DETERMINATION OF NOISE LEVELS, PERCEPTION AND AUDITORY EFFECT AMONG STUDENTS IN SELECTED PUBLIC SECONDARY SCHOOLS IN IBADAN, NIGERIA

BY

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CERTIFICATION

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DEDICATION

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ABSTRACT

Children of school age are considered to be among the group most vulnerable to the adverse effects of noise. Most schools in Nigeria face adverse environmental conditions including noise and its related impact is poorly documented. This study assessed the ambient noise levels in schools, determined the prevalence of hearing impairment and documented students' perception of noise in their learning environment.

The study was a descriptive cross-sectional survey. Three schools were purposively selected within different high activity areas in Ibadan viz: Methodist Grammar School (MGS) Bodija (Market area), Anglican Grammar school (AGS) Total Garden (Traffic area) and Oke-Bola Comprehensive High school (OBCHS) Oke-Bola (Industrial area). Abadina College (AC) University of Ibadan (Academic area) was selected as the control. A systematic random sampling technique was used to select 300 participants from senior secondary classes. A validated semi-structured questionnaire was used to elicit information on their perception of noise, while a calibrated noise level meter was used to measure noise levels in four different locations in each school for one month. Pure-tone audiometry test at standard frequencies was conducted on the exposed and control groups. The observed noise levels and audiometric outcomes were compared with WHO limits. Data were analysed using descriptive statistics, ANOVA and Chi-square test.

The respondents' age ranged between 15-19 years and the mean age was 15.6±0.7 years: and 55.7% were females. Most of the respondents (89.3%) were aware of the adverse effects of noise. Majority, 87.0% admitted that loud noise could result in hearing loss. Most (98.7%) reported that noise was capable of affecting their academic performance. Majority of respondents from AGS (80%) and MGS (86%) reported headache as the most severe noise related non-auditory effect compared with the control (26.7%) ($p< 0.05$), while 64% of respondents in OBCHS reported tiredness as the most severe noise related non-auditory effect compared to 41.3% in the control. The range of noise levels in the exposed (65.4 dBA-82.1 dBA) and control (58.5 dBA-71.3 dBA) groups exceeded the WHO recommended limits for school environments (35 dBA). The mean noise levels for the specific exposed groups include 73.8±5.1 dBA (AGS), 76.0±8.0 dBA (MGS), and 70.8±8.5 dBA (OBCHS) compared to the control of 63.8±5.3 dBA ($p<0.05$). The

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prevalence of hearing impairment at ≥41 dBA in the better ear among the participants in the market (MGS) and traffic (AGS) areas were 20.0% each and 10.0% in the industrial area (OBCHS) compared to 0.0% in the control area (AC) ($p<0.05$).

High noise levels and hearing impairment were more pronounced among the participants from the major noise generating areas. There is need for Oyo State Government to formulate specific policy guidelines on land use requirement aimed at preventing vulnerable groups especially school children from being exposed to hazardous noise levels.

Key Words: Ambient noise levels, Hearing impairment, Noise perception, School environment

Word count: 453

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CHAPTER ONE

INTRODUCTION

Sound is a particular auditory impression perceived by the sense of hearing which when present where unwanted is called noise pollution. Noise is an unpleasant, undesirable and a discordant sound (EPA, 1998). The noise problems plaguing the modern society such as the roar of airlifts, the thunder of heavily laden Lorries, trailers, tankers and the thumps and whines of industrial societies is incomparable with the noise problem of the past. These provide us with noisy backgrounds that pose serious health implications which considerably, affect economic development. According to WHO (2001), Traffic noise is the main source of environmental noise exposure. Anomoharan at al, (2004) while studying noise level in Agbor, Delta State observed that the environmental noise was caused predominantly by big trucks, luxury passenger buses and by commercial activities. Similarly, Onuu (1999) observed that road traffic noise constitutes the largest proportion of environmental noise in urban areas.

Like the home and the work place, the school is also an important part of man's environment. Worldwide, more children enroll in school more than ever before in history. An estimated 83 per cent of primary school age children now attend school, and of these, 84 per cent complete primary school (UNESCO, 2002). The School Sanitation and Hygiene (SSHE) Global Symposium held in 2004 recognized that School is important for cognitive, creative and social development of children to learn better and to face the challenges of future life. Schools are therefore expected to ensure the best possible conditions for children's physical and intellectual development. Environmental noise is one of the main factors that adversely affect these optimal conditions. Moreover, children are rarely exposed to single sources, although one noise source may indeed be more salient in certain school situations. Yet, children are exposed to a wide range of noise

sources that vary across school location and classroom position and it is likely that these noise sources interact (Dockrell & Shield, 2002).

Noise levels are measured in Decibels (dB), one decibel is the threshold of hearing. Approximately 60 dB is the level of normal talking. According to W.H.O (2001), the permissible noise level in school environments should not exceed 35dB. Exposure for more than 6 hours a day to sound in excess of 85dB is potentially hazardous (WHO. 2001). According to Ochsner (2003), both the amount of noise and the length of time one is exposed to noise determine its ability to damage hearing. Hearing loss often occurs gradually, becoming worse over time. For this reason, many people do not become aware of their hearing loss until it is too late to avoid permanent damage.

The adverse effects of noise on hearing may be classified into three categories namely, Temporary Threshold Shift (TTS), Permanent Threshold Shift (PTS) and acoustic trauma (Wolfgang, 2005). Reports from studies indicate that for the 90th percentile of noise exposed population, the risk of presumed noise- induced hearing loss (NIHL) increases exponentially for noise levels beyond 85dBA and results to permanent threshold shift over prolonged period (WHO, 1997, 2001). According to WHO (2001), noise has both auditory and non-auditory effects.

Although the direct physical consequence of listening to loud noise, especially over a period of time, is hearing loss and tinnitus (auditory effect), the effects of noise do not stop with the ears. Noise at even lower intensities can have an indirect impact on our physiological and psychological systems (Non auditory effects) such as annoyance and irritability, hypertension, high stress levels, sleeplessness, increased heart rate, cardiovascular constriction, labored breathing, and changes in brain chemistry (WHO 2004). These health effects, in turn, can lead to social handicap, reduced productivity, decreased performance in learning, absenteeism in the workplace and school, increased drug use, and accidents (WHO, 2004). Furthermore, stress and hypertension are among the leading causes of health problems, whereas tinnitus can lead to forgetfulness, severe depression and at times panic attacks (Field, 1993). Noise is thus a hazard to our overall health and well-being.

Most people do not recognize noise as an insidious pollutant or attribute it to any psychological impacts though they may consider it as nuisance during sleep hours. In studies carried out in developed societies such as Europe, it was demonstrated that children living and attending schools near airports, elevated trains, and highways suffer distractions, lack of concentration and restlessness. This leads to poor scores and lower productivity in their academic performances as compared to their peers in less noisy environments (Stansfeld et al, 2005). In developing countries like Nigeria where urban laws and proper land use conditions are relegated to the background, similar studies are lacking. Hence, there is the need to conduct such investigation since several students learn in these types of school settings.

1.1 Statement of Problem

Noise-induced hearing impairment (NIHI) is hardly a matter of public health concern in many developing countries such as Nigeria. In Nigeria, there is poor knowledge on the effect of noise on the hearing function of most people. Hence, it is often taken for granted. This can be attributed to ignorance, negligence and poverty. Furthermore, substantial data on this field is lacking in Nigeria as much work has not been done. There are few or poorly enforced noise-pollution control laws in many parts of the country. In developing countries like Nigeria, many children do not have access to ideal or serene learning environments. Noise control in the school environment is hence, a real public health challenge that calls for concern as a considerable proportion of information needed by people today relies on hearing via the telephone, radio and television. Children are the future hope and a defect in their learning environment due to the menace of noise affects their overall productivity hence hindering them from maximizing their individual potentials.

1.2 Justification of Study

In Nigeria, the gap in knowledge about the adverse effect of noise on health has encouraged poor building codes and urban planning implementations. Hence, most of the schools in Ibadan are poorly located with a great majority along main roads. This study will provide information on the perceived effects of noise pollution on the students in

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schools based on the level and frequency of noise the students are exposed to. Noise levels identified beyond threshold limits would be identified as potential sources for inducing hearing impairment of those found to suffer from sensor neural hearing defect. Furthermore, the information gathered in this research would elicit better awareness on the health effect of noise among the school authorities, the students and the general public. This would further assist policy makers and all the stakeholders to know the intensity of the problem and the need for greater attention and enforcement of law regarding noise control.

1.3 Objectives of Study

1.3.1 Broad Objective

The main objective of this study was to determine the noise levels, perception and auditory effect among students in selected public secondary schools in Ibadan.

1.3.2 Specific Objectives

The specific objectives of this study were to:

1. Document students attitude to noisy learning environments
2. Determine students' perception towards noisy learning environments
3. Determine the prevalence of hearing impairment among the students.
4. Determine perceived health problems (non-auditory effect) related to noise among the students in the selected schools.
5. Develop a risk assessment map for schools in the study area.

1.4 Prospects of the Study

This study would be able to determine the level of noise generated at the different environmental settings (market, industry, main road and academic area). It would thus, be an effective step in gathering, establishing and documenting a data base on the perceived effects of noise pollution on the students in schools based on the level and frequency of noise the students are exposed to. Study findings especially the risk map would serve as a guide and template for replicating similar studies in other locations within Oyo state and the rest of the country.

1.5 Limitations to the Study

The school authorities were reluctant in releasing the children during school hours and demanded that they be compensated by providing them with standard lunch and transport to and fro the hospital. This made the study capital intensive and expensive.

The students on their part had euphoria for going to hospitals especially the University College Hospital which they believed was associated with unmanaged ailments and deaths. Many participants were willing to take the audiometry test but declined because it entailed coming to the ENT Department of UCH. The school authorities also shared the same view and opined that if the test equipment was brought to their schools, they would be glad to participate as the children would not face the risk associated with travel to the hospital. Hence, it was an uphill task convincing them to come to UCH where the audiometric test was conducted.

The hearing impairment reported by this study could not be directly associated to the noise levels obtained from the study sites. This was because of the possibility of other confounding factors of noise exposure apart from noise in their school environments as well as the absence of a base-line study for comparison.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of Noise

In the discipline of acoustics, noise is defined as complex sound waves with irregular vibrations and no definite pitch (Frohly et al., 2000). In the field of engineering, noise is defined as a signal that interferes with the detection of or quality of another signal. The combined disciplines of psychology and acoustics (psychoacoustics) study the response of humans to sound. They define noise as unwanted sound. Sometimes, sounds that are soothing for some are irritating to others. An expert on noise, Kryter (1996) defined noise as "acoustic signals which can negatively affect the physiological or psychological well-being of an individual". Basically, noise is unwanted sound. It is a pollutant and a hazard to human health and hearing. In fact, it has been described as the most pervasive pollutant in America (EPA, 1998). Noise is both a public health hazard and an environmental pollutant as well.

2.2. Sources of Noise

Noise sources are divided into two categories:

2.2.1 Industrial sources: Noise created from industrial activity termed Industrial source- chimneys noise, different machines noise etc.

2.2.2 Non Industrial sources: Noise created from other than industrial activity, termed Non -Industrial source e.g. loudspeaker noise, traffic, automobiles, airplanes, construction works sound etc.

2.3 Noise Level

The concept of noise level is essential in sound hygiene. It is the magnitude representing how loud a given sound is, measured in A-weighted scale in decibels (abbreviated dBA). Noise level is measured with an electronic instrument called noise level meter. Table 2.1 shows the noise level for several noise sources and typical environments. It should be noted that noise level depends not only on the source, but also on the acoustic environment in which the source is located, as well as the distance and location of the listener or meter.

2.4 Characteristics of Noise

Noise can either be continuous, intermittent (impact) or impulsive. Both impact and impulse noises are produced by a sudden intense sound wave but impact noise is caused by a collision while impulse noise is due to an explosion (Dobie, 1998). Since noise levels are likely to fluctuate throughout the time of exposure, the standard accepted by the Occupational Safety and Health Administration (OSHA) regulations is known as the 5dB rule; for every 5dB increase in noise intensity, exposure time must be cut by half (the time exposed must be cut by half in order to deliver equal sound energy to the ear). A 90dBA exposure is allowed for 8 hours, a 95dBA exposure is allowed for 4 hours, and so on to a maximum allowable intensity of 115dBA for 15 minutes.

2.5 Properties of Sound

There are two important properties of sound namely, frequency and loudness (intensity).

a. Frequency

Frequency is the rate at which the source produces sound waves, i.e. complete cycles of high and low pressure regions. In other words, frequency is the number of times per second that a vibrating body completes one cycle of motion. The unit for frequency is the hertz (Hz = 1 cycle per second. Low pitched or bass sounds have low frequencies. High-pitched or treble sounds have high frequencies. A healthy, young person can hear sounds with frequencies from roughly 20 to 20,000 Hz. The sound of human speech is mainly in the range 300 to 3,000 Hz (Kryter, 1996).

Table 2.1: Noise level for several noise sources and typical environments

Description	Sound Level (dBA)
Pain threshold	120
Discotheque, full volume	110
Pneumatic drill at two meters	105
Noisy industrial environment	90
Piano at one meter, medium strength	80
Quiet car passing by at two meters	70
Normal conversation	60
Nighttime urban noise	50
Inside room (daytime)	40
Inside room (nighttime)	30
Recording studio	20
Soundproof room	10
Hearing threshold at one kHz	0

Source: EPA (1998).

b. Loudness

Loudness or intensity depends upon the amplitude of the vibrations, which initiated the noise. The loudness of noise is measured in decibels (dB). The smallest distinguishable noise or the 'reference' sound pressure, which is understood to be 0.0002 microbar or dynes/cm^2. A dyne is 1/1,000, 000th of atmospheric pressure. It has been observed that the human ear responds to real loudness of a sound, but perceived intensity (Park, 2002).

2.6 Octave Band and A-Weighting

Sound pressure levels in decibels were used to define the noise aspect of damage-risk criteria before the 1950s (Olishijski and Hartford, 1975). Following recognition that the overall intensity of a noise by itself was not sufficient to describe the potential for damage, and the frequency characteristics must also be considered, criteria incorporating spectral levels, usually octave-band levels, were developed (WHO, 2001). An octave band analysis is a relatively lengthy procedure requiring expensive instrumentation. There was some concern that the layman had difficulty in interpreting the results.

Recognizing the desirability of a single reading and the fact that most data on Noise Induced Permanent Threshold Shift (NIPTS) were available for single-weighted noise levels, the Intersociety Committee in USA, in 1967, proposed the use of A-weighted sound levels in the development of criteria (EPA, 1973). Thus, most sound level meters are equipped with a filter that is designed to de-emphasize the physical contribution from frequencies to which the human ear is less sensitive. This filter is referred to as the A filter, and measurements taken using the A filter are reported as dB(A). This is known as the A level on a sound pressure meter.

The basic instruments used in noise studies are:

1. The sound level meter which measures the intensity of sound in dB or dBA.
2. The "Octave Band Frequency Analyser" which measures the noise in octave bands.
3. The "Audiometer" used for carrying out an audiogram. An audiogram is a hearing test that is generally performed in a soundproof room using sophisticated, calibrated equipment. A trained professional, most commonly a certified

audiologist, usually administers the test. Earphones are placed over the person's ears, and tones are presented to each ear, one at a time. The softest level at which the sounds can be heard is recorded.

Other physical qualities of noise include: Spectral shape, abruptness or impulsiveness, intermittency, duration and temporal variations (EPA, 1983).

2.7 Environmental Noise

Environmental noise (also known as community, residential or domestic noise) is the unwanted sound received in an outdoor location from all sources in a community. It excludes sounds that are experienced by listeners in occupational settings as well as the sounds emitted by consumer products and experienced by listeners in their homes (Agarwal, 2002). Major sources of environmental noise include road, rail, and air traffic; industries; construction and public works; lawn and garden equipment; snow-removal equipment and amplified music (Defra, 2003; Anomohanran et al., 2004). Other important sources of environmental noise especially in Nigeria includes churches, markets, social gatherings and parties that are usually associated with loud music from loud speakers of musicians and record players. Ebeniro and Abumere (1999) viewed environmental noise as an unwanted signal which in most cases is sound. Leventhall (2003) asserted that noise is an undesired sound and that both noise and sound are similar acoustic waves carried on oscillating particles in the air.

The extent of the environmental noise problem is very large. In the USA in the early 1970s, over 40 % of the population was estimated to be exposed to A-weighted sound levels from vehicular traffic that exceed 55 dB (Berglund and Lindvall, 1995); in the European Union and Japan, this percentage is even higher (Silverman, 2000). In contrast to many other environmental problems, the population exposed to unacceptable noise continues to grow, accompanied by an ever-increasing number of complaints (Stansfeld et al, 2000). According to the National Institute on Deafness and Other Communication Disorders (NIDCD, 2007), more than 30 million Americans are exposed to hazardous sound levels on a regular basis. Of the 28 million Americans who have some degree of hearing loss, over one-third has been affected, at least in part, by noise.

Noise in our environment affects physical heath. Noise also has psychological and social implications and affects our well being and quality of life (NIDCD, 2007). Unfortunately, public awareness of the hazardous effects of noise is low - especially noise considered to be non-occupational. To this end, the fourth Wednesday in April has been declared International Noise Awareness Day (INAD). As part of International Noise Awareness Day, a "Quiet Diet" is encouraged and is launched by observing 60 seconds of no noise from 2:15 to 2:16 PM. The reduction, if not stopping of everyday noises around us raises our awareness of the impact noise has on health and hearing (NIDCD, 2007). Table 2.2 shows typical examples of noise sources and their examples.

2.8 Anatomy of the Human Ear

The ear is made of three parts: outer ear (pinna and ear canal) (Fig 2.1), middle ear (eardrum also called the tympanic membrane and three minute bones called ossicles) (Fig 2.2), and inner ear (cochlea and labyrinth) (Fig 2.3). The first two parts carry out the conduction of sound coming into the ear towards the inner ear. Much in the same way as a lever, they convert the high-amplitude and low-pressure vibrations of airborne sound present at the outer ear into low-amplitude and high-pressure vibrations needed for waterborne transmission in the inner ear. The cochlea, a snail-shaped organ buried in the temporal bone, contains the hair cells (so called because they are terminated by hair-like structures) which perform the conversion of sound waves into nervous impulses. These impulses, in turn, make their way into the brain cortex, where the actual sensation of sound is evoked and the auditory signal decoded. Hair cells are most delicate, since they are extremely small (thousands of them would fit in one centimeter). They are thus easily damaged, and once destroyed they do not reproduce themselves (WHO, 1997, 2001).

Table 2.2: Type of Environmental Noise Sources and their Examples

Sources of Environmental Noise	Examples
Transportation	Aircrafts, Trains, Road vehicles, Vessels
Industrial buildings	Factories – machineries, Air-Conditioning systems
Commercial buildings	Office buildings - Air-Conditioning systems Restaurants - Air-Conditioning systems, Kitchen Ventilating systems
Construction sites	Site formation (e.g. Excavation), Piling, Road work, Demolition, Renovation
Domestic buildings	Mahjong playing, Hi-Fi, Musical Instruments
Public places	Open markets, Busy streets, Amusement parks
Products	Intruder alarms of buildings and Motor vehicles

Source: EPA 2004

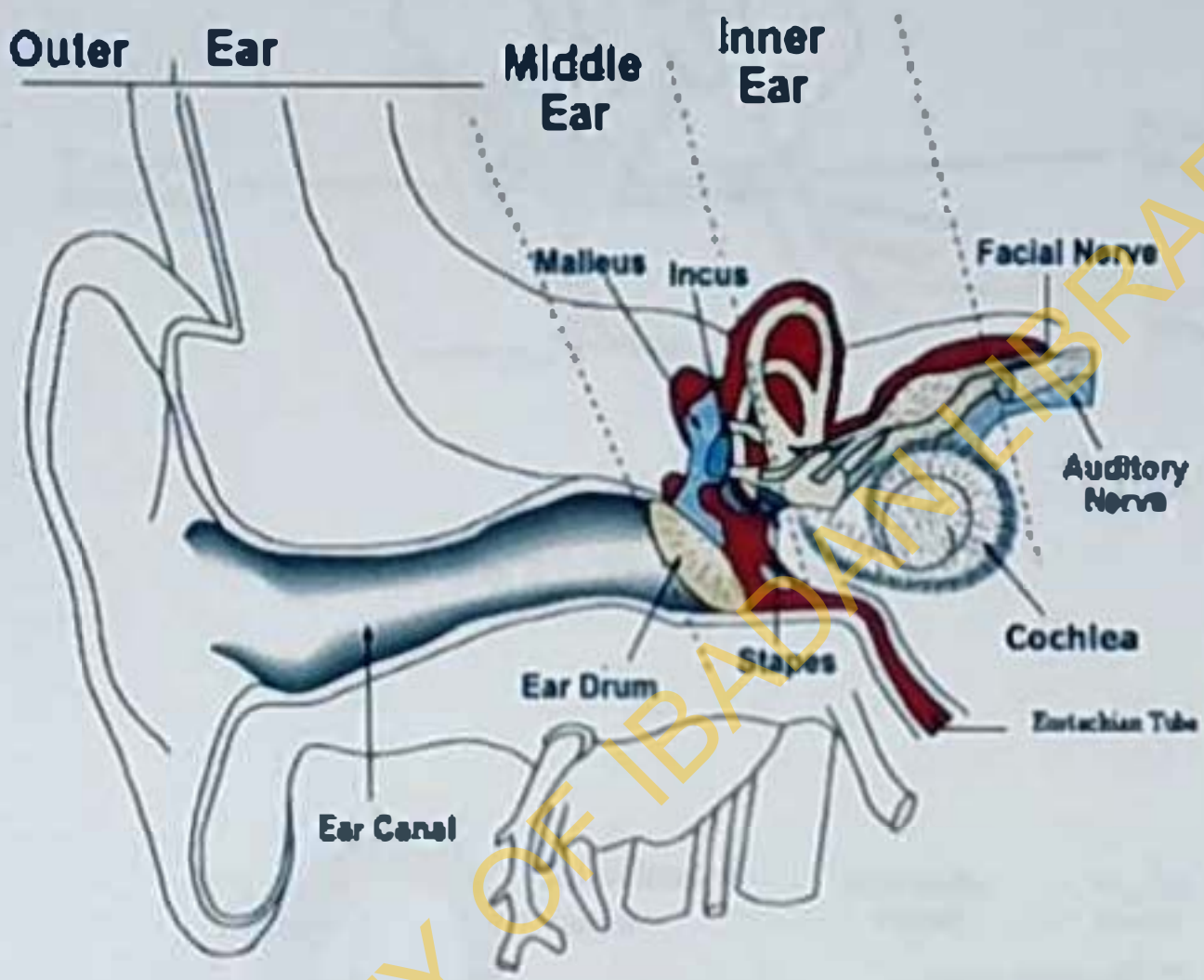

Fig 2.1: Anatomical representation of the human ear

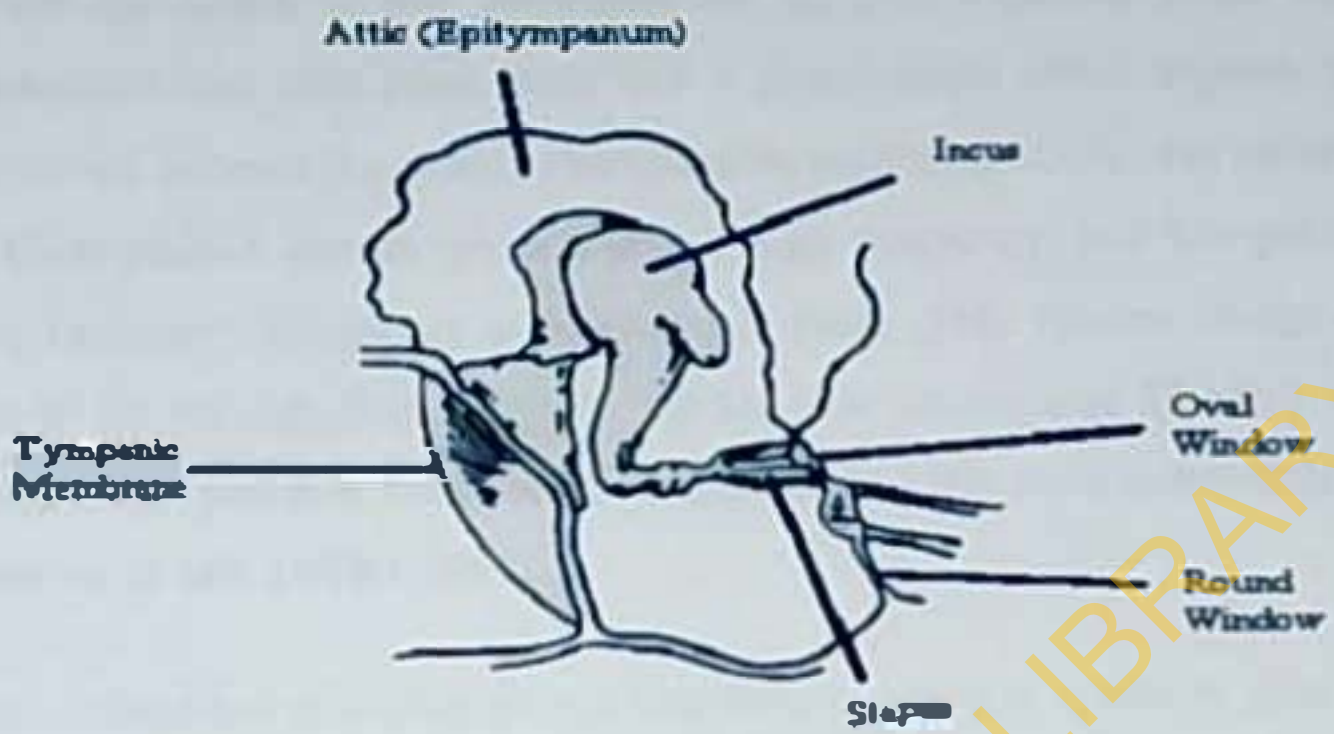

Fig 2.2: The middle ear

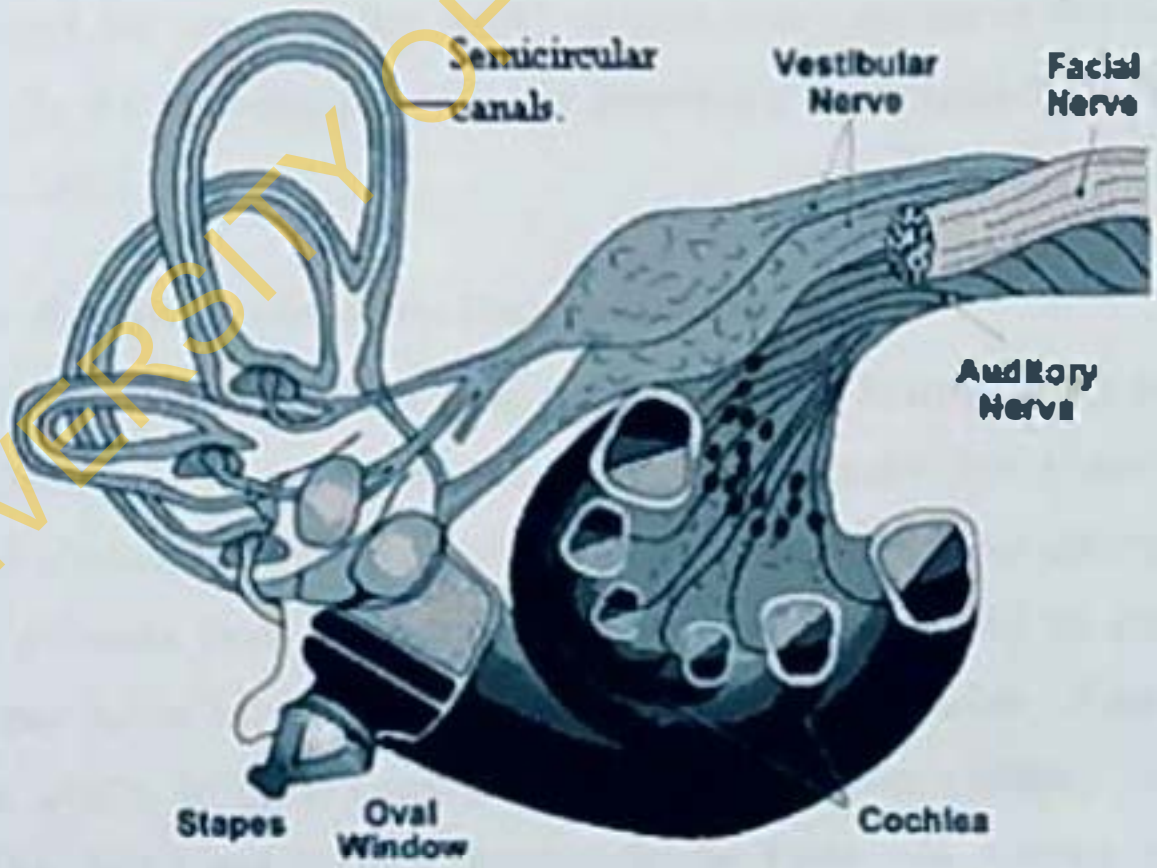

Fig 2.3: The inner ear

2.9 Physiological Functions of the Human Ear

Sound waves are generated by the vibration of an object. The vibrating object transmits its vibration to the air, which in turn communicates its own vibration to the ear. These vibrations, wherever they take place, constitute a phenomenon which repeats again and again with a certain cadence (i.e. with a characteristic number of cycles per second, called frequency). High-pitched sounds (treble) have a high frequency, and low-pitched ones (bass), a low frequency. Frequency is measured in Hertz (Hz). Human beings can hear sounds from 20 Hz through (hopefully) 20,000 Hz (also abbreviated 20 kHz). Actually, very few people can perceive frequencies as high as 20 kHz; most individuals will not hear much above 16 kHz (WHO, 2002).

Sounds may be classified according to their frequency contents or spectrum. Most real-life sounds contain more than one frequency. Single-frequency sounds are called "pure tones" or simply "tones," and are very seldom found in nature; an exception is whistles. Voiced sounds, such as the vowels and many musical sounds in which a pitch can be perceived, contain several frequencies, all of which are multiples of the lowest frequency (i.e., the fundamental frequency). Other sounds, usually called "noise" (such as environmental noise, the noise of the sea or of the wind), contain many unrelated frequencies. Voiced sounds, especially the high-pitched ones, are potentially more hazardous than un-pitched sounds (WHO, 2002).

2.10 Effects of Noise Exposure on Human Health

Some people believe noise does not pose a serious risk to human health because it often does not produce visible effects and a distinct cause-and-effect ("dose response" in medical terms) relationship between a single noise event and a clear adverse health effect. Nevertheless, evidence from a number of recent studies especially on children provides ample proof that noise harms human health and decreases quality of life (Haines et al 2001, Griffith, 2003). In today's noisy society therefore, even children and young adults are at risk. The WHO and the U.S. Environmental Protection Agency consider a daily average sound exposure equivalent to $L_{Aeq} = 70$ dB(A) to be safe for the ear (WHO 2000). The effects of noise are broadly classified as non-auditory and auditory (hearing loss) health effects.

2.10.1 Non-Auditory Effects of Noise

Even ear-safe sound levels can cause non-auditory health effects if they chronically interfere with recreational activities such as sleep and relaxation, if they disturb communication and speech intelligibility, or if they interfere with mental tasks that require a high degree of attention and concentration (Evans and Lepore, 1993). The signal-noise ratio (in terms of signal processing) should be at least 10 dB(A) to ensure undisturbed communication.

Most environments contain a combination of sounds from more than one source (e.g., trains, boom-box cars, car horns and alarms, market, and heavy trucks). Adverse health effects are related to total noise exposure from all sources. In residential populations, combined sources of noise pollution will lead to a combination of adverse effects, such as sleep disturbances; cardiovascular disturbances; interference at work, school, and home; and annoyance; among others (WHO, 2007). Below are the major non-auditory effects of noise;

a. Sleeping Disturbance

Sleeping is one of the most important phenomenon that reflects the different physiological and psychological activity in humans (Hobson, 1989). Environmental noise is one of the major causes of disturbed sleep (Berglund and Lindvall 1995, Stansfeld and Matheson 2003). A number of studies show that with exposure to noise, the primary sleep disturbances are difficulty falling asleep, frequent awakenings, waking too early, and alterations in sleep stages and depth. Apart from various effects on sleep itself, noise during sleep causes increased blood pressure, increased heart rate, increased pulse amplitude, vasoconstriction, changes in respiration, cardiac arrhythmias, and increased body movement (Hobson, 1989, Matheson, 2003). For each of these, the threshold and response relationships may be different. Some of these effects (waking, for example) diminish with repeated exposure; others, particularly cardiovascular responses, do not (Ohrstrom and Bjorkman, 1998). Secondary effects (so-called after effects) measured the following day include fatigue, depressed mood and well-being, and decreased performance (Carter, 1996). Decreased alertness and disrupted circadian rhythms, which

lead to accidents, injuries, and death, have also been attributed to lack of sleep (Coren, 1996). Vallet (1989) reported that with the noise from highway, subjects took longer to fall asleep and had less deep sleep so that the young to middle aged groups become more like the 50 – 60 year old group in their depth of sleep. Evans and Lepore, (1993) concluded that there were 50% more people awakened by airplanes noise than any other noise. Low frequency sound is more disturbing, even at very low sound pressure levels; these low frequency components appear to have a significant detrimental effect on health (Leventhal, 2004).

b. Hypertension

A growing body of evidence confirms that noise pollution has both temporary and permanent effects on humans (and other mammals) by way of the endocrine and autonomic nervous systems. It has been postulated that noise acts as a nonspecific biologic stressor eliciting reactions that prepare the body for a "fight or flight" response (Berglund and Lindvall, 1995, Babisch, 2005, Ising and Kruppa, 2004). For this reason, noise can trigger both endocrine and autonomic nervous system responses that affect the cardiovascular system and thus may be a risk factor for cardiovascular disease (Berglund and Lindvall 1995, Babisch 2005, Ising and Kruppa 2004, Evans and Lepore 1993, Babisch 2003). These effects begin to be seen with long-term daily exposure to noise levels above 65 dB or with acute exposure to noise levels above 80 to 85 dB (Berglund and Lindvall 1995, Suter 1991).

Acute exposure to noise activates nervous and hormonal responses, leading to temporary increases in blood pressure, heart rate, and vasoconstriction. Studies of individuals exposed to occupational or environmental noise show that exposure of sufficient intensity and duration increases heart rate and peripheral resistance, increases blood pressure, increases blood viscosity and levels of blood lipids, causes shifts in electrolytes, and increases levels of epinephrine, nor-epinephrine, and cortisol (Suter, 1991). Sudden unexpected noise evokes reflex responses as well.

Cardiovascular Effect and Hypertension cause loss in daily life performance and lead to premature death (Ising and Kruppa, 2004). Tomei *et al* (1991) correlated the cardiovascular effects with noise intensity, type and duration of exposure and reported that there was prevalence of electrocardiogram abnormalities in pilots exposed to higher noise intensity. He also indicated that the higher hypertensive response to noise in hypersensitive pilots suggested that basal hypertension was not responsible for the effects. Temporary noise exposure produces readily reversible physiologic changes. However, noise exposure of sufficient intensity, duration, and unpredictability provokes changes that may not be so readily reversible.

Other studies that have been done on the effects of environmental noise have shown an association between noise exposure and subsequent cardiovascular disease disease (Berglund and Lindvall 1995, Babisch 2005, Ising and Kruppa 2004, Evans and Lepore 1993, Babisch 2003). Even though the increased risk for noise-induced cardiovascular disease may be small, it assumes public health importance because both the number of people at risk and the noise to which they are exposed continue to increase (Berglund and Lindvall 1995, Babisch 2005). Children are at risk as well. Children who live in noisy environments have been shown to have elevated blood pressures and elevated levels of stress-induced hormones (Babisch 2005, Evans and Lepore 1993, Bronzaft, 2000). However, a study conducted on deaf children and their hearing counterparts in a school situated close to a high traffic and railway in south-west Nigeria, revealed that noise exposure alone was not sufficient to bring about an increase in blood pressure of the studied population (Nwaorgu and Arulogun, 2006).

c. Impaired Task Performance

The effects of noise pollution on cognitive task performance have been well-studied. Noise exposure causes changes in the psychological and behavioral activity of man. Noise pollution impairs task performance at school and at work, increases errors, and decreases motivation (Cohen 1980, Evans and Lepore, 1993). Reading attention, problem solving, and memory are most strongly affected by noise. It is also seen that a person subjected to the noise exposure shows irritating behavior. Two types of memory deficits

have been identified under experimental conditions: recall of subject content and recall of incidental details. Both are adversely influenced by noise. Deficits in performance can lead to errors and accidents, both of which have health and economic consequences (Berglund and Lindvall 1995).

Cognitive and language development and reading achievement are diminished in noisy homes, even though the children's schools may be no noisier than average (Bronzaft, 2000). Cognitive development is impaired when homes or schools are near sources of noise such as highways and airports (Evans and Lepore 1993, Lee and Fleming 2002). Noise affects learning, reading, problem solving, motivation, school performance and social and emotional development (Suter 1991, Stansfeld and Matheson 2003, Bronzaft 2000, Stansfeld *et al* 2005). These findings suggest that more attention needs to be paid to the effects of noise on the ability of children to learn and on the nature of the learning environment, both in school and at home. Moreover, there is concern that high and continuous environmental noise may contribute to feelings of helplessness in children (Evans and Lepore 1993, Bronzaft 2000).

Noise produces negative after-effects on performance, particularly in children. It appears that the longer the exposure, the greater the effect. Children from noisy areas have been found to have heightened sympathetic arousal indicated by increased levels of stress-related hormones and elevated resting blood pressure (Bronzaft 2000). These changes were larger in children with lower academic achievement. Haines and Stansfeld in 1996 and 1997 conducted a multilevel modeling on the effect of aircraft noise on performance test in schools around Heathrow. The study established a dose-response relationship between children who attend school close to airport in fly pathways in-flight paths showing a deficit on standardize tests of scholastic achievement compared to students in quite schools.

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d. Blood Pressure and Heart Rate

A number of researches showed the close relationship between exposure to noise and Blood Pressure. Peterson et al (1981) showed the elevation of blood pressure on noise exposure in Rhesus monkeys. Singh et al (1982) compared the individual exposed to noise in the work place with unexposed individuals and found that blood pressure (B.P) und heart rate were significantly higher in noise exposed individuals. In addition, 18% of the noise exposed individuals had irregular cardiac rhythms. Johsson and Hansson (1997) reported that male workers with noise induced hearing loss had higher SBP and DBP than subjects with normal hearing.

e. Negative Social Behavior and Annoyance Reactions

Annoyance is defined as a feeling of displeasure associated with any agent or condition believed by an individual to adversely affect him or her. Perhaps a better description of this response would be aversion or distress. Noise has been used as a noxious stimulus in a variety of studies because it produces the same kinds of effects as other stressors (Babisch, 2005). Annoyance increases significantly when noise is accompanied by vibration or by low frequency components (Leventhal, 2004). The term annoyance does not begin to cover the wide range of negative reactions associated with noise pollution, these include anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion. Lack of perceived control over the noise intensifies these effects (Berglund and Lindvall 1995, Stansfeld and Matheson 2003).

Social and behavioral effects of noise exposure are complex, subtle, and indirect. These effects include changes in everyday behavior (eg., closing windows and doors to eliminate outside noises; avoiding the use of balconies, patios and yards; and turning up the volume of radios and television sets); changes in social behavior (example; aggressiveness, unfriendliness, nonparticipation, or disengagement); and changes in social indicators (example; residential mobility, hospital admissions, drug consumption, and accident rates); and changes in mood (increased reports of depression) (Berglund and Lindvall 1995).

The degree of annoyance produced by noise may vary with the time of day, the unpleasant characteristics of the noise, the duration and intensity of the noise, the meaning associated with it, and the nature of the activity that the noise interrupted (Berglund and Lindvall 1995). Annoyance may be influenced by a variety of non-acoustical factors including individual sensitivity to noise (Soames, 1999) These include fear of the noise source, conviction that noise could be reduced by third parties, individual sensitivity, the degree to which an individual feels able to control the noise, and whether or not the noise originated from an important economic activity (Berglund and Lindvall 1995, Stansfeld and Matheson 2003).

Other less direct effects of annoyance are disruption of one's peace of mind and the enjoyment of solitude. Greater annoyance has been observed when noise is of low frequency, is accompanied by vibrations that contain low-frequency components, or when it contains impulses such as the noise of gun shots (Berglund and Lindvall, 1995, Leventhal, 2004). Annoyance is greater when noise progressively increases rather than remaining constant. Average outdoor residential day-night sound levels below 55 dB were defined as acceptable by the EPA; acceptable average indoor levels were less than 45 dB (EPA, 1983). To put these levels into perspective, sound levels produced by the average refrigerator or the sounds in the typical quiet neighborhood measure about 45 dB (EPA, 1983). Sound levels above this produce annoyance in significant numbers of people.

The results of annoyance are privately felt dissatisfaction, publicly expressed complaints to authorities (although underreporting is probably significant), and the adverse health effects already noted. Given that annoyance can connote more than slight irritation, it describes a significant degradation in the quality of life, which corresponds to degradation in health and well-being. In this regard, it is important to note that annoyance does not abate over time despite continuing exposure to noise (Bluhm, *et al* 2004).

f. Interference with Spoken Communication

In 1974, in an attempt to protect public health and welfare against the adverse effects of noise, the EPA published so-called safe levels of environmental noise that would permit normal communication both in and out of doors (EPA, 1974). Noise pollution interferes with the ability to comprehend normal speech and may lead to a number of personal disabilities, handicaps, and behavioral changes. These include problems with concentration, fatigue, uncertainty, lack of self confidence, irritation, misunderstandings, decreased working capacity, disturbed interpersonal relationships, and stress reactions. Some of these effects may lead to increased accidents, disruption of communication in the classroom, and impaired academic performance (Evans and Lepore 1993, Stansfeld and Matheson, 2003). Particularly vulnerable groups include children, the elderly, and those not familiar with the spoken language (Berglund and Lindvall, 1995).

2.10.2 Auditory (Hearing Loss) Effects of Noise

Hearing plays an important role in behavioral and psychological activity of humans. Hearing loss is one of the most important consequences of noise exposure. Hearing impairment is typically defined as an increase in the threshold of hearing. It is assessed by threshold audiometry. Impaired hearing may come from the workplace, from the community, and from a variety of other causes (e.g., trauma, ototoxic drugs, infection, and heredity). Hearing handicap is the disadvantage imposed by hearing impairment sufficient to affect one's personal efficiency in the activities of daily living. It is usually expressed in terms of understanding conventional speech in common levels of background noise (ISO 1990).

Worldwide, noise-induced hearing impairment is the most prevalent irreversible occupational hazard. In the developing countries, not only occupational noise, but also environmental noise is an increasing risk factor for hearing impairment. In 1995, at the World Health Assembly, it was estimated that there are 120 million person swith disabling hearing difficulties worldwide (Smith 1998). It has been shown that men and women are equally at risk of noise-induced hearing impairment (ISO 1990, Berglund and Lindvall 1995). Studies suggest that children seem to be more vulnerable than adults to noise induced hearing impairment (Berglund and Lindvall 1995).

Noise induced hearing loss often occurs at higher frequencies first, at around 4000 Hz. Hearing damage can then extend to lower frequencies and become relatively more severe after increasing exposure at higher levels. Noise induced hearing impairment may be accompanied by abnormal loudness perception (loudness recruitment), distortion (paracusis), and tinnitus. Tinnitus may be temporary or may become permanent after prolonged exposure (Berglund and Lindvall 1995). The eventual results of hearing losses are loneliness, depression, impaired speech discrimination, impaired school and job performance, limited job opportunities, and a sense of isolation (Suter 1991, Brookhouser 1996).

There are two types of hearing loss in humans that are caused by noise exposure;

i. **Temporary Threshold Shift (TTS):** It is the partial hearing loss which is recorded to last within few hours, up to four weeks. It depends upon the length of exposure of noise.
ii. **Noise Induced Permanent Threshold Shift (NIPTS):** It is the total hearing loss, which is not reversible. The exposure to noise above 105 dB of 8 hours/day for several years causes NIPTS.

Degree of hearing loss

Degree of hearing loss refers to the severity of the loss. There are five broad categories that are typically used. The numbers are representative of the patient's thresholds, or the softest intensity that the sound is perceived:

1. Normal range or no impairment = 0 dB(A) to 20 dB(A)
2. Mild loss = 20 dB(A) to 40 dB(A)
3. Moderate loss = 40 dB(A) to 60 dB(A)
4. Severe loss = 60 dB(A) to 80 dB(A)
5. Profound loss = 80 dB(A) or more

Iso average of 500, 1000, 2000, 3000, 4000 and 6000Hz

(Source: WHO, 2002)

2.10.3 Groups Vulnerable to the Effects of Noise Pollution

Vulnerable groups, generally underrepresented in study populations, include patients with various diseases, patients in hospitals or those who are rehabilitating from injury or disease, the blind, the hearing impaired, fetuses, infants, young children, and the elderly. Although anyone might be adversely affected by noise pollution, groups that are particularly vulnerable include neonates, infants, children, those with mental or physical illnesses, and the elderly. Because children are particularly vulnerable to noise induced abnormalities, they need special protection (Brookhouser 1996, American Academy of Pediatrics 2003). This vulnerability to noise may be an age related sensitivity but may also be due to increased risk based on behavior (personal music systems, loud concerts) or to an inability of the very young to remove themselves from a noxious source (American Academy of Pediatrics 2003). The evidence is strong enough to warrant monitoring programs in schools and elsewhere to protect children from noise exposure (Brookhouser 1996, American Academy of Pediatrics 2003).

The effects of noise on the fetus and newborn are unclear. Exposure to noise during pregnancy may increase the risk of high-frequency hearing loss in the newborn, shortened gestation, prematurity, and intrauterine growth retardation (Jansen and Tauscher 1978, Brookhouser 1996, American Academy of Pediatrics 2003). Noise in the NICU may cause cochlear damage and may impair the growth and development of the premature infant (Roizen, 1999). Even though studies have been inconsistent with respect to noise and congenital malformations, the data were sufficiently compelling for the National Research Council to recommend that pregnant women avoid noisy work settings (Hirosawa, 2000).

2.11 Characteristics of the School Environment

Schools are lively, often noisy, places where children learn to manage their own noise and where they are asked to modify their behavior as required by the surrounding community. Schools should ensure the best possible conditions for children's physical and intellectual development, and noise is one of the main factors that adversely affect these optimal conditions (WHO, 2008). In addition, school children are exposed to multiple sources of noise in the school itself -from the hallways, nearby classes, heating and ventilation

systems, adjacent highways, overhead jets, holes cut in walls for electrical wiring or sprinklers, appliances, or over crowdedness, outside the school, when traveling to and from the school and during their recreational activities. Noise control in the school environment is a real public health challenge (Anderson, 1996).

2.12 Noise Levels in Schools

Until very recently classroom acoustics standards in the United States had not yet been formalized (Lubman, 1997). In 1995 the American Speech-Language-Hearing Association recommended that classrooms noise levels, averaged over all frequencies in the human audibility range (20 – 20,000 Hz), should not exceed 30 dB. In 2002, American National Standards Institute adopted 35 dB as the maximum background noise (Sutherland and Lubman, 2003) which is also the standard for the World Health Organization (WHO, 2000). In Sweden the standard is also 35 dB (Evans, 2000).

2.13 Impact of Noise on Children

Children and adolescents are considered high risk group to the effect of noise (Bistrup *et al.* 2001). Noise has particularly harmful effects on children as noise in the classroom or at home interferes with communication and therefore learning processes (Evans et al. 2001). High noise levels during classes have been shown to affect cognitive performance (Bistrup *et al.* 2001). Reading and memory have been reported to be impaired in school children who were exposed to high levels of aircraft and traffic noise (Maris *et al.*, 2000, Hygge et al. 2002). Some studies have shown higher stress hormones levels and higher mean blood pressure readings in children exposed to high levels of community noise (Herbeck 2000, Passchier-Vermeer 2000). A recent study found evidence of high-frequency hearing loss in nearly one third of a cohort of college students (Mostafapour *et al.*, 1998).

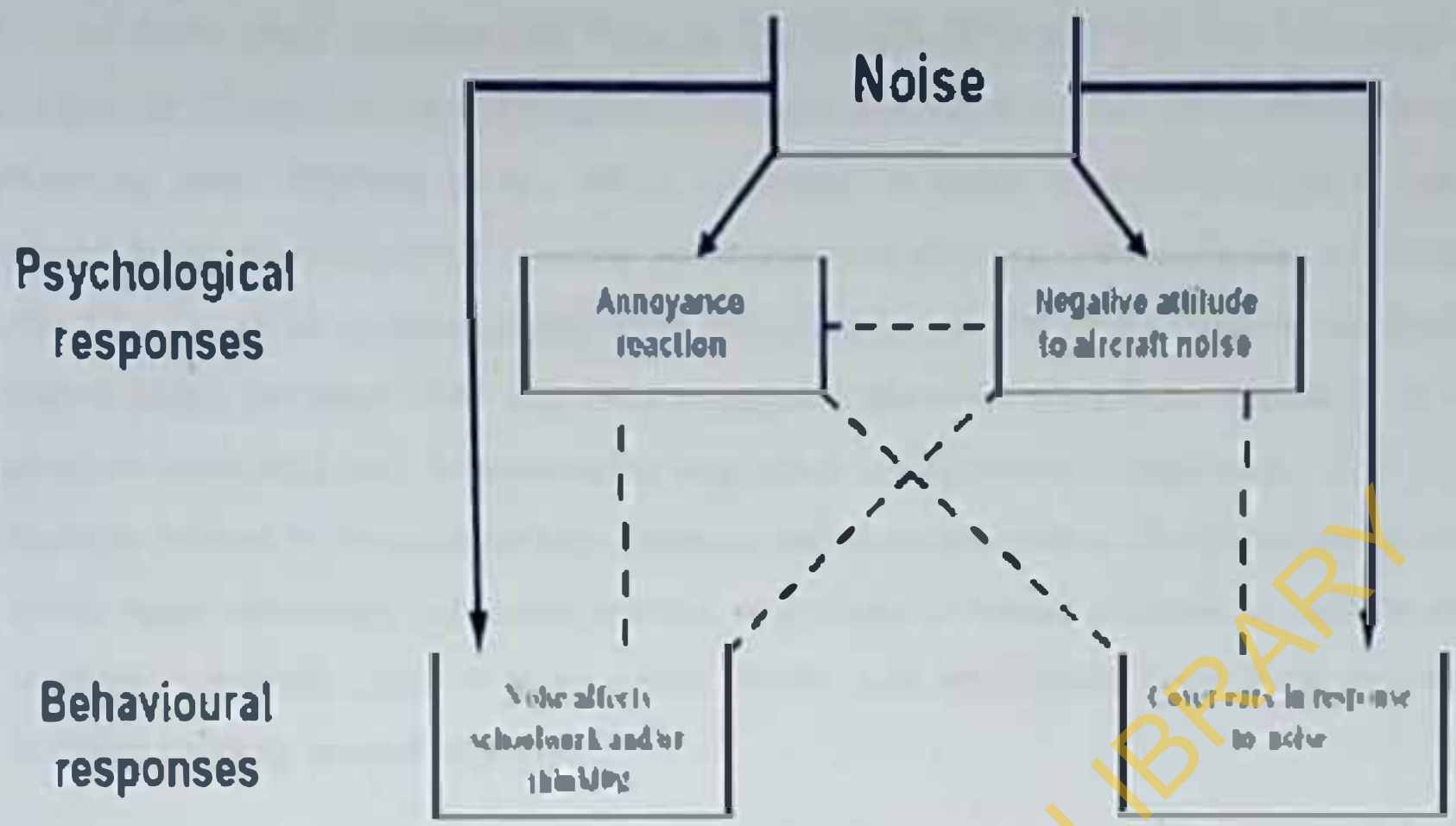
Research has demonstrated that children in a noisy environment have problems filtering out background noise and interpreting speech. A study for the European Commission (known as RANCH) investigated road traffic and aircraft noise exposure and children's cognition and health. It was found that children exposed to noise levels over 55 dB(A) achieved lower scores in reading tests (Stansfeld *et al.*, 2005). Affected children will be disadvantaged in their development of speech and reading abilities as well as more general

communication skills (Karchmer and Allen, 1999). Noise may also have effects on foetal development due to (stress) effects on expectant mothers (EPA, 1978). Environmental noise also has cognitive effects in older children and adults due to hindering communication, as shown by studies of aggression, mental health and anxiety.

The impact of noise on children's health and development in schools impose a considerable health and financial burden, which could be greatly reduced if noise concerns were taken into account as early as possible when a school is being designed.

2.14 Urban Laws and Location of Schools

The UK and Japan enacted national laws on noise pollution in 1960 and 1967 respectively, but these laws were not at all comprehensive or fully enforceable as to address: generally rising ambient noise, enforceable numerical source limits on aircraft and motor vehicles or comprehensive directives to local government. Although other States and local governments have similar laws, the entire issue of land use is extremely complicated with a vast array of competing considerations entering into any actual land use control decisions. For this reason, it is nearly impossible to measure the progress of using land use laws to control the effects of noise.



The solid lines indicate reported responses to noise. The dashed lines indicate possible relationships between these responses, as they tended to occur together in children's responses to noise. The associations do not necessarily imply causation

Figure 2.4. Thematic response pattern in a number of children exposed to high levels of aircraft noise

Source: Ranch Project, 2003

In most developing countries like Nigeria, the growth of mega cities had been unplanned and haphazard resulting in the locating of schools in areas that pose environmental hazards including noise (Hardoy et al., 1992). Learning in noisy environments as a result of schools being poorly located in noisy environmental settings, ultimately has a detrimental effect on the children maximizing their potentials. A review of a series of studies in the United States between 1980 and 1986 concluded there are significant increases in blood pressure associated with schools being near noisy urban streets (Evans et al., 1991). Other findings related to location include German and Russian studies (Berglund and Lindvall, 1986) again indicating increased systolic and diastolic blood pressure in middle school children in schools close to noisy urban streets, and abnormally high blood pressure in children residing around airports.

Exposure to traffic noise at elementary schools also has been associated with deficits in mental concentration, making more errors on difficult tasks, and greater likelihood of giving up on tasks before the time allocated has expired. Furthermore, another study conducted in Los Angeles (Cohen *et al*., 1986) found blood pressure does not habituate or decline with continued noise exposure over time, that is, children don't get used to noise. In effect, then, the location of schools is of critical importance if they are to be sustainable for effective teaching and learning.

2.15 Noise Pollution Control in Schools and Other Environments

The Noise Control Act of 1972 gives the Federal Environmental Protection Agency (EPA), the authority to establish noise regulations to control major sources of noise, including transportation vehicles and construction equipment. After a watershed passage of the U.S. Noise Control Act of 1972, the program was abandoned at the federal level under President Ronald Reagan in 1981 and the issue was left to local and state governments. The Federal Government has essentially no authority to regulate land use planning or the land development process. Federal-Aid Highway Act (FHWA) and other Federal agencies encourage State and Local governments to practice land use planning and control in the vicinity of highways. The Federal Government advocates that local governments use their power to regulate land development in such a way that noise sensitive land uses such as schools are either prohibited from being located adjacent to a

highway, or that the developments are planned, designed, and constructed in such a way that noise impacts are minimized.

Many recommendations have been suggested from different studies on the most practical approach to control noise pollution in schools and other noise sensitive environments. They include:

a. Spotting Noise Risk Zones

Global or strategic noise planning tries to prevent noise issue arising and to optimize the use of limited resources by mapping and managing the noise environment of a large area such as a city.

Geographical Information System (GIS) is being used to monitor and forecast noise pollution patterns in many countries around the globe. It has been widely used in environmental modeling and analysis including noise pollution monitoring in the western hemisphere of the world. GIS could be an indispensable tool for noise analysis and management even in developing countries like Nigeria (Mehdi *et al*., 2002). In addition to its powerful capabilities in spatial database development, spatial data processing, management and modeling, it provides visualization and map-making tools that can be used to effectively present the variability of noise intensity.

b. Legislation to Control Noise Pollution

At present, there is no specific and detailed legislation to control noise pollution in Nigeria. Government should pass the "Noise Pollution Act" to meet Nigerian condition especially with respect to siting of schools. Apart from such kind of central legislation, there should be a city noise control code for all major cities in Nigeria. Creation of unnecessary noise has to be prohibited and should be punishable under law.

c. Public Awakening and the Control

It is important that public awakening is also very essential for the control and prevention of noise pollution. In developing countries like Nigeria, most of the persons lack any idea about the ways in which noise pollution could be controlled. Very few scientists are aware

of the problem and its control. Many developing countries are still ignorant of the grave effects of noise pollution. In this regard, television, radio, internet and newspapers should give a campaign for wide publicity (Kamboji, 1999). Awareness about the harmful effects of noise pollution may be created among students at all levels through curriculum.

d. Plantation

Plants are efficient absorbers of noise, especially noise of high frequency. A dense ever green hedge can reduce the noise of microphones by 20dB. Therefore, plantation on both sides of the street, highways and in the schooling environment can curb the noise pollution effectively.

e. Noise Reduction at Source Level

Steps should be taken to reduce the noise at source level. Industrial areas, aerodromes, and highways should be located away from school environments and outside the city limits. Ban on the use of pressure horn should be strictly implemented. Police departments may be assisted by NGOs, students and the general public.

f. Exchange of Scientific Knowledge

Scientific knowledge regarding the pollutants and control of environmental pollution may be exchanged internationally so that the developing and under developed countries may also be able to control the ever increasing problem of pollution.

Wherever needed, environmental laws may be formulated or modified as the case may be for effective implementation of these recommendations.

2.16 Noise Regulation and Law Enforcement in Urban Areas

Noise regulation includes statutes or guidelines relating to sound transmission established by national, state or provincial and municipal levels of government. Man works and lives under various types of noisy environment and today, most countries of the world are aware of the ill-effects of noise on human health. To avert the hazard associated with noise and also to enjoy comfort and convenience, many countries of the world have

carried out the exercise of finding out the most suitable ambient noise levels to which a human being can be exposed with the least harm in that particular environment. Consequently, national standards have been adopted by many countries laying down maximum permissible noise level for environment and occupational noise exposure to give relief to the people working or living in those environments. These standards vary from country to country and have laid in the form of recommendations, guidelines or statutory requirements as per the economic conditions, advancement of technology and burden on industry.

Some countries have their specific legislation on noise. For instance, in the United States of America, the Noise Control Code, 1972, New York Noise Control Code, 1972 and Chicago Noise control Regulations, 1971, in Great Britain, the Control of Pollution Act, 1974, in Japan, Noise control laws of 1968, are the specific laws to control the growing problem of noise pollution (Agarwal, 2002). These standards are compared below.

a. Environmental Quality Standards of Noise in United States of America

In the United states, absolute criteria for noise exposure to a community do not exist, instead there are guidelines (USEPA, 1974), published by the US Environmental Protection Agency in 1974 as follow up of the Noise control Act of 1972. These guidelines prohibit excessive noise in general terms but do not forbid construction or operation of other facilities on the basis of the effects of anticipated noise emissions in nearby communities. However, regulations restricting new housings in certain areas imposed by the US Department of Housing and Urban Development do exist. As per these regulations, housing is not acceptable in areas where noise levels exceed 80dB (A) for one hour or more during the day or 75dB (A) for 8 hours in a day and it is normally unacceptable (discretionary) if noise exceeds 65dB (A) for 8 hours in a day or is subjected to loud repetitive noise (Agarwal, 2002).

Table 2.3: Equivalent Sound levels Identified as Requisite to Public Health and Welfare by the US Environment Protection Agency (US-EPA)

s/n	Area	Measure dB (A)	Indoor		Outdoor	
			Activity Influence	Hearing Loss Consideration	Activity Influence	Hearing Loss Consideration
1	Residential	L_{dn}*	45	-	55	-
2	Hospital	$L_{eq}(24)$**	-	70	-	70
3	Educational	$L_{eq}(24)$	45	70	55	70
4	Commercial/Traffic	$L_{eq}(24)$	-	70	-	70
5	Industrial Recreational Area	$L_{eq}(24)$	-	70	-	70
6	Farmland/General unpopulated land	$L_{eq}(24)$	-	-	-	70

Source: Pollution Management vol. 5 (Agarwal, 2002)

*L_{dn} It is day-night average sound level.

** $L_{eq}(24)$ It is a 24 hour equivalent or average A-weighted sound level.

b. WHO Guideline Values for Community Noise in Specific Environments

The role of WHO in the control of noise pollution is also noteworthy (Kamboj, 1999). It is to raise the standard of health of the people which can adversely be affected by noise. Although, WHO is not an authority to prescribe the limits of noise, it recommends some permissible limits of noise which are just advisory as a reference document to evaluate the impact of community noise for its member-states. The WHO guidelines values in Table 2.4 are organized according to specific environments. The effects of noise on performance are particularly relevant to a school environment. When multiple adverse health effects are identified for a given environment, the guideline values are set at the level of the lowest adverse health effect (the critical health effect). The guideline values represent the sound pressure levels that affect the most exposed receiver in the listed environment. Similar guidelines were being developed by the EPA, but ended with termination of federal funding in 1982 (Shapiro, 1991). According to WHO, noise acts as a distracting stimulus which causes interference with many kind of tasks especially mental activities involving vigilance, information gathering, and analytical processes.

c. Environmental Quality Standards of Noise in the United Kingdom (UK)

The current British standard in the United Kingdom for noise insulation in buildings BS8233:1999 (3) provides some recommended internal ambient noise levels of activity (see table 2.5). In 2003 the Department for Skills and Education published Building Bulletin 93 'Acoustic design for schools' also called BB93 with L_{Aeq} 35dB for classroom noise. In terms of acoustics, it replaced Building Bulletin 87 'Environmental Design Criteria for Schools also called BB87 with L_{Aeq} 40dB for classroom noise.

Table 2.4: Guideline values for community noise in specific environments

Specific Environment	Critical health effect(s)	L_{Aeq} [dB(A)]	Time base [hours]	L_{Amax} fast [dB]
Outdoor living area	Serious annoyance, daytime and evening	55	16	-
	Moderate annoyance, daytime and evening	50	16	-
Dwelling, indoors	Speech intelligibility & moderate annoyance, daytime & evening	35	16	
Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class room & pre schools, indoors	Speech intelligibility, Disturbance of information extraction, message communication	35	During class	-
Pre-school Bedrooms, Indoor	Sleep disturbance	30	Sleeping-time	45
School, playground Outdoor	Annoyance (external source)	55	During play	-
Hospital, ward Rooms, indoors	Sleep disturbance, night-time	30	8	40
	Sleep disturbance, daytime and evenings	30	16	-
Hospitals, treatment Rooms, indoors	Interference with rest and recovery	#1		
Industrial, Commercial Shopping and traffic Areas, indoors and Outdoors	Hearing Impairment	70	24	110
Ceremonies, festivals And entertainment Events	Hearing impairment (persons <5 times/year)	100	4	110
Public addresses, Indoors and outdoors	Hearing impairment	85	1	110
Music and other Sounds through Headphones/earphones	Hearing impairment (free-field value)	85 #4	1	110
Impulse sounds from toys, fireworks and Firearms	Hearing impairment (adults)	-	-	140 #2
	Hearing impairment (children)	-	-	120 #2
Outdoors in parkland And conservations area	Disruption of tranquility	#3		

Source: Guidelines for community noise (WHO, 2000).

Key:

#1: As low as possible;

#2: Peak sound pressure (not Lmax, fast), measured 100 mm from the ear;

#3: Existing quiet outdoor areas should be preserve and the ratio of intruding noise to natural background sound should be kept low;

#4: Under headphones, adapted to free-field values

L_{max} *Maximum root mean square A-weighted sound pressure level*

L_{min} *Minimum root mean square A-weighted sound pressure level*

L_{Aeq} *Continuous Equivalent Noise Level in dB(A)*

L_{AeqT} *Continuous Equivalent Noise Level in dB(A) 0of a time*

Varying noise is a single figure noise level which over the period of time under consideration, contains the same amount of A-weighted sound energy as the time varying noise over the same period of time.

Table 2.5: Ambient Noise Levels and Activity for the UK

Criterion	Typical situation	Design range L_{Aeq} in dB
Reasonable industrial working conditions	Heavy engineering	70-80
	Light engineering	65-75
Reasonable speech or telephone communication	Cafeteria	50-55
	Corridor	45-55
Reasonable condition for study and work requiring concentration	Library, office	40-50
	Meeting room	35-40
Reasonable listening conditions	Classroom	35-40
	Lecture theatre	30-35
Reasonable resting/sleeping conditions	Living rooms	30-40
	Bedrooms	30-35

Source: British Standard (BS) 8233, (1999).

d. Environmental Quality Standards of Noise in Japan

Under the Japanese Noise Regulation, the perfectural governors have been empowered to designate residential areas, schools of preserving living environment through prevention of noise. while designation such areas perfectural governors shall establish "regulatory standard" (maximum permissible level of noise) for specified hours in respective zones within the standards set forth by the Director General of the Environmental Agency (Kamboj, 1999).

Japanese Environmental Quality Standards for Noise in different areas and for various sources of noise, the maintenance of which is desirable for preservation of the living environment and conductive to the protection of human health are shown in Table 2.6.

e. Environmental Quality Standards of Noise in India

Through the promulgation of the comprehensive Air Act of 1986, noise pollution has become an offence in India (Agarwal, 2002). The various limits for the urban environmental ambient noise in Leq issued in 1989 vide notification from the Ministry of Environment and forests have been shown in Table 2.7. These standards have been defined taking into account the international standards and local weather conditions and customs etc. Table2.7 reflects these standards.

Table 2.6: Environmental Quality Standards for Noise in Japan

Category	Area Affected		Sound Level (dB)	
			Day time (6am-10pm)	Night time (10pm-6a
AA	Areas, which require particular quietness. For instance areas where medical facilities are concentrated		50 or less	40 or less
A	Exclusively residential area	General area	55 or less	45 or less
		Area facing roads with two lanes or more	60 or less	55 or less
B	Area which is used mainly for residence	General area	55 or less	45 or less
		Area facing roads with two lanes or more	65 or less	60 or less
C	Commercial & Industrial areas	General area	60 or less	50 or less
Special case	Area facing trunk road (heavy traffic lanes)		70 or less	65 or less

Source: http://www.env.go.jp (accessed 12th October, 2008)

Table 2.7: Ambient Noise Levels (Leq) Applicable in India

Area Code	Category of Area	Environmental Noise Standards Leq dB(A)	
		Day Time (6am-9pm)	Night Time (9pm-6am)
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Source: Agarwal, 2002

f. Noise Standards in Pakistan

In the past thirty years, noise in all areas especially urban areas, has been increasingly rapid. In developing countries like Pakistan, the growth of their mega cities has been unplanned and haphazard resulting in many environmental hazards including noise pollution (Hardoy, et al., 1992). There is no legislation to deal with noise emanating from railway engines, aircrafts, airport or industrial or construction activities. Public complaints on noise pollution are often received in the federal and provincial environmental protection agencies, but in the absence of national standards for noise, these agencies are handicapped to take any legal action.

The Pakistan Environmental Protection Agency (Pak-EPA) exercising its power under clause (d) of section 6(1) of the Pakistan Environmental Protection Ordinance (PEPO), 1983 with the approval of the Pakistan Environmental Protection Council (PEPC) established National Environmental Quality Standards (NEQS), inter alia, for motor vehicle exhaust and noise. Pakistan NEQS for motor vehicle noise allows the maximum permissible noise emission limit of 85 dB(A) for new vehicles at a distance of 7.5 meters from the source without specifying the type of motor vehicle and measuring technique (Sheikh, et al., 1997).

Table 2.8: National Environmental Quality Standards for Motor Vehicle Exhaust and Noise in Pakistain

S.No	Parameter	Standards (maximum permissible limit)		Measuring method
1	Smoke	40% or 2 on the Ringelmann scale during engine acceleration mode		To be compared with Ringelmann Chart at distance of 6 meters or more
2	Carbon monoxide	Emission Standards:		Under idling conditions: Non dispersive infrared detection through gas analyser
		New Vehicles 4.5%	Used Vehicles 6%	
3	Noise			Sound meter at 7.5 meters from the source

Source: National Environmental Quality Standards (NEQS) (S.R.O 742(1)/93), 1993.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The study was carried out in Ibadan North and Ibadan South west L.G.As, Oyo state. Ibadan, the capital of Oyo state is the largest city in West Africa. It is located in south-western Nigeria, 78km inland from Lagos and is a prominent transit point between the coastal region and the areas to the north. It lies between latitude 7 ° and 9°30' east of prime meridian. Ibadan covers a land area of 12 kilometers radius. It has an altitude generally ranging from 152 to 213m with isolated ridges and peaks rising to 274m (FEPA, 1998). Its population is estimated to be about 3.8million according to the National Population Commission's (NPC) 2006 census estimates. It is reputed to be the largest indigenous city in Africa, south of the Sahara. The principal inhabitants of the city are the Yorubas. Ibadan has over 300 schools made up of both public and private nursery, primary and secondary schools.

Fig 3.1: Map of Nigeria showing the location of Oyo state.

Source: FEPA, 1998.

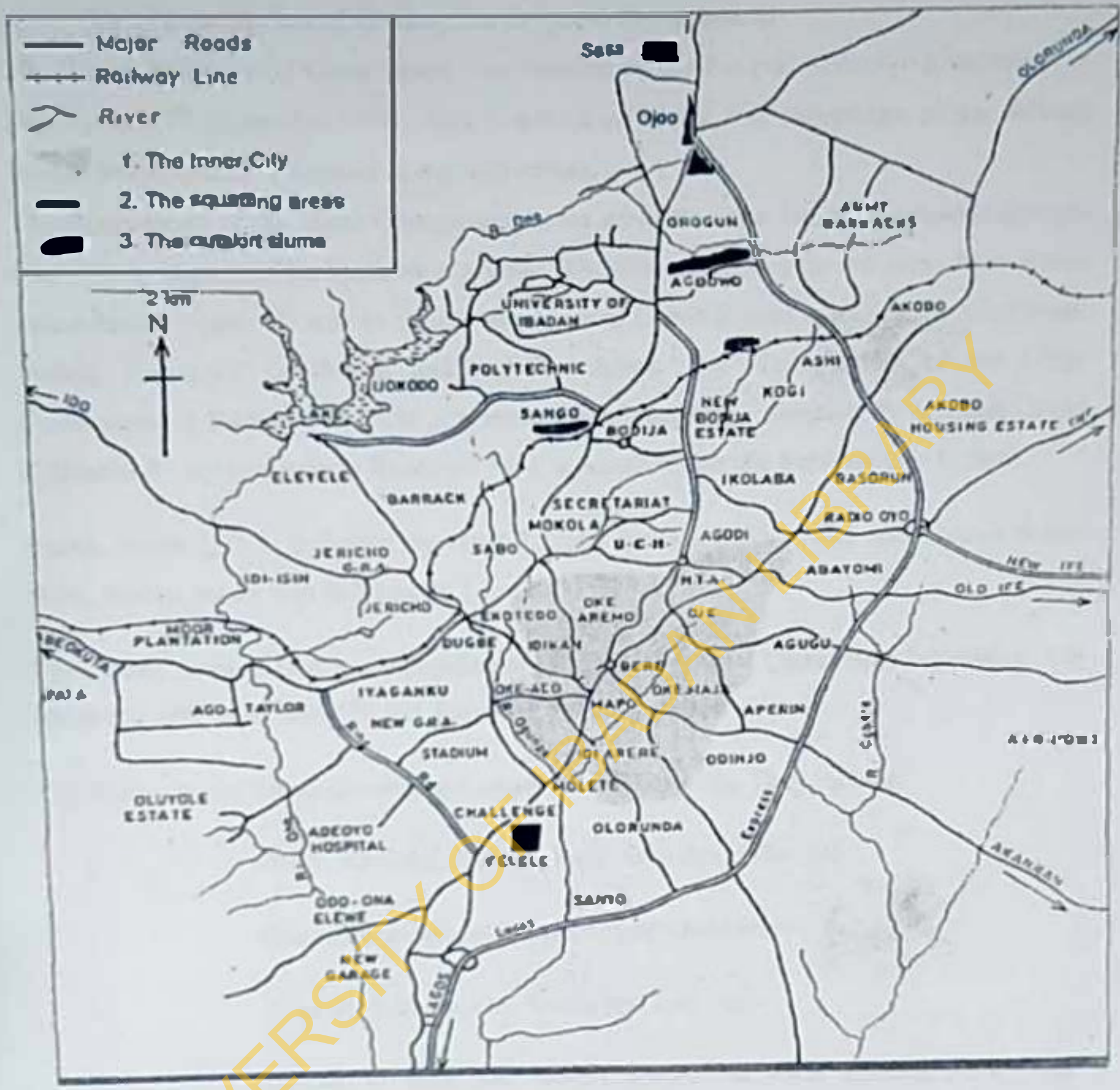


Fig 3.2: Map of Ibadan metropolis

Source: Ministry of Lands, Oyo state.

a. Brief Description of Ibadan North Local Government

The Ibadan North Local Government was founded by the Federal Military Government of Nigeria on 27th September 1991. This Local Government was carved out of the defunct Ibadan Municipal Government along with others.

The components of the Local Government cover areas between Beere roundabout through Oke-Are to Mokola, Oke Itunu and Ijokodo. The other components are areas from Beere roundabout to Gate, Idi-Ape to Bashorun and up to Lagos/Ibadan expressway, Secretariat, Bodija, University of Ibadan and Agbowo Areas. The Headquarters of the Local Government is Bodija. The local government headquarters is temporarily accommodated at Quarter 87 at Government Reserved Area at Agodi where the Secretariat is located.

Ibadan North L.G.A is bound by other L.G.As including Akinyele, Ido, Ibadan South West, Ibadan South East and Lagelu L.G.As.

The Ibadan North L.G.A has a population of 308,119 people. Comprising population was about 152,608 males and 155,511 females (2006 population census).

The Ibadan North Local Government comprises of 12 wards. They include:

1	Beere, Keninke, Agbadagbudu, Oke Are, Odo Oje
2	Ode Oole, Inalende, Oniyanrin and Oke Oloro
3	Adeoyo, Yemetu, oke Aremo and Isale Alfa
4	Itunba, Idi omo, Oje Igosun, Kube, Oke apon, Abenla, Aliwa/Total Garden and NTA Area.
5	Bashorun, Oluwo, Ashi, Akingbola, Ikolaba and Gate.
6	Sabo Area
7	Oke Itunu, Cocacola and Orenieji Areas
8	Sango, Ijokodo

9	Mokola, Ago Tapa and Premier Hotel Areas
10	Bodija, Secretariat, Awolowo, Obasa, Sanusi
11	Samonda, Polytechnic, University of Ibadan
12	Agbowo, Bodija Market, Oju Irin, Barika, Iso Patako Lagos/Ibadan Express Road.

This Local Government consists of Multi-ethnic nationalities predominantly dominated by the Yorubas. Others include the Igbos, Edos the Urhobo, Itsekiris, Ijaws, Nupes, Fulanis and Foreigners who are from Europe, America, Asia and other parts of the world.

Majority of the population of Ibadan North Local Government are in the private sector. They are mainly traders and Artisans. A good number of their workers are civil servants who live predominantly around Bodija Estate, Agbowo, Sango, Mokola, the University of Ibadan and the Polytechnic Ibadan.

b. Brief Description of Ibadan South West Local Government

Ibadan South West Local Government has a land mass of about 244.55km square. This feature makes it one of the largest Local Government in Oyo State. The Local Government is located near Government Reservation Area (GRA), Iyaganku with its administrative headquarters at Oluyole Estate within the office complex of the former Ibadan Metropolitan Planning Authority along Bashorun M.K.O Abiola Way (Former Ring Road), Ibadan.

Ibadan South West Local Government is approximately 150km from Lagos by the most direct route and 659km from Abuja, Federal Capital Territory (FCT). It is bound by Ibadan North West and Iddo Local Government in the West and by Ibadan North West and South East Local Government in the East.

Ibadan South West Local Government has a population figure of 283,098 with an estimate of 139,622 males and 143,476 females according to the final result of 2006 census released by the National Population Commission (NPC).

There are 82 primary and 26 secondary schools in the LGA. The press centre of the Nigeria Union of Journalists (NUJ). Oyo State Council at Iyaganku also falls within the LGA. And within the Premises of the Press Centre is the Nigeria Institute of Journalism (NIJ), Ibadan Centre.

3.2 Study Design

The study design is a comparative cross-sectional survey which comprises noise level measurements. Questionnaire administration and exposure assessment (Pure-tone audiometry) among students attending selected schools within noisy environments and serene environments (as reference group).

The schools located in noisy areas constituted the focus of this study. Schools were selected purposively based on their proximity to activity areas like; market, main road and industrial area. On the other hand, a school located in a perceived comparatively low noise zone served as the control. The school was selected based on its location in a site away from noisy markets, busy main roads, industries as well as all other forms of high environmental noise.

3.3 Sampling Area

The sampling areas include Bodija market (Market area), Queen Elizabeth road Total Garden (main road/traffic area), which are both within Ibadan North, and the Ibadan small scale industrial layout, former NTC road, Oke-Bola (Industrial area) in Ibadan South West. Schools selected include Methodist Grammar School (MGS) Bodija, Anglican Grammar School (AGS) Queen Elizabeth road Total Garden, and Oke-Bola Comprehensive High School (OBCHS) Oke-bola. Each, representing schools located close to the market, main road and industrial areas respectively. Abadina college (AC) located within the university of Ibadan also in Ibadan North was used as the reference population.

3.3.1 Characteristics of the Sampling Area

Bodija market is located by the Secretariat - University of Ibadan road. The market is known for its characteristic rowdiness, and irritating noise that constantly pollutes the air as a result of loud chattering by both the buyers and sellers alike, generators and grinding machines. The market is the major market in Ibadan also comprising of a car park very close by where conductors engage in frequent shouting of their destinations to attract passengers. Added to this is a busy road adjacent the school gate that generates high noise level as a result of automobiles and the occasional locomotive engines of trains.

Queen Elizabeth road, Total Garden is a major road adjacent the school gate connecting two very busy areas known as 'total garden' and 'Mokola'. It is characterized by a heavy highway traffic density. The noise generated comes from horn honking, the engine exhaust, sirens, motor bikes and faulty equipment like defective mufflers.

Ibadan small scale Industrial layout, former NTC road, Oke-Ibola is a small scale industrial layout as the name implies, provided by the government of Oyo state to help provide indigenous people of the state and foreigners, job opportunities and a means of revenue generation. The industrial area is known to harbour over ten (10) currently functioning small scale industries ranging from saw milling and furniture production, pure water, printing press, canned juice among others. These activities generate loud noise from their machines and generators that power their production processes hence, affecting the learning environments of schools located close by.
All the schools studied were less than 10meters away from the noise source.

University of Ibadan (UI) is an academic community with minimal activity compared to other three locations. It is an institution concerned about learning and research. UI is a serene area with comparatively reduced activity which served as the control area. Though it has features like church, Mosque, car park, residential quarters, canteen, maintenance unit and Hotel inside the university community, the residences, campus and schools within are located some distance away (>50meters) from these activity areas.

3.4 Data Collection

3.4.1 Study Population

The study population consisted of students, 15 years of age and above who were found to be willing to participate and attending the secondary schools of interest for at least 3years as at the time of the study. They must have given their informed consent to participate. The control group comprised students attending schools in serene environment.

3.4.2 Criteria for School Selection

The schools located at the various environmental noisy sites considered for the study were selected based on the following criteria:

1. The school must be a mixed school (heterogeneous).
2. The school must be a government day secondary school
3. The school must be located within the LGAs selected for the study.
4. The school must be located not more than 100m away from a possible noisy setting/area like a large/major market, a busy main road and an industrial site.

A reference population in a serene environment, away from all possible forms of high environmental noise was used for comparison purposes.

3.4.3 Eligibility Criteria for Study Participants

The following were major criteria for selection of study participants:

1. The participants should be within 15-20 years (both males and females are involved).
2. The participants should be resident in low noise level areas (achieved through preset questionnaire).
3. Must attend any of the selected schools within the study area.
4. Must be a student in the school for at least 3 years.
5. Must be in the senior secondary class.

6. Participants with previous history of traumatic hearing loss (ringing in the ear) before enrollment into the school would be excluded
7. Participants must not be on ototoxic drugs like streptomycin, gentamicin etc
9. Participants must be willing to take part in the study

3.4.4 Sample Size

The minimum sample size for the study was calculated so that the obtained result of the study was within 95% confidence interval. A study conducted in a textile manufacturing plant in Addis Ababa, Ethiopia showed that the prevalence of Noise Induced Hearing Loss (NIHL) among workers, who were exposed to noise, was 34.3%. Also, another study conducted in the general population showed a prevalence of hearing loss of 14.3% (Ayele and Yemane, 1994)

The minimum sample size for the study was obtained using the formula below, according to Bamgboye, (2005);

$$n = \frac{(Z_{1-\alpha/2} + Z_{\beta})^2 (P_1(1-P_1) + P_2(1-P_2))}{(P_1 - P_2)^2}$$

Where:

n = the desired sample size

$Z_{1-\alpha/2}$ = standard normal deviate at 5% level of significance = 1.96

Z_{β} = standard normal deviate corresponding to 95% power = 1.64

P_1 = proportion with hearing impairment within the group in noisy area = 34.3%

P_2 = proportion with hearing impairment within the group in quiet area = 14.3%

$$n = \frac{(1.96+1.64)^2 (0.343(1-0.343) + 0.143(1-0.143))}{(0.343-0.143)^2}$$

$$\frac{12.96 \times 0.347902)}{0.04}$$

$$\frac{4.50881}{004} = 113$$

Adjusting for anticipated 25% non response rate:

$$\frac{113 \times 100}{75} = 150.7$$

Rounding up to the nearest tens, the sample size was made up to 150 in each group (study and reference) for better precision in the study. Therefore, the total number of participants (n) was 300.

3.5 Sampling Procedure

The sampling procedure was activity driven (purposive sampling). Ibadan North was selected purposively since it harbours the biggest market in Ibadan (Bodija market) and has schools located close to it. Similarly, major main roads exist in Ibadan North like the Queen Elizabeth road which is known for its constant heavy traffic density and also harbors schools in close proximity. Hence, two-thirds of the noisy settings required for the study were addressed. Ibadan South West was also chosen because of its high industrial activity.

Using a cluster sampling technique, a main road and busy market were selected from Ibadan North (Queen Elizabeth road, oil Total Garden and Bodija market respectively) and an industrial area selected form Ibadan South West (Ibadan small scale industrial layout, former NIC, Oke-bola Ibadan). Schools located close to these noisy areas were identified and studied (based on the inclusion criteria for schools). One school per cluster was purposively selected within the different high activity (noise levels) areas in Ibadan which includes Methodist Grammar School (MGS) Bodija (Market area), Anglican Grammar School (AGS) Queen Elizabeth road Total Garden (Traffic area), and Oke-Bola Comprehensive High School (OBCHS) Oke-bola (Industrial area). Abadina College (AC) located within the University of Ibadan was selected as the reference school.

Using a systematic random sampling technique, the 300 respondents involved were proportionately allocated among the senior secondary (SS) II classes of the studied schools. The populations among the schools in the experimental group were relatively similar thus the same allocation of fifty (50) respondents was selected per school. The

reference group was allocated 150 respondents which were also proportionately selected using a sampling fraction according to the population in the area of the selected class (SS II). The participants from each school consented and met the eligibility criteria stated above.

For the exposure assessment, (audiometric test) 20% of the participants in each study group were randomly selected and subjected to audiometric test.

3.6 Study Methods

The study methods were grouped into four main methods namely, survey (Questionnaire administration, Focused Group Discussion (FGD), and observational check list), field sampling (Noise levels and GIS measurements), exposure assessment (Pure-tone audiometry), and statistical methods (Data management and analysis).

3.6.1 Survey Method

A 70-item, semi-structured self administration questionnaire was developed and used for data collection. The questionnaire was divided into 8 sections namely, Section A: socio-demographic information; Section B: school information; Section C: knowledge about noise; Section D: attitude towards noisy learning environments; Section E: perceptions about noisy learning environment; Section F: experiences and coping mechanisms related to noise pollution; Section G: residential environment; and Section H: health conditions. Signed informed consent was received from each respondent having read through and understood the purpose for the study. Participation was voluntarily and the information provided was kept strictly confidential. Pre-test was carried out to ascertain the effectiveness of the questionnaire. Other survey instruments used include an observational check list and an in-depth interview for the school principals.

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3.6.2 Environmental Field Sampling Method

a. **Ambient Noise Level Measurement:** The equipment used in measuring noise in the selected schools of interest was the Quest type 2 sound level meter (SLM) model 2700. A Global positioning system (GPS) equipment was used to determine the coordinates of every site where readings were taken.

The desired response of the SLM was set at "slow". When measurements were made, the microphone was located in such a way as not to be in the acoustic shadow of any obstacle in appreciable field of reflected waves. Noise levels were measured in the classrooms close to the head region of the students (while they maintained sitting and standing postures), the corridors, play ground and gate area near the noise source (about 10m from the school). For each of the selected schools, four measurements were taken for a period of 20-30 seconds each (Peterson, 1981).

b. **Frequency of measurement:** The frequency of the ambient noise level was determined at three different periods of the day: 8-9am, 10-11am and 12noon-1pm. The purpose of the periodic determinations was to identify peak periods for noise levels in the different learning environments.

These measurements were done in a month (twenty times) within the school days of the week. A prepared data collection form was developed and used to record all information from the fieldwork.

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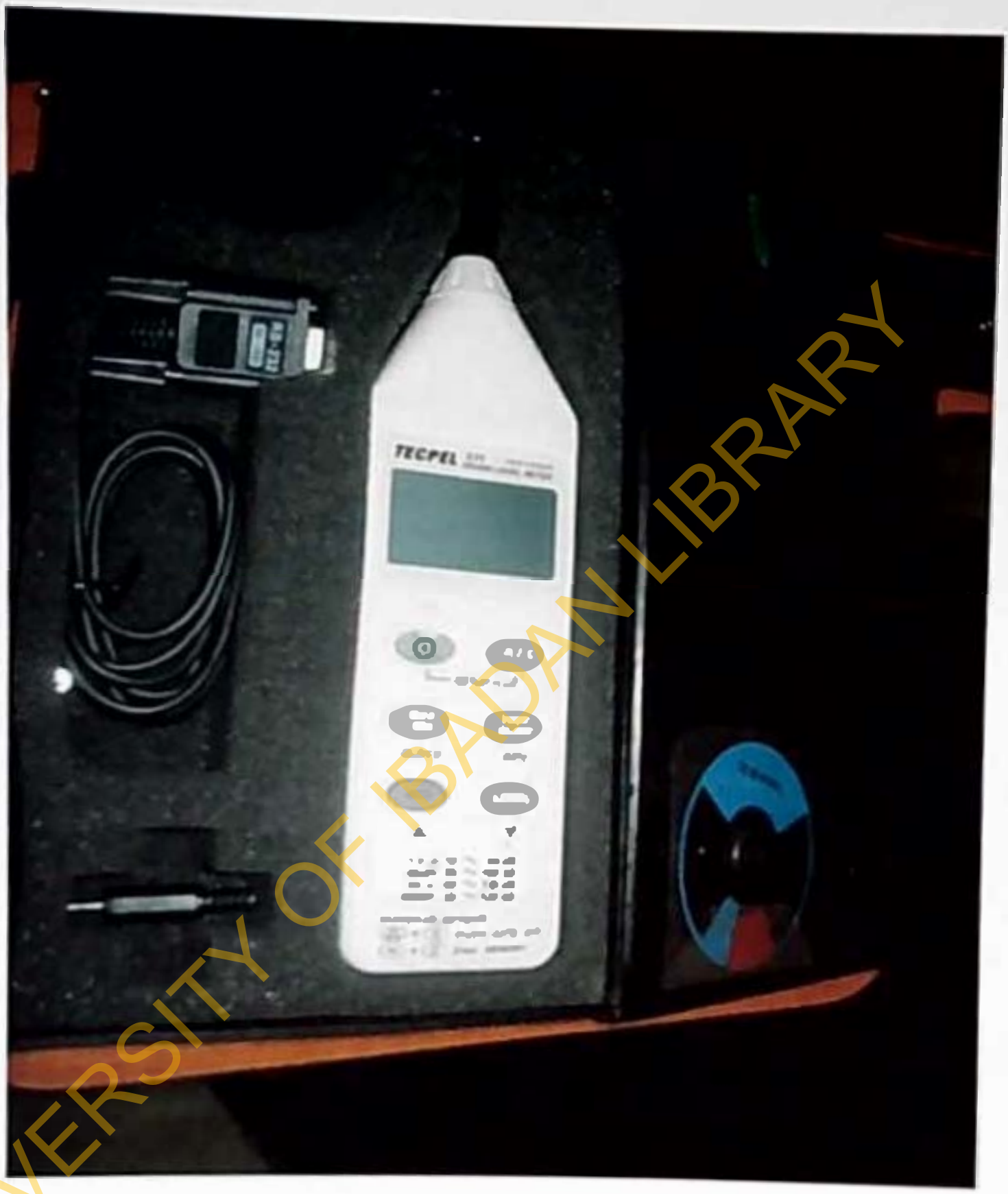

Plate 3.1: The sound level meter

Plate 3.2: Global Positioning System Equipment

Plate 3.2: Global Positioning System Equipment

Plate 3.3: Kamplex Audiometer

3.6.3 Exposure Assessment (Audiometric Test)

Audiometric test was carried out on a subset of the participants (20%) from the selected schools located at different noise exposure sources. The criteria for selection were based on students that showed interest (volunteers). Blood, urine and any tissue sample were not collected in this study.

The audiometric test was performed by the clinical staff of the Ear, Nose and Throat (ENT) Department at the University College Hospital (UCH) Ibadan. The equipment used was the high quality Kamplex computer audiometer B23, (Model 27) (see fig7). Frequency Spectrum Calibration in decibel was done to fulfill the International Organisation for Standardization criteria (ISO 8253-1) for audiometric testing environments (ISO 1989).

Prior to the commencement of the test, subjects underwent Otopharyngeal examination (audioscopic examination) to be screened for any form of Otopathy for exclusion from the study.

A pure-tone audiometry (air conduction and bone conduction) for both ears were conducted on all selected parucipants and at different sound fiequencies in ascending order as follows: 1, 2, 3, 4, 6 and 8 kHz and then in descending order to 0.5KHz following the IOSH (1999) requirements.

The audiologist was blinded to the participant's subject group to avoid bias. The results were used to relate to the environmental noise in terms of correlation to determine if there was any significant difference between the noise level recorded from the schools and the noise impact obtained from the audiometric results. The students were provided lunch and were transported to and from their schools at the end of the exposure assessment.

3.6.4 In-Depth Interview

In-depth interview was carried out with principals of the four studied schools. An average of 10 minutes was used for each interview. Before the commencement of each session, participants were given full disclosure of the nature of the study and confidentiality of information to be provided was ensured. Permission to use a tape recorder was obtained.

3.6.5 Observational Check List

Observational check list was used to authenticate the response given by the respondents. Indicators observed were: External features of the school premises, internal features of the school building, noise control facilities and distance of the noise sources from the schools.

3.6.6 Data Management and Analysis

Data Collection Process: All results from the field were compiled and properly recorded in a prepared form. This was done on a daily basis to forestall the occurrence of missing data. In addition, all audiometric data and environmental noise level data were recorded in separate data collection forms.

Four Research Assistants were employed and trained as field workers in the administration of questionnaire and noise level measurement. At the end of each working day, the data collected were checked for completeness and stored.

Data Analysis: All data collected were analysed, using SPSS software (version 15). Descriptive statistics were summarized using proportions, means, standard deviations, bar graphs, and frequency tables as well as Chi-square (X^2), ANOVA and t-test, all at 5% level of significance.

3.6.7 Preliminary Survey and Standardization of Instrument

Before embarking on this research work a preliminary survey was done to obtain some preliminary information and for informed consent (only site visitations were done. No measurements were carried out). Instruments used for the study, consisting of the semi-structured questionnaires, in-depth interview, and observational check list were pre-tested in another public secondary school, different from the ones used for the study but with similar characteristics. The purpose of this was to take the students real learning situation into account, so as to strengthen the data collection process and make the methodology more robust.

3.6.8 Ethical Considerations

Approval of the study was obtained from the Boards of management of the selected schools. Signed informed consent forms written in English from each participating student were also obtained. Approval was on the condition that:

1. The research will in no way inflict harm on the participants (non-maleficience) and every participant will be treated equally as much as possible.
2. Absolute confidentiality would be fully assured. That is, all information given by the participants would not be disclosed.
3. All participants would be duly informed of all the processes involved in the research before commencement (for this study, the audiometric test and questionnaire administrations only).
4. At any point in time any participant who wished to withdraw was free to do so.
5. Adequate informed consent would be sought for from the students and the school authority.

The research protocol was submitted to the UI / UCH joint Ethical Review Board for consideration.

CHAPTER FOUR

RESULTS

4.1 General Description of the School Environments

All the studied schools in the experimental group were located close to peculiar sources of noise which the students were exposed to in degrees relative to the different activities and the individual proximities of the noise sources to the schools. The control area (AC-University of Ibadan) provided a serene environment being a place of reduced activity because of its academic characteristic. Although there were features like church, Mosque, car park, residential quarters, canteen, maintenance unit and Hotel inside the university community, these features were located far away from the school area. The general information obtained from the selected schools indicates that all the schools were mixed (males and females). AGS recorded the highest student population (Table 4.1). The least average window size was recorded at AC. The smallest average playground size was recorded at OBCHS (Table 4.2). From the GPS readings the school with the highest elevation is MGS (Table 4.3).

Results from observation checklist revealed that the buildings of most of the schools studied were old and dilapidated as at the time of study. Walls and floor cracks were visible. Most classes lacked ceilings thus increasing the student's exposure to heat, radiation, noise and their associated impacts. Furthermore the classrooms were basically overcrowded (50-60students per class) with only one entrance in most classes. The classrooms were usually rowdy, noisy and unconducive for learning.

Table 4.1: General Information about the Schools Studied

Name of school	AC	OBCHS	MGS	AGS
Year established	1977	1979	1978	1977
Number of students	1318	1187	1265	1333
Number of teaching staff	66	45	50	64
Number of non teaching staff	32	20	25	28
Total population	1416	1252	1340	1425
Average number of students per class	50	50	55	60
School category	Mixed	Mixed	Mixed	Mixed
Type of school	Government	Government	Government	Government
Average number of arms	6	5	5	5
Major source of noise	Nil	Industry	Market	Main road
School location	University of Ibadan	NTC Road-Oke Bola	Bodija-Secretariat road	Total Garden

Table 4.2: Area and Dimensions of the Schools under Study

School	Window/meters (m)	Door (m)	Class (m)	Playground (m)	Distance fr (Gate to no source (m)
AC	1.31x1.22 (*5)	2.2x0.77 (*1)	9.17x8.00	157.3x53.3	—
OBCHS	2.74x1.26 (*3)	2.0x0.82 (*1)	11.91x11.71	46.9x33.42	10.53
MGS	2.4x1.16 (*6)	2.1x0.99 (*1)	7.0x6.93	75.0x40.6	10.20
AGS	2.2x1.14 (*6)	2.0x0.8 (*2)	10.2x15.57	50.0x43.2	11.7

Key: * = Number per class

4.2 Sampling Locations

On-site ambient noise level measurements were carried out in four (4) sampling points/locations per school under the study. They include Classroom (point 1), Corridor (point 2), Playground (point 3) and Gate side (point 4) respectively. The Global Positioning System (GPS) facility was used to determine all the actual positions where the readings were taken (Table 4.3) which was used to develop the noise risk assessment map for all the schools under the study (Fig 4.7).

4.3 Noise Level Measurements

Noise level measurements were carried out in the 4 sampling points (Classroom, Corridor, Playground and Gate area) in each school within five school days for a period of one month. The calibrated noise level meter was used to measure noise levels in all the 4 different locations in each school. Measurements were carried out within three (3) periods of school hours (8-9 am, 10-11 am, and 12-1 pm). The reason for the periodic measurements was to determine the peak noise level periods in the schools. The time frame 8 am-9 am represents the period within which they have their morning classes, 10 am-11 am represents their break time and 12 noon-1 pm represents the period within which they are just about to close from school. The measurements were carried out in the exposure and control groups respectively. The total noise level measurement recorded per school was 240 while 60 recordings were recorded per location.

4.3.1 Ambient Noise levels at OBCHS

The mean noise levels obtained at the various times (8 am-9 am, 10 am-11 am and 12 noon-1 pm) across the 4 sampling points in OBCHS showed significant differences ($p=0.000$). All the noise levels measured within the 3 periods from the first to the fourth sampling points in OBCHS had a mean noise level >70.8 dBA that exceeded the World Health Organisations (WHO) allowable threshold limit of 35 dBA for school environments. The control (AC) similarly recorded a mean noise level of 63.8 dBA from the 4 points which also exceeded the WHO allowable limits (Figure 4.1 displays the noise levels obtained at the different periods and locations).

Table 4.3: GPS Spatial Mapping Data

School	Location	Longitude	Latitude	Altitude
AC				
(Control)	Corridor	N07.45511°	E003.90164°	211m
	Playground	N07.45507°	E003.90181°	204m
	Gate	N07.45423°	E003.90158°	206m
OBCHS	Corridor	N07.37717°	E0033.87759°	210m
	Playground	N07.37721°	E003.87737°	203m
	Gate	N07.37787°	E003.87720°	208m
MGS	Corridor	N07.42929°	E003.91303°	239m
	Playground	N07.42912°	E003.91293°	238m
	Gate	N07.42918°	E003.91263°	248m
AGS	Corridor	N07.39879°	E003.90782°	227m
	Playground	N07.39872°	E0003.90800°	220m
	Gate	N07.39837°	E003.90823°	218m

Obtained results from the multiple comparison of mean noise levels measured between the exposure points and the control points at 12 noon-1 pm periods showed that points 1 to 4 differ significantly from the control due to the fact that at these points, interfering noise from industrial activities from the industry (usually at top gear within this period) considerably affects the ambient noise quality of the school environment. Other periods were not significantly different from the control owing to the fact that production processes and generator use are minimal at these periods. Statistically significant differences were observed in the mean noise level between exposure points and the control points ($p=0.000$).

The period between 10am-11am showed that the average noise level across the exposure points were at the maximum and above 70 dBA at all the four points measured (Table 4.4). This could be as a result of the additional loud noise contributed by the students as a result of their chattering during their break periods. The mean noise range was 65.4-78.4 dBA across all the exposure points.

4.3.2 Ambient Noise levels at AGS

The average noise levels measured at the three different periods across the four sampling points in this school compared to the control differed significantly ($p<0.05$). The overall mean noise level across all the 4 exposure points was 73.8 dBA. The overall mean noise level obtained from AGS and the control (63.8 dBA) all exceeded the WHO allowable threshold limits for school environment. The peak noise level for the school was measured between 10am-11am which is owing to the fact that the school is located by a very busy highway where the interference of vehicular movements affects the noise levels in the school environment considerably. This is enhanced by subsequent hold ups resulting in loud horn hooting making the school environment very noisy. This further leads to the raised voices of the students in attempt to overshadow the traffic noise to be heard during their play and physical exercises at break time.

The Gate area within the period of 10am-11am showed the highest noise level of 80.6 dBA. This could be attributed to the fact that apart from the traffic interference, hawkers that sell snacks to the students are stationed by the gate area thus attract a crowd of

students that come to patronize them during break time. The range in noise levels for the exposure points was between 70 dBA to 75.3dBA for 8am-9am period. 73.6 dBA to 80.1 dBA for 10 am-11 am period and 70.6 dBA to 74.4 dBA for 12noon-1pm period (Figure 4.2). The overall mean range was 70-80.1dBA (Table 4.4).

Comparing individual exposure points with the control at 8 am-9 am and 12 noon-1 pm periods, a significant difference was shown in all the points ($p<0.05$).

4.3.3 Ambient Noise levels at MGS

Results obtained from the sampling points of MGS Bodija showed a mean noise of 74 dBA, 80.4 dBA and 73.6 dBA for the periods of 8 am-9 am, 10 am-11 am and 12 noon-1 pm respectively. The control area had 60 dBA, 70.8 dBA and 62 dBA for the same periods respectively (Figure 4.3). A statistical significant difference was observed in the mean noise levels at the three different periods when compared with the mean noise levels recorded for the control area ($p<0.05$). The mean noise levels in this school also exceeded the environmental school exposure limit indicating possible health hazards with an overall mean of 76 dBA. The overall mean range was 70.2-82.1 dBA (Table 4.4).

The highest noise level measurement was recorded in MGS from all the schools measured. This could be owing to the fact that the school is located in close proximity to a dual noise source including a very busy and rowdy market as well as a busy road that cuts across the market by the school. Fig 4.5 displays the overall mean noise levels per location for the studied schools measured at the students sitting and standing positions compared to WHO guideline limits while Fig 4.6 shows the overall mean noise levels of all the locations and periods per studied school. The control school was found to have elevated noise levels during their break time with peak noise level recorded at the play ground (71.3 dBA) which could be as a result of their loud conversations during games and play at this times (Fig 4.4).

Table 4.4: Environmental Noise Levels (dBA) according to the Various Locations (Mean±SD)

School Name	Classroom			Corridor			Playground			Gate area			Mean value
	8-9am	10-11am	12-1pm	8-9am	10-11am	12-1pm	8-9am	10-11am	12-1pm	8-9am	10-11am	12-1pm	
AC	63.1±1.6	69.4±3.2	64.8±2.7	59.3±1.1	69.3±2.2	61.1±1.6	58.5±1.0	71.3±2.4	59.8±1.0	58.9±1.1	70.1±1.5	60.3±2.4	63.8
OBCHS	68.2±1.8	71.7±0.8	71.4±3.7	65.6±2.3	71.5±2.5	68.3±1.4	66.0±1.9	73.7±2.3	75.8±2.7	65.4±1.1	78.4±2.7	73.8±1.1	70.8
MGS	75.6±2.8	78.7±5.5	75.9±2.3	74.0±2.4	80.2±3.9	73.5±2.4	70.2±2.4	82.1±4.2	73.3±4.0	76.3±2.3	80.5±1.6	71.6±1.1	73.8
AGS	72.2±1.4	76.4±1.1	72.1±2.4	70.0±1.6	73.6±1.7	71.8±1.2	71.6±1.6	77.6±2.8	70.6±1.4	75.3±3.2	80.1±2.3	74.4±3.9	76.0

Key:
SD= Standard Deviation

Fig 4.1: Ambient Noise Levels across the Sampling Points in OBCHS

Key: OBCHS= Oke Bola Comprehensive High School (Industrial area)

Fig 4.2: Ambient Noise Levels across the Sampling Points in AGS

Key: AGS= Anglican Grammar School (Traffic area)

Fig 4.3: Ambient Noise Levels across the Sampling Points in MGS

Key: MGS = Methodist Grammar School (Market area)

Fig 4.4: Ambient Noise Levels across the Sampling Points in AC (Control)

Key: AC = Abadina College (Academic area)-Control

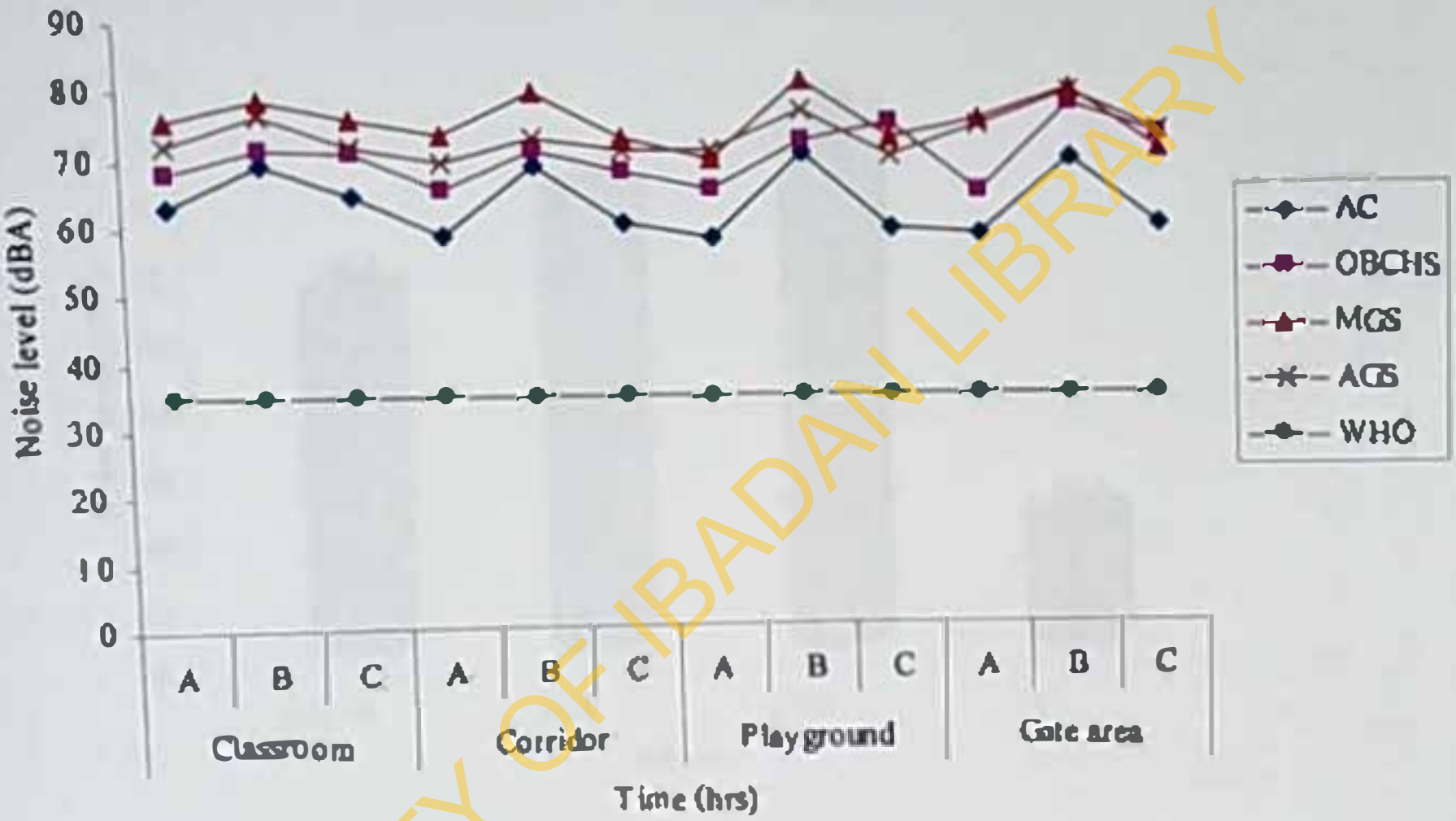

Fig 4.5: Chart showing Trend of Mean Noise Levels per Location in all the Schools Compared to WHO Limits

Key:
A = 8am-9am (During class)
B = 10am-11am (Break time)
C = 12noon-1pm (Shortly before closing)
AC = Abadina College (Academic area)-Control
OBCHS= Oke Bola Comprehensive High School (Industrial area)
MGS = Methodist Grammar School (Market area)
AGS = Anglican Grammar School (Traffic area)
WHO = World Health Organization's Standard for School Learning Environment

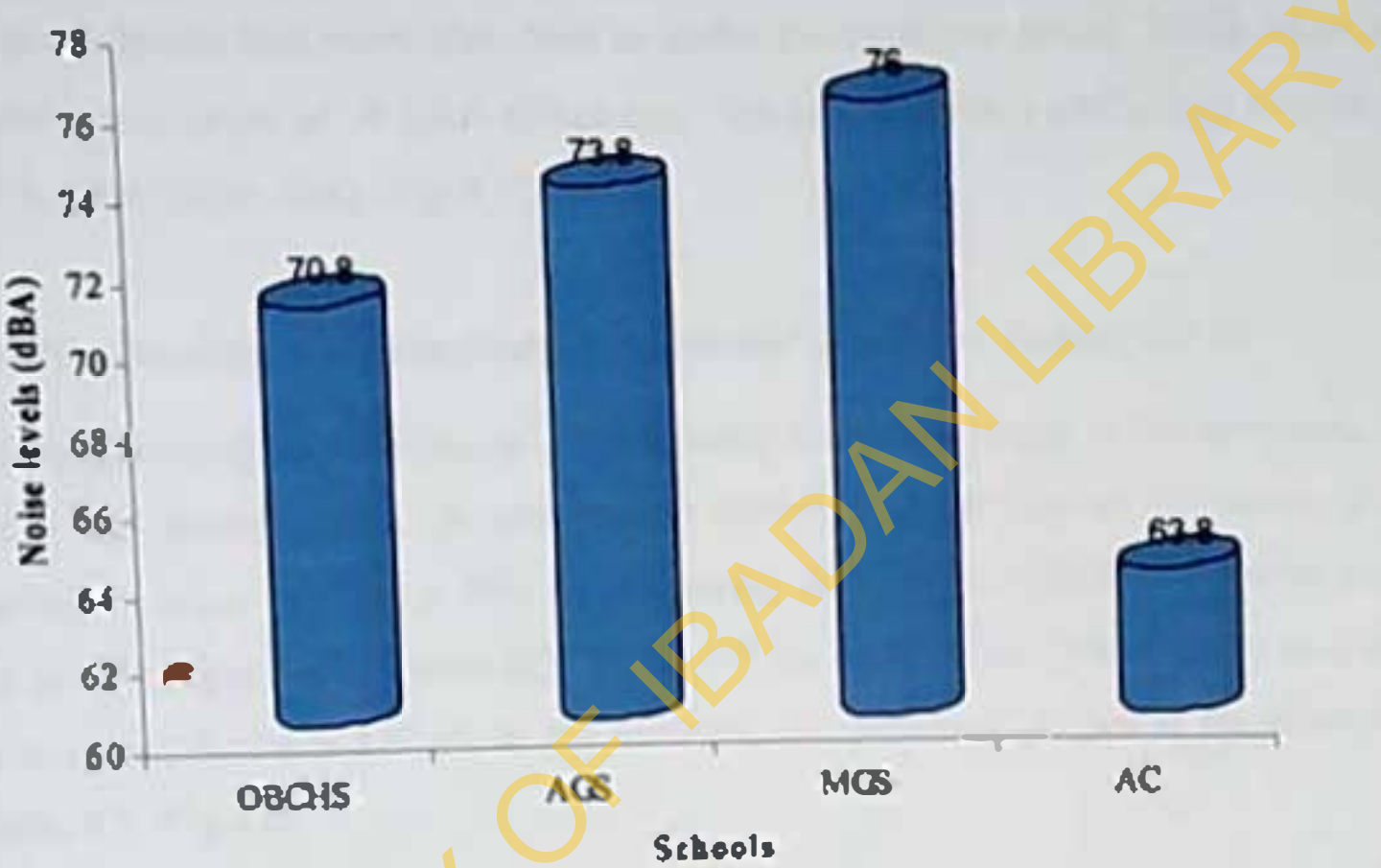

Fig 4.6: Overall mean Noise Levels of different Schools

4.3.4 Noise Assessment Risk Map

The mean noise levels recorded from the exposure group and the control alike were all found to exceed the WHO guide line limits of 35 dBA for school learning environment. Based on the results obtained, the Risk map developed shows the actual ground positions of the schools on the map, indicating the schools at low risk (36-65dBA) and high risk (66-95dBA) in relation to their mean noise levels measured. All the schools in the exposed group had noise levels that were classified as under the high risk group. MGS recorded the highest mean noise level of 76 dBA (High risk) while the control (AC), had a mean noise level of 63.8 dBA (Low risk) (Fig 4.6).

4.4 Traffic Density Measurement at Anglican Grammar School (AGS)

The traffic density at Queen Elizabeth's Road, being the main source of environmental noise around AGS was determined. The observation showed that the number of motor cars were more than motor bikes generally. The mean average number of vehicles that were recorded within the study period per day was 6238 and 5197 for motor bikes. The highest frequency of cars was recorded between 8-9 am in the morning and between 1-2 pm in the afternoon for bikes (Table 4.5, Fig 4.8)

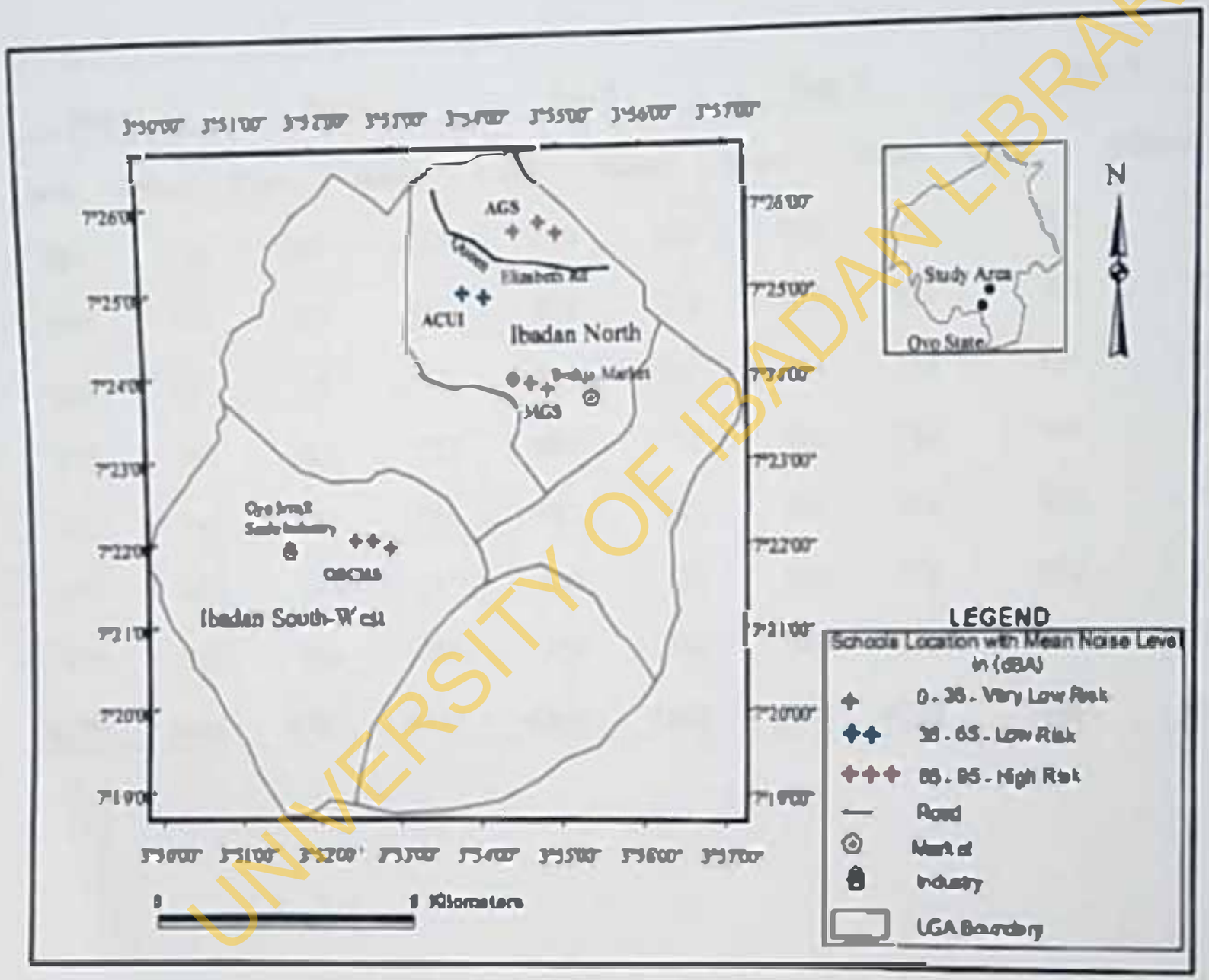

Fig. 1 Map showing Mean Noise Level Measurements per Month of Studied Schools in (dBA)

Table 4.5: Mean Traffic Density during Five School Days per Month at AGS (Traffic area)

	Day1		Day2		Day3		Day 4		Day 5		Grand Mean	
Time	Cars	Bikes	Cars	Bikes	Cars	Bikes	Cars	Bikes	Cars	Bikes	Cars	Bikes
7-8am	884	776	887	718	886	697	880	761	802	736	868	738
8-9am	919	744	953	765	928	758	938	734	967	768	941	754
9-10am	988	756	913	717	892	702	974	710	854	677	930	712
10-11am	818	763	918	727	889	731	862	730	794	712	856	733
11-12noon	921	746	912	736	882	723	841	764	813	755	874	745
12-1pm	859	813	845	715	849	723	860	771	812	750	845	756
1-2pm	936	819	904	755	939	769	942	758	898	696	924	759
Total	6325	5416	6362	5133	6266	5104	6298	5228	5940	5094	6238	5197

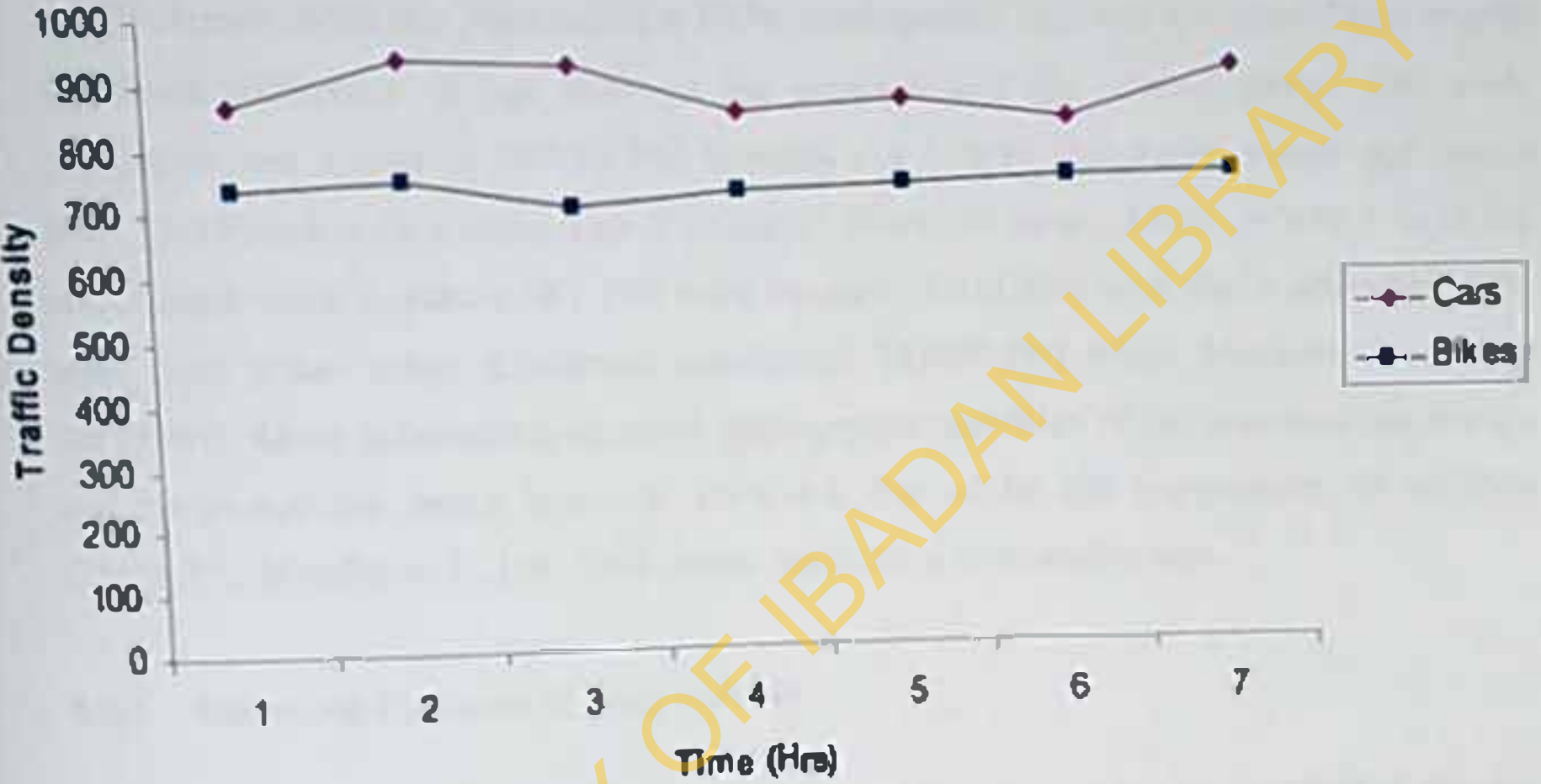

Fig 4.8: Mean Daily Traffic Density at AGS

Key:

1= 7am-8am
2= 8am-9am
3= 9am-10am
4= 10am-11am
5= 11am-12noon
6= 12noon-1pm
7= 1pm-2pm
AGS= Anglican Grammar School

4.5 Survey (Questionnaire) Results

4.5.1 Socio demographic Characteristics of Respondents

A total of 300 copies of questionnaires were administered to the study population comprising of 150 respondents from the exposed group (50 participants per school) and 150 from the control group. All the respondents were drawn from the senior secondary (SS) II classes. With this population, a 100% participatory rate was achieved There was no significant difference in age between the exposed and the control group. The study population was a total of 167(55.7%) females and 133(44.3%) males whose age ranges from 15-19years with a mean age of 15.6±0.7 years. Of these, About 245(81.7%) of the respondents were Yoruba's, 4(1.3%) were Hausa's, 33(11.0%) were Ibo's while 18(6.0%) were from other tribes. Christians constituted 242(80.7%) while Muslims constituted 58(19.3%). More information on socio demographic variables of the experimental groups and the control are shown below in Table 4.6. Out of the 300 respondents, 60 students (35(58.3%) females and 25(41.7%) males) underwent audiometric test.

4.5.2 Schooling Features of Respondents

All the respondents had been schooling for more than 3 years in their attended schools under the study (Table 4.7). This is an important inclusion criterion for respondents to be enrolled into the study. This is to give ample time capable of inducing or aggravating hearing impairment and the physiological health effects of exposure to noise. For the specific exposure groups, 24%, and 38% of the respondents from OBCHS, and MGS respectively reported that they enjoyed their school environment which showed a significant difference ($p>0.05$) when compared to the same response from the control (89.3%). Most (72%) of the respondents from AGS reported that they enjoyed their school environment and this showed no significant difference when compared to the control (89.3%).

Table 4.6: Socio Demographic Characteristics of Respondents

Socio demographic factors		Schools N(%)			
		Exposed Group			Control
		OBCHS	AGS	MGS	AC
Age	15-16years	45(90.0)	48(96.0)	42(84.0)	147(98.0)
	17-18years	4(8.0)	2(4.0)	6(12.0)	3(2.0)
	≥19years	1(2.0)	-	2(4.0)	-
Sex	Males	21(42.0)	22(44.0)	22(44.0)	68(45.3)
	Females	29(58.0)	28(56.0)	28(56.0)	82(54.7)
Religion	Christianity	37(74.0)	39(78.0)	40(80.0)	126(84)
	Islam	13(26.0)	11(22.0)	10(20.0)	24(16.0)
Ethnicity	Yoruba	44(88.0)	41(82.0)	40(80.0)	120(80.0)
	Ibo	4(8.0)	7(14.0)	9(18.0)	13(8.7)
	Hausa	0(0.0)	1(2.0)	1(2.0)	2(1.3)
	Others	2(4.0)	1(2.0)	0(0.0)	15(10.0)

Table 4.7: Schooling Features of Respondents

Schooling information		Schools N(%)			
			Exposed Group		Control
		OBCHS	AGS	MGS	AC
Year of admission	2002	1(2.0)	1(2.0)	8(16.0)	17(11.3)
	2003	30(60.0)	39(78.0)	33(66.0)	101(67.3)
	2004	19(38.0)	10(20.0)	9(18.0)	32(21.3)
Enjoy school environment	Yes	12(24.0)	36(72.0)	19(38.0)	134(89.3)
	No	38(76.0)	14(28.0)	31(62.0)	16(10.7)

4.5.3 Knowledge and Awareness of Respondents about Noise

The result on knowledge of respondents (Table 4.8) revealed that majority of the respondents in the four schools had good knowledge of noise. Majority (87.0%) admitted that loud noise can result in hearing loss. Most (98.7%) reported that noise was capable of affecting their academic performance. Forty-one respondents (82.0%), 40(80.0%), 47(94.0%) and 144(96.0%) from OBCHS, AGS, MGS and AC respectively knew that noise is any loud and disturbing sound. The number of respondents that had knowledge that noise is harmful to health includes 47(94.0%) OBCHS, 39(78.0%) AGS, 46(92.0%) MGS and 140(93.3%) in AC (control). All of the respondents believed that noise can affect their academic performance except only 4 respondents (8.0%) from AGS. A total of 46(92.0%) and 43(86.0%) respondents from OBCHS, 27(54.0%) and 31(62.0%) respondents from AGS, 44(88.0%) and 43(86.0%) from MGS and 144(96.0%) and 143(95.0%) respondents from AC reported that exposed to noise was capable of causing deafness and loss of sleep respectively.

The results on the levels of Knowledge, Attitude and Perception (Table 4.11) shows that the proportion of respondents with good Knowledge about noise accounted for 88% at OBCHS (Industrial area), 76% at AGS (Traffic area), 88% at MGS (Market area) and 94.7% at the control, AC (Academic area). The respondent's had good attitude to noise as demonstrated by a positive attitude by a major proportion of them including 76% from OBCHS, 70% from AGS, 76% from MGS and 82% of the respondents from AC. There was a significant difference between Knowledge and perception of the respondents from the four schools studied ($P<0.05$) particularly among the exposed group. They all had good knowledge about noise pollution whereas, the awareness did not reflect in their perception to noise in their school environment.

Table 4.8: Knowledge of Exposed Group and the Control about the Health Effects of Noisy Environments

Variable	Options	Schools N(%)			
		Exposed Group			Control
		OBCHS	AGS	MGS	AC
Noise is any loud and disturbing sound	Yes	41(82.0)	40(80.0)	47(94.0)	144(96.0)
	No	9(18.0)	10(20.0)	3(6.0)	6(4.0)
Noise is harmful to health	Yes	47(94.0)	39(78.0)	46(92.0)	140(93.3)
	No	3(6.0)	11(22)	4(8.0)	10(6.7)
Noise can affect academic performance	Yes	50(100)	46(92.0)	50(100)	150(100)
	No	0(0.0)	4(8.0)	0(0.0)	0(0.0)
Noise causes Deafness	Yes	46(92.0)	27(54.0)	44(88.0)	144(96.0)
	No	4(8.0)	23(46.0)	6(12.0)	6(4.0)
Noise causes blindness	Yes	2(4.0)	4(8.0)	0(0.0)	4(2.7)
	No	48(96.0)	46(92.0)	50(100)	146(97.3)
Noise causes annoyance	Yes	33(66.0)	37(74.0)	39(78.0)	140(93.3)
	No	17(34.0)	13(26.0)	11(22.0)	10(6.7)
Noise causes loss of sleep	Yes	43(86.0)	31(62.0)	43(86.0)	143(95.3)
	No	7(14.0)	19(38.0)	7(14.0)	7(4.7)
Noise causes malaria	Yes	9(18.0)	12(24.0)	17(34.0)	18(12.0)
	No	41(82.0)	38(76.0)	33(66.0)	132(88.0)

4.5.4 Attitude of Respondents towards Noise

The results on the attitude/beliefs (Table 4.9) revealed the proportion of the respondents from the exposed group (major noise generating areas) that agreed that the constant exposure to loud noise can result in hearing loss. This accounted for 90% at OBCHS, 80% at AGS and 88% at MGS while 96% also agreed from the control environment (AC). About 88.0% respondents from MGS and 96.0% each from OBCHS and AGS, agreed that learning in a noisy environment can lead to lack of concentration while 95% from the control group (AC) also agreed to same. Similarly, 52.0% and 70.0% of respondents from MGS, OBCHS and AGS each respectively as well as 74.7% from the control (AC) agreed that noise can cause one to become aggressive and easily annoyed. A good proportion in AC (73.4%) and MGS (70.0%) disagreed that noise would have no health effect on one if such one is able to cope with it while less proportion disagreed from OBCHS (50.0%) and AGS (56.0%). Other variables relating to attitude are shown on Table 4.9.

4.5.5 Perceptions of the Respondents towards Noisy Learning Environments

More than half of the participants in two of the studied environmental groups who were exposed to noise pollution agreed that their schooling environment was noisy [OBCHS (58.0%), AGS (52.0%)] while only 34.0% respondents from MGS agreed that their schooling environment was noisy.

Based on the noise levels generated in the schooling environments, 60% of the respondents from OBCHS and 62% each of respondents from AGS and MGS responded that they have never felt like changing their school to a school in a more quite environment. This means that they do not believe that noise from their schooling environment poses potential risk to affect their learning and health conditions when compared to other schools probably in less noisy environments. Other variables relating to perception are shown in Table 4.10.

Table 4.9: Attitude of Exposed Group and the Control towards Noisy Learning Environment

		Schools N(%)			
		Exposed Group			Control
Variable	Options	OHCHS	AGS	MGS	AC
Exposure to high noise constantly can result to hearing loss	Yes	45(90.0)	40(80.0)	44(88.0)	144(96.0)
	No	5(10.0)	10(20.0)	6(12.0)	6(4.0)
Noise can cause lack of concentration	Yes	48(96.0)	48(96.0)	44(88.0)	143(95.3)
	No	2(4.0)	2(4.0)	8(12.0)	7(4.7)
Noise can cause one to become aggressive and easily annoyed	Yes	35(70.0)	35(70.0)	26(52.0)	112(74.7)
	No	15(30.0)	15(30.0)	24(48.0)	38(25.3)
Noise can affect sleep	Yes	48(96.0)	42(84.0)	46(92.0)	147(98.0)
	No	2(4.0)	8(16.0)	4(8.0)	3(2.0)
Noise can contribute to anti-social behaviors	Yes	22(44.0)	18(36.0)	20(40.0)	60(40.0)
	No	28(56.0)	32(64.0)	30(60.0)	90(60.0)
Noise increases frequent headaches	Yes	46(92.0)	34(68.0)	48(96.0)	144(96.0)
	No	4(8.0)	6(12.0)	2(4.0)	6(4.0)
Noise has no effect if one can cope with it	Yes	25(50.0)	22(44.0)	15(30.0)	40(26.6)
	No	25(50)	28(56.0)	35(70.0)	110(73.4)

4.10: Perception among Exposed Group and the Control to Noisy Learning Environment

Variables	Options	Schools N(%)			
		Exposed Group			Control
		OBCHS	AGS	MGS	AC
Rating of learning environment	Noisy	21(42.0)	24(48.0)	17(34.0)	17(11.3)
	Not noisy	29(58.0)	26(52.0)	33(66.0)	133(88.7)
Ever felt like leaving school for another in more quiet environ.	Yes	20(40.0)	19(38.0)	19(38.0)	17(11.3)
	No	30(60.0)	31(62.0)	31(62.0)	133(88.7)
Noise in school will not allow one to learn well	Yes	25(50.0)	26(52.0)	21(42.0)	15(10.0)
	No	25(50.0)	24(48.0)	29(58.0)	135(90.0)
Noise in school will not allow one hear well	Yes	30(60.0)	28(56.0)	20(40.0)	21(14.1)
	No	20(40.0)	22(44.0)	30(60.0)	128(85.9)
Noise in school will not allow one concentrate well	Yes	32(64.0)	30(60.0)	31(62.0)	34(22.8)
	No	18(36.0)	20(40.0)	19(38.0)	115(77.2)
Noise in school will not allow one pay proper attention	Yes	29(58.0)	32(64.0)	35(70.0)	34(23.0)
	No	21(42.0)	18(36.0)	15(30.0)	114(77.0)
Noise in school will affect academic performance	Yes	17(34.0)	27(55.1)	23(46.9)	23(15.4)
	No	33(66.0)	23(46.0)	27(54.0)	127(84.6)
Noise in school will affect health generally	Yes	18(36.0)	22(44.0)	14(28.0)	25(16.9)
	No	32(64.0)	28(56.0)	36(72.0)	123(83.1)

Table 4.11: Variations in Respondents' Knowledge, Attitude and Perception in Study Locations

Varinble	Option	School Name				P-value
		OBCHS	AGS	MGS	AC	
		n=50	n=50	n=50	n=150	
Knowledge about noise	Good	44(88.0)	38(76.0)	44(88.0)	142(94.7)	
	Poor	6(12.0)	12(24.0)	6(12.0)	8(5.3)	0.087
Attitude to noise						
	Positive	38(76.0)	35(70.0)	38(76.0)	123(82.0)	0.124
	Negative	12(24.0)	15(30.0)	12(24.0)	27(18.0)	
Perception of school						
	Noisy	21(42.0)	24(48.0)	17(34.0)	17(11.3)	0.000
	Not noisy	29(58.0)	26(52.0)	33(66.0)	133(88.7)	

LeGend:
The 50th percentile of the number of questions asked was used as an indicator to ascertain those with good and bad knowledge, hence, those with scores above the median were said to have good knowledge and those with scores below the median had bad knowledge

4.5.6 Residential Characteristics

On residential noise, all the respondents enrolled in the study were those who were not residents of noisy areas or any form of hazardous noise. This was achieved by allowing the students fill out a section of the questionnaire separately prepared pertaining to their residential characteristics as well as supply full details of their residential address. The information supplied was then critically considered if they satisfied the criterion for enrollment by ensuring that on an average, each participant was not exposed to hazardous noise at home. This criterion was used to minimize the confounding variables to the study to a reasonable level. Table 4.12 shows details of the residential characteristics of the respondents.

4.5.7 Experiences and Coping Mechanisms of respondents to Noise

Most of the respondents (80% OBCHS, 62% AGS and 80% MGS) in the exposed group reported that they often experience loud noise in their school environment. Despite their exposure to noise, only few of the respondents from the exposed group agreed that their academic performances were affected badly with respect to noise. About 22% of the respondents from OBCHS, 32% from AGS and 24% from MGS reported that their current academic performance was excellent.

Only a few of the respondents from each school in the exposed group agreed that they were aggressive (easily quarrelsome) which had no significant difference when they were compared to the control (10%) ($p>0.05$). These results were similar to the responses obtained for their being aggressive before they started attending the present school under the study which means that the noise in their present school had little or no effect on them in this respect. Each response also showed no significant difference when compared to the control (14.7%) ($p>0.05$).

Only 16% of the respondents from OBCHS, 26% from AGS and 30% from MGS reported that people had to repeat themselves and often shout before they could hear them with 12% agreeing to same from the control.

Table 4.12: Residential Characteristics of the Exposed and Control Groups Related to Noise

Residential environment		Schools N(%)			
		Exposed Group			Control
		OBCHS	AGS	MGS	AC
Live in noisy residential area	Yes	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	No	50(100)	50(100)	50(100)	150(100)
Residence close to religious centre (<100m away)	Yes	6(12.0)	5(10.0)	11(22.0)	26(17.3)
	No	44(88.0)	45(90.0)	39(78.0)	124(82.7)
Residence on the major road side	Yes	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	No	50(100)	50(100)	50(100)	150(100)
Residence close to industry	Yes	0(00)	0(0.0)	0(0.0)	0(0.0)
	No	50(100)	50(100)	50(100)	150(100)
Residence close to market	Yes	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	No	50(100)	50(100)	50(100)	150(100)
Frequently exposed to loud music from neighbors	Yes	13(26.0)	5(10.0)	5(10.0)	16(10.7)
	No	37(74.0)	45(90.0)	45(90.0)	134(89.3)
Neighbours use generators	Yes	9(18.0)	12(24.0)	4(8.0)	44(29.3)
	No	41(82)	38(76.0)	46(92.0)	106(70.7)
Use generator at home.	Yes	8(16.0)	10(20.0)	14(28.0)	32(21.0)
	No	42(84.0)	40(80.0)	36(72.0)	118(78.7)

Table 4.13: Experiences and Coping Mechanisms of Exposed Group and the Control Related to Noise

		Schools N(%)			
		Exposed Group			Control
Variable	Options	OBCHS	AGS	MGS	AC
Often experience loud noise in school environment	Yes	40(80.0)	31(62.0)	40(80)	24(16.0)
	No	10(20.0)	19(38.0)	10(20.0)	126(84.0)
Easily angry and quarrelsome before schooling here	Yes	10(20.0)	11(22.0)	8(16.0)	22(14.7)
	No	40(80.0)	39(78.0)	42(84.0)	128(85.3)
Quarrel easily and frequently now in this school	Yes	8(16.0)	13(26.0)	9(18.0)	15(10.0)
	No	42(84.0)	37(74.0)	41(82.0)	135(90.0)
Have difficulty in hearing teacher clearly	Yes	4(8.0)	5(10.0)	4(8.0)	5(3.3)
	No	19(38.0)	35(70.0)	20(40.0)	111(74.0)
	Sometimes	27(54.0)	10(20.0)	26(52.0)	34(22.7)
People repeat selves and shout before you can hear	Yes	8(16.0)	(26.0)	15(30.0)	18(12.0)
	No	2(84.0)	37(74.0)	35(70.0)	132(88.0)
Have difficulty in picking specific voice in a gathering	Yes	5(10.0)	7(14.0)	6(12.0)	17(11.3)
	No	22(44.0)	25(50.0)	19(38.0)	110(73.3)
	Sometimes	23(46.0)	18(36.0)	25(50.0)	23(15.3)
Find self reading lips when talked to	Yes	9(18.0)	5(10.0)	7(14.0)	4(2.7)
	No	29(58.0)	28(56.0)	26(52.0)	125(83.3)
	Sometimes	12(24.0)	17(34.0)	17(34.0)	21(14.0)
Present academic abilities	Poor	0(0.0)	0(0.0)	0(0.0)	1(2.0)
	Fair	8(16.0)	5(10.0)	4(8.0)	14(9.3)
	Good	31(62.0)	29(58.0)	34(68.0)	71(47.3)
	Excellent	11(22.0)	16(32.0)	12(24.0)	64(42.7)

The act of reading lips which is a coping mechanism and also an attribute of not hearing well was reported by 14% of respondents from MGS with 34% doing it sometimes while the control showed 2.7% of the respondents were used to rending lips while 14% were doing it sometimes ($p<0.05$). More information on other experiences and coping mechanism with respect to noise are represented in Table 4.13.

4.5.8 Noise-Related Health Problems among Exposed Group

Table 4.14 shows the health problems suffered by the respondents in both the exposed and control groups. Most respondents reported that they hear well despite their exposure to noise in their schooling environment. Average time spent in school was similar for each school under the study with approximately 7 hours per day.

Respondents that had Tinnitus were 28% at OBCHS, 30% at AGS, 40% at MGS and 10% at AC while the proportion of respondents that suffered ear pains were 30% at OBCHS, 14% at AGS, 12% at MGS and 14.6% at AC. Headache was also reported by 80% respondents at OBCHS, 60% at AGS, 86% at MGS and 26.7% at AC. However, the proportion that reported irritability and lack of concentration were (36% and 6.1%) in OBCHS, (32% and 60%) in AGS, (44% and 66%) in MGS, and (25.3% and 36.6%) in AC. Majority of respondents from AGS (80%) and MGS (86%) reported headache as the most severe noise related non-auditory health effect compared with the control (26.7%) ($p<0.05$), while 64% respondents of OBCHS reported tiredness as the most severe noise related non-auditory health effect compared to 41.3% in the control.

More than 50% of all the respondents from the exposed group reported that they suffer lack of concentration as a result of noise and each showed significant difference when compared to the control (36.6%) ($p<0.05$). Only about 24% of respondents from MGS and 20% each from OBCHS and AGS reported that they had suffered measles in the past. These showed no significant difference when compared to the control (16%) ($p>0.05$). This means that, the history of measles among some of the respondents has no effect on the health out comes of the students exposures to noise. More information on other noise related health conditions are presented on Tables 4.14a&b.

Table 4.14a: Noise-Related Health Effects among Exposed Group and their Control as perceived

Variable	Options	Schools N(%)			
		Exposed Group			Control
		OBCHS	AGS	MGS	AC
Have difficulty with hearing well	Yes	2(4.0)	4(8.0)	6(12.0)	5(3.3)
	No	48(96.0)	46(92.0)	44(88.0)	145(96.7)
Suffered accident resulting to head injury that affected ears	Yes	1(2.0)	2(4.0)	1(2.0)	5(3.3)
	No	49(98.0)	48(96.0)	49(98.0)	145(96.7)
Presence of Tinnitus (ringing in the ear)	Yes	14(28.0)	15(30.0)	20(40.0)	16(10.7)
	No	36(72.0)	35(70.0)	30(60.0)	134(89.3)
Ear pain	Yes	15(30.0)	7(14.0)	6(12.0)	22(14.6)
	No	35(70.0)	43(86.0)	44(88.0)	128(85.3)
Headache	Yes	30(60.0)	40(80.0)	43(86.0)	40(26.7)
	No	20(40.0)	10(20.0)	7(14.0)	110(73.3)
Tiredness	Yes	32(64.0)	32(64.0)	38(76.0)	62(41.3)
	No	18(36.0)	18(36.0)	12(24.0)	88(58.7)
Inability to sleep well	Yes	18(36.0)	17(34.0)	25(50.0)	45(30.0)
	No	32(64.0)	33(66.0)	25(50.0)	105(70.0)

Table 4.14a: Noise-Related Health Effects among Exposed Group and their Control as perceived

Variable	Options	Schools N(%)			
		Exposed Group			Control
		OBCHS	AGS	MGS	AC
Have difficulty with hearing well	Yes	2(4.0)	4(8.0)	6(12.0)	5(3.3)
	No	48(96.0)	46(92.0)	44(88.0)	145(96.7)
Suffered accident resulting to head injury that affected ears	Yes	1(2.0)	2(4.0)	1(2.0)	5(3.3)
	No	49(98.0)	48(96.0)	49(98.0)	145(96.7)
Presence of Tinnitus (ringing in the ear)	Yes	14(28.0)	15(30.0)	20(40.0)	16(10.7)
	No	36(72.0)	35(70.0)	30(60.0)	134(89.3)
Ear pain	Yes	15(30.0)	7(14.0)	6(12.0)	22(14.6)
	No	35(70.0)	43(86.0)	44(88.0)	128(85.3)
Headache	Yes	30(60.0)	40(80.0)	43(86.0)	40(26.7)
	No	20(40.0)	10(20.0)	7(14.0)	110(73.3)
Tiredness	Yes	32(64.0)	32(64.0)	38(76.0)	62(41.3)
	No	18(36.0)	18(36.0)	12(24.0)	88(58.7)
Inability to sleep well	Yes	18(36.0)	17(34.0)	25(50.0)	45(30.0)
	No	32(64.0)	33(66.0)	25(50.0)	105(70.0)

Table 4.14b: Noise Related health Effects among Exposed Group and their Control Continued

Variable	Options	Schools N (%)			
		Exposed Group			Control
		OBCHS	AGS	MGS	AC
Irritability/easily annoyed	Yes	18(36.0)	16(32.0)	22(44.0)	38(25.3)
	No	32(64.0)	34(68.0)	28(56.0)	112(74.7)
Lack of concentration	Yes	32(64.0)	30(60.0)	33(66.0)	55(36.6)
	No	18(36.0)	0(40.0)	17(34.0)	95(63.3)
Poor social interaction	Yes	14(28.0)	10(20.0)	11(22.0)	23(15.3)
	No	36(72.0)	40(80.0)	39(78.0)	127(84.7)
Presently on any drug	Yes	9(18.0)	6(12.0)	7(14.0)	17(11.3)
	No	41(82.0)	44(88.0)	43(86.0)	133(88.7)
Suffered a sickness that affected hearing ability	Yes	0(0.00)	1(2.0)	3(6.0)	6(4.0)
	No	50(100)	49(98.0)	47(94.0)	144(96.0)
Have suffered from measles	Yes	10(20.0)	10(20.0)	12(24)	24(16.0)
	No	40(80.0)	40(80.0)	38(76.0)	126(84.0)
On malaria prevention drug	Yes	3(6.0)	5(10.0)	6(12.0)	10(6.7)
	No	47(94.0)	45(90.0)	44(880)	140(93.3)

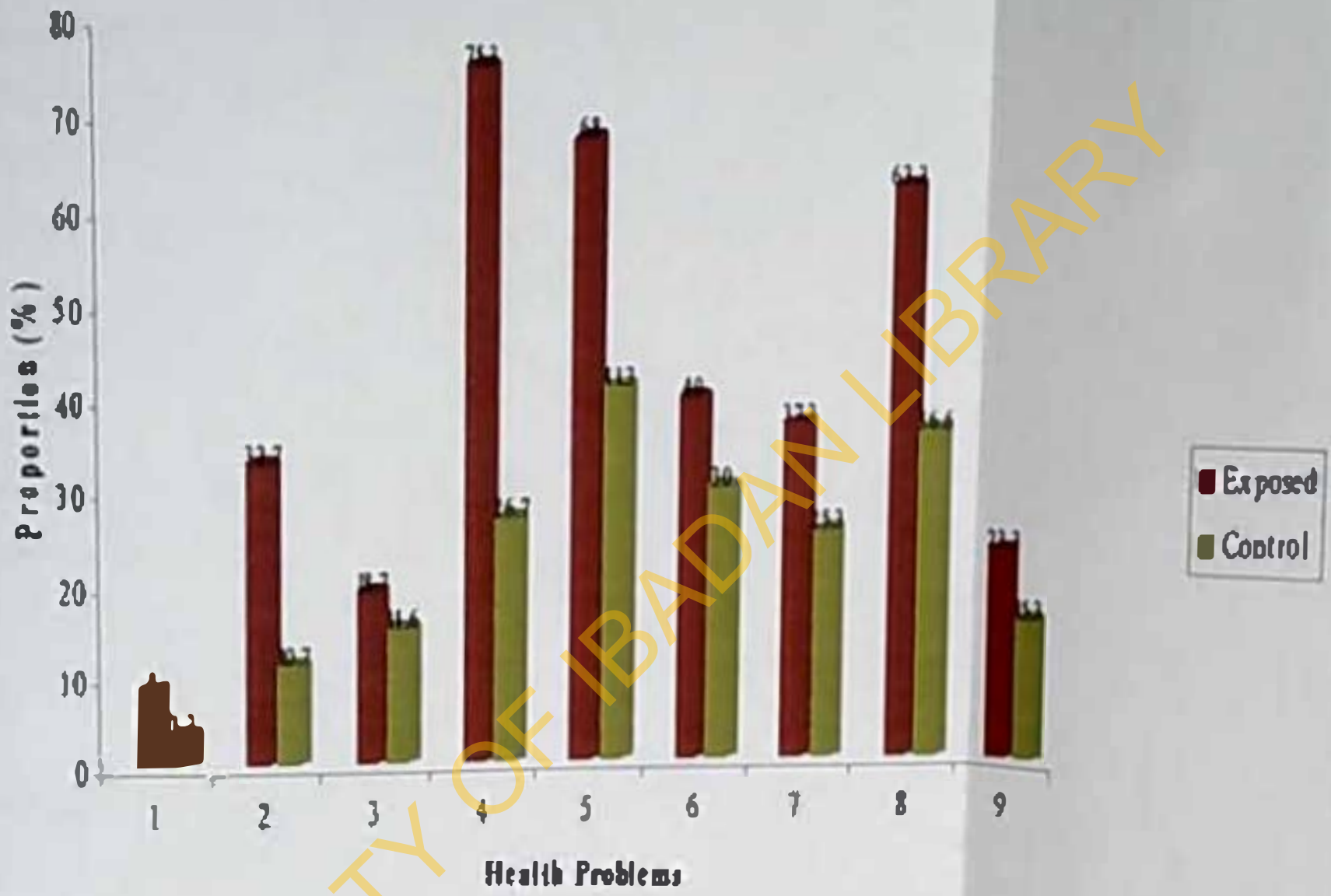

Fig 4.9: Comparison of Health conditions of Exposed and control groups

KEY:

1- Hearing loss
2- Tinnitus
3- Ear pain
4- Headaches
5- Tiredness
6- Sleep disturbance
7- Irritability
8- Lack of concentration
9- Poor social interaction

4.6 Audiometry Data

Pure tone audiometry was conducted on 60 (20%) selected participants from both the exposed and the control groups based on the number that volunteered to undergo the test. They comprised of 30 respondents from the control group and 30 from the exposed group (10 per school). Both Air Conduction (AC) und bone conduction (BC) were done. For the AC, the pure tone average was calculated over frequencies of 500, 1000, 2000, and 4000 Hz respectively. The prevalence of hearing impairment among the exposed group was 16.7% in the better ear at ≥41dBHL (moderate to profound hearing loss) while the control group recorded 0.0%. There was a significant difference between the two groups. For the specific exposed groups, AGS and MGS each revealed a hearing loss prevalence of 20.0%, OBCHS revealed a hearing loss prevalence of 10.0% and AC (the control group) revealed no case of noise induced hearing loss ($P<0.05$). The severity of hearing impairment among those affected was detected at pure tone frequencies of 4000 Hz with the overall exposure group recording 16.7% for the 4000 Hz as compared to theircontrol (0.0%) ($P<0.05$). It was observed that the higher the frequency, the poorer the level of hearing as this was more conspicuous among the overall exposure group (Figure 4.15).

The calculated mean hearing threshold for the exposed group at 4000 Hz was 2.2 times that of the control group at the same frequency and 1.7 times that of her hearing threshold at 500Hz. The mean hearing threshold value at 4000 Hz for the overall exposed Group was 25dB HTL (SD±18.6) and 13dB HTL (SD±6.4) for her controls. Better hearing thresholds were observed at the lower frequencies (Figure 4.15). Bone conduction results revealed the same pattern of hearing loss shown in AC although not as high as in AC. which suggests that the hearing impairment among the participants was sensorineural.

4.7 Audiometry Outcome and Students Perception

Out of the 60 respondents that were tested for auditory effect (30 from the exposed and 30 from the control groups). 43.3% respondents from the exposed group agreed that their schools were noisy while only 6.7% from the control group also agreed that their schooling environment was noisy. Nonetheless, the estimated risk of students perception

to noise in their school environments and hearing impairment showed no significance (P = 0.193).

Fig 4.10: Prevalence of Hearing Impairment Among specific Exposed Groups and the Control

Key:
AC = Abadina College (Academic area)-Control
OBCHS- Oke Bola Comprehensive High School (Industrial area)
MGS - Methodist Grammar School (Market area)
AGS - Anglican Grammar School (Traffic area)

Fig 4.11: Prevalence of Hearing Impairment among specific Exposed Group (OBCHS) and the Control

Key:

OBCHS= Oke Bola Comprehensive High School (Industrial area)

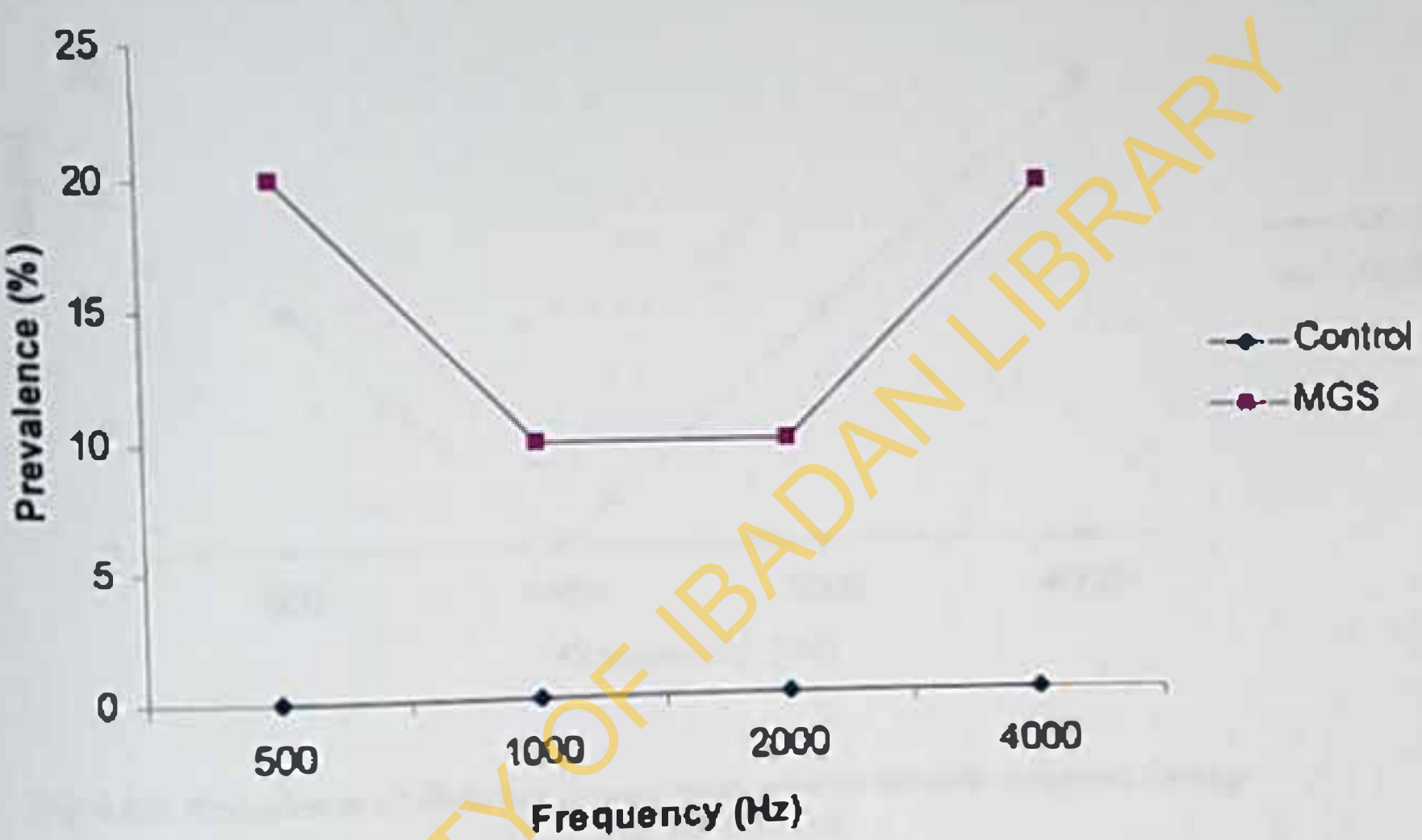

Fig 4.12: Prevalence of Hearing Impairment among specific Exposed Group (MGS) and the Control

Key:

MGS = Methodist Grammar school (Market area)

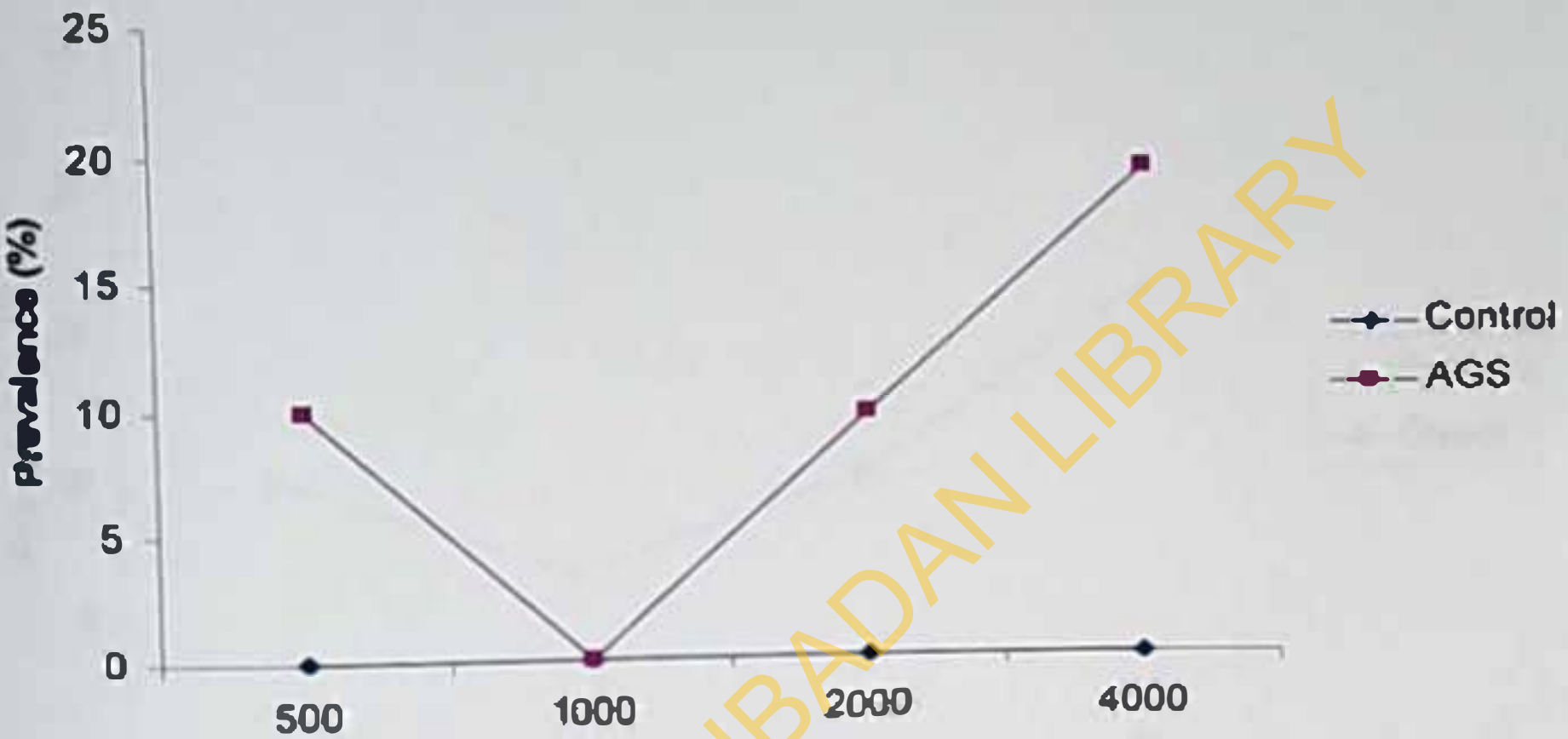

Fig 4.13: Prevalence of Hearing Impairment among specific Exposed Group (AGS) and the Control

Key:

AGS = Anglican Grammar School (Traffic area)

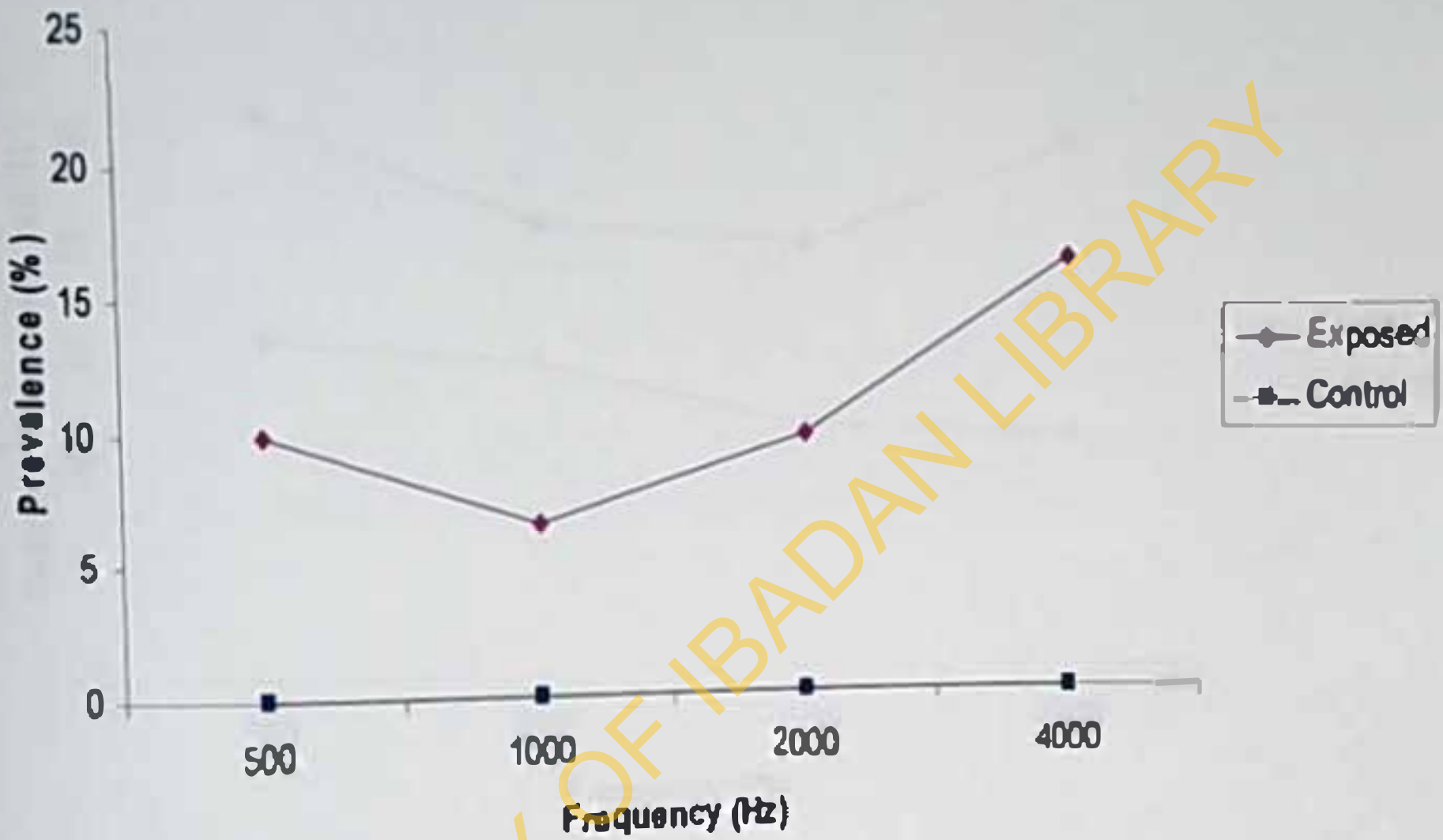

Fig 4.14: Prevalence of Hearing Impairment at different frequencies among the entire exposed Group and the Control

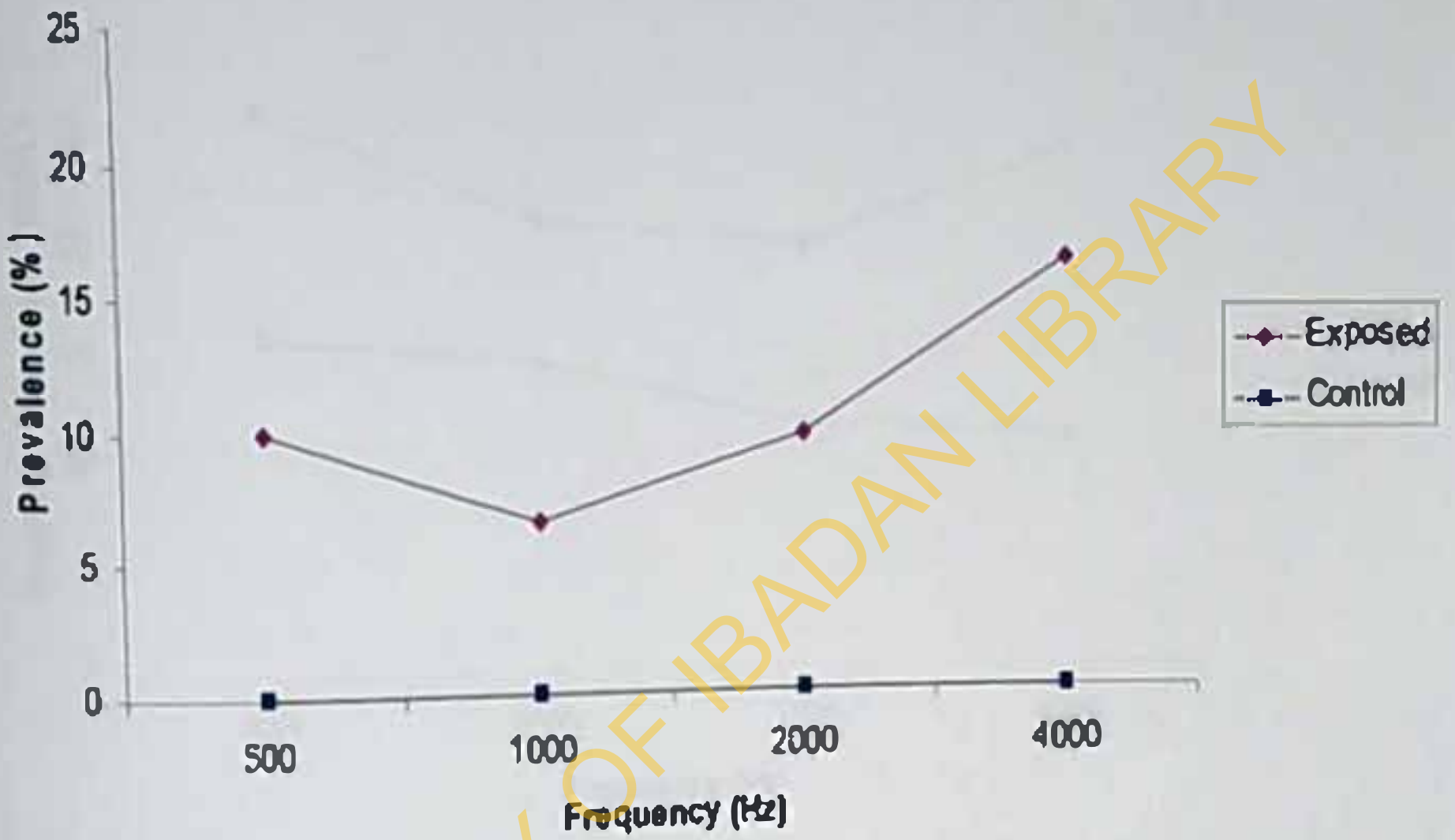

Fig 4.14: Prevalence of Hearing Impairment at different frequencies among the entire exposed Group and the Control

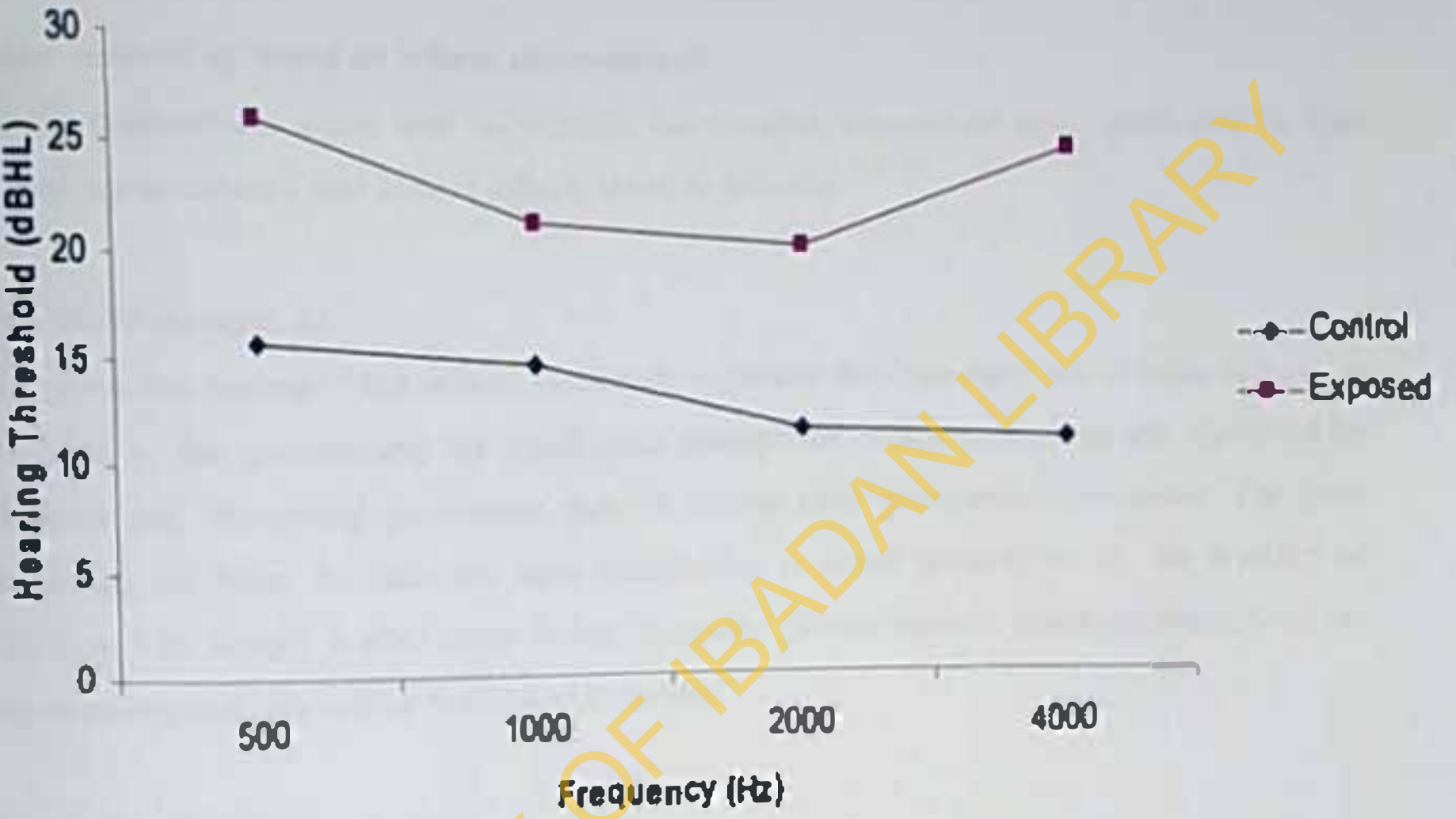

Fig 4.15: Mean hearing threshold at the test frequencies for the entire exposed and Control groups

4.8 In-depth Interview Findings

Results of In-depth interview with school principals on the assessment of noise pollution in their school environments, health complains commonly reported by their students, health effects they record that are associated with noise among others are reported below:

Major sources of noise in school environment

All the respondents were able to identify the peculiar sources of noise pollution in their school environments and how it affects them as follows:

OBCHS-Principal A:

He responded saying: "this school is directly opposite the Oyo state small scale industries provided by the government for small scale enterprises. Many a time we are disturbed by the loud and disturbing generators used to power their production processes. The road separating us from the industry also contributes to noise generation by the hooting of vehicles. The school is also close to the '*Iyagoba*' police barrack and high count, thus we are sometimes disturbed by the sound of sirens".

MGS-Principal B:

Horns blaring from vehicles especially Lorries on the *Bodija- Secretariat* road are the major sources of noise disturbing our learning environment coupled with the market positioned directly behind the school. This noise can be very disturbing and interferes with learning periods.

ACS-Principal C:

The major noise source is vehicular movement along the *Queen Elizabeth* road by vehicles coming from and going to *Mokola* or *Total Garden* which are central and busy areas, thus the road is always very busy. It becomes very disturbing when there is a mass campaign i.e. team movements, and police vans or VIPs with sirens parading the road. All these distract classes.

AC-Principal D:

Usually they do not experience any loud noise from the external environment because of the school's location which is in a quiet environment inside the University of Ibadan, and with an nppreciable distance from the main road. The only noise we experience is student's noise especially during break and closing periods.

Measures to control noise pollution in school environment

All the schools studied especially the experimental group seemed helpless and had virtually no effective control mechanism against noise pollution in their school environments.

OBCHS-Principal A:

Have no special control mechanism but have rather developed the habit of adapting to the noise. When the noise is loud enough to distract the students, we instruct the students to be attentive to their teachers. The teachers may also, occasionally have to increase the tone of their voices to be audible.

MGS-Principal B:

No control mechanism.

AGS-Principal C:

The noise actually becomes very disturbing occasionally, like when the cars blare horns close to the students class windows and sirens from police or VIPs vehicles. In such cases, they only block ears with hands until the noise fades.

AC-Principal D:

Simply caution the students to stop making noise when the classes get noisy.

Effectiveness of the control methods

The principals of the schools were unable to assess positively, the effectiveness of the control methods they employed mainly because the methods were not standard and there were no effective implementation methods.

OBCHS-Principal A: The methods are rather poor because the noise actually still disturbs.

MGS-Principal B:

Not effective, since nothing is actually done to prevent the noise.

AGS-Principal C:

The method is fairly effective, but the noise still causes a lot of distractions especially during classes.

AC-Principal D:

The method is appreciably effective.

Challenges faced in the process of noise pollution management

All the schools apart from the control group identified a common challenge which was availability of fund. They expressed that lack of funds from the part of the government prevented them from ameliorating the noise pollution they face.

Perceived health effects associated with noise pollution?

All the principals expressed good knowledge of the health effects of noise especially to students in learning environments

●BCHS-Principal A:

Noise affects speech and makes comprehension slow.

MGS-Principal B:

Noise can cause distraction, it affects attention, and can affect the students overall academic performance negatively.

AGS-Principal C:

Noise is known to cause deafness, nervousness, disturb thinking and affects our psychological feelings.

AC-Principal D:

Noise is very harmful to health. It is known to affect concentration, can cause irritation and poor performance in school work. It can also affect sleep and when too loud and over a period of time can cause deafness.

Common health complaints experienced among the students

Among the students common health complains mentioned by the principals, there were complains that suggested noise origin especially the ones common across the experimental schools and absent in the control school.

OBCHS-Principal A:

They usually complain about chest pain, headache, cough and weakness.

MGS-Principal B:

They include Headache, Tiredness and sometimes injury as a result of fighting.

AGS-Principal C:

They come usually to complain either about headache, tiredness, fever and occasionally, cold.

AC-Principal D:

Basically, it's usually Fever.

Perceived negative effect of noise on the student's academic performance

Most of the principals acknowledged that the noise generated from their school environments were capable of interfering with the student's academic performances but they were of the opinion that the effect of the noise was negligible because the students seem to be coping with it. One principal attributed this to the fact that most students are always exposed to noisy environments and have thus gotten used to it.

OBCHS-Principal A:

"Yes, I think so but I don't think it is severe. The negative impact is minimal because the students are used to regular noisy backgrounds both at home and at school and have thus adapted to this condition though not ideal."

MGS-Principal B:

"Of course it does because the best environment to learn is a serene and quiet one. The system happens to be defective but we encouraged our students to practice and read on their own not necessarily in school but after school hours in quiet environments to make up."

AGS-Principal C:

"The noise affects their concentration and most likely, their overall academic performance, but the loud noise of sirens are occasional."

AC-Principal D:

"No. The environment is basically quiet and serene."

Teachers style of teaching to make the students hear better

Majority of the principals answered in the affirmative, pointing the reason for this to the teacher's ability to control the class and noisy environments that can cloud the audibility of what the teachers are saying.

OBCHS-Principal A:

"Yes they do, especially when the school environment is noisy, and/or the students not paying rapt attention in class."

MGS-Principal B:

"They do, but not all the time. It depends on the teacher's control of the class."

AGS-Principal C:

"Not really. They are usually audible but may have to shout if the environment is uncontrollably noisy."

AC-Principal D:

"They seldom do so."

Suggestions by the principals for improving the learning environment of school children

Government interventions were pointed out as the ultimate remedy for improving the learning environments of the students. Most of the suggestions rendered by the principals were directed towards preventive practices which includes: the sitting of the school building in secure environments, government building sound proof class rooms and erecting warning sign posts to dissuade motorists from blaring their horns within the school vicinity. One principal was of the opinion that since the noise source in its school environment was from an economic industry to the state and thus can not be removed, he therefore suggested that the government should provide a nearby clinic to monitor the effect of the noise generated on the students health and that the industry should look for ways to mask their generated noise especially from generators and production machines. This would have a lesser effect on the students learning environment and the general health of the students he said

OBCHS-Principal A:

The noise generated in the school environment is from an income generating industry thus the industry can not be removed. The government should therefore, provide a clinic close by to monitor the effect of the noise generated on the students health. Also, the industry should look for ways to mask their generated noise especially from generators and

production machines. This would have a lesser effect on the students learning environment and the general health of the students.

MGS-Principal B:

The government must try to put into consideration the location of siting a school. Policy makers should be employed to ensure that schools are sited in serene and noise free environments to enable our children maximize their potentials academically.

AGS-Principal C:

The government should build sound proof classrooms to mask out noise from external sources as well as erect strict warning sign posts to warn motorist against horn blaring and stress in the school vicinity.

AC-Principal D:

The siting of a school is very important. It must be appreciably far away from every source of hazardous noise. Also, in schools located near noisy areas like busy roads, government should try to build sound proof classrooms to shield the students from such external noise interference.

The findings of the FGD showed that the school principals were all aware of the sources of noise pollution in their school environments and how it affected them. They also pointed out that they were rather helpless in the control of the loud noise they usually experience and pointed out the dare need for government intervention to curb the menance.

CHAPTER FIVE

DISCUSSION

Environmental noise, an underrated hazard in school environment has continually affected the health and academic performance of students exposed to it. This study shows that the level of noise obtained in the studied schools was capable of causing noise induced hearing impairment which agrees with the findings of Airo et al (1996) that noise level >70dBA was potential for causing hearing damage in young adults. This study has been able to obtain a reasonably reliable baseline data on the consequences of hazardous noise exposure among students in the local schools in Ibadan. This has wider application in other schools in similar areas.

5.1 Noise from Industrial Area

Noise levels from the study demonstrated that students in schools located close to industries as seen at OBCHS are exposed to noise in levels that exceed the WHO recommended limits for school environments (35 dBA). The usual range of values allowed for industrial activities is 40 - 45 dBA at night, and 50 - 55 dBA during the day, at the nearest residence or at the boundary of the premises (EPA, 1974), but further controls may be specified if there are prominent discrete tones or impulses. Much depends on the existing noise levels, the character of the area and the nature of the development.

Majority of the equipments used in the industry are heavy machines that generate a lot of noise coupled with the massive generator plants used to generate power almost through out the week because of the irregular supply of electricity. The generators in turn emit harmful gases including Nitrogen II Oxide and Carbon monoxide which are responsible for respiratory disorders. This has made the industrial site a hazard to the students learning and health. Most specifically, the industrial site was dominated by Publishers and furniture makers who use large and noisy production equipments for their production processes

along side massive generators that can power these equipments (See Appendix 5, Plate 6). The noise from the Industrial area contributed significantly to the noise related ailments recorded among the students in that area.

5.2 Noise form Traffic Area

Previous study conducted in *Agbor* Benin City, Nigeria has shown that traffic noise is the most predominant source of noise in urban areas (Onnu, 1996). This falls in line with the result of the noise level recorded from AGS (traffic area) in this study which exceeded the noise level recorded from the industrial area. Also importantly, the students are exposed to loud impact noise from blaring horns from lorries and occasional siren from convoy movement of the police or the government. WHO recommends that exposure to impact noise should not exceed 120 dBA (capable of inducing hearing impairment). The motor vehicles recorded to ply the area were found to be more in number than the motor bikes (Fig 4.8) indicating that the motor vehicles are chiefly the sources of traffic noise that constitute nuisance to the children's school environments

5.3 Noise from Market area

The noise data obtained from MGS also demonstrated that the respondents were exposed to noise level above the WHO recommended limits for learning environments (35dBA). Mean noise level recorded here (76 dBA) exceeded the result recorded from AGS and was the highest recorded of all the studied schools. This could be attributed to its dual proximity to both market and traffic noise.

5.4 Hearing Impairment among Respondents

Many epidemiological and environmental noise studies conducted in schools has shown that students exposed to noise are affected by it not only psychologically but physiologically also. Hearing impairment was appreciably noticed among the percentage of respondents that underwent the audiometric test. Even after matching and stratifying for confounders such as exposure to vibrations, ototoxic drugs and medical conditions as causes of hearing loss, the association with environmental noise was evident.

Majority of noise studies conducted in Nigeria tend to focus more on noise effects in occupational settings with little attention paid to schools (Olusanya et al., 2000). The students involved in this study show that school children especially in Ibadan are suffering from the health effects of noise including hearing impairment which is as a result of the hazardous noise they are exposed to daily in their schooling environments. This affects their overall academic performances thus preventing them from maximizing their individual potentials. The data obtained as regards the prevalence of hearing impairment (16.7 %) of the exposed group is similar to the findings of Costa. et al., (1990) which significantly differ from their control group ($p<0.05$).

For the specific exposure groups, MGS and AGS both had the highest level of hearing impairment of 20% each. This was probably enhanced in the schools by the traffic noise they were both exposed to. Traffic noise around AGS was usually high as a result of the busy nature of the road that linked the school under study as well as other schools, churches and the largest teaching hospital in West Africa, UCH. This therefore accounted for the high frequency of vehicles recorded that ply the studied road for either school runs, medical care, church service or work hence making the road very busy. The road was also found to be associated with loud impact noise (instantaneous sounds) which could be very loud and disturbing especially from sirens and horn blaring during hold-ups. In addition, a large proportion of the respondents from AGS reported that they often experience loud noise in their school environment in respect to the automobile noise. This result agrees with the WHO findings that traffic noise is the highest source of environmental noise. Similarly, MGS had a dual noise source from the market and the road adjacent to it linking the market, other schools and the University of Ibadan. This thus was considered to be responsible for the highest noise level measured compared to other schools under the study and the high prevalence of hearing impairment.

Respondents from OBCHS also had an appreciable prevalence of hearing impairment (10%). Their school location close to an industry is also a contributory factor since the industrial activities generate loud noise that are way above the WHO recommended limit (35 dBA) for school environments thus interfering with their learning processes as well as their mental and physical health.

Among the exposed group, hearing impairment was predominant at the speech frequency (4000Hz) which had a mean threshold of 25dB HTL (SD±18.6). This agrees with the findings of Nelson et al., 2005, that a typical notch (sign of noise induced hearing impairment) is seen at the 4000 Hz frequency which grows deeper and wider with continuous exposure to noise. The results for the specific exposed group at the 4000Hz frequency demonstrated that hearing loss was more at this frequency (Fig 4.11-4.13). There was significant difference from the control which also signifies that the hearing impairment is noise induced. The calculated prevalence of hearing impairment for each frequency (that is 500Hz, 1000Hz, 2000Hz and 4000Hz) plotted for the exposed group (Fig 4.14) showed a J-shaped plot with turning points at the 2000Hz and 4000Hz respectively. This means that most of the participants in the exposed group had more hearing impairment from the frequency of 2000Hz and above. This finding agrees with the findings of Satterfield, 2001, who stated that sensorineural damage results more often from noise pollution compared with bone conduction and is more pronounced at the hearing frequency. This partly explains our finding of lower frequency of hearing impairment for bone conduction.

Considering the level of environmental noise exposure and its associated effect, a very important factor to also put into consideration is the issue of duration of exposure. The mean schooling years of the students in the exposed group were similar to that of the control but the noise related effect was more predominant in the exposed group than the control. This means that the long years of schooling in very noisy environment has contributed to the effect on their hearing ability as also demonstrated by Chiang et al., 2006.

5.5 Perception of students in the exposed Group

Though the respondents all had a good knowledge and attitude towards noise and its effect, not up to half of the respondents from the entire exposed group perceived their school environment as a very noisy one capable of affecting their health generally or would want to change school for a less noisy school. In effect it means that they got used

to the noise over time and did not perceive that the condition could be better else where. This is similar to the findings of Haines et al., (2003) who reported that students tend to get used to noise as a coping mechanism over time. Contrarily, a good percentage agreed that the noise in their schooling environment would not allow them learn properly, hear what the teacher was saying, concentrate well and could also lead to distractions from their academic work. However, more than half of the respondents disagreed that the noise in their schooling environment would affect their general health such as hearing impairment. This is why they could undermine the hazard and adhere to the noisy learning environment. The control group also had a high knowledge and a positive attitude to noise with a corresponding high perception of their school as a quite environment conducive for learning. Nonetheless, there not being exposed to high noise level inevitably accounted for their not suffering from hearing impairment.

Residential noise level is another extraneous risk factor that would probably contribute to the degenerating hearing condition of the exposed group. Activities that generate noise in residential areas includes, traffic noise, religious activities, the use of generator sets, exposure to loud music and other low scale industrial activities. However, the interference of these factors with the obtained results was controlled from the inclusion/Exclusion criteria of participants that joined the study. Only those that described their residential areas as quite and supplied answers to the residential aspect of the used questionnaire that satisfied the criteria for inclusion were used for the study. Usually, it is very difficult to obtain sufficient quantitative data about the exposure to noise in the past and present conditions (Babisch and Ising, 1989; Struwe et al., 1996).
Notwithstanding, these activities are reduced during the nights.

5.6 Coping Mechanism to Noise

Most of the respondents from the exposed group agreed that they often hear loud noise from their school environment. An appreciable number (Table 4.13) also agreed that they sometimes have difficulty in picking a specific voice in a gathering, thus find themselves reading lips as a coping mechanism to the adverse effect of noise. This result is in line with the findings of Haines et al., (2003) who reported that school children device coping

mechanisms to shut out the effect of noise in their schooling environment like using their hands to block their ears to shut out loud impact noise.

5.7 Other health problems associated with noise exposure among the exposed group

Empirical studies conducted over the past 30 years have shown an explicit relationship between physical characteristics of school buildings and educational outcomes. Therefore, it is imperative to access the optimal physical environment of the schools to ensure that they comply with an ideal school environment and are conducive for the children's mental and emotional balance. This has a significant role to play in ensuring that each child is provided with the opportunity to maximize his/her potentials academically. All the studied schools were sited close to major sources of noise. Furthermore, the buildings had cracked walls, broken ceilings and windows which expose the students to noise besides other hazards from the different noise sources in degrees relative to their individual proximities to the schools.

Notably, noise control facilities listed including; absorbers, reflectors and alternators were absent in all the schools studied. The absence of noise control measures in all the schools could also be responsible for the severities of these problems especially in schools exposed to loud and persistent traffic, generators and heavy production machines that generate related environmental noise. The impact of noise on children's health and development in schools imposes a considerable financial burden, which could be greatly reduced if noise concerns were taken into consideration as early as possible when a school is being planned.

Noise is not only a risk factor to the development of hearing disability but also a factor to other health conditions such as tinnitus. This study has been able to show that an appreciable proportion of students in the exposed group, suffer silently from tinnitus (ringing in the ear) which is a first recognizable indicator of hearing damage in this case. Headache, tiredness and Lack of concentration are also serious complains reported by a large majority of the respondents which are due to noise induced stress as a result of it's frequency and intensity resulting in frustration to sieve it out and concentrate. This agrees with the findings by Hockrell and Shield, (2002) that children are aware of environmental noises but their own reported levels of environmental noise and the effect are related to objective observations of the noise.

Noise levels in the children schooling environment obviously contributed significantly to the decline in the physical and psychological status of the respondents. Nonetheless, another angle not always focused on is the area of nutritional status of students, which may also be an additive factor. Henderson et al. (2006) revealed that a high noise level induces the generation of reactive oxygen species in the inner ear which interferes with the regenerative process. Now, in retrospect considering their poor perception to noise in their schooling environment, despite their high knowledge as regards the consequences of noise, the need to consume adequately, the foods that are rich in antioxidants (vitamins C and E) may be far fetched. The study shows that a lot of work is to be done by both the government and individuals in the combating of the great hazards posed by noise in and around school environments and to achieve serenity for learning processes to be maximized especially in Ibadan.

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CHAPTER SIX

Conclusions and Recommendations

6.1 Conclusions

As the population grows with development, there is increasing exposure to noise pollution, which has profound public health implications. Noise pollution creates a need for action at the local level, as well as for improved legislation and management. Urban noise pollution produces direct and cumulative adverse health effects by degrading residential, social, working, and learning environments with corresponding real (economic) and intangible (well-being) losses.

Children are our future and leaders of tomorrow. As the nation strives towards achieving adequate health care for the populace, the schools and learning environments must not be neglected.

The outcome of the study revealed that noise levels measured indoor (classroom) and outdoor (corridor, playground and gate side) for all the schools were higher than WHO permissible levels for school environment (35dBA) making it hazardous to their health and learning. An appreciable percentage (16.7%) of the exposed group suffered from hearing impairment ranging from 10% to 20% across the studied exposed group, the impact of the noise was mostly greatest at the speech frequency (4000Hz). The most reported health problems associated with exposure to noise within the school environment were Headache, Tiredness and Lack of concentration.

Poor perception of the respondents to the noisy conditions of their schooling environment contributed to the prevalence of these health effects. The greatest contribution to this menace was the lack of noise control facilities in the schools by the school authorities

The result from this study shows that a good number of schools in Ibadan are faced with noise levels that exceed the WHO recommended limits hence, presenting a harsh and unconducive environment for children to learn in, which ultimately exposes them to the risk of hearing loss. The impact of noise on children's health and development in schools is of major public health concern. This could be greatly reduced if noise problems were taken into consideration as early as possible when a school is being designed. In summary, children are indeed influenced by the presence of environmental noise. These findings suggest that schools should be located in areas that are as noise-free as possible.

6.2 Recommendations

In relation to the results obtained from this study, appropriate recommendations are those that put into consideration the socio-cultural setting. Research has revealed that noise has multiple effects on school children including noise induced hearing loss which is presently incurable and irreversible. However, it could be prevented. Therefore noise conservation programme is recommended for schools. This programme can not be done in isolation but should be an integral part of the school curriculum and criteria for siting schools. For this programme to be actualized, some enabling processes must be put in place.

1. Financial resource is highly needed
2. A sound political will should be enunched and all decisions should involve all and sundry
3. The government should enact and enforce a ban on the use of pressure horns
4. Environmental and occupational hygienists should be involved for technical knowledge and experience to enhance the running of the programme which requires great expertise.
5. School buildings should be located as far as possible from noise source. The noise level drops about 6dB each time the distance is doubled.
6. Trees and shrubs may be planted in front of school premises to provide some absorption of sound.
7. Vegetation buffer zones must be created in different parts of the city. Efforts should be made for roadside plantations

8. The awareness of the harmful effect of noise pollution should be created among students of all levels through their curriculum
9. A regular sound monitoring should be carried out to ensure the effectiveness of these measures
10. As part of the school and industrial control, the use of barriers in the work site and the school environment, absorbers, reflectors and alternators would be very effective in the reduction of noise.
11. Clinics should be incorporated in the schools to maintain regular and flexible check ups of the students and most importantly, audiometric testing should be a basic component which should be carried out periodically.
12. Intake of recommended daily allowance of antioxidants is necessary for the students as research has shown that they counter the biochemical anomaly resulting from noise exposure.
13. The noise exposure limit capable of inducing hearing loss (85 dBA) by WHO should be reduced to 75 dBA as we can observe from this study and most recent studies carried out on noise level less than the recommended exposure limit still recorded hearing impairment. Therefore, developing countries like Nigeria still using 90dB(A) as their permissible exposure limit according to FEPA guidelines of 1991 should be restructured.
14. The Power Holding Company of Nigeria (PHCN) should improve in the county to reduce the use of generating sets which generates loud noise that pollutes the environment.
15. All kind of commercial activities including market, both small and large scale industries as well as high ways must not be sighted around schools.
16. Government should build sound proof class rooms for schools to mask noise effect.
17. Warning sign posts should be erected in school areas to dissuade motorist from blaring their horns within the school vicinity.
18. As present, there is no specific and detailed legislation to control noise pollution in Nigeria. However, there is an urgent need for the Government to get a legislation passed for the control of noise pollution. Existing ordinances and laws should also be enforced.

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APPENDIX I

ENVIRONMENTAL HEALTH SURVEY

QUESTIONNAIRE ON DETERMINATION OF NOISE LEVELS, PERCEPTION AND AUDITORY EFFECT AMONG STUDENTS IN SELECTED PUBLIC SECONDARY SCHOOLS IN IBADAN, NIGERIA.

Dear Respondent,

I am a postgraduate student of the Department of Epidemiology, Medical Statistics and Environmental Health (EMSEH), College of Medicine, University of Ibadan. I am presently carrying out a study whose objective is to assess students' perception and the perceived health effects of environmental noise around selected government secondary schools in Ibadan. Findings from this study will help in the formulation of strategies aimed at making our schools more environmental-friendly with minimal noise levels. Please be informed that participation is voluntary. I wish to inform you that there are no right or wrong answers to the questions. Please, be rest assured that all information provided by you would be used for research purposes only and strict confidentiality would be ensured. No name is required in filling the questionnaire. Please try and give honest responses to the questions as much as possible. You are free to ask questions were you are not clear.

Thanks for your co-operation.

Brown, G.E.

FOR OFFICE USE ONLY

SERIAL NUMBER_____

INSTRUCTION: PLEASE TICK (√) ANSWERS WHERE APPROPRIATE

SECTION A: SOCIO – DEMOGRAPHIC INFORMATION

1. Age of respondent (last birthday). ----------
2. Sex: 1. Male---- 2. Female ----
3. Religion: 1. Christianity---- 2. Islam---- 3. Traditional----
   4. Others (specify) _____
4. Ethnic group: 1. Yoruba ------ 2. Hausa------ 3. Ibo-------
   4. Others (please specify) _____
5. Class of respondent: 1. Senior secondary (SS) 1----
   2. SS2----
   3. SS3----
6. School location _____
7. Area of residence _____

SECTION B: SCHOOLING INFORMATION

8. What year were you admitted into this school? _____
9. Do you enjoy your school environment? 1. Yes ---- 2. No ----
10. If "No". Why? _____

11. What time do you usually get to school? ----------

12. What time do you usually close from school? ----------

SECTION C: KNOWLEDGE ABOUT NOISE

13. Which of the following explains what noise is? 1. Any loud and disturbing sound------ 2. Any sound that we can hear------ 3. Any sound that others can hear---------- 4. Don't know----------
14. Do you think noise is harmful to people's health? 1. Yes---- 2. No----
15. Which of the following problem(s) in the table below can noise cause?

PROBLEMS	Tick √	
	Yes	No
a. Affect academic performance		
b. Deafness		
c. Blindness		
d. Annoyance		
e. Loss of sleep		
f. Malaria		

16. Which other health problem (s) not listed in the table above can noise also cause for people? _____

SECTION D: ATTITUDE TOWARDS NOISY LEARNING ENVIRONMENT

Instruction: For each statement, please indicate by ticking (√) whether you Strongly Agree (SA), Agree (A), Not Sure (NS), Disagree (D), or Strongly Disagree (SD).

SNo	Statement	SA	A	NS	D	SD
17	Any student who is constantly exposed to high noise levels could develop hearing loss					
18	High noise levels can cause lack of concentration					
19	Students who are exposed to constant high level noise can become aggressive/easily annoyed					
20	Noise can cause people not to be able to sleep well					
21	Exposure to high noise level does not in any way contribute to anti- social behaviours					
22	High noise levels increases frequent headaches					
23	High noise levels can not have any health effect on one if he/she can cope with it.					

SECTION E: PERCEPTIONS OF NOISY LEARNING ENVIRONMENT

24. How do you rate your learning environment? 1. Extremely noisy-------

2. Fairly noisy-------- 3. Fairly quiet------- 4. Extremely quiet---------

25. If your learning environment is noisy, are you affected by it?
1. Yes ----- 2. No-----

26. If you are affected by the noise in your learning environment, in what way?

_____

_____

27. Have you at any time felt like leaving this school to another school that is in a more quiet environment? 1. Yes------- 2. No-------

Based on the location of your school and the noise generated around your school environment, do you see your school as one that:

		Tick √	
		Yes	**No**
28.	Will not allow one to learn well		
29.	Will not allow one to hear well		
30.	Will not allow one to concentrate well		
31.	Will not allow one to pay proper attention		
32.	Will affect your academic performance		
33.	Will affect your health generally		

34. How do you feel generally about the noise level in or around your school environment? ----------

---

SECTION F: EXPERIENCES AND COPING MECHANISMS RELATING TO NOISE POLLUTION

35. Do you often experience loud noise in your school environment?
1. Yes ---------- 2. No---------

36. If yes, what is the major source(s) of noise in your school environment?
1. Busy market -------- 2. Automobiles--------
3. Industries-------- 4. Others (specify) _____

37. Before you started schooling here, do you easily get angry and quarrel at any slightest misunderstanding with people around you?
1. Yes---------- 2. No----------

38. Now, that you are in this school, do you pick quarrels easily and frequently with your colleagues? 1. Yes-------- 2. No--------

39. Do you find it difficult to hear clearly when your teacher is teaching?
1. Yes------- 2. No------- 3. Sometimes--------

40. If yes or sometimes, why? ----------

---

41. Do people have to repeat themselves and shout often even at a close range before you hear and understand them?
1. Yes------- 2. No-------

42. In a gathering, do you find it difficult to differentiate or pick out a specific voice talking to you? 1. Yes----- 2. No----- 3. Sometimes-------

43. Do you find yourself knowingly or unknowingly reading lips when people talk to you?
1. Yes ------- 2. No -------- 3. Sometimes---------

44. Comparing your previous and present academic abilities in school, how would you describe your academic performance?
1. Poor -----
2. fair -----
3. good -----
4. excellent -----

SECTION G: RESIDENTIAL ENVIRONMENT

		Yes	No	Don't know
45.	Is your residential area noisy?			
46.	Is your house very close to any religious centre?			
47.	Is your house very close to a busy road?			
48.	Is your house very close to a manufacturing industry?			
49.	Is your house very close to a busy market?			
50.	Do your neighbours frequently play loud music?			
51.	Do your neighbours usually use generators?			
52.	Do you use generators in your house?			

53. If question 51 is YES, how often----------

SECTION H: HEALTH CONDITIONS

54. Did you have hearing problem before you enrolled into this school?
1. Yes---- 2. No----

55. Do you have difficulty with hearing now? 1. Yes ------ 2. NO------

56. How often do you go for hearing check-ups?
1. Once in 6 months -------- 2. Once a year ---------
3. I never go for check- ups----------
4. Others (please specify) ----------

57. Have you at any time suffered from measles? 1. Yes--------- 2. No ----------

58. If yes, what year? ----------

59. Have you ever been involved in an accident and sustained severe head injury that affected your ears? 1. Yes ----- 2. NO-----

60. Have you ever suffered from any of the following health conditions in the table below?

	Noise related health problems	Yes	No
a.	Tinnitus (ringing in the ear)		
b.	Ear pains		
c.	Headaches		
d.	Tiredness		
e.	Inability to Sleep well		
f.	Irritability/ Easily annoyed		
g.	Lack of concentration/forgetfulness		
h.	Aggressive/rude response to situations		
i.	Poor helping behavior.		
j.	Poor social interaction/not friendly		

61. Are you presently on any drug? 1. Yes------ 2. No------
62. If "Yes" please name the drug _____

63. Have you ever had any sickness that affected your hearing ability?
1. Yes ------- 2. No--------
64. If 'YES' please state which sickness ----------
65. Have you ever visited any hospital because of hearing problems?
1. Yes ------- 2. No------
66. If "Yes" when? _____
67. How do you manage your hearing related problem?
1. Self medication ------ 2. Clinic ------ 3. Traditional---- 4. None----
5. I don't have ear problem----------
68. Are you on any malaria prevention drug? 1. Yes---- 2. No--------
69. If yes which one and how long have you been on it? _____

70. Please state any other health problem that you may be experiencing._____

APPENDIX 2

INFORMED CONSENT FORM

My name is **BROWN, GENEVA EVALEE** a Masters student of Public Health with speciality in Environmental Health in the Department of Epidemiology, Medical Statistics and Environmental Health (EMSEH), Faculty of Public Health, College of Medicine, University of Ibadan.

We are currently carrying out a research on the perceived health impact of noise on specific school settings in Ibadan, of which, yours is one of them. I'll be required to ask you some questions contained in a structured questionnaire. Be rest assured that your answers will be kept strictly confidential.

A number will be assigned to you and your name will not be written on the form and will never be used in connection with any information disclosed to us. This information provided by you and others will improve the quality of the findings which would be used to suggest to Opinion leaders, Policy makers, Government and Non- Governmental Organizations to assist in providing quality healthcare services for you so as to optimize your learning ability and ensure a conducive learning environment.

As part of the exercise, audiometric test will be performed on you, but **blood or any tissue sample would not be collected.** All the processes involved will not cause you any injury.

However, if you decide to withdraw at any particular point in time you are very free to do so but we would be grateful if you participate fully and willingly.

Consent: Now that the study has been well explained to me and I fully understand the content of the study process and have obtained permission from my parents/guardian, I will be willing to take part in the study.

.....

Signature/Thumbprint of participant/Date

.....

Signature of Interviewer / Date

.....

Signature/Thumbprint of Witness/ Date (If required)

APPENDIX 3

IN-DEPTH INTERVIEW GUIDE FOR SCHOOL PRINCIPALS

TOPIC: DETERMINATION OF NOISE LEVELS, PERCEPTION AND AUDITORY EFFECT AMONG STUDENTS IN SELECTED PUBLIC SECONDARY SCHOOLS IN IBADAN, NIGERIA.

Introduction

Good day Sir/Ma, I am grateful that you spared your valuable time for this interview. My name is Brown, Geneva Evalee. I would appreciate your full cooperation in this interview. This interview is part of a research work that intends to find out some vital information on the noise levels and its associated effects among students in selected government secondary schools in Ibadan.

Please Sir/Ma, you are free to express your views on any issue pertinent to the questions during this session.

Thanks for your anticipated cooperation.

INTERVIEW

1. What are the major sources of noise pollution in your school environment?
2. What measures do you use to control noise pollution in your school environment?
3. How effective are the control methods?
4. What challenges do you face in the process of noise pollution management?
5. What health effects do you know that are associated with noise pollution?
6. What common health complains are experienced/reported among the students of this school?
7. Do you think the noise level in this school environment has an effect on the students' academic performance?
8. Do the teachers have to shout while delivering lectures before the students can hear?
9. What suggestions do you have for improving the learning environment of school children with respect to noise?

APPENDIX 4

OBSERVATIONAL CHECK LIST FOR ASSESMENT OF SCHOOL PREMISIS

ID NO-----

NAME OF SCHOOL-----

LOCATION-----

NUMBER OF STUDENTS-----

AVERAGE NUMBER OF STUDENTS PER CLASS-----

NUMBER OF STAFF (Teaching/ Non-teaching) -----/-----

YEAR ESTABLISHED-----

TYPE OF SCHOOL-----

ARMS-----

Vegetation	Absent	Present and functional	Present and Non functional	Remarks

	RANKING				
Overall building structures	Very good (5)	Good (4)	Fair (3)	Poor (2)	Very poor (1)
Walls					
Floor					
Roof/Ceiling					
Doors/Windows					

Noise control facility	Absent	Present and functional	Present and non functional	Remarks
Absorbers				
Reflectors				
Attenuators				

Location of school	Yes	No	Remark
Market area			
Major main road			
Industrial area			
Serene area			

School distance from noise source	Yes	No	Remarks
<10m			
<50m			
<100m			
<200m			
>200m			

Frequency of noise generated from school environment	Yes	No	Remarks
Intermittent			
Continuous			

Appendix 5

Ceiling condition of studied schools

Window pattern of classrooms

Automobile Traffic around studied school environments

Major Market in close proximity to studied school

Industrial area close to studied school environment

Large noisy production Equipment and Exhaust pipes from Generator house in Industry emitting noise and harmful gases in school area