ASSESSMENT OF AMBIENT NOISE LEVELS IN THE METROPOLITAN CITIES OF INDIA

&

A Special Emphasis on Delhi for the years 1995, 1999 & 2011

A major thesis submitted towards the partial fulfilment of the requirement for the award of the degree of

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IN

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This is to certify that the thesis entitled

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Is being submitted by Ritika Singh (Roll no. 04/ENV/2K10) in partial fulfilment for the award of "Master of Technology in Environmental Engineering" in Delhi Technological University, Delhi and is the original work carried out by her under my guidance and supervision. The matter contained in this thesis has not been submitted elsewhere for award of any other degree.

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ABSTRACT

Noise has been identified as a pollutant under the Air (Prevention and Control of Pollution) Act, 1981, as amended by amendment act, 1987. The ambient noise standard has been laid down and notified under environmental protection Act (G.S.R. 1063 (E) dt. 26th Dec. 1989). Ambient noise is a composite of sounds from many sources. The ambient noise level is increasing day by day in urban estates due to fast growth of urbanisation and rapid change in life style of people.

Acoustic noise beyond a certain limit is harmful. Noise is usually unwanted sound pollutant which produces undesirable physiological and psychological effects in an individual, by interfering with one's social activities like work, rest, recreation, sleep etc. The fact that a regulation to abate noise is in force should remove all doubts about the damaging aspect of noise pollution. The metropolitan cities are being more polluted and the main thrust is towards the estimation of level of noise pollution in these cities. Measurement of noise levels were carried out in 7 metropolitan cities in India, viz. Bangalore, Chennai, Delhi, Hyderabad, Kolkata, Lucknow and Mumbai to assess ambient noise level during Diwali week. Measurement of noise levels were carried out in 4 zones of the metropolitan cities, viz. Commercial, Industrial, Residential and Silence zones. Based on the data of the measured equivalent noise levels in the residential, commercial, industrial, and silence zones of the 7 cities, it can be stated that during day time noise levels from 40 to 60 dB(A) prevail in residential areas away from traffic roads, noise levels from 60 – 80 dB(A) prevail in residential areas close to traffic roads and in commercial areas, noise level from 70 – 90 dB(A) exits at the traffic junctions and in industrial areas, and noise level from 80 - 105 dB(A) exists in areas with heavy traffic (Singal,2000, 2005). Even the silent zones are quite noisy as has been shown by data collected by CPCB. Further, merely 30% of the residential colonies in metropolitan cities have noise level within prescribed limits, the quiet period is only during the early morning hours from 0200 – 0500 hours when noise level falls within 40 – 45 dB(A), and the ambient noise levels during festivities e.g. Diwali festival becomes quite high i.e., from 85 – 120 dB(A). All noise level measurements were A-weighted.

INTRODUCTION

CHAPTER 1

INTRODUCTION

Mechanical energy released by any source in a medium creates vibrations of molecules. The molecules start vibrating in the oscillatory mode and the energy travels through the medium in form of vibrations. If the oscillation in the medium are in the range of 20 Hz to 20 KHz it is audible by human ears and categorises as sound. The frequency below 20 Hz is known as sub sonic and above 20 KHz are categorised as Ultrasonic and these are beyond audible range. For example, when one plays a musical instrument, say a guitar, the vibrating chords set air particles into vibration. The vibration of air particles produces sound.

The sound waves act as stimulus and the effect of stimulus produces on our senses is called sensation. The source of mechanical disturbance in the medium act as a transmitter where as our ear are receivers. Sensation is something that we experience and it could be different for different human, for example any song or voice creates different sensation for different person; it may be music for someone and the noise for other human. Stimuli can be measured which is produced from instrument whereas it is difficult to measure sensation.

'Noise' is any unwanted sound. It can be produced by many sources - man's vocal cord, a running engine, a vibrating loudspeaker diaphragm, an operating machine tool, and so on. There are two important characteristics of sound or noise - frequency and loudness. Sound is the quickly varying pressure wave travelling through a medium. When sound travels through air, the atmospheric pressure varies periodically. The number of pressure variations per second is called the frequency of sound, and is measured in Hertz (Hz) which is defined as cycles per second. The higher the frequency, the more high-pitched a sound is perceived. The sounds produced by drums have much lower frequencies than those produced by a whistle.

The response of the human ear to sound is dependent on the frequency of the sound. The human ear has peak response around 2,500 to 3,000 Hz and has a relatively low response at low frequencies. Another property of sound or noise is its loudness. A loud noise usually has a larger pressure variation and a weak one has a smaller pressure variation. Pressure and pressure variations are expressed in Pascal (Pa). To express sound or noise in terms of Pa is quite inconvenient because we have to deal with numbers from as small as 20 to as big as 2,000,000,000. A simpler way is to use a logarithmic scale. As such, the loudness of sound is commonly expressed in decibel (dB).

In the "A-weighting" scale, the sound pressure levels for the lower frequencies and higher frequencies are reduced by certain amounts before they are being combined together to give one single sound pressure level value. This value is designated as dB(A). The dB(A) is often used as it reflects more accurately the frequency response of the human ear. A perceived loud noise has a high dB or dB(A) value and a soft noise has a low one.

Noise pollution in urban areas is now being recognized as a major environmental issue around the world. With increasing awareness of the adverse impacts of noise on human health, more and more people becoming less tolerant to environmental noise. According to World Health Organization, noise pollution is nowadays the third most hazardous environmental type of pollution, preceded only by air (gas emission) and water pollution.

Noise Pollution in larger cities is an ever-growing problem due to the fact that the urban environment is becoming increasingly crowded, busy and noisy. The people living in the metropolis have leading sources of noise as Road Traffic Noise, Air Craft Noise, Noise from railroads, Resident & Community Noise and Construction Noise etc. Therefore, in order to assess the impact of noise on the citizen in 7 major Metropolitan cities for 24 hours across the nation.

Under section 2(a) of Air (Prevention and Control of Pollution) Act, 1981 noise is defined as air pollutant "Air pollutant" means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment."

Increasing ambient noise level in public places from various sources, inter-alia, industry activity, construction activity, generators sets, loud speakers, public address systems, music systems, vehicular horns and other mechanical devices have deleterious effects on human health and the psychological well being of the people. Therefore, it is considered necessary to regulate and control of noise producing and generating sources with the objective of maintaining the ambient air quality standards in respect of noise.

Objectives of Study

- To assess the noise level status of 7 metropolitan cities of India, viz. Delhi, Bangalore, Kolkata, Lucknow, Mumbai, Hyderabad and Chennai.
- To perform statistical analysis of noise monitoring data.
- To compare the measured noise level against absolute noise standard and its violation.
- To identify the factors of significant contributors as to take overall decision at the source itself.
- To express about each significant factor and its individual impact and also find alternative schemes.
- To find collective significant factor and its collective impacts as to help to the planners to take decision at the earliest possible stage.
- To communicate the information to the public for creating awareness.

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

In recent years, due to the rapid increase in population density, building density, traffic density and energy consumption, the outdoor air quality has deteriorated in the crowded urban areas. Noise is also a pollutant which has a significant effect on air pollution level.

A study was conducted in the residential areas of Delhi, India, to assess the variation in ambient noise levels during pre Diwali month (DM), Diwali day (DD) and post Diwali month during the period 2006 to 2008. The use of fireworks during DD showed the ambient noise level were 1.2 to 1.3 times higher than normal day. The correlation between noise level and gaseous pollutant were moderate ($R^2 \geq 0.5$). The average concentration of the pollutants during DD was found higher in 2007 which could be due to adverse meteorological conditions. The statistical interpretation of data indicated that the celebration of Diwali festival affects the ambient air and noise quality. The study would provide public awareness about the health risks associated with the celebration of Diwali festival so as to take proper precautions (Mandal *et al.*, Prakash *et al.;* 2011).

Fireworks display during festive celebrations can cause acute short term air pollution. Deepawali – the festival of light- is celebrated in India, every year during October or November with great fireworks display. Concentration of air pollutants such as SPM, PM_{10}, $PM_{2.5}$, SO_2 and NO_2 were monitored for 6 consecutive days during Deepawali in Salkia, a densely populated residential area near Kolkata, India, for assessing the impacts of firewoks on ambient air quality. The pollutant concentrations as recorded on Deepawali were found to be several times higher compared to a typical winter day value. The results indicated the huge contribution of fireworks on the pollution levels. The probable health impact of this huge though short lived deterioration of ambient air quality is estimated through monte carlo's simulation in terms of increase in relative risk of mortality and morbidity in exposed individuals and found to be extremely high. It suggests some control on fireworks during festive celebrations (Thakur *et al*., chakraborty *et al.*, 2010).

A study was conducted which shows a new approach to monitor noise pollution involving citizens and built upon the notions of participatory sensing and citizen science which enable citizens to measure their personal exposure to noise in their everyday environment by using GPS-equipped mobile phones as noise sensors. The geo-localised measures and user generated meta-data can be automatically sent and shared online with the public to contribute to the collective noise mapping of cities. The prototype, called Noise Tube, can be found online (Maisonneuve *et al.*, Stevens *et al*.; 2008).

A noise assessment study was conducted in Kerala, which shows the measurement of noise levels in the three major cities in Kerala viz., Thiruvananthapuram, Kochi, and Calicut shows that commercial zones experience about 15 dB(A) noise level above the prescribed limit the

silence zones experience similar noise levels and hence about 25 dB (A) above the prescribed limit. Special events like festivals, election campaigns generate noise levels that are prohibitively above the permissible limit with the only redeeming factor being that they last over a comparatively shorter duration (Sampath. *et al*., Murali Das *et al.*, 2004).

During day time noise levels from 40 to 60 dB(A) prevail in residential areas away from traffic roads, noise levels from 60 – 80 dB(A) prevail in residential areas close to traffic roads and in commercial areas, noise level from 70 – 90 dB(A) exits at the traffic junctions and in industrial areas, and noise level from 80- 105 dB(A) exists in areas with heavy traffic (Singal *et al*., 2000, 2005). Even the silent zones are quite noisy as has been shown by data collected by CPCB.

According to D.B. Smith, 20 dB is whisper, 40 dB is quiet office, 60 dB is normal conversation and 80 dB is the level at which sound become physically painful.

Noise studies made by (Ingerslev *et al*., 1987) further shows that for noise exposures of 80 dB(A) to 100 dB(A) for a period of 10 years, the percentage of persons who get hearing handicap, increases from zero to as high as 42. This percentage increases only marginally with more number of years of exposure.

To assess the Ambient Noise Level status of India, 7 metropolitan cities, viz. Delhi, Bangalore, Kolkata, Lucknow, Mumbai, Hyderabad and Chennai have chosen. These cities have their own continuous noise monitoring stations which are located at various locations within the state, and connected to the Central Receiving Station, CPCB Delhi, through GPS server. These cities are divided into 4 zones viz. are industrial, commercial, residential and silence zones. Various Noise parameters e.g. L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) are calculated for every noise monitoring station all over the nation.

BASICS OF NOISE & ITS CHARACTERISTICS

CHAPTER 3

BASICS OF NOISE & ITS CHARACTERISTICS

3.1 SOUND

Sound is such a common part of everyday life that we rarely appreciate all of its functions. It provides enjoy-able experiences such as listening to music or to the singing of birds. It can alert or warn us for example with the ringing of a telephone, or a wailing siren. Sound can be heard underwater too, just as in air. Whales are familiar with this and communicate with one another. Dolphins too have complex system of communication.

A sound source radiates power and this result in a sound pressure. Sound power is the cause. Sound pressure is the effect. What we hear is sound pressure but it is caused by the sound power emitted from the source. The sound pressure that we hear or measure with a microphone is dependent on the distance from the source and acoustic environment (or sound field) in which sound waves are present. This is in turn depends on the size of the room and the sound absorption of the surfaces.

Sound may be defined as any pressure variation (in air, water or other medium) that human ear can detect. If variation in atmospheric pressure occurs more rapidly i.e. at least 20 times a second, then it can be heard and hence is called sound. Sound travels as small waves of pressure through air at a speed of about 740 miles per hour and what we hear are sound waves provided by vibrations of air molecules.

Sound is produced by vibrating objects and reaches the listener's ears as waves in the air or other media. When an object vibrates, it causes slight changes in air pressure. These air pressure changes travel as waves through the air and produce sound. To illustrate, imagine striking a drum surface with a stick. The drum surface vibrates back and forth. As it moves forward, it pushes the air in contact with the surface. This creates a positive (higher) pressure by compressing the air. When the surface moves in the opposite direction, it creates a negative (lower) pressure by decompressing the air. Thus, as the drum surface vibrates, it creates alternating regions of higher and lower air pressure. These pressure variations travel through the air as sound waves.

3.2 NOISE

The word "noise" descends from the Latin word "nausea," meaning seasickness, or, more generally, any similar sensation of disgust, annoyance, or discomfort. Noise is usually defined as unwanted sound pollutant which produces undesirable physiological and psychological effects in an individual, by interfering with one's social activities like work, rest, recreation, sleep etc. A sound might be unwanted because it is:

- Loud
- Unpleasant or annoying

• Intrusive or distracting

Usually the sound of a violin is referred to as music - is something pleasing. Depending on other factors, the sound may be perceived as noise. Noise perception is subjective. Factors such as the magnitude, characteristics, duration, and time of occurrence may affect one's subjective impression of the noise.
Noise is also considered a mixture of many different sound frequencies at high decibel levels. Before measuring noise, we need to know the type of noise so that we can choose the parameters to measure, the equipment to use, and the duration of the measurement.

1. Continuous Noise: Continuous noise is produced by machinery that operates without interruption in the same mode, for example blowers, pumps and processing equipment. Measuring for just a few minutes with handheld equipment is sufficient to determine the noise level.

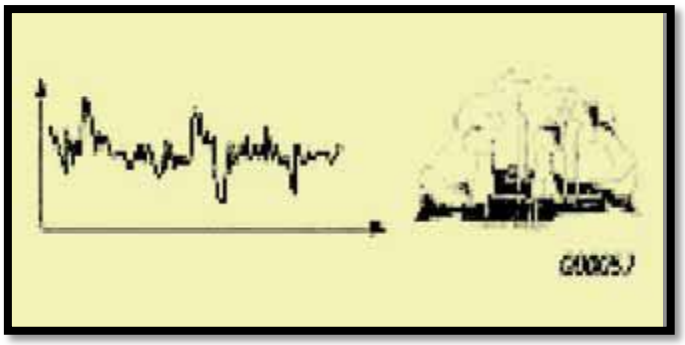


Figure3.1 Generation of continuous noise

2. Intermittent Noise: When machinery operates in cycles, or when single vehicles or airplanes pass by, the noise level increases and decreases rapidly. For each cycle of a machinery noise source, the noise level can be measured just as for continuous noise. A single passing vehicle or aircraft is called an event. To measure the noise of an event, the sound exposure level is measured, combining level and duration into a single description.

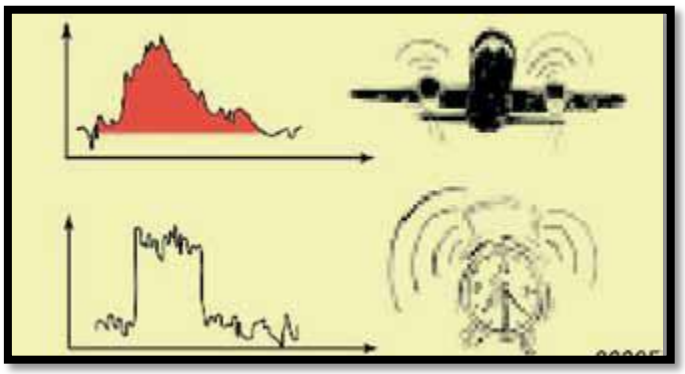


Figure3.2 Generation of intermittent noise

3. Impulsive Noise: The noise from impacts or explosions, e.g. from a pile driver, punch press or gunshot is called impulsive noise. It is brief and abrupt, and its startling effects cause greater annoyance than would be expected from a simple measurement of sound pressure level.

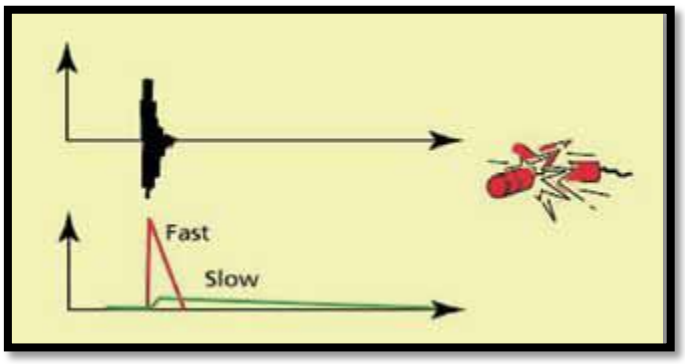


Figure3.3 Generation of impulsive noise

3.3 Classification of Noise

1. Ambient Noise: It is the noise from all sources combined-factory noise, traffic noise, bird song etc.

2. Specific Noise: Specific noise is the noise from the source under investigation. The specific noise is a component of the ambient noise and can be identified and associated with specific source.

3. Residual Noise: Residual Noise is ambient noise without specific noise. The residual noise is the noise remaining at a point under certain conditions when the noise from the specific source is suppressed.

4. Background noise: Background noise is also a common one but should not be confused with residual noise.

3.4 Sources of Noise

Variety of sources of noise cumulatively leads to noise pollution. Though the sources of noise seem almost to be infinite, but the various sources of noise to which a person is exposed can be categorised as follows:

Industrial noise:

The industry in which drilling, grinding, turning, riveting, fabricating, welding, hammering, forging, compressing, breaking, moulding, streaming, boiling, cooling, heating, venting, painting, pumping, packing and transporting are involved is creates the most serious of all large-scale noise problems, subjecting a significant fraction of the working population to potentially hazardous noise levels.

Mechanical noise is the major part of industrial noise. The noise is due to machinery of all kinds and often increases with the type of operation and power of the machines. The

characteristics of industrial noise vary considerably depending on specific industrial process. High noise levels common in petrochemical, steel industries, thermal power stations, cement industries, and mines etc can be due to presence of unsteady force and its structural elements caused by moving parts, vibration of heavy equipments, noise from engines, gear, bearings, rotating and reciprocating machines, combustion, fans, pressurised flow, during shifting of raw materials and end products, trucks and dumpers.

Non-industrial noise

Some of the important non-industrial sources are as follows:

Community: the community noise is an unwise display of man's vanity and whims. It occurs due to various activities of community during religious festivals, fairs, marriages, or public functions. The use of amplifiers provides one of most frequent sources of disturbances. Loudspeaker systems are in almost continual use at many open- air events. Loudspeakers and amplified music are rampantly used in unrestricted way at restaurants, marriage, functions and clubs, religious and festive gatherings and even in sale of lottery tickets. There is also the perennial problem of the use of portable radios and cassette players on beaches or in places where either people have gone in search of peace. Most of the problems which occur in public originate from three main groups of sources.

- Amplified sound: loud speakers, public gatherings, and festivals
- Rowdy behaviour: people not thinking about the amount of noise they are creating.
- Leisure activities: such as rash driving adopting various kind of horns or music in vehicle.

Traffic: In cities, surface vehicles have increased tremendously and use of pressure horn become a constant source of noise pollution. The rising environmental noise level is because of appreciable growth of scooters, motor cycles, passenger cars, tempo, heavy trucks and buses. It disturbs more people in any country than all other form of noise nuisance. Today metropolitan cities have become noisiest cities in the world due to increasing number of vehicles. Everywhere it is growing in intensity. Noise can be generated from individual vehicle or from continuous flow of vehicles of all types. Traffic noise can be classified in to two distinct categories:

Those related to engine speed: noise from vehicle can be from engine, intake, exhaust, cooling fan, gear box, horns, and from accessories air compressor, hydraulic pump, electrical generators etc. Diesel powered vehicle add another dimension to noise problem.

Those related to road speed: related to road speed include engagement of gears, rolling noise produced by tyre and aerodynamically generated noise. Traffic noise affects those persons in great extent who live adjacent to roads. Overall, the factors of traffic noise depend on the following:

Traffic parameters

- Vehicle volume
- Vehicle mix
- Average speed

Road way characteristic

- Pavement width
- Flow characteristic
- Gradient
- Surface finish

Observer characteristic

- Observer distance
- Element size
- Shielding
- Observer relative height

Aircraft noise:

The use of aircrafts of many types has been generating varying types of noise. The higher the speed of an aircraft, then greater would be the noise pollution. The invention of supersonic aircrafts has added more noise for the plight of persons who live near aerodromes. Taking off and landing of an aircraft produces unbearable noise for a normal human being.

It has been observed that supersonic jet planes are one of the biggest irritants in today's noisy world. The noise of these planes may sometimes break window panes, crack plaster and shake buildings. By these effects of noise can very easily understand that what would be the effects of such noise on human body.

Miscellaneous:

In India and many other countries urbanisation has been developing very fast and huge buildings have been being constructed with fastest speed. During demotion of huge sites and construction of new buildings, huge machines, which produce a lot of noise, are being commissioned and it has become a common scene in every big city where construction work is in progress. A lot of noise has been created during the construction of repair work of roads in cities.

3.5 Impacts of Noise

The development of society, modern technology, exploitation of nature have lead to more and more sound sources giving higher and higher noise levels. Noise is one of the most widely and most frequently experienced problems in the metropolitan cities. Noise effects man both physically, psychologically, pathologically and socially.

a) Human health:

The World Health Organization (WHO) defines health as “A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.” We separate noise effects into two broad categories: auditory (noise-induced hearing loss) and non-auditory (behavioural and physiological effects). Behavioural effects are those that are associated with activity interference. This includes interference with communication, rest or and sleep, and learning; or that produces annoyance. Non-auditory physiological health effects include such things as cardiovascular disease and hypertension. These categories of effects are examined in the following sections.

1. Noise-Induced Hearing Loss - Hearing loss is measured as "threshold shift". Threshold refers to the quietest sound a person can hear. When a threshold shift occurs, the sound must be louder before it can be heard - a person's hearing is not as sensitive as it was before the threshold shift. The natural decrease of hearing sensitivity with age is called presbycusis. For hundreds of years it has been known that excessive exposure to loud noises can lead to noise-induced temporary threshold shifts, which in time can result in permanent hearing impairment, causing individuals to experience difficulty in understanding speech.

2. Community Annoyance - Social survey data have long made it clear that individual reactions to noise vary widely for a given noise level. Nevertheless, as a group, people's aggregate response to factors such as speech and sleep interference and desire for an acceptable environment is predictable and relates well to measures of cumulative noise exposure such as DNL.

3. Speech Interference - One of the primary effects of aircraft noise is its tendency to drown out or "mask" speech, making it difficult or impossible to carry on a normal conversation without interruption. The sound level of speech decreases as distance between a talker and listener increases. As the level of speech decreases in the presence of background noise, it becomes harder and harder to hear. As the background level increases, the talker must raise his/her voice, or the individuals must get closer together to continue their conversation.

4. Sleep Interference - The effect of aviation noise on sleep is a long recognized concern of those interested in addressing the impacts of noise on people. Historical studies of sleep disturbance were conducted mainly in laboratories; field studies also were conducted, in which subjects were exposed to noise in their own homes, using real or simulated noise. The data from these field studies show a consistent pattern, with considerably less percent of the exposed population expected to be behaviourally awakened than had been shown with laboratory studies.

5. Non-Auditory Health Effects - In spite of considerable worldwide research, there is little solid evidence supporting a claim that noise affects human physical and mental health in the workplace or in communities. Our scientific understanding is far from being able to reliably demonstrate a cause-effect relationship. Researchers have based such claims on laboratory studies of extremely high noise levels or of animals. Many effects observed with intense noises, capable of harming our hearing in a short time, cannot be assumed to occur at

moderate and low levels, or to manifest themselves in chronic clinical effects at moderate and low levels. For practical noise control considerations, the present status of our knowledge means that the criteria for evaluating noise impact, with respect to its direct and indirect effects on health, are the same criteria as those applied to prevent any hearing impairment. In other words, by using criteria that prevent noise induced hearing loss, minimize speech and sleep disruption, and minimize community reactions and annoyance, any effects on health will also be prevented.

6. The Effects of Noise on Children's Learning - There has been much attention focused recently on the issue of the effects of aviation noise on children and their learning. The research suggests that there are effects in the areas of reading, motivation, language and speech, and memory. One common theory for the causes of these problems is speech interference: if children who are learning to read cannot understand their teacher, they may develop reading problems. The strength of sound level and its subjective feeling, effects on human being are summarized in table 1.

Table 3.1: Various sound levels and its effects on human being

Sound source	**strength of sound in dB(A)**	**subjective feeling of human beings**	**Effects on human**
Rockets and missiles, heavy explosives	150 - 160	unbearable	Above 150 dB(A) may cause severe damage to the whole body such as loss of hearing of both ears, dizziness, nausea, disturbance of speech, confusion or psychosis
Jet planes and cannons, explosives	140	unbearable	
Aircraft propeller and machine guns	130	unbearable	
Diesel, steam engine, and ball mills, crackers	120	unbearable	Above 90 dB(A) headache, dizziness, tinnitus, insomnia, deafness, heart diseases, hypertension, gastric ulcer, neurosis, temporary hearing threshold shift.
Electric saws and looms, heavy trucks	110	Ear ache	
Lorries, highway vehicles and very busy streets	90 -100	Very noisy	50- 90 dB(A) may cause various degrees of effects in sleeping, studying, working and talking Sense of noisy feeling
Commercial place, air conditioners, loud voice & busy streets	70 - 80	noisy	
Office complex, average loudness of voice	60		
	60	noisy	
Ordinary room	50	quiet	Pleasant feeling
Silent night, library	30 - 40	Very quiet	
Hospital, bedroom at night, church	20 - 30	Very quiet	Silence feeling
In sound proof room broadcasting studio	10 - 20	Very quiet	
Lower limit of hearing	0	Very quiet	Threshold of hearing

b) Animal Health:

In general, a noise impact to wildlife can be determined by the degree to which the noise disrupts a functioning ecosystem. Noise has the potential to affect wildlife in a variety of ways, varying between different types of animals. Research shows that the degree of reaction to noise often varies with age, sex, season, situation, previous exposure to noise (habituation), noise level, and frequency spectrum. Potential noise effects on wildlife include; auditory damage, physiological changes, and behavioural alterations. These effects are further characterized into primary and secondary effects. Primary effects are direct physical effects to the animal. Secondary effects are indirect changes which occur between the animal and its environment.

1. Physiological Effects - Physiological effects, such as metabolic and hormonal changes, are often associated with stress. Stress in wildlife in their natural setting is typically a difficult response to quantify. For wildlife, stress reactions are part of survival and a routine occurrence. Stress reactions involve what is commonly referred to as the "fight or flight" response. When this reaction is inappropriate, such as fleeing from a non-threaten noise, impacts begin to occur. Inappropriate reactions unnecessarily deplete an animal's energy resources which can increase susceptibility to predators, disease, and starvation.

2. Behavioural Effects - Changes in normal behavioural patterns are the most apparent effects of noise on wildlife.

2.6 Noise Pollution

Noise pollution refers to sounds in the environment that are caused by humans and that threaten the health or welfare of human or animal inhabitants. The most common source of noise pollution by far, the one that affects the most people on the planet is motor vehicles.
Aircraft and industrial machinery are also major sources. Additional noise pollution is contributed by office machines, sirens, power tools, and other equipment. The response of ear to sound is very dependent on the frequency content of the sound. The ear has a peak response around 2.5 – 3 kHz and has a relatively low response at low frequencies.

Threshold of Pain: sound level at which the ear starts to feel pain. The threshold of pain is different for sounds of different frequencies.

2.7 Air Act & Noise Rules

Under section 2(a) of Air (Prevention and Control of Pollution) Act, 1981 noise is defined as air pollutant "Air pollutant" means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment."
Increasing ambient noise level in public places from various sources, inter-alia, industry activity, construction activity, generators sets, loud speakers, public address systems, music systems, vehicular horns and other mechanical devices have deleterious effects on human

health and the psychological well being of the people. Therefore, it is considered necessary to regulate and control of noise producing and generating sources with the objective of maintaining the ambient air quality standards in respect of noise.

Central Government notified the Noise Pollution (Regulation and Control) Rules, 2000 as it is published in the Gazette of India, Extraordinary, Part-II –section 3(ii), vide S.O 123 (E) dated 14.2.2000. In reference to abovementioned rules following responsibilities are vested with State Governments, District Magistrate, Police Commissioner, or any other officer not below the rank of Deputy Superintendent of Police:

1. Enforcement of Noise Pollution control measures and the due compliance of ambient air quality standards in respect of noise.
2. Restriction on the use of Loud Speakers/ Public Address system.
3. Restriction on the use of Horns, Sound emitting construction equipment and bursting of Fire crackers.
4. Prohibition of continuance Music Sound or Noise.
5. Authority shall act on the complaint and take action against the violator in accordance with the provisions of rules.
6. Disallowing sound producing instrument after 10 p.m to 6 a.m except in closed premises.
7. State Government may permit loud speakers or public address system in night hours (between 10.00 p.m. to 12.00 midnight not exceeding 15 days in year.

Table 3.2: Ambient Air Quality Standards in Respect of Noise is notified under Noise Pollution (Regulation and Control) Rules, 2000

Area code	Category of Area / Zone	Limit in dB (A) Leq*	
		Day time	Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Note:

1. Day time is from 6 AM to 10 PM

2. Night time is from 10 PM to 6AM

3. Silence Zone is defined as areas up to 100 meters around premises such as hospitals, educational institutes and courts. Silence Zones are declared by competent authority.

4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

*dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

A "decibel" is a unit in which noise is measured.

Leq: It is energy mean of the noise level over a specific period.

METHODOLOGY

CHAPTER 4
METHODOLOGY

The ambient noise level termed as the total noise associated with a given environment and usually comprises sound from many sources both near and far. In order to assess the ambient noise level at different stations in the seven big cities of India viz., Delhi, Bangalore, Kolkata, Lucknow, Mumbai, Hyderabad and Chennai, monitoring was conducted during October 2011. The noise level was monitored for 24 hours continuously at each station, through central receiving station located at CPCB Delhi. Morning, afternoon, evening, and night hours are considered according to the various activities of the entire day.

4.1 Measurement techniques

Sound is mechanical energy from vibrating source transmitted by cycling series of compressions and rare fractions of molecules of the material through which it passes (Chanlett 1973).

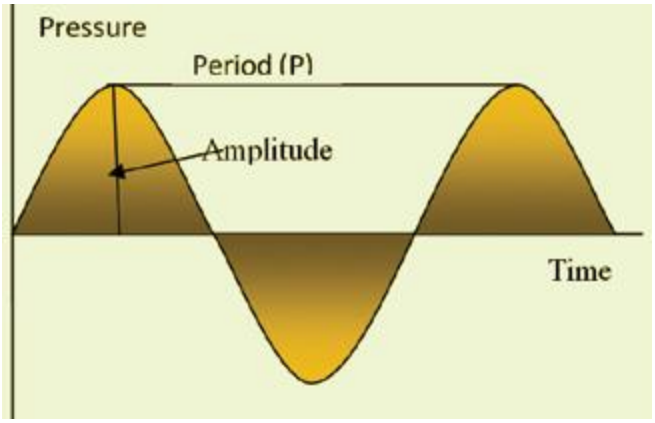


Figure4.1 Relationship between pressure, amplitude & time period

Sound waves are often simplified to a description in terms of sinusoidal plane waves, which are characterized by these generic properties:

- Frequency, or its inverse, the period
- Wavelength
- Amplitude
- Intensity

Frequency: The number of compression and rare fraction of the air molecules in a unit of time is described as the frequency. The normal range of hearing for a healthy person extends from approximately 20 Hz up to 20,000 Hz.

Amplitude (A) of the wave is the height of the peak sound pressure measured above or below the zero pressure line. Distance between successive peaks or troughs are called the wavelength (λ) which is related to frequency (f) by the relation:

$$\lambda = C / f$$

4.1.1 Measuring Sound Levels

Sound produced from any source is stimuli and it can be measured as sound pressure. The sound pressure range varies from 20μPa- 200 Pa and it can be expressed on a scale based on the log of the ratio of measured sound pressure and a reference standard pressure Sound Level,

$$L = Log10\ P/Po$$

Where,
P= Measured quantity of sound pressure or sound power, or sound intensity.
Po=Reference standard quantity of sound pressure, or sound power, or sound intensity (20 × 10-6 Pa)
L= Sound Level in Bels (B)
However, above unit bels (B) is turn out to be a rather large unit, a smaller unit of decibels (dB) is generally used.

$$L = 10\ log10\ (P/P0)\ (dB)$$

Sound Pressure level,

$$Lp = 20\ Log10\ (Pr.m.s/20\mu Pa)$$

The logarithmic unit of measurement means, for example, 80dB is 10 times louder than 79dB. This is one of the motivations for using the decibel scale to measure sound intensity.

4.1.2 Noise rating system

1. Leq: Leq is that statistical value of sound pressure level that can be equated to any fluctuating noise level. For e.g. a sound of 40 dB last for 5 min, for the next 10 min sound is 85 dB and then followed by a sound of 100 dB for next 5 min, will compose a fluctuating noise level, which is indicative of producing the same effect over the entire time period of 5+10+5= 20 minutes in dB. This value is called Equivalent continuous equal energy level, Leq.

Leq = 10Log $\sum_{i=1}^{i=n}(10)^{Li/10}$ X (ti/tt)
Where,
n= number of sound samples
Li=the noise level of any ith sample,
ti= time duration of ith sample,
tt= total time period of event.

Leq is also defined as the constant noise level, which over a given time, expands the same amount of energy, as is expanding by the fluctuating levels over the same time.
A sound level meter that measures the sound pressure level with a "flat" response will indicate the strength of low frequency sound with the same emphasis as higher frequency sounds.
Therefore, sound meter is equipped with frequency-weighting filter.
The human ear does not respond uniformly to sounds of all frequencies being less efficient to low and high frequencies as compared to medium range frequencies. In order to obtain sound level which cover wide range of frequencies and conforms approximately to the response of the human ear, frequency weighting filter is used. Resultant sound level obtained is A-weighted sound.
Therefore, we measure sound level as Leq in dB(A).

2. Ln: The Ln is a statistical measure indicating how frequently a particular Sound level is exceeded. The value of Ln will represent the sound pressure level that will exceed for N% of the gauging time. For e.g. L_{60} over entire period is 70 dB and this 70 dB shows that the sound level will exceed 70 dB for 60 % of the measuring time. Ln is nothing but percentile value over the measuring time, i.e. L_{90}, L_{50}, and L_{10}.

3**. Skewness:** The skewness of a data population is defined by the following formula, where μ_2 and μ_3 are the second and third central moments.

$$\gamma_1 = \mu_3 / \mu_2^{3/2}$$

Intuitively, the skewness is a measure of symmetry. As a rule, negative skewness indicates that the mean of the data values is less than the median and the data distribution is left-skewed; positive skewness would indicates that the mean of the data values is larger than the median and the data distribution is right-skewed. Of course, this rule applies only to unimodal distributions whose histograms have a single peak.

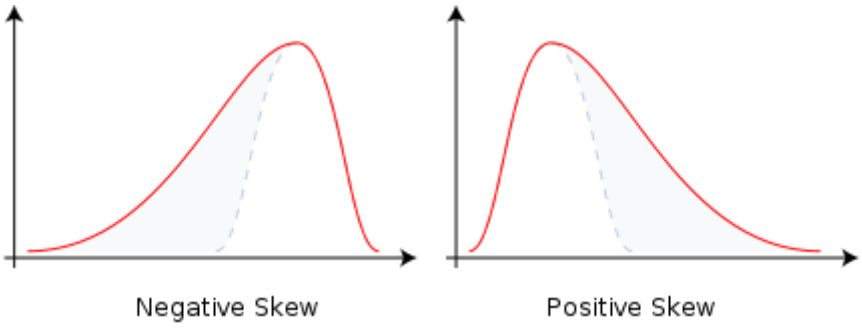


Figure 4.2 Graphical representation of negative and positive skew

4**. Kurtosis:** In probability theory and statistics, kurtosis is the measure of the "peak" of the probability distribution of a real-valued random variable. In a similar way to the concept of skewness, *kurtosis* is a descriptor of the shape of a probability distribution and just as for

skewness; there are different ways of quantifying it for a theoretical distribution and corresponding ways of estimating it from a sample of a population.

4.1.3 Tool used in statistical analysis of noise monitoring data – SPSS

SPSS is among the most widely used programs for statistical analysis in social science. It is used by market researchers, health researchers, survey companies, government, education researchers, marketing organizations and others. The original SPSS manual (Nie, Bent & Hull, 1970) has been described as one of "sociology's most influential books". In addition to statistical analysis, data management (case selection, file reshaping, creating derived data) and data documentation (a metadata dictionary is stored in the datafile) are features of the base software.

Statistics included in the base software:

- Descriptive statistics: Cross tabulation, Frequencies, Descriptives, Explore, Descriptive Ratio Statistics
- Bivariate statistics: Mean, t- Test, Correlation (bivariate, partial, distances), Nonparametric tests
- Prediction for numerical outcomes: Linear Regression
- Prediction for identifying groups: Factor Analysis, Cluster analysis (two-step, K-means, hierarchical), Discriminant.

SPSS can read and write data from ASCII text files (including hierarchical files), other statistics packages, spreadsheets and databases. SPSS can read and write to external relational database table via ODBC and SQL.

Statistical output is to a proprietary file format (*.spv file, supporting pivot tables) for which, in addition to the in-package viewer, a stand-alone reader can be downloaded. The proprietary output can be exported to text or Microsoft word, PDF, Excel, and other formats. Alternatively, output can be captured as data (using the OMS command), as text, tab-delimited text, PDL, XLS, HTML, XML, SPSS dataset or a variety of graphic image formats (JPEG, PNG, BMP and EMF).

4.2 Instrumentation

The basic tool of all noise measurement is the sound level meter intended for field use meeting rigorous environmental specifications. A sound level meter is a sensitive electronic volt meter used to measure the electrical signal from a microphone. It is calibrated in sound pressure level for use with a particular microphone, which is ordinarily attached to the instrument. It is expensive and easily damaged by careless use or handling, particularly by the untrained persons and repairs can be very expensive.

All these instruments of whatever complexity have common elements: microphone, input amplifier (adjustable), weighing networks, output amplifier and indicating meter as to meet the accuracy and the facilities. In addition, some may have complex indicators, memory, auxiliary inputs and a host of accessories which may or may not be vital for noise measurement. The vital common parts of a sound level meter are:

1. Microphone:

Microphone is very important and there are three main types – crystal, moving coil and condenser. Crystal and moving coil types are severely affected by humidity and temperature. Condenser type which is referred as electrostatic or capacitor microphone are stable, have a wide range, are not affected by temperature, never have a power failure, and can be calibrated at any frequency. Many different methods of microphone calibration have been developed. The most widely accepted absolute calibration method is the reciprocity method, which is used generally for calibrating standard microphones in the laboratories as to meet American national standards ANSI and IEC standards. But most microphones are calibrated by a substitution method in which a previously calibrated reference microphone is used as a standard comparison.

2. Input amplifier (adjustable):

This is linked with one control switch to the output amplifier in stages of some dB attenuation. It follows immediately after the microphone and it is designed for amplifying electrical signal obtained from microphone to the accurate attenuation of the input signal in steps of some dB.

3. Weighting networks

These are introduced between the input amplifier and the output amplifier. The weightings, known as A, B and C weighting networks are internationally agreed. The use of all the scales A, B and C can be advantageous in obtaining a broad outline of the frequency of the noise being measured.

4. Output amplifier

The electrical output from the filter circuits is fed through two amplifier stages with associated attenuators. The attenuators can again amplifying accurately varied in some dB steps.

5. Indicating meter

After the frequency weightings and amplifiers, it converts the electrical signal from alternating current to direct current to cause the needle of the display meter to register the sound pressure level directly in decibels either in the form of analog or digital outputs. The moving coil indicators include two damping characteristics FAST and SLOW both in accordance with British standard specifications. The response speed of the needle plays a large part in the reading for noise which varies with time, as noise mostly do. The actual response speed is defined as the averaging time of the exponential integration in the root mean square (rms) circuit in the meter. The infinite number of time constants possible, have

been standardised in (international electrochemical commission) IEC 651 to 3 options as below:

'S' (slow)	Time constant for 1 second
'F' (fast)	Time constant for 125 mSec
'I' (impulsive)	Time constant for 35 mSec

Sound level meters are used to measure many types of sound under different conditions, and for variety of reasons. The instrument is carefully handled to obtain valid and consistent results.

4.2.1 Principle of Operation:

The diaphragm and back plate form the parallel of a simple air-capacitor which is polarized by a charge on the back plate. When the diaphragm vibrates in a sound field, the capacitance of the capacitor varies and an output voltage is generated. The voltage signal replicates the sound-field pressure variations as long as the charge on the microphone backplate is kept fixed. The electric signal produced by the microphone is quite small and so it is amplified by a preamplifier before being processed.
Several different types of processing may be performed on the signal. The signal may pass through a weighting network. It is relatively simple to build an electronic circuit whose sensitivity varies with frequency in the same way as the human ear, thus simulating the equal loudness contours.

4.2.3 Noise Monitoring System:

Nowadays, Noise Monitoring System (NMS) is used for measuring real time noise since large number of stations can be managed easily using this technology. NMSs are optimized for outdoor use with small, custom designed enclosure, and also designed for use in all climatic environments. NMS consist of a weatherproof cabinet containing a noise level analyzer and a battery, a communication device for transmitting data to receiving station, a back plate and an outdoor microphone (for measuring sound) all of which can be mounted on a mast. Some of the features and particulars of NMS are mentioned as follows:

- NMSs are modular both in hardware and software.
- The NMS has been specifically designed to operate unattended in inhospitable environments protecting the contents from weather, tampering, vandalism etc. The robust, durable, weatherproof cabinet includes a kit for fastening the cabinet to a wall or pole. Protection is also provided for the cabling, to reduce the risk of tampering or accidental damage
- The NMS includes one battery, but up to two batteries can be used so that the NMS can function when there is no usable local power source or mains power has been disrupted. The batteries are charged whenever external AC or DC is applied to the NMS.
- The NMS can be powered from a variety of sources, such as solar panels, connected through the DC supply input.

- Data Retrieval with automatic and manual operation and data storage in a SQL database, in order to allow the users to carry out their data analysis and data processing.
- The NMS supports GPS, so that with a standard commercial GPS receiver and antenna unit, longitude, latitude and height can be monitored and stored in the NMS with the noise measurements. Data from NMS is directly transferred to main server (Central Receiving Station) via GPRS.
- Basic architecture of NMS and its network is given below:

Figure 4.3 Noise monitoring system

4.2.4 Central Receiving Station:

The Central receiving station gets data from all remote stations through GPRS mode, processes the Noise data and generates different reports. The central station software allows CPCB officials for research, development, and analysis of the noise data. The data from the Remote unit can be displayed through Internet to the authorize addresses. The central receiving station receiving station comprises hot redundant servers including web hosting server and software for analysis and other purpose.

Hot redundant servers including web hosting server: The High-end dual servers have been used for data reception, processing, visualization, communication and archiving. The servers are hot redundant mode to insure that under no condition data reception process fails as in the event of failure of main server the alternate hot redundant servers takes over the entire process automatically within milliseconds.

Central Receiving Software: Software package is capable for communication, from measuring and acquisition stations, both locally and remotely via a PC. It is intuitive and easy to use application which runs on Windows, Windows® Operating System (2000 SP4, XP

SP2). Data Retrieval in real time or by command with automatic and/or manual operation and data storage in a Microsoft Access database, or alternatively in a SQL database, in order to allow and carry out the data analysis and data processing.

Software Management

- Software is capable for requesting, downloading, editing, processing and representation and management of data.
- The software integrates the entire data request commands made to the stations in real time data or data saved in the memory.
- Software allows the user to change and/or modify the configuration of the stations, enables to perform tasks such as date and time synchronisation with the computer and adds new measuring channels specifying the different sampling and storage periods, as well as the statistical calculations to be stored.

Data Analysis

- Data enquiry over several days
- Comparison of readings between stations
- Daily statistics enquiry
- Strip charts of the daily statistics.
- Comparison between the daily statistics of various stations
- Comparison between parameters from the same station or from different stations.

Visualization of Data

- Enquiry of data in Table Form
- Enquiry of data in graph form
- Temporary graphs composition window

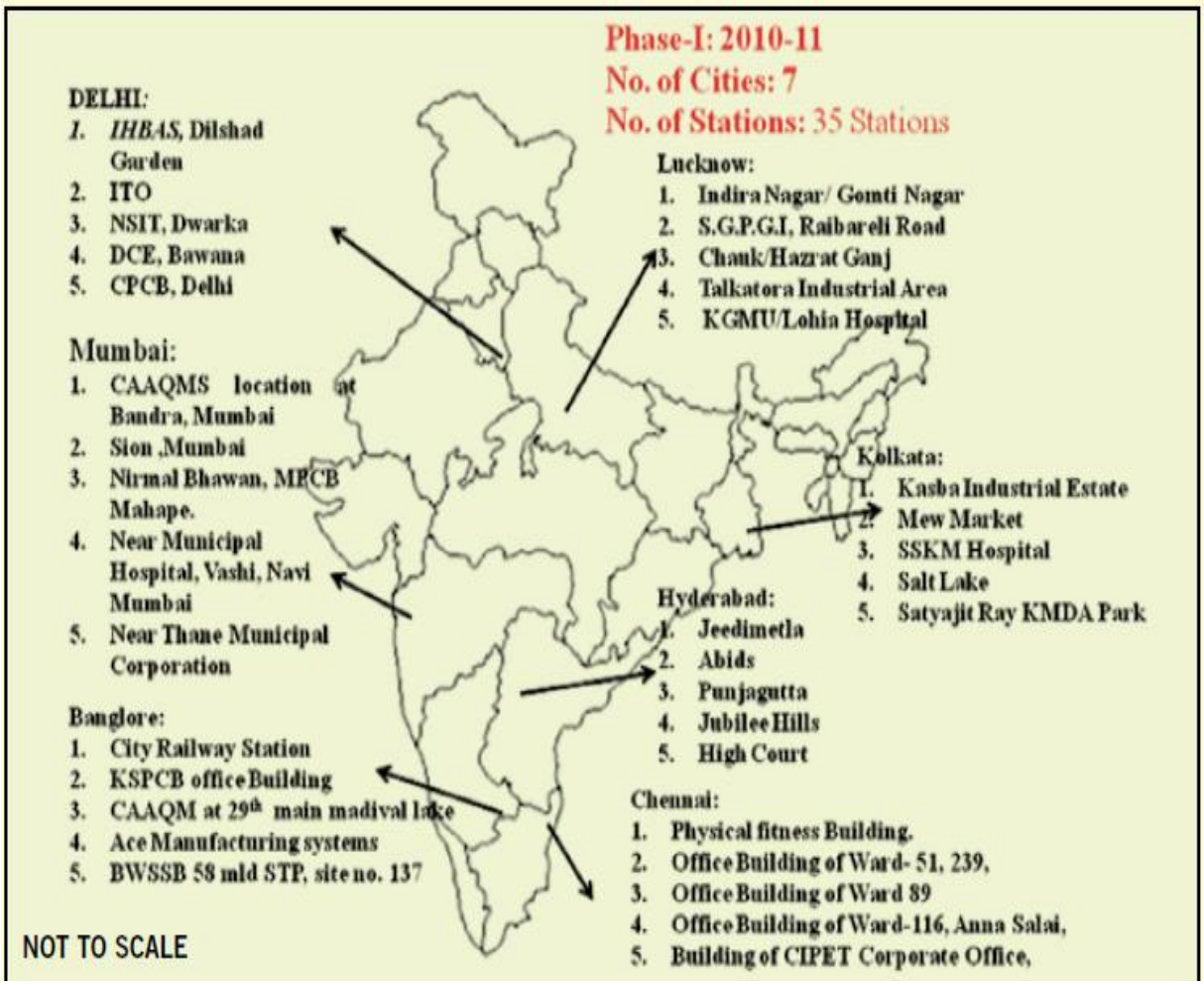
Additional Features

- Printing of various reports and graphs.
- Zoom in and Zoom out facility with automatic graph scale Resizing.
- Registers all the events like Information messages, error messages.
- Information of the communications resources used by the PC at that moment.

4.3 Area under study

The noise monitoring was conducted in the following 7 cities of India: Delhi, Bangalore, Kolkata, Lucknow, Mumbai, Hyderabad and Chennai.

Figure 4.4: Map showing various noise monitoring stations across the nation



RESULTS & DISCUSSION

CHAPTER 5

RESULTS & DISCUSSION

Ambient Noise Level data of 7 metropolitan cities (Bangalore, Hyderabad, Kolkata, Delhi, Lucknow, Chennai and Mumbai) spread over 7 states (Karnataka, Andhra Pradesh, West Bengal, Delhi, Uttar Pradesh, Tamil Nadu & Maharashtra) and their respective calculated noise parameters are given in Table 5.1, 5.2, 5.3, 5.4 and 5.5 and figures 5.1 to 5.28. Raw data is taken from the Central Pollution Control Board in txt. format.

Table 5.1: Various Calculated Ambient Noise Parameters (23/10/2011)

S. No.	City	Station	L 90	L 50	L 10	L max	L min	Leq dB(A)	
								Day time	Night time
1	**Bangalore**	btm	55.761	62.392	65.446	67.431	53.609	63.869	56.654
2		marthhali	50.877	52.543	54.031	55.289	50.013	52.635	52.137
3		pari	53.524	64.072	66.981	79.947	50.826	61.185	57.726
4		nisa	45.594	53.729	57.025	62.533	43.08	54.878	47.417
5		pnya	49.212	51.606	55.624	92.05	46.958	49.366	N/A
6	**Chennai**	eyeh	46.824	60.847	64.208	70.163	43.738	62.261	49.619
7		gndy	69.767	74.472	75.748	89.853	66.692	75.485	70.546
8		prmb	52.536	66.674	68.788	72.02	47.034	67.608	56.392
9		tngr	57.453	71.978	74.388	75.869	53.267	72.567	61.001
10		trln	53.141	66.327	68.944	81.62	48.341	67.594	55.795
11	**Delhi**	cpcb	49.206	59.765	62.293	64.299	46.259	60.355	52.564
12		dce	46.997	48.812	50.989	54.239	45.941	49.497	48.013
13		dgdn	47.247	50.814	57.102	64.049	44.178	52.850	49.090
14		ito	71.292	72.019	73.382	103.213	68.408	69.497	N/A
15		nsit	53.814	55.805	72.601	101.476	50.498	62.095	55.164
16	**Hyderabad**	abit	60.923	70.734	74.477	78.208	56.445	72.001	63.984
17		jdmt	55.215	61.773	64.546	65.658	53.262	62.702	56.492
18		pngt	68.8282	74.324	75.6928	76.319	65.193	74.525	70.509
19	**Kolkata**	gprk	58.4884	60.838	71.8028	72.579	55.695	64.653	59.656
20		hq	53.8127	59.2755	61.1677	72.01	51.12	60.032	55.367
21		ptli	49.5875	53.9895	59.441	90.05	47.195	53.651	51.786
22		sskm	53.5162	57.4725	60.7034	62.829	50.859	58.704	54.600
23		newmarket	57.5829	64.8685	67.5219	68.703	56.919	65.676	59.159
24	**Lucknow**	hgnj	61.3934	69.479	74.5789	76.76	56.416	71.159	64.262
25		ingr	44.4415	50.3005	57.1736	64.511	42.252	53.484	45.996
26		tlkt	52.7267	60.1375	66.3684	68.735	49.116	62.598	54.256
27	**Mumbai**	ahsp	58.7406	63.184	64.3175	65.443	56.267	63.511	60.233
28		bndr	67.2488	68.4255	69.3235	70.508	65.79	68.588	67.812

29		hq	62.1308	64.464	65.6405	67.093	60.131	64.923	62.846
30		tmco	55.6022	59.2535	62.0212	66.994	52.355	59.847	57.565
31		vhsp	54.5844	66.7985	69.2663	70.565	50.008	66.938	58.178

Table 5.2: Various Calculated Ambient Noise Parameters (26/10/2011)

S. no.	**City**	**Station**	**L 90**	**L 50**	**L 10**	**L max**	**L min**	**Leq dB(A)**	
								Day time	**Night time**
1	**Bangalore**	btm	56.8277	67.067	71.7508	78.101	54.423	68.343	59.561
2		mart	51.5379	56.2455	65.1934	70.027	50.971	58.396	54.156
3		pari	54.3267	66.2345	70.1945	89.994	51.576	61.917	44.252
4		nisa	46.2211	62.77	73.5036	79.328	45.079	65.563	51.368
5		pnya	53.933	56.609	68.815	74.008	52.703	51.995	N/A
6	**Chennai**	eyeh	46.7549	65.605	77.8286	84.002	43.367	70.998	52.711
7		gndy	71.5848	74.2045	76.6348	87.624	68.605	70.540	52.98
8		prmb	67.1116	72.411	80.295	102.11	58.563	69.349	57.891
9		tngr	58.7335	71.2915	77.4446	83.426	52.133	73.028	61.437
10		trln	53.3694	71.395	79.3741	84.733	44.822	74.430	58.409
11	**Delhi**	cpcb	49.6503	60.0655	75.7784	80.416	46.292	61.790	57.977
12		dce	48.288	50.1655	64.7158	67.915	46.511	53.400	52.520
13		dgdn	46.6363	51.9375	75.1651	77.584	43.801	57.510	54.180
14		ito	70.9316	71.4	86.4128	102.729	70.01	56.464	N/A
15		nsit	53.592	59.099	73.224	99.705	52.757	54.156	20.121
16	**Hyderabad**	abit	60.3737	71.789	80.1722	98.433	56.56	73.964	65.932
17		jdmt	54.503	62.4305	65.5573	69.433	52.623	63.327	57.520
18		pngt	68.0776	75.7375	80.7213	82.906	66.238	76.805	71.648
19	**Kolkata**	gprk	59.5071	63.6945	68.1194	73.35	57.096	65.185	61.802
20		hq	54.2538	60.663	63.886	65.491	51.988	61.456	57.142
21		ptli	45.472	53.992	69.7074	73.284	43.927	58.956	51.954
22		sskm	51.3544	60.0105	64.6439	69.62	49.117	60.851	55.823
23		New market	57.7156	65.0555	67.1461	70.063	56.237	65.689	60.343
24	**Lucknow**	hgnj	59.2087	70.307	73.7485	75.72	54.543	70.413	63.273
25		ingr	41.4695	51.431	70.9926	79.108	38.7	55.597	49.955
26		tlkt	50.235	59.5545	68.946	78.154	48.295	61.471	54.999
27	**Mumbai**	ahsp	57.5379	63.9395	69.8138	72.209	54.839	65.068	61.198
28		bndr	66.1742	68.512	72.4375	74.781	64.6	69.320	67.747
29		hq	61.5579	63.936	65.9142	67.703	59.036	64.289	62.841
30		tmco	53.251	61.2665	72.5409	78.146	51.277	63.794	58.211
31		vhsp	55.2578	67.9365	74.3393	77.518	48.701	69.205	60.321

Table 5.3: Various Calculated Ambient Noise Parameters (29/10/2011)

S. no.	City	Station	L 90	L 50	L 10	L max	L min	Leq dB(A)	
								Day time	Night time
1	**Bangalore**	btm	52.096	64.74	67.0928	75.345	48.878	65.501	55.724
2		mart	53.1502	54.1655	65.0797	72.163	51.006	56.875	53.896
3		pari	61.08	67.0265	72.082	88.415	54.801	65.141	46.972
4		nisa	47.0493	54.384	57.7773	68.292	44.607	54.037	48.105
5		pnya	54.093	57.2865	59.3745	86.101	51.367	54.070	N/A
6	**Chennai**	eyeh	46.1118	61.442	65.1376	66.711	43.174	62.825	49.029
7		gndy	69.7028	75.427	76.651	93.382	66.524	71.472	53.623
8		prmb	53.2013	67.495	69.2744	72.866	48.284	68.097	56.894
9		tngr	58.4569	73.275	76.3796	77.982	53.689	74.249	61.040
10		trln	52.2339	66.5725	68.5663	71.947	47.234	67.389	55.368
11	**Delhi**	cpcb	48.2022	60.3595	63.9905	66.696	45.012	61.387	50.912
12		dce	49.5002	50.484	51.7571	53.901	48.364	50.769	50.183
13		dgdn	46.0777	49.282	53.1017	57.785	43.748	50.992	47.293
14		ito	68.2015	72.9195	73.8945	74.435	66.826	68.719	69.651
15		nsit	52.8413	55.1565	61.8061	67.533	51.421	57.047	54.395
16	**Hyderabad**	abit	59.9863	73.6405	75.8889	94.096	55.528	65.506	63.835
17		jdmt	57.8109	62.216	65.1384	66.353	54.956	63.150	59.262
18		pngt	69.4441	76.515	77.935	80.348	66.888	76.848	71.682
19	**Kolkata**	gprk	59.2196	62.7225	65.5084	68.427	56.871	63.443	60.424
20		hq	53.016	60.6735	62.7766	67.026	49.162	61.091	56.143
21		ptli	44.517	51.27	60.7973	65.615	41.762	53.922	49.168
22		sskm	53.0359	58.204	64.0853	64.784	50.737	60.826	54.419
23		New market	56.8487	65.5265	68.1658	77.998	55.834	66.480	59.484
24	**Lucknow**	hgnj	59.5224	70.131	74.6075	75.984	50.9	71.813	62.513
25		ingr	45.7119	50.132	53.7626	55.402	44.486	51.426	46.926
26		tlkt	47.9486	56.8265	63.3222	70.406	44.545	59.614	50.351
27	**Mumbai**	ahsp	57.8054	63.6635	65.5487	66.876	56.341	64.319	59.408
28		bndr	65.6881	68.6015	69.5465	70.474	64.103	68.684	66.784
29		hq	61.0755	64.342	66.0247	68.191	59.477	65.055	61.859
30		tmco	53.2855	60.29	62.7646	66.371	51.433	60.858	55.468
31		vhsp	53.7008	67.5325	70.1397	72.26	48.144	67.755	58.023

AMBIENT NOISE LEVEL PARAMETERS FOR BANGALORE HAS BEEN CALCULATED IN TABLE 5.1, 5.2 AND 5.3 AND SHOWN IN FIGURE 5.1, 5.2, 5.3, & 5.4

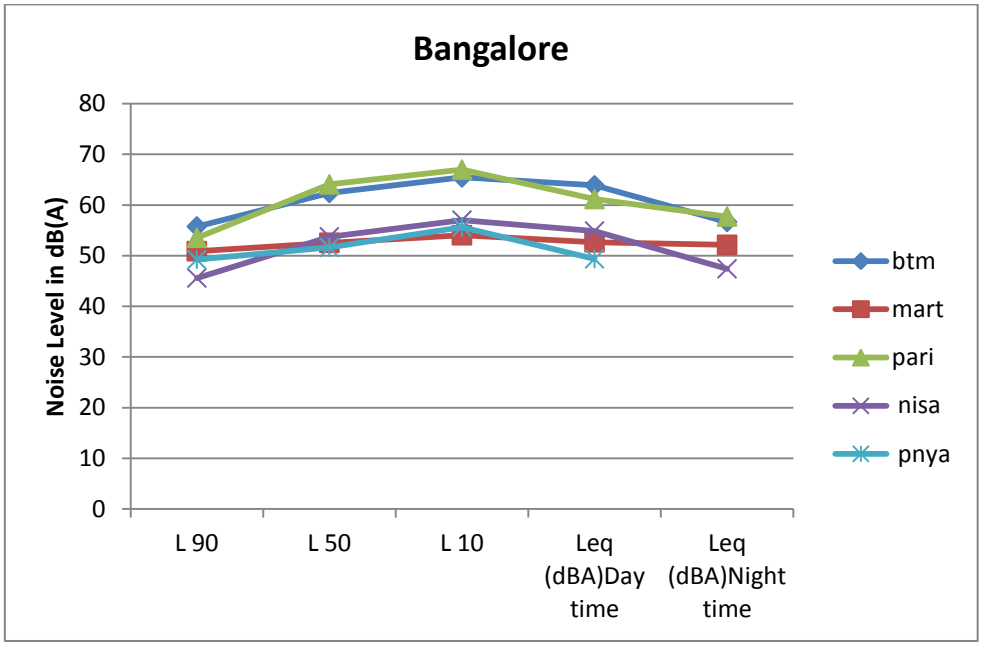


Figure 5.1: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day 1 i.e. 23/10/2011

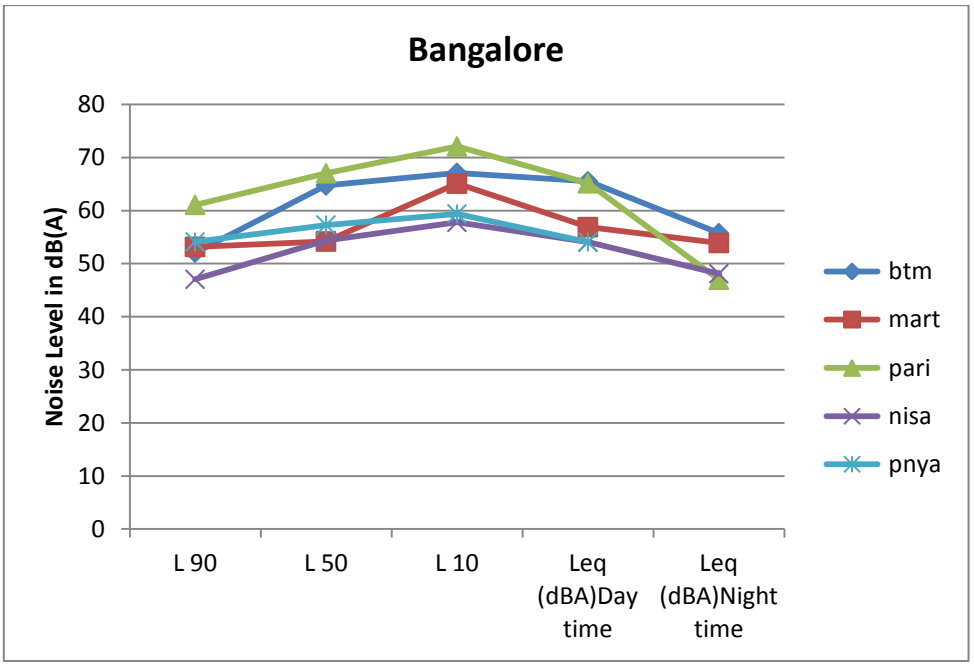


Figure 5.2: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day 2 i.e. 26/10/2011

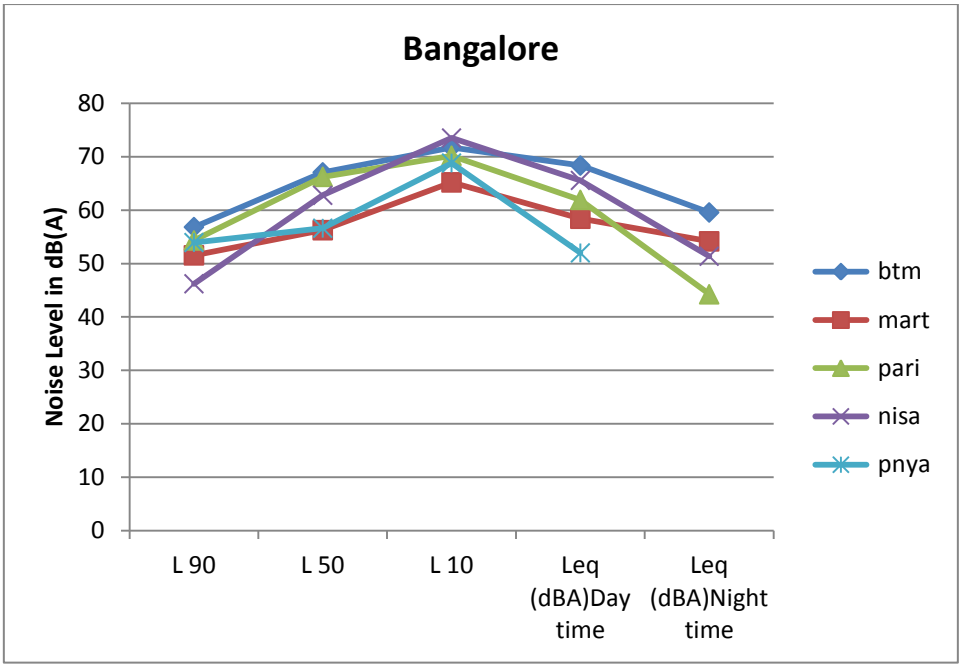


Figure 5.3: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day 3 i.e. 29/10/2011

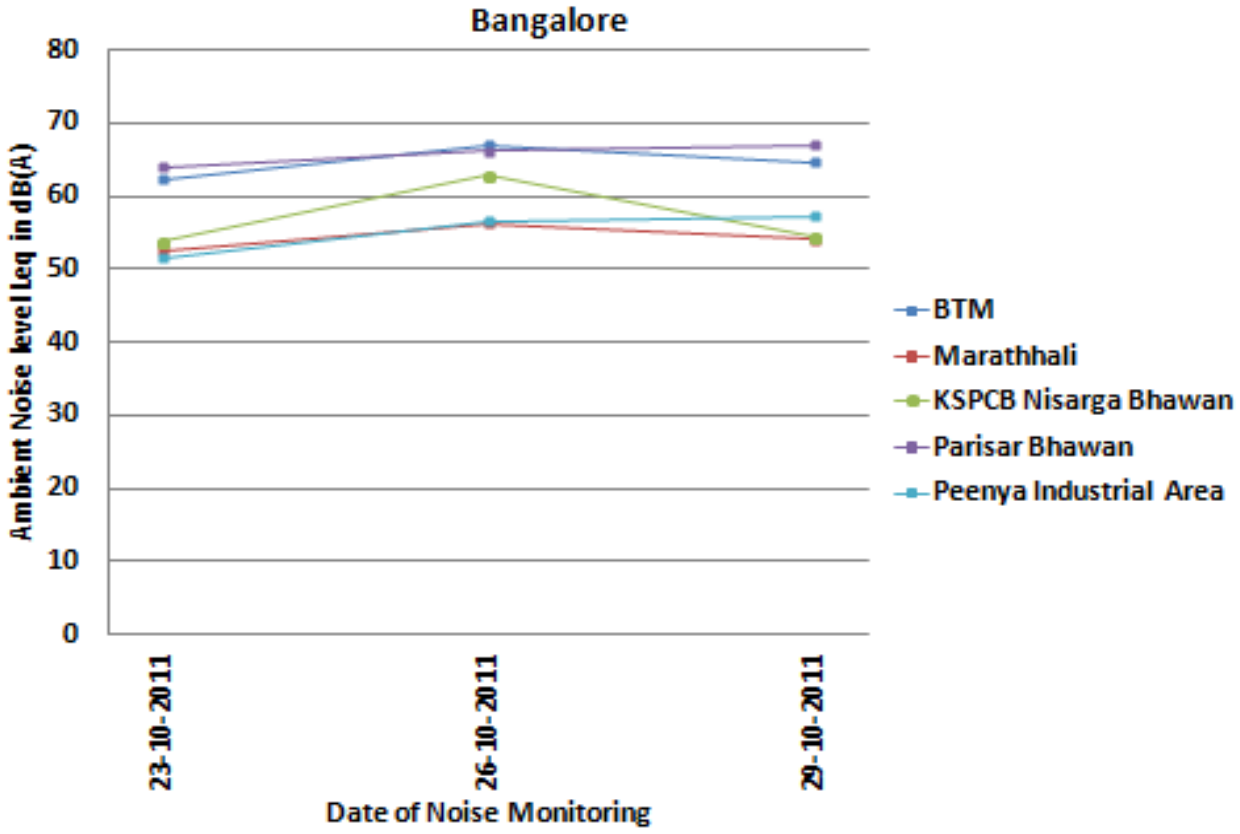


Figure5.4: Comparison of Leq values at various Noise Monitoring stations

Bangalore:

From figures 5.1, 5.2, 5.3 & 5.4, it is clear that the ambient noise level, Leq was more on 26/10/2011 i.e. Diwali day than any other day. Leq for peenya industrial area was in between 60 to 70 dB(A), which is in between the standard Leq of 75 dB(A) (day time) and 70 dB(A) (night time). This implies that industrial area alone contribute a major proportion in noise pollution. Leq of commercial area of Bangalore i.e. Nisarga bhawan was near 65 dB(A) very much close to the standard Leq dB(A) value of 65 dB(A) (day time) & 55 dB(A) (night time). From figures shown above, it is clear that Diwali festival results in increased ambient noise level considerably.

AMBIENT NOISE LEVEL PARAMETERS FOR CHENNAI HAS BEEN CALCULATED IN TABLE 5.1, 5.2 AND 5.3 AND SHOWN IN FIGURE 5.5, 5.6, 5.7, & 5.8

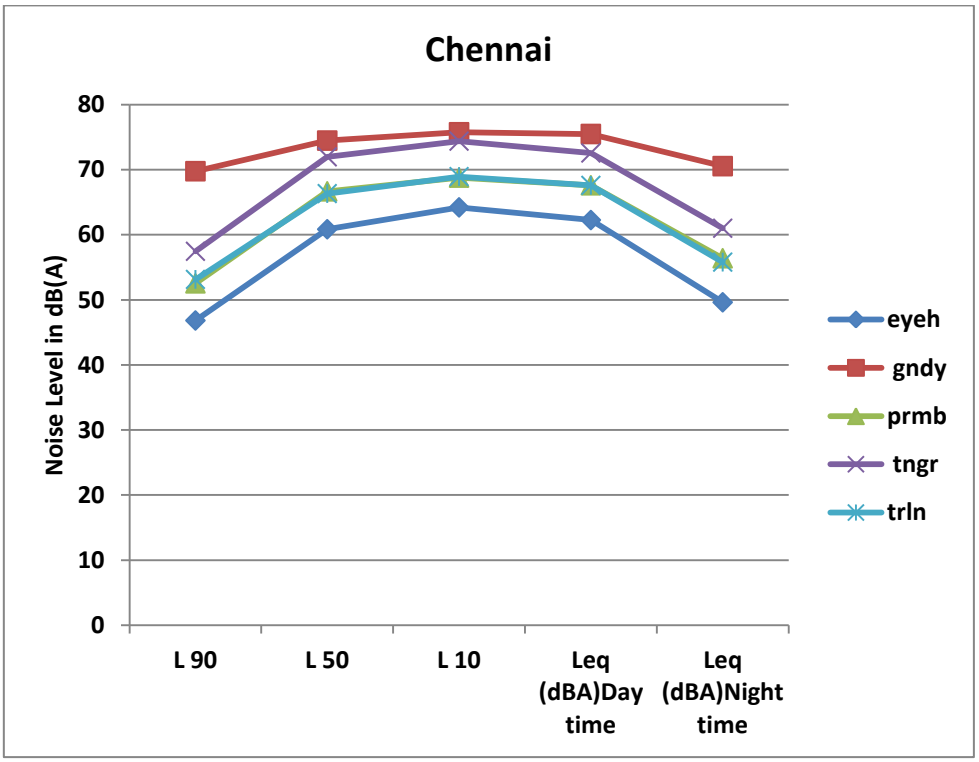


Figure 5.5: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day 1 (23/10/2011)

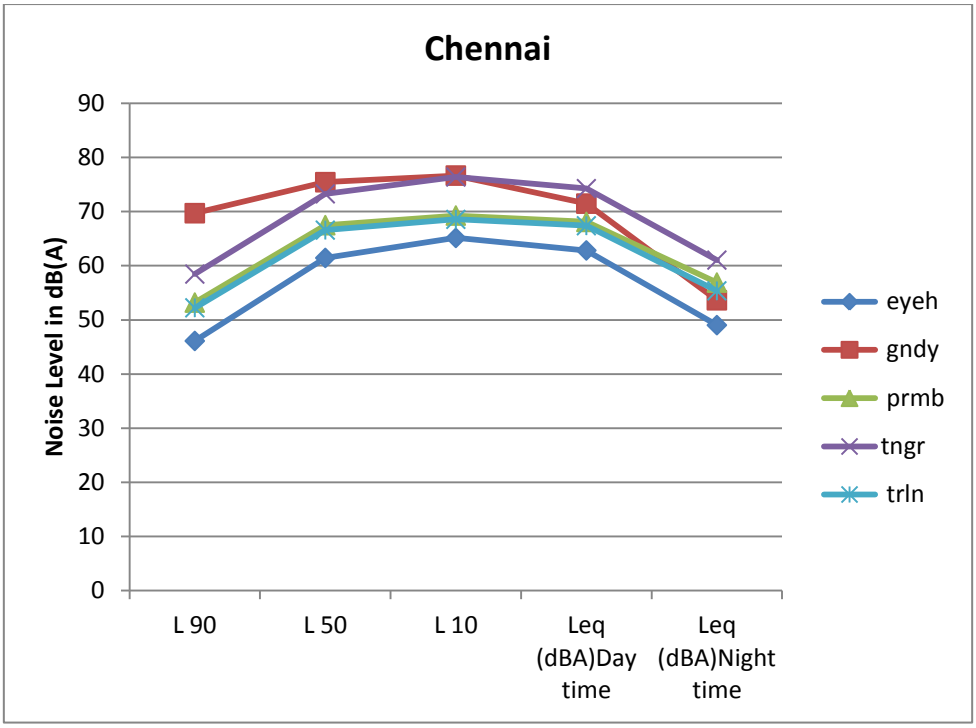


Figure5.6: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day2 i.e. 26/10/2011

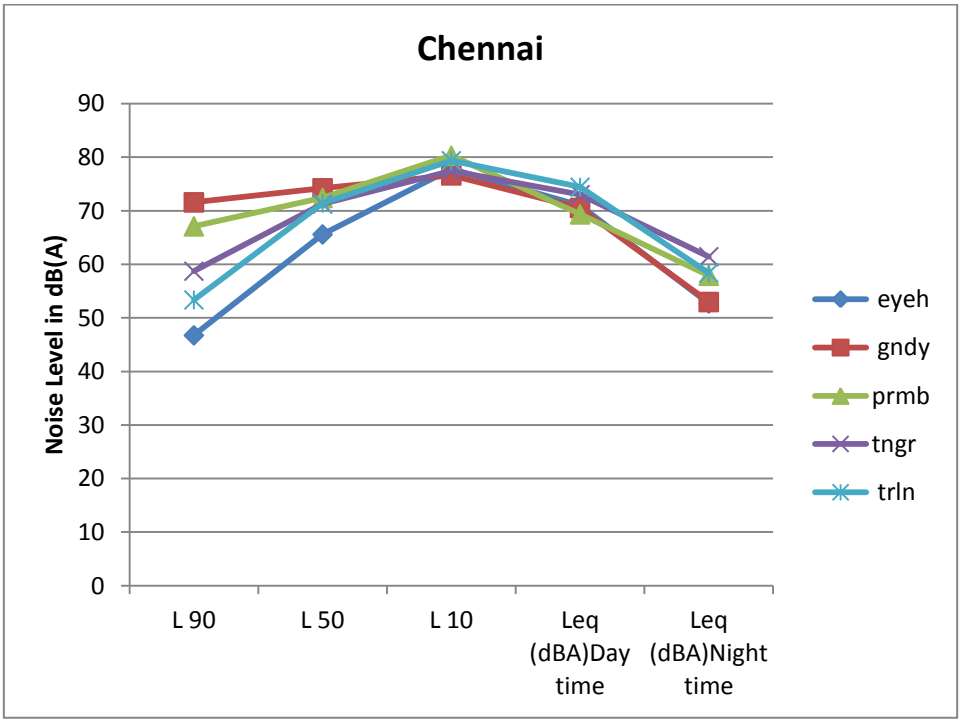


Figure 5.7: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day3 i.e. 29/10/2011

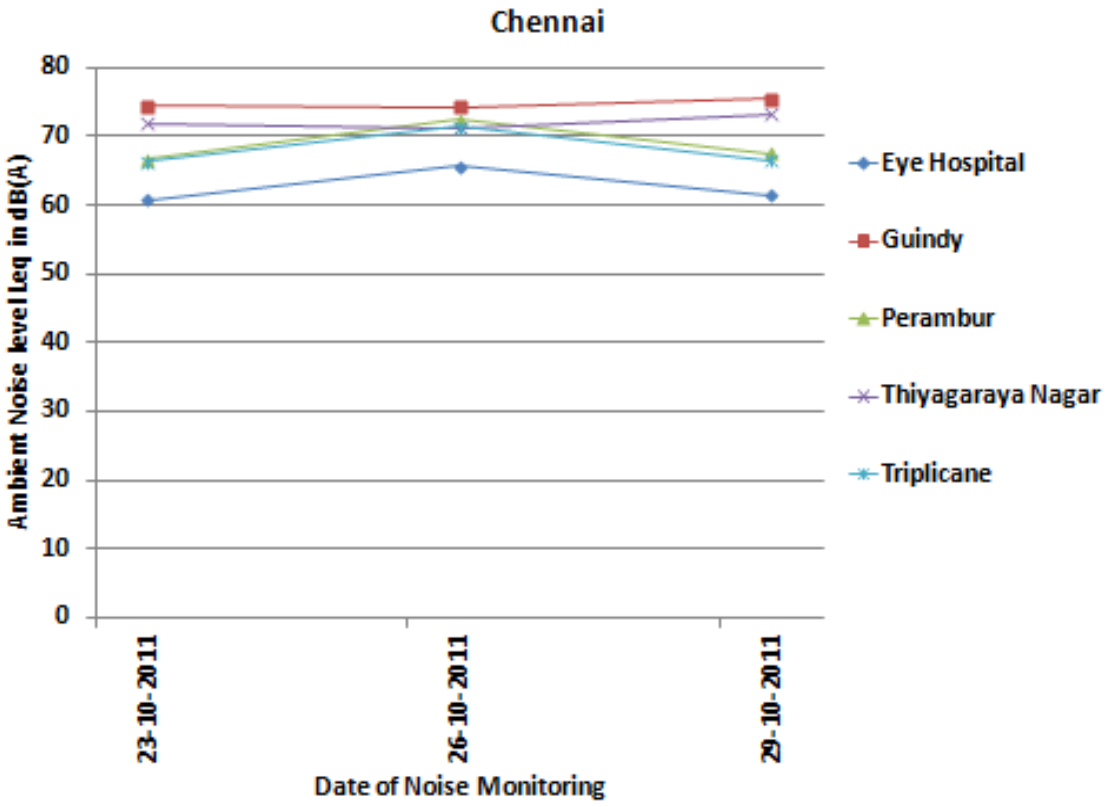


Figure5.8: Comparison of Leq values at various Noise Monitoring stations

Chennai:

The ambient noise level, Leq was maximum on 26/10/2011 i.e. Diwali at Guindy station, which is the commercial area of Chennai which is more than 75 dB(A), that is there is a slight increase in Leq value from the standard for commercial areas which is 65 dB(A) (day time) & 55 dB(A) (night time). The ambient noise level of silence zone in Chennai i.e. eye hospital is around 65 dB(A) which is very much high from the standard Leq of 50 dB(A) (day time) & 40 dB(A) (night time) which shows that there must be some ongoing activity which is contributing towards the increasing ambient noise level.

AMBIENT NOISE LEVEL PARAMETERS FOR DELHI HAS BEEN CALCULATED IN TABLE 5.1, 5.2 AND 5.3 AND SHOWN IN FIGURE 5.9, 5.10, 5.11, & 5.12

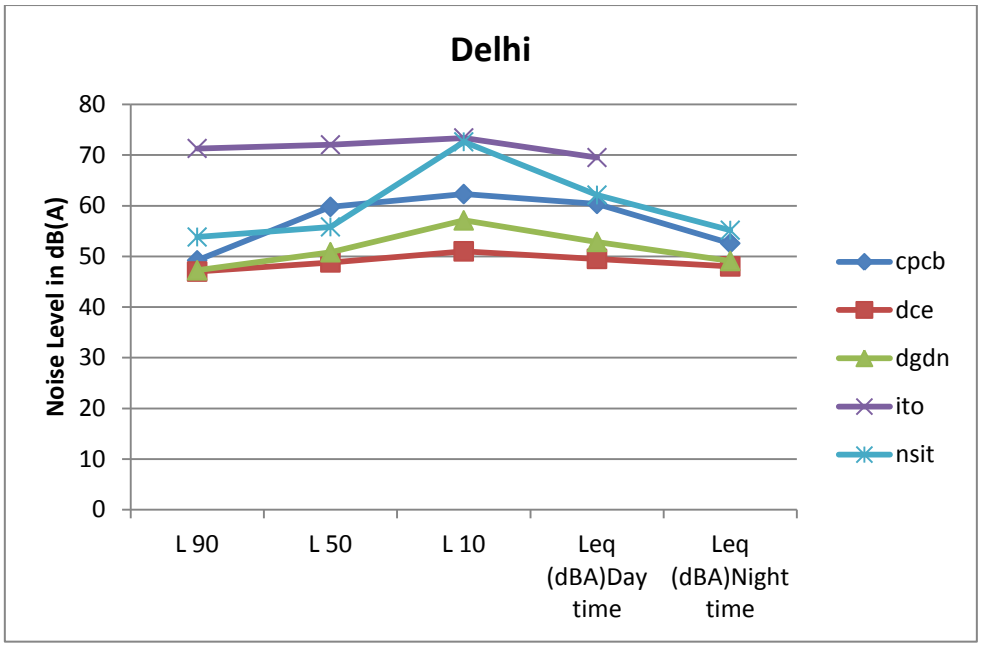


Figure 5.9: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day1 i.e. 23/10/2011

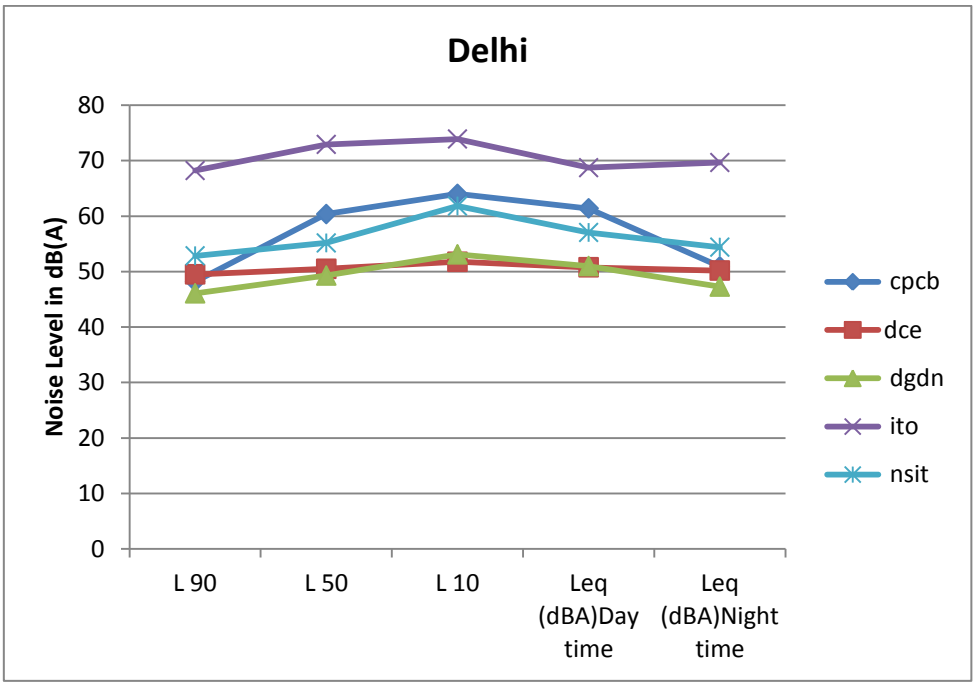


Figure 5.10: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day2 i.e. 26/10/2010

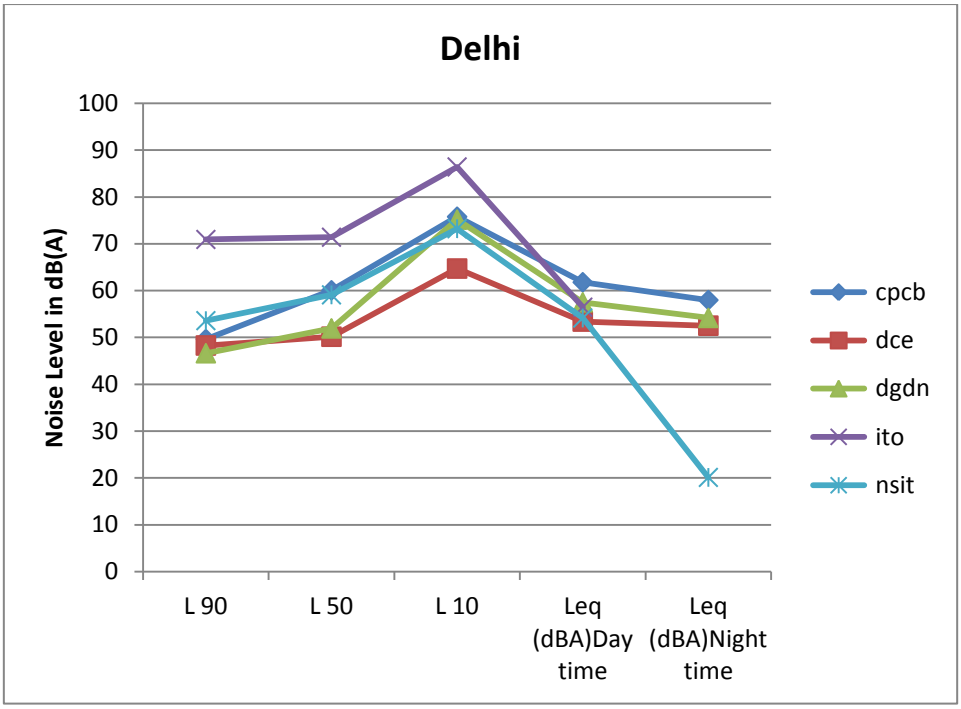


Figure 5.11: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day 3 i.e. 29/10/2010

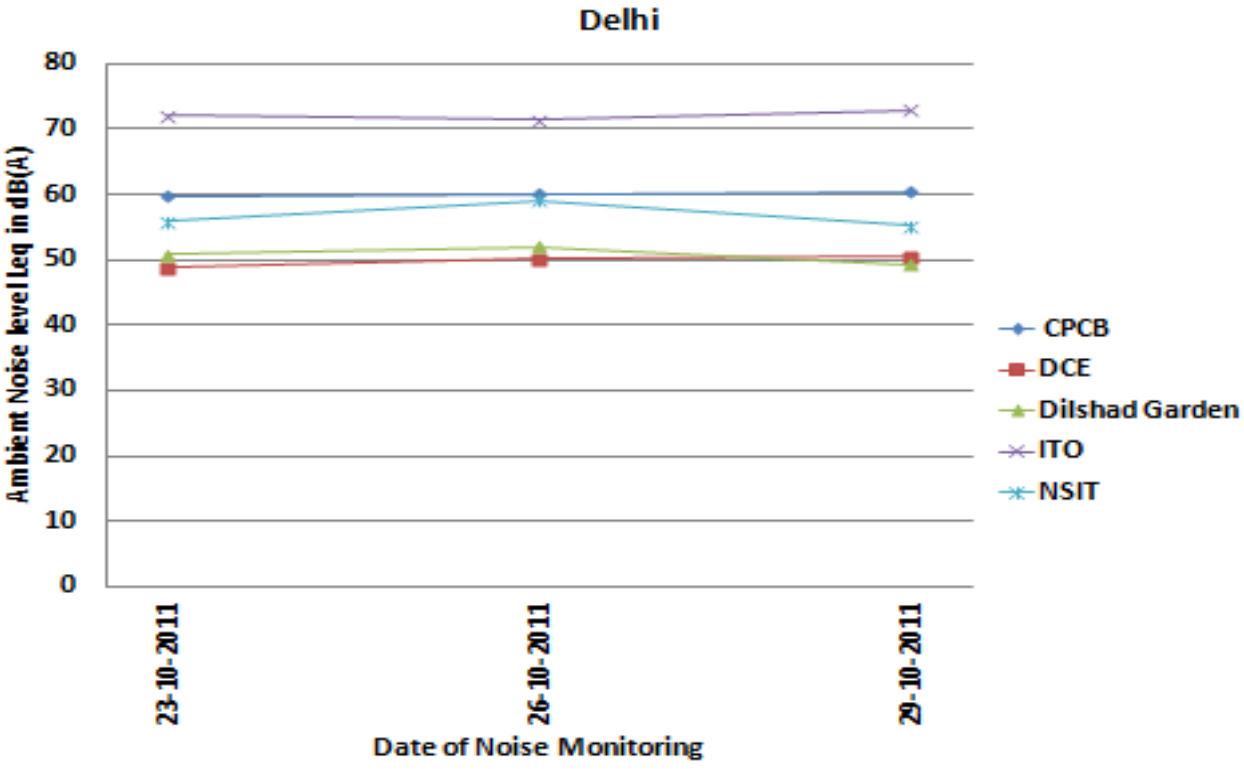


Figure 5.12: Comparison of Leq values at various Noise Monitoring stations

Delhi:

The ambient noise level (Leq) at ITO, which is a commercial area of Delhi was very high, around 75 dB(A) which is crossing 65 dB(A) (day time) & 55 dB(A) (night time) the standard for commercial area. This area is a business hub, a place full of office buildings, and huge amount of traffic flows per hour here. The Leq for CPCB (residential area) is approximately 60 dB(A) which is above the standard ambient noise level for residential areas of 55 dB(A) (day time) & 45dB(A) (night time). The Leq for DCE (silence zone) is 50 dB(A) which is falling within the standard for ambient noise level for silence zone i.e. 50 dB(A) (during day time) & 40 dB(A) (during night time). The Leq for IHBAS, Dilshad garden (silence zone) is slightly above 50 dB(A) on Diwali. And this increase may be due to the bursting of crackers in nearby dilshad garden residential area.

AMBIENT NOISE LEVEL PARAMETERS FOR HYDERABAD HAS BEEN CALCULATED IN TABLE 5.1, 5.2 AND 5.3 AND SHOWN IN FIGURE 5.13, 5.14, 5.15, & 5.16

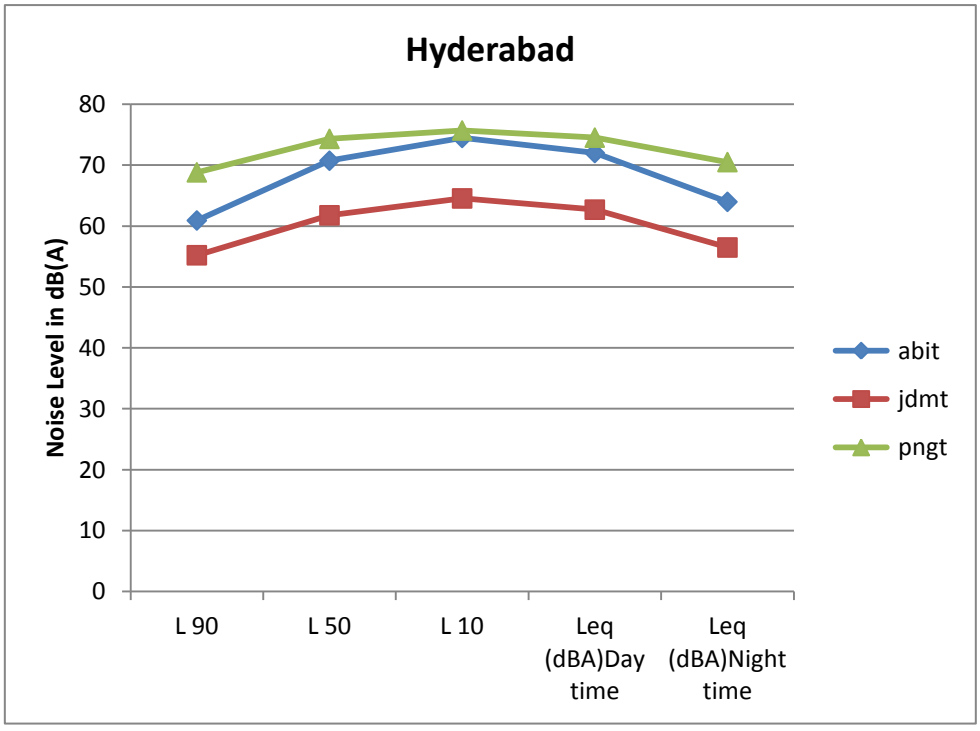


Figure5.13: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day1 i.e. 23/10/2011

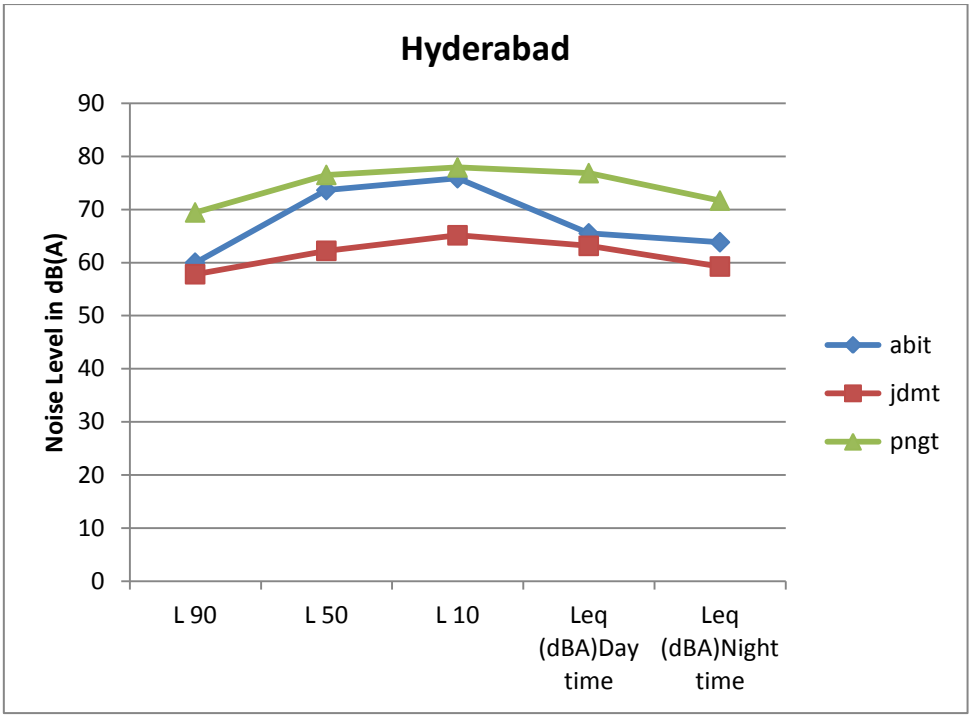


Figure 5.14: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day2 i.e. 26/10/2011

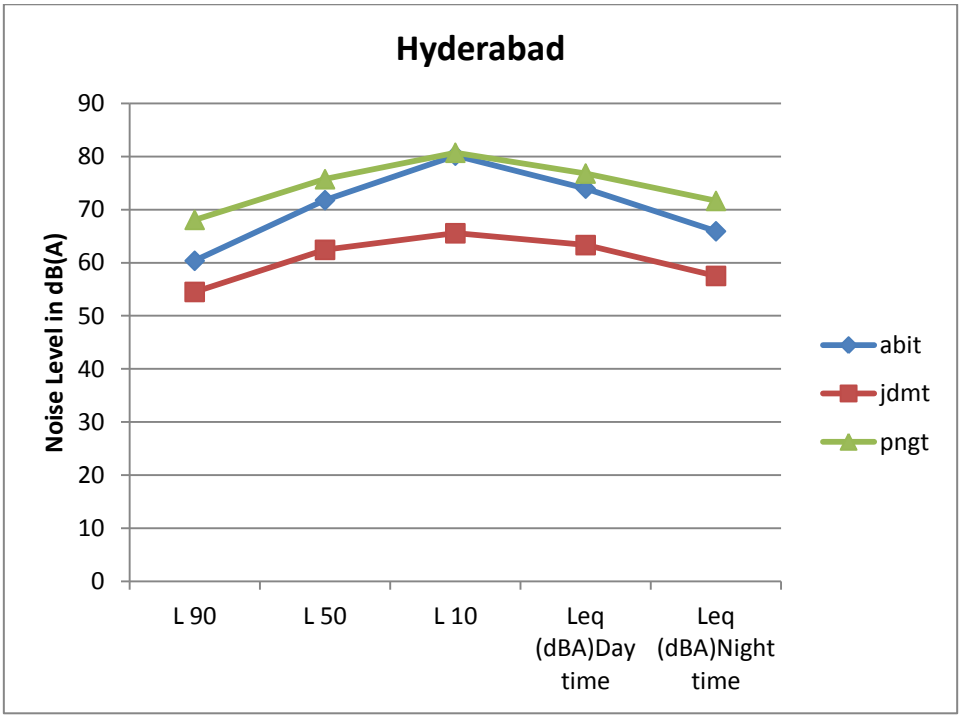


Figure 5.15: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day3 i.e. 29/10/2011

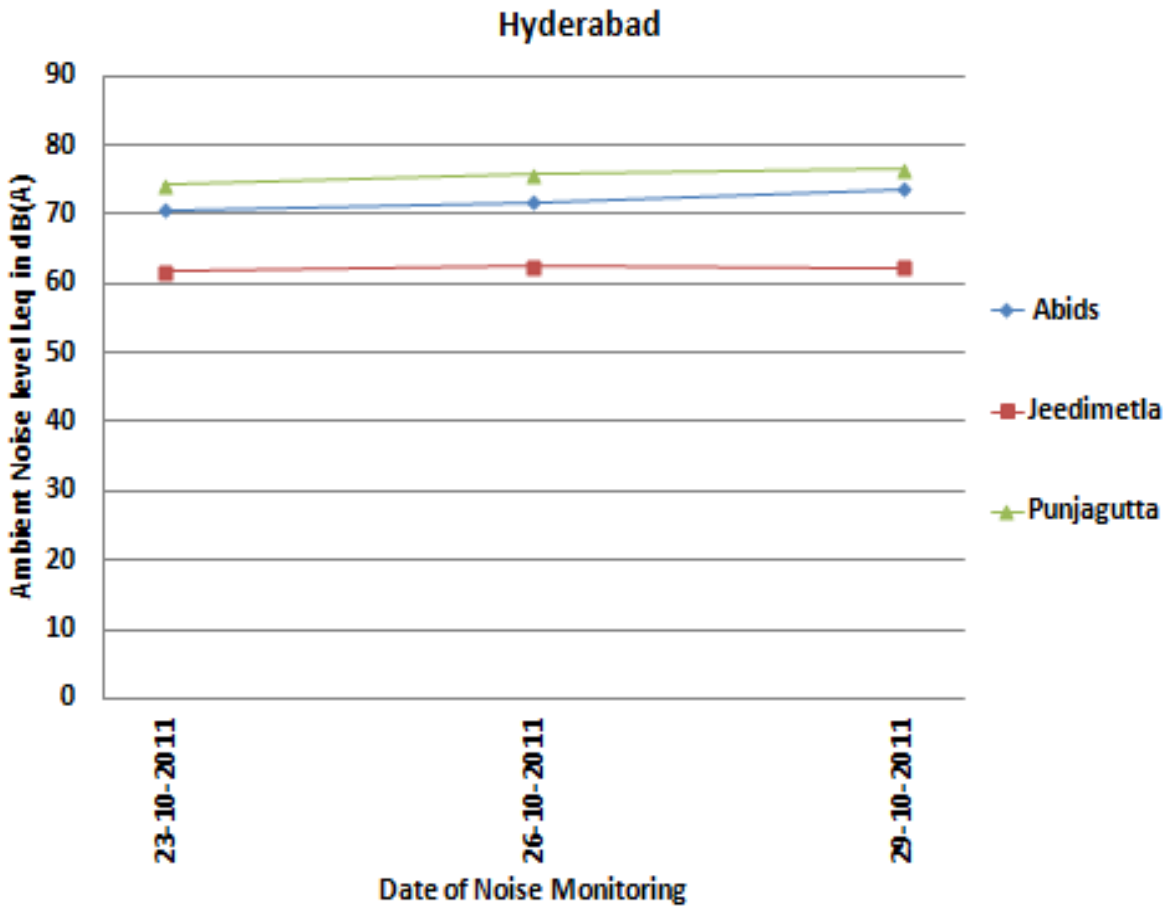


Figure5.16: Comparison of Leq values at various Noise Monitoring stations

Hyderabad:

The ambient noise level, Leq for Abids is 75 dB(A), which is exceeding the prescribed standard of 65 dB(A) for commercial areas. The ambient noise level, Leq for jeedimetla is 63 dB(A), which is falling within prescribed commercial area standards. The ambient noise level, Leq for punjagatta is 78 dB(A), which is slightly more than the prescribed ambient noise level standard for commercial areas.

AMBIENT NOISE LEVEL PARAMETERS FOR KOLKATA HAS BEEN CALCULATED IN TABLE 5.1, 5.2 AND 5.3 AND SHOWN IN FIGURE 5.17, 5.18, 5.19, & 5.20

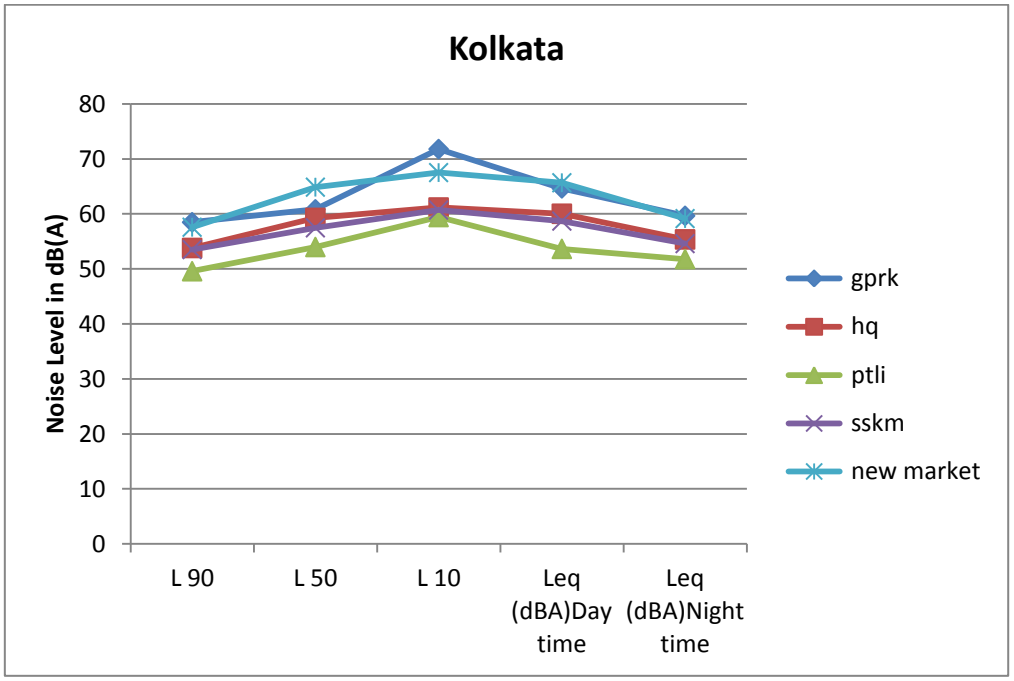


Figure 5.17: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day1 i.e. 23/10/2011

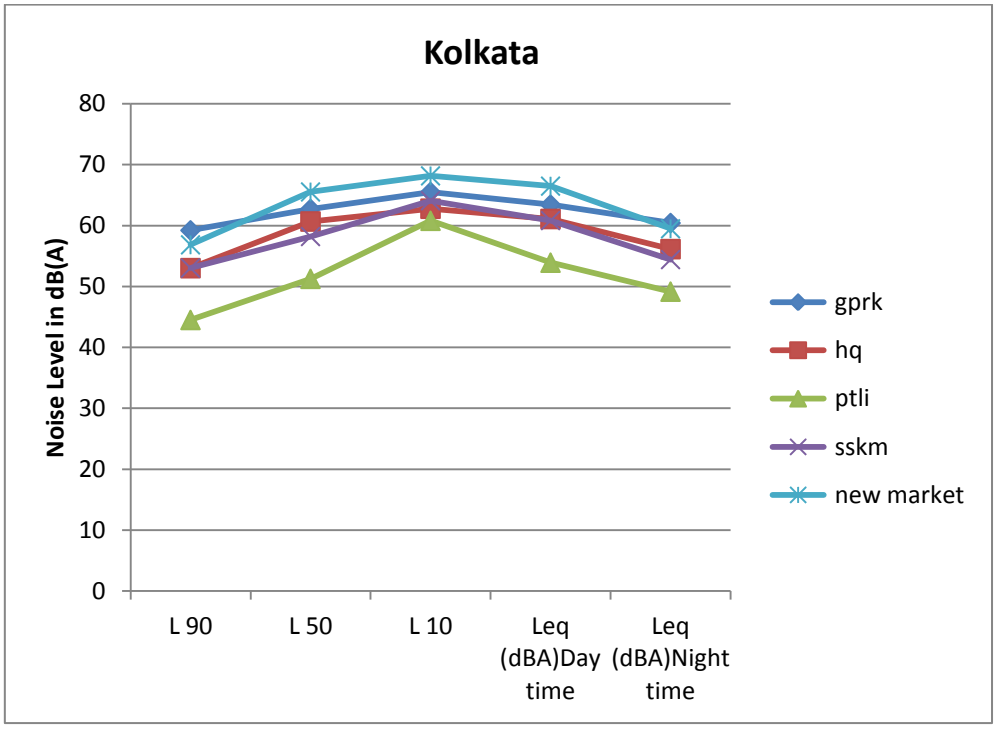


Figure 5.18: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day2 i.e. 26/10/2011

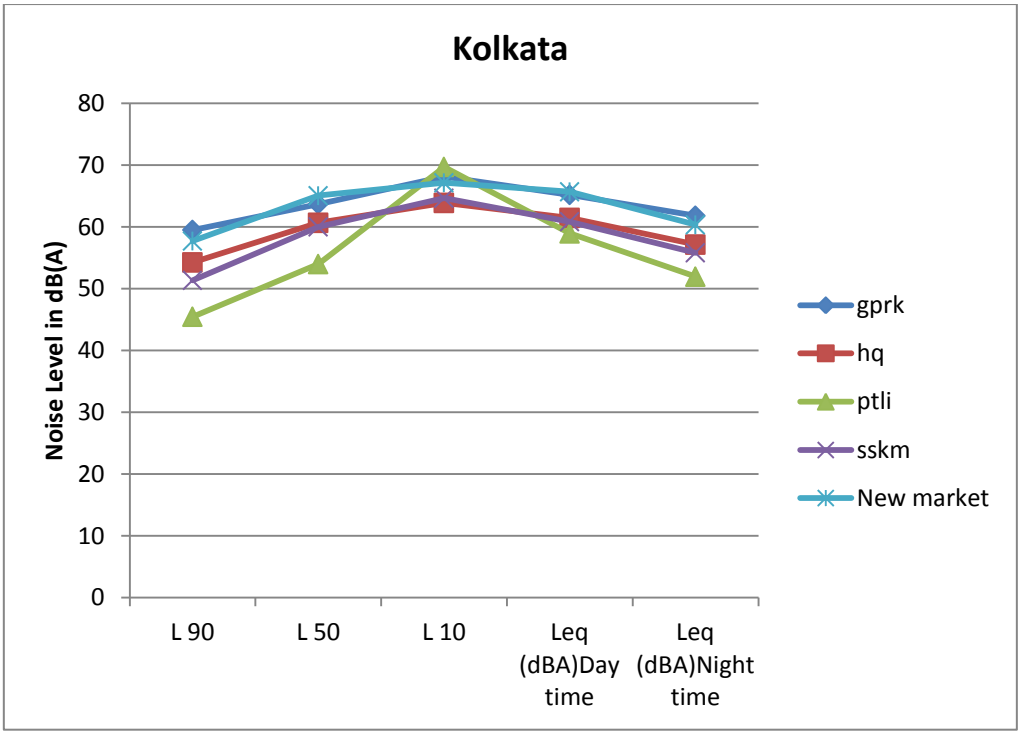


Figure 5.19: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day3 i.e. 29/10/2011

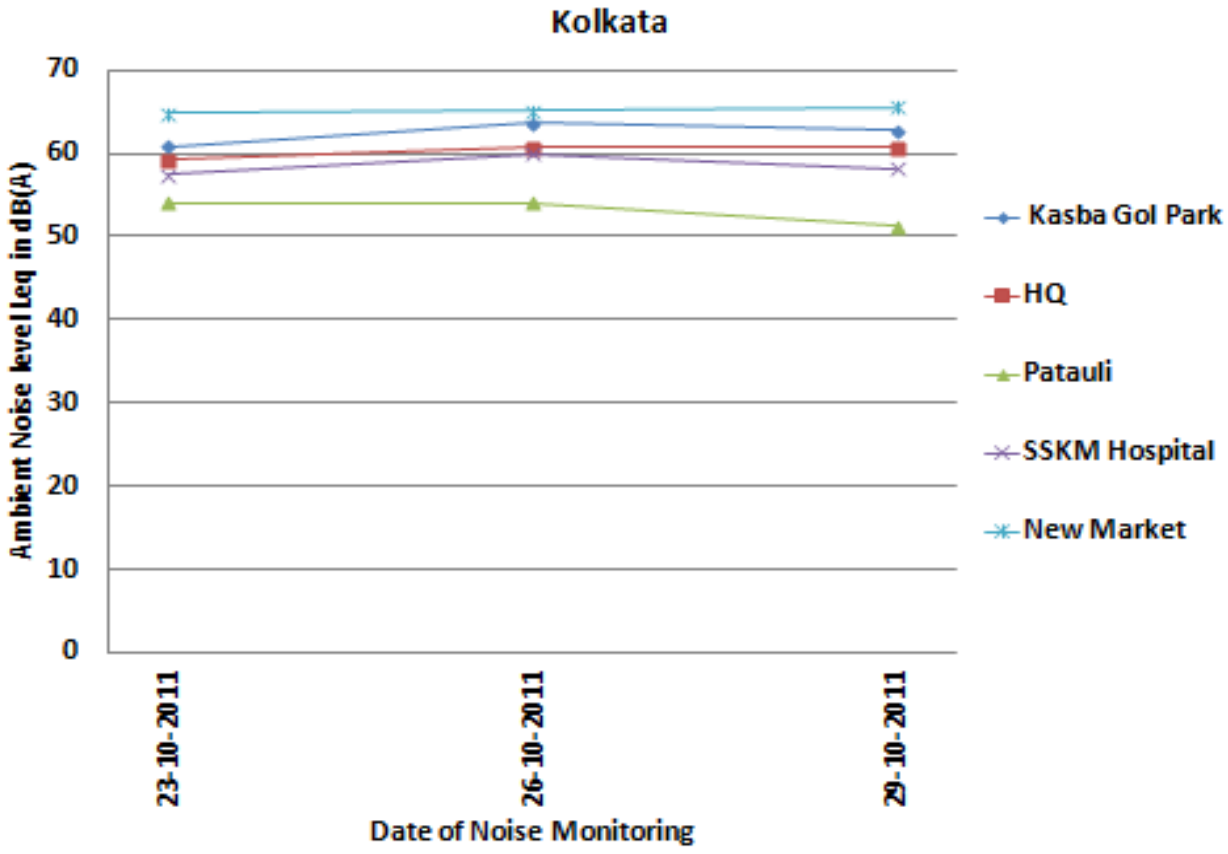


Figure 5.20: Comparison of Leq values at various Noise Monitoring stations

Kolkata:

The Leq for kasba golpark (residential area) is 65 dB(A), which is 10 dB(A) more than the prescribed Leq for residential areas. The Leq for SSKM Hospital is 60 dB(A), which is 10 dB(A) more than the prescribed Leq for silence zones. The Leq for patauli is 55 dB(A), which is within the prescribed Leq (Day time) = 65 dB(A) for commercial areas. These figures depicts that the Leq dB(A) for commercial areas is either near the standard or exceeding the standard ambient noise level for commercial areas.

AMBIENT NOISE LEVEL PARAMETERS FOR LUCKNOW HAS BEEN CALCULATED IN TABLE 5.1, 5.2 AND 5.3 AND SHOWN IN FIGURE 5.21, 5.22, 5.23, & 5.24

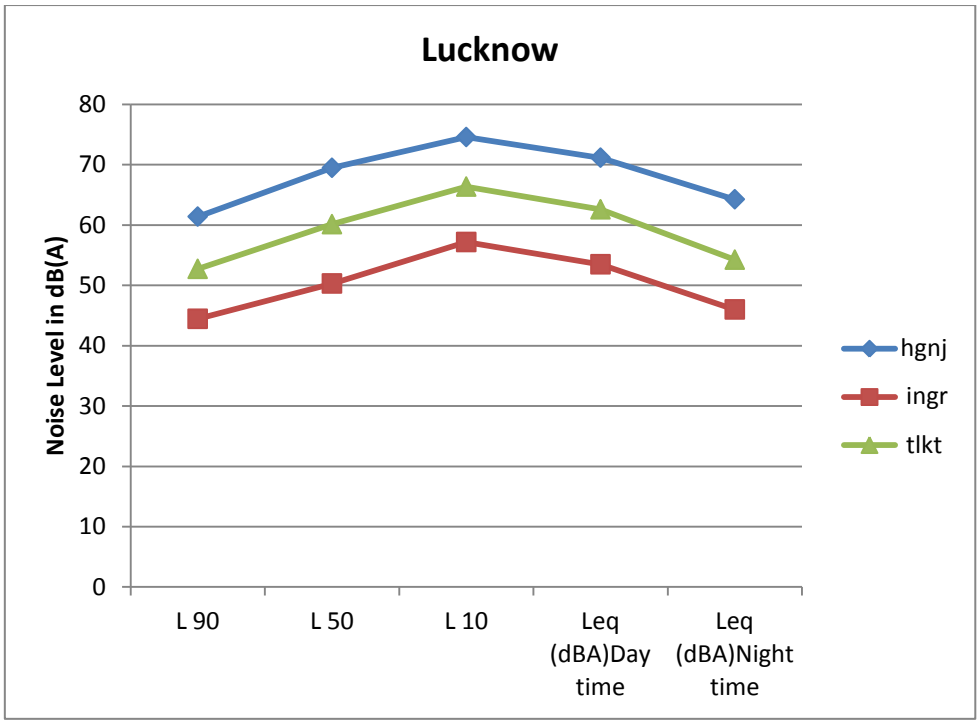


Figure 5.21: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day1 i.e. 23/10/2011

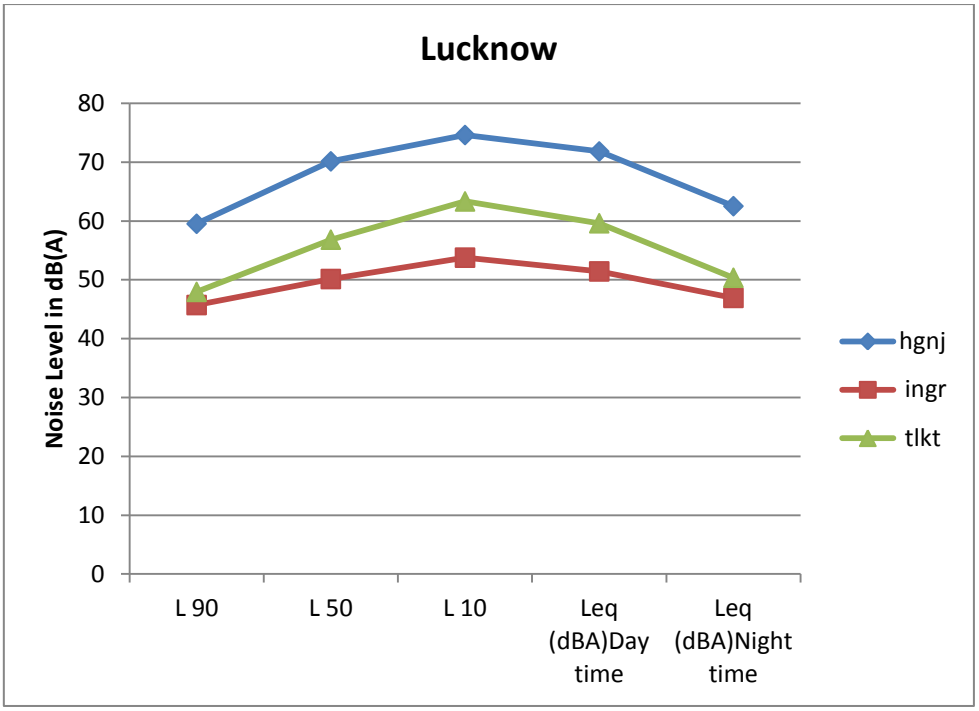


Figure 5.22: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day 2 i.e. 26/10/2011

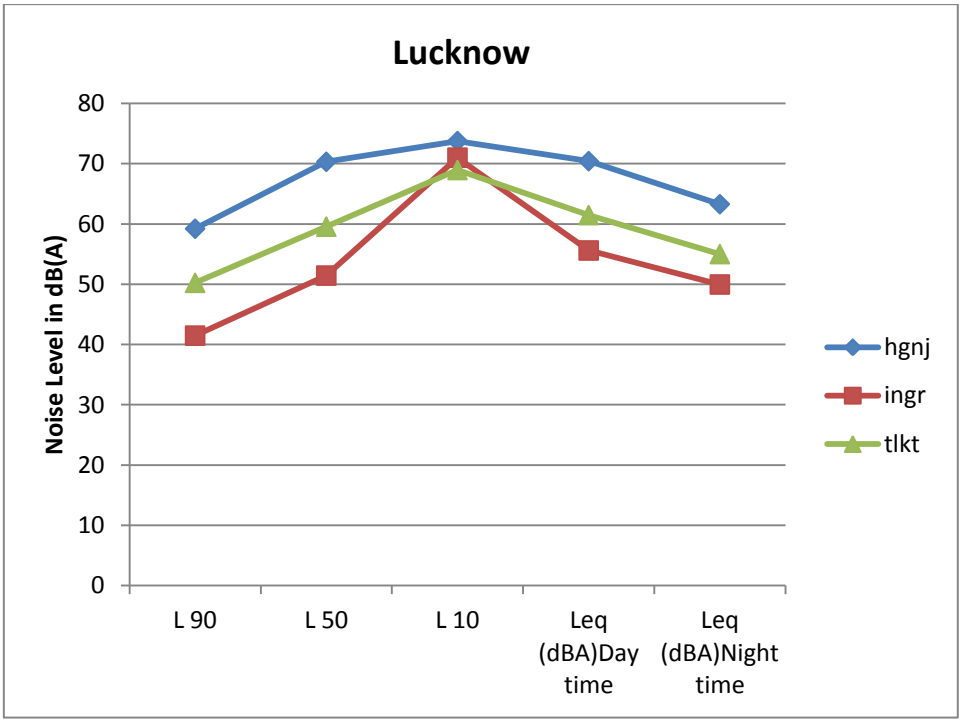


Figure 5.23: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day3 i.e. 29/10/2011

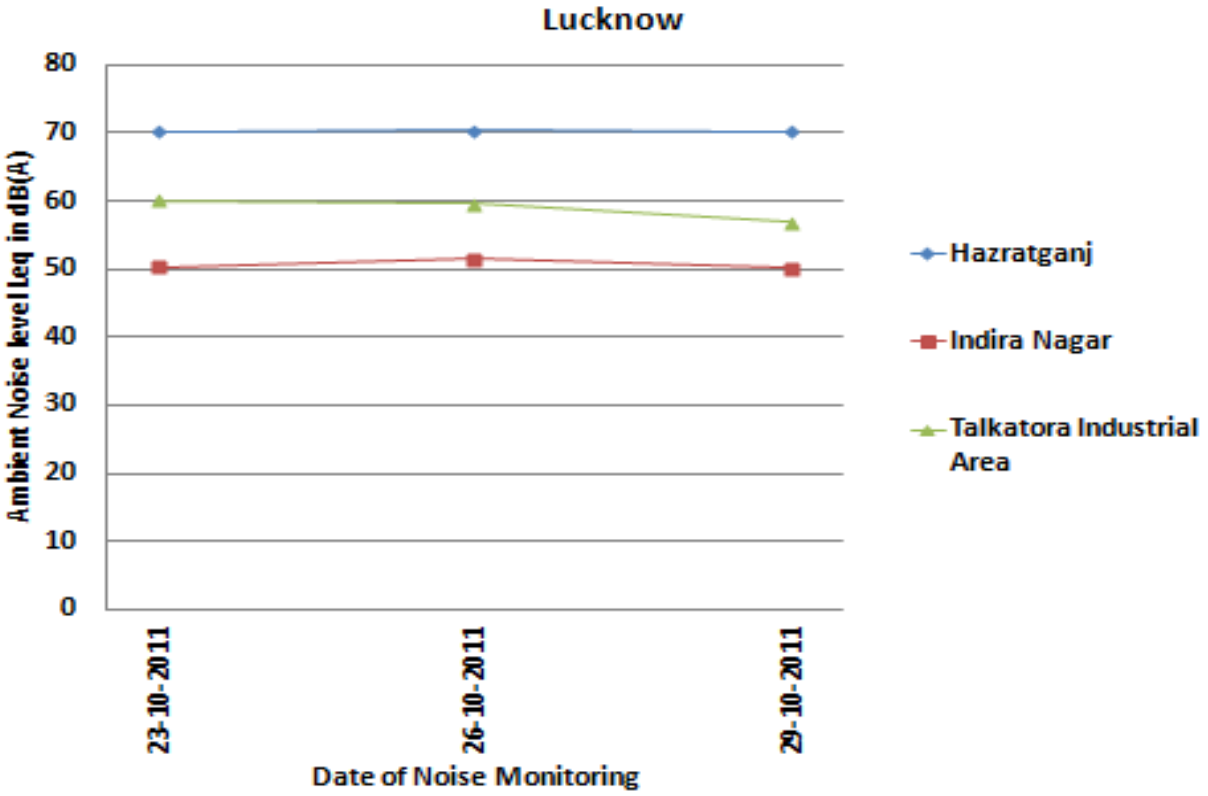


Figure5.24: Comparison of Leq values at various Noise Monitoring stations

Lucknow:

The Leq for Hazrat ganj (commercial area) is 70 dB(A), which is 5 dB(A) more than the standard ambient noise level, Leq (day) of 65 dB(A) for commercial areas. The Leq for Indira nagar (residential area) is 52 dB(A), which is falling within the standard for residential areas prescribed by the government. The Leq for Talkatora industrial area is 60 dB(A), which is 15 dB(A) less than the standard ambient noise level for industrial areas i.e. 75 dB(A) (day time).

AMBIENT NOISE LEVEL PARAMETERS FOR MUMBAI HAS BEEN CALCULATED IN TABLE 5.1, 5.2 AND 5.3 AND SHOWN IN FIGURE 5.25, 5.26, 5.27, & 5.28

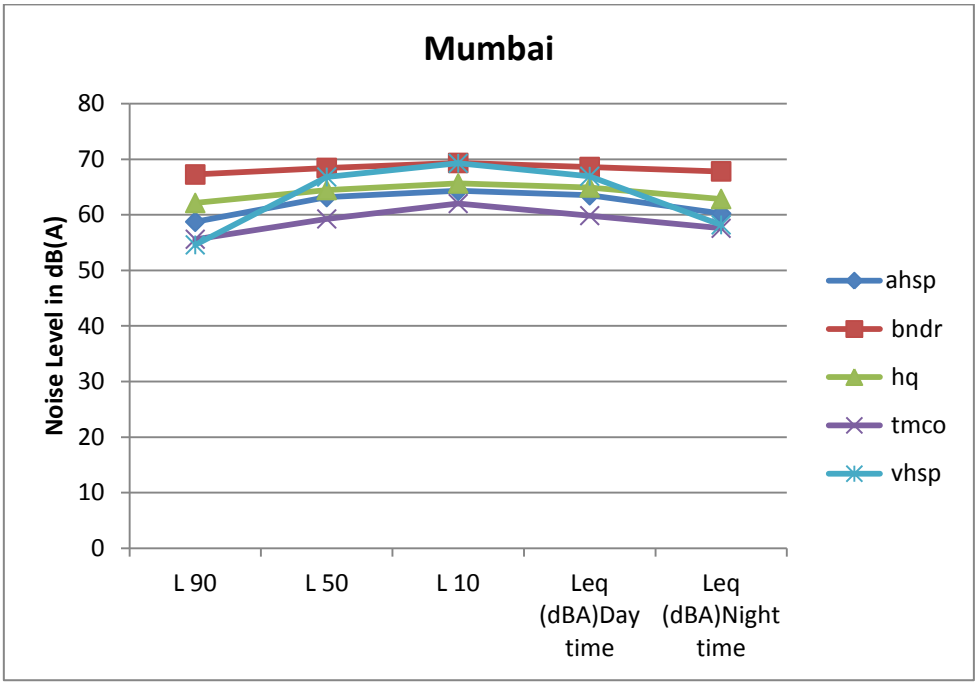


Figure 5.25: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day 1 i.e. 23/10/2011

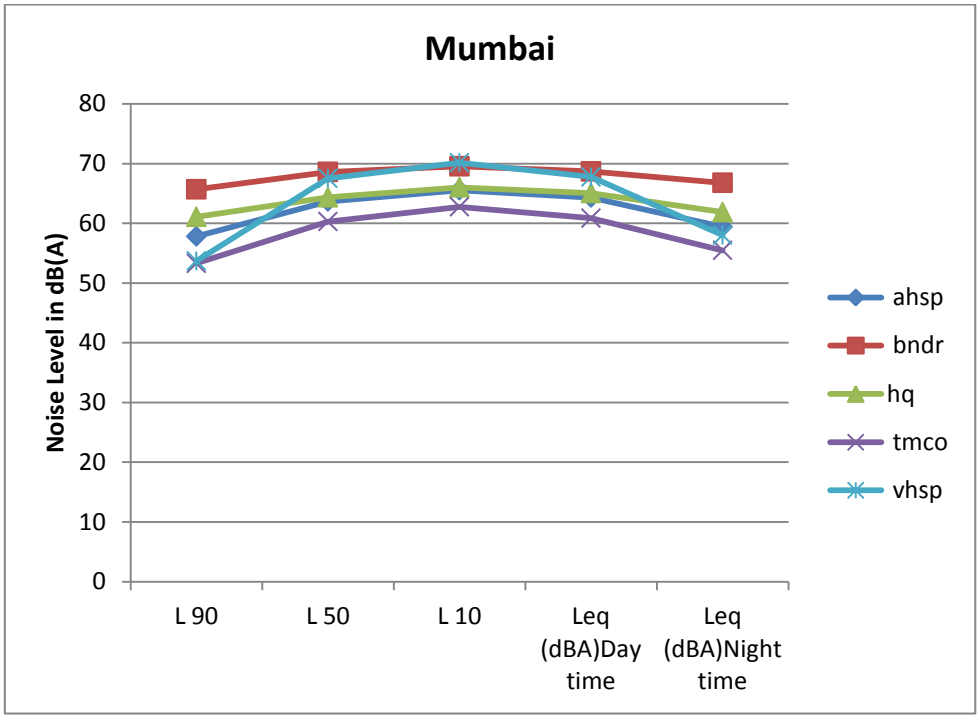


Figure 5.26: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day 2 i.e. 26/10/2011

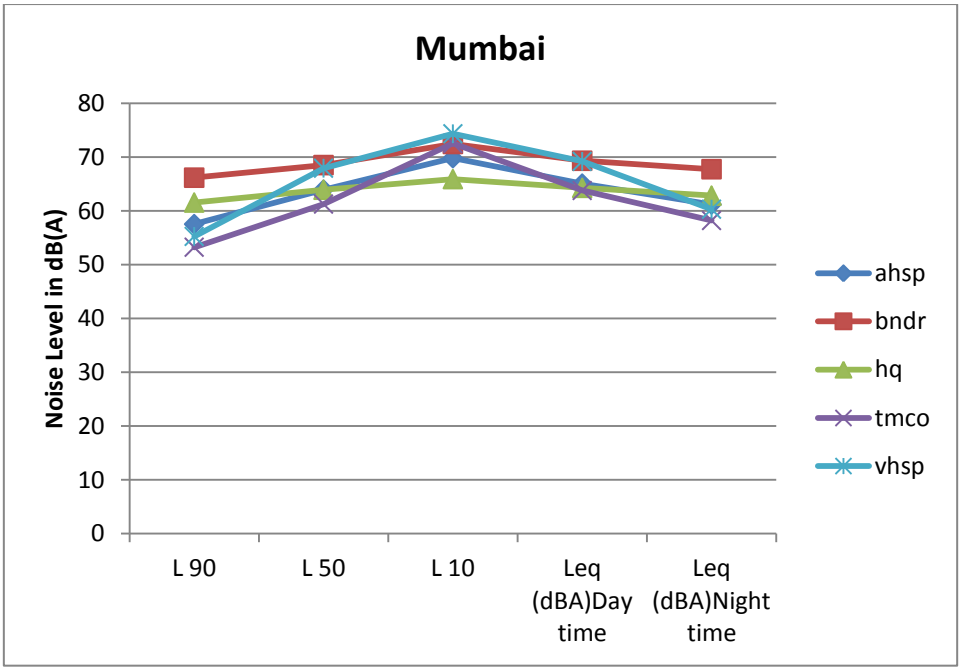


Figure 5.27: Graphical Representation of L_{90}, L_{50}, L_{10}, L_{eq} (Day time) and L_{eq} (Night time) of day3 i.e. 29/10/2011

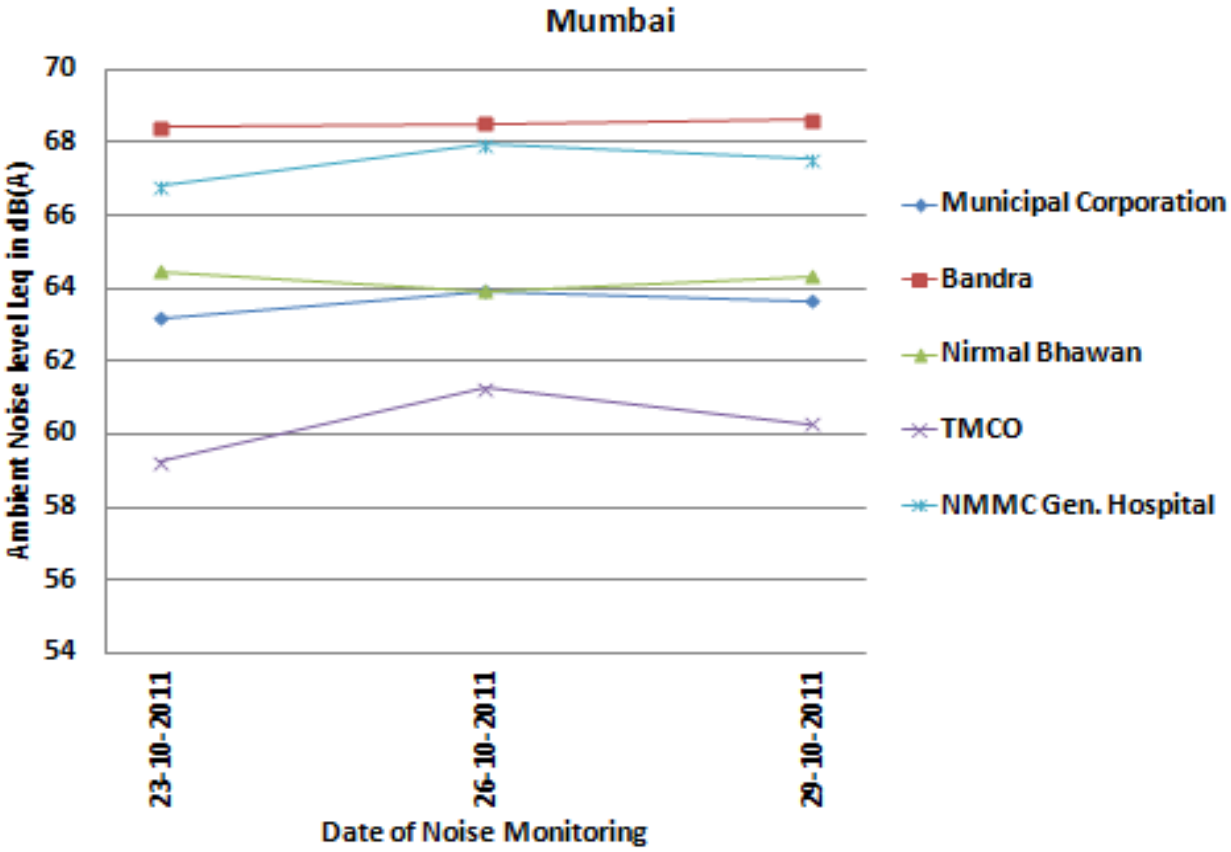


Figure 5.28: Comparison of Leq values at various Noise Monitoring stations

Mumbai:

From the figure it is clear that, In MUMBAI, the noise levels in all locations were exceeding the standards. On comparing the noise levels during day time & night time, it shows that the noise level were higher during both day time and night time. The Leq for NMMC Gen. Hospital (silence zone) is 68 dB(A), which is 18 dB(A) more than the standard ambient noise level for silence zone i.e. 50 dB(A). The Leq for Municipal Corporation (commercial area) is 64 dB(A), which is falling within the standard ambient noise level for commercial area. The Leq for Bandra (residential area) is 69 dB(A), which is 14 dB(A) more than the standard noise level for residential area i.e. 55 dB(A).

Statistical Analysis

Table 5.4: Calculations of Statistical parameters of day 1 noise monitoring data

City 23/10/2011	Station	Mean	Median	Variance	Standard Deviation	Skewness	Kurtosis
Bangalore	btm	61.464	62.489	14.451	3.801	-0.513	-1.418
	mart	52.469	52.609	0.903	0.95	-0.517	-0.612
	pari	62.642	63.846	27.193	5.214	-0.453	0.371
	nisa	52.391	54.057	16.993	4.122	-0.55	-1.006
	pnya	54.03	52.325	40.488	6.363	2.659	7.961
Chennai	eyeh	58.047	61.218	44.057	6.637	-0.967	-0.533
	gndy	73.838	74.81	9.442	3.072	0.394	2.61
	prmb	63.869	66.969	39.495	6.284	-1.247	0.126
	tngr	68.712	71.999	42.374	6.509	-0.976	-0.506
	trln	63.66	66.679	39.319	6.27	-1.027	-0.433
Delhi	cpcb	57.757	60.33	23.973	4.896	-1.1	-0.255
	dce	49.002	48.994	1.809	1.345	0.166	-1.311
	dgdn	51.596	50.336	12.829	3.581	0.441	-1.069
	ito	74.129	72.062	22.511	4.744	2.167	3.96
	nsit	59.784	55.701	102.24	10.111	2.211	3.611
Hyderabad	abit	69.328	70.88	25.746	5.074	-0.714	-0.355
	jdmt	60.632	61.769	11.278	3.358	-0.582	-1.085
	pngt	73.186	74.043	6.45	2.539	-0.969	-0.168
Kolkata	gprk	62.987	61.083	24.569	4.956	1.079	-0.522
	hq	58.476	59.436	7.664	2.768	-0.476	-0.322
	ptli	56.082	54.145	53.293	7.3	2.072	4.564
	sskm	57.336	57.202	6.161	2.483	-0.473	-0.697
	new market	63.504	64.876	13.071	3.615	-0.652	-1.043
Lucknow	hgnj	68.86	69.336	24.834	4.983	-0.385	-1.264
	ingr	50.987	51.276	19.7	4.438	0.011	-1.125
	tlkt	59.817	60.334	24.447	4.944	-0.18	-1.291
Mumbai	ahsp	62.418	63.329	4.086	2.021	-1.595	1.464
	bndr	68.329	68.467	0.561	0.749	-1.264	1.687
	hq	64.23	64.509	1.707	1.306	-0.889	0.568
	tmco	59.086	59.419	3.438	1.854	-0.481	-0.055
	vhsp	64.018	66.942	31.573	5.619	-0.891	-0.691

Majority of the times the Ambient noise level is greater than the mean noise level, then it is known as negative skew, e.g. Hyderabad, Mumbai, Bangalore, Chennai and Lucknow have negative skew, while Delhi has positive skew. Kurtosis signifies the "peakedness" of the

normal distribution. Variance is the measure of dispersion from the mean value. Standard deviation is the square root of the variance.

Table 5.5: Calculations of Statistical parameters of day 2 noise monitoring data

City 26/10/2011	Stations	Mean	Median	Variance	Standard Deviation	Skewness	Kurtosis
Bangalore	btm	65.416	67.266	31.325	5.596	-0.423	-0.779
	mart	56.982	56.297	21.637	4.651	1.279	1.456
	pari	64.033	65.972	32.578	5.707	-1.056	0.037
	nisa	60.831	62.77	92.139	9.598	-0.233	-0.787
	pnya	59.422	56.866	29.324	5.415	0.817	-1.061
Chennai	eyeh	64.903	64.745	117.895	10.857	-0.582	-0.555
	gndy	74.701	74.396	7.745	2.782	1.047	2.802
	prmb	74.354	72.792	39.09	6.252	1.264	3.825
	tngr	69.164	71.423	46.016	6.783	-0.779	-0.24
	trln	69.09	71.77	92.436	9.614	-0.856	-0.097
Delhi	cpcb	60.519	60.389	74.425	8.627	0.724	0.224
	dce	53.106	49.847	38.428	6.199	1.392	0.388
	dgdn	56.4	52.95	102.611	10.129	1.052	-0.158
	ito	75.286	71.615	59.675	7.724	1.94	2.71
	nsit	64.217	60	115.627	10.753	0.673	-0.864
Hyderabad	abit	71.287	72.233	63.187	7.949	0.455	0.7
	jdmt	61.391	62.329	14.262	3.776	-1.011	-0.158
	pngt	75.086	75.776	17.341	4.164	-0.457	-0.321
Kolkata	gprk	64.057	63.682	10.813	3.288	0.262	-0.472
	hq	60.018	60.575	10.594	3.254	-0.852	-0.131
	ptli	56.621	54.36	73.248	8.558	0.4	-0.966
	sskm	59.175	59.954	21.639	4.651	-0.529	-0.27
	New market	63.907	64.514	11.418	3.379	-1.034	0.059
Lucknow	hgnj	68.033	70.717	31.906	5.648	-0.679	-1.107
	ingr	53.716	52.01	102.036	10.101	1.067	0.545
	tlkt	59.314	60.157	43.929	6.627	0.285	-0.352
Mumbai	ahsp	63.778	64.038	16.201	4.025	-0.108	-0.255
	bndr	68.795	68.406	4.448	2.109	0.648	-0.626
	hq	63.806	63.826	2.361	1.536	-0.184	0.178
	tmco	61.933	60.908	42.343	6.507	0.36	-0.599
	vhsp	66.244	68.007	43.096	6.564	-0.713	-0.333

Majority of the times the Ambient noise level is greater than the mean noise level, then it is known as negative skew, e.g. Hyderabad, Mumbai, Bangalore and Chennai, while Delhi has

positive skew. Kurtosis signifies the "peakedness" of the normal distribution. Variance is the measure of dispersion from the mean value. Standard deviation is the square root of the variance.

Table 5.6: Calculations of Statistical parameters of day 3 noise monitoring data

City 29/10/2011	Stations	Mean	Median	Variance	Standard Deviation	Skewness	Kurtosis
Bangalore	btm	62.241	64.833	31.861	5.644	-1.01	-0.451
	mart	55.882	54.364	17.502	4.183	2.205	3.761
	pari	67.526	67.594	35.149	5.928	1.545	5.926
	nisa	53.298	54.77	18.618	4.314	-0.486	-0.941
	pnya	57.675	56.881	21.885	4.678	3.082	11.172
Chennai	eyeh	58.226	61.508	54.75	7.194	-0.91	-0.719
	gndy	74.882	75.547	10.876	3.297	0.502	4.127
	prmb	64.362	67.651	38.359	6.193	-1.235	0.037
	tngr	69.846	73.192	50.516	7.107	-0.793	-0.982
	trln	63.382	66.689	39.466	6.282	-1.053	-0.475
Delhi	cpcb	57.895	60.29	35.405	5.95	-0.665	-1.134
	dce	50.573	50.478	0.513	0.716	-0.018	-0.402
	dgdn	49.759	49.492	7.09	2.663	0.434	0.139
	ito	72.031	73.132	4.544	2.131	-1.192	-0.054
	nsit	56.163	54.949	11.734	3.425	1.456	1.385
Hyderabad	abit	70.853	73.847	41.273	6.424	-0.703	-0.282
	jdmt	61.854	61.914	7.113	2.667	-0.313	-1.348
	pngt	75.126	76.683	11.689	3.419	-1.185	-0.106
Kolkata	gprk	62.436	62.76	4.419	2.102	-0.039	-0.202
	hq	59.441	60.79	13.233	3.637	-1.136	0.614
	ptli	52.337	51.177	26.933	5.189	0.37	-0.456
	sskm	58.69	58.167	15.359	3.919	-0.114	-0.947
	new market	64.148	66.11	18.172	4.262	-0.793	-0.778
Lucknow	hgnj	68.713	69.991	37.358	6.112	-1.009	0.293
	ingr	49.926	50.497	7.361	2.713	-0.299	-1.101
	tlkt	56.526	57.537	30.566	5.528	-0.168	-1.062
Mumbai	ahsp	62.682	63.589	7.854	2.802	-0.904	-0.452
	bndr	68.05	68.809	2.098	1.448	-0.938	-0.609
	hq	63.989	64.339	3.675	1.917	-0.495	-0.929
	tmco	59.061	60.376	11.047	3.323	-0.803	-0.794
	vhsp	64.511	67.882	37.802	6.148	-0.931	-0.482

Majority of the times the Ambient noise level is greater than the mean noise level, then it is known as negative skew, e.g. Hyderabad, Mumbai, Bangalore, Kolkata, Chennai and Lucknow. Kurtosis signifies the "peakedness" of the normal distribution. Variance is the

measure of dispersion from the mean value. Standard deviation is the square root of the variance.

Delhi's statistical calculation shows positive skew of all the zones, on 23/10/2011 & 26/10/2011. On 29/10/2011, Commercial and Industrial zones of Delhi e.g. ITO and CPCB have negative skew, while residential and silence zones show positive skew e.g. Dilshad garden and NSIT college respectively.

Discussion

Based on the data of the measured equivalent noise levels in the residential, commercial, industrial, and silence zones of the 7 cities, it can be stated that during day time noise levels from 40 to 60 dB(A) prevail in residential areas away from traffic roads, noise levels from 60 – 80 dB(A) prevail in residential areas close to traffic roads and in commercial areas, noise level from 70 – 90 dB(A) exits at the traffic junctions and in industrial areas, and noise level from 80- 105 dB(A) exists in areas with heavy traffic (Singal,2000, 2005). Even the silent zones are quite noisy as has been shown by data collected by CPCB. Further, merely 30% of the residential colonies in metropolitan cities have noise level within prescribed limits, the quiet period is only during the early morning hours from 0200 – 0500 hours when noise level falls within 40 – 45dB(A), and the ambient noise levels during festivities e.g. Diwali festival becomes quite high i.e., from 85 – 120dB(A).

Further it has been found that traffic noise is the most annoying source of noise, and that the percentage of people highly annoyed by noise varies generally from 5 to 10 % in the comparatively quiet locations (diurnal Leq values about 55 – 60 dB(A)), and up to 30 % in the noisiest locations (with diurnal Leq values about 70 – 75dB(A)). Organisation for Economic Cooperation and Development in a report (OECD, 1986) has also stated that around 20 % of the people globally suffer from noise levels exceeding 65 dB(A), where most people become annoyed or have disturbed sleep or undergo adverse health effects, and another 40 % of the people are living in the so called grey areas (sound pressure levels in the range 55 – 65 dB(A) where noise levels are such as to cause serious annoyance only during night time.

It has been generally found that the degree of annoyance caused by any activity always depends upon the relative benefits derived from it under the conditions one is placed in. For example, the degree of annoyance experienced by the housewife due to equivalent noise levels from domestic appliances is less compared to traffic noise, and the degree of annoyance experienced by the children due to equivalent noise levels from bursting of crackers on Diwali is less compared to industrial noise.

Under noisy conditions, criterion for 100 % sentence intelligibility for normal people is that speech interference level should be about 10 dB(A) lower than the A – weighted sound pressure level for the same degree of interference. During relaxed conversation at home, a speech level of approximately 55dBA is required for a background noise level of 45 dB(A). As the background noise level increases, people naturally tend to raise their voice to overcome the masking effect.

Noise studies made by Ingerslev (1987) further shows that for noise exposures of 80 dB(A) to 100 dB(A) for a period of 10 years, the percentage of persons who get hearing handicap, increases from zero to as high as 42. This percentage increases only marginally with more number of years of exposure.

High intensity impulsive sounds due to bursting of crackers, exceeding a sound pressure level of 140 dB for more than 200 milliseconds regardless of rise of time spectrum and presence of oscillatory transients have been seen to cause instant damage to the ear (acoustic trauma) without any chance of recovery in the threshold shift at high frequencies. For the initial threshold shifts less than 40dB, recovery may be completed in 200 – 1000 minutes, however for the threshold shifts exceeding 40 dB, recovery has been found to be slow and in some cases may not completed at all leading to permanent threshold shift.

Noise affects even birds and animals. On animals, noise produces the same effect as it does on humans. According to one of the reports of the ministry of environment and forests, GOI, about 5 – 10 % birds of Delhi city die during Diwali festival every year. This is due to exposure to heavy sounds of crackers of the bird species that are 1000 times more sensitive to sound than man. Loud sounds can cause behavioural change, hypertension and brain haemorrhage resulting in sudden death.

Based on the statistical calculations of the ambient noise monitoring data, the most polluting city is Chennai, the 2nd most polluting city is Hyderabad, 3rd most polluting city is Bangalore, 4th polluting city is Mumbai, 5th polluting city is Kolkata, 6th polluting city is Lucknow and the last is Delhi.

CASE STUDY

Ambient Noise Levels of Delhi in 2011 compared to the year 1995, 1999

CHAPTER-6

CASE STUDY- AMBIENT NOISE LEVELS OF DELHI IN 2011 COMPARED TO THE YEAR 1995 & 1999

Delhi is located in northern India between the latitudes of 28°-24'-17" and 28°-53'-00" North and longitudes of 76°-50'-24" and 77°-20'-37" East. Delhi shares borders with the States of Uttar Pradesh and Haryana. Delhi has an area of 1,483 sq. kms. Its maximum length is 51.90 kms and greatest width is 48.48 kms.

Delhi is situated on the right bank of the river Yamuna at the periphery of the Gangetic plains. It lies a little north of 28 n latitude and a little to the west of 78 longitude. To the west and south-west is the great Indian Thar desert of Rajasthan state, formerly known as Rajputana and, to the east lies the river Yamuna across which has spread the greater Delhi of today. The ridges of the Aravalli range extend right into Delhi proper, towards the western side of the city, and this has given an undulating character to some parts of Delhi. The meandering course of the river Yamuna meets the ridge of Wazirabad to the north; while to the south, the ridge branches off from Mehrauli. The main city is situated on the west bank of the river.

Table 6.1: Noise quality in accordance with the land use pattern

Land use	**% of land**
Residential	45 -55
Commercial	4-5
Industrial	4-5
Green/ Recreational*	15 - 20
Public & Semi-Public Facilities	8 - 10
Circulation	10-12

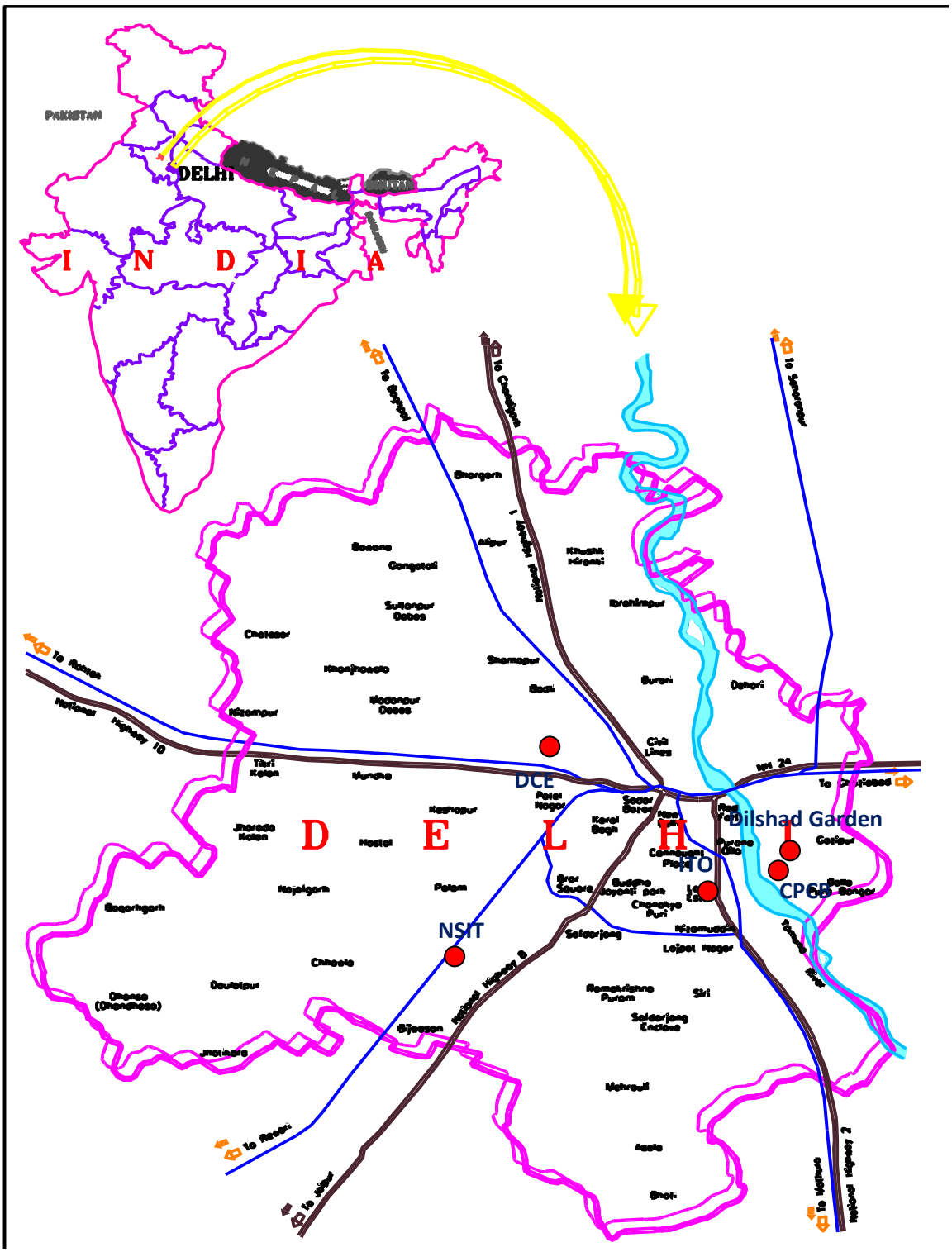
* This does not include green areas within the various gross land use categories.

Based on the data of the measured equivalent noise levels in the residential, commercial, industrial, and silence zones of the 7 metropolitan cities, it can be stated that during day time noise levels from 40 to 60dB(A) prevail in residential areas away from traffic roads, noise levels from 60 – 80dB(A) prevail in residential areas close to traffic roads and in commercial areas, noise level from 70 – 90dB(A) exits at the traffic junctions and in industrial areas, and noise level from 80- 105dB(A) exists in areas with heavy traffic (Singal,2000, 2005). Even the silent zones are quite noisy as has been shown by data collected by CPCB. Further, merely 30% of the residential colonies in metropolitan cities have noise level within prescribed limits, the quiet period is only during the early morning hours from 0200 – 0500 hours when noise level falls within 40 – 45dB(A), and the ambient noise levels during festivities e.g. Diwali festival becomes quite high i.e., from 85 – 120dB(A).

6.1 DELHI MONITORING NETWORK

There are five monitoring stations, established by CPCB, located at 5 different places in Delhi which represents the ambient noise quality of the city viz., DCE, NSIT, CPCB, ITO and Dilshad garden. Location of all five stations has been depicted in the map shown below

Figure 6.1: Map of Delhi showing ambient noise monitoring stations across the city



6.2 POPULATION

As per 2001 Census, NCT of Delhi had a total population of 138 lakh. NCT Delhi is highly urbanized with 93.18% of its population living in urban areas as against the national average of 27.81%. During 1991-2001, the urban population of Delhi increased at 3.87 % annual growth rate. With the continuation of the present population trend, the total population of NCTD by the year 2011, 2012 and 2021 would be 182 lakh, 188.2 lakh and 225 lakh respectively.

There has been increase in natural growth from 55.80% in 1981 to 59.21% in 1991 and 60.18% in 2001 and decrease in the net migrants from 44.20% in 1981 to 40.78% in 1991 and 39.82% in 2001. However, a reduction in the rate of natural growth and increase in migration between 2001and 2021 is envisaged in the MPD 2021. The net increase of population in NCT-Delhi is given below:

Table6.2: Population in NCT-Delhi

Year	Addition by natural growth	Increase by migration	Net increase (in lakh)
1981	12.0 (55.8 %)	9.52 (44.2 %)	21.54 (100%)
1991	18.9 (59.2%)	13.05 (40.8%)	32.0 (100%)
2001	26.66 (60.18%)	17.64 (39.82%)	44.30 (100%)
2011	24.2 (54.8%)	20.0 (45.2%)	44.2 (100%)
2021	24.0 (50%)	24.0 (50%)	48.0 (100%)

Note: Figures (in bracket) indicate percentage to total net increase.
{Source: Census of India and projections by DDA Sub-Group (MPD- 2021)}

6.3 TRAFFIC DENSITY OF DELHI

Delhi has significant reliance on its transport infrastructure. The city has developed a highly efficient public transport system with the introduction of the Delhi Metro, which is undergoing a rapid modernization and expansion. There are 5.5 million registered vehicles in the city, which is the highest in the world among all cities most of which do not follow any pollution emission norm (within municipal limits), while the Delhi metropolitan region (NCR Delhi) has 11.2 million vehicles. Delhi and NCR lose nearly 42 crore (420 million) man-hours every month while commuting between home and office through public transport, due to the traffic congestion. Therefore serious efforts, including a number of transport infrastructure projects, are under way to encourage usage of public transport in the city.

The period between 1981 and 2001 has seen a phenomenal increase in the growth of vehicles and traffic in Delhi. There has been a rise in per capita trip rate (excluding walk trips) from 0.72 in 1981 to 0.87 in 2001. Keeping in view the population growth, this translates into an increase from 45 lakh trips to around 118 lakh trips. The population of motor vehicles has increased from 5.13 lakh in 1981 to 32.38 lakh in 2001, and the number of buses has increased from 8,600 to 41,483 during this period (Source: Delhi master plan, MPD- 2021).

Besides the above, Delhi has developed as a borderless city and an urban continuum comprising of a number of rapidly growing towns in Haryana and UP. This has added to the flow and movement of traffic within Delhi. Despite measures by way of increasing the length of the road network and road surface space through widening, construction of a number of flyovers/grade separators and, launching of the Metro, the traffic congestion has continued to increase unabated. This has its inevitable consequences in terms of accidents, pollution, commuting time, and wasteful energy / fuel consumption.

6.3.1 History: Prior to independence in 1930s, public transport in the city was in private hands, with people relying mainly on tongas and the bus services of the 'Gwalior Transport Company' and 'Northern India Transport Company'. But with the growing city, it soon proved inadequate, thus Delhi Transport Corporation (DTC) bus system was established in May 1948. The next big leap in city transport was the opening of Delhi Metro, a rapid transit system in 2002.

6.3.2 Overview: Public transport in the metropolis includes the Delhi Metro, the Delhi Transport Corporation (DTC) bus system, auto-rickshaws, cycle-rickshaws and taxis. With the introduction of Delhi Metro, a rail-based mass rapid transit system, rail-based transit systems have gained ground. Other means of transit include suburban railways, inter-state bus services and private taxis which can be rented for various purposes. However, buses continue to be the most popular means of transportation for intra-city travel, they cater to about 60% of the total commuting requirements. Private vehicles account for 30% of the total demand for transport, while the rest of the demand is met largely by auto-rickshaws, taxis, rapid transit system and railways. Indira Gandhi International Airport (IGI) serves Delhi for both domestic and international air connections, and is situated in the south-western corner of the city. In 2005-2006, IGI recorded traffic of more than 20.44 million passengers. (Both Domestic and International),

6.4 Zone-wise Variation in Average Ambient Noise Level in Delhi

The Leq average ambient noise level at Residential Zone was found to be 57 dB(A), 61 dB(A) in the day time and night time respectively in the year 1995, in 1999 it was 68 dB(A), 65 dB(A) in the day time and night time respectively, and in 2011, it was 57 dB(A) and 52 dB(A) during day time and night time respectively, were recorded.

The Leq average ambient noise level at Commercial Zone was found to be 70 dB(A), 71 dB(A) in the day time and night time respectively in the year 1995, in 1999 it was 74 dB(A),

72 dB(A)) in the day time and night time respectively, and in 2011, it was 69 dB(A) and 52 dB(A) during day time and night time respectively, were recorded.

The Leq average ambient noise level at Industrial Zone was found to be 74 dB(A), 75 dB(A) in the day time and night time respectively in the year 1995, in 1999 it was 78 dB(A), 75 dB(A) in the day time and night time respectively, and in 2011, it was 69 dB(A) and 70 dB(A) during day time and night time respectively, were recorded.

The Leq average ambient noise level at Silence Zone was found to be 68 dB(A), 72 dB(A) in the day time and night time respectively in the year 1995, in 1999 it was 65 dB(A), 61 dB(A) in the day time and night time respectively, and in 2011, it was 56 dB(A) and 52 dB(A) during day time and night time respectively, were recorded.

Table 6.3: Ambient Noise Levels at various zones during 1995, 1999 & 2011

	Ambient Noise Level, Leq in dB(A)							
Month &Yr.	Day time	Night time	Day time	Night time	Day time	Night time	Day time	Night time
Oct. 1995	57	61	70	71	74	75	68	72
Oct. 1999	68	65	74	72	78	75	65	61
Oct. 2011	57	52	69	52	69	70	56	52
CPCB std.	55	45	65	55	75	70	50	40
Zone	Residential		Commercial		Industrial		Silence	

Table 6.3 and figure 6.2 reveals the following:

In Residential areas, there is a considerable reduction in the ambient noise level in past 15 years, due to public awareness about the air and noise pollution and strict rules laid by the govt. under Air Act. The industries have been shifted from the residential areas to the distant places and due to the shifting of majority of industries; there is a countable reduction in the ambient noise level of the industrial areas. In commercial areas, the night time ambient noise level is reduced to an extent, due to less use of privately owned vehicles, and restriction on the use of pressure horns in public vehicles. It is reduced in silence areas also because of growing public awareness & stringent rules made by the govt. as prohibition on the use of horns in the sensitive areas like hospitals and institutions. Increasing ambient noise level in public places from various sources, industry activity, loud speakers, public address systems, music systems, vehicular horns and other mechanical devices have deleterious effects on human health and the psychological well being of the people. Therefore, it is considered necessary to regulate and control of noise producing and generating sources with the objective of maintaining the ambient air quality standards in respect of noise.

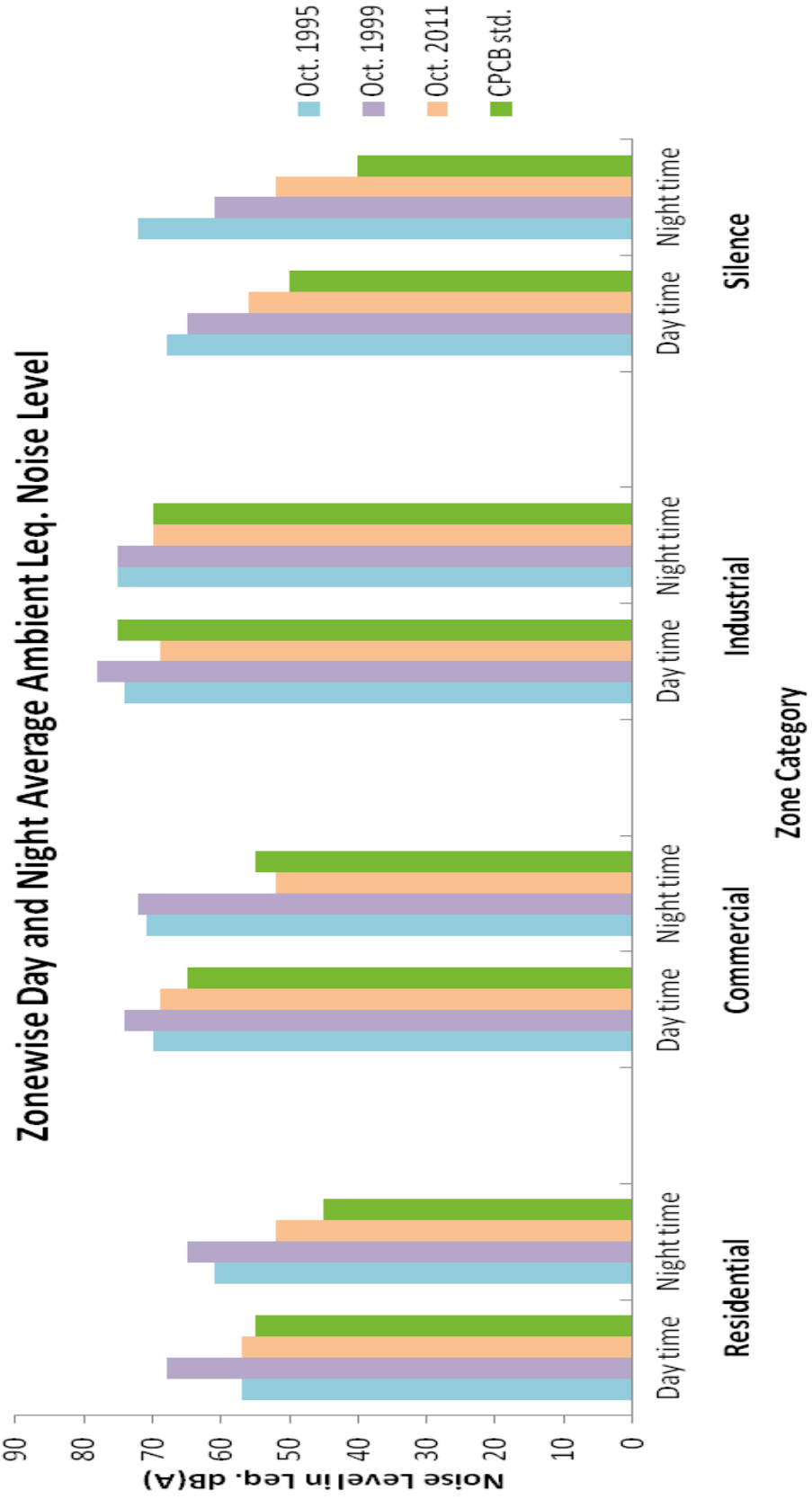


Figure 6.2: Average Ambient Noise Level at various zones during 1995, 1999 & 2011

CONCLUSION

CHAPTER 7

CONCLUSION

During Diwali week, the measurement of ambient noise levels in the 7 major cities of India viz. Bangalore, Chennai, Delhi, Hyderabad, Kolkata, Lucknow and Mumbai, shows that the commercial zones experience about 20 dB(A) noise level above the prescribed limit. The industrial zones experience about 15 dB(A) noise level above the prescribed limit, the residential zones experience about 10 dB(A) noise level above the prescribed limit, the silence zones experience similar noise levels and hence about 10 dB(A) above the prescribed limit. Special events like Diwali festival and election campaigns generate noise levels that are prohibitively above the permissible limit with the only redeeming factor being that they last over a comparatively shorter duration.

Based on the statistical calculations of the ambient noise monitoring data, the most polluting city is Chennai, the 2^{nd} most polluting city is Hyderabad, 3^{rd} most polluting city is Bangalore, 4^{th} polluting city is Mumbai, 5^{th} polluting city is Kolkata, 6^{th} polluting city is Lucknow and the last is Delhi.

Delineation of silence zones and commercial zones with closer measurements spatially will help to make these zone classifications more meaningful.

Whereas During normal days, it has been seen that road transport is the dominant source of noise in an urban area. It has been estimated that more than 20 % of the inhabitants in India and in many other countries suffer from noise levels that scientists and health experts consider unacceptable. Under these high noise level conditions, most people become annoyed, have disturbed sleep, and may encounter adverse effect on their cardiovascular and psycho – physiological systems.

RECOMMENDATIONS AND FUTURE PLAN OF WORK

CHAPTER 8
RECOMMENDATIONS & FUTURE PLAN OF WORK

1. Awareness should be generated among public because most of the noise is generated due to unawareness.

2. Reduction of traffic density, movement of vehicles to the inner arterial roads should be restricted in the residential areas.

3. Use of horns and pressure horns in case of buses, trucks and heavy vehicles should be strictly banned.

4. Residential colonies should be constructed with such a architectural design as to reduce the level of noise reverberation.

5. The commercial and industrial activities should be restricted strictly in residential areas.

6. Unorganised, highly congested commercial activities should not be encouraged very near to the residential colonies.

7. Residential colonies should not be allowed to develop nearby industrial areas and workers in the industries should not be exposed to noise levels more than the prescribed levels.

8. The noise from the industrial machines should be restricted by providing proper vibration isolators, damping material, designing, maintenance and silencing devices.

9. Special training should be given to the industrial personnel for reducing the noise level during operating process and handling the machine and materials.

10. Proper maintenance of vehicles reduces the ambient noise level. Public should be made aware through media, advertisement etc. to reduce the noise level.

11. The condition of roads should be improved in order to reduce the noise pollution.

12. Traffic should be regulated in a scientific manner in order to avoid traffic jams which will cause increase in ambient noise level.

13. Generators should be avoided as far as possible, if used it should be fitted with acoustic hoods, walls around the building and silencing devices such as mufflers.

14. Vegetation buffer zone and road side plantation should be developed in different parts of the nation.

15. The noise generating sources like public address system, music systems on the occasion of marriage should be kept preferably at low volume and should not be used atleast after mid night hours and it should not violate the ambient noise level standards as prescribed by the authority.

16. Progression should be laid for reducing the noise at the source, screening the noise, modifying the noise and providing protection devices.

18. Instead of using privately owned vehicles i.e. cars, motorcycles, people should use public conveyance vehicles i.e. buses. In order to avoid traffic congestion & jams and hence should save our precious environment from noise and air pollution.

17. This project work could be used on a larger scale to check the ambient noise level inside the premises of industrial, commercial, residential and silence zones on regular basis and hence could make our environment noise pollution free.

ANNEXURES

ANNEXURE 1

Raw data of Ambient Noise Monitoring is taken from CPCB in txt form, which is further converted into the usable form.
Two types of data used in noise parameters calculations are

- Data on hourly basis or Hourly Data
- Data on 10 minutes interval basis

BANGALORE

Date/Time	E.1713 BNG_BTM	E.1711 BNG_Mart	E.1693 BNG_Nisa	E.1682 BNG_Pari	E.1685 BNG_Pnya
00:00	56.297	54.368	49.612	60.785	
01:00	52.886	53.931	47.349	62.065	
02:00	50.475	53.824	47.593	58.339	
03:00	51.787	53.631	45.132	58.008	
04:00	53.024	53.622	46.232		
05:00	55.924	53.497	47.322		
06:00	60.205	57.123	52.849		
07:00	64.044	66.977	55.176	87.316	73.591
08:00	65.081	54.749	56.219	72.687	52.368
09:00	66.306	55.521	59.252	69.57	56.881
10:00	65.876	55.444	56.765	65.508	56.195
11:00	66.448	55.29	57.628	66.18	57.461
12:00	66.471	54.866	58.389	67.624	56.392
13:00	66.397	54.361	56.234	68.729	55.713
14:00	66.119	53.555	54.505	69.515	56.656
15:00	67.273	53.219	59.577	70.866	56.981
16:00	68.582	53.015	55.277	69.077	58.206
17:00	66.533	56.589	55.785	67.824	57.374
18:00	66.702	64.462	55.036	67.583	58.861
19:00	64.893	67.482	55.858	66.233	57.859
20:00	64.236	53.557	53.698	66.342	56.255
21:00	62.852	53.793	52.068	67.214	54.329
22:00	64.774	54.939	52.626	67.594	
23:00	60.622	53.362	48.977	68.989	

Table A1.1: Tabular Representation of hourly raw data of Bangalore on 29/10/2011

CHENNAI

Date/Time	E.1684 CHN_Eyeh	E.1710 CHN_Gndy	E.1706 CHN_Prmb	E.1692 CHN_Tngr	E.1717 CHN_Trln
00:00	49.504		76.972	62.243	57.213
01:00	47.722		93.068	59.965	53.231
02:00	44.91			56.113	50.715
03:00	45.123			55.02	48.068
04:00	48.551			57.788	58.315
05:00	60.218			62.913	69.613
06:00	63.982			68.549	72.967
07:00	64.737	82.312	79.51	69.633	74.366
08:00	64.396	78.121	78.664	69.991	74.422
09:00	70.467	73.052	71.726	71.584	72.72
10:00	74.149	74.033	71.391	71.944	74.41
11:00	73.572	74.396	73.574	74.308	72.521
12:00	70.203	75.185	73.332	73.472	72
13:00	69.372	74.724	69.996	73.145	69.616
14:00	76.268	74.255	72.711	72.194	71.541
15:00	63.953	76.64	69.425	71.263	68.65
16:00	64.589	76.452	69.184	72.003	69.888
17:00	75.588	75.307	72.792	72.307	76.785
18:00	77.881	74.641	78.859	78.325	82.192
19:00	82.579	74.308	79.645	78.543	83.105
20:00	74.647	72.647	76.469	78.059	78.742
21:00	69.6	72.568	72.32	73.128	76.965
22:00	64.754	71.499	70.423	71.241	71.479
23:00	60.909	69.782	62.668	66.217	58.639

Table A1.2: Tabular Representation of hourly raw data of Chennai on 29/10/2011

DELHI

Date/Time	E.1671 DEL_CPCB	E.1672 DEL_DCE	E.1670 DEL_DGDN	E.1683 DEL_ITO	E.1688 DEL_NSIT
00:00	52.04	49.673	48.611	69.659	54.924
01:00	48.589	49.897	45.514	68.093	54.17
02:00	48.831	50.16	46.029	67.698	52.857
03:00	48.084	50.409	45.872	67.652	52.912
04:00	47.819	50.527	46.152	68.824	52.651
05:00	48.983	50.429	47.618	70.516	53.655
06:00	52.957	51.218	48.982	72.351	55.738
07:00	58.062	50.719	50.696	72.33	55.942
08:00	59.197	51.178	49.514	72.652	54.975
09:00	63.646	50.777	50.403	73.14	55.384
10:00	64.701	49.937	51.256	73.533	54.797
11:00	64.469	49.893	48.948	73.742	54.554
12:00	64.044	49.816	49.471	74	53.33
13:00	62.724	49.027	48.163	73.866	54.426
14:00	62.898	50.171	49.042	73.712	53.86
15:00	62.202	51.443	50.404		54.451
16:00	61.609	51.181	50.658	73.778	55.495
17:00	61.812	52.04	53.341	73.568	58.654
18:00	62.109	51.173	56.103	73.256	61.029
19:00	61.383	51.425	53.794	73.132	61.737
20:00	61.386	51.377	53.323	73.263	62.909
21:00	58.995	50.929	51.774	73.195	65.481
22:00	57.924	50.346	50.088	72.357	58.253
23:00	55.032	50.022	48.464	72.407	55.742

Table A1.3: Tabular Representation of hourly raw data of Delhi on 29/10/2011

HYDERABAD

Date/Time	E.1673 HYD_Abit	E.1689 HYD_Jdmt	E.1691 HYD_Jhls	E.1687 HYD_Pngt	E.1690 HYD_Zoo
00:00	64.571	60.754		71.27	
01:00	62.727	61.081		70.155	
02:00	59.717	58.757		68.633	
03:00	58.09	57.371		67.808	
04:00	59.596	57.893		68.605	
05:00	65.478	58.68		71.129	
06:00		58.495		75.17	
07:00		59.64		75.348	
08:00	70.418	62.203		76.409	
09:00	82.46	64.07		76.037	
10:00	73.259	64.738		76.717	
11:00	73.539	65.09		76.649	
12:00	76.182	64.669		76.644	
13:00	75.509	63.989		77.363	
14:00	74.475	64.837		77.012	
15:00	74.378	64.534		76.757	
16:00	74.257	64.813		77.785	
17:00	74.414	65.014		78.169	
18:00	75.337	63.272		77.182	
19:00	74.75	61.857		77.174	
20:00	74.962	61.211		77.551	
21:00	74.156	61.971		77.607	
22:00	72.136	61.781		78.844	
23:00	68.363	57.78		77.012	

Table A1.4: Tabular Representation of hourly raw data of Hyderabad on 29/10/2011

LUCKNOW

Date/Time	E.1704 LKN_Hgnj	E.1714 LKN_Ingr	E.1716 LKN_Lhsp	E.1709 LKN_PGI	E.1686 LKN_Tlkt
00:00	65.56	48.76			48.72
01:00	66.58	45.979			50.524
02:00	60.091	45.812			49.245
03:00	52.997	46.949			48.656
04:00	59.598	46.24			46.455
05:00	59.288	45.72			52.09
06:00	62.048	48.045			53.041
07:00	67.455	48.782			53.06
08:00	67.502	51.487			57.206
09:00	69.067	51.943			66.313
10:00	70.916	50.427			62.417
11:00	73.027	50.163			62.279
12:00	74.148	53.6			61.469
13:00	74.251	53.66			59.205
14:00	74.515	50.87			61.327
15:00	74.416	51.802			63.083
16:00	74.28	50.959			62.908
17:00	74.645	52.156			60.624
18:00	73.979	52.807			57.868
19:00	74.38	54.141			58.648
20:00	72.777	50.568			58.131
21:00	71.608	51.407			56.238
22:00	69.019	50.15			53.363
23:00	66.968	45.799			53.757

Table A1.5: Tabular Representation of hourly raw data of Lucknow on 29/10/2011

KOLKATA

Date/Time	E.1707 KOL_Gprk	E.1708 KOL_HQ	E.1719 KOL_Ptli	E.1705 KOL_SSKM	E.1720 KOL_Nmkt
00:00	60.475	56.868	46.195	55.887	58.558
01:00	58.268	53.985	43.408	54.176	56.529
02:00	59.023	52.337	45.115	51.995	56.682
03:00	59.746	50.415	45.494	52.518	56.411
04:00	60.346	53.678	49.127	52.049	57.66
05:00	61.584	57.498	50.934	56.095	59.771
06:00	60.141	57.385	49.87	57.693	62.257
07:00	61.436	59.327	52.551	57.88	63.902
08:00	61.731	59.882	51.367	58.868	63.976
09:00	62.608	60.912	49.965	61.058	64.375
10:00	62.913	61.285	50.207	63.961	65.904
11:00	64.458	61.392	51.233	64.338	67.292
12:00	62.916	60.741	52.321	63.989	67.289
13:00	63.923	60.747	49.971	64.054	67.448
14:00	63.734	60.504	49.096	63.831	67.947
15:00	64.52	61.167	51.121	61.646	68.56
16:00	65.975	60.854	55.201	61.804	67.52
17:00	66.783	60.833	57.858	61.388	69.802
18:00	63.685	62.059	60.038	59.169	67.112
19:00	63.647	62.061	58.797	58.214	67.302
20:00	63.688	63.742	59.729	57.205	66.685
21:00	62.931	64.56	63.433	58.12	66.316
22:00	61.675	62.615	57.52	57.045	66.763
23:00	62.278	61.749	55.558	55.589	63.501

Table A1.6: Tabular Representation of hourly raw data of Kolkata on 29/10/2011

MUMBAI

Date/Time	E.1712 MMB_Ahsp	E.1715 MMB_Bndr	E.1718 MMB_HQ	E.1702 MMB_TMCO	E.1703 MMB_Vhsp
00:00	59.565	68.084	61.802	62.745	61.783
01:00	58.428	66.556	60.892	56.048	57.816
02:00	57.424	65.418	61.13	54.069	52.626
03:00	56.862	64.984	61.191	53.029	51.586
04:00	57.904	65.76	60.726	52.681	55.744
05:00	60.697	65.98	61.194	53.574	54.485
06:00	61.874	66.234	62.512	57.748	58.945
07:00	62.142	67.159	64.26	60.961	62.335
08:00	63.311	67.536	64.872	60.713	65.012
09:00	65.116	68.805	67.266	60.009	68.666
10:00	64.183	69.172	66	60.932	69.483
11:00	64.945	69.229	65.722	61.138	70.876
12:00	64.988	69.531	65.754	62.77	71.447
13:00	66.007	69.16	65.787	62.019	69.921
14:00	65.399	69.168	65.346	60.039	67.994
15:00	65.109	69.073	65.634	61.049	68.681
16:00	65.18	68.988	64.779	61.65	68.434
17:00	64.596	69.155	65.086	61.881	68.102
18:00	64.521	69.495	65.324	61.4	68.849
19:00	63.692	68.837	64.402	62.548	68.88
20:00	63.486	68.582	64.122	59.544	68.688
21:00	64.563	68.814	64.01	59.332	67.771
22:00	62.995	69.09	64.277	56.594	67.446
23:00	61.39	68.403	63.663	55.005	62.702

Table A1.7: Tabular Representation of hourly raw data of Mumbai on 29/10/2011

LCF1 (Max.) (dBC)	LCF1 (Min.) (dBC)	LAS1 (Ins) (dBA)	LAS1 (Avg.) (dBA)	LCS1 (Ins) (dBC)	LCS1 (Avg.) (dBC)	LAE1 (Ins) (dBA)	LAE1 (Avg.) (dBA)	LCE1 (Ins) (dBC)	LCE1 (Avg.) (dBC)	LPeakC1 (Ins) (dBC)
66.572	63.156	50.722	49.518	64.645	64.232	50.929	49.517	64.808	64.234	71.427
66.585	63.678	50.098	50.471	64.314	64.747	50.098	50.372	64.349	64.743	71.071
65.917	62.814	49.373	49.57	63.861	63.828	49.333	49.607	63.825	63.847	70.664
65.71	63.222	50.119	49.364	64.958	64.297	50.188	49.385	64.808	64.291	72.045
66.482	63.315	48.698	49.853	63.676	64.488	48.96	49.906	63.863	64.527	69.65
65.266	63.435	49.948	49.242	64.722	64.339	49.912	49.253	64.748	64.337	71.141
67.205	64.189	50.931	50.372	64.669	64.9	51.465	50.401	64.789	64.91	72.393
66.808	63.041	48.688	49.914	63.931	64.152	48.745	50.037	63.993	64.176	70.236
66.253	63.531	49.823	49.23	64.686	64.441	49.935	49.241	64.944	64.438	71.268
66.116	63.465	49.254	50.021	63.983	64.708	49.332	50.05	63.883	64.733	70.918
66.401	63.263	49.143	49.667	64.433	64.318	49.625	49.705	64.568	64.32	71.234
65.688	64.123	49.926	49.931	64.81	64.903	50.105	49.948	64.876	64.91	71.747
65.831	63.59	50.231	49.956	64.917	64.614	50.403	49.978	65.093	64.623	72.69
68.59	63.942	50.195	50.389	64.676	64.873	50.282	50.422	64.771	64.89	72.107
66.442	63.702	50.424	50.301	64.479	64.627	50.325	50.327	64.482	64.643	71.605
65.36	62.746	49.9	50.427	63.912	64.383	50.768	50.46	63.943	64.405	70.627
64.918	62.77	49.16	50.018	63.609	63.804	49.187	50.082	63.497	63.822	70.652
67.683	63.002	49.444	49.637	64.299	64.258	49.489	49.692	64.376	64.261	71.736
69.458	63.832	50.712	50.431	64.902	64.662	50.518	50.567	64.834	64.667	72.533
68.874	63.481	50.843	50.88	64.224	64.885	51.818	50.908	64.441	64.903	72.939
65.281	63.389	50.191	50.316	64.343	64.31	50.376	50.358	64.483	64.32	73.061
71.059	63.03	49.807	51.337	63.638	64.589	49.811	51.493	63.793	64.614	71.118
64.548	62.407	49.122	49.166	63.255	63.37	49.181	49.2	63.559	63.387	70.275
68.455	61.223	49.354	49.873	64.446	64.203	49.441	49.929	64.375	64.206	70.894
67.621	63.854	50.64	50.502	65.109	64.906	51.874	50.527	65.206	64.908	72.651
67.081	63.805	50.284	50.869	64.922	64.802	50.41	50.946	64.801	64.82	73.611
67.361	63.449	55.585	50.393	65.819	64.51	52.17	50.38	64.949	64.518	74.483
70.149	63.297	49.907	51.207	63.838	64.507	49.894	51.401	63.94	64.545	70.942
68.477	62.514	56.427	50.183	65.116	63.861	57.164	50.141	65.544	63.855	74.104
65.522	63.429	49.821	49.636	64.954	64.304	49.767	49.766	64.914	64.324	72.2
73.227	63.967	50.503	51.032	65.163	65.249	50.545	51.109	65.209	65.256	72.767
66.224	62.949	49.874	50.303	64.094	64.552	49.942	50.336	64.159	64.58	72.2
66.613	63.355	50.105	50.418	64.516	64.333	50.205	50.442	64.229	64.346	72.738
68.873	62.539	50.11	50.373	63.635	63.962	50.083	50.43	63.44	63.987	70.428
77.873	62.056	51.91	50.643	70.918	64.005	56.362	50.766	73.093	63.94	79.257
71.925	62.942	48.936	49.376	64.292	63.987	48.74	49.493	63.784	64.129	72.097
70.667	63.154	50.62	50.551	64.286	64.491	50.657	50.592	64.533	64.509	71.886
66.957	62.374	50.336	50.447	64.612	64.37	50.241	50.49	64.573	64.38	71.876

Table A1.8: Tabular Representation of Data on 10 minutes interval at D.C.E. Noise Monitoring Station, Delhi on 29/10/2011

ANNEXURE 2

CALCULATION SHEET

DEL_DCE											
06:00	51.218						5.1218	132373.2	5.1218	0.320113	3.201125
07:00	50.719						5.0719	118004.9	5.0719	0.316994	3.169938
08:00	51.178						5.1178	131159.6	5.1178	0.319863	3.198625
09:00	50.777						5.0777	119591.4	5.0777	0.317356	3.173563
10:00	49.937						4.9937	98559.84	4.9937	0.312106	3.121063
11:00	49.893						4.9893	97566.34	4.9893	0.311831	3.118313
12:00	49.816						4.9816	95851.74	4.9816	0.31135	3.1135
13:00	49.027						4.9027	79928.19	4.9027	0.306419	3.064188
14:00	50.171						5.0171	104016	5.0171	0.313569	3.135688
15:00	51.443						5.1443	139411.9	5.1443	0.321519	3.215188
16:00	51.181						5.1181	131250.2	5.1181	0.319881	3.198813
17:00	52.04						5.204	159955.8	5.204	0.32525	3.2525
18:00	51.173						5.1173	131008.7	5.1173	0.319831	3.198313
19:00	51.425						5.1425	138835.3	5.1425	0.321406	3.214063
20:00	51.377						5.1377	137309.3	5.1377	0.321106	3.211063
21:00	50.929						5.0929	123851.1	5.0929	0.318306	3.183063
											50.769
22:00	50.346						5.0346	108292.9	5.0346	0.629325	6.29325
23:00	50.022						5.0022	100507.9	5.0022	0.625275	6.25275
00:00	49.673						4.9673	92747.03	4.9673	0.620913	6.209125
01:00	49.897						4.9897	97656.24	4.9897	0.623713	6.237125
02:00	50.16						5.016	103752.8	5.016	0.627	6.27
03:00	50.409						5.0409	109875.3	5.0409	0.630113	6.301125
04:00	50.527						5.0527	112901.6	5.0527	0.631588	6.315875
05:00	50.429						5.0429	110382.4	5.0429	0.630363	6.303625
											50.18288

Table A2.1: Tabular Representation of Calculation sheet (MS Excel) of Ambient Noise Level, Leq at DCE, Delhi on Day 3 i.e. 29/10/2011

ANNEXURE 3

S.P.S.S. CALCULATION

Descriptive Statistics

	N	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
L10	31	65.535242	6.8747636	47.262	-.257	.421	-.792	.821
L50	31	61.844274	7.3368540	53.829	-.043	.421	-.880	.821
L90	31	55.421526	7.0999288	50.409	.685	.421	-.028	.821
LeqdBADaytime	31	62.73335	7.172196	51.440	-.187	.421	-.658	.821
LeqdBANighttime	29	57.06272	6.441067	41.487	.405	.434	-.137	.845
Valid N (listwise)	29							

Table A 3.1: Tabular Representation of Statistical Parameters calculated by SPSS for Day 1 i.e. 23/10/2011

Descriptive Statistics

	N	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
L10	31	66.063784	6.8343682	46.709	-.198	.421	-.241	.821
L50	31	62.654919	7.7300552	59.754	-.025	.421	-.829	.821
L90	31	55.181123	6.9886793	48.842	.518	.421	-.321	.821
LeqdBADaytime	31	62.88258	6.845556	46.862	-.127	.421	-.528	.821
LeqdBANighttime	30	56.29447	6.625929	43.903	.507	.427	-.211	.833
Valid N (listwise)	30							

Table A 3.2: Tabular Representation of Statistical Parameters calculated by SPSS for Day 2 i.e. 26/10/2011

Descriptive Statistics								
	N	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
L10	31	72.419900	5.6592237	32.027	.421	.421	-.321	.821
L50	31	63.766323	6.9176472	47.854	-.243	.421	-.691	.821
L90	31	55.659613	7.5710843	57.321	.449	.421	-.200	.821
LeqdBADaytime	31	64.29900	6.599709	43.556	-.043	.421	-.788	.821
LeqdBANighttime	29	56.49214	9.015653	81.282	-2.292	.434	9.103	.845
Valid N (listwise)	29							

Table A 3.3: Tabular Representation of Statistical Parameters calculated by SPSS for Day 3 i.e. 29/10/2011

REFERENCES

1. Pollution control law series: PCLS/02/2010 (Sixth Edition).

2. Mathematical Marvels, A primer on Logarithms by Sh. Shailesh Shirali.

3. Water and Wastewater Engineering by Prof. S.K Garg.

4. Handbook on Environmental Noise by Bruel & Kjaer.

5. Fundamentals of Noise and vibration by Frank Fahy and John Walker.

6. Noise pollution and its measurement newsletter publication of CPCB.

7. Reference from website:www.freehearingtest.com/about.shtml

8. Reference from website: www.wikipedia.com.

9. S.Sampath, S.Murali Das and V.Sasi Kumar, Oct. 2004. Ambient noise levels in major cities in Kerala.

10. Kameswaran, S., 1992. Noise in the workplace, Science Today, August

11. Sharp, B.H. & Donovan, P.R., 1979. Motor vehicle noise. In: handbook of Noise control (2^{nd} edition). (Ed.) Harris C.M., New York, Mc–Graw Hill Book Company.

12. Indian journal of Air Pollution Control, March, 2011.

13. Singal, S.P., March, 2011. Exposure of Urban Communities to Noise Pollution.

14. O.E.C.D., 1986. Report – Fighting Noise. Organisation for Economic Cooperation and Development Publication, Paris.

15. Ingerslev, F., 1987. Danish regulations for industrial noise exposure, occupational and environmental noise. Inter – noise 87,1589-1592.

16. Miller, J.D., 1974. Effects of noise on people. J. Acoust. Soc. Amer., 56, 729-764.

17. Singal, S.P., 2000, 2005. Noise pollution and control strategy. Narosa publishing house, New Delhi.

18. Ward, W.D. and Glorig, A., 1961. A case of fire cracker induced Hearing loss. Larynogo scope, 71, 1590-1596.

19. MoEF, GOI, 1999a. Ambient Air Quality Standards in Respect of Noise. Notification no. 528 (E), 28th june, Ministry of Environment & Forests, Government of India.

20. MoEF, GOI, 1999b. Noise standards for Firecrackers. Notification no. 682 (E) Sr. 89, 5th october, Ministry of Environment & Forests, Government of India.

21. G. Singh, December 2000; Ambient noise level status in Delhi (1995-1999).

22. R. Singh, Dr. Mandal, March 2012; Assessment of Ambient noise level in the metropolitan cities during Diwali.

23. Master plan of Delhi, MPD-2021.