve the recorded data with the aid of the sound level meter software. The sound level meter software , matlab and microsoft excel was used to analyse the recorded data. Results of the analysis are available in the next chapter.

Out of the 3600 readings obtained from the measurement of sound levels for one hour duration, the first 60 readings are presented for funeral grounds, churches, bus terminals and companies at the Appendix.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

This Chapter looks at the results and the discussions of noise levels measured at bus terminals, churches, companies and funeral gatherings.

The records of sound levels in bus terminals, churches, companies and funeral gatherings are presented in tables and graphs.

Tables 4.1, 4.2, 4.3 and 4.4 shows that there is variation in noise level for each period of the day for the bus terminals.

In Table 4.1, the results of the equivalent sound levels for the morning and afternoon sessions for Kwame Nkrumah University Of Science and Technology (KNUST) Bus Terminal are presented for each day. Day two recorded the highest sound level for the morning and afternoon session of 82.7 dBA and 82.5 dBA respectively. Figures 4.1, 4.2 and 4.3 shows the graphs of the sound levels measured during a period of one hour for the three bus terminals. The other graphs are presented in the Appendix.

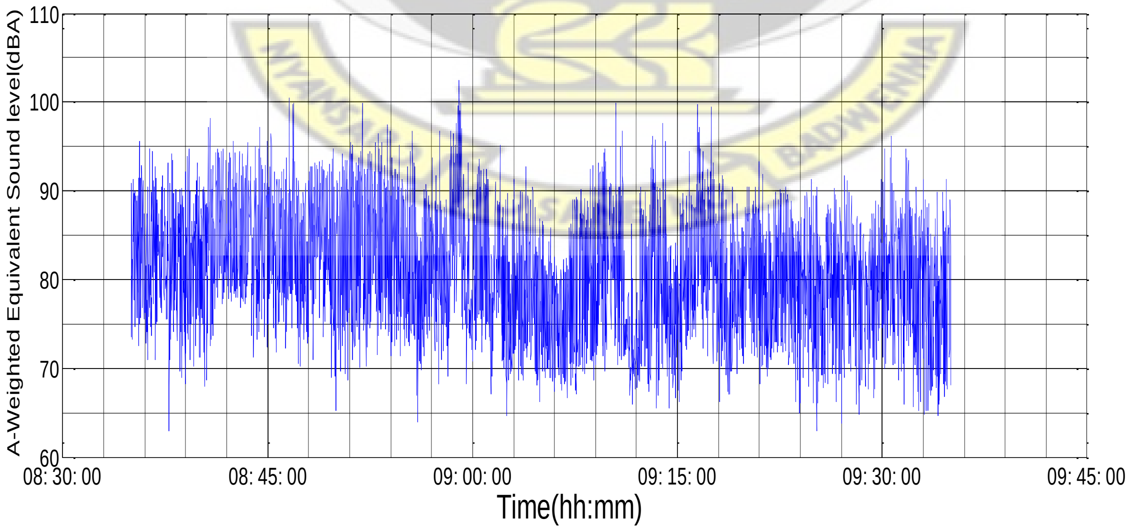

Figure 4. 1: Graph of measured sound levels at KNUST Bus Terminal in the morning (Day 1)

Table 4. 1: Equivalent sound levels for the morning and afternoon session for KNUST Bus Terminal

	Day 1	Day2	Day 3
Morning	81.4 dBA	82.7 dBA	75.6 dBA
Afternoon	73.7 dBA	82.5 dBA	75.7 dBA

Table 4.2 presents the results of the equivalent sound levels for the morning and afternoon session for Anloga Bus Terminal for each day. Day three recorded the highest sound level for the morning and afternoon session of 72.7 dBA and 72.8 dBA respectively.

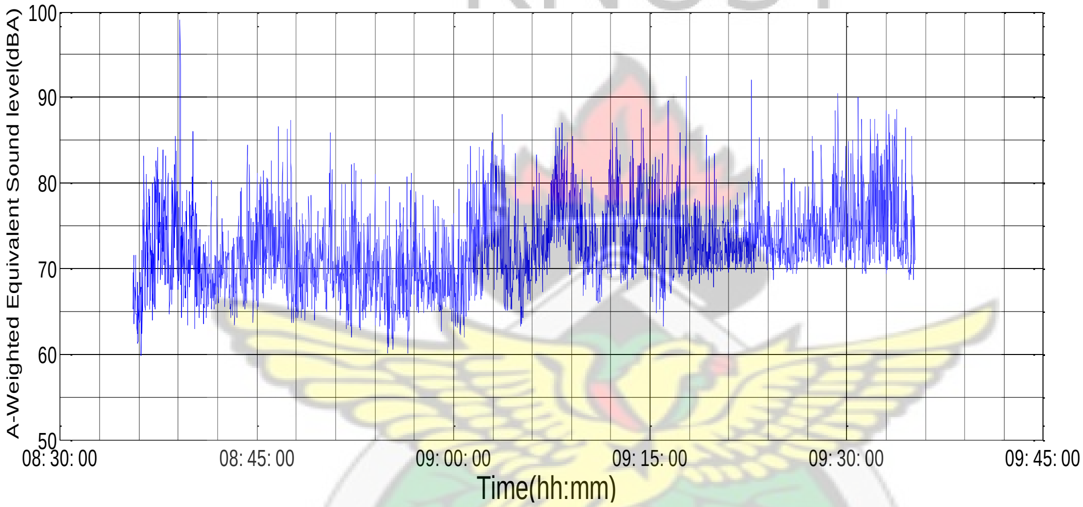

Figure 4. 2: Graph of measured sound levels at Anloga Bus Terminal in the morning (Day 1)

Table 4. 2: Equivalent sound levels for the morning and afternoon session for Anloga Bus Terminal

	Day1	Day2	Day3
Morning	72.6 dBA	72.3 dBA	72.7 dBA
Afternoon	70.1 dBA	71.9 dBA	72.8 dBA

Table 4.3 presents the results of the equivalent sound levels for the morning and afternoon session for Kejetia Bus Terminal. Day two recorded the highest sound level of 81.3 dBA and 80.5 dBA respectively. Table 4.4 contains the average noise level for the morning and

afternoon sessions for the three Bus Terminals. It also contains daytime noise level which was calculated using the average morning and afternoon noise values and Equation 2.1.

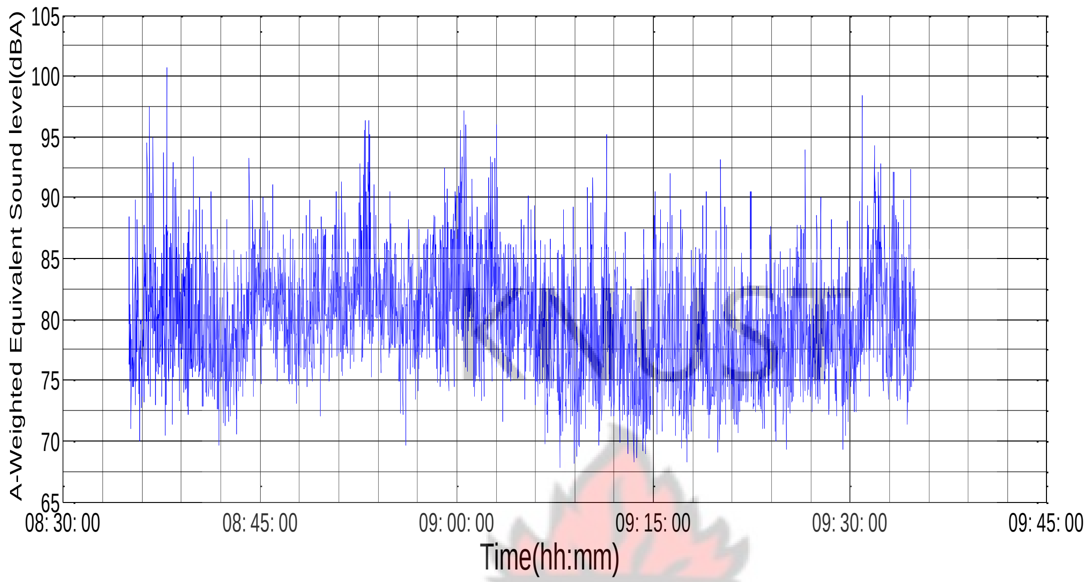

Figure 4. 3: Graph of measured sound levels at Kejetia Bus Terminal in the morning (Day 1)

Table 4. 3: Equivalent sound levels for the morning and afternoon session for Kejetia Bus Terminal

	Day 1	Day 2	Day 3
Morning	79.8 dBA	81.3 dBA	74 dBA
Afternoon	79.8 dBA	80.5 dBA	74.3 dBA

Table 4. 4: Daytime noise level for the three Bus Terminals

	KNUST Bus Terminal	Anloga Bus Terminal	Kejetia Bus Terminal
Morning	79.9 dBA	72.5 dBA	78.4 dBA
Afternoon	77.3 dBA	71.6 dBA	78.2 dBA
Daytime noise level	78.8 dBA	72.1 dBA	78.3 dBA

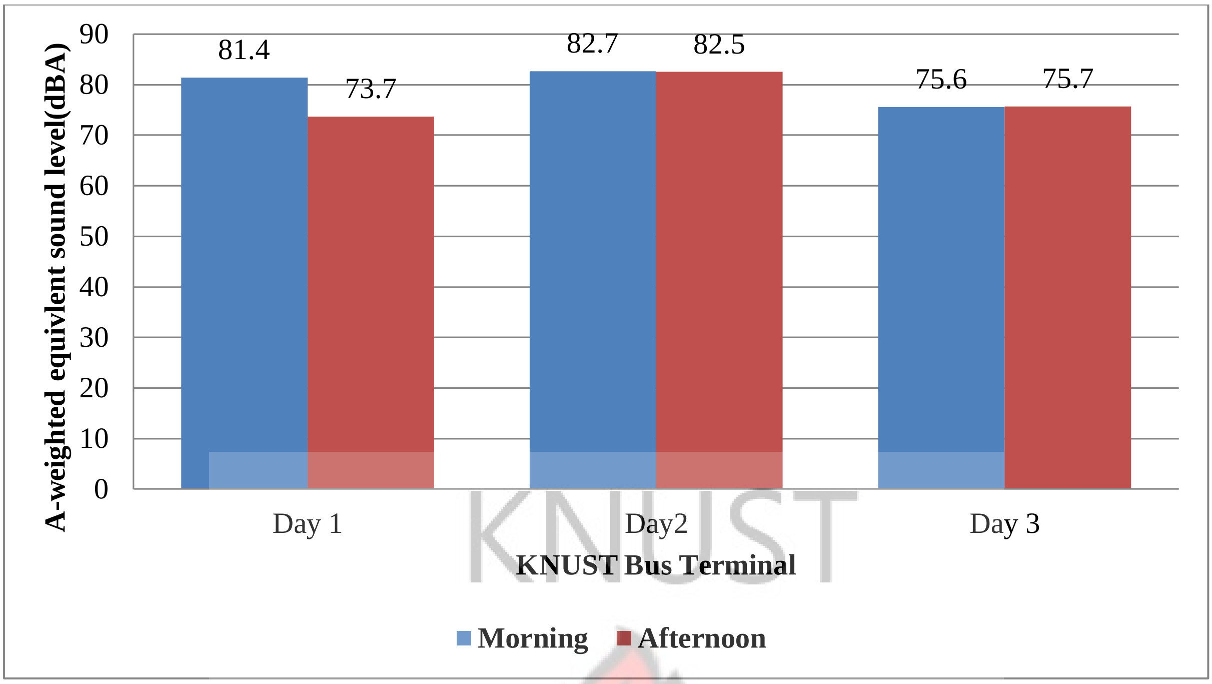

Figure 4. 4: Bar graph of Equivalent noise levels for KNUST Bus Terminal

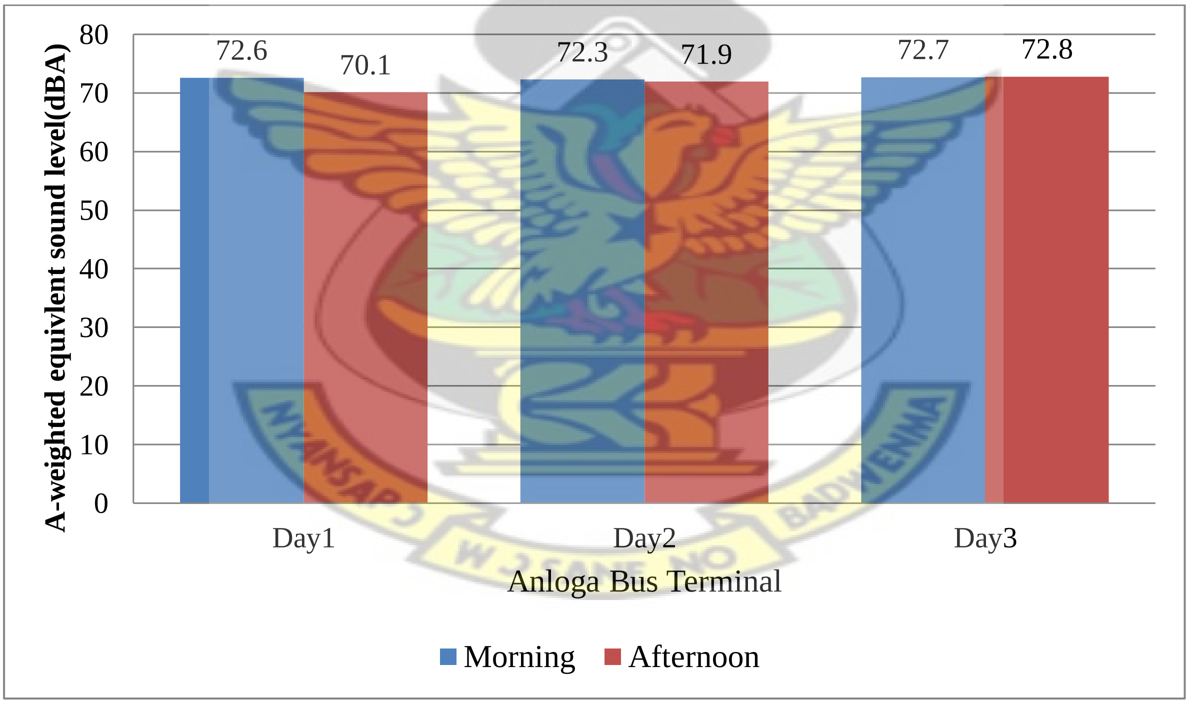

Figure 4. 5: Bar graph of Equivalent noise levels for Anloga Bus Terminal

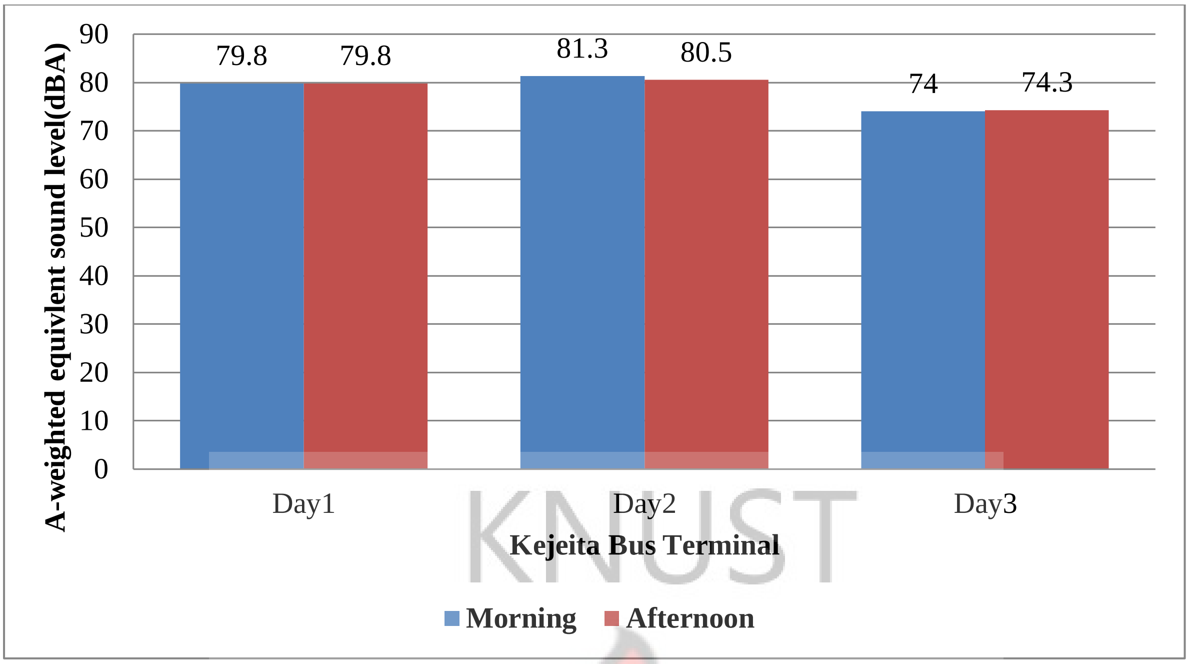

Figure 4. 6: Bar graph of Equivalent noise levels for Kejeita Bus Terminal

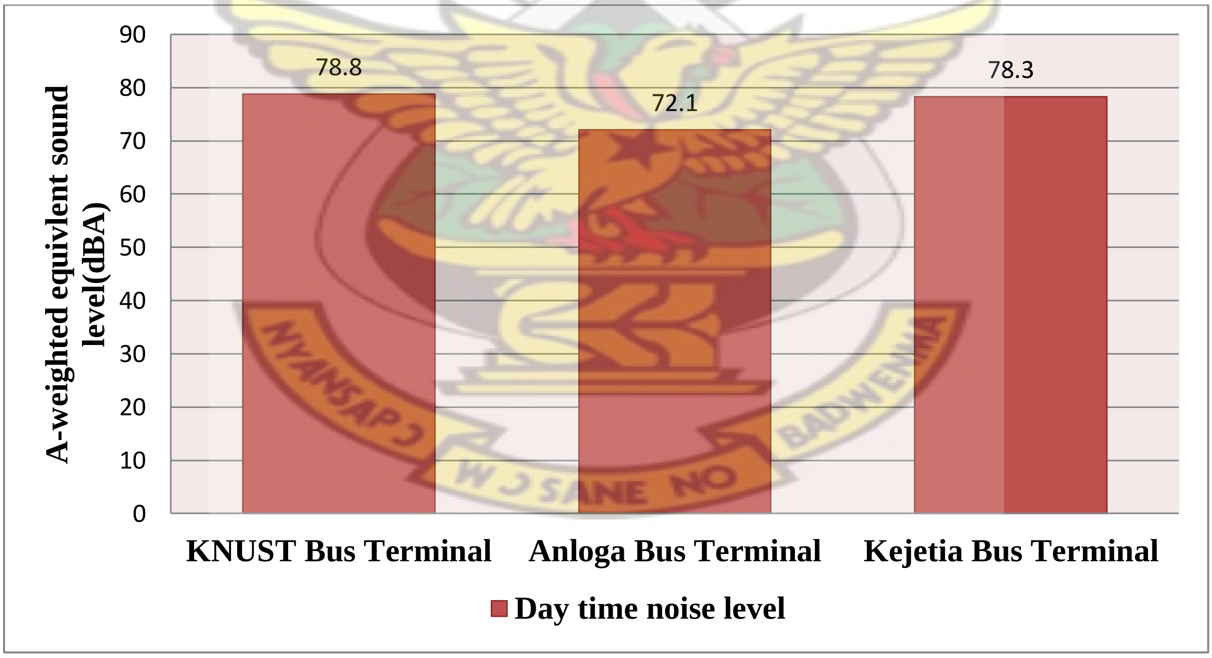

Figure 4. 7: Bar graph of Daytime noise level for the three Bus Terminals.

From the Figure 4.7, KNUST Bus Terminal recorded the highest daytime noise level of 78.8 dBA. This high value is attributed to the fact that there are a lot of activities at the terminal during the daytime. The volume of vehicles plying the network of roads in this station is very high coupled with business activities on daily bases. Major sources of noise was from traffic noise, vehicle horn, rolling tyres, human conversation, musical instruments, radio players from vehicle as well as preaching using loud speakers. This attests to the finding of Essandoh and Armah (2011) that most environmental noise results from road traffic and commercial activities. The next to KNUST was Kejetia Bus Terminal which recorded 78.3 dBA.The difference is quite small. There are also a lot of activities during the day time and the volume of vehicles plying the network of roads at this station was high. Anloga Bus Terminal recorded the lowest daytime noise level of 72.1 dBA. This results from the fact that business and commercial activities at the station was minimal. Major sources of noise were traffic noise, vehicle horn, rolling tires, human conversation and radio players from vehicles.

The study revealed that the bus terminals were exposed to noise level exceeding the maximum allowable limit of 70 dBA for predominantly commercial areas. From table 4.5, KNUST Bus terminal exceeded the allowable limit set by EPA by 8.8 dBA, Anloga Bus terminal exceeded the allowable limit by 2.1 dBA and kejetia Bus terminal also exceeded the allowable limit by 8.3 dBA.

Table 4. 5:Excess dB from the Bus terminals

	Day time noise level	**EPA Noise level limit**	**Excess**
KNUST Bus Terminal	78.8 dBA	70 dBA	8.8 dBA
Anloga Bus Terminal	72.1 dBA	70 dBA	2.1 dBA
kejetia Bus Terminal	78.3 dBA	70 dBA	8.3 dBA

Table 4.6 shows that there is variation in noise levels for the three Churches. It shows the noise levels for three Sundays for each church and the average noise level. Church A, Church B and Church C recorded 78.3 dBA, 82.8 dBA and 81.4 dBA respectively. The graph is shown in Figure 4.11. Figures 4.8, 4.9 and 4.10 show the graphs of the sound levels measured during a period of one hour for the churches. The other graphs are presented in the

Appendix. The source of noise is mainly from loud speakers. The noise from all the speakers was mainly from musical instruments, praises, worship and preaching using microphones. Church B recorded the highest noise level as a result of noise from a number of loud speakers from intense praise and worship compared to Church C and Church B. The noise levels from the three Churches exceeded the maximum allowable limit of 60 dBA during the day for light industrial areas and places of entertainment and public assembly such as churches and mosques.

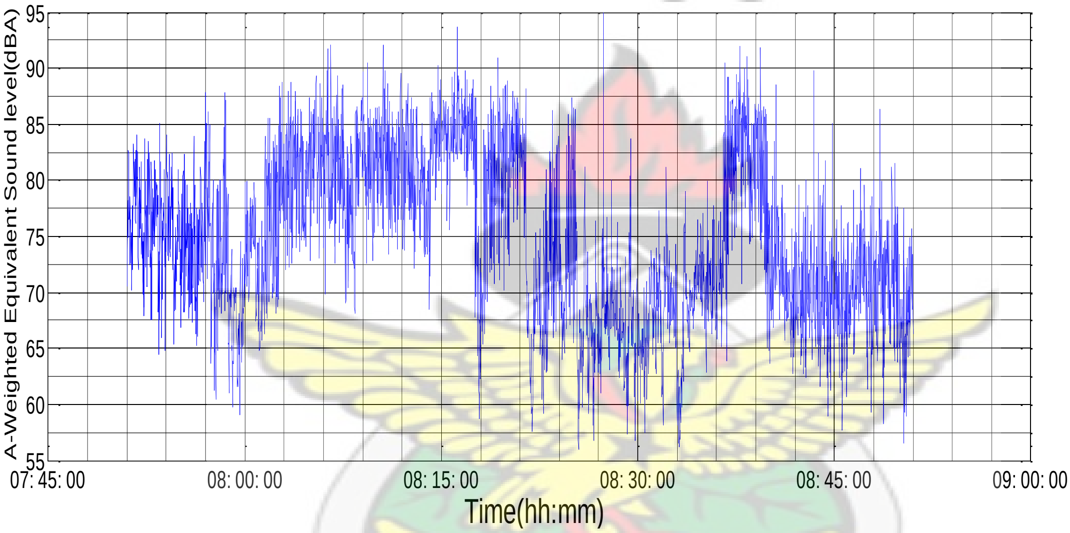

Figure 4. 8: Graph of measured sound levels at Church A (Day 1)

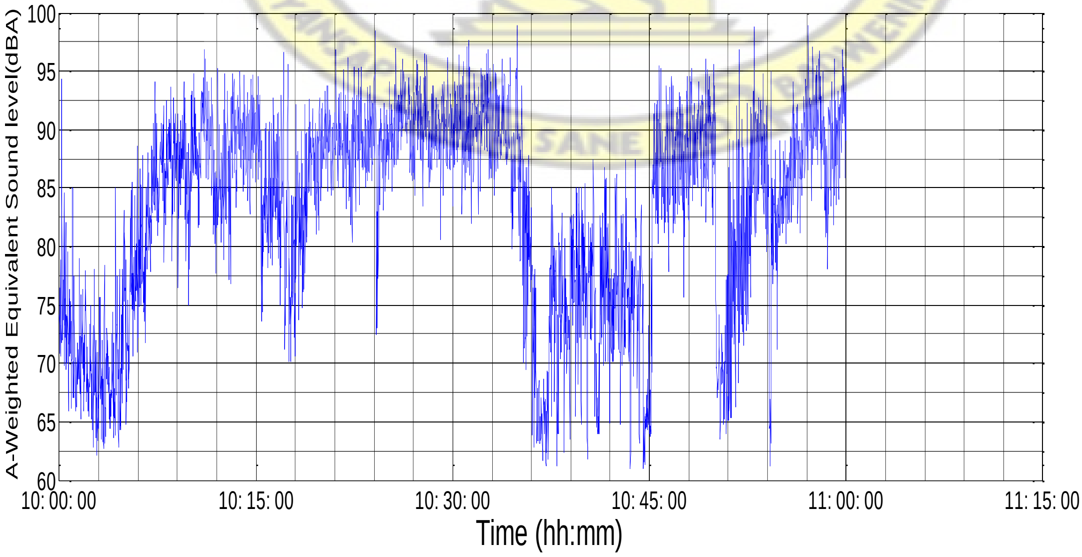

Figure 4. 9: Graph of measured sound levels at Church B (Day 1)

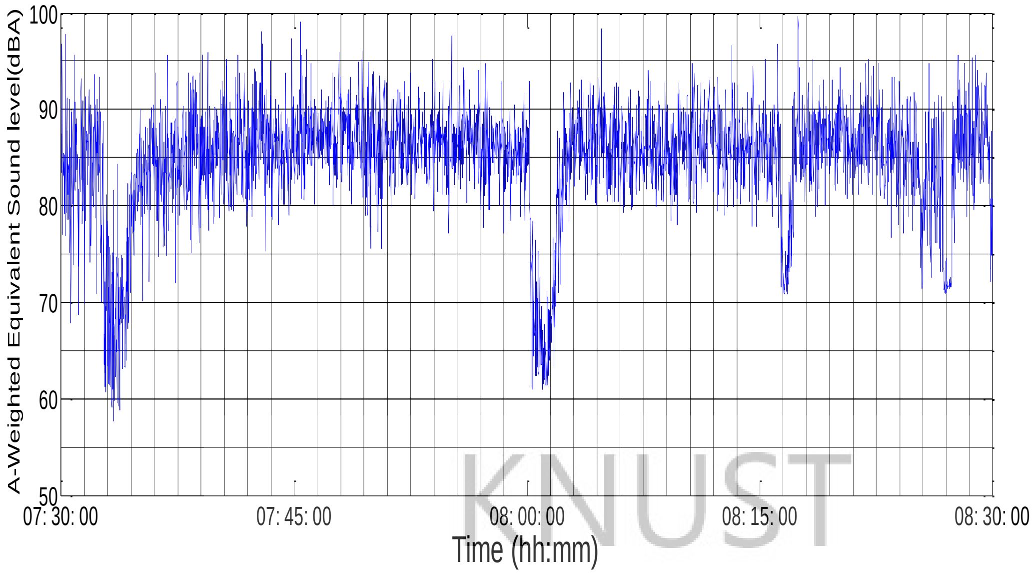

Figure 4. 10: Graph of measured sound levels at Church C (Day 1)

Table 4. 6: Equivalent Sound Levels at the Churches

	Church A	Church B	Church C
Noise level 1	74.8 dBA	84.5 dBA	84.7 dBA
Noise level 2	81.8 dBA	80.6 dBA	78.4 dBA
Noise level 3	78.4 dBA	83.4 dBA	81 dBA
Average Noise level	78.3 dBA	82.8 dBA	81.4 dBA

It can be seen from Table 4.7 that , Church A exceeded the allowable limit set by EPA by 18.3 dBA, Church B exceeded the allowable limit by 22.8 dBA and Church C exceeded the allowable limit by 21.4 dBA.

Table 4. 7: Excess dB from Churches

	Church A	Church B	Church C
Noise Level	78.3 dBA	82.8 dBA	81.4 dBA
EPA noise level limit	60 dBA	60 dBA	60 dBA
Excess	18.3 dBA	22.8 dBA	21.4 dBA

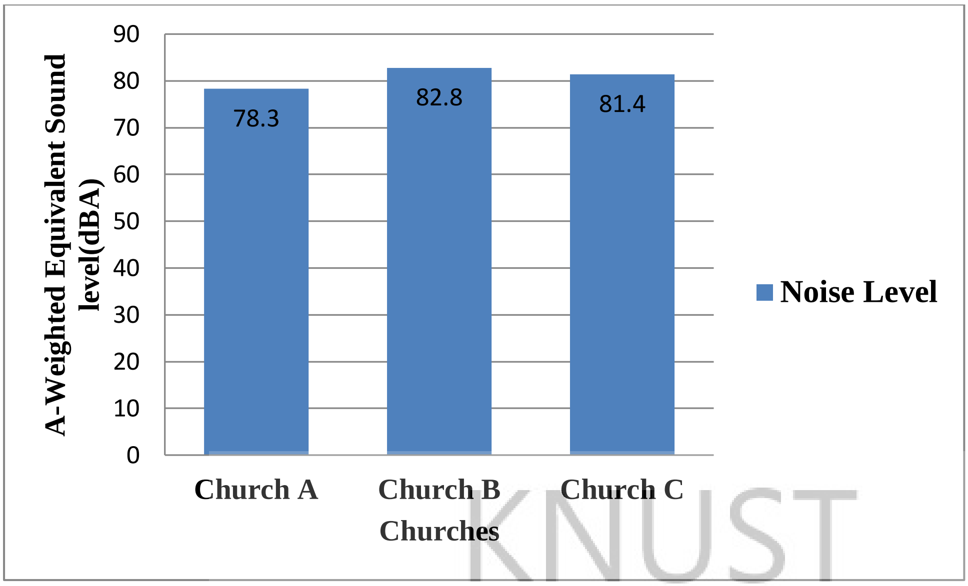

Figure 4. 11:Graph of Equivalent Sound Levels for the churches.

Table 4.8 and Figure 4.14 show that there is variation in noise level at the funeral grounds. Funeral ground 1 recorded the highest noise level of 84 dBA, followed by funeral ground 3 of 83.6 dBA then funeral ground 2 of 79.2 dBA. Figures 4.7, 4.8 and 4.9 shows the graphs of the sound levels measured during a period of one hour for the funeral grounds.

Major sources of noise were from music played from DVD players. The noise emanated from large blared loudspeakers. Some funeral grounds had the volume of their music players very high. Funeral ground 1 had a number of large loudspeakers compared to Funeral ground 2 and Funeral ground 3. This resulted in the recording of the highest noise level at Funeral ground 1 of 84 dBA.

The study showed that noise levels from the funeral ground exceeded the maximum allowable limit of 65 dBA for public assembly by EPA Standards.

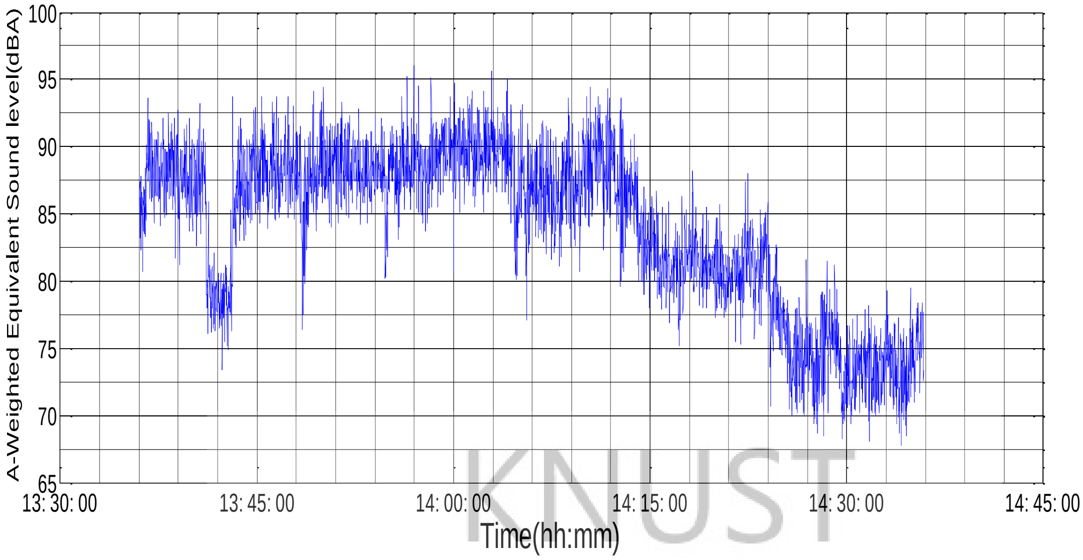

Figure 4. 12: Graph of measured sound levels at Funeral ground 1

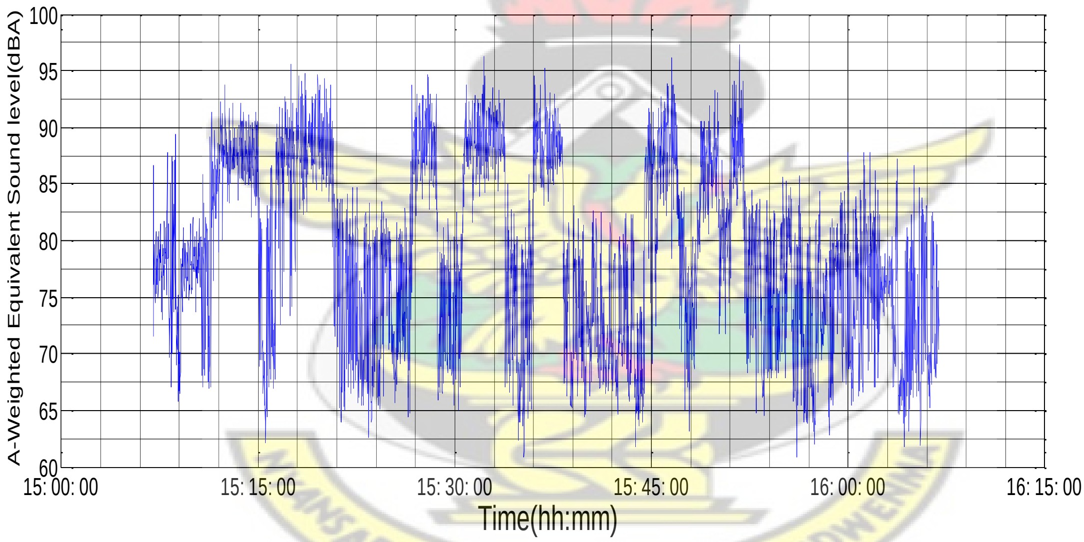

Figure 4. 13: Graph of measured sound levels at Funeral ground 2

Table 4. 8: Equivalent Sound Levels at the funeral grounds

	Funeral ground 1	**Funeral ground 2**	**Funeral ground 3**
Noise Levels	84 dBA	79.2 dBA	83.6 dBA

From Table 4.9, funeral ground 1 exceeded the allowable limit by 19 dBA, funeral ground 2 exceeded the allowable limit by 14.2 dBA and funeral ground 3 exceeded the allowable limit set by EPA by 18.6 dBA.

Table 4. 9: Excess dB from funeral grounds

	Funeral ground 1	**Funeral ground 2**	**Funeral ground 3**
Noise Levels	84 dbA	79.2 dBA	83.6 dBA
EPA noise level limit	65 dBA	65 dBA	65 dBA
Excess	19 dBA	14.2 dBA	18.6 dBA

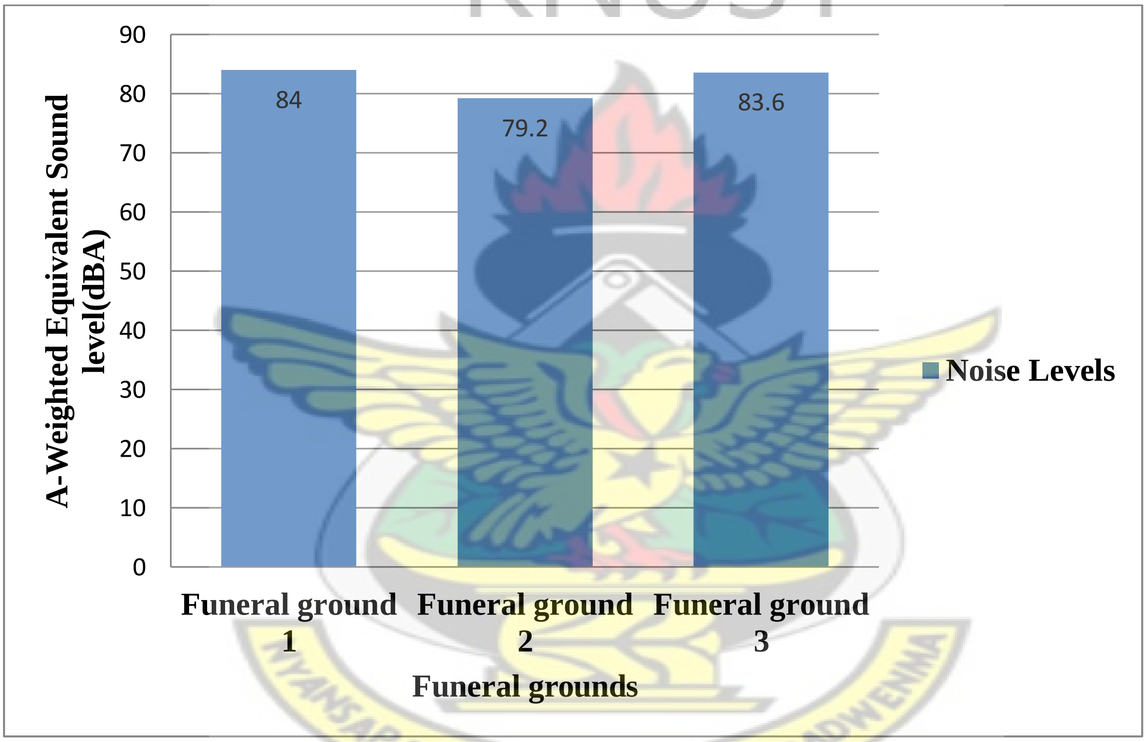

Figure 4. 14: Equivalent Sound Levels for the Funeral grounds.

Table 4.10, 4.11 and 4.12 represent the variation in noise levels for the two timber companies studied. In Table 4.7, the results of the average equivalent sound levels for the morning and afternoon sessions for Company A are presented for each day. In Table 4.8, the results of the average equivalent sound levels for the morning and afternoon sessions for Company B are presented for each day. Figures 4.15 and 4.16 shows the graphs of the sound levels measured during a period of one hour for the industries.The other graphs are presented in the Appendix.

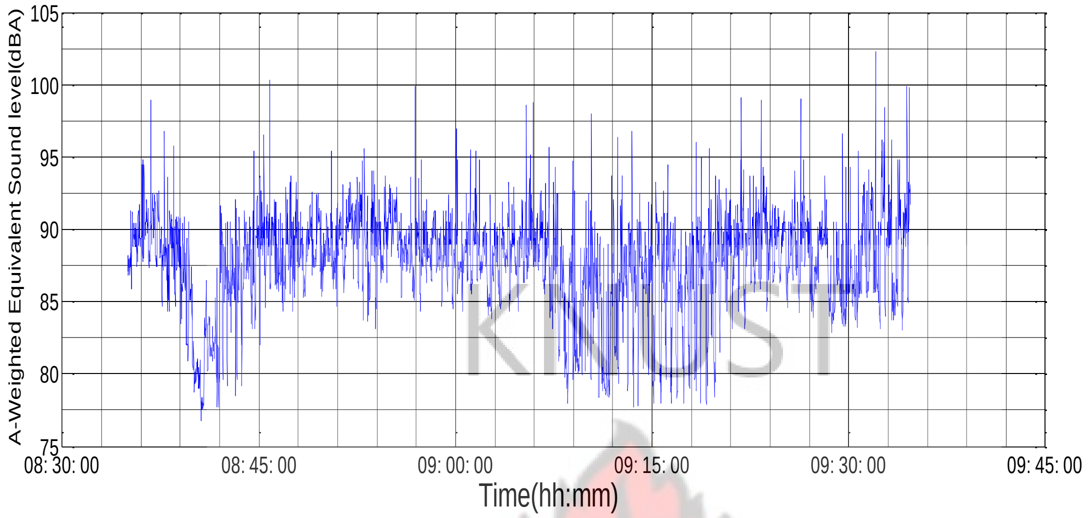

Figure 4. 15: Graph of measured sound levels at Company A in the morning (Day 1)

Table 4. 10: Equivalent Sound Levels for the morning and afternoon sessions for Company A

	Day 1	Day2	Day 3
Morning	87.6 dBA	79.1 dBA	78.5 dBA
Afternoon	83.3 dBA	86.9 dBA	86.8 dBA

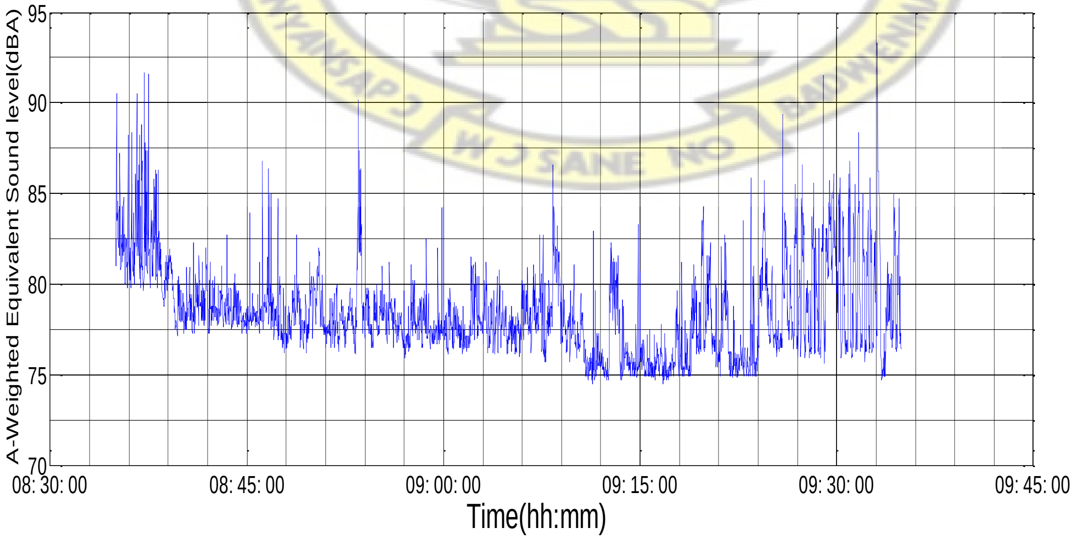

Figure 4. 16: Graph of measured sound levels at Company B in the morning (Day 1)

Table 4. 11: Equivalent Sound Levels for the morning and afternoon sessions for Company B

	Day 1	**Day2**	**Day 3**
Morning	78.4 dBA	84.1 dBA	81.2 dBA
Afternoon	85.4 dBA	77.8 dBA	86.6 dBA

Table 4. 12: Day time noise level for both companies.

	Company A	**Company B**
Morning	81.733 dBA	81.233 dBA
Afternoon	85.667 dBA	83.267 dBA
Daytime noise level	84.1 dBA	82.4 dBA

Table 4.12 depicts the daytime noise levels for the two companies which were determined by using the average sound levels for the morning and afternoon sessions and Equation 2.1. Figure 4.17, 4.18 and 4.19 show the graphs for noise levels at the companies. From Figure 4.9, Company A recorded the highest daytime noise level of 84.1 dBA while Company B recorded 82.4 dBA. Figures 4.15 and 4.16 shows the graphs of the sound levels measured during a period of one hour for the industries.The other graphs are presented in the Appendix Company A recorded the highest as a result of the fact that their working place was an open one so the noise did not emanate only from the machines in the working environment but also from outside the working environment, compared to Company B where the working environment was inside a building. Noise emanated from some machines like the band saw, cross cut saw, chain saw, edger saw, moulding machines and planning machines.

The results shows that the noise level from the industries were above the recommended level of 70 dBA for predominantly heavy industrial areas set by the EPA-Ghana.

Table 4. 13: Excess dBA from the Companies

	Day time noise level	**EPA noise level limit**	**Excess**
Company A	84.1 dBA	70 dBA	14.1 dBA
Company B	82.4 dBA	70 dBA	12.4 dBA

From Table 4.13, Company A exceeded the allowable limit set by EPA by 14.1 dBA, and Company B exceeded the allowable limit by 12.4 dBA.

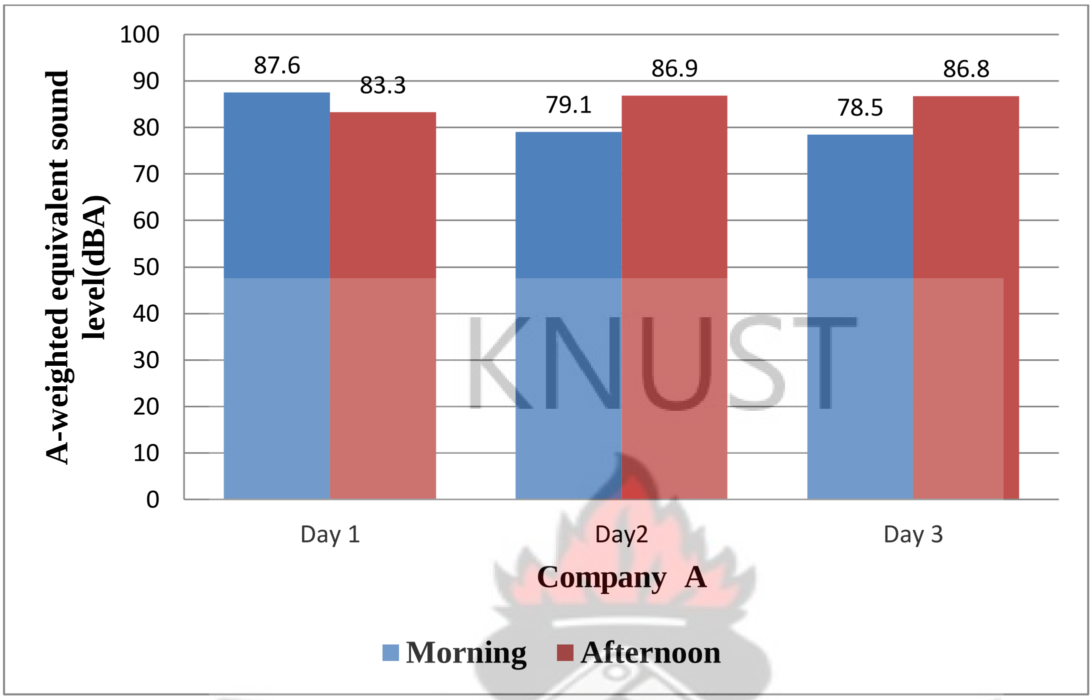

Figure 4. 17: Equivalent Sound Levels for Company A

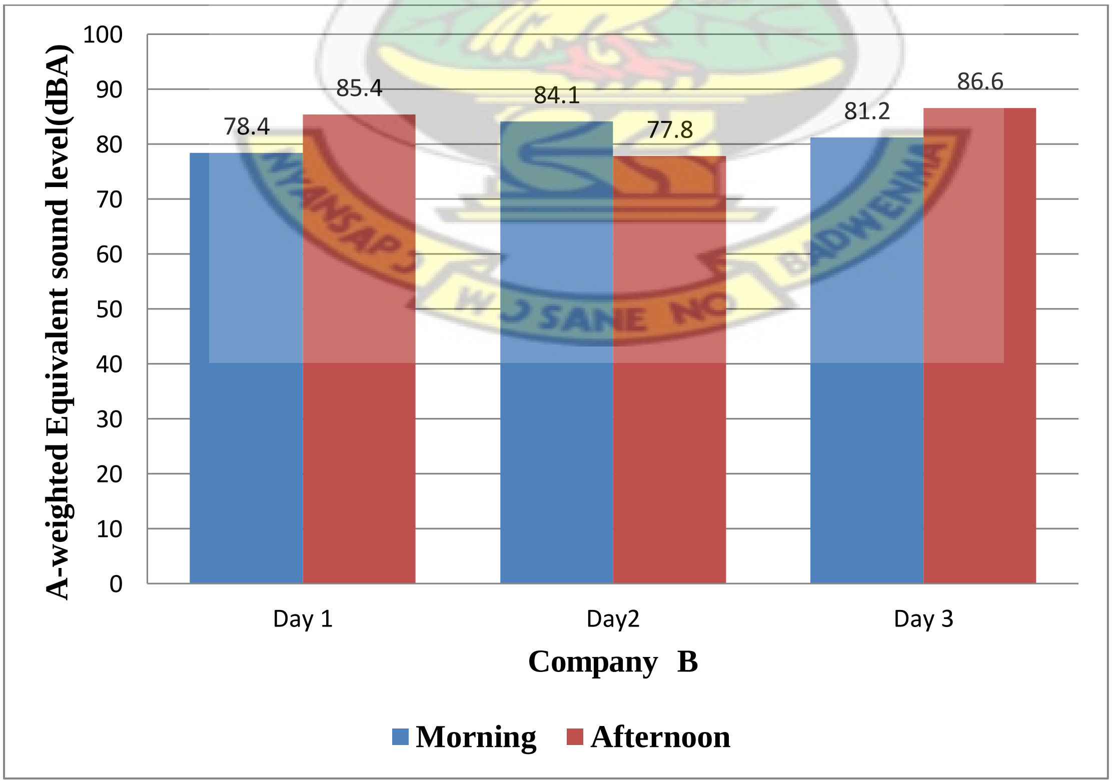

Figure 4. 18: Equivalent sound level for Company B

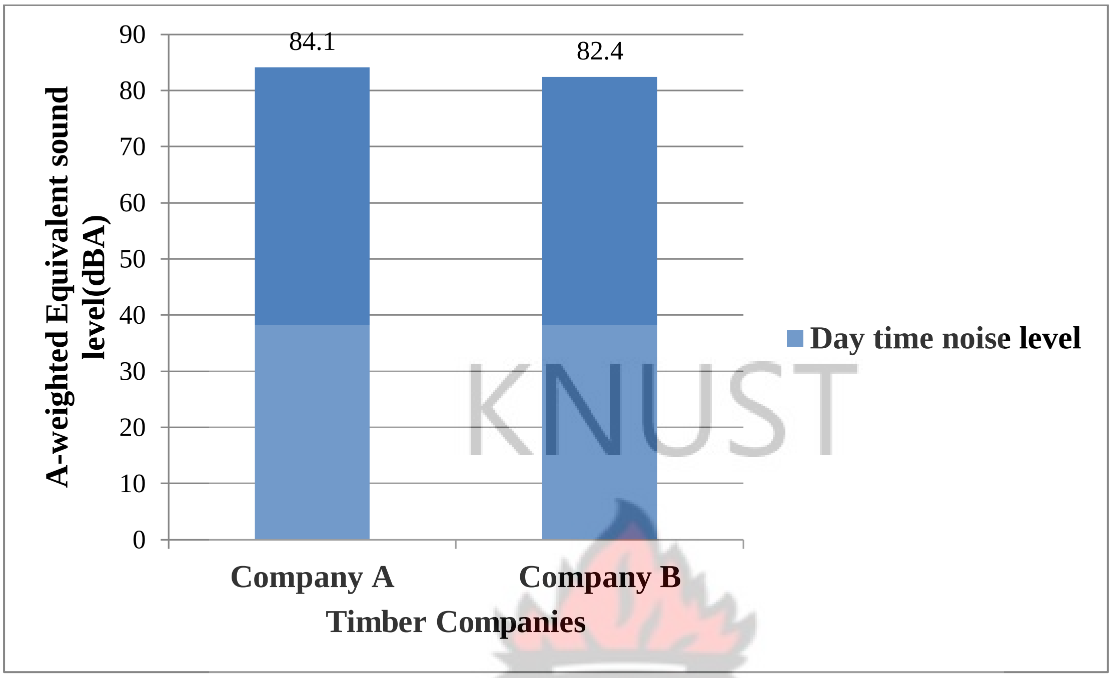

Figure 4. 19: Day time noise levels for the two companies.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The main aim of this study was to measure noise levels using the sound level meter at different areas in Kumasi including some churches, industries, bus terminals and funeral grounds, and to determine whether the noise generated in Kumasi metropolis is beyond acceptable limits by EPA standards and consequently their effects on humans and the environment.

It was realised from the measurement and analysis that the daytime noise levels from the Church A, Church B and Church C were 78.3 dBA, 82.8 dBA and 81.4 dBA respectively. Which exceeded the maximum allowable limit of 60 dBA during the day for light industrial areas and places of entertainment and public assembly such as churches and mosques by 18.3 dBA, 22.8 dBA and 21.4 dBA respectively.

The two timber industries, Company A and Company B recorded day time noise levels of 84.1 dBA and 82.4 dBA respectively, exceeding the maximum allowable limits of 70 dbA for predominantly heavy industrial areas set by the EPA-Ghana by 14.1 dBA, 12.4 dBA respectively.

The three bus terminals namely KNUST, Anloga and Kejetia from the research had their day time noise levels to be 78.8 dBA, 72.1 dBA and 78.3 dBA respectively, exceeding the maximum allowable limit of 70 dBA for predominantly commercial areas by 8.8 dBA, 2.1 dBA and 8.3 dBA respectively.

Funeral ground 1 recorded the highest noise level of 84 dBA, followed by funeral ground 3 of 83.6 dBA, then funeral ground 2 of 79.2 dBA. The study showed that noise levels from the funeral grounds exceeded the maximum allowable limit of 65 dBA for public assembly set by EPA by 19 dBA, 18.4 dBA and 14.2 dBA respectively .

The excess decibels at the funeral grounds and Companies were between 10 dBA and 20 dBA. Which means the change in decibel levels is between double loudness and quadruple loudness. The excess decibels at the bus terminals were less than 10 dBA, implying that the change in decibel levels is clearly noticeable. Churches B and C had their excess decibels exceeding 20 dBA, implying their decibel levels were more than four times as loud whiles Church A excess decibels was less than 20 dBA. This means the change in decibel levels is less than quadruple loudness.

The noise levels at the areas were unacceptable and could pose a health risk to the populace. This will affect their physical and mental well-being negatively. At industry, it will increase the risk of accidents because workers will not be able to hear and communicate effectively. Considering noise levels at these areas, the noise levels could affect the cardiovascular systems resulting in an increase in blood pressure and also leading to hearing loss.

An Urgent step should be taken to reduce noise levels in these areas.

5.2 Recommendation

From the findings, the following are recommended:

I. The appropriate body in charge of noise regulation should make sure the legislation for noise pollution is enforced. That will go a long way to bring the noise levels in areas within the permissible limits.

II. The Public should be made aware of the adverse effects of noise pollution. The television, radio and the newspaper should be used as media to promote campaign on noise pollution, its effects and control.

III. There should be a ban on the use of pubic loudspeakers at funeral gathering.

IV. Further studies should be carried out to determine noise levels at night for areas in Kumasi.

V. Further studies should be done to determine noise levels in areas like school, residential areas, night clubs and other commercial areas to find whether their noise levels generated is beyond acceptable limits by EPA.

VI. A future work should be done to develop noise maps for areas in Kumasi. Noise maps are essential tools to communicate the results of assessments of noise to the public, and also for the government to come out with noise correction measures.

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APPENDICE

APPENDIX 1: DATA FROM FUNERAL GROUNDS

FUNERAL GROUND 1
27-07-2013,13:36:01, 85.60, dBA
27-07-2013,13:36:02, 86.60, dBA
27-07-2013,13:36:03, 87.40, dBA
27-07-2013,13:36:04, 83.20, dBA
27-07-2013,13:36:05, 86.30, dBA
27-07-2013,13:36:06, 86.20, dBA
27-07-2013,13:36:07, 85.10, dBA
27-07-2013,13:36:08, 82.30, dBA
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27-07-2013,13:36:10, 85.70, dBA
27-07-2013,13:36:11, 84.90, dBA
27-07-2013,13:36:12, 86.60, dBA
27-07-2013,13:36:13, 85.30, dBA
27-07-2013,13:36:14, 86.30, dBA
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27-07-2013,13:36:16, 83.40, dBA
27-07-2013,13:36:17, 80.70, dBA
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27-07-2013,13:36:19, 86.10, dBA
27-07-2013,13:36:20, 85.60, dBA
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27-07-2013,13:36:23, 83.70, dBA
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27-07-2013,13:36:25, 83.50, dBA
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27-07-2013,13:36:27, 86.80, dBA
27-07-2013,13:36:28, 83.90, dBA
27-07-2013,13:36:29, 88.40, dBA
27-07-2013,13:37:00, 90.00, dBA

FUNERAL GROUND 2
27-07-2013,15:07:00, 71.50, dBA
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27-07-2013,15:07:12, 80.80, dBA
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27-07-2013,15:07:16, 78.40, dBA
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27-07-2013,15:07:18, 76.10, dBA
27-07-2013,15:07:19, 78.40, dBA
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27-07-2013,15:07:24, 76.50, dBA
27-07-2013,15:07:25, 78.60, dBA
27-07-2013,15:07:26, 80.80, dBA
27-07-2013,15:07:27, 79.10, dBA
27-07-2013,15:07:28, 78.40, dBA

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27-07-2013,13:36:50, 90.50, dBA
27-07-2013,13:36:51, 86.10, dBA
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27-07-2013,13:36:59, 91.80, dBA

27-07-2013,15:07:29, 79.20, dBA
27-07-2013,15:07:30, 77.70, dBA
27-07-2013,15:07:31, 76.50, dBA
27-07-2013,15:07:32, 81.50, dBA
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27-07-2013,15:07:35, 79.60, dBA
27-07-2013,15:07:36, 76.90, dBA
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27-07-2013,15:07:55, 79.00, dBA
27-07-2013,15:07:56, 78.80, dBA
27-07-2013,15:07:57, 78.80, dBA
27-07-2013,15:07:58, 78.40, dBA

27-07-2013,15:07:59, 81.20, dBA
27-07-2013,15:08:00, 75.20, dBA

FUNERAL GROUND 3

03-08-2013,13:14:31, 83.50, dBA
03-08-2013,13:14:32, 88.60, dBA
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03-08-2013,13:14:34, 83.50, dBA
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03-08-2013,13:14:36, 87.80, dBA
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03-08-2013,13:14:08, 80.70, dBA
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03-08-2013,13:14:04, 81.20, dBA
03-08-2013,13:14:05, 88.50, dBA
03-08-2013,13:14:03, 86.10, dBA

03-08-2013,13:14:01, 81.20, dBA
03-08-2013,13:14:02, 85.10, Dba

APPENDIX 2: DATA FROM CHURCHES

CHURCH A

21-07-2013,7:51:01, 70.50, dBA
21-07-2013,7:51:02, 73.40, dBA
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21-07-2013,7:51:04, 80.60, dBA
21-07-2013,7:51:05, 74.90, dBA
21-07-2013,7:51:06, 82.70, dBA
21-07-2013,7:51:07, 82.50, dBA
21-07-2013,7:51:08, 80.20, dBA
21-07-2013,7:51:09, 79.60, dBA
21-07-2013,7:51:10, 76.50, dBA
21-07-2013,7:51:11, 77.80, dBA
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21-07-2013,7:51:14, 72.50, dBA
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APPENDIX 4:DATA FROM BUS TERMINALS

TECH BUS TERMINAL

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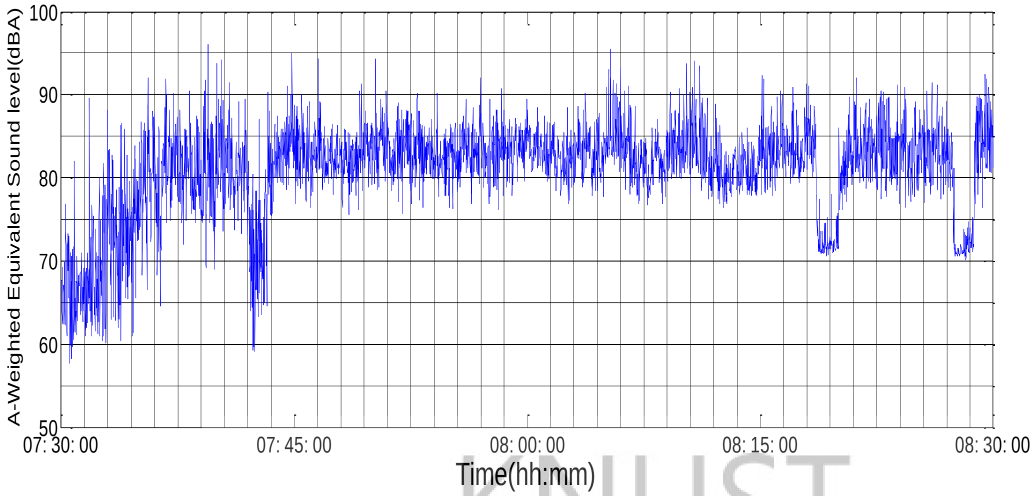

Figure A1: Graph of measured sound levels at Church C (Day 2)

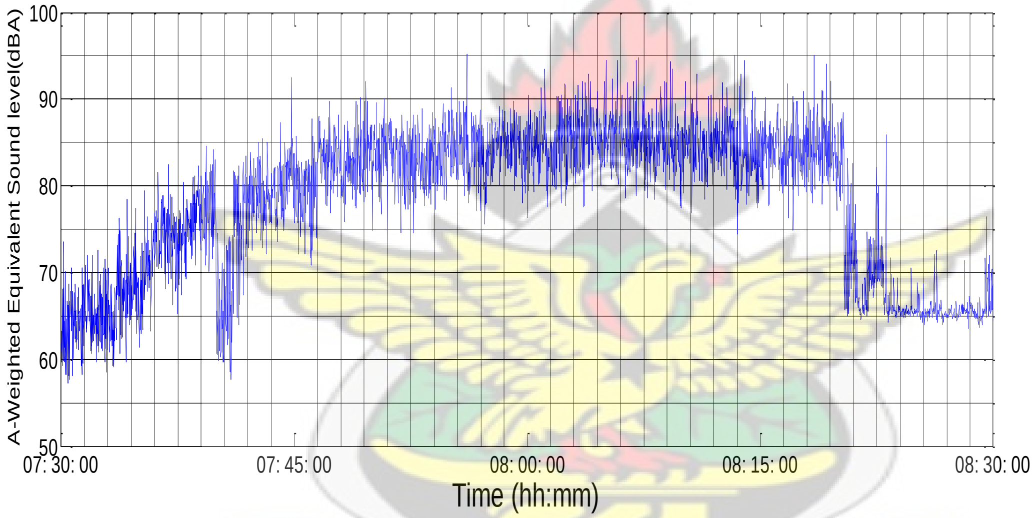

Figure A2: Graph of measured sound levels at Church C (Day 3)

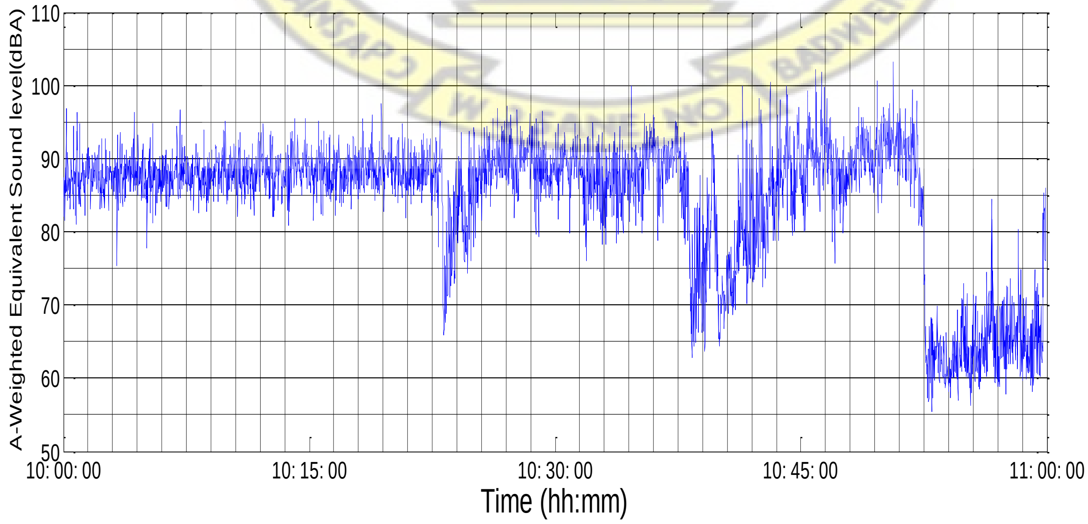

Figure A3: Graph of measured sound levels at Church B (Day 2)

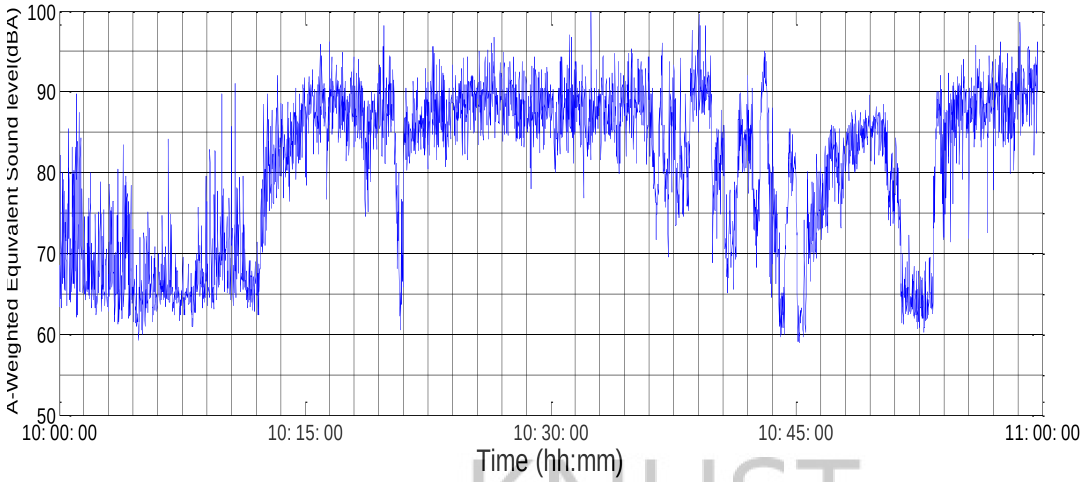

Figure A4: Graph of measured sound levels at Church B (Day 3)

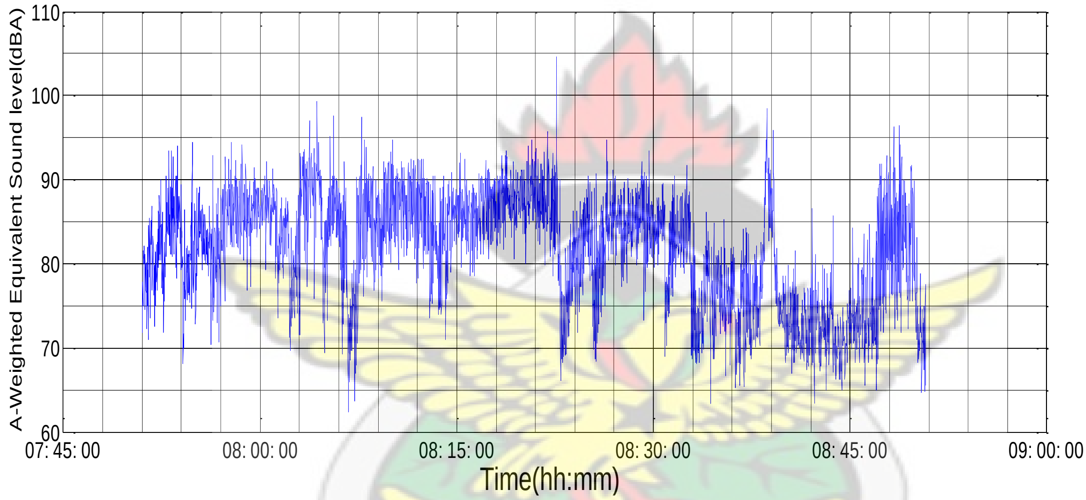

Figure A5: Graph of measured sound levels at Church A (Day 2)

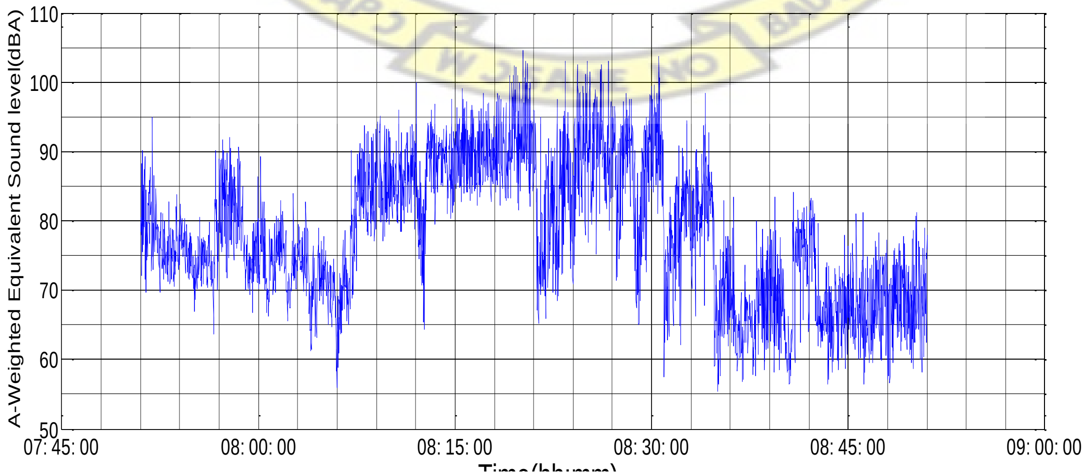

Figure A6: Graph of measured sound levels at Church A (Day 3)

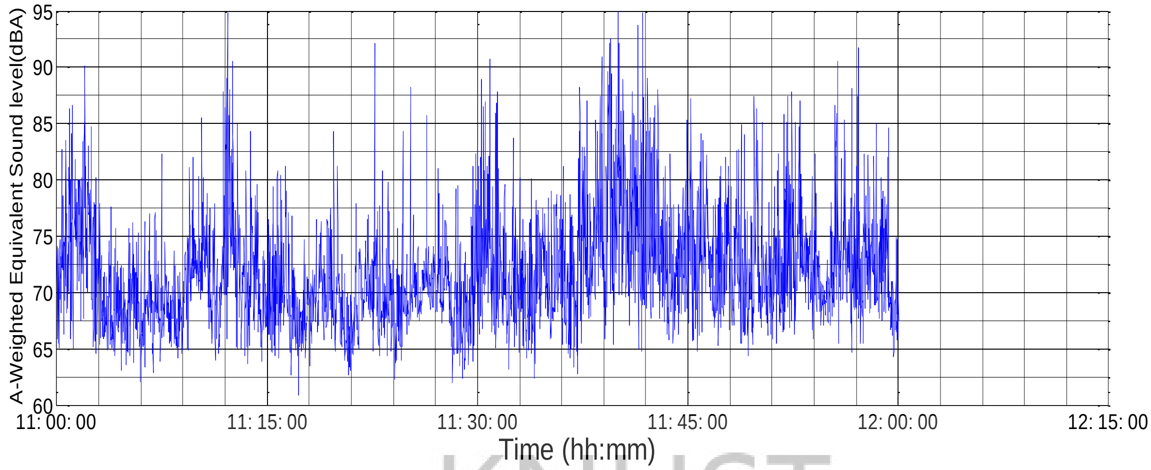

Figure A7: Graph of measured sound levels at Anloga Bus Terminal in the morning (Day 2)

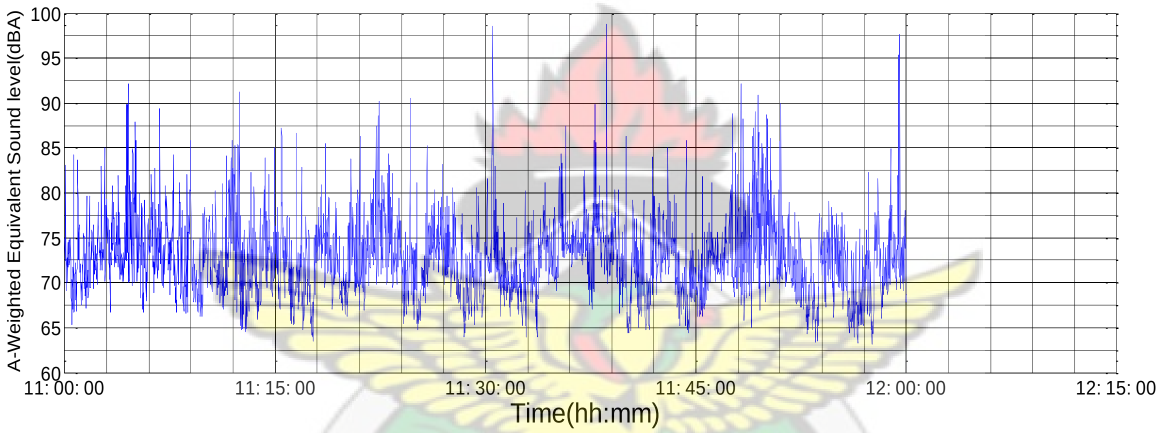

Figure A8: Graph of measured sound levels at Anloga Bus Terminal in the afternoon (Day 3)

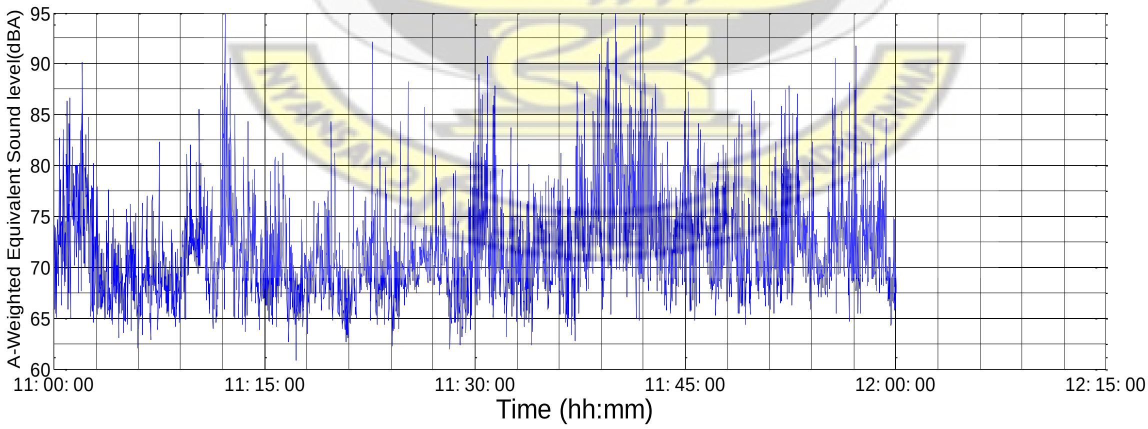

Figure A9: Graph of measured sound levels at Anloga Bus Terminal in the afternoon (Day 3)

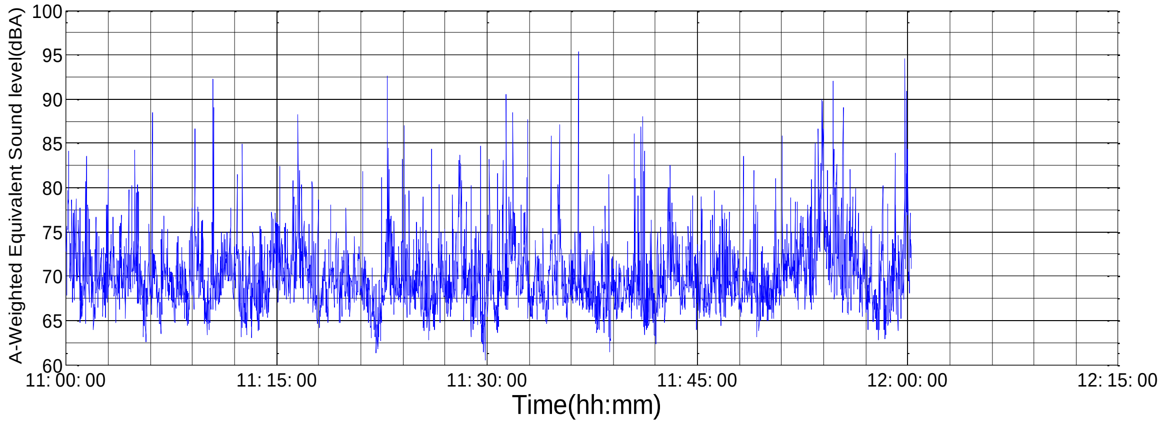

Figure A10: Graph of measured sound levels at Anloga Bus Terminal in the afternoon (Day 1)

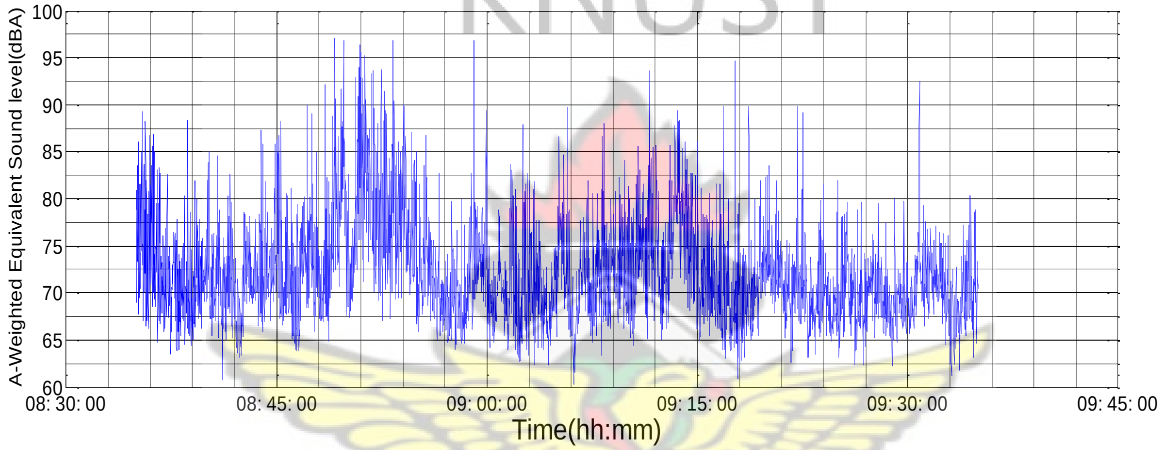

Figure A11: Graph of measured sound levels at Anloga Bus Terminal in the morning (Day 2)

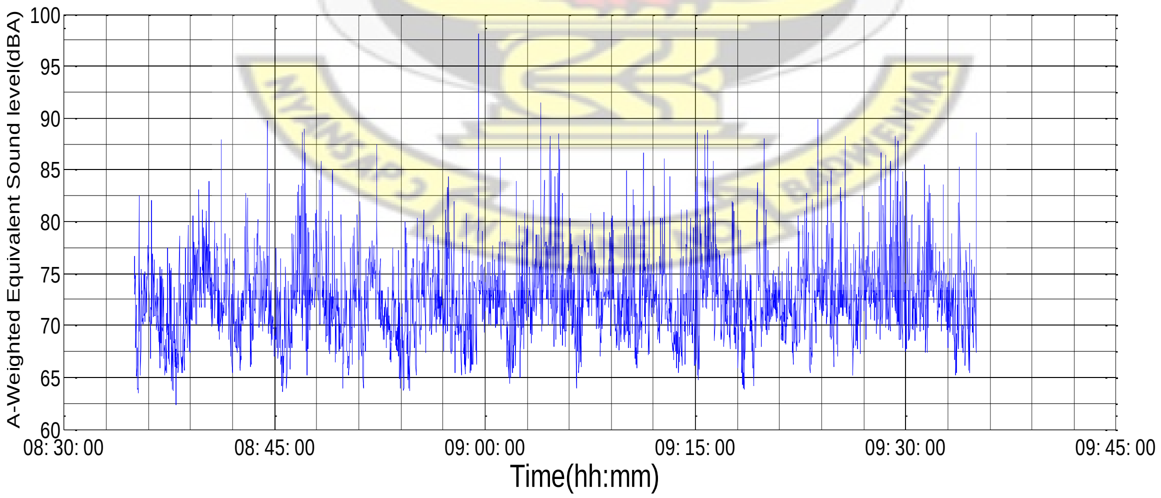

Figure A12: Graph of measured sound levels at Anloga Bus Terminal in the morning (Day 3)

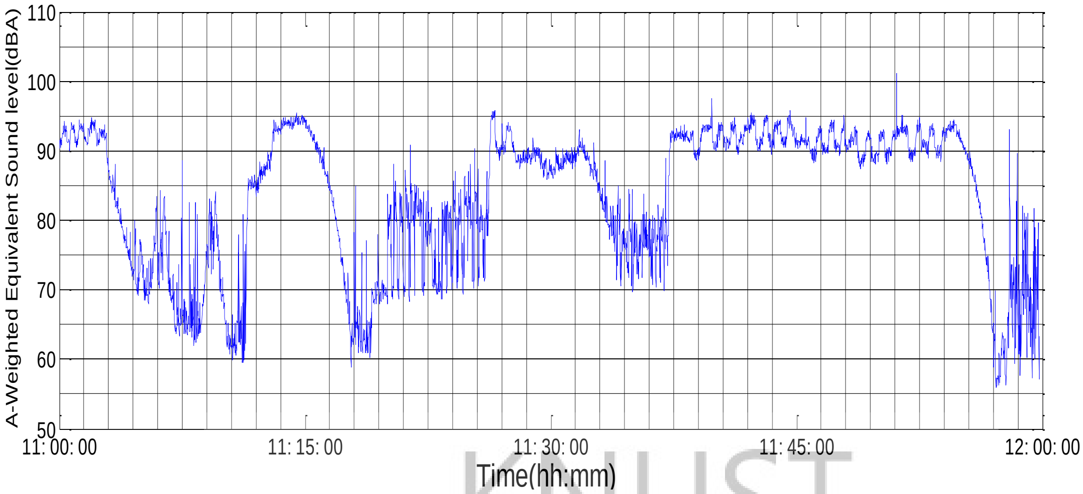

Figure A13: Graph of measured sound levels at Company A in the afternoon (Day 1)

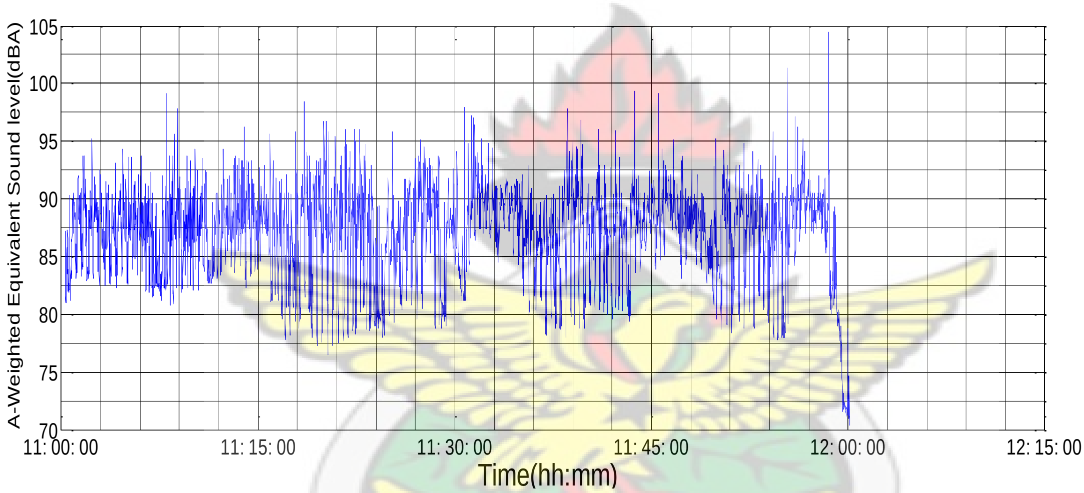

Figure A14: Graph of measured sound levels at Company A in the afternoon (Day 2)

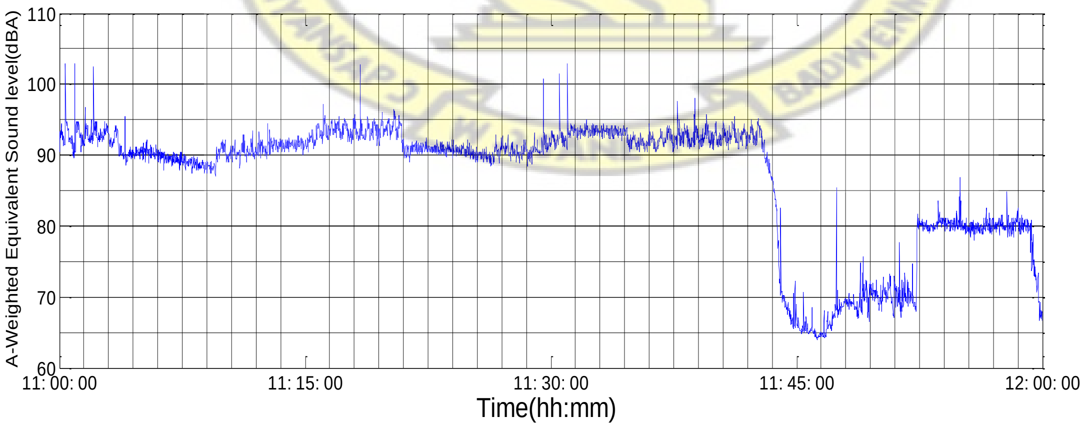

Figure A15: Graph of measured sound levels at Company A in the afternoon (Day 3)

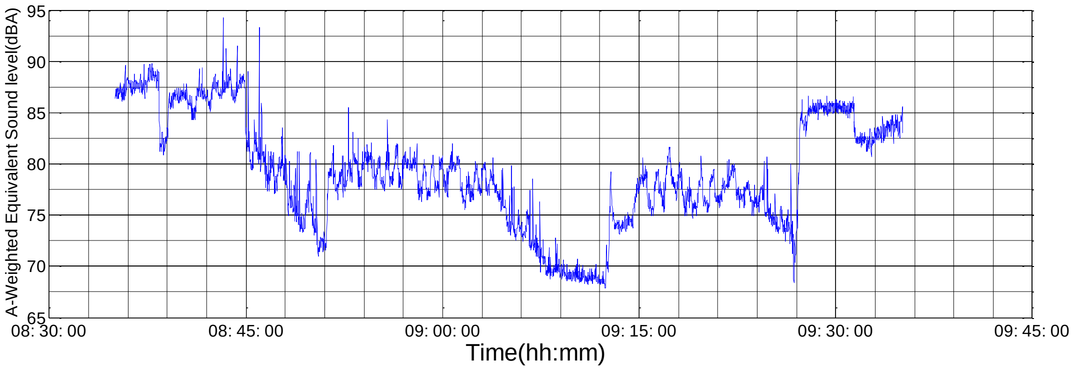

Figure A16: Graph of measured sound levels at Company A in the morning (Day 2)

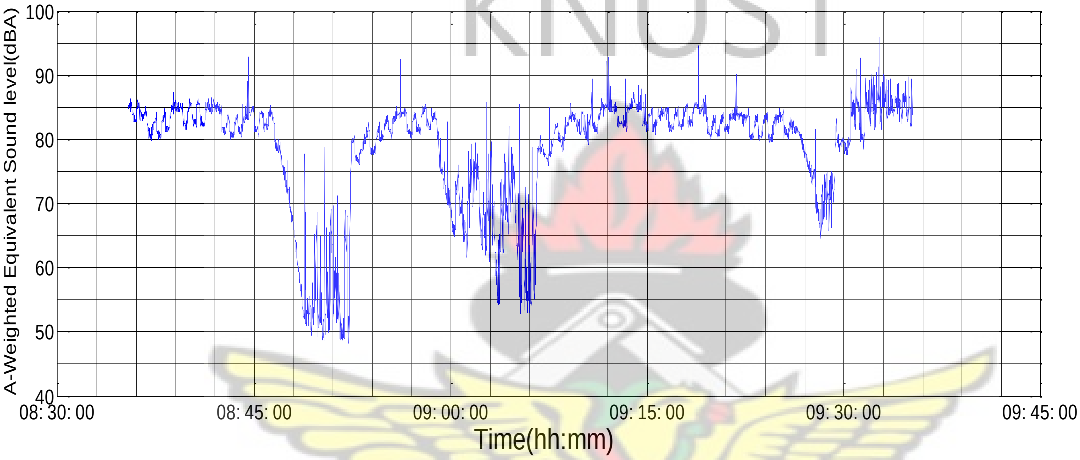

Figure A17: Graph of measured sound levels at Company A in the morning (Day 3)

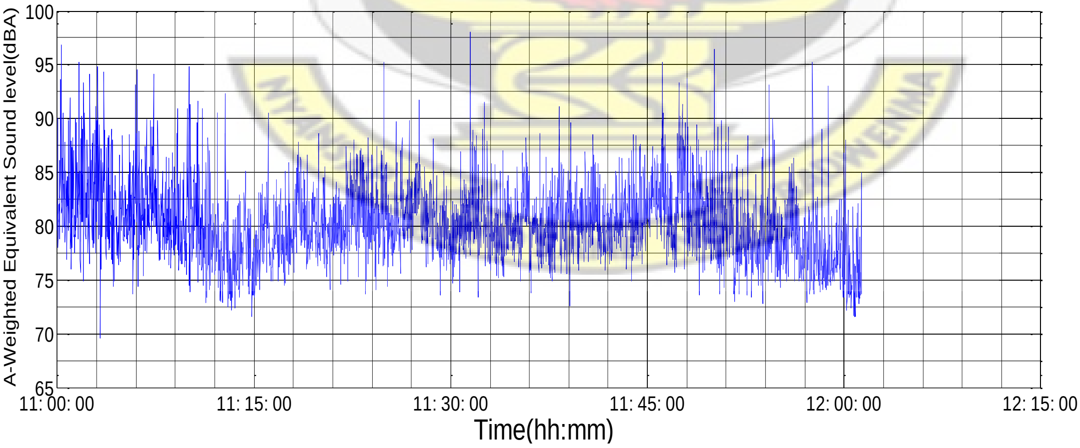

Figure A18: Graph of measured sound levels at Kejetia Bus Terminal in the afternoon (Day 2)

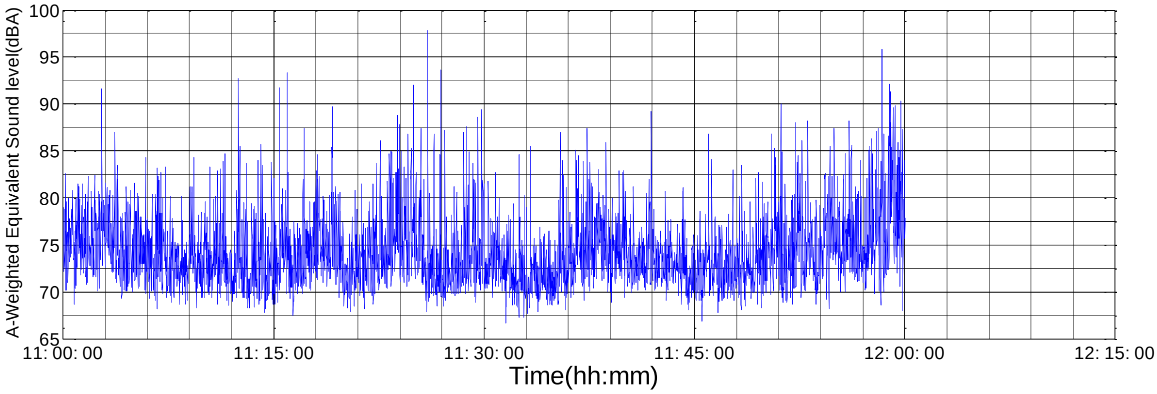

Figure A19: Graph of measured sound levels at Kejetia Bus Terminal in the afternoon (Day 3)

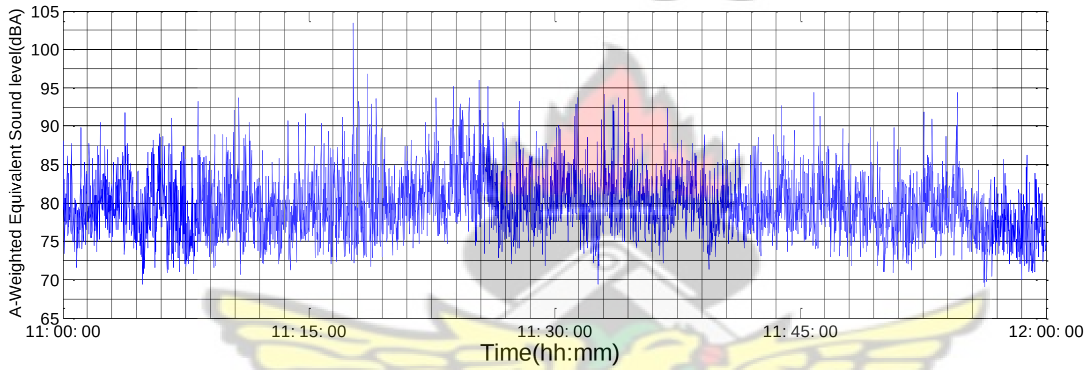

Figure A20: Graph of measured sound levels at Kejetia Bus Terminal afternoon (Day 1)

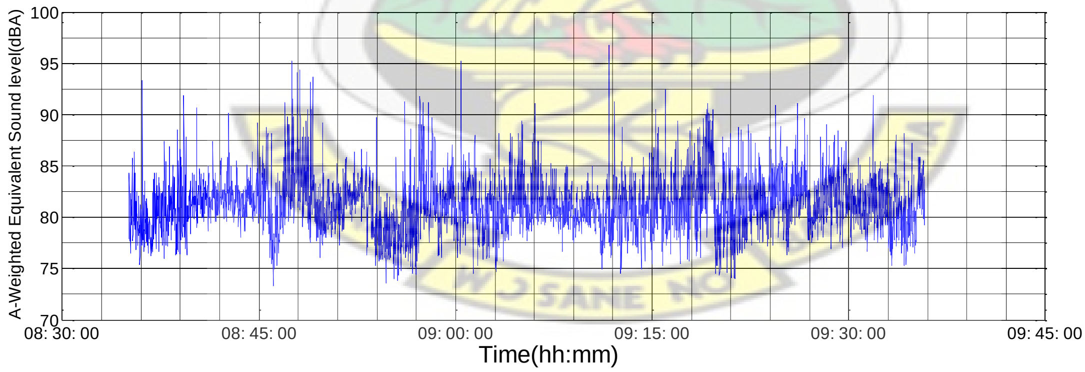

Figure A21: Graph of measured sound levels at Kejetia Bus Terminal morning (Day 2)

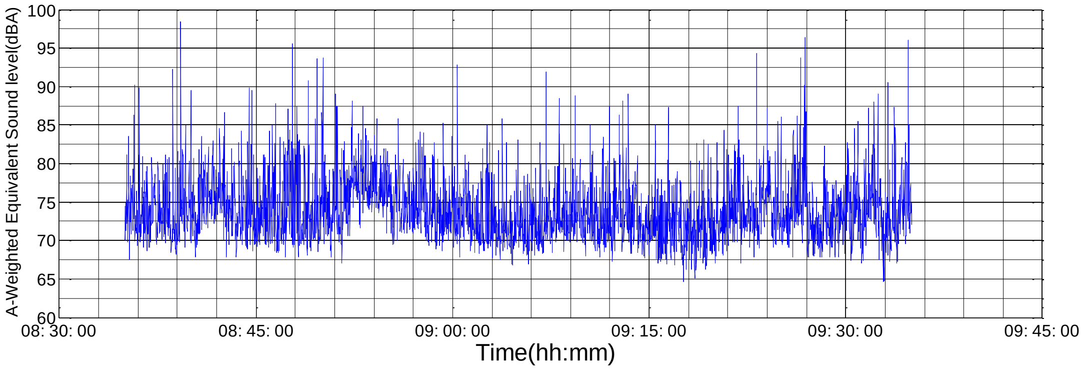

Figure A21: Graph of measured sound levels at Kejetia Bus Terminal in the morning (Day 3)

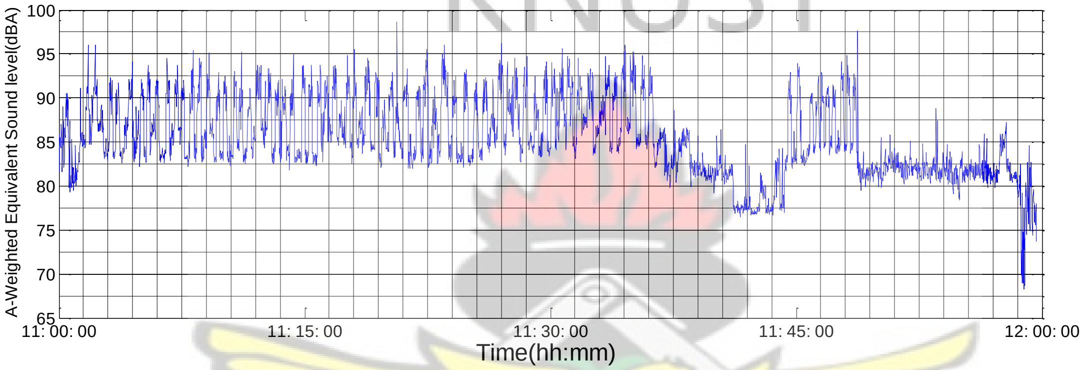

Figure A22: Graph of measured sound levels at Company B in the afternoon (Day 1)

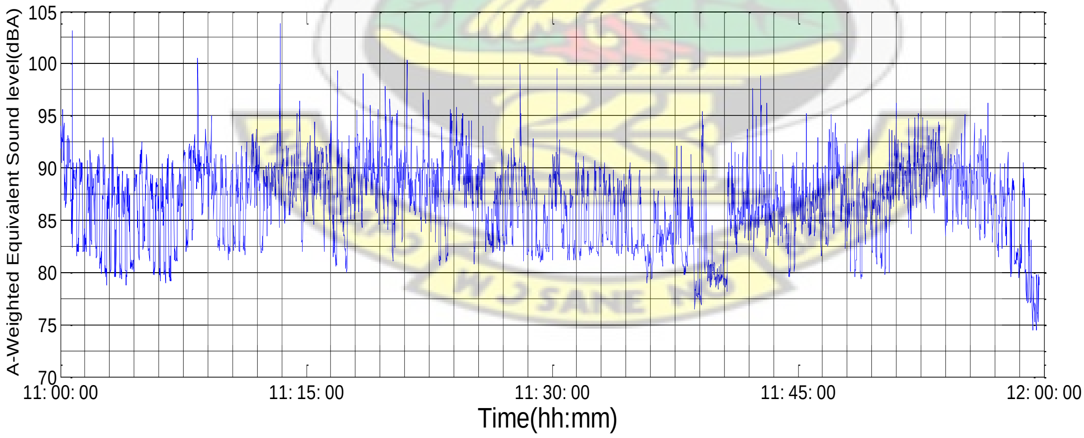

Figure A23: Graph of measured sound levels at Company B in the afternoon (Day 2)

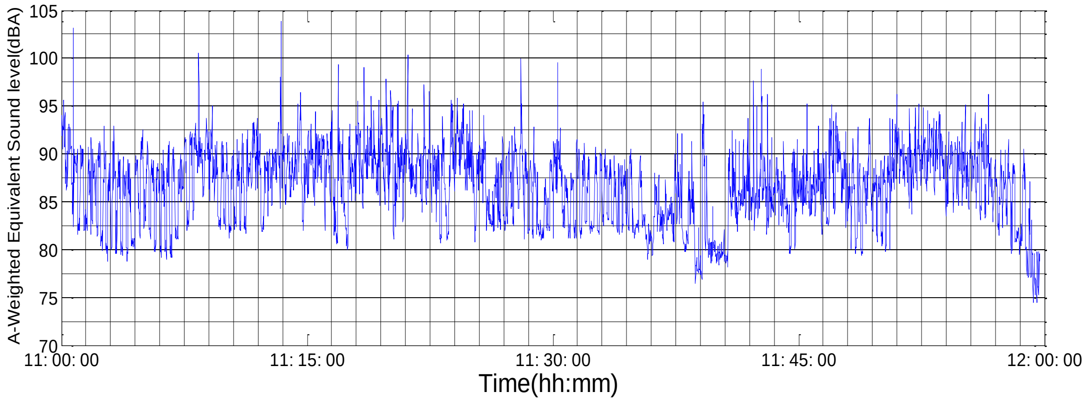

Figure A24: Graph of measured sound levels at Company B in the afternoon (Day 3)

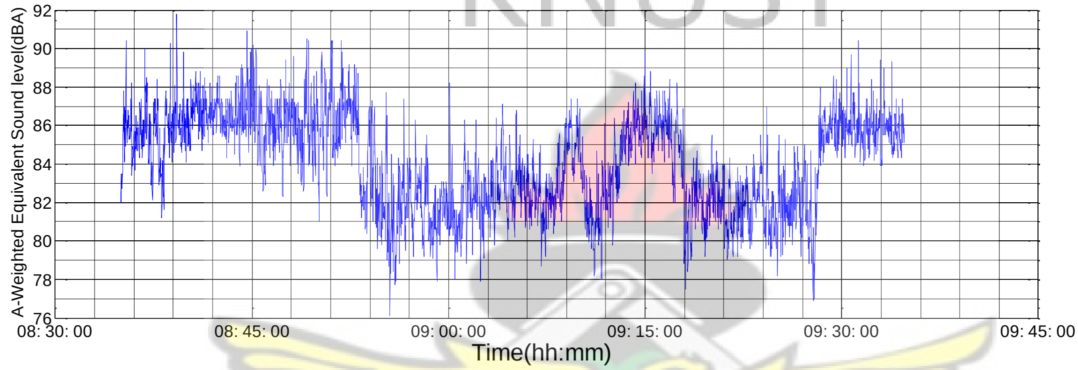

Figure A25: Graph of measured sound levels at Company B in the morning (Day 2)

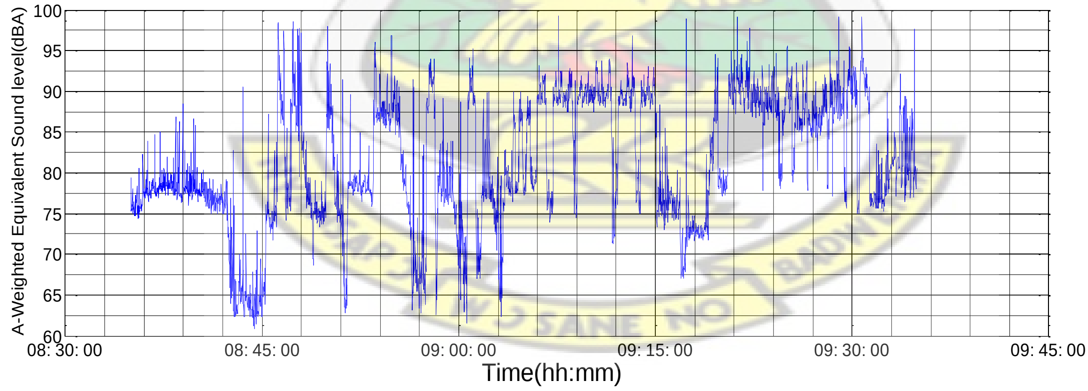

Figure A26: Graph of measured sound levels at Company B in the morning (Day 3)

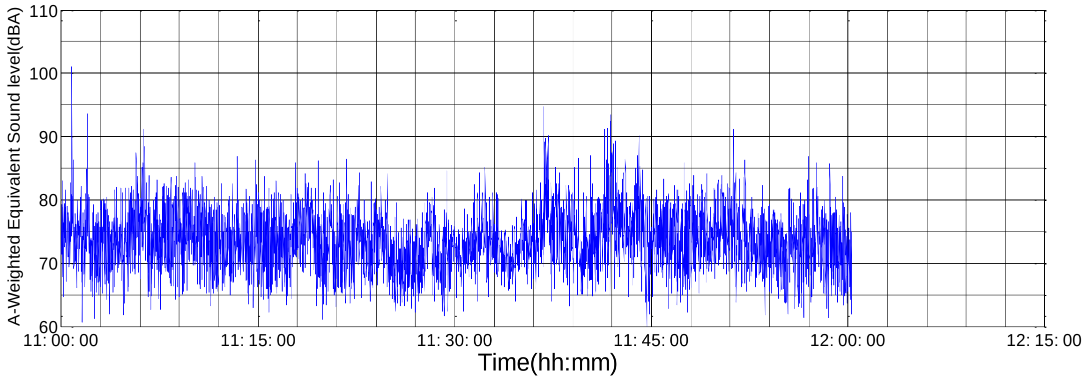

Figure A27: Graph of measured sound levels at KNUST Bus Terminal in the afternoon (Day 1)

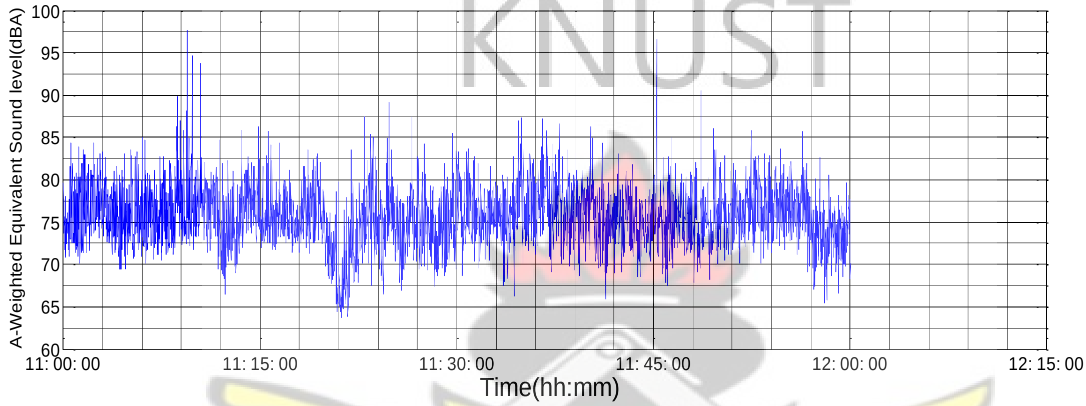

Figure A28: Graph of measured sound levels at KNUST Bus Terminal in the afternoon (Day 2)

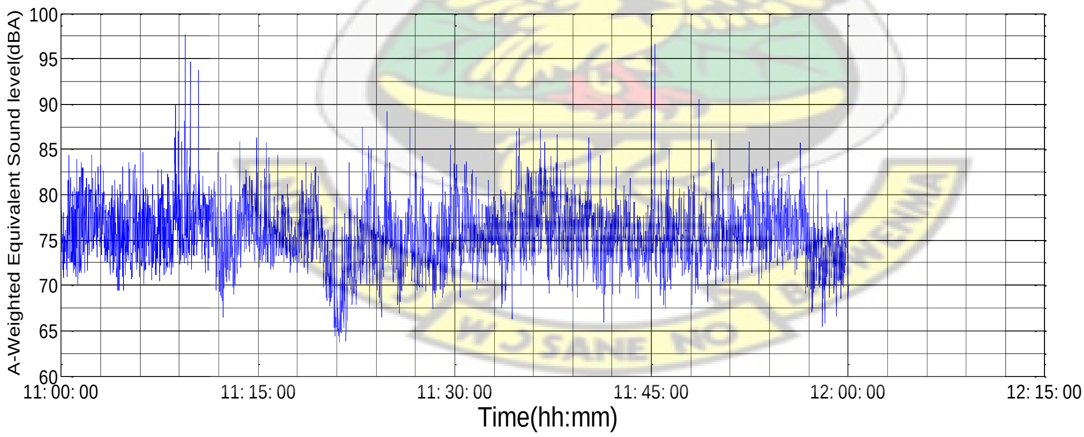

Figure A28: Graph of measured sound levels at KNUST Bus Terminal in the afternoon (Day 3)

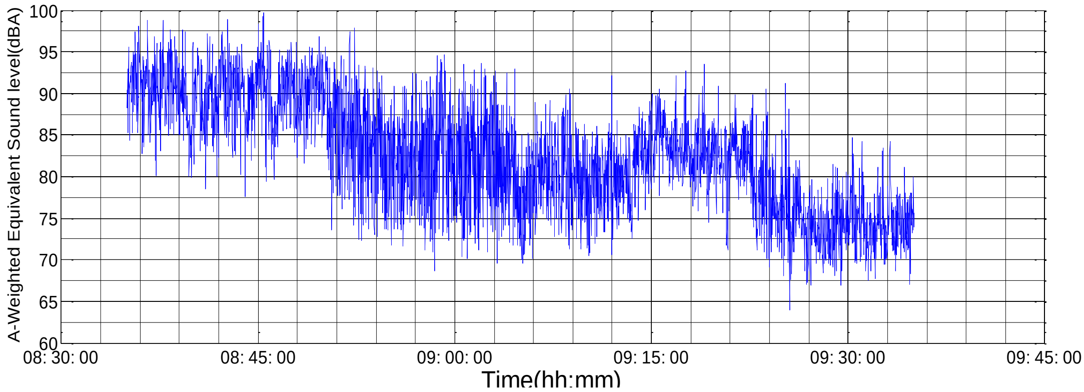

Figure A29: Graph of measured sound levels at KNUST Bus Terminal in the morning (Day 2)

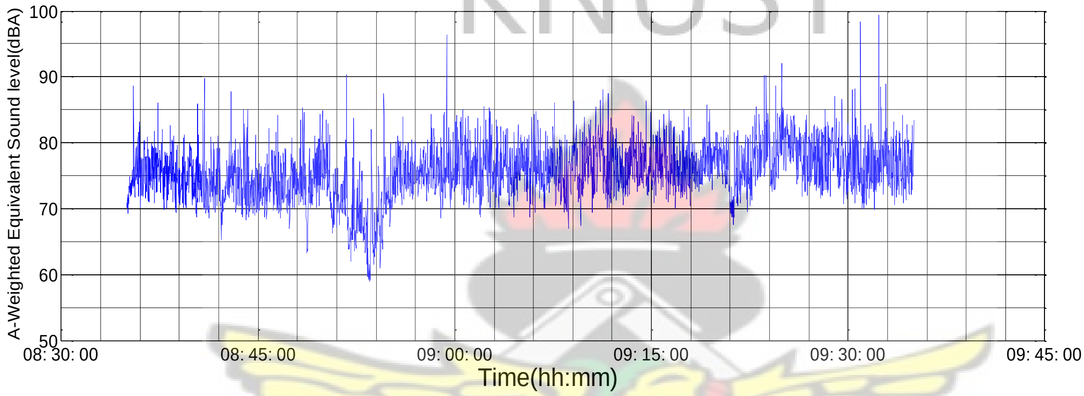

Figure A30: Graph of measured sound levels at KNUST Bus Terminal in the morning (Day 3)