ASSESSMENT OF NOISE POLLUTION AND ITS EFFECTS ON HUMAN HEALTH IN AIZAWL CITY, MIZORAM

by

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CERTIFICATE

This is to certify that Miss Lalremruati Ralte has submitted the Ph.D Thesis entitled **"Assessment of Noise Pollution and Its Effects on Human Health in Aizawl City, Mizoram"** under my supervision**,** for the requirement of the award of the Degree of Doctor of Philosophy in the Department of Environmental Science, Mizoram University, Aizawl. The authenticity and content of the thesis is the original work of the Research Scholar, and the nature and presentation of the work are the first of its kind in Mizoram. It is further certified that no portion(s) or part(s) of the content of the thesis is borrowed from any other resources nor reproduced from any other publications.

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DECLARATION

I, **Miss. Lalremruati Ralte**, hereby declare that the subject matter of this thesis entitled **"Assessment of Noise Pollution and Its Effects on Human Health in Aizawl City, Mizoram"** is the record of work done by me. The contents of the thesis does not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the award of the degree of Doctor of Philosophy in the Department of Environmental Science.

(LALREMRUATI RALTE)

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List of abbreviations

%	:	Percentage
>	:	Greater than
<	:	Less than
a.m	:	ante-meridian (before noon)
BBC	:	British Broadcasting Corporation
CPCB	:	Central Pollution Control Board
CrPC	:	Code of Criminal Procedure
CTRN	:	Calculation of Road Traffic Noise
C.W.P	:	Civil Writ Petition
dB	:	Decibel
dBA	:	A-weighted Decibel
dBHL	:	Decibels Hearing Level
DOE	:	Department of Environment
et al.	:	and others
HSS	:	Higher Secondary School
Hz	:	Hertz
i.e.,	:	that is

kH_Z	:	Kilo-Hertz
LCD	:	Liquid Crystal Display
Ldn	:	Day-Night Average Sound Level
Leq	:	Equivalent Continuous Sound Level
Lmax	:	Maximum Sound Level
Lmin	:	Minimum Sound Level
MPCB	:	Mizoram Pollution Control Board
MRI	:	Magnetic Resonance Imaging
MZU	:	Mizoram University
NH	:	National Highway
NIHL	:	Noise Induced Hearing Loss
NIPTS	:	Noise Induced Permanent Threshold Shift
NITTS	:	Noise Induced Temporary Threshold Shift
p.m	:	post-meridian (after noon)
PSIL	:	Preferred Speech Interference Levels
SEL	:	Sound Exposure Level
SPL	:	Sound Pressure Level
SPSS	:	Statistical Package for Social Sciences
SLM	:	Sound Level Meter

TTS	:	Temporary Threshold Shift
USEPA	:	United States Environment Protection Agency
WHO	:	World Health Organisation

INTRODUCTION CHAPTER - I

1.1 General

The population of the world is increasing at a fast growth rate that contributes to high level of pollution in the environment. Pollution means, "the presence of undesirable substance in any segment of environment, primarily due to human activity discharging by-products, waste products or harmful secondary products, which are harmful to man and other organisms" (Santra, 2001).

Environmental Pollution is now considered as a global phenomenon, which attracts the attention of human beings for its severe long term consequences. There is an increasing trend in environmental pollution and the state of the environment continues to deteriorate. The present environmental pollution problems are universal both in the developed as well as developing countries. All these problems are resulting as a consequence of rapid growth of population, excessive exploitation of natural resources, urbanization and industrialization (Singh and Dev, 2010). Such activities, although desirable for human development and welfare, lead to generation and release of objectionable materials into the environment thus turning it foul, and rendering our life miserable. The pollution not only contaminates the environment but ultimately affects human health and efficiency. Environmental pollutants not only have local implications but also worldwide impact. Like other environmental pollutants, the effects noise is also worldwide.

The word 'noise' is derived from the Latin word "Nausea" meaning sea sickness. The definition of noise itself is highly subjective. To some people the roar of an engine is satisfying or thrilling; to others it is an annoyance. What is considered noise by one listener may be considered desirable by another. Burns (1973) and White (1975) showed that sound that might be enjoyable to some people may be

intolerable to others, depending upon a person's interests, activity and mood. It has been possible to assess impurities in the air quantitatively, or to decide, which water have been polluted as of biological demand. But not so in case of noise pollution, different people are affected differently when they are at home, and when they are outside or at work (Mahandiyan, 2006). For example, a sweet melody of morning may be irritating to those who still want to be in bed, whereas a loud noise of music may be joyful to those who are a part of a dancing party in the club. Broadly speaking, any form of unwelcome sound is noise pollution, whether it is the roar of a jet plain overheard or the sound of a barking dog, a block away.

A large number of psychologists have defined the term noise. According to Kiely (1997) noise is defined as unwanted sound, consequently it can be considered as the wrong sound in the wrong place at the wrong time. In legal terms, noise can be considered as an assault on an individual (Kumar *et al*., 2004).

According to Singal (2005) noise is just any sound undesired by the recipient and may adversely affect the health and well-being of individuals or population.

Noise can also be defined as an unwanted sound, a potential hazard to health and as a communication dumped into the environment with regard to the adverse effect it may have on unwilling ears (Vanadeep and Krishnaiah, 2011). Noise can also be defined as any sound which produces an undesired effect or is unwanted (Bistrup, 2001).

In the context of the medical literature, noise can be defined as extremely intense sound capable of producing damage to the inner ear (Suskovic, 2012).

Webster defines noise as “a sound that lacks agreeable musical quality or is noticeably loud, harsh or discordant”.

Singh (1991) defined noise pollution as, "the state of discomfort and restlessness caused to humans by unwanted high intensity sound known or simply means the unwanted sound dumped into the atmosphere leading to health hazards".

Sound is an important part of man's contact with the environment and has served as a critical means for survival in evolution. Sounds around us can arouse reactions of fear or delight, influence our nervous system and also serve as a source of enjoyment (Rylander, 2006).

Sound is a form of energy which is generally measured in definite unit called '*Hertz (Hz)'* (Khopkar, 2004). It is a special type of pressure wave, which is usually transmitted through air (also through solids and liquids but with very low intensity) and is received by the receiving mechanism, the hearing apparatus (ear). The speed of sound waves depends upon the density and elasticity of the transmitting medium such as gas (air), liquid and solids (Singh, 1991). The environmental sound is in the region of 20 Hz to 20,000 Hz. Sound waves consist of variations in pressure or oscillations of the medium in which they travel. High-pressure sound or high intensity sound termed as 'unwanted sound' is called NOISE, which causes discomfort to human beings and interferes with their efficiency (Santra, 2001).

Sound does not need necessarily to be loud to annoy any person. A creaking floor, a scratch on a record, amplified music or a dripping tap, though may be quiet low in intensity, can cause as much irritation as loud thunder (Craik and Stirling, 1986).

The intensity of sound is measured in units called decibels (dB). The threshold of hearing is 0 dB and threshold of pain is 130 dB. Speech runs 65 to 70 dB. The loudest sound that a person can hear without discomfort is about 80dB (Saxena, 1999).

During the early years of the 20th century, the first noise measuring instrument was invented, qualitative estimate of some of the noise sources (aeroplane) began, and the first careful studies in sound absorption, sound insulation and sound propagation were carried out.

Like air pollution and water pollution, noise is recognized today as a major pollutant of the environment. It is no less a pollutant than the toxic chemicals in our environment, but is studied less. There are different sources of noise pollution. The sources of noise pollution are divided into three main categories, such as:

1) *Natural sources* – Some natural activities produce noise, which disturbs the human existence in many ways. Though this source of environmental noise is unavoidable and inevitable, yet its health hazards may be reduced by way of protection (Mahandiyan, 2006). Some of the natural activities responsible to cause noise are cloud thunder, high velocity wind such as hurricanes, gales, thunder storms, earthquake, high intensity rainfall, hail storms, heavy waterfalls, surf currents etc.

2) *Biological sources* – Sounds of varying intensities of wild and tame animals such as roars of lions in circus cages. Street dogs are perpetual sources of noise pollution in rural areas. Man also creates different types of sounds and noise such as during laughing, crying, singing, weeping, quarreling etc.

3) *Artificial sources* – Artificial sources include noise created by man through his activities and creations such as musical instruments, industries, automobiles, aircrafts, railways, construction, social noise, factories, loudspeakers, domestic appliances etc.

Noise pollution leaves no residue in the body, therefore, it is difficult to measure its cumulative effects or distinguish noise impacts from other similar stressors (Schmidt, 2005).

The effects of noise pollution on human are generally of four types:

1) General effects: General effects of noise on human include speech interference, annoyance, sleep interference and related after effects and problems (Singh, 1991). Speech interference simply means non-audibility of speech to a particular person due to loud community noise. Speech reception is the most important and also the most complex use of the auditory system. Noise can either mask the speech to make it inaudible or by making only some frequencies leaving it audible but of reduced intelligibility (Vijayalakshmi, 2003). WHO statistics points out that around 5 percent of the children in developing countries suffer from varying degree of communication interference. This is because of the noisy environment in most of the institutions (Agarwal, 2005).

Sounds of all types cause annoyance and irritation in most of the people. The annoyance caused by high intensity sound sometimes causes mental imbalances. Neurotic people are more sensitive to noise than balanced people, which express great annoyance with even low level of noise as crowd, highway, radio, etc. (Agarwal, 2005). Noise reduces the depth and quality of sleep and thereby adversely affects the overall mental and physical health. In addition, night time noise greater than 40 dBA has been suggested to potentially lead to sleep interference (WHO, 2009). Low frequency noise of even 50 to 60 dBA may affect the higher centers of brain, and cause an alteration of normal sleep pattern and prevent deep sleep (Agarwal, 2005).

2) Auditory effects: Auditory effects include damages done to hearing mechanism in human due to various types of noise. The human ear is a very sensitive instrument. If the hearing mechanisms are damaged in any way either by excessive noise levels or by diseases which affect the brain, the auditory nerve or the auditory ossicles, then hearing will be impaired (Vijayalakshmi, 2003). The effects of high intensity noise on human beings are represented by threshold of hearing – 0 dBA, threshold of pain –

120 dBA, pain in ear – 140 dBA, damage in ear drum – 160 dBA (Vasudevan, 2006). Auditory fatigue appears in the 90 dBA and may be associated with side effects as whistling and buzzing in ears. Deafness can be caused due to continuous noise exposure. Permanent loss of hearing occurs at 100 dBA (Singh, 1991). If hearing loss remains undetected, it may lead to impairment of an individual's ability to function. Hearing deafness depends upon three factors: i) the level of noise ii) the pressure and frequency of sound waves; and iii) the period of exposure to noise every day (Mahandiyan, 2006).

3) Psychological effects: High-level noise causes many behavioral changes among humans as well as animals. Unwanted noise very often causes annoyance, irritation, and fatigue, which results into, low performance, low efficiency and frequent errors. Noise produces negative after-effects on performance, particularly in children. Cognitive development is impaired when homes or schools are near sources of noise such as highways and airports (Lee and Fleming, 2002). Further, high frequency of high level noise and exposure of human beings for long period to such high level noise may cause tension in muscles, nervous irritability and strain and neurotic mental disorder.

Symptoms of tiredness are one of the consequences of noise pollution, and in people doing mental work there may be a considerable deterioration in efficiency or even a complete loss of the ability to do work. In noisy environment for longer duration, they become more fatigued, make more errors and lead to lowered efficiency that may result into reduced output, increased absenteeism and higher rate of accidents and injuries (Agarwal, 2005).

4) Physiological effects: Annoyance, irritation, anxiety, strain and stresses caused by noise pollution may cause changes in hormone content of blood which in turn may introduce changes in human bodies. Berglund *et al*. (1999) reported the noise level 55 dBA is sufficient to cause serious annoyance in outdoor environment. Noise pollution of various sorts caused by varying level of noise may cause high blood pressure, heart diseases, dilation of pupils of the eyes, tensing of the voluntary and involuntary muscles, diminution of gastric secretion, neuromuscular tension, nervousness, stomach and intestinal diseases such as ulcer etc. Lung damage occurs at 190 dBA (Vasudevan, 2006). Sudden very high-level noise caused by sonic booms or explosion may lead to termination of pregnancy in early stages. Data from older studies suggest that it is possible that when pregnant women are exposed to high levels of aircraft noise (Ldn > 62 dBA), small reductions in birth weight occur (Wu *et al*., 1996). Many cases of congenital defects in newly born babies have been reported in the areas, which are generally closed to high noise region. Prolonged chronic noise can also produce stomach ulcers as it may reduce the flow of gastric juice and change its acidity. Children from noisy areas have been found to have heightened sympathetic arousal indicated by increased levels of stress-related hormones and elevated resting and blood pressure (Bronzaft, 2000).

Noise pollution affects not only human health, but also affects other living creatures and even the non-living beings. Other effects of noise pollution can be described as follows:

1) *Effects of noise pollution on plants and animals:*

Noise pollution caused by traffic and machinery is recognised as a significant human health problem, with noise levels likely to increase in the future. Effects on specific species of animals and plants are also known. While some species avoid

noisy areas, possibly because noise interferes with communication or their ability to find prey, others may seek refuge in noisy areas because there is a lack of predators or competing species. A study on the effects of noise pollution from natural gas wells in the US reveals that it may have reduced the number of young trees growing locally by changing the types of animals that visit the area. However, in the same woodland environment, flowering plants pollinated by hummingbirds seem to benefit from the noise (Francis *et al*., 2012).

Noise also has various adverse effects on wildlife. There is decline in migratory birds to a habitat if it becomes noisy. Studies of songbird behaviour and ecology near oil and gas development found a significant reduction in pairing success, bird density, and bird species diversity caused by noise (Habib *et al*., 2007 and Bayne *et al*., 2008).

Psychological and environmental consequences of noise could be serious to the survival of wildlife. They may affect their food habits, health, and mating behavior. Animals rely on hearing to avoid predators, obtain food, and communicate. Auditory systems of some animals are particularly at risk to physical damage from chronic noise, for example desert animals that have evolved an acute sense of hearing. Studies have documented hearing loss caused from motorcycle noise in the desert Iguana (Bondello, 1976) and the kangaroo rat, an endangered species (Bondello and Brattstrom, 1979).

2) *Effects of noise on non-living things:*

The high intensity of noise, such as vibrations emanating from heavy machinery causes shattering of window glasses, loosening the plaster of house walls, cracks in walls, cracks in household crockery and breaking down the hanging in the house. Sometimes it may even cause the shattering of the foundation of the buildings.

Sometimes fast moving jet planes and heavy vehicles plied on public roads, damage building structures. The noise may also cause depreciation of the residential property located nearby airports, highways, industrial areas and other noise prone places.

Noise was considered a pollutant even in the earlier historical times. In the days of Julius Ceasar, clattering of chariots on the cobble stone streets of Rome was identified as noise pollution. Martial (one of the generals of Julius Ceasar) complained that the noise on the streets at night sometimes sounded as though the whole of Rome was travelling through his bedroom (Embleton, 1977). Complaints about the nuisance of noise become more frequent during the 19^{th} century. Many of the prominent learned people wrote that noise disturbed their concentration and other activities. For example, in the 1820s, Schopenhauer, the German philosopher, wrote an essay on noise (Durant, 1962). He complained in particular of the noise of cracking whips and made an observation that people of great intellect were being disturbed by noise. In 1871 and 1889, the weekly journal edited by Charles Dickens featured two articles on noise. Charles Dickens also organized a petition to British Parliament in London complaining of noise produced by the street musicians (Singal, 2005).

In urban localities all over the world, noise pollution has been recognized as a major factor affecting public health and well-being. It is an ever growing nuisance. Noise in big cities is considered by the World Health Organization to be the third most hazardous type of pollution, right after air and water pollution (WHO, 2005). Man-made sources are mainly responsible for increasing the ambient noise level in urban localities. Automobiles, industrial units, low flying aircraft and loudspeakers have been recognized as a major source of noise affecting a large number of peoples.

Noise pollution is different from other types of pollutions. The hazardous consequences of air pollution and water pollution are easy to see but noise pollution does not leave much evidence that can be seen and identified immediately. It, however, leaves lasting effects, some short, and some long on our body mechanism and metabolism (Gupta, 1999). The worrisome effects of noise are dangerous enough that noise problem is considered next to crime by certain countries (Kapoor and Singh, 1995). Noise affects us in many ways. It damages hearing, disrupts our sleep and annoys us in our everyday lives. It interferes with conversation, concentration, relaxation and leisure (Chiras, 2006). Thickly populated, poverty stricken third world countries are however, the most affected ones, wherein the ill effects of noise pollution are rarely given serious attention (Asthana and Asthana, 1999). The U.S. Census Bureau reports that noise is the number one complaint people have about their neighborhoods, and the major reason why they wish to move. The Census Bureau's "Surveys of Neighborhoods Problems, "conducted over the past three decades, has consistently placed noise among the top four issues of concern (Kerwin, 2012).

Noise problems and complaints increased dramatically by the end of 19th century and beginning of the 20th century as US and European societies became more urbanized and mechanized. With time, the problem of noise was taken up both socially and politically and legislative and control measures were introduced to reduced noise pollution (Hay, 1975 and 1982).

The introduction of the first noise standards date back to the early 50s. In the 60s and 70s, numerous noise standards were introduced in many countries of the world as also by International Standards Organization. In the 70s, many countries adopted rather effective laws on noise control, which became useful in noise abatement at work.

1.2 Noise as an Environmental Problem in India:

Noise pollution is a significant problem not only in developed country, but also all over the world, and India is one of the developing countries that is experiencing and producing high level of noise pollution. In the past thirty years, noise in all areas, especially in urban areas, has been increasing rapidly. There are numerous effects on the human environment due to the increase in noise pollution. Big cities in India are suffering from noise pollution because of phenomenal growth in automobiles and other noise pollutants consequent upon unchecked growth of urban population. Most of the big cities in India have high level of noise pollution; generally above 70 dB (Shrivastava, 2004). Sources of noise pollution include inter alia, vehicular traffic, neighbourhood, electrical appliances, TV and music system, public address systems, railway and air traffic, and generating sets. Most of the people inhabiting metropolitan cities or big towns and those working in factories are susceptible to the adverse effects of noise. Characteristically, it affects the rich and the poor alike. The problem of noise pollution is less in small towns and villages. But, those residing in villages/towns along the national/state highways or close to railway tracks do bear the burn of excessive noise. The number of motor vehicles in India has grown from about 54 million in 2001 to more than 141 million in 2011(The Red Book, 2013). Indiscriminate use of horn by the vehicles and widespread use of loud speakers in Indian social and religious ceremonies cause several health hazards to the urban inhabitants (Singh and Davar, 2004). Another major factor contributing to the noise pollution in India is that in many of the cities, the industrial and commercial units are either not very far from the residential areas, or they are sometimes set up in the residential areas.

Noise pollution continues to grow, accompanied by an increasing number of complaints from affected individuals. It is an urban territorial serious phenomenon. Noise health effects are the health consequences of elevated sound levels. Increased traffic noise and the wider spread of a 24 hour society have contributed to rising complaints about disturbance and annoyance caused by noise.

Through the promulgation of the comprehensive Environment (Protection) Act in 1986, India also recognized rules on the maximum limits of concentration of environmental pollutants including noise. Earlier to this act, noise pollution figured in the Indian Penal Code (1860), Motor Vehicle's Act (1939), Industries Act (1951), Air Act (1981) and in some of the state legislation; however the problem of noise pollution was a continued source of inconvenience to the people, since it was vaguely defined in the acts and no standards/limits of noise pollution were defined in specific terms. In 1999, Ministry of Environment and Forests, Govt. of India published draft rules for noise pollution, specifying the standards/limits for noise pollution in different category, and in the next year the Government notified the Noise Pollution (Regulation and Control) Rules, 2000.

The standards recommended by the Environment Protection Rules, 1986 and Noise Pollution (Regulation and Control) Rules, 2000 is shown in the following table:

Table 1.1: Noise standard recommended by Environment Protection Rules, 1986 and Noise Pollution (Regulation and Control) Rules, 2000

Area Code	Category of Zone	Limits in dBA (Leq)	
		Day Time	Night Time
A	Industrial zone	75	70
B	Commercial zone	65	55
C	Residential zone	55	45
D	Silence zone	50	40

Day time shall mean from 6:00 a.m to 10:00 p.m

Night time shall mean from 10:00 p.m to 6:00 a.m

1.3 Noise Pollution in Mizoram:

Mizoram, as compared to other states, is rather fortunate in terms of pollution problems. But now, those days are gone due to various reasons. Because of the increase in population, workshop/factory, vehicles and other manmade activities, Aizawl city, the state capital of Mizoram has started facing pollution problems and becomes noisier as compared to the last decade.

Nowadays in Aizawl city, noise pollution is more severe and widespread than ever before. We are all the time surrounded by artificial noises in the streets, markets, schools and even inside our own homes. But among the masses of people, there is little or no conscience concerning noises. No action has been taken to control noise pollution emanating out of different sources except banning of crackers burning during Christmas and New Year. The whole Mizoram used to celebrate Christmas and New Year with great splendour. Like most part of the world, fireworks and

crackers used to be a part and parcel of this celebration. The noise level during these times used to be very high, sometimes reaching up to 100 dBA. But a complete change took place in the year 2009 when the government of Mizoram announced a complete ban on fireworks and crackers. The prohibition has been a complete success since then and now virtually not a sound of crackers or fireworks can be heard during these times of the year. The noise level during 31st December, 2011 and 1st January, 2012 was 46.3 dBA during day time and 36.7 dBA during night time and was within the national standard (MPCB, 2012).

1.4 Objectives:

The major objectives of the proposed study are as follows:

1. To quantify noise intensity in different selected sites of Aizawl city.

2. To compare the results with the standards laid by Environment Protection Rules, 1986 and The Noise Pollution (Regulation and Control) Rules, 2000.

3. To assess the effects of noise pollution on human health in the study sites.

4. To formulate appropriate strategy for control of noise pollution.

REVIEW OF LITERATURE CHAPTER - II

Noise is one of the most widespread environmental pollutants because of increasing human activities concentrated in towns and cities affecting the human efficiency and health. Noise pollution causes a number of adverse effects on human beings ranging from mild annoyance to permanent loss of hearing. The effects of noise are difficult to quantify because tolerance levels among different populace and types of noise vary considerably. There is a large amount of scientific literature assessing the effects of noise on human beings. Today, one of the most important calamities in urban life is unwanted, meaningless and unmusical sound, which is technically called noise pollution (Malakootian, 2001).

It has been observed that hearing loss due to noise dates back from the Bronze Age (Hinchcliffe, 1967). Weber *et al.* (1967), in their study have analysed the history of hearing loss found in the 10,000 populations of the Colorado city. The audiogram showed that in 3.4% of the population, there was a sudden drop in hearing level of 15 dB or more between 2-4 kHz, while hearing loss at and below 2 kHz did not exceed 10 dB. No specific cause was found to be associated with this noise induced hearing loss. It could possibly be associated with shooting, fire crackers, explosions and/or the operations of farm implements. The percentage of hearing loss was maximum (6%) in areas with big game hunting. Walden *et al.* (1975) reported that significant hearing loss in 20-30% of the personnel working in the combat branch of US army takes place with two or more years of service. Studies also show that about half of the soldiers in America who complete combat training suffer so much hearing loss that they no longer meet the enlistment requirements for combat units (Chiras, 2006).

Burns and Robinson (1970) have pointed out that sound levels in excess of 165 dB SPL even for short durations are likely to cause cochlear damage. Exposure to

high intensity noise produced by rock and roll and other music also shows that considerable threshold shift is produced due to these exposures (WHO, 1980). According to study carried out by (Kowalkzuk, 1967) audiograms of pop musicians have been seen to show typical hearing loss in both the ears. Fletcher (1972) has reported that men and women who are exposed to over amplified music are equally at risk of hearing damage. Fearn and Hanson (1984) found a statistically significant hearing loss in the group that admitted frequent attendance to pop music entertainment. A study of Canadian military band showed that many players had a hearing loss, even though the band played for only 1hour/day (Agarwal, 2005).

According to Ward (1986), the primary effect of noise is to increase hearing thresholds, i.e. to make hearing poor. Exposure to extremely intense noise may cause an immediate permanent hearing loss (acoustic trauma), and in contrast, exposure to less intense noise may cause the gradual development of hearing damage. During each exposure to noise, say, a person enters a very noisy area for a short time, he may experience a temporary loss in hearing sensitivity if a test is performed immediately after the exposure (the standard interval of time is 2 minutes). This hearing loss is just temporary, called the Temporary Threshold Shift (TTS), since the ear has a tendency to recover in due course of time after the subject return to a quiet environment. This type of temporary shift in hearing threshold is named as Noise Induced Temporary Threshold Shift (NITTS) in the language of audiometry. However, if the exposure is high enough or if the exposures are repeated in quick succession, the TTS may not recover completely, and Noise Induced Permanent Threshold Shift (NIPTS) begins to develop. Both continuous noise and impulse noise can be responsible for hearing loss.

Axelsson and Hamernik (1987) have presented two examples of permanent hearing loss due to a single exposure to an exploding fire cracker. In one case, a

unilateral loss of 40 dB at 4 kHz was found for a cracker exploding at a distance of 1m from the ear; in the other case, a bilateral loss of 60 dB at 4 kHz in one ear and 25 dB in the other ear was found for a cracker exploding close to the ear.

Globally, over 120 million people are estimated to have disabling hearing difficulties. In the USA during 1990 about 30million people were exposed to a daily occupational noise level above 85 dB, compared with more than 9 million people in 1981, these people mostly in the production and manufacturing industries. In Germany and other developed countries as many as 4-5 million, that is 12-15% of all employed people are exposed to noise level 85 dB or more. In Germany, an acquired noise related hearing impairment that results in 20% or more reduction in earning ability is compensate-able. In 1993 nearly 12500 such new cases were registered (*http://www.who.int*). From the study carried out in the industries around Sivas it was specified that the noise levels detected in all the industries are much above the 80 dBA that is specified in the regulations: 73.83% of the workers in these industries are disturbed from the noise in their workplaces, 60.96% of them have complaints about their nervous situations, 30.96% of these workers are suffering hearing problems (Atmaca *et al.,* 2005).

Besides affecting the hearing mechanism, noise pollution causes a number of effects on human health. In biochemical studies of man, it has been established that excretion of hormones of epinephrine, morepinephrine and corticosteroids increases when the human system is subjected to stress. Human subjected to noise stress of 90 dB at 2000 Hz for 70 minutes were seen to excrete epinephrine and morepinephrine in higher quantities than under normal conditions (Welch and Welch 1970). In another study, humans exposed to 40-60 dBA noise level for a few hours every day for several days, were seen to excrete 17 hydroxy corticosteroids and moradrenalin in

significantly increased quantities (Osada *et al.,* 1973). According to studies carried out in Japan, it has been found that at high level of sounds (85 to 120 dB) the gastric juice in stomach and salivary secretions are decrease resulting in upsetting of digestive system.

Lukas (1972) observed that women are more sensitive to noise during sleep than men and that middle aged women were particularly sensitive to sub sonic jet aircraft flyovers and simulated sonic booms. Dobbs (1972) also observed that sleep of children and young person's was less affected by noise than that of middle aged or older people. On the other hand, Thiessen (1978) while experimenting on sleep disturbance due to truck noise of 65 dBA observed that young and old people had nearly the same response while middle-aged subjects only were more sensitive.

It has been reported that symptoms of mental disorder were more common among those who were very annoyed by noise exposure (Tarnopolsky *et al.,* 1978).

Pregnant women may be at risk when they are exposed to high noise level; and higher rates of birth defects may happen in babies whose mothers live near airports (Sides, 1985).

It has been reported that traffic is one of the major sources of noise (Skanberg and Ohsrom, 2002). The road traffic noise levels reported for 22 sites in Lahore by Ahmad (1992 and 1994) show that in Lahore city traffic noise levels vary in the range of 74 - 90 dB (A) and average values in the range of 77 - 85 dB (A) and traffic noise level at these sites fluctuates in the range of 3 - 11 dB (A), which is unimaginable.

Bond (1996) reported that 16% of people in Europe are exposed to 40 dB or more of traffic noise in their bedrooms at night compares it with W.H.O's average estimates of 30 to 35 dB for undisrupted sleep.

A study carried out by Zannin *et al.* (2002) concluded that the city of Curitiba, one of the most populated cities in Brazil, and considered as a model of urban development in the third world, is environmentally noise polluted. About 93.3% of the locations measured in this study show during the day equivalent sound levels over 65 dB(A), the limit for preventive medicine. Over forty percent (40.3%) of the locations measured show during the day extremely high values of equivalent sound levels over, 75 dB (A). The findings of the social survey showed that traffic noise was the major source of annoyance for the citizens.

In the study dealing with urban noise pollution conducted by Calixto *et al.* (2003), 73% pointed to traffic as the main noise source among all the respondents who felt annoyed by the noise generated in streets. An investigation reported by Piccolo *et al.* (2004) indicated that main roads of Messina, Italy are overloaded by traffic flow during daytime and that more than 25% of the residents are highly disturbed by road traffic noise.

It has been concluded in a study conducted by Georgiadou *et al.* (2004) in Thessaloniki, Greece, that there is a significant correlation between traffic noise and mean traffic volume. In addition, the mean daily values; Leq are close to the national limit of 67 dB (A). The measurements showed that Thessaloniki experiences a problem with noise level, which, given the annual average increase in traffic volume of 6% during the past decade, might get worse.

The result of the study carried out by Islam *et al.* (2004) shows that in Lahore, the levels of road traffic noise vary in the range of 60.4 - 97.3 dB (A), with LA99, LA90, LA50, LA10 and LA1 in the range of 63.1 - 66.3, 68.3 - 74.1, 74.8 - 82.4, 84.3 - 87.5 and 89.6 - 94.1dB (A), respectively and estimated LAeq8h values 82.4 - 85.4 dB (A). The evaluated PSIL are found to be in the range of 58.3 - 77.5 dB for about

80% of the daytime. The results show that the LA90 values of noise levels at these survey sites exceed 68.3 dB (A), which are above the maximum permissible noise levels recommended for community annoyance in the urban residential areas. The LA50, LA10 and evaluated LAeq 8 h values at these sides exceed 78.8, 87.5 and 82.4 dB (A), respectively, indicating that traffic noise levels in Lahore city are excessively high and much above the limits recommended for community annoyance and may result in adverse effects on roadside traders and dwellers, who are constantly exposed to such a high level non-occupational noise for a long duration.

It has also been found that the noise level in the streets of Rio-de-Janeiro, the most chaotic city, often hit 120 dB (Agarwal, 2005).

Measurements of traffic noise levels in Muscat city carried out by Al-Harthy and Al-Jabri (2006) indicated higher noise levels than those set by the Omani noise standard of 65 dB(A) for residential areas.

A survey carried out in the UK has estimated that 14% of the adult population was bothered by neighbourhood noise, compared with 11% from road traffic noise, and 7% bothered by aircraft noise (Mahandiyan, 2006).

A survey of the traffic noise level in Lahore city carried out during Nov-Feb 2004 has also shown that the average noise level was found to cross the permissible limits of 85 dBA (Aftab *et al.*, 2007).

Very high environmental noise levels due to traffic of vehicles were observed during the study conducted by Murthy *et al*. (2007) causing disturbance and even some health problems. Headache, bad temper, hearing problem, loss of concentration were some of the significant effects manifested by noise pollution. 92% of students reported that their studying was disrupted by frequent air-horns of vehicles.

A study carried out by Aslam *et al*. (2008) reveals that Public transport drivers are exposed to excess noise on roads in Lahore city. About 75% of them are suffering from NIHL and 10% have disabling hearing impairment.

From the study conducted by Shobaki and Jamrah (2008), it was found out that Zarqa and Irbid cities are environmentally noise polluted due to the rapid and widespread introduction of mechanical methods for production of goods and equipment and for their transportation. The results of the investigation showed that the measured noise levels from all the selected sources were high during the day time and night time, and the noise problem is not only limited to day time, but continues in night time in these cities, and a sound at night may be more annoying than that heard during the day. And these noise levels were higher than those set by Jordanian limits during day time and night time. The results of the social survey revealed that the exposure to high noise levels will affect the people in terms of annoyance depending mainly on the individuals, sleep disturbances, effect on the ability to work, loss of concentration, and will affect the health and cause hearing problems.

The results of the study conducted in Kerman, Iran established the fact that noise level in the city of Kerman is more than the acceptable limit of 60 dBA, which is the daytime governmentally prescribed noise limit for residential-commercial areas. The results of the interview questionnaire revealed the that the main isolated noise source was traffic and street noise, 86% and 86.8% of the subjects answered that traffic noise produce physical and psychological annoyance to them. The main outcomes of exposure to noise were: irritability, insomnia, difficulty in concentrating and conservation disruption (Mohammadi, 2009).

Even the hospitals are not free from noise. Too many patients and visitors contribute to the noise. Most of the hospitals are situated along the roadside, where

heavy traffic passes on. The hospital generators, air conditioners, flooding toilets and diagnostic machines make their own contributions to make the noise level high. The London Free Press in Ontario, Canada reports that researchers at the University of Western Ontario undertaken a study to reduce noise from Magnetic Resonance Imaging (MRI) machines. MRI is extremely effective in detecting many diseases by using radio waves and magnetic fields. However, the machine contains a magnet, whose gradient coil generates significant amounts of vibration and noise. The noise is bothersome and possibly damaging, to both patients and technicians. If MRI noise is reduced, it can be used to diagnose problems of the inner ear. Currently, MRI machines are unable to make images of the inner ear, because the noises from the MRI machines cause the inner ear to vibrate and move (London Free Press, 2000).

Investigations in USA, Britain and Russia have revealed that noise pollution not only affects directly the hearing mechanism of animals including human beings but also tells upon their overall health. It hinders bodily efficiency by causing mental upset, insomnia and irritability leading to palpitation of the heart, rise in blood pressure and general debility (Gupta, 2006).

From the study carried out by Dursun and Ozdemir (2006) in Konya city in Turkey, it was found out that threshold level of 65 dBA was exceeded at all the region measured. Noise source factors were mainly transportation vehicle, architectural faults, usage of the non-isolated materials in the construction, vehicle horns and music, conditioning systems of some industrial work yards, machine stroke noise, on the other hand project or faulty material for road surface noise can also be included in noise source.

The City of Amman, Jordan, has been subjected to persistent increase in road traffic due to overall increase in prosperity, fast development and expansion of

economy, travel and tourism. Jamrah *et al*. (2006) investigates traffic noise pollution in Amman. The results of the investigation showed that the minimum and the maximum noise levels are 46 dB(A) and 81 dB(A) during day-time and 58 dB(A) and 71 dB(A) during night-time. The measured noise level exceeded the 62 dB(A) acceptable limit at most of the locations. CTRN prediction model was successful in predicting noise levels at most of the locations chosen for this investigation, with more accurate predictions for night-time measurements.

High noise levels on the streets were observed throughout the city of Tokat, Turkey from the report of Ozer *et al.* (2009). At fifty of sixty-five measurement points (76.9%), noise values exceeded 65 dB(A), limit value according to Turkish noise control regulation, while at fifteen points (23.1%) this value was under the limit value. Statistical analysis revealed that, there were significant differences in noise levels among the streets ($P < 0.05$). The results showed that noise should be mentioned among the major environmental problems and studies aim at preventing it should have great priority.

Oyedepo and Saadu (2009) carried out a study in Ilorin Metropolis, Nigeria. The results show that Industrial areas have the highest noise pollution levels (110.2 dBA) followed by busy roads/Road junctions (91.5 dBA), Passengers loading parks (87.8 dBA) and Commercial areas (84.4 dBA). The noise pollution levels in Ilorin metropolis exceeded the recommended level by WHO at 34 of 47 measuring points. It can be concluded that the city is environmentally noise polluted and road traffic and industrial machineries are the major sources of it.

Evaluation and analysis of noise pollution levels has been carried out by Sisman and Unver (2011) in Corlu, Turkey to determine the level of noise. The selected areas of study are commercial centers, road junctions/busy roads, passenger

loading parks and public parks. Measurements of noise were carried out in the morning, in the midday and in the evening. The results of this study show that the noise levels in Corlu exceeded 65 dB(A), limit value according to Turkish Noise Control Regulation allowed values at 17 of 18 measurements points. Statistical analysis revealed that, there were significant differences in noise levels among the streets ($P < 0.05$).The results of the study showed that noise should be mentioned among the major environmental problems in Corlu.

Essandoh and Armah (2011) also carried out study to evaluate the noise pollution levels in Kotokuraba commercial area of Cape Coast, Ghana. The focus was on five selected areas as commercial centers, road junctions/busy roads, passengers loading parks, high-density residential areas, and low density residential areas and found that the transportation is the main cause of noise pollution.

From the study carried out by Abiodun *et al.* (2011) in Lagos Metropolis it was found out that the mean noise level recorded for the various locations fall below the recommended noise level specified by Federal Ministry of Environment (F.E.P.A., 1991). However, at Idumota Commercial Centre (ICC) and Ikeja Domestic Airport (IDA) the recorded mean noise level is very close to the recommended level.

Results of the study conducted by Patrick and Babatope (2013) showed that Obantoko residents are in constant exposure of generator noise which results in adverse health effect of the habitants which includes hearing impairment, interference with spoken communication, sleep disturbances, cardiovascular disturbances, impaired task performance and negative social behaviour and annoyance reactions.

Airport noise is another source of noise pollution in big cities. In Sydney there has been 100,000 noise complaints a year, most of which relate to noisy neighbours. In March 2000, the *Daily Telegraph* reported that Sydenham, near Sydney's

Kingsford Smith Airport, experiences some of Australia's worst noise pollution. Recently, the noise from a Boeing 747 flying over the suburb was recorded as 106 dB, the equivalent of standing in front of a loud rock band *(http://www.who.int).*

Results obtained by Franssen *et al*. (2002) indicated that exposure to aircraft noise of Amsterdam Airport affected the health status of the population living around the airport in terms of annoyance, sleep disturbances, cardiovascular diseases and reduced performance.

Aircraft noise like noise from locomotives and industrial mills in the early twentieth century, was considered a sound of progress and development of technology, but as time advanced particularly with the introduction of turbo-jet technology in the early 1950's, the noise generated from the aircrafts is considered responsible to pollute our environment to a large extent. Community objection to aircraft noise became strong for the first time in UK during early 1960's, particularly by those people who lived either near the airport or below the flight path (Singal, 2005).

In the last decades, noise levels have risen tremendously in major cities all over the world, especially in the developing countries, including cities of the South East Asia countries. The increase of modern conveniences in the densely populated cities brought with it a lot of noise. The cumulative effect of traffic, factories, audio equipment, cell phones, airplanes, are all adding to unwanted noise to the city's environment (*www.soundhearing2030.org*).

The noise level in Bangkok streets is one of the worst in the world; there are complaints of jet planes and industries that produce loud and disturbing noise. In most of the streets in Bangkok the noise level was observed to be over 90 dB

(Maxwell, 1972). During 1996-2000, Pollution Control Department monitors both ambient and roadside noise levels of Bangkok. 6 monitoring stations along the major roads recorded that 24-hr average noise level exceeded the ambient noise level of the 70 dBA standard in which noise levels ranged from 73.9-79.7 dBA. These noise levels could affect the long term hearing of those living nearby. Day-Night Average Sound Level (Ldn) could cause severe discomfort to 40-70% of the population living nearby. It is obvious that the major source of noise pollution is traffic; the other sources are construction activities and industry. The noise level from boats during rush hour (6.00-10.00 a.m.) along the canal sides is about 10 decibel higher than the normal level. Such high noise level causes a great annoyance to people who live nearby the canals (Bangkok State of the Environment, 2001).

Juang *et al.* (2010) found out that the average sound levels measured in three Hospitals in Taiwan during daytime were higher than the environmental daytime noise limit of 50-dB requirement in Taiwan, and certainly surpass the USEPA guideline value of 45 dB at daytime. It was concluded that noise pollution inside and outside the wards either directly or indirectly affects, in a simultaneous manner, the subjective perception of noise, emotions, physiology and experience of noise inside and outside the wards of both the medical care staff and the patients and visitors.

From the study carried out by Yusoff and Ishak (2005) in Malaysia, result of the Leq versus days of the week for Sunway Residential area in relation to the Government and Department of Environment, DOE's guidelines, clearly show that the noise levels in the study area exceed DOE's guidelines on a daily basis. It was reported that cars are the major contributor to noise pollution.

In Hong Kong, over 6,000 noise complaints were made during 2012, second only to the more than 13,000 complaints about air pollution. A joint survey by the

Environmental Protection Department and Chinese University found that about 11 per cent and 8 per cent of the Hong Kong adult population felt "highly annoyed" by renovation noise and traffic noise respectively, the latter being the primary cause of sleep disturbance *(http://www.scmp.com)*.

Shanghai's local environmental protection departments receive an average of 100,000 complaints about noise pollution every year, accounting for roughly 48 per cent of all environmental pollution complaints (China Daily, 2012).

In India, the problem of noise pollution is wide spread. It has been found recently that 90 to 110 million people are bothered by environmental noise pollution every day and approximately 50 million are adversely affected in terms of health in India (Gupta, 2006). In 1976 the Government of India had included the noise–induced hearing loss as a notifiable disease under the Factories Act, 1948. Big cities are much more afflicted with noise pollution than the smaller ones. Several studies reported that noise level in metropolitan cities exceeds specified standard limits.

Indian Council of Medical Research (1983) has also reported a collaborative study on prevalence and aetiology of hearing impairment over the cities of Kolkata, Delhi, Madras and Trivandrum. A total number of 11,665 persons in the rural and 10,935 individuals in the urban areas were examined. The prevalence of hearing impairment was found to be 10.7% in the rural and 6.8% in the urban populations. Disorder of hearing showed an increasing trend with advancing age with a marked increase after 60 years of age. Up to 35 years of age, hearing impairment was more of the conductive type. Those exposed for over ten years to high noise levels due to working or residing in the neighbourhood of certain noisy industries, showed higher prevalence of hearing impairment.

Gupta and Vishwakarma (1989) have studied hearing threshold levels of 600 people (200 in the age group 3-8 years, 200 in the age group 9-15 years, 100 in the age group 6-21 years and 100 in the age group 22-31years) before and after Deepawali festival in India. The noise level was reported in the range 130-190 dB (mean 150 dB) at a distance of 3m from the cracker burst site. Two days after the festival, 3.8% of all subjects showed hearing loss primarily at 4 kHz. After 3 months the percentage of subjects with mean hearing loss of 29 dB at 4 kHz were 3, 3, 2 and 1 in the respective age groups. This hearing loss due to exposure to fire crackers during one single festival was categorised as permanent in nature wherein 1.2% of the subjects in the two lower age groups suffered hearing loss.

Results of an audiometric survey conducted at Mine-P, a limestone and dolomite quarry situated around Rourkela, Orissa shows that there is an increase in the average hearing threshold levels of mine workers in relation to their period of service. Employees who had work more than 21 years developed mild to moderate hearing loss (Tripathy, 2002).

It is heartening and alarming to note the factual accuracy, which is broadcast by BBC Radio on September 23, 1999, that nearly a quarter of the police force, in the southern city of Bangalore, are suffering from hearing disabilities on account of multiplying noise pollution. A pilot study, conducted by Bangalore's Institute of Speech and Hearing, reveals that traffic constable at the city's main junctions are worst-hit victims of noise pollution. Sudden horning is one of the foremost causes of accidents on the road. 'Suniye', an institute for deaf, reports that daily on an average at least four persons are turning to total deafness in Delhi including one child in womb (The Navbharat Times, 2003).

Bombay Environmental Action Group has carried out the analysis in the year 1986, according to which 75% of the persons involved in mental jobs lose concentration in their work, 69% get disturbed in sleep, 65% of the children get disturbed their studies, 59% of the persons go restless, 53% of the people feel interference in speech communication, 49% get headache, 46% persons get angry and 36% persons feel impairment in hearing (Singal, 2005).

Noise damages the delicate sensory cells of inner ear, the cochlea. Evidence from field studies indicates that men incur more hearing loss than women from comparable noise exposure (Purohit and Agrawal, 2006).

It has been investigated that three out of five Indian (especially in big cities and towns) have already lost some power of hearing which they will never retrieve (Gupta, 2006). Child labourers suffer from permanent hearing losses due to their exposure of debilitating noise level at tender age.

A subjective survey to elicit people's response to the problem of noise due to road traffic in the city of Vishakapatnam has also been reported by Rao and Rao (1990a and 1990b). In this survey 1195 persons belonging to 43 different locations in the city pursuing different professions were examined. Analysis of their response showed that noise level on the city roads was highly disturbing even for carrying out a simple conversation. According to 77% of the responding persons, trucks and buses were the most annoying vehicles on road. Air horns used by the motor vehicles were particularly a single major factor contributing highly to noise pollution.

According to the day long noise survey in Delhi conducted by Central Pollution Control Board (1989) the so called quiet areas like hospitals had high noise level and Pusa campus was the only most quiet area in Delhi during day time.

Nagi *et al*. (1993) found that the noise level produced by household equipments and appliances sometimes reaches up to 97 dB which is more than the acceptable (45 dB) noise level. This excessive noise could carry several ill-effects viz. annoyance, speech interference, sleep disturbances, mental stress, headache and lack of concentration. Similarly, Singh (1984) noted that the workers exposed to high noise levels have a higher incidence of circulatory problems, cardiac diseases, hypertension, peptic ulcer, and neurosensory and motor impairment. Pyrotechnics like crackers and bombs are sources of unbearable noise generation during festivals like Diwali, Id, Baisakhi, Christmas etc. and other celebrations.

Ravichandran *et al.* (1997) in Tiruchirapalli City reveal that, none of the areas had noise levels less than 45 dB (A). Residential areas, silence zone and commercial places, all exceed the limit prescribed by the Central Pollution Control Board. The various factors which contribute to noise pollution are increasing population, urbanization, industrialization technological change and the usual relegation of environmental considerations to a position of secondary importance relative to economics.

Traffic noise surveys conducted in Karachi (Shaikh *et al*., 1987 and Shaikh *et al*., 1997) shows that the levels of traffic noise vary in range of 61 to 97 dB (A) which are much above the community annoyance limits recommended by the International Standards and some other countries.

Koijam *et al.* (1998) studied the noise levels in selected urban areas of Imphal valley and found 72 to 77 dB (A) in morning 71 to 77 dB(A) in after noon and 60 to 68 dB(A) in night. The observed noise levels were more than the standard permissible limit.

A survey conducted by the State Pollution Control Board indicated that noise in mega cities like Mumbai and Kolkata is as high as 95 dB, of which the vehicles contribute 70 to 85 dB. From the results of a survey made in Kolkata by Chakrabarty *et al*. (1998) interviews were conducted among 1160 people selected at random in 14 localities of Kolkata. These people lived near the traffic junctions in buildings built along the main roads on all sides of the traffic junctions. From the subjectively judged sleep quality, it was found that 67.93% of the respondents had sound sleep, 27.15% had slightly disturbed sleep and 4.91% had severely disturbed sleep.

Kumari *et al.* (2003) studied the noise levels at ten major hospitals in the Town of Hisar and found that, the ambient noise levels around all the hospitals are beyond the standards prescribed by Central Pollution Control Board, India. The Leq level varies from 71.19 to 61.92 dB (A).

Naik and Purohit (2003) reported that the noise levels were measured at ten residential locations at Bondamunda both during day and night time exceeded the noise standards recommended by CPCB. The noise generally came from many sources such as radio, TV, VCR, music system, coolers, motor cycle, chattering among people, children playing, traffic noise, use of loud speakers at the religious, cultural and social functions etc.

The results obtained in a study on environmental noise pollution in the city of Salem revealed that road traffic noise has been a major contributor to the annoyance, which is substantiated by the result of continuous monitoring of noise equivalent levels (Leq) at a number of silence, residential, commercial, industrial zones and road intersections (Thangadurai *et al*., 2005). Study carried out on the intensity of noise in different zones of the Kanpur city also revealed that most of the zones surveyed are under the threat of noise menace (Divya and Shukla, 2005).

The average noise level (Leq) of all the residential area, traffic point and silence zone in the study area of Rourkela Industrial Complex exceeds the prescribed standard during the study period. The noise levels of commercial areas like railway station and local market exceed the limit between 8.00 a.m to 5.00 p.m, but in the bank and post office, the noise level exceeds during the busy transaction hours between 10.00 AM to 2.00 PM (Naik, 2005).

The study carried out in Asansol city by Banerjee and Chakraborty (2006) revealed that night time noise levels (10.00 p.m – 6.00 a.m) in all the locations exceeded the limit prescribed by Central Pollution Control Board. The day time noise level was much higher at all locations in respect to the night time noise level. The Day-Night equivalent noise level (Ldn) was determined and ranged between 67.16 dB (A) and 89.44 dB (A).

Kisku *et al.* (2006) carried out study at 12 locations with sound level meter to assess day time and night time noise levels of Lucknow city. The noise level during day time and night time in residential areas, commercial cum traffic areas, and industrial areas were higher than their prescribed standards which may pose a significant impact on quality of life. Gangwar *et al*. (2006) also reported that noise level in Bareilly, Metropolitan city was slightly higher than the prescribed limit of the Central Pollution Control Board.

Sagar and Rao (2006) studied Noise Pollution Levels in Visakhapatnam city (India) and found that ambient air quality noise levels are alarming even in the absence of conveyor system indicating the impact of vehicular traffic.

From the survey carried out by Mishra *et al*. (2008) it was found out that automobile and loudspeaker are the major sources of noise pollution in Roorkee, the study area. The adverse impact of noise may result in improper communication,

sleepless and hearing impairment. Pathak *et al*. (2008) also reported that traffic noise became main reason of headache, high blood pressure, and other stresses among the exposed individuals in adjoining working places in Varanasi city.

The study carried out by Banerjee *et al*. (2008) in Asansol, an industrial town of eastern India, revealed that all the location in the study area exceeded the limit prescribed by CPCB. Based on the finding it can be said that the population in this industrial town are exposed to significantly high noise level, which is caused mostly due to road traffic.

Nandanwar *et al.* (2009) studied the effect of traffic noise on the quality of life among residents around the major road intersections in Nagpur city. Majority of the subjects expressed annoyance due to traffic noise during daily activities, and of these 29% were extremely, 24% very much, 22% to some extent, and 19% little annoyed. 33% of subjects reported more annoyance during evening than daytime. Most identified causes due to traffic noise were headache, nervousness, and hearing problems.

Goswami (2009) also studied traffic noise in terms of standard noise indices, community response, and community health effects in Balasore city. It was reported that 63% respondents were not satisfied with the noise level in their dwellings. Of the different sources of environmental noise, the most significant was identified as road traffic, with 49% of respondents reported being highly annoyed by the road traffic stream. 28% of subjects reported sleep disruption due to night time movement of vehicles.

Mishra *et al.* (2010) reported traffic noise along a rapid bus transit corridor in Delhi city. On the basis of the study, relationship between different noise parameters and annoyance level was quantified using linear and multiple regressions. It was

observed that 68% of the subjects reported the problem of stress due to traffic noise exposure. The subjects identified hearing loss (64%), blood pressure (56%), depression (48%), agitation (36%), and fatigue (12%).

Wani and Jaiswal (2010) studied traffic noise and subjective community response in the Gwalior city. The honking of horns, flow of ill maintained vehicles, poor road conditions and encroachments on road sides cause traffic congestion were found to be the reason for high noise level in Gwalior. Based on a questionnaire survey, it was reported that 50% of the subjects were always annoyed and 33% had a constant headache. For speech interference, 43% subjects reported highly affected, 21% moderately affected, 32% low, and 4% least affected.

Chauhan and Pande (2010) in their "*Study of noise level in different zones of Dehradun City, Uttarakhand"* observed that all selected sites in the study area were exposed to higher noise level as compared to Indian standard noise level prescribed by CPCB, New Delhi, India. Automobiles specially three wheelers (autorikshaw or vikram) and poor maintenance as well as music systems used in these three wheelers were found to be major sources of noise pollution in Dehradun, resulting in improper communication, sleeplessness and reduced efficiency.

In the study, *"Assessment of Urban Noise Pollution in Vijayawada City, Andra Pradesh, India"* carried out by Kumar (2011) the noise levels in the urban areas are above the permissible limits. It was understood clearly from the study that the noise levels are elevated in urban areas compared to suburban areas mainly because of traffic noise.

Patil *et al.* (2011) reported subjective analysis on traffic noise and the quality of life among residents around the major arterials roads in Amravati city. It was reported that majority of the subjects were aware of the interference of traffic noise

with daily activities and impact on health. It was observed that 16.8% were extremely and 21.1% were very much annoyed due to vehicle noise. Reported maximum annoyance (47%) was highest during the midday and afternoon, while 50% of subjects reported headache, nervousness, and hearing difficulties due from exposure to noise.

Agarwal and Swami (2011) studied the impact of noise pollution on residents dwelling near roadside in Jaipur city. It was reported that road traffic was the major source of noise in the area. Results of a health survey reported about 52% of subjects were suffering from frequent irritation, 46% had hypertension, and 48.6% reported difficulties in sleep due to traffic noise and that female subjects were more sensitive toward noise-related health problems. It was explained that in India the numbers of housewives are higher than the working-class females and due to continuous living in a particular surrounding they have to face noise-related problems daily.

The noise survey conducted by Alam (2011) reveals that noise environment of the Guwahati city is not so satisfactory as per the standards prescribed by CPCB and "The Noise Pollution (Regulation and Control) Rules, 2000".The scenario is deteriorating day by day with exponential increase in population as well as the number of vehicles in city road. Moreover, inappropriate traffic management, lack of parking space and poor road condition has contributed a lot to the noisy environment of the city. The greenery and forest cover decreasing at alarming rate due to unplanned growth and urbanisation has resulted in reducing noise cushion in the city.

Vartika (2011) carried out a study in different zones in Dehradun city. The measurements of noise levels have been recorded at the different Silence, Residential and Commercial zones of the city. The analysis has revealed that noise pollution

levels are rather higher than prescribed Indian Standards at all the examined sites such as Survey Chock, Clock Tower and Prince Clock. It is evident from the noise data analysis that during the months of September to March, noise pollution of the Dehradun city is higher than in comparison to other months of the year. This could be due to celebrations of the festivals and marriages during this period.

From the study carried out by Pradhan *et al*. (2012) 41% respondents described themselves as being personally affected by noise pollution more than that of water, air or waste pollution. The most imperative finding was that the day time traffic noise was ranked in first place among the most frequently identified types of sound and was considered unpleasant by the majority.

The study carried out by Swain *et al.* (2012) explicitly revealed that the noise levels are more than the permissible limit in all the investigated sites in Bhubaneswar. Moreover, it clearly depicts that the transportation sector is one of the major contributors to noise in this city. Similarly, in the study conducted by Mangalekar *et al*. (2012) the average noise level at all sites was found to be above the prescribed limits of CPCB. The noise level showed a significant variation at different sites which gradually increased or decreased on the basis of location of the site. The average noise level dB (A) was highest at Industrial area followed by commercial area and residential area, while lowest at silence zone. One of the major causes for this increased level is increased number of vehicles and the enhanced transportation activities.

Hunashala and Patil (2012) carried out "*Assessment of noise pollution indices in the city of Kolhapur, India*". The results indicated that the highest Leq of 72.25 dBA was observed in industrial-cum residential zone followed by 64.47 dBA in commercial-cum-residential zone, 63.71 dBA in educational zone, 53.26 dBA in

recreational zone and 42.84 dBA in silence zone. For educational zone, Leq observed were above the statutory limits, while for other zones it was marginally below. The noise assessment study clearly revealed the alarming condition of noise pollution in Kolhapur.

From the study carried out in Dindigul – Bangalore road (NH-209) by Subramani *et al.* (2012) it was found out that traffic noise from highways creates problems for surrounding areas, especially when there are high traffic volumes and high speeds.

Reddy and Jherwar (2012) carried out a study on "*Effects of Noise Pollution With Relation To Hypertension".* This study investigated the current state of evidence for potential health effects caused by exposure to noise. The health impacts considered were annoyance, mental health effects, cardiovascular (heart and blood vessels) effects, sleep disturbances, delayed language and reading skills in children and hearing impairment. With the exception of mental health, the study found that there was sufficient evidence to link noise exposure with adverse health effects. Results clearly indicate that the persons residing at station 1, 2 and 3 areas are exposed to noise pollution show hypertension, irritation and sleeplessness and associated cardiac disorders. Few cases of depression and mood swings were also observed among affected stations. These were associated with indigestion, head ache and annoyance. The results of task performance were poor in affected areas compared to the control.

A study carried out by Mirsanjari and Zorufchin (2012) in Region 6, Tehran revealed that the noise levels in four commercial centres have been determined up to limit level. In all the locations, the noise level has increased due to vehicular noise. The results of another interviewed questionnaire carried out by Mirsanjari (2013) in

Tehran also revealed that the main source of noise in the study area was traffic. More than half of the total sample population expressed annoyance with traffic noise during daily activities.

Study conducted in West Bengal shows that about 78.83% respondents feel unpleasant from vehicle horn; 16.77% from the noise of Lorries and buses and 4.39% from other sources (Mondal and Das, 2013).

From the study conducted in Morena city, the noise levels in all three areas (i.e. residential, commercial and silence area) are found to exceed the noise limit prescribed by the CPCB. The honking of air horns, flow of ill maintained vehicles, poor road conditions and encroachments found on road sides that cause traffic congestion were found to be the reasons for high noise levels in the area. Unfortunately the patients in General hospital and the students in educational institutions are exposed to very high noise levels. This will cause adverse health effects on patients or aggravate their illness in general hospital (Singh and Dadoriya, 2013).

The results of the study conducted by Balashanmugam *et al.* (2013a) also showed that the level of noise pollution in Chidambaram town exceeds the acceptable limits set by the CPCB. Even in the residential areas and vulnerable institutions like schools and hospitals, noise is much higher than the acceptable limit. It was observed that in these locations the noise level varies considerably due to the high volume of traffic flow and commercial activities.

Other study carried out by Balashanmugam *et al.* (2013b) in Cuddalore town also indicated that the noise levels in the town are escalating at a very fast rate with growing population and heavy traffic accumulation. Noise levels obtained at different locations of the town viz. *commercial, residential, industrial* and *silence zones* are

found to be exceeding the noise level /limits prescribed by the CPCB and "The Noise Pollution (Regulation and Control) Rules, 2000". Even in the residential areas and vulnerable institutions like schools and hospitals, noise level is much higher than the acceptable limit. It was also observed that higher noise level in the town is due to rapid and unplanned urbanization resulting in great influx of people from all parts of the region and country, improper management of town roads and traffics, lack of sufficient parking spaces and exponential growth of both private and public vehicles in the city.

Kumar *et al.* (2013) carried out a "*Study on Noise Pollution level in Parks of Allahabad City, India"* and it was found out that the noise level was higher than the prescribed standard level for silent zone by CPCB at all parks under investigation.

The noise levels in Chennai are also higher than that of standards specified by Tamilnadu Pollution Control Board (TNPCB) (55 dB). It is concluded from buffer analysis that the area up to 10 m is worst affected by noise and beyond 25 m, the noise is considerably less and the effect is tolerable (Karthik, and Partheeban, 2013).

Zonunsanga (2005) has found that the noise level of five major traffic points in Aizawl city are higher than the standards prescribed by Environmental Protection Rules, 1986 (schedule-III).

Noise Pollution also has adverse effects on teaching-learning. Bhatnagar *et al*. (1991) found on evaluation that noise adversely affects performance of both mental and mechanical tasks. Annoyance level tests and personnel reactions showed that better performance was achieved in the controlled noise environments of 65 dBA, while noisy conditions of 84 dBA were very disturbing, and however, the best results were in calm conditions.

In the study carried out by Pachpande *et al*. (2005) the data on self-reported hearing status and audiometric analysis of school teachers and students was collected from the schools located in the near vicinity of NH-6 passing through Jalgaon city. About 84% teachers and 92% students have reported hearing difficulty in the questionnaire. In the audiometric testing mild hearing loss (25 to 35 dBHL) was observed in both the subject groups. The strategies need to adopt for protection of the teachers/students from the noise exposure are suggested.

Shield and Dockrell (2008) carried out a study on *"The effects of classroom and environmental noise on children's academic performance"*. The result showed that both chronic and acute exposure to environmental and classroom noise has a detrimental effect upon children's learning and performance. For external noise it appears to be the noise of individual events which have the most impact, while background noise in the classroom also has a significant negative effect. Children with special educational needs were found to be more susceptible to the effects of classroom babble upon verbal tasks than other children. These results raise specific challenges for national and international policies which aim to educate all children in 'inclusive' environments.

From the study "*Assessment of Noise and Associated Health Impacts at Selected Secondary Schools in Ibadan, Nigeria*" carried out by Ana *et al.* (2009) it was found out that noise levels indoors (classrooms) and outdoors (playgrounds) across schools were higher than WHO permissible levels for community learning environments. The most reported health problems potentially associated with acute (large or episodic) and/or chronic (continuous or intermittent) exposure to noise within the school environment were lack of concentration and tiredness. Evidence has suggested that noise in learning environments has considerable effects on the

learning abilities and the general productivity of children in terms of their academic performance as compared to children in serene learning environments.

A study of noise problem was carried out by Debnath *et al.* (2012) in some educational institutes of Nagaon town, Assam, India by taking measurement on noise level in dB(A) with the help of Noise Level Meter and by questionnaire supplied to students, teachers and officials. The analysed result clearly shows that the rate of noise level in all the institutes (in and out) is very high and not suitable for teaching-learning process.

The results from the study "*Traffic Noise as a Serious Effect on Class Teachers in Firoozabad City, Iran*" carried out by Karami *et al*. (2012) showed that traffic noise was a significant factor that affected the teachers by reducing their teaching efficiency and by disturbing other educational procedures.

Wokocha (2013) found out that the high noise level in Omoku Agip Gas plant creates a lot of problems in teaching and learning in schools around the area. It causes stress and fatigue, high blood pressure to teachers and school children as well as hearing impairment, making teaching and learning uninteresting.

In the *"Study effects of school noise on learning achievement and annoyance in Assiut city, Egypt"* carried out by Ali (2013) there was strong relationship between noise levels and percentage of highly annoyed respondents. 57% of respondents said that noise obstructed their learning achievement. Younger students were more annoyed than older one. Respondents said that road traffic, railway noise, chatter in class room and scraping sounds from tables and chairs were the most annoying sources.

Besides affecting teaching-learning process and human health noise pollution also results in riots and even death. A middle-aged woman living in Soho became affected by the incessant noise from a newly open discotheque. She complained to the management, the Police, the Local Authority, but nothing was done to reduce the noise. Her action took the form of suicide. In a quiet part of Middlesex with an ambient noise level of 30 to 40 decibels lived Fred, a lusty, healthy builder's labourer. The M4 Motorway was built within a few feet of his cottage home. The resultant traffic caused the noise level to rise to 80 and 90 decibels so this poor man suffered an increase of 100,000 times in the noise level. He took it for some weeks. Discovered there was nothing he could do about it and his action was also directed against the self. He left a note which read "The Noise; the Noise; I just couldn't stand the Noise" (Connell, 1972).

In Italy, a 44 year old man, took an overdose of drugs because his eleven children made too much noise while he was watching the Olympic Games on television (Nunez, 1998).

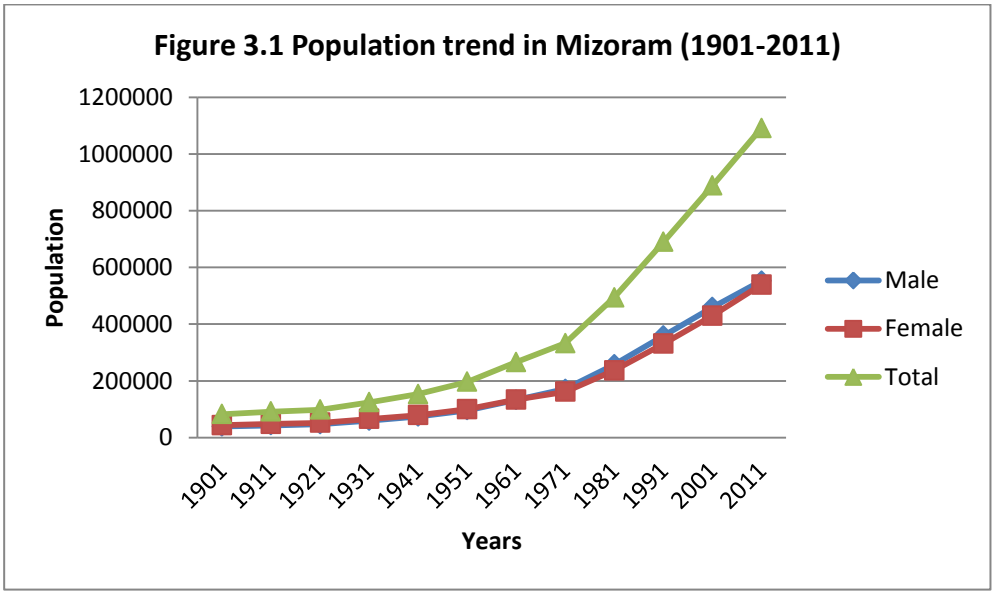
There are reported cases, in which the noise of loudspeaker has resulted in to communal riots. Such type of incidents took place in the city of Meerut, in April 1987 (The Navbharat Times, 1987). The incident was repeated second time in the same city, and created the problem of law and order. Indiscriminate use of loudspeaker from religious places and platforms instigated the people of one sector against another, and thrown the city into the flames of communal riots, resulting into the loss of innocent lives and destruction of public and private property. To control this situation, an order, u/s 144, CrPC, was issued by the Addl. District Magistrate, mainly to check and control the use of loudspeakers. Another incident of communal riots, due to noise, was caused by the indiscriminate use of loudspeaker Moradabad city, of

same state, UP. On April 4, 1990, loudspeaker was being used at the place of worship, which was objected by persons of other community. The communal riots resulted into the exchange of stone throwing and destruction of property of innocent persons. Several shops were looted and put to fire and disrupted the peaceful life of the people (The Navbharat Times, 1990). Further, it has also been noticed that in recent years, the frequent use of loudspeaker and use musical appliances by the extremist, especially in the states of J&K and Punjab, has become a means of propagation of anti-national activity, threatening national integrity of the country (Sunday Magazine, 1990).

A petition has been filed before the Supreme Court of India. The immediate provocation for filling the petition was that a 13 year old girl was a victim of rape whose cries for help sunk and went unheard due to blaring noise of music over loudspeaker in the neighbourhood. The victim girl later in the evening set herself ablaze and dead of 100% burn injuries (C.W.P. No. 72/98).

3.1 Mizoram: Location and Population

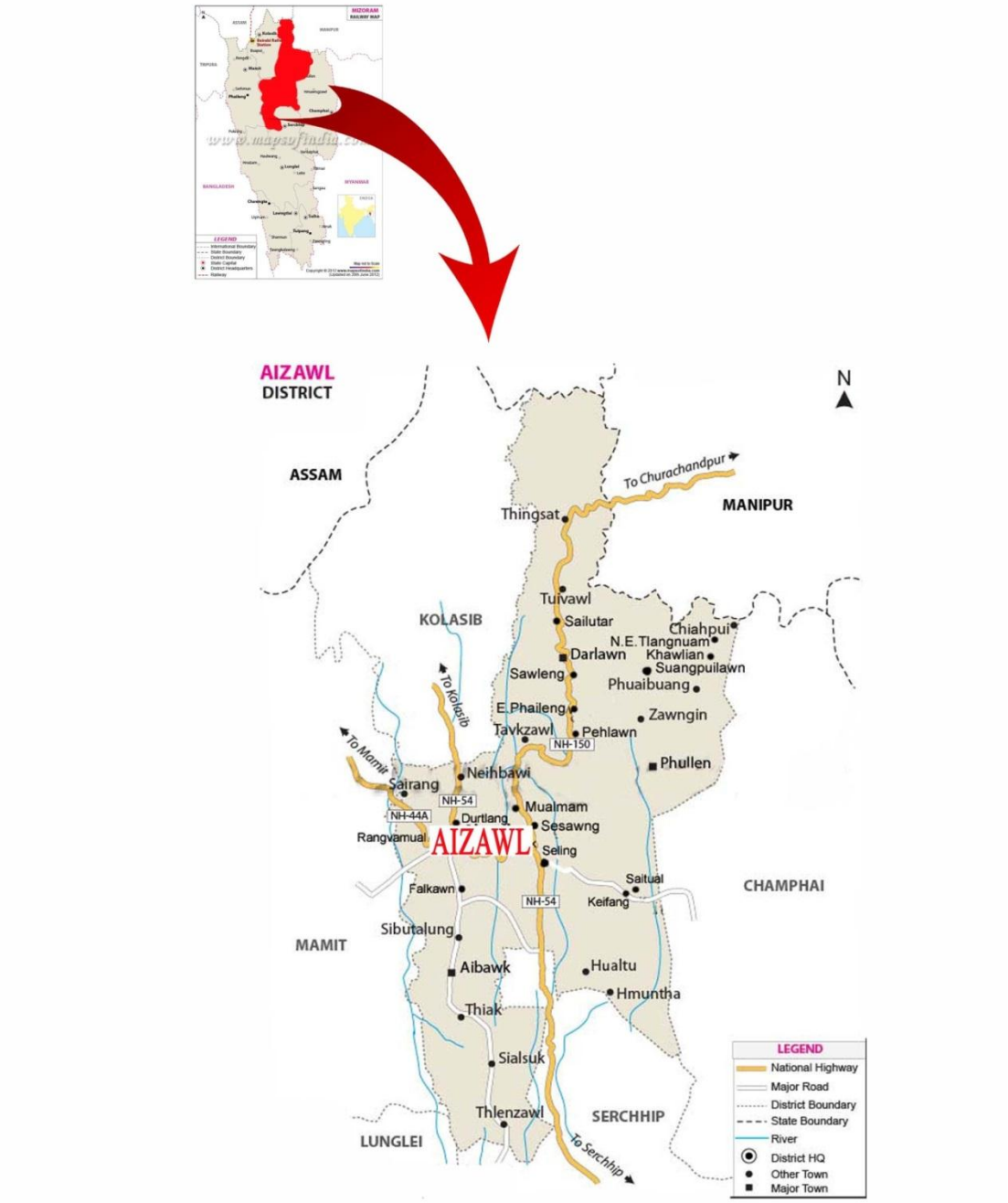
Mizoram lies in the north eastern part of India; much of its southern part is sandwiched between Myanmar and Bangladesh. The state is situated between 21˚.58' N to 24˚.35'N latitudes and 92˚.15' E to 93˚.29'E longitudes, extending over a geographical area of 21,081 sq.km. The length of the state from north to south is 277 km and the width from east to west is 121 km. Mizoram has interstate boundaries with Assam (123 km.), Tripura (66 km.) and Manipur (95 km.). Mizoram is divided into 8 Administrative Districts and 3 Autonomous Districts with 23 Sub-divisions and 26 R.D Blocks. There are 830 villages in the state. According to the 2011 (provisional) census, population of the state is 10,91,014 with 5,52,339 male and 5,38,675 female. The population density is 52 persons per sq.km. The urban population of the state is 5,61,977 and that of the rural population is 5,29,037. The decadal population growth (1991-2011) is 22.78% (Statistical Handbook, 2012). The population trend in Mizoram from 1901-2011 is shown in figure 3.1.



(Source: Statistical Handbook, 2012)

Aizawl district is situated in the north-central part of Mizoram and is bound by Champhai district of Mizoram and Manipur state on the east, on the west by Mamit and Kolasib districts of Mizoram, by Assam state on the north and by Serchhip district of Mizoram on the south. The total geographical area of Aizawl district is 3576 sq.km, occupying 16.96 % area of the state with a population of 404,054, out of which 312,837 is urban population and the rural population is 91,217. The population density of Aizawl district (113 per sq.km.) is very high as compared to other districts of the state. The second highest population density of the state is shows by Kolasib district with the population density of 60 per sq.km. Out of the total population of Aizawl district, 291,822 populations reside in Aizawl city, the state capital of Mizoram (Statistical Handbook, 2012). Aizawl city is the political and cultural centre of the state. It is here the State Legislature is situated. It is also the seat of the government and all important government as well as public sector offices is located. It is also the commercial hub of the state and all commercial and economic activities are centered in the city. Aizawl has become the centre of Road network in Mizoram connecting the north and south, east and west. More than 26% of the Mizoram population resides in Aizawl.

Figure 3.2. Map showing Aizawl district



3.2 Study sites

In Aizawl city, there is no separate place for industries, workshops/factories, institutions, offices, and hospitals. Therefore, on the basis of location, the study area was divided into four zones such as Industrial Zone, Commercial Zone, Residential Zone and Silence Zone. In each zone, four sites each are selected from different locations of the city. The selected sites are as follows:

Zone 1- Industrial Zone:

According to the standards prescribed by the Noise Pollution (Regulation and Control) Rules, 2000, the permissible limit of noise level (Leq) in the industrial zone during day time is 75 dBA. The following four sites were selected under the industrial zone, but after five months of study the LB Mechanised Carpentry had been replaced by furniture showroom. Therefore, the study was continued only in three sites from the industrial zones.

1) Industrial Estate, Zuangtui
2) HB Motors, Chanmari
3) LB Mechanised Carpentry, Lower Chanmari
4) LBS Bike Bazar, Bawngkawn

Zone 2 - Commercial Zone:

For commercial zone, the permissible limit of noise level (Leq) during day time is 65 dBA according to the standards prescribed by the Noise Pollution (Regulation and Control) Rules, 2000. The following sites were selected from the commercial zones:

1) New Market, Dawrpui

2) Millennium Centre, Dawrpui

3) Zangena Petrol Pump, Ramhlun 'N'

4) MIZOFED Petrol Pump, Tuikual

Zone 3 - Residential Zone:

The prescribed standard of noise level (Leq) for residential zone recommended by the Noise Pollution (Regulation and Control) Rules, 2000 during day time is 55 dBA. The following sites were selected from different parts of Aizawl City:

1) Chaltlang (northern part of Aizawl City)

2) Bazar Bungkawn (eastern part of Aizawl City)

3) College Veng (western part of Aizawl City)

4) Sikulpuikawn (southern part of Aizawl City)

Zone 4 - Silence Zone:

Silence zone is defined as an area comprising not less than 100meters around hospitals, educational institutions and courts. The silence zones are zones which are declared as such by the competent authority. The prescribed limit (Leq) for silence zone during day time is 50 dBA. The selected sites for silence zones were as follows:

1) Civil Secretariat Complex, Khatla

2) Civil Hospital, Dawrpui

3) Govt. Mizo Higher Secondary School, Chanmari

4) Mizoram University (MZU) Campus, Tanhril

Figure 3.3 Location maps of study sites

Photo Plate 3.1 : Zone 1- Industrial Estate, Zuangtui

Photo Plate 3.2: Zone 1- HB Motors, Chanmari

Photo Plate 3.3: Zone 1- LBS Bike Bazar, Bawngkawn

Photo Plate 3.4: Zone 2- New Market, Dawrpui

Photo Plate 3.5: Zone 2- Millennium Centre, Dawrpui

Photo Plate 3.6: Zone 2- Zangena Petrol Pump, Bawngkawn

Photo Plate 3.7: Zone 2- MIZOFED Petrol Pump, Tuikual

Photo Plate 3.8: Zone 3- Chaltlang

Photo Plate 3.9: Zone 3- Bazar Bungkawn

Photo Plate 3.10: Zone 3- College Veng

Photo Plate 3.11: Zone 3- Sikulpuikawn

Photo Plate 3.12: Zone 4- Civil Secretariat Complex, Khatla

Photo Plate 3.13: Zone 4- Civil Hospital, Dawrpui

Photo Plate 3.14: Zone 4- Govt. Mizo HSS, Chanmari

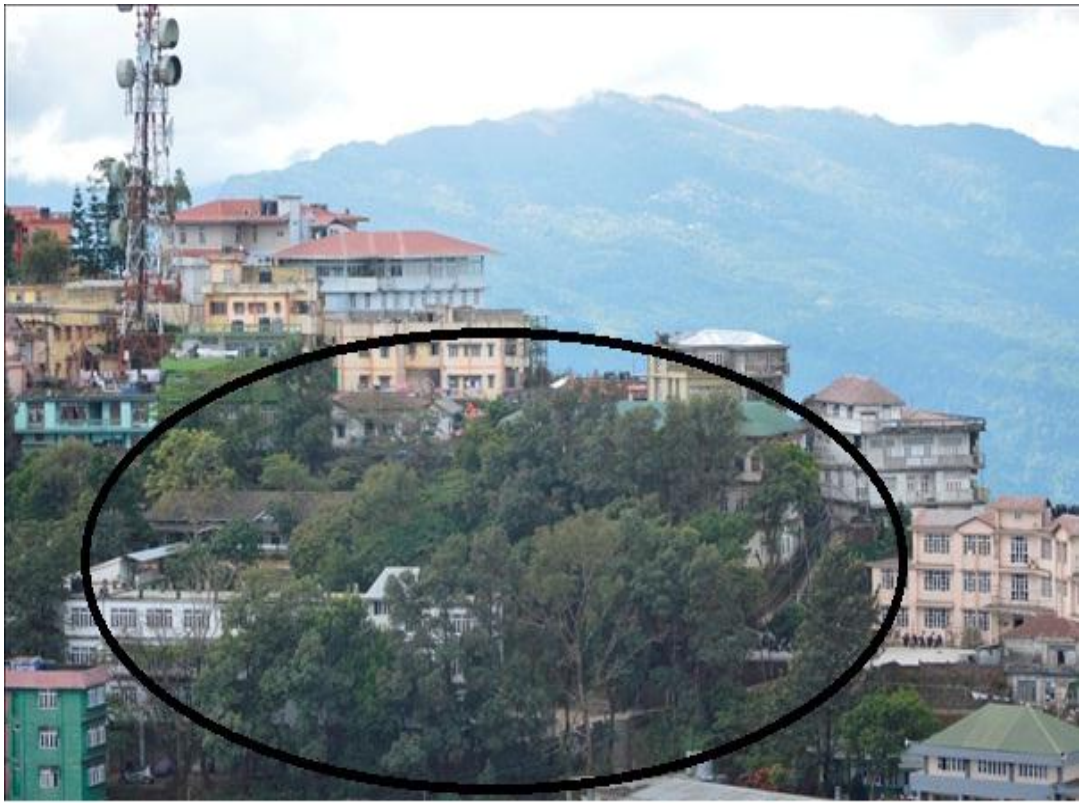


Photo Plate 3.15: Zone 4- Mizoram University Campus, Tanhril

4.1. Measurement of Noise Level:

The Integrating Sound Level Meter 2031A was used for recording the noise level in the study sites. This integrating sound level meter is a type-1 instrument with SPL, Leq, Lmax, Lmin and SEL measurement. It is very simple to operate and is an ideal and essential tool for noise measurement and data collection in the field. It has a wide measurement range and a host of features like A, C, and Linear weighting. The meter can be used to read spot values, calculate short or long term Leq, SEL, maxima and minima and time duration of the data collection. A slow, fast and impulse time response, Max Hold, detachable microphone, rechargeable battery and an alphanumeric display are provided on the instrument. All parameters of the instrument are software controlled and are checked internally by the self-test mode.

Steps in taking the noise level:

1. The operational function of data recording was done on a switch on mode of SLM at the selected sites and the numerical values displayed on LCD were recorded.
2. Readings were taken thrice a day (morning 6 a.m – 7 a.m, daytime 12 noon – 1 p.m and evening 4 p.m – 5 p.m) and twice a month (one week interval) at each site for two years (i.e. August 2009 – July 2010).
3. In case of institutions and workshops readings were taken from 9 a.m – 10 a.m for morning time since these places were opened only from 9 a.m.
4. After recording Lmax, Lmin and Leq of the noise level, the result was compared with the standards of Noise Pollution (Regulation and Control) Rules, 2000.

Photo Plate 4.1: Sound Level Meter 2031A

4.2. Study on the effects of noise pollution:

The study on the effects of noise pollution was carried out with the help of the following –

(i) Questionnaire: Study on the effects of noise pollution and the health status was conducted by using questionnaire among the inhabitants of the study area such as students and teachers in the institutions, patients in the hospitals, workers in the industries, and certain people in the commercial and residential zones.

(ii) Hospital Record: Record on the health parameters related to noise pollution was collected from the Civil Hospital, Aizawl.

(iii) Secondary Data: Secondary data was collected from books, reference, e-journals, published articles, internet facilities, government records and publications.

4.3 Identification of sources of noise:

The different sources of noise were also identified by using questionnaire among the inhabitants in the study area.

4.4 Statistical Analysis:

To check validity of the data and significance of results, two-way ANOVA and correlation coefficients were computed.

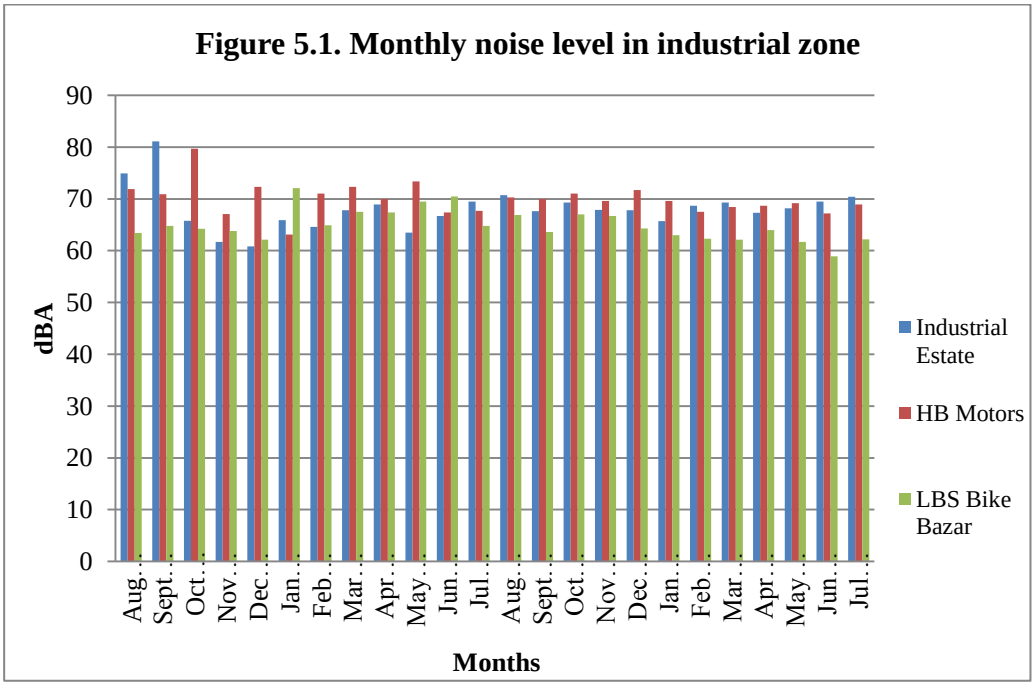
The results for noise intensity, sources of noise and its effects on human health in the study area are presented below:

5.1 Measurement of noise level:

Measurement of noise level was done by using Integrating Sound Level Meter 2031A. The following results are obtained from the measurement:

5.1.1 Monthly noise level in different zones

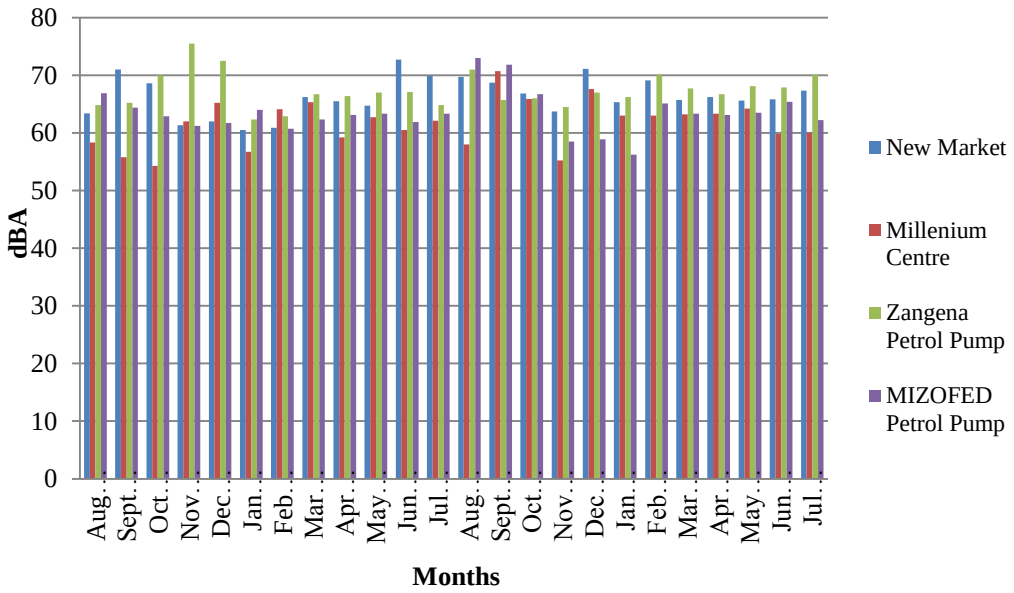
The monthly noise levels during the two years in different zones are presented in the following figures:



The monthly noise level in industrial zone ranged from 58.9 dBA – 81.1 dBA. The noise level in Industrial Estate ranged from 60.8 dBA – 81.1 dBA, the noise level in HB Motors ranged from 63.1 dBA – 79.7 dBA, and the noise level in LBS Bike Bazar ranged from 58.9 dBA – 72.1 dBA. The highest noise level (81.1 dBA) was found in Industrial Estate, Zuangtui in the month of September, 2009 and the lowest

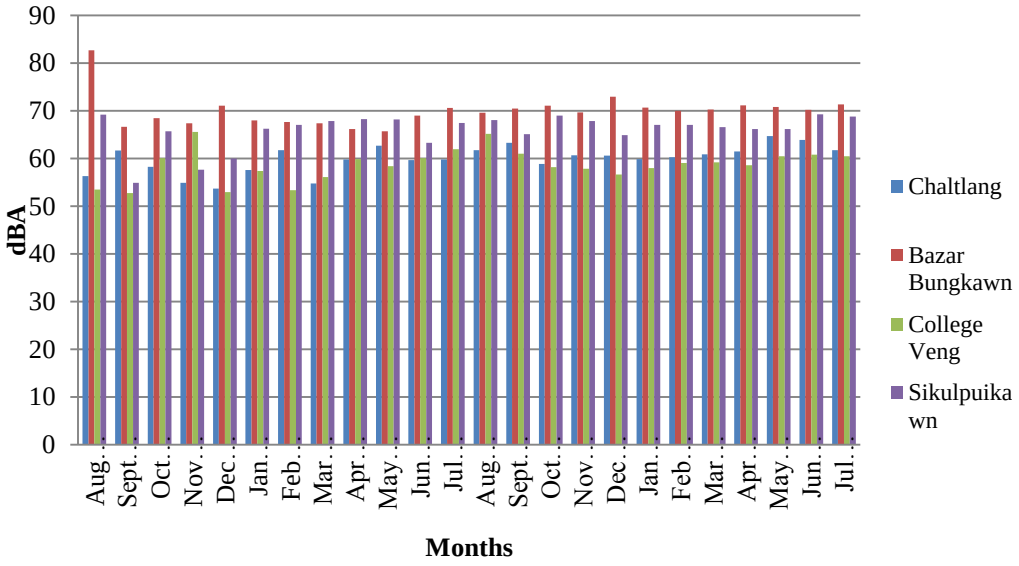
noise level (58.9 dBA) was found in LBS Bike Bazar in the month of June, 2011 (Figure-5.1).

Figure 5.2. Monthly noise level in Commercial zone

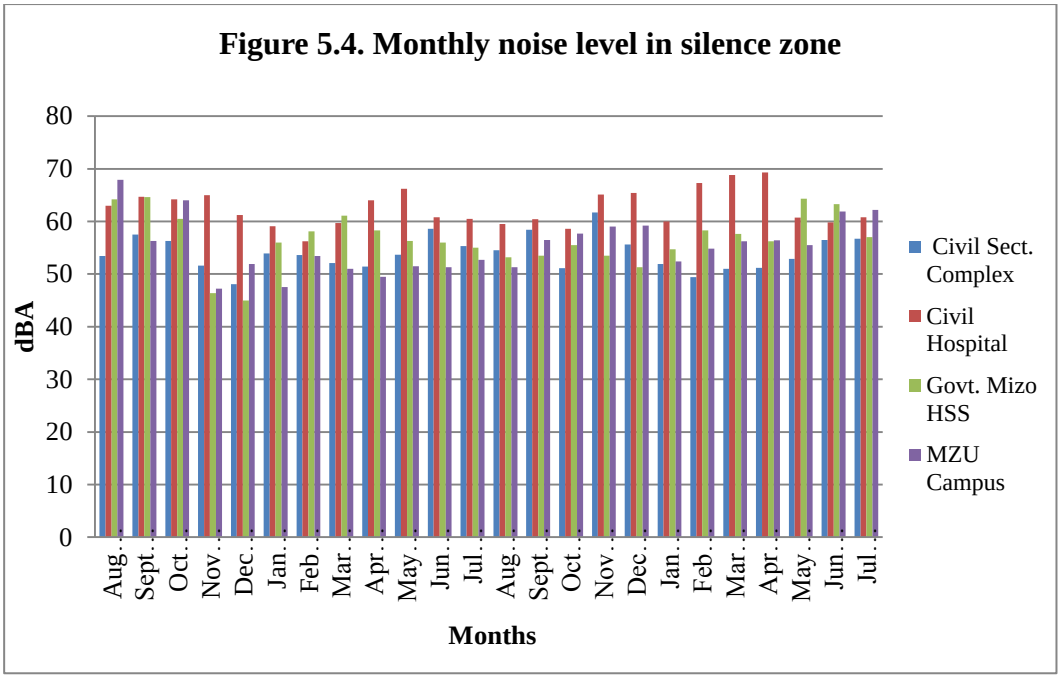


In commercial zone, the monthly noise level ranged from 54.3 dBA – 75.5 dBA. The noise level in New Market ranged from 60.5 dBA – 72.7 dBA. The noise level ranged from 54.3 dBA – 70.7 dBA in Millennium Centre. The noise level in Zangena Petrol Pump ranged from 62.3 dBA – 75.5 dBA, and the noise level in MIZOFED Petrol Pump ranged from 56.2 dBA – 73 dBA. The highest noise level (75.5 dBA) in commercial zone was found in Zangena Petrol Pump in the month of November, 2009. The lowest noise level (54.3 dBA) was found in Millennium centre in the month of October, 2009 (Figure-5.2).

Figure 5.3. Monthly noise level in residential zone



The monthly noise level in residential zone ranged from 52.8 dBA – 82.7 dBA. The noise level ranged from 53.7 dBA – 64.7 dBA in Chaltang. The noise level in Bazar Bungkawn ranged from 65.7 dBA – 82.7 dBA. In College Veng, the noise level ranged from 52.8 dBA – 65.6 dBA and the noise level in Sikulpuikawn ranged from 54.9 dBA – 69.3 dBA. The highest noise level (82.7 dBA) in residential zone was observed in the month of August, 2009 at Bazar Bungkawn, and the lowest noise level (52.8 dBA) was found in College Veng in the month of September, 2009 (Figure-5.3).



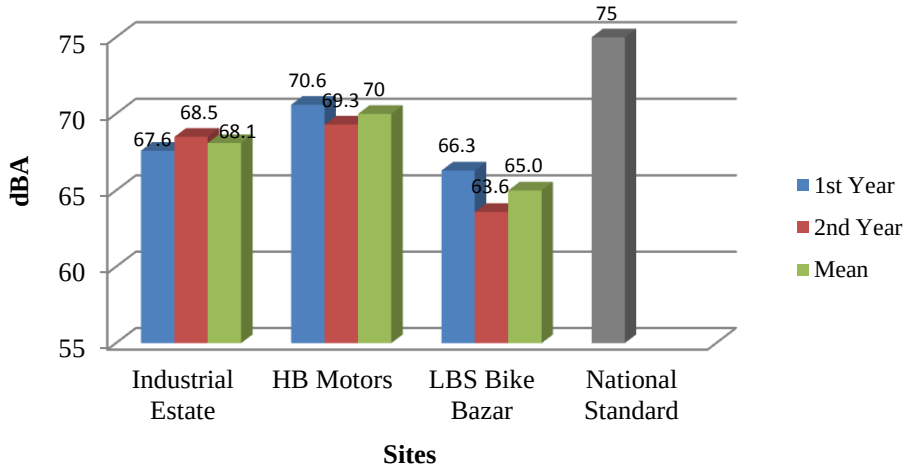
The monthly noise level in silence zone ranged from 45 dBA – 69.3 dBA. The noise level in Civil Sect. Complex ranged from 48.1 dBA – 61.7 dBA. The noise level in Civil Hospital ranged from 56.2 dBA – 69.3 dBA. In Govt. Mizo HSS, the noise level ranged from 45 dBA – 64.6 dBA and the noise level in MZU Campus ranged from 47.2 dBA – 67.9 dBA. The highest noise level (69.3 dBA) in silence zone was found in Civil Hospital in the month of April, 2011, and the lowest noise level (45 dBA) was found in Govt. Mizo HSS in the month of December, 2009 (Figure-5.4).

The monthly noise level in different sites during the first year and second year is given in Appendix-I and Appendix-II.

5.1.2 Yearly noise levels in different zones

The mean noise levels in different zones are presented in the following figures:

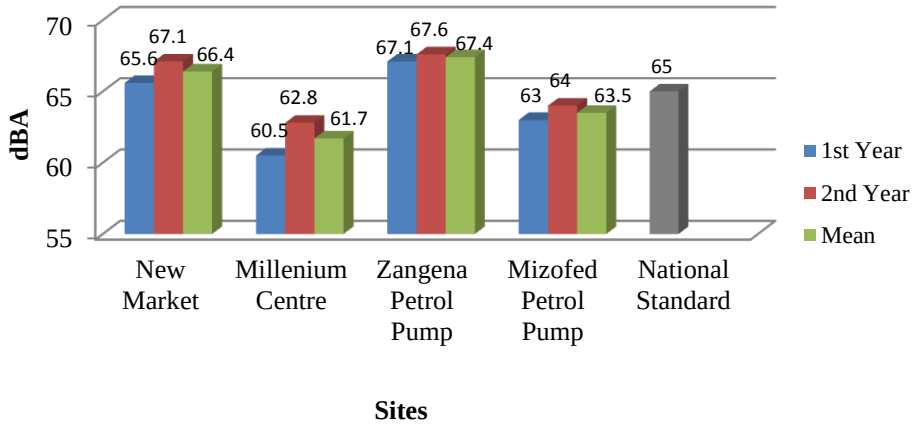
Figure 5.5. Yearly noise level in industrial zone



In zone 1, the noise level ranged from 63.6 dBA – 70.6 dBA. The highest noise level among the industrial zone was observed in HB Motors in the first year and second year. The highest noise level in the first year was 70.6 dBA and in the second year the highest noise level was 69.3 dBA . The lowest noise level was also observed in LBS Bike Bazar in the first year second year. The lowest noise level in the first year was 66.3 dBA, and the lowest noise level in the second year was 63.6 dBA. During the two years, the highest mean noise level (70 dBA) in industrial zone was observed in HB Motors, and the lowest mean noise level (65 dBA) was observed in LBS Bike Bazar. The noise level in all the three sites were within the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000 (*i.e*, 75 dBA). In Industrial estate, Zuangtui, the noise level was increased in the second year by 0.9 dBA. In HB Motors, the noise level was decreased in the second year by 1.3

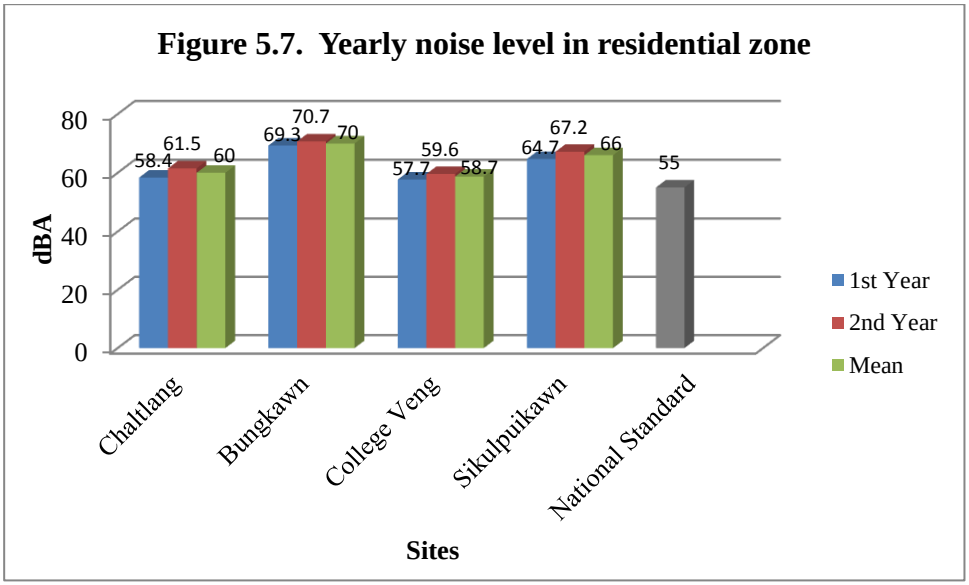
dBA. LBS Bike Bazar also showed a decrease in noise level by 2.7 dBA in the second year (Figure-5.5).

Figure 5.6. Yearly noise level in commercial zone



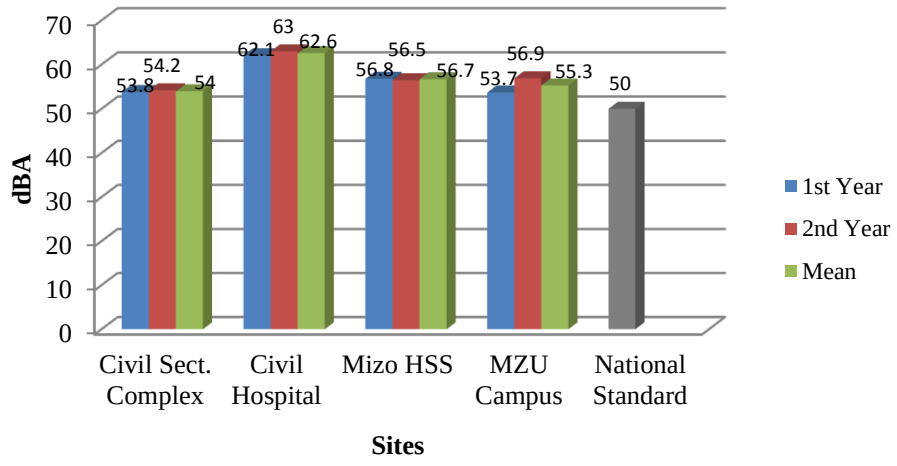
In zone 2, the noise level ranged from 60.5 dBA – 67.6 dBA. The highest noise level was observed in Zangena Petrol Pump in the first year and second year. The highest noise level in the first year was 67.1 dBA, and the highest noise level in the second year was 67.7 dBA. The lowest noise level was observed in Millennium Centre in both the first year and second year. The lowest noise level in the first year was 60.5 dBA, and in the second year the lowest noise level was 62.8 dBA. During the two years the highest mean noise level (67.4 dBA) was observed in Zangena Petrol Pump, and the lowest mean noise level (61.7 dBA) was observed in Millennium Centre. New Market (66.4 dBA) and Zangena Petrol Pump (67.4 dBA) exceeded the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000 (*i.e*, 65 dBA). The other two sites, Millennium Centre (61.7 dBA) and MIZOFED Petrol Pump (63.5 dBA) are within the standard noise level. In all the four sites under zone 2, the noise levels were increased in the second year. In New Market,

the noise level was increased by 1.5 dBA in the second year. In Millennium Centre, the noise level was increased in the second year by 2.3 dBA, and the noise level was increased by 0.5 dBA in Zangena Petrol Pump. Mizofed Petrol Pump also showed an increase by 1 dBA in the second year (Figure-5.6).



In zone 3, the noise level ranged from 57.7 dBA – 70.7 dBA. The highest noise level was observed in Bazar Bungkawn in both the first year and second year. The lowest noise level in both the first year and second year was observed in College Veng. The highest noise level in the first year was 69.3 dBA, and the lowest noise level was 57.7 dBA. In the second year, the highest noise level was 70.7 dBA and the lowest noise level was observed to be 59.6 dBA. The mean noise level was highest in Bazar Bungkawn (70.0 dBA). The lowest mean noise level (58.7 dBA) was observed in College Veng. The result shows that all the four sites in residential zone exceeded the national standard noise level (*i.e.*, 55 dBA). The noise level was increased in the second year by 3.1 dBA, 1.4 dBA, 1.9 dBA and 2.5 dBA in Chaltlang, Bazar Bungkawn, College Veng and Sikulpuikawn respectively (Figure-5.7).

Figure 5.8. Yearly noise level in silence zone

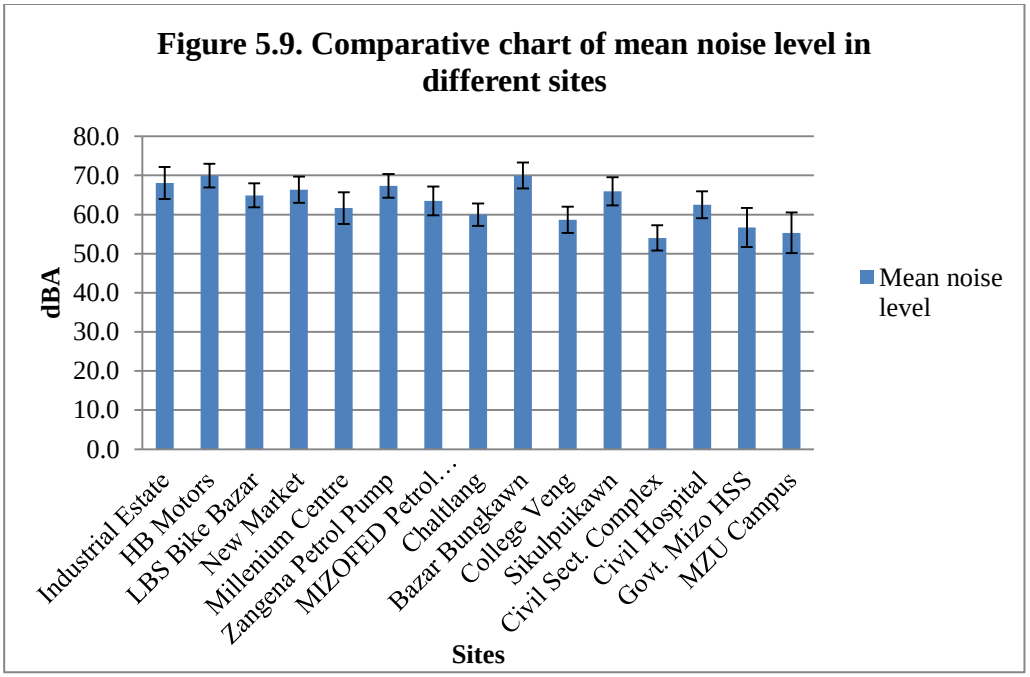


In zone 4, the noise level ranged from 53.7 dBA – 63 dBA. The highest noise level was observed in Civil Hospital in both the first year and second year. The lowest noise level was found in MZU campus in the first year, and in the second year Civil Secretariat Complex showed the lowest noise level. The highest noise level during the two years was 63 dBA and the lowest noise level was 53.7 dBA. The mean noise level in silence zone was highest in Civil Hospital (62.6 dBA) and lowest in Civil Secretariat (54 dBA). All the four sites exceeded the standard noise level which is 50 dBA during day time. Increase in noise level was observed in three sites such as Civil Secretariat Complex, Civil Hospital and MZU Campus by 0.4 dBA, 0.9 dBA and 3.2 dBA respectively. In Mizo HSS, the noise level was decreased by 0.3 dBA in the second year (Figure-5.8).

5.1.3 Comparison of mean noise levels in different sites

The monthly noise level and the overall mean level of noise in different sites were compared and the result is shown below:

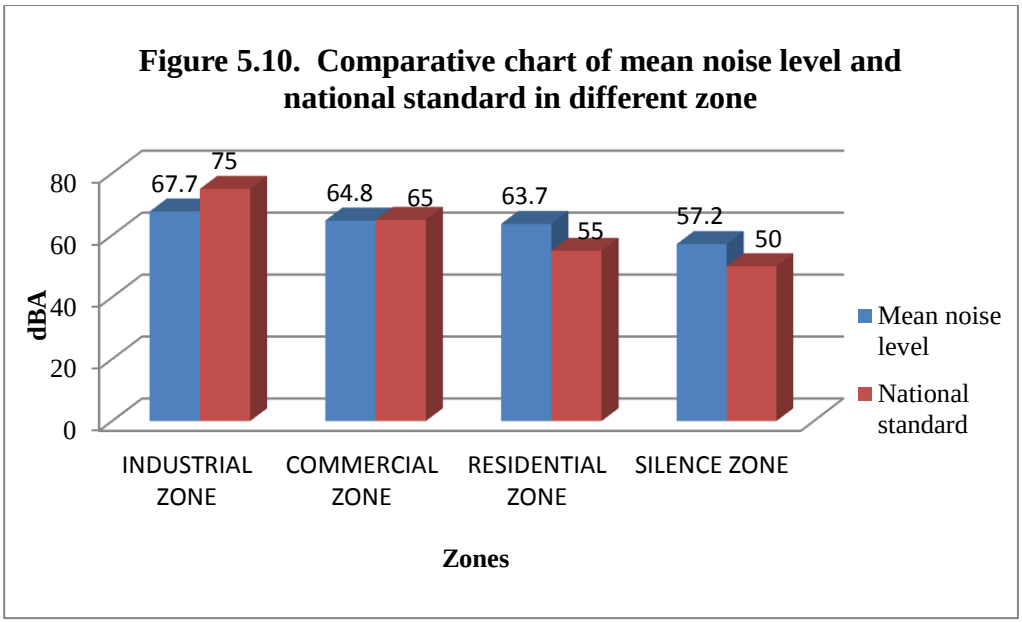
Figure 5.9. Comparative chart of mean noise level in different sites



During the two years of study, the monthly noise level ranged from 45 dBA – 82.7 dBA. The highest monthly noise level (82.7 dBA) was found in Bazar Bungkawn in the month of August 2009 and the lowest monthly noise level (45 dBA) was found in Govt. Mizo HSS in the month of December, 2009. The overall mean level of noise was highest (70 dBA) in HB Motors with an SD of ± 3.05 and in Bazar Bungkawn with an SD of ± 3.28. The lowest value of mean noise level (54 dBA) was found in Civil Secretariat Complex with and SD of ± 3.22 (Figure-5.9).

5.1.4 Comparison of mean noise level in different zones and national standard:

Figure 5.10. Comparative chart of mean noise level and national standard in different zone



The result shows that the mean noise level was highest in industrial zone (67.7 dBA) but was within the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000 (i.e., 75 dBA). The second highest mean noise level was in commercial zones (64.8 dBA) and was also found to be lower, but almost same with the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000 (i.e., 65 dBA). The mean noise level in residential zone (63.7 dBA) was found to be higher than the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000 (i.e., 55 dBA). The lowest mean noise level was found in silence zone (57.2 dBA) that exceeded the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000, i.e., 50 dBA (Figure-5.10).

5.2 Effects of noise pollution in the study area:

Study on the effects of noise pollution was carried out with the help of questionnaire. The questionnaire was responded by 100 people each in commercial

zone, residential zone and silence zone. In industrial zone, since the study was continued only in three sites only 90 respondents answered the questionnaire. (The questionnaire for the present study is given in Appendix- III).

The results obtained from the questionnaire are presented below:

5.2.1 Presence of noise problems in the study area

The responses on presence of noise problems in different zones are presented in the following tables:

Table 5.1. Presence of noise problems in industrial zone

Presence of noise problem	Industrial Estate	HB Motors	LBS Bike Bazar	Total
Yes	60 (100)	10 (76.9)	17 (100)	87 (96.7)
No	0	3 (23.1)	0	3 (3.3)
No. of Respondent	60	13	17	90

(Figures in parentheses are percentage)

In industrial zone, 96.7% of the respondents said that noise problems occurred in their area. All the respondents in Industrial Estate, Zuangtui and LBS Bike Bazar said that noise problems occurred in their area and, 76.9% of respondents in HB Motors said that noise problems occurred in their area (Table-5.1).

Table 5.2. Presence of noise problems in commercial zone

Presence of noise problem	New Market	Millennium Centre	Zangena Petrol Pump	MIZOFED Petrol Pump	Total
Yes	40 (100)	26 (66.7)	11 (100)	9 (90)	86 (86)
No	0	13 (33.3)	0	1 (10)	14 (14)
No. of Respondent	40	39	11	10	100

(Figures in parentheses are percentage)

In commercial zone, 86% of the respondents said that noise problems occurred in their area. All the respondents in New Market and Zangena Petrol Pump said that noise problems occurred in their area. 90% of the respondents in MIZOFED Petrol Pump said that noise problems occurred in their area, and presence of noise problems was lowest in Millennium Centre, 66.7% of the respondents said that noise problems occurred in their area (Table-5.2).

Table 5.3. Presence of noise problems in residential zone

Presence of noise problem	Chaltlang	Bazar Bungkawn	College Veng	Sikulpuikawn	Total
Yes	18 (72)	25 (100)	20 (80)	25 (100)	88 (88)
No	7 (28)	0	5 (20)	0	12 (12)
No. of Respondent	25	25	25	25	100

(Figures in parentheses are percentage)

In residential zone, 88% of the respondents said that noise problems occurred in their area. All the respondents in Bazar Bungkawn and Sikulpuikawn said that noise problems occurred in their area. Presence of noise problems was lowest in Chaltlang, 72% of the respondents said that noise problems occurred in their area. 80% of the respondents in College Veng said that noise problems occurred in their area (Table-5.3).

Table 5.4. Presence of noise problems in silence zone

Presence of noise problem	Civil Sect. Complex	Civil Hospital	Govt. Mizo HSS	MZU Campus	Total
Yes	10 (38.5)	19 (95)	19 (79.2)	14 (46.7)	62 (62)
No	16 (61.5)	1 (5)	5 (20.8	16 (53.3)	38 (38)
No. of Respondent	26	20	24	30	100

(Figures in parentheses are percentage)

In silence zone, 62% of the respondents said that noise problems occurred in their area. Presence of noise problems was highest in Civil Hospital, 95% of the respondents in Civil Hospital said that noise problems occurred in their area. 79.2% of respondents from Govt. Mizo HSS and 46.7% of respondents from MZU Campus said that noise problems occurred in their area. Complaint on noise problems was lowest in Civil Secretariat Complex, 38.5% of the respondents in this area said that noise problems occurred in their area (Table-5.4).

Table 5.5. Comparison of presence of noise problems in different zone

Presence of noise problem	Industrial Zone	Commercial Zone	Residential Zone	Silence Zone	Total
Yes	87 (96.7)	86 (86)	88 (88)	62 (62)	320 (82.1)
No	3 (3.3)	14 (14)	12 (12)	38 (38)	70 (17.9)
No. of Respondent	90	100	100	100	390

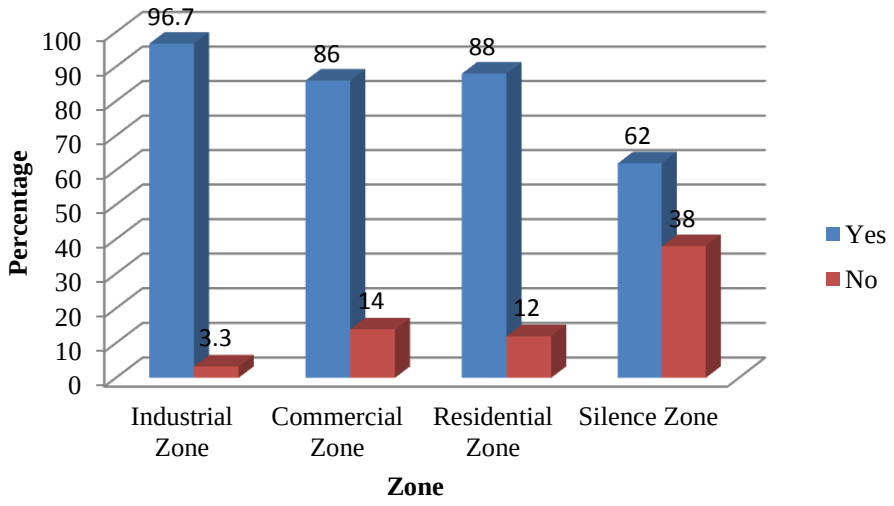
(Figures in parentheses are percentage)

Out of the total respondents, 82.1% said that noise problems occurred in their area. 96.7% of the respondents in industrial zone said that noise problems occurred in their area. 88% of respondents from residential zone and 86% of respondents from commercial zone said that noise problems occurred in their area. Presence of noise

problems was lowest in silence zone, 62% of the respondents from silence zone said that noise problems occurred in their area (Table-5.5).

The comparative chart showing the presence of noise problems in different zones is shown in the following figure:

Figure 5.11. Comparative chart of presence of noise problem in different zones



The present study reveals that the percentage of respondents having noise complaints was highest in industrial zone followed by residential zone, commercial zone and silence zone (Figure-5.11).

A positive and significant correlation of noise intensity was established with the presence of noise problem in the study area (Appendix – IV).

5.2.2 Problems faced due to noise pollution in the study area

Noise pollution caused different types of problem in the study area. The type of problems faced by the respondents was different since the tolerance level of noise was different among different people. The different types of problems faced by the inhabitants in the study area are presented in the following tables:

Table 5.6. Types of problem faced in industrial zone

Problem	Industrial Estate	HB Motors	LBS Bike Bazar	Total
Annoyance	35 (58.3)	8 (61.5)	11 (64.7)	54 (60)
Sleep disturbance	6 (10)	0	2 (11.8)	8 (8.9)
Stress	19 (31.7)	0	5 (29.4)	24 (26.7)
No. of respondents	60	13	17	90

(Figures in parentheses are percentage)

In industrial zone, the major problem faced by inhabitants was annoyance. Respondents from both Industrial Estate and LBS Bike Bazar were having annoyance, stress and sleep disturbance while respondents from HB Motors were having only annoyance. 60% of the total respondents said that noise pollution caused annoyance to them. 26.7% of the respondents were having stress due to noise pollution and respondents having insomnia due to noise pollution was 8.9% (Table-5.6).

Table 5.7. Types of problem faced in commercial zone

Problem	New Market	Millennium Centre	Zangena Petrol Pump	MIZOFED Petrol Pump	Total
Annoyance	28 (70)	12 (30.8)	4 (36.4)	1(10)	45 (45)
Sleep disturbance	4 (10)	1(2.6)	0	3 (30)	8 (8)
Stress	14 (35)	3 (7.7)	0	3 (30)	20 (20)
No. of respondents	40	39	11	10	100

(Figures in parentheses are percentage)

In commercial zone, three sites such as New Market, Millennium Centre and MIZOFED Petrol Pump were having annoyance, stress and sleep disturbance while respondents from Zangena Petrol Pump were having only annoyance. Annoyance was

the major problem faced in New Market, Millennium Centre and Zangena Petrol Pump. 45% of the total respondents said that noise pollution caused annoyance to them. The major problems faced in MIZOFED Petrol Pump were stress and sleep disturbance. Out of the total respondents, 20% said that they were having stress and 8% of the respondents said that they were having sleep disturbance due to noise pollution (Table-5.7).

Table 5.8. Types of problem faced in residential zone

Problem	Chaltlang	Bazar Bungkawn	College Veng	Sikulpuikawn	Total
Annoyance	13 (52)	14 (56)	10 (40)	17 (68)	54 (54)
Sleep disturbance	2 (8)	8 (32)	0	4 (16)	14 (14)
Stress	3 (13)	8 (32)	0	10 (40)	21 (21)
No. of respondents	25	25	25	25	100

(Figures in parentheses are percentage)

In residential zone, the major problem faced in each site was annoyance. Three sites such as Chaltlang, Bazar Bungkawn and Sikulpuikawn were having annoyance, stress and sleep disturbance. The only problem faced in College Veng was annoyance. Out of the total respondents, 54% said that annoyance is the problem they faced due to noise pollution. 21% of the respondents were having stress, and 14% of the respondents were having sleep disturbance due to noise pollution in their area (Table-5.8).

Table 5.9. Types of problem faced in silence zone

Problem	Civil Sect. Complex	Civil Hospital	Govt. Mizo HSS	MZU Campus	Total
Annoyance	5 (19.2)	10 (50)	19 (79.2)	11 (36.7)	45 (45)
Sleep disturbance	1 (3.8)	0	2 (8.3)	6 (20)	9 (9)
Stress	1 (3.8)	0	3 (12.5)	6 (20)	10 (10)
No. of respondents	26	20	24	30	100

(Figures in parentheses are percentage)

The major problem faced in all the sites under silence zone was annoyance. Three sites such as Civil Secretariat Complex, Govt. Mizo HSS and MZU Campus were having annoyance, stress and sleep disturbance respondents from Civil Hospital were having only annoyance. Out of the total respondents, 45% said that noise pollution caused annoyance to them. 10% of the respondents were having stress and 9% of the respondents were having sleep disturbance due to noise pollution in their area (Table-5.9).

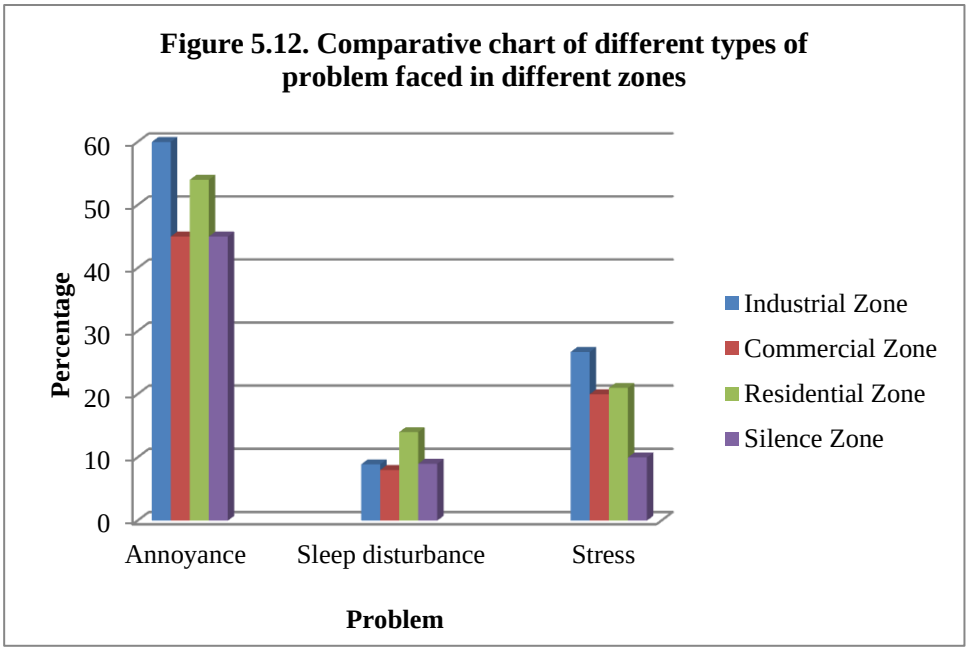
Table 5.10. Comparison of types of problem faced in different zone

Problem	Industrial Zone	Commercial Zone	Residential Zone	Silence Zone	Total
Annoyance	54 (60)	45 (45)	54 (54)	45 (45)	198 (50.7)
Sleep disturbance	8 (8.9)	8 (8)	14 (14)	9 (9)	39 (10)
Stress	24 (26.7)	20 (20)	21 (21)	10 (10)	75 (19)
No. of respondents	90	100	100	100	390

(Figures in parentheses are percentage)

The result shows that the major problem faced in the study area was annoyance. About half of the total respondents were having annoyance due to noise pollution. 19% were having stress and 10% were having sleep disturbance due to noise pollution in their area (Table-5.10).

The comparative chart showing the different types of problem in the study area is shown in the following figure:



The percentage of respondents having annoyance was highest in industrial zone followed by residential zone. Commercial zone and silence zone were having the lowest percentage of respondents facing annoyance. The percentage of respondents having stress was highest in industrial zone followed by residential zone, commercial zone and silence zone. The percentage of respondents having sleep disturbance was highest in residential zone, followed by silence zone, industrial zone and commercial zone (Figure-5.12).

Statistical analysis reveals that there was a positive correlation of noise intensity with annoyance, stress and insomnia (Appendix – V).

5.2.3 Health problems of the respondents

Noise pollution can directly and indirectly affect human health. The effects of noise pollution such as annoyance, stress and insomnia can lead to certain diseases.

The inhabitants in the study area were also having different health problems that can be cause by noise pollution.

The health problems of the inhabitants in the study area are presented in the following:

Table 5.11. Health problems of the respondents in industrial zone

Disease	Industrial Estate	HB Motors	LBS Bike Bazar	Total
Cardiovascular disease	0	2 (15.4)	2 (11.8)	4 (4.4)
Headache	18 (30)	1 (7.7)	5 (29.4)	24 (26.7)
Hearing problem	1 (1.7)	0	0	1 (1.1)
No. of respondents	60	13	17	90

(Figures in parentheses are percentage)

The respondents in industrial zone were having headache, cardiovascular disease and hearing problem. Out of the total respondents 26.7% were having headache. 4.4% were having cardiovascular disease and 1.1% were having hearing problem. The percentage of respondents having headache was highest in Industrial Estate, Zuangtui followed by LBS Bike Bazar and HB Motors. Respondents from Industrial Estate were having headache and hearing problem while respondents from HB Motors and LBS Bike Bazar were having headache and cardiovascular disease (Table-5.11).

Table 5.12. Health problems of the respondents in commercial zone

Disease	New Market	Millennium Centre	Zangena Petrol Pump	MIZOFED Petrol Pump	Total
Cardiovascular disease	4 (10)	1 (2.6)	0	0	5 (5)
Diabetes	1 (2.5)	0	0	0	1 (1)
Headache	11 (27.5)	4 (10.3)	1 (9.1)	3 (30)	19 (19)
Hearing problem	0	1 (2.6)	0	0	1 (1)
Kidney problem	1 (2.5)	0	0	0	1 (1)
Lung disorder	0	1 (2.6)	0	0	1 (1)
No. of respondents	40	39	11	10	100

(Figures in parentheses are percentage)

In commercial zone, respondents were having cardiovascular disease, diabetes, headache, hearing problem, kidney problem and lung disorder.19% of the respondents were having headache, and 5% of the respondents were having cardiovascular disease. 1% each of the respondents was having diabetes, lung disorder, hearing problem and kidney problem. The percentage of respondents having headache was highest in MIZOFED Petrol Pump followed by New Market, Millennium Centre and Zangena Petrol Pump. Respondents in New market were having headache, cardiovascular disease, diabetes and kidney problem. Respondents in Millennium Centre were having headache, cardiovascular disease, lung disorder and hearing problem, while respondents in Zangena Petrol Pump and MIZOFED Petrol Pump were having only headache (Table-5.12).

Table 5.13. Health problems of the respondents in residential zone

Disease	Chaltlang	Bazar Bungkawn	College Veng	Sikulpuikawn	Total
Cardiovascular disease	2 (8)	5 (20)	1 (4)	1 (4)	9 (9)
Diabetes	3 (12)	6 (24)	1 (4)	1(4)	11 (11)
Headache	5 (20)	6 (24)	0	11(44)	22 (22)
Hearing problem	0	2 (8)	0	2 (8)	4 (4)
Kidney problem	0	1 (4)	0	0	1 (1)
Lung disorder	2 (8)	6 (24)	0	4 (16)	12 (12)
No. of respondents	25	25	25	25	100

(Figures in parentheses are percentage)

Respondents in residential zone were having cardiovascular disease, diabetes, headache, hearing problem, kidney problem and lung disorder. The percentage of respondents having headache, lung disorder, diabetes, cardiovascular disease, hearing problem and kidney problem was 22%, 12%, 11%, 9%, 4% and 1% respectively. Respondents in Chaltlang were having headache, cardiovascular disease, diabetes and lung disorder. Respondents in Bazar Bungkawn were having headache, cardiovascular disease, diabetes, lung disorder, hearing problem and kidney problem. In Sikulpuikawn, the diseases of the respondents were headache, cardiovascular disease, diabetes, lung disorder and hearing problem while respondents in College Veng were having only cardiovascular disease and diabetes (Table-5.13).

Table 5.14. Health problems of the respondents in silence zone

Disease	Civil Sect. Complex	Civil Hospital	Govt. Mizo HSS	MZU Campus	Total
Cardiovascular disease	1 (3.8)	0	5 (20.8)	0	6 (6)
Diabetes	0	0	1 (4.2)	0	1 (1)
Headache	2 (7.7)	1 (5)	5 (20.8)	7 (23.3)	15 (15)
No. of respondents	26	20	24	30	100

(Figures in parentheses are percentage)

The diseases of the respondents in silence zone were cardiovascular disease, diabetes and headache. Out of the total respondents 15% were having headache, 6% were having cardiovascular disease and 1% was having diabetes. The percentage of respondents having headache was highest in MZU Campus followed by Govt. Mizo HSS, Civil Secretariat and Civil Hospital. Respondents in Civil Secretariat were having headache and cardiovascular disease. Respondents in Govt. Mizo HSS were having headache, cardiovascular disease and diabetes while respondents in Civil Hospital and MZU Campus were having only headache (Table-5.14).

Table 5.15. Comparison of health problems of the respondents in different zone

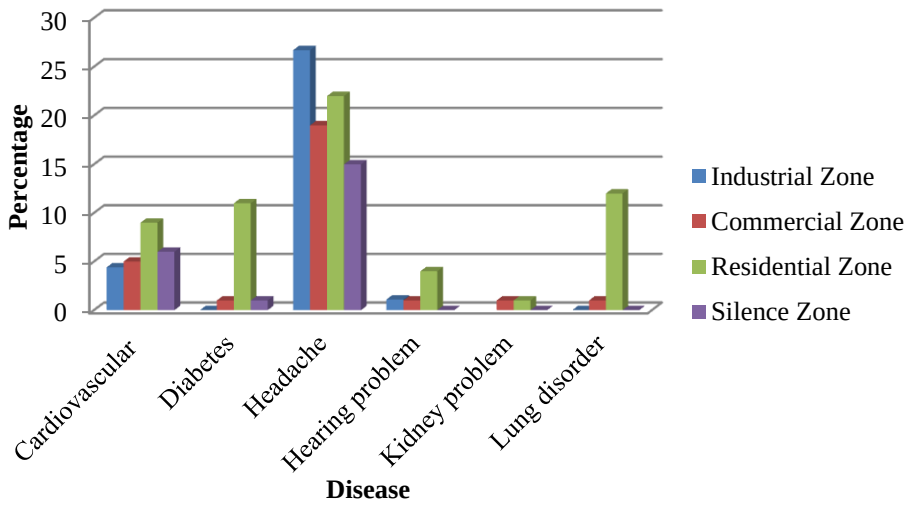
Disease	Industrial Zone	Commercial Zone	Residential Zone	Silence Zone	Total
Cardiovascular disease	4 (4.4)	5 (5)	9 (9)	6 (6)	24 (6.2)
Diabetes	0	1 (1)	11 (11)	1 (1)	13 (3)
Headache	24 (26.7)	19 (19)	22 (22)	15 (15)	80 (20.5)
Hearing problem	1 (1.1)	1 (1)	4 (4)	0	6 (1.5)
Kidney problem	0	1 (1)	1 (1)	0	2 (0.5)
Lung disorder	0	1 (1)	12 (12)	0	13 (3)
No. of respondents	90	100	100	100	390

(Figures in parentheses are percentage)

The most common type of noise related disease in the study area was headache. Out of the total respondents 20.5% were having headache. 6.2% of the respondents were having cardiovascular disease and 3% each were having diabetes and lung disorder, 1.5% of the respondents said that they were having one of the most common types of noise related disease called hearing problem and 0.5% were having kidney problem (Table-5.15).

The comparative chart showing the types of disease faced in different zones is shown in the following figure.

Figure 5.13. Comparative chart of diseases of the respondents in different zones



The study reveals that respondents having headache was highest in industrial zone followed by residential zone, commercial zone and silence zone. Respondents' having cardiovascular diseases was highest in residential zone followed by silence zone, commercial zone and industrial zone. Diabetes problem was found only in three zones such as residential zone, commercial zone and silence zone, and residential zone showed the highest percentage of respondents having diabetes. Lung disorder was found in residential zone and commercial zone only, residential zone showed the

higher percentage of respondents having lung disorder. Hearing problem was found in three zones such as residential zone, industrial zone and commercial zone. The highest percentage of respondents having hearing problem was found in residential zone followed by industrial zone and commercial zone. Kidney problem was found only in two zones such as commercial zone and residential zone, and the percentage of respondents having kidney problem was same in these two zones (Figure-5.13).

A positive correlation of noise intensity was established with headache, cardiovascular disease, stomach ulcer, diabetes, lung disorder, hearing problem and kidney problem (Appendix – VI).

5.2.4 Noise related diseases in Civil Hospital, Aizawl

The health status of the in-patient was collected from the Civil Hospital, Aizawl and noise related diseases were listed out. The observation is shown in the following table:

Table 5.16. Noise related diseases in Civil Hospital during the year 2009-2010

	YEAR	
NAME OF DISEASES	**2009**	**2010**
Cardiovascular disease	298	493
Diabetes	129	175
Hearing problem	266	407
Headache	13	10
Kidney problem	126	176
Lung disorder	742	820
TOTAL	**1574**	**2081**

During the year 2009, out of the total cases, 1574 recorded diseases were the diseases that can be caused by noise pollution and these diseases were increased to 2081 in the next year, 2010 (Table-5.16).

5.3 Sources of noise in the study area

The sources of noise in the study area were also identified by using questionnaire. The respondents from different zones listed out the different sources of noise in their area.

5.3.1 Responses from different zones

The different sources of noise listed out by the respondents from the four zones are presented in the following tables:

Table 5.17. Sources of noise in industrial zone

Sources of noise	Industrial Estate	HB Motors	LBS Bike Bazar	Total
Machine	59 (98.3)	13 (100)	5 (29.4)	77 (85.6)
Vehicle	31 (51.7)	13 (100)	17 (100)	61 (68)
Others	0	0	15 (88.2)	15 (16.7)
No. of respondents	60	13	17	90

(Figures in parentheses are percentage)

The major source of noise identified in industrial zone was machine. 85.6% of the respondents said that machines were the sources of noise and 68% of the respondents said that vehicles were the sources of noise in their area. 16.7% of the respondents said that there were other sources of noise such as religious places/activities, house-hold items, fireworks, loud music, loudspeaker, etc. All the respondents in HB Motors identified machines and vehicles as the sources of noise. In Industrial Estate, 98.3% of the respondents said that machines were the sources of noise and 51.7% said that vehicles were the source of noise in their area. All the

respondents in LBS Bike Bazar said that vehicles were the sources of noise and 29.4% said that machines were the sources of noise in their area (Table-5.17).

Table 5.18. Sources of noise in commercial zone

Source of noise	New Market	Millennium Centre	Zangena Petrol Pump	MIZOFED Petrol Pump	Total
People	37 (92.5)	13 (33.3)	0	3 (30)	53 (53)
Vehicles	26 (65)	27 (69.2)	11 (100)	10 (100)	74 (74)
Others	0	0	0	3 (30)	3 (3)
No. of respondents	40	39	11	10	100

(Figures in parentheses are percentage)

In commercial zone, 74% of the respondents said that vehicles were the sources of noise and 53% said that people were the sources of noise. 3% of the respondents said that there were other sources of noise such as religious places/activities, house-hold items, fireworks, loud music, loudspeaker, etc. All the respondents in Zangena Petrol Pump and MIZOFED Petrol Pump identified vehicles as the sources of noise in their area. In New Market, 92.5% said that people were the sources of noise, and 65% said that vehicles were the sources of noise. 69.2% of the respondents in Millennium Centre identified vehicles as the sources of noise and 33.3% identified people as the sources of noise in their area (Table-5.18).

Table 5.19. Sources of noise in residential zone

Source of noise	Chaltlang	Bazar Bungkawn	College Veng	Sikulpuikawn	Total
Animal	1 (4)	0	0	0	1 (1)
People	2 (8)	5 (20)	0	6 (24)	13 (13)
Vehicles	24 (96)	25 (100)	21 (84)	25 (100)	95 (95)
Others	0	2 (8)	0	0	2 (2)
No. of respondents	25	25	25	25	100

(Figures in parentheses are percentage)

Out of the total respondents in residential zone 95% said that vehicles were the sources of noise, 13% said that people were the sources of noise and 1% identified animals as the sources of noise. Besides these identified sources, 2% of the respondents said that there were other sources of noise such as religious places/activities, house-hold items, fireworks, loud music, loudspeaker, etc. in their area. All the respondents in Bazar Bungkawn and Sikulpuikawn said that vehicles were the sources of noise in their area. 96% of the respondents in Chaltlang and 84% of the respondents in College Veng identified vehicles as the sources of noise. People were identified as the sources of noise by 24%, 20% and 8% of the respondents in Sikulpuikawn, Bazar Bungkawn and Chaltlang respectively (Table-5.19).

Table 5.20. Sources of noise in silence zone

Source of noise	Civil Sect. Complex	Civil Hospital	Govt. Mizo HSS	MZU Campus	Total
Animal	6 (23.1)	0	2 (8.3)	5 (16.7)	13 (13)
People	11 (42.3)	4 (20)	16 (66.7)	9 (30)	40 (40)
Vehicles	21 (80.8)	18 (90)	20 (83.3)	14 (46.7)	73 (73)
Others	12 (46.2)	0	9 (37.5)	5 (16.7)	26 (26)
No. of respondents	26	20	24	30	100

(Figures in parentheses are percentage)

The different sources of noise identified in silence zone were animals, people and vehicles. The major sources of noise in silence zone were vehicles. 73% of the total respondents said that vehicles were the sources of noise. 40% of the respondents said that people were the sources of noise and 13% said that animals also contributed to noise. 26% said that there were other sources like religious places/activities, house-hold items, fireworks, loud music, loudspeaker, etc. in their area. In Civil Secretariat Complex, 80.8% said that vehicles were the sources of noise, 42.3% said that people were the sources of noise and 23.1% said that animals were the sources of noise in their area. Respondents from Civil Hospital identified vehicles (90%) and people (20%) as the sources of noise in their area. Majority of the respondents from Govt. Mizo HSS said that vehicles and people were the sources of noise. In MZU Campus, 46.7% identified vehicles and 30% identified people as the sources of noise in their area (Table-5.20).

Table 5.21. Comparison of sources of noise in different zone

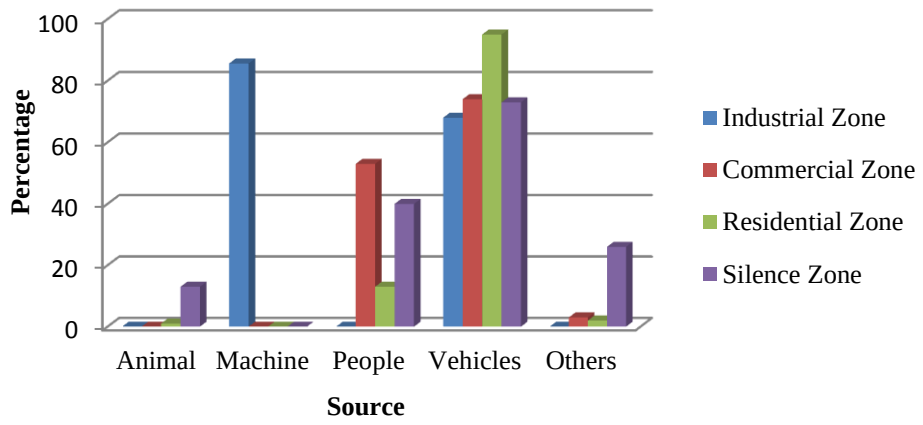
Source of noise	Industrial Zone	Commercial Zone	Residential Zone	Silence Zone	Total
Animal	0	0	1 (1)	13 (13)	14 (3.6)
Machine	77 (85.6)	0	0	0	77 (19.7)
People	0	53 (53)	13 (13)	40 (40)	106 (27)
Vehicles	61 (68)	74 (74)	95 (95)	73 (73)	303 (77.7)
Others	0	3 (3)	2 (2)	26 (26)	31 (7.9)
No. of respondents	90	100	100	100	390

(Figures in parentheses are percentage)

The different sources of noise identified in the study area were vehicles, people, machines and animals. From the total respondents, 77.7% said that vehicles were the sources of noise in their area. In industrial zone, identified sources of noise were vehicles (67.8%) and machine (85.6%). 74% of respondents from commercial zone identified vehicles as the sources of noise and 53% identified people were also the source of noise in their area. In residential zone, 95% of respondents said that vehicles were sources of noise. 13% said that people were the sources of noise and 1% said that animals were also the sources of noise in their area. In silence zone, 73% of the respondents identified vehicles as the sources of noise, 40% identified that people were the sources of noise and 13% said that animals were also the sources of noise (Table-5.21).

The comparative chart showing the sources of noise in different zones is shown in the following figure:

Figure 5.14. Comparative chart of sources of noise in different zones

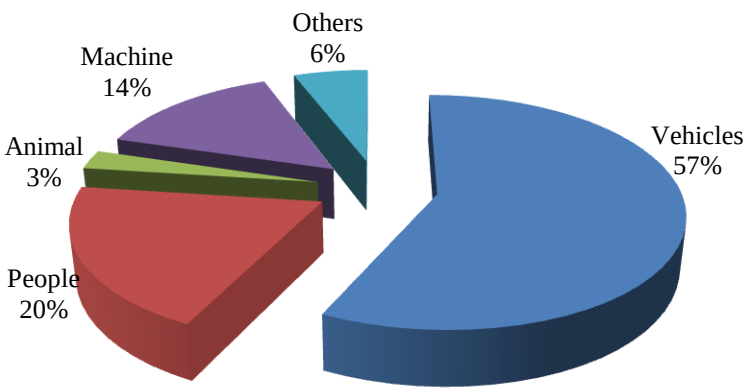


The study reveals that vehicles sources were highest in residential zone followed by commercial zone, silence zone and industrial zone. People sources of noise were highest in commercial zone followed by silence zone and residential zone. Machines as the sources of noise were identified only in industrial zone and, animals as the sources of noise were identified in silence zone and residential zone (Figure-5.14).

5.3.2 Contribution of different sources of noise (in percentage)

The contribution percentage of different identified sources in the study area was calculated and presented in the following figure:

Figure 5.15. Contribution of different sources of noise in the study area



The result shows that the major source of noise in the study area was vehicle that contributed about 57% of the total sources of noise. Other sources of noise were people that contributed about 20% of noise source, machine that mainly came from industry contributed about 14% of the total sources of noise. 3% of the sources of noise were contributed by animals and the rest 6% of the noise came from other sources (Figure - 5.15).

DISCUSSION

Noise is one of the physical factors that are outcome of our modern life. Noise pollution including noise from transport, workshop, factory, construction activities and neighbours is a significant environmental problem in many rapidly urbanizing areas. Migration of people from rural to urban areas, expansion of cities, infrastructure development and population growth are important factors resulting in motorization and consequent increase in levels of various urban pollution (Banerjee, 2008; Duran and Gonzalez, 2009; Roozbahani *et al.*, 2009; Omidvari and Nouri, 2009).

Noise Level in the study sites:

The present study reveals that the noise level in all the three sites under industrial zone were within the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000, however, the mean noise level in HB Motors was close to the noise standard. Similar observation was reported by Abiodun (2011) and Hunashala and Patil (2012). Industries in Aizawl city are small as compared to those of other cities. The type of industries is usually of small scale industry. The machines used are also simple and the noises produced are not so high. The numbers of people working in these sites are also less as compared to big industries of other cities. This may result in the noise level lower than the national standard. But, the noise level is likely to increase in all these sites in the near future due to development and improvement in the quality and use of machines, and also due to rapid and unplanned urbanization. Only 1.1% of the total respondents in industrial zone said that they were using ear protection device while working. Even though the noise level did not exceed the national standard, 96.7% of the respondents from industrial area said that noise problems occurred in their area. More than half of the respondents said

that noise pollution caused annoyance to them. Other complaints like stress, insomnia, headache, cardiovascular disease and hearing loss also occurred in the area. This may be due to continuous exposure to noise pollution. According to Bande *et al.* (2013), the slightest unwanted sound can become very annoying if it continues for any length of time. Nelson (1987) reported that long term exposure to occupational noise can result in permanent hearing loss. Commonly experienced noise effects may also include annoyance deterioration of sleep quality, and stress-related various type of heart disease. Kiernan (1997) also finds that an even relatively low level of noise affects human health adversely. It may cause hypertension, disrupt sleep and/or hinder cognitive development in children. In Industrial Estate, Zuangtui, the noise level was increased in the second year. The other two sites showed decrease in noise level. The decrease in noise level in HB Motor Works was due to the reason that part of the workshop was shifted to some other place in the second year, thereby leaving the workshop with lesser number of machines and workers. LBS Bike Bazar which was located on the roadside was a combination of bike workshop and a showroom for accessories. In the second year, the bike workshop was shifted downstairs in the same building that resulted in the decrease of noise level since the noise came from the workshop only.

Two sites in commercial area such as New Market and Zangena Petrol Pump exceeded the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000. But, the overall mean noise level in commercial zone was within the national standard. Similar observation was shown by Hunashala and Patil (2012). Naik (2005) also reported that the noise levels two study sites in commercial area of Rourkela exceed the noise standard while in other two sites the noise level exceed the standard only during the busy transaction hours, and not the whole day. New Market

is the biggest market in Aizawl city and is located in the centre of the city. Thousands of people moving in and out of this market every day. This is the main reason for the high level of noise in this area. Zangena Petrol Pump is also one of the biggest and oldest petrol pumps in the city and is situated along the roadside that makes the noise level high in the area. Researches have proved that a loud noise during peak marketing hours creates tiredness, irritation and impairs brain activities so as to reduce thinking and working abilities (Mahandiyan, 2006). The noise levels in all the sites under commercial zone were increased mainly due to vehicular noise. Similar observation was reported by Mirsanjari and Zorufchin (2012).

All the study sites in residential zone exceeded the national standard for noise level. This result is similar with the observation reported by Ravichandran *et al.* (1997), Naik (2005), Vartika (2011) and Singh and Dadoriya (2013). The highest mean noise level was found in Bazar Bungkawn. Although Bazar Bungkawn is a residential site it is located at the market area. The predominant source of noise in this site was traffic noise. Vehicular traffic noise problem is contributed by various kinds of vehicles like medium trucks/buses, automobiles and two wheelers heavy moving vehicle during morning time. Similar trend of result was reported by Skanberg and Ohsrom (2002), Calixto *et al.* (2003), Piccolo *et al*. (2004), Al-Harthy and Al-Jabri (2006), Aftab *et al*. (2007) and Murthy *et al*. (2007). The lowest noise level was observed in College Veng which is located at the eastern part of the city and is far from the market area. The main contributor for noise in this area was also automobile, but lesser as compared to other residential areas.

In silence zone also, the noise level in all the study sites were above the national standard. Similar observation was reported by Ravichandran *et al.* (1997), Vartika (2011), Mangalekar *et al*. (2012), Singh and Dadoriya (2013) and

Balashanmugam *et al*. (2013b). The highest noise level among the silence zone was observed in Civil Hospital which is located in the centre of the city and in the market area. As it is the government hospital and the biggest hospital in the city the number of patients and visitors was higher as compared to other hospitals of Aizawl city. Sometimes, loud speakers are used in this hospital that also contributes to high level of noise. A survey in Roorkee carried out by Mishra *et al.* (2008) also found out that automobile and loudspeaker are the major sources of noise pollution in the study area. The lowest noise level in the present study was observed in Civil Secretariat Complex. Civil Secretariat Complex is located far from the market place. The main source of noise in this place is automobile but lesser as compared to other sites in silence zone.

From the present study, it was found out that the noise level was highest in industrial zone followed by commercial zone, residential zone and silence zone. Similar trend of result was reported by Hunashala and Patil (2012) and Mangalekar *et al*. (2012).

Effects of noise pollution in the study area:

The present study reveals that majority of the respondents said that noise problems occurred in their area. The effects may not be same since the tolerance level is different among different people. The general types of effects caused by noise pollution in the study area were annoyance, sleep disturbance and stress. This result is consistent with the results reported by Franssen *et al*. (2002) , Shobaki and Jamrah (2008), Nandanwar *et al.* (2009), Goswami (2009), Wani and Jaiswal (2010), Patil *et al.* (2011), Reddy and Jherwar (2012). The most widespread and well documented subjective response to noise is annoyance, which may include fear and mild anger, related to a belief that one is being avoidably harmed (Cohen and Weinstein, 1981).

The degree of annoyance produced by noise may vary with time of the day, the unpleasant characteristics of the noise, the duration and intensity of the noise, the meaning associated with it, and the nature of activity that the noise interrupted (Berglund and Lindvall, 1995).

Social surveys conducted in various cities throughout the world also revealed that road traffic noise is the major source of nuisance and annoyance (Dora, 1999). Because of its annoyance and disturbance implications, noise adds to mental stress and hence affects the general well-being of those exposed to it (Balashanmugam *et al*., 2013b). A 2005 study by Spanish researchers found that in urban areas households are willing to pay approximately four Euros per decibel per year for noise reduction (Barreiro *et al*., 2005).

Environmental noise is one of the major causes of disturbed sleep. Noise exposure during sleep may increase blood pressure, heart rate and finger pulse amplitude as well as body movements. There may also be after-effects during the day following disturbed sleep; perceived sleep quality, mood and performance in terms of reaction time all decreased following sleep disturbed by road traffic noise (Stansfeld and Matheson, 2003).

The World Health Organization (WHO) states that there is sufficient evidence that night noise exposure causes self-reported sleep disturbance and noise induced sleep disturbance is viewed as a health problem. WHO also state that there is evidence, albeit limited, that disturbed sleep causes fatigue, accidents and reduced performance (Naish *et al*., 2012). According to Goines and Hagler (2007) acute exposure to noise activates nervous and hormonal responses, leading to temporary increases in blood pressure, heart rate, and vasoconstriction. It is known, for example,

that continuous noise in excess of 30 dB disturbs sleep. For intermittent noise, the probability of being awakened increases with the number of noise events per night.

Respondents in the study area were also having many health problems which are related to noise pollution such as cardiovascular disease, diabetes, headache, hearing problem, kidney problem and lung disorders. Similar observation was reported by Weber *et al.* (1967), Fearn and Hanson (1984), Axelsson and Hamernik (1987), Nagi *et al*. (1993), Murthy *et al*. (2007), Aslam *et al*. (2008), Nandanwar *et al.* (2009), Agarwal and Swami (2011) and Reddy and Jherwar (2012). Noise pollution causes significant health effects, such as cardiovascular problems, hypertension, increased levels of diabetes, changes in social behaviour and induces depressive tendencies (WHO 2001). From the record of the Civil Hospital, Aizawl, about 1574 cases recorded during the year 2009 were diseases that can be caused by noise pollution and the cases were increased to 2081 in the next year, 2010. According to Rosen and Olin, (1965) high noise levels can contribute to cardiovascular effects and exposure to moderately high levels during a single eight-hour period causes a statistical rise in blood pressure of five to ten points and an increase in stress. Non-auditory physical health effects that are biologically plausible in relation to noise exposure and annoyance from noise exposure include changes in blood pressure, heart rate, and levels of stress hormones (Babisch *et al*., 2006 and Mahmood *et al*., 2008). Pathak *et al*. (2008) also reported that traffic noise became main reason of headache, high blood pressure, and other stresses among the exposed individuals in adjoining working places in Varanasi city.

One of the most common problems associated with noise is hearing problem which is also seen in the study area. The major cause of hearing loss is occupational exposure, although other sources of noise, particularly recreational noise, may

produce significant deficits. 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. Studies suggest that children seem to be more vulnerable than adults to noise induced hearing impairment (Berglund *et al*., 1999). Exposure to noise during the day also permanently damages our hearing. Noise generated by traffic, noise that we are exposed at work, listening to loud music and most importantly, the neglect of hearing protection are the main causes of noise-induced hearing loss. It has been shown that short exposure to loud noise has the same effect as longer exposure to noise that is somewhat quieter (Suskovic, 2012). Detailed occupational noise studies by a team from Manchester University in 1971 confirmed that noisy industrial process and conditions produced hearing loss to the workers involved (Mahandiyan, 2006).

Noise pollution also has influence on teaching-learning. If the students and teachers are annoyed by noise and if they are having stress and insomnia, it can seriously affect the performance of the students and teachers. Noise pollution has the ability to cause reading delays, behavioural difficulty and constant distraction. Noise intensity level in wider area including its effects on teaching-learning would be interesting to be taken up in future. The effects of noise pollution on cognitive task performance have been well-studied by Valentine *et al*. (2010). Noise pollution impairs task performance at school and at work, increases errors and decreases motivation. Reading attention, problem solving, and memory are most strongly affected by noise. 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.

In residential populations, combined sources of noise pollution will lead to a combination of adverse effects such as impaired hearing; sleep disturbances; cardiovascular disturbances; interference at work, school, and home; and annoyance, among others. These effects are the result of stress from noise, stress that has been increasingly linked to illness (Babisch, 2005).

Sources of noise pollution in the study area:

The present study reveals that the predominant sources of noise in the study area were vehicles. More than half of the sources of noise came from vehicle. Similar result was observed by Skanberg and Ohsrom (2002), Calixto *et al.* (2003), Thangadurai *et al*. (2005), Banerjee *et al.* (2008), Goswami (2009), Agarwal and Swami (2011), Pradhan *et al*. (2012), Subramani *et al*. (2012) and Mirsanjari (2013). Since Aizawl city is not well planned and lack spaces homes, schools, offices, hospitals, commercial business centers, and other community buildings were built close to the main roads of the municipality and in every convenient ways without buffer zones or adequate sound proofing. This improper management and unplanned urbanization coupled with increase in vehicles result in lack of sufficient parking spaces and increase in noise pollution in the city. Traffic noise is probably the most rigorous and pervasive type of noise pollution. Traffic noise has become a serious problem nowadays because of inadequate urban planning of the city in the past. The problem has been compounded by increases in traffic volumes (two wheelers, heavy motor vehicles, and other vehicles) far beyond the expectations of the early urban planners (Balashanmugam *et al*., 2013b). Undoubtedly, the most important source of noise pollution in urban areas is related to road vehicles (Behzad *et al*., 2007). Urban traffic noise is one of the most critical types of noise and normally considered more interfering than the other types of noises (Unweltbundesamt, 2000; Zannin *et al.*,

2003). The noise level increases with increased total number of vehicles and with the increase in speed of vehicles (Subramani *et al*., 2012).

In Mizoram, the number of vehicles on road is increasing every year. The number of vehicles on road in the state from the year 2009 – 2012 is shown in table 5.22.

Table 5.22. Trend in increase of vehicles in Mizoram

Year	No. of vehicles (all types)	Increase percentage
2009 - 2010	80,188	16.00%
2010 – 2011	91,922	14.63%
2011 – 2012	106,105	15.43%

(Source: Economic Survey Mizoram, 2012-13)

The total number of motor vehicles on road in the State up to the end of 2011-2012 for both Private and Government vehicles was 91,922. The number of vehicles on road has increased by 11,734 (14.63%) during 2010-2011 as against 80,188 at the end of the previous year i.e. 2009-2010. And during the year 2011-2012 the number of vehicles on road was increased by 14,183 (11.68%) as against 91,922 at the end of the previous year i.e. 2010-2011. Out of the total number of vehicles during 2011-2012, 56.81% were two wheelers while 36.9% were light motor vehicles (Auto Rickshaw, Motor Cab, Maxi cab, Motor Car, Jeep, and Gypsy). Trucks and Lorries constituted 4.03% and Bus (contract carriage) constituted 1.1% of all vehicles on road (Statistical Handbook, 2012).

Other identified sources of noise in the study area were people, machines and animals. The behaviour of the people greatly influence on the increase and decrease of noise intensity since people themselves are one of the major sources of noise.

Noise is generally produced by industrial activities, transportation and cultural activities, but also by the common individuals (Gloag, 2005). Unnecessary honking and shouting, speed of the vehicles, playing loud music, quarrelling etc. can cause annoyance and disturbance to the neighbours. These activities can be controlled by each individual. Machines especially in industries are another source of noise. At present, there is no separate place or area for different zones, therefore workshops, factories and industries are located within the residential area as well as the commercial area. The noise produced by machines that mainly came from industries may also cause problems to the people staying in the nearby area. This clearly depicts that proper planning and management of the city is important. Industrial noise sources and main roads must be separated from human living place during preparation of city settling plans (Romilly, 1999 and Jans, 2000). Besides the above sources, animals were identified as the source of noise in the study area. The most common noise problem caused by the animal is barking of the dogs.

There were other sources of noise like loudspeaker, religious activities, and household items in the study area. Similar observation was reported by Nagi *et al*. (1993) and Naik and Purohit (2003). Due to development and improvement in the standard of living, household items like washing machine, fans, grinder, air-conditioner, music system and other electronic equipment became one of the common sources of noise. Though they do not cause too much of problem, the effect of noise emitted on human health cannot be neglected. Furthermore, noise can be generated from neighbourhood noise consisting of neighbouring apartments and noise within one's own apartment (Niemann *et al*., 2006).

SUMMARY AND CONCLUSION CHAPTER - VI

Noise pollution is a significant environmental problem in many urban areas and it is predicted that in the near future the intensity of noise and complaints due to noise pollution will increase significantly because of rapid increase in population and unplanned urbanization, business activities, industrialization, technological development and exponential growth of both private and public vehicles in the city. Noise adversely affects general health and well-being in the same way as does chronic stress. It adversely affects future generations by degrading residential, social, and learning environments with corresponding economic losses (Goines and Hagler, 2007). Several researchers worldwide have studied the urban noise pollution showing that noise pollution is becoming a severe problem in the urban environment, and Aizawl city is no exception to it. In Aizawl city, there is no sufficient study about the noise pollution and its effects on human health.

In view of this, the present research was taken up to quantify noise intensity and to assess the effects of noise pollution in Aizawl city. This study also tried to formulate strategies for control of noise pollution in the study area.

Since there is no separate places for establishing workshop/factory, markets, schools, offices and homes the study area was divided into four zones such as industrial zone, commercial zone, residential zone and silence zone. Based on their location four sites each were selected under each zone.

Noise measurement was taken by using Integrating Sound Level Meter 2031A. Readings were taken thrice a day (morning 6 a.m – 7 a.m, daytime 12 noon – 1 p.m and evening 4 p.m – 5 p.m) and twice a month (one week interval) at each site for two years (i.e. August 2009 – July 2010). In case of institutions and workshops

readings were taken from 9 a.m – 10 a.m for morning time since these places were opened only from 9 a.m. After recording Lmax, Lmin and Leq of the noise level, the result was compared with the standards of Noise Pollution (Regulation and Control) Rules, 2000.

The study on the effects of noise pollution was carried out with the help of the following –

(i) Questionnaire: Study on the effects of noise pollution and the health status was conducted by using questionnaire among the inhabitants of the study area such as students and teachers in the institutions, patients in the hospitals, workers in the industries, and certain people in the commercial and residential zones. The sources of noise were also identified by using this questionnaire.

(ii) Hospital Record: Record on the health parameters related to noise pollution was collected from the Civil Hospital, Aizawl.

(iii) Secondary Data: Secondary data was collected from books, reference, e-journals, published articles, internet facilities, government records and publications.

To find out the relation between noise intensity and the presence of problems, types of problems and diseases faced by the inhabitants in the study area correlation coefficients were computed with the help of SPSS package.

The findings of the present study can be summarized as follows:

1. The monthly noise level ranged from 58.9 dBA – 81.1 dBA in industrial zone, 54.3 dBA – 75.5 dBA in commercial zone, 52.8 dBA – 82.7 dBA in residential zone and 45 dBA – 69.3 dBA in silence zone.

2. The yearly noise level in industrial zone ranged from 63.6 dBA – 70.6 dBA. The highest mean noise level was observed in HB Motors, and the lowest mean noise level was observed in LBS Bike Bazar.
3. The noise levels in all the sites under industrial zones were within the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000. This may be due to the reason that industries in Aizawl city are small as compared to those of other cities. The type of industries is usually small scale industry. The machines used are also simple and the noises produced are not so high. The number of people working in these sites is also less compared to big industries in other cities.
4. The yearly noise level in commercial zone ranged from 60.5 dBA – 67.6 dBA. The highest mean noise level was observed in Zangena Petrol Pump, and the lowest mean noise level was observed in Millennium Centre.
5. In commercial zone, noise level in Zangena Petrol Pump and New Market were found to exceed the noise standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000. The noise levels in the other two sites were within the national standard.
6. The high noise level in Zangena Petrol Pump was due to the fact that this petrol pump was one of the biggest and oldest petrol pumps in the city, and it was located on the roadside.
7. New Market is also the biggest market in Aizawl city and is located in the centre of the city. Thousands of people moving in and out of this market every day that contributed to the high level of noise in this area.

8. In residential zone, the yearly noise level ranged from 57.7 dBA – 70.7 dBA. The highest mean noise level was found in Bazar Bungkawn and the lowest mean noise level was found in College Veng.
9. Bazar Bungkawn though a residential site is located at the market area. This results in the high level of noise.
10. The noise levels in all the sites under residential zones were found to exceed the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000.
11. In silence zone, yearly noise level ranged from 53.7 dBA – 63 dBA. The highest mean noise level was found in Civil Hospital and the lowest mean noise level was found in Civil Secretariat Complex.
12. The reason for high noise level in Civil Hospital lies on the fact it is the largest hospital in the city and is located in the market area and centre of the city. As it is the government hospital as well as the largest hospital in the city thousands of patients and visitors also contributed to the high level of noise in the hospital every day. Sometimes, loud speakers are used in this hospital that also contributes to high level of noise.
13. The noise levels in all the four sites under silence zone were found to exceed the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000.
14. Among the four zones studied industrial zone was found to have the highest noise level followed by commercial zone, residential zone and silence zone.

15. The overall mean noise level during the study period was 67.7 dBA in industrial zone, 64.8 dBA in commercial zone, 63.7 dBA in residential zone and 57.2 dBA in silence zone.
16. It has been found out from the study that out of the fifteen study sites, only five of them were within the standard level and the other ten sites exceeded the standard prescribed by the Noise Pollution (Regulation and Control) Rules 2000.
17. Out of the total respondents, 82.1% said that noise problems occurred in their area. A positive and significant correlation of noise intensity was established with the presence of noise problem in the study area.
18. The general problems faced by the respondents were annoyance, stress and insomnia. A positive correlation of noise intensity was established with annoyance, stress and insomnia.
19. Among the general problems, the most common problem was annoyance faced by 50.7% of the total respondents.
20. The most common noise related diseases faced by the respondents was headache. Other diseases faced in the study area were cardiovascular disease, diabetes, lung disorder, hearing loss and kidney problem. A positive correlation of noise was established with these different diseases.
21. During the year 2009, 1574 cases reported in the Civil Hospital were noise related diseases, and the cases were increased to 2081 in the next year.
22. The main source of noise identified in the study area was vehicle that contributes about 57% of the total sources of noise. Other sources of noise identified were people, machines and animals.

The present study depicts that the intensity of noise in Aizawl city is increasing and it certainly will continue to increase due to ongoing urbanization, population growth, increase in vehicles and also due to lack of knowledge and understanding about the health effects of noise pollution. The increase in population coupled with the increase in number of motor vehicles is showing alarming levels of traffic congestion, air pollution, and noise pollution and road accidents (Mishra *et al*., 2010). According to Gayathri *et al*. (2012) prevalence of noise is implicated in various illness of human and it is responsible for increased morbidity associated with modern life style. It is the responsibility of every citizen to prevent the increase of noise intensity. Therefore, it is recommended that awareness about the noise nuisance must be given to the masses of people through education, media, lectures and other programme so that the harmful effects of noise pollution can be reduced and abated.

RECOMMENDATIONS FOR CONTROL AND ABATEMENT OF NOISE POLLUTION:

1. Public must be aware and educate about noise nuisance through adequate news media, lectures, radio talks and other programs.
2. All automobile workshops and other industries should be located far from residential area and those that are on roadsides and public places used to be re-allocated at other peripheral sites of the city.
3. Noise produce from industries can be controlled by covering the room walls with sound absorber as acoustic tiles or construction enclosures around the industrial machinery.
4. The workers exposed to noise can be provided with wearing devices as earplugs and earmuffs.
5. A good and proper planning before building a school is very important.

6. The best way to protect the institutions from noise disturbance is to locate the institutions in isolated areas.
7. Building a high fence using concrete wall or wood around the institutions proves to be useful for protecting the institutions from noise disturbance.
8. Controlling the speed limit of vehicles near school surroundings.
9. Planting of evergreen trees around or nearby areas of noise can proved to be effective measure for control of noise pollution as green trees reduce the intensity of noise.
10. Use of loudspeaker outside close premises induce public nuisance, be it religion or sports or political campaigns or banquet hall should be controlled.
11. To reduce the noise created by vehicles creation of 'No Vehicle Zone' around silence zone is recommended.
12. Old vehicles and bike without silencer should be banned.
13. Avoiding unnecessary use of horn and whistle.
14. Bike racing during night time should be banned.
15. Playing loud music by vehicles during night time should be banned.
16. The role of NGOs, researchers and professionals, media and concerned individuals is significant in minimizing the environmental hazard of noise pollution.
17. Proper implementation of laws to control noise pollution and regular supervision is also one of the important ways to control noise pollution.
18. Prohibition of crackers, lights and bombs during Christmas time and New Year's celebration remarkably and recommendable to be continued.

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Appendix I: Monthly noise level during the first year (August 2009 – July 2010).

SITES	MEAN LEVEL OF NOISE IN dBA (Leq) FROM AUG'09 - JULY'10 (1st YEAR)												
	AUG '09	SEP '09	OCT '09	NOV '09	DEC '09	JAN '10	FEB '10	MAR '10	APR '10	MAY '10	JUN '10	JUL '10	S.D ±
INDUSTRIAL ZONES													
Industrial Estate	74.9	81.1	65.8	61.7	60.8	65.9	64.6	67.8	68.9	63.5	66.7	69.5	5.68
HB Motor Works	71.9	70.9	79.7	67.1	72.3	63.1	71	72.3	70	73.4	67.4	67.7	4.11
LBS Bike Bazar	63.4	64.8	64.2	63.8	62.1	72.1	64.9	67.5	67.4	69.5	70.5	64.8	3.12
COMMERCIAL ZONES													
New Market	63.4	71	68.6	61.3	62	60.5	60.9	66.2	65.5	64.7	72.7	69.9	4.18
Millennium Centre	58.3	55.8	54.3	62	65.2	56.7	64.1	65.3	59.2	62.7	60.5	62.1	3.68
Zangena Petrol Pump	64.8	65.2	70	75.5	72.5	62.3	62.9	66.7	66.4	67	67.1	64.8	3.86
Mizofed Petrol Pump	66.9	64.4	62.9	61.2	61.7	64	60.7	62.3	63.1	63.3	61.9	63.3	1.66
RESIDENTIAL ZONES													
Chaltlang	56.3	61.7	58.3	54.9	53.7	57.6	61.8	54.8	59.8	62.7	59.7	59.8	3
Bazar Bungkawn	82.7	66.7	68.5	67.4	71.1	68	67.7	67.4	66.2	65.7	69	70.6	4.53
College Veng	53.5	52.8	60.1	65.6	53	57.4	53.4	56.1	59.9	58.4	60.1	62	4.07
Sikulpuikawn	69.2	54.9	65.7	57.7	60	66.3	67.1	67.9	68.3	68.2	63.3	67.5	4.69
SILENCE ZONES													
Civil Sect. Complex	53.4	57.5	56.3	51.6	48.1	53.9	53.6	52.1	51.4	53.7	58.6	55.3	2.88
Civil Hospital	63	64.7	64.2	65	61.2	59.1	56.2	59.7	64	66.2	60.8	60.5	2.95
Govt. Mizo HSS	64.2	64.6	60.5	46.4	45	56	58.1	61.1	58.3	56.3	56	55	6.06
MZU Campus	67.9	56.3	64	47.2	51.9	47.5	53.4	51	49.5	51.5	51.3	52.7	6.29

Appendix II: Monthly noise level during the second year (August 2010 – July 2011).

SITES	MEAN LEVEL OF NOISE IN dBA (Leq) FROM AUG'10 - JULY'11 (2nd YEAR)												
	AUG '10	SEP '10	OCT '10	NOV '10	DEC '10	JAN '11	FEB '11	MAR '11	APR '11	MAY '11	JUN '11	JUL '11	S.D ±
INDUSTRIAL ZONES													
Industrial Estate	70.7	67.6	69.3	67.9	67.8	65.7	68.7	69.3	67.3	68.2	69.5	70.4	1.41
HB Motor Works	70.3	70	71	69.6	71.7	69.6	67.5	68.4	68.7	69.2	67.2	68.9	1.32
LBS Bike Bazar	66.9	63.6	67	66.7	64.3	63	62.3	62.1	64	61.7	58.9	62.2	2.42
COMMERCIAL ZONES													
New Market	69.7	68.7	66.8	63.7	71.1	65.3	69.1	65.7	66.2	65.6	65.8	67.3	2.15
Millennium Centre	58	70.7	65.9	55.2	67.6	63	63	63.2	63.3	64.2	59.8	60	4.21
Zangena Petrol Pump	71	65.7	66	64.5	67	66.2	70.1	67.7	66.7	68.1	67.9	70.1	1.98
Mizofed Petrol Pump	73	71.8	66.7	58.5	58.9	56.2	65.1	63.3	63.1	63.5	65.4	62.2	4.99
RESIDENTIAL ZONES													
Chaltlang	61.8	63.3	58.9	60.7	60.6	59.9	60.3	60.9	61.5	64.7	63.9	61.8	1.71
Bazar Bungkawn	69.6	70.5	71.1	69.7	73	70.7	70	70.3	71.2	70.8	70.2	71.4	0.92
College Veng	65.2	61	58.2	57.9	56.7	58	59.1	59.2	58.6	60.5	60.8	60.5	2.21
Sikulpuikawn	68.1	65.1	69	67.9	64.9	67.1	67.1	66.6	66.2	66.2	69.3	68.8	1.46
SILENCE ZONES													
Civil Sect. Complex	54.5	58.4	51.1	61.7	55.6	51.9	49.4	51	51.2	52.9	56.5	56.7	3.65
Civil Hospital	59.5	60.4	58.6	65.1	65.4	60	67.3	68.8	69.3	60.7	59.8	60.8	3.93
Govt. Mizo HSS	53.2	53.5	55.5	53.5	51.3	54.7	58.3	57.6	56.2	64.3	63.3	57	3.95
MZU Campus	51.3	56.5	57.7	59	59.2	52.4	54.8	56.2	56.4	55.5	61.9	62.2	3.33

Appendix III: Questionnaire on Assessment of Noise Pollution and Its Effects on Human Health in Aizawl City, Mizoram

Address:_____ Gender (1 = men, 2 = women):_____
Age:_____ Date of survey (dd/mm/year):_____

1. Do you know what noise pollution is?
   1 = yes 2 = no

2. Is there any problem of noise pollution in your area?
   1 = yes 2 = no 3 = do not know

3. Does any particular noise annoy you on a daily basis?
   1 = yes 2 = no 3 = do not know

4. What are the major sources of noise pollution in your area?

   i. Vehicles
      1 = yes 2 = no 3 = do not know

   ii. People
      1 = yes 2 = no 3 = do not know

   iii. Machines
      1 = yes 2 = no 3 = do not know

   iv. Animals (dogs, cats, etc.)
      1 = yes 2 = no 3 = do not know

   v. Religious places (temple, church, mosque, etc.)
      1 = yes 2 = no 3 = do not know

   vi. House-hold items like washing machines, grinders, etc.
      1 = yes 2 = no 3 = do not know

   vii. Others (fireworks, loud music, loudspeaker, etc.)
      1 = yes 2 = no 3 = do not know

5. Have you ever lodged a complaint about a neighbour being too noisy?
   1 = yes 2 = no 3 = do not know

6. Are you aware that there are rules and regulations regarding noise pollution?
   1 = yes 2 = no 3 = do not know

7. Problems due to noise pollution:
    i. No disturbance
    1 = yes 2 = no 3 = do not know

    ii. Annoyance
    1 = yes 2 = no 3 = do not know

    iii. Stress
    1 = yes 2 = no 3 = do not know

    iv. Sleep disturbance
    1 = yes 2 = no 3 = do not know

    v. Other problems
    1 = yes 2 = no 3 = do not know
    (If yes, write the problem_____)

8. Do you have the following health problems?
    i. Headache
    1 = yes 2 = no 3 = do not know

    ii. High blood pressure
    1 = yes 2 = no 3 = do not know

    iii. Hearing problem
    1 = yes 2 = no 3 = do not know

    iv. Diabetes
    1 = yes 2 = no 3 = do not know

    v. Lung disorder
    1 = yes 2 = no 3 = do not know

    vi. Kidney disorder
    1 = yes 2 = no 3 = do not know

    vii. Other disease
    1 = yes 2 = no 3 = do not know
    (If yes, write the name of the disease_____)

9. Do you use ear protection device while working?
    1= yes (if yes, write the name of the device ----------) 2= no

10. Give suggestions to control the noise pollution in your area.

Appendix – IV: Correlation between noise intensity and the presence of noise problems in the study area.

Correlations

		Noise	Problem
Noise	Pearson Correlation	1	.786**
	Sig. (2-tailed)		.001
	N	15	15
Problem	Pearson Correlation	.786**	1
	Sig. (2-tailed)	.001	
	N	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix V: Correlation between noise intensity and the problems faced in the study area.

Correlations

		Noise	Annoyance	Insomnia	Stress
Noise	Pearson Correlation	1	.347	.163	.349
	Sig. (2-tailed)		.206	.561	.203
	N	15	15	15	15
Annoyance	Pearson Correlation	.347	1	-.092	.309
	Sig. (2-tailed)	.206		.745	.262
	N	15	15	15	15
Insomnia	Pearson Correlation	.163	-.092	1	.751**
	Sig. (2-tailed)	.561	.745		.001
	N	15	15	15	15
Stress	Pearson Correlation	.349	.309	.751**	1
	Sig. (2-tailed)	.203	.262	.001	
	N	15	15	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix VI: Correlation between noise intensity and the health problems in the study area.

Correlations

		Noise	Cardio	Diabetes	Headache	Hearing	Kidney	Lung
Noise	Pearson Correlation	1	.197	.225	.284	.416	.424	.356
	Sig. (2-tailed)		.483	.420	.306	.123	.115	.192
	N	15	15	15	15	15	15	15
Cardio	Pearson Correlation	.197	1	.564*	.090	.218	.508	.372
	Sig. (2-tailed)	.483		.028	.751	.435	.053	.173
	N	15	15	15	15	15	15	15
Diabetes	Pearson Correlation	.225	.564*	1	.153	.602*	.741**	.849**
	Sig. (2-tailed)	.420	.028		.585	.018	.002	.000
	N	15	15	15	15	15	15	15
Headache	Pearson Correlation	.284	.090	.153	1	.482	.197	.399
	Sig. (2-tailed)	.306	.751	.585		.069	.482	.141
	N	15	15	15	15	15	15	15
Hearing	Pearson Correlation	.416	.218	.602*	.482	1	.501	.909**
	Sig. (2-tailed)	.123	.435	.018	.069		.057	.000
	N	15	15	15	15	15	15	15
Kidney	Pearson Correlation	.424	.508	.741**	.197	.501	1	.621*
	Sig. (2-tailed)	.115	.053	.002	.482	.057		.013
	N	15	15	15	15	15	15	15
Lung	Pearson Correlation	.356	.372	.849**	.399	.909**	.621*	1
	Sig. (2-tailed)	.192	.173	.000	.141	.000	.013	
	N	15	15	15	15	15	15	15

*. Correlation is significant at the 0.05 level (2- tailed).

**. Correlation is significant at the 0.01 level (2-tailed).