CHAPTER I

NOISE POLLUTION
1.1 Introduction:

Pollution, in general, is a by-product of some essential functions or activities. Therefore, it is almost impossible to completely eliminate the pollutant, but can be controlled or reduced. Most of the pollutant can be tolerated up to a certain level, the level being dependent on the type of the pollutant. When the level of pollution continues to increase, it becomes necessary to know the amount by which the permissible limit has been exceeded so that their increase can be checked by the introduction of suitable regulations. To know the level of pollution the pollutant has to be measured. In the case of noise pollution, measurements are all the more essential because of the incapability of our auditory system to recognize slow changes in the noise levels.

Noise pollution in the environment has been a unique situation which makes it difficult to adequately compare noise with other environmental pollutants. Although it is tempting to consider its analogy with water, air or solid waste problems, noise should be considered a totally separate entity. Noise, a physical pollutant, is not easily recognized. This is because the sensitivity of human ear gets automatically adjusted to the ambient level of sound and therefore slow increases in the ambient level go unnoticed. Therefore noise continues to do the damage, silently.

Noise pollution is a major problem for the quality of life in urban areas [1]. Noise affects everybody and is likely to continue as a major issue well into the next two decades. To understand noise we must understand the different
types of noise, where noise comes from, the effect of noise on humans and the various ways of measuring it, and its hazards.

Noise is a disturbance to the human environment that is escalating at such a high rate that it will become a major threat to the quality of human lives. In the past thirty years, noise in all areas, especially in urban areas, has been increasing rapidly [2]. There are numerous effects on the human environment due to the increase in noise pollution. The influence of noise on the human body can be due to the direct effects upon the auditory system, on non-auditory physiological processes and on purely psychological mechanisms [3].

1.2 Need to study:

The same sound may be experienced differently when heard by different persons or by the same person at different times. Noise is unwanted sound. But ‘unwanted’ can change from time to time depending on the frame of mind of the listener. One may enjoy listening to music when out with many friends and in a relaxed mood, and resent the imposition of the very same music at a time when he is studying for an important examination. Various factors including age, general health level, and participation in the activity etc. are responsible for causing the sound count. The same level of sound at different times may be enjoyable, or may be a ‘noise’.

Noise may take many forms, yet all types of noise share one basic thing and it is that, it can cause injury to somebody. Noise is, in fact, a form of assault upon the senses. The burden is shared by each and every one of us. In varying forms and for various good reasons, we have all contributed to and continue to contribute to increase in noise levels until such levels have reached dangerous proportions. Traffic, construction, recreation – the sounds of all of these at the same time and in a limited space combine to produce the cumulative effect.
1.2.1 Noise conditions:

a. Loudspeakers and firecrackers used for social, religious and political functions and for recreational and commercial activities: Loudspeakers are used for all and every type of function, whether social, political, religious, commercial or recreational. Noise from loudspeakers in addition, to other types of noises which already exist, adds to the already existing levels.

b. While noise emanates from many different sources, transportation noise is perhaps the most pervasive and difficult source to avoid in society today [4]. Noise survey in various cities throughout the world has revealed that traffic noise is typically the largest contributor to recorded sound levels and the most important source of annoyance [5-7]. In India, the contribution of traffic noise is about 55% of the total noise pollution [8]. Road traffic noise including noise from engines, horns, reverse horns, music systems used in cars, etc.: A certain amount of noise from cars plying along congested roads is unavoidable. However, excessive use of horns, reverse horns, unnecessary revving of engines and high decibel levels of some types of cars contribute in enhancing overall noise levels.

c. Construction is a necessary part of development, and construction activity often proceeds at a rapid pace. To meet the demands of the basic necessity of living, the construction of buildings, highways and city streets causes a lot of noise. Pneumatic hammers, air compressors, bulldozers, loaders, dump trucks and pavement breakers are the major sources of noise pollution in construction sites. It is the responsibility of persons carrying out such activities, which is often commercial in nature, to ensure minimum discomfort to others. No effort is made to incorporate construction methods which reduce noise levels, to provide silencers or other technical aids to machines to minimize sound, disturbing the sleep and health of many.
d. All of us depend on machines and instruments without which we would be helpless. These are aids to our effective functioning in today’s world and are considered essential. Refrigerators, air conditioners, washing machines, mobile phones and many others fall into this category. Sometimes, these are inappropriately used and cause disturbances to others due to excessive noise.

1.2.2 Traditional and Social Aspects:

Indian festivals are traditionally celebrated with song and dance in large groups, using musical instruments, drums and fireworks. Unfortunately in recent years, it has become a trend to amplify the celebrations using loudspeakers and the festivals have become very noisy. Noise levels have greatly increased in recent years by the use of loudspeakers and other sound amplification systems used indiscriminately in crowded cities during festivals, marriages and other functions. The firecrackers also traditionally used for celebration are another major source of excessive noise. They are used indiscriminately in residential areas, next to hospitals, schools, with little considerations. Atom bombs, chain bombs, etc. are permitted for manufacture provided they do not exceed 125dB –the level of a jet engine taking off at 25 m. These are then used in areas where peaceful environments are essential for health and well being of individuals.

1.3 Noise Measurement:

Noise measurements are usually required to establish the properties of a noise field so that optimum means for its control can be determined [9]. In general, it is possible to make noise measurements only at particular points in a noise field. Thus many measurements are required to determine adequately the distribution of noise in space.

For noise measurements in air, an instrument is available for measuring the root-mean–square (rms) value of noise on a weighted logarithmic scale.
This instrument is called a sound-level meter, and a reading in decibel (dB) obtained on it is called a sound level.

The quantification of sound levels for the purpose of determining whether they have been hazardous to health and welfare, or exceed local legally adopted limits, can be a complex task. Depending upon, the purpose of the measurement and the desired accuracy of the result, a wide range of measurements techniques and sound level descriptors are suggested by different workers.

1.3.1 Sound measuring Devices:

The simplest measurement parameters for characterizing noise is linear pressure level measured in decibels at the source. The measured sound level can be adjusted, by weighting particular frequencies within the signal spectrum to give a signal to value which approximates to response of human ear. Of the several weighting systems developed, the A weighting is most widely used [9]. The A weighted sound pressure level dB(A) is used almost universally for environmental noise assessment, many standards are based on it and most noise meters are equipped to register dB(A) unit directly.

Instrumentation for monitoring of noise has various levels of sophistication and accuracy, dependent upon the parameters sought to be measured. International standards for sound level meters recognize four grades or types of meter. These are:

Type 0: Laboratory reference—highest accuracy.
Type 1: Precision
Type 2: General Purpose (Field use)
Type 3: Survey-Lowest accuracy.
Fig. 1.1 Sound Level Meter
1.3.2 Sound Level Meter:

The sound level meter is used to measure the rms value of a sound weighted according to frequency content. The sound level meter was originally standardized to indicate sound level, a single number in decibels giving the total sound pressure level weighted by an approximation to the loudness level sensitivity of the human ear for pure tones.

A typical sound level meter consists of a microphone, an amplifier with a calibrated logarithmic attenuator, a set of frequency response (weighting) networks, and an indicating meter with a logarithmic scale (Fig.1.1). The electrical signal produced by the microphone in the presence of sound is read on the meter after having been weighted for frequency content by the weighting networks.

The sound level meter is basically a device for field use and so it is generally self-contained and battery operated. It is reliable, portable, stable under battery operation and lightweight. The input impedance is sufficiently high to provide minimal loading for high impedance microphones. The output impedance is low, and the output level is high enough to drive most analyzers.

1.4 Physical Aspects of Noise:

Sound:

Acousticians define sound as a sensation in the ear created by pressure variations or vibrations in the air [10]. Sound is composed of many frequencies, some of which may affect one person more than another. Because engineers measure sound in decibels (dB) on a logarithmic scale, when two sources of sound, each measuring 70 dB (A), are added together, the resulting sound level is not 140 dB (A) but 73 dB (A). The (A) refers to a weighting scale that approximates the manner in which humans hear higher frequencies better than lower frequencies [10].
For listeners sound is defined as acoustic energy in the frequency range from 20,000 Hz to below 20 Hz that is typical of the human auditory system. The sound output of a source constitutes its power and the intensity of sound at a point in space is defined by the rate of energy flow per unit area. Intensity is proportional to the mean square of the sound pressure and, as the range of this variable is so wide, it is usual to express its value on a logarithmic scale, in decibels (dB). Sound pressure has the unit Pascal (Pa), while sound pressure level has the unit dB. The effects of noise depend strongly upon frequency of sound-pressure oscillation. Therefore, spectrum analysis is important in noise measurement [11].

Sound is a vibratory disturbance created by a moving or vibrating source, in the pressure and density of a gaseous, liquid medium or in the elastic strain of a solid which is capable of being detected by the hearing organs. Sound is transmitted in air only as a longitudinal wave motion. It is, therefore, may be thought of as mechanical energy of a vibrating object transmitted by pressure waves through a medium to human (or animal) ears.

From a physical point of view there is no difference between the concepts of sound and noise, although it is an important distinction for the human listener. Noise is a class of sounds that are considered as unwanted. In some situations, but not always, noise may adversely affect the health and wellbeing of individuals or population. Since long agreed among experts, it is not possible to define noise exclusively on the basis of physical parameters of sound. Instead, it is common practice to define noise operationally as audible acoustic energy that adversely affects, or may affect, the physiological and psychological wellbeing of people.
**Noise:**

The word noise is derived from the Latin word, “Nausea”. It may be defined in law as excessive, offensive persistent sound.

For Vitles, ‘Noise is an unwanted sound’.

In the words of Harrel, “Noise is an unwanted sound which increases fatigue and under some industrial conditions it causes deafness”.

According to Encyclopedia Britannica, “Acoustics noise is defined as any under ride sound. Usually, noise is mixture of many tones combined in a non-musical manner.

According to Encyclopedia Americanna, “Noise by definition is unwanted sound. What is pleasant to some ears may be extremely unpleasant to others, depending on a number of psychological factors. In other words, any sound may be noise if circumstances cause it to be disturbing.

Noise, defined as unwanted or excessive sound, is an undesirable by-product of our modern way of life. It can be annoying, can interfere with sleep, work, or recreation, and in extremes may cause physical and psychological damage [12].

Noise can be considered as any unwanted sound that adversely affects quality of life by interfering with speech, sleep, learning, leisure, and property values. But noise can be subjective—one person may enjoy loud music while the person next door may be annoyed by the sound [13].

Noise - is defined as (airborne) sound that is loud, unpleasant, unexpected or undesired, and may therefore be classified as a more specific group of sounds. Perceptions of sound and noise are highly subjective: one person's music is another's headache. The two terms are often used synonymously, although few would call the sound that emanates from a highway anything but noise.
Characteristics of Sound and Noise

Sound waves involve a succession of compressions and refractions of an elastic medium such as air. These waves are characterized by the amplitude of sound pressure changes, their frequency, and the velocity of propagation. The speed of sound \(c\), the frequency \(f\), and the wavelength \(\lambda\) are related by the equation

\[
\lambda = \frac{c}{f} \quad \text{(1.1)}
\]

A mechanical energy flux accompanies a sound wave, and the rate at which sound energy arrives at, or passes through, a unit area normal to the direction of propagation is known as the sound intensity \(I\). Sound intensity can be defined in any direction, often as a vector. In a free sound field, the sound intensity is related to the root mean square of the sound pressure \(p\), the static mass density of the medium \(\rho\), and speed of sound \(c\) in the medium.

\[
I = \frac{p^2}{\rho c} \quad \text{(1.2)}
\]

The total sound energy emitted by a source per unit time is known as the sound power and is measured in Watts (W). Sound intensity (Eq. 2) is normally measured in Watts per square meter (W/m²). Sounds are described by means of time-varying sound pressure, \(p(t)\). Compared to the magnitude of the atmospheric pressure, the temporal variations in sound pressure, caused by sound are extremely small. The values of sound pressure between \(10^{-5}\) and \(10^2\) Pa (or Newton per square meter, N/m², according to Système International d’Unités, SI) are relevant for the human listener. Since the range of this variable is so wide, it is usual to express its value on a logarithmic scale in dB. Sound intensity level is defined as 10 times the logarithm (to the base 10) of the ratio of the sound intensity of a target sound to the sound intensity of another sound. Any acoustic quantity that is related to sound energy, for example, power or mean square pressure, may be expressed as a dB-value. To
establish an absolute level, a reference value must be agreed. Thus, the sound pressure level \( (L_p) \) of a sound expressed in dB-values depends on the mean square sound pressure \( (p^2) \) such that

\[
L_p = 10 \log_{10} \left[ \frac{p}{p_{\text{ref}}} \right]^2 \quad \ldots \ldots \ldots \ldots (1.3)
\]

Where, the reference pressure \( p_{\text{ref}} \) has an internationally agreed value of \( 2 \times 10^{-5} \) N/m\(^2\) (often given in micropascal, 20 µPa). The corresponding standardized reference values for sound power level and sound intensity level are \( 10^{-12} \) W and \( 10^{-12} \) W/m\(^2\), respectively.

**Frequency of a wave:** is referred to as the number of times per second that the wave passes from a period of compression through a period of rarefaction and starts another period of compression.

**Receptor:** Locations at which noise is measured are referred to as noise receptors. Noise receptors are defined as places where people are typically located, such as residences, hotels, commercial buildings, parks etc.

**Threshold of audibility:** The point at which sounds are barely detectable. In clinical hearing assessment, normal hearing falls within a range of 0 to 25 dB of the threshold of audibility.

**Pitch:** It is defined as the relative highness or lowness of a sound. Pitch is determined by how rapidly the object vibrates. The rate of vibration is termed as the frequency. Higher the frequency, higher is the pitch and vice-versa.

**Loudness:** The physical magnitude of a sound is given by its intensity. The subjective or perceived magnitude is called its loudness [11]. Primarily, loudness depends on intensity, frequency and duration [14-17]. It is the perceptual of sound. Various procedures exist by which loudness may be estimated from physical measurements. The simplest methods involve the measurement of the sound pressure level through a filter or network of filters that mimics the frequency response of the auditory system (weighting circuits
Various calculation procedures have also been developed for predicting loudness. Loudness has the unit sone, whereas loudness level has the unit phon. There is a unique relationship between sone and phon at least for levels above 40 phon or 1 sone (ISO 131, 1979a). [11]

1.5 Major causes of Noise:

Traffic noise is the main source of noise pollution caused in urban areas. With the ever-increasing number of vehicles on road, the sound caused by the cars and exhaust system of autos, trucks, buses and motorcycles is the chief reason for noise pollution.

People living beside railway stations put up with a lot of noise from locomotive engines, horns and whistles and switching and shunting operation in rail yards. This is one of the major sources of noise pollution.

Construction noise is one of the sources of noise pollution in urban areas. Though not a prime reason, industrial noise adds to the noise pollution. Machinery, motors and compressors used in the industries create a lot of noise which adds to the already detrimental state of noise pollution.

Generators, air conditioners and fans create a lot of noise in the buildings and add to the prevailing noise pollution. Household equipments, such as vacuum cleaners, mixers and some kitchen appliances are noisemakers of the house.

1.6 Need to assess road traffic noise:

A common form of noise pollution is from transportation, principally motor vehicles [18]. Road Traffic Noise generated by traffic on main road network is a major source of noise in urban areas. Traffic related noise pollution accounts for nearly two-third of the total noise pollution in a metropolitan city. In India, the number of vehicles is growing at an annual rate of more than 7 percent per annum [19]. Approximately, 60-80 percent of the
noise level in cities comes from vehicles [20]. Kempler [21] showed that driving behavior influences greatly the noise emission levels and that appropriate speed limits allow noticeable noise reductions. With an increase in population and development in the region, there have been significant increases in traffic volumes on the road network and a subsequent increase in road traffic noise levels [22].

Three types of vehicles which generates noise are distinguished as follows [23]:
1. Noise generated by the vehicle system – the engine, the gear box, the exhaust system, the drive shaft, the chassis, the wheels, etc.
2. Rolling noise, evolving as a result of tyres and road surface contact. It depends on the type of tyres and road surface as well as ambient conditions. The noise increases as speed of a vehicle increases and also during hard braking of a vehicle.
3. Noise generated due to the driver’s attitude: abrupt increase of the engine’s rpm at the start or awaiting, undisciplined driving, use of sound signal, which significantly increases traffic generated noise level [24].

Roadway noise is the collective sound energy emanating from motor vehicles. The intensity of roadway noise is depending on the following variables: traffic operations (speed, truck mix, age of vehicle fleet), roadway surface type, tire types, roadway geometrics, terrain, micrometeorology and the geometry of area structures.

Roadway noise is the most widespread environmental component of noise pollution worldwide. There are a variety of effective strategies for mitigating adverse sound levels including: use of noise barriers, limitation of vehicle speeds. The traffic noise of motor vehicles is the most important type of noise to which people are exposed in their everyday life. Not only those who
are in the vehicles, but particularly those who are in the vicinity of roads on which the vehicles move are exposed to that noise irrespective of the fact whether they are inside or outside rooms.

Highway traffic noise is a major contributor to overall transportation noise. A broad-based effort is needed to control transportation noise. This effort must achieve the goals of personal privacy and environmental quality while continuing the flow of needed transportation services for a quality society. In fact, traffic noise impacts more people than any other environmental noise source. Traffic noise can affect the ability to work, learn, rest, relax, sleep, etc. Excessive noise can lead to mental and physical health problems.

In many areas, noise is one of the most obvious impacts of daily road use. However, its effects are often given lower priority than economic or other environmental impacts, largely because they are rarely visible and are difficult to quantify monetarily. It is therefore important to understand how road noise comes to exceed acceptable levels, and what can be done to prevent, mitigate, or compensate for its effects.

1.7 Traffic Noise Analysis:

Analysis of the traffic noise impacts expected from construction of a highway involves a number of technical steps [11]. The traffic noise analysis includes the following for each alternative under detailed study:

1. Identification of existing activities, developed lands, and undeveloped lands for which development is planned, designed and programmed, which may be affected by traffic noise from the highway;

2. Determination of existing noise levels;

3. Prediction of traffic noise levels;

4. Determination of traffic noise impacts; and
5. Examination and evaluation of alternative noise abatement measures for reducing or eliminating the traffic noise impacts.

1.8 Sources of road traffic noise:

The noise of road vehicles is mainly generated from the engine and from frictional contact between the vehicle and the ground and air. In general, road contact noise exceeds engine noise at speeds higher than 60 km/h. The sound pressure level from traffic can be predicted from the traffic flow rate, the speed of the vehicles, the proportion of heavy vehicles, and the nature of the road surface. Special problems can arise in areas where the traffic movements involve a change in engine speed and power, such as at traffic lights (signals), hills, and intersecting roads.

Noise from traffic can be classified into two types, ‘bulk traffic flow noise’ and ‘intermittent traffic noise’. ‘Bulk traffic flow noise’ is from the combination of all noise from vehicles traveling along a road. At low traffic speeds, vehicle engines, transmissions, exhausts and brakes cause the majority of road traffic noise. As speed increases, noise from the interaction between tyres and the road increases and at speeds in excess of approximately 70km/hr, this becomes the dominant component. Air disturbance by moving vehicles also becomes an important factor at higher speeds. ‘Intermittent traffic noise’ is caused by individual vehicles, is often noticed at night, and can cause sleep disturbance. Sources of intermittent traffic noise are:

- heavy vehicles, which are inherently louder than cars and light vehicles;
- modified cars and motorcycles;
- noisy truck engine brakes;
- noisy exhaust systems;
- loud music from vehicles;
- empty heavy vehicles (banging due to body panels and loose structures);
• vehicle horns; and
• Driver behavior (for example, rapid acceleration and sudden braking).

Levels of highway traffic noise typically range from 70 to 80 dB (A) at a distance of 15 meters (50 feet) from the highway. These levels affect a majority of people, interrupting concentration, increasing heart rates, or limiting the ability to carry on a conversation. The noise generated by a conversation between two people standing 1 meter (3 feet) apart is usually in the range of 60-65 dB (A). Most people prefer the noise levels in their homes to be in the 40-45 dB (A) range, similar to the levels found in a small office. A reduction of sound from 65 to 55 dB (A) reduces the loudness of the sound by one half, while a reduction of sound from 65 to 45 dB(A) results in a loudness reduction of one quarter.

Noise associated with road development has four main sources: a) vehicles; b) friction between vehicles and the road surface; c) driver behavior; and d) construction and maintenance activity.

**Vehicular noise**

Vehicle noise comes from the engine, transmission, exhaust, and suspension, and is greatest during acceleration, on upgrades, during engine braking, on rough roads, and in stop-and-go traffic conditions. Poor vehicle maintenance is a contributing factor to this noise source.

**Road noise**

Frictional noise from the contact between tires and pavement contributes significantly to overall traffic noise. The level depends on the type and condition of tires and pavement. Frictional noise is generally greatest at high speed and during quick braking.
Driver behavior

Drivers contribute to road noise by using their vehicles’ horns, by playing loud music, by shouting at each other, and by causing their tires to squeal as a result of sudden braking or acceleration.

Construction and maintenance

Road construction and maintenance generally require the use of heavy machinery, and although these activities may be intermittent and localized, they nevertheless contribute tremendous amounts of sustained noise during equipment operation.

Spatial relationships

Perhaps the greatest determinant of noise impacts is the spatial relationship of the road to potential noise receptors [25]. The closer the road to receptors, the greater the impact. The higher the population density in roadside areas, the greater the number of people likely to be receptors, and, consequently, the greater the impact.

Doubling the distance between the road and the receptor results in a decrease of 3 dB (A) in the noise level.

When traffic on a road is doubled, the noise level increases 3 dB (A), all other factors being equal.

Doubling the speed results in an increase of 6 dB (A).

The level of traffic-related noise is dependent on traffic volume, traffic speed, and the type of vehicle [26]. A vehicle produces noise from the engine, the exhaust system, and the tires. When a vehicle is traveling more than 50 mph, 75% to 90% of all the noise it generates is produced at the contact point between the tires and the pavement.

- Traffic at 65 miles per hour sounds twice as loud as traffic at 30 miles per hour.
- 2000 vehicles per hour sound twice as loud as 200 vehicles per hour.
- One truck at 55 miles per hour sounds as loud as 28 cars at 55 miles per hour.

1.9 Road traffic noise impacts:

Noise associated with road development affects the environment through which roads pass by degrading human welfare, by sonically vibrating structures, and by disrupting wildlife.

Human welfare

Even when it is not perceived consciously, chronic exposure to road noise can affect human welfare in varying degrees, both physiologically and psychologically. Chronic noise exposure can be a source of annoyance, creating communication problems and leading to elevated stress levels as well as associated behavioral and health effects. It can cause auditory fatigue, temporary and permanent lessening of hearing ability, sleep disorders, and can even contribute to learning problems in children.

Vibration

The vibration induced by the resonance of traffic noise can have a detrimental effect on structures standing near the road. This is of particular concern in the case of cultural heritage sites, which may have been standing for many centuries, but which were not designed to withstand such vibration. Makeshift or lightly constructed buildings, common in many developing countries, may be the first to succumb to vibration damage.

1.10 Determining the nature and scale of impacts:

Vehicular factors

Different vehicle types produce different levels of noise. In general, heavy vehicles such as transport trucks make more noise than do light cars; they tend to have more wheels in contact with the road and often use engine brakes while decelerating. Poorly maintained vehicles, such as those with
incomplete exhaust systems or badly worn brakes, are noisier than well-maintained ones.

**Road surfaces**

The physical characteristics of the road surface and its surroundings play a large role in determining noise output. Well-maintained, smooth-surfaced roads are less noisy than those with cracked, damaged, and patched surfaces. Expansion joints in bridge decks are especially noisy. Roadside surfaces such as vegetated soil tend to absorb and moderate noise, while reflective surfaces like concrete or asphalt do not have any beneficial function.

**Road geometry**

The vertical alignment of the road can affect the ease with which noise can be transmitted to roadside receptors. For instance, siting a road in a cut below ground level or on a raised platform may serve to keep receptors out of the impact zone. Also, the presence of barriers along the roadside, whether specially installed for noise control or naturally occurring, can lower the impact of road noise. Vehicles tend to produce the most noise while ascending and descending steep slopes and while rounding sharp corners; this means that roads which incorporate these features will tend to be noisier at those points.

**Environmental factors**

Weather conditions such as temperature, humidity, wind speed, and prevailing wind direction can play a role in determining how individual sites are affected by road noise.

Temperature and humidity determine air density, which in turn affects the propagation of sound waves. Downwind sites are generally exposed to greater noise levels than are sites upwind of roads. Ambient noise levels, associated with industrial and other human activity, affect the perception of the magnitude of the road noise impact. In areas with low ambient noise levels, the
noise from a new road development will generally be more noticeable than a similar noise level would be in an environment with higher ambient noise levels. New roads in quiet areas or noisy trucks at night are often perceived as worse than higher levels of noise in a busy area during the workday. On the other hand, measured noise levels and potential health impacts are highest where traffic noise combines with noise from other sources, possibly producing an unacceptable overall noise level.

**Traffic stream**

The noise production of a particular traffic stream is determined by a number of factors: the type of vehicles in the stream and their level of maintenance; the number of vehicles passing per unit time; the constancy of flow - vehicles tend to be noisier in stop-and-go traffic; and the speed of traffic flow - noisiest at high speeds. The relationship between traffic stream cycles and ambient noise is also important; ambient noise levels are generally lowest at night, and if traffic noise peaks at night, the impact will be great. Conversely, if traffic noise peaks at the same time that ambient noise levels do, the effects will be less noticeable.

**1.11 Noise Hazards:**

Road noise impacts will be greatest where busy roads pass through densely populated areas. Some receptors are more sensitive, to noise exposure than others. Road noise in industrial zones and uninhabited areas without much wildlife is not likely to be particularly problematic, whereas residential suburbs and particular localities such as schools or hospitals may experience significant impacts. It should be recognized that there are some locations (such as busy urban intersections) where it is very difficult to implement noise-limiting measures.
Noise is frequently overlooked as a form of pollution because it is ubiquitous, it has no chemical toxicity and there are no attributable deaths. Noise has demonstrable effects on sleep, stress levels and disturbance to activities such as communication and learning. The reported effects of traffic noise on people’s health are wide ranging and may include:

1. **Psychological effects** - annoyance and behavior reactions;
2. **Physiological effects** – sleep disturbance, cardiovascular disorders such as high blood pressure and heart disease, hearing loss and general fatigue through sleep loss; and
3. **Social effects** – restrictions on people’s social activities, anti-social behavior and effects on work efficiency.

The methodology states “relatively large changes in traffic flows are required to bring about perceivable changes in noise levels. For freely moving traffic a difference of about 3 dB (A) is required before there is a perceivable change in noise level. A 25% increase or 20% decrease in traffic flow, if speed and other factors remain unaltered only results in a 1dB change [27].

Principal noise effects are both health and behavioral in nature. Sound is a particular auditory impression perceived by the sense of hearing. The presence of unwanted sound is called noise pollution. Unwanted sounds can seriously damage and effect psychological health. For instance, noise pollution can cause annoyance and aggression, hypertension, high stress levels, hearing loss, and other harmful effects depending on the level of sound, or how loud it is. Furthermore, stress and hypertension are the leading causes to health problems.

Noise is harmful. Damage caused by noise can range from bursting of eardrum, permanent hearing loss (in a recent survey 80% of Traffic Police in Pune were found to be deaf), cardiac and cardiovascular changes, stress,
fatigue, lack of concentration, deterioration in motor and psychomotor functions, nausea, disturbance of sleep, headaches, insomnia, and loss of appetite and much other damage is caused [27]. Pregnant women exposed to high noise levels may be at risk. Harmful effects are there even if you do not feel you are being disturbed. Psychological disturbances and emotional distress also occur - violent conduct by persons continuously exposed to unbearable noise.

**Noise effects on human body are:**

**Hearing**

Hearing as a human feature is defined as capacity of detecting sounds within the frequency range of 16-20000 Hz. Human hearing usual threshold lays between 0 and 26 dB. The threshold of hearing is 0 dB at 1 kHz, extrapolated from tests on young people. It varies with frequency as we are less sensitive at lower and higher frequencies, hence the use of A-weighting etc., to relate meter measurements to subjective assessments. The threshold of pain varies, in the literature from 120 dB to 140 dB.

**Acceptable Noise for Residential Areas**

Literature specifies a day-night limit value for residential area sound level of 55dB in order to protect inhabitants from work interference, annoyance and fatigue. If the outdoor sound level exceeds 70dB, they are very likely to be severely annoyed and possibly lose their hearing.

**Indoor and Outdoor**

Many outdoor noises annoy people more than inside noises do, and a typical reaction is to turn on indoor sources to cover up the outside noises, subjecting them to an even higher level of sound.
Noise-Induced Permanent Threshold Shift (NIPTS)

NIPTS is a permanent shift in the hearing threshold (a lowering of the sensitivity) of the ears due to exposure to noise. It is not reversible. NIPTS can result from either a single exposure to high intensity impulsive noise such as blasts or explosions or to longer exposures to lower, but still damaging noise levels. Typically, hearing loss due to noise exposure occurs first at the higher frequencies, particularly around the 4000 Hz level (3000-6000 Hz). For our study this means that we should pay more attention to noise in higher frequency range.

Maximum Level of Noise Protecting General Population from Damage

Environmental noise to which an individual is exposed to 24 hr a day, 7 days a week, at the level of that person’s ear, should be limited to 75 dB (within margin of safety). However, annoyance and discomfort will appear much sooner.

1.12 Remedial measures for traffic noise:

There are basically four options for controlling traffic noise: constructing (or increasing the height of) a barrier wall, increasing the isolation quality of the home, masking the noise, or controlling the noise directly at the source. Barrier Walls Constructing or increasing the height of a barrier wall could result in a noticeable decrease in traffic noise. However, certain guidelines must be met in order for the wall to be effective:

Material

The wall must be solid with no penetrations in order to be effective. Any penetration, opening or gate can degrade the effectiveness of the barrier. Concrete walls are preferred, but other types of walls can also be effective. A barrier does not have to be a wall; it could also be a large earthen berm. A common misconception is that typical landscaping or vegetation can act as an
effective barrier for traffic noise. Unless the vegetation is 100' thick and very dense, it will provide very little if any noise reduction.

**Distance**

Typically, a barrier is more effective the closer it is to the source or to the receiver. Noise barriers are generally only effective for homes within 300 ft. of the roadway.

**Height**

The noise from automobile traffic is primarily from the tires on the pavement. This noise source is at 0' above the ground. Noise from large trucks is typically engine and exhausts noise and is approximately 8' above the ground. In order to be effective, a barrier wall must at least block the line of sight from the noise source to the receiver. Although a 6' high wall can help to reduce auto traffic noise, it will do little if anything for heavy truck traffic. On the same note, if a home is on a hill or elevated above the roadway, a 6' high wall may not be adequate in blocking the line of sight, even for auto traffic.

Increasing the height of an existing wall by 1-2 ft. may make a difference depending on the line of sight issues mentioned above. However, if the wall already blocks the line of sight, increasing the height of the wall by a couple of feet will not provide a noticeable reduction. In fact, some regulatory agencies state the general rule of thumb: each 1 ft. of height added to a wall, above the height that breaks the line of sight between the source (traffic) and receiver (residence), reduces the noise level by ½ decibel.

**Isolation Quality**

Traffic noise can also be controlled at the receiver by increasing the isolation quality of the home. Noise is transmitted primarily through the weakest points. Almost always, the weakest points in the home would be the windows. Depending upon the isolation quality of the current windows,
upgrading the window assemblies could provide at least some relief. Replacing the windows will not help dramatically if you already have decent windows.

Window isolation quality is expressed as a Sound Transmission Class (STC) rating. The higher the rating, the better the isolation quality of the window. A typical single pane window has an STC rating of 22-25. A typical dual pane window has an STC of 27-32. Specialty windows with higher STC ratings are also available.

In existing residences it could be very costly to replace the majority of the windows. Another option that may be less expensive and could produce even better results is to add a window insert in addition to your existing windows. The window insert is placed inside your existing window sill.

Please note that it is important to upgrade the windows that are both parallel and perpendicular to the roadway. It is almost never worthwhile to do anything to the exterior wall of the home, particularly if there is a window(s) in the wall.

Masking

Noise can also be masked at the receiver. Sound masking can be implemented outside or inside your home. This can be accomplished by an electronic sound masking system playing white noise/pink noise through noise generators. Other options include, indoor and outdoor water features, fans, or recordings of soothing sounds. However, this is sometimes perceived as adding more noise to a noisy environment.

Control at the Source

As a resident you may not be able to control traffic noise at the source, but there are ways of limiting problems with traffic noise in the design of future roadways. Traffic noise increases with higher speed limits and with shorter distances from the road to the home. Recessing the roadway can reduce the
noise impact. Use of quiet pavement such as rubberized asphalt can also reduce
the impact by 4-5 decibels. Unlike conventional asphalt, rubberized asphalt
maintains its noise reduction properties over several years.

**Prevention**

Noise problems can be avoided by moving the road alignment or
diverting traffic away from noise-sensitive areas using bypass roads. Choosing
alignments which minimize steep slopes and sharp corners, especially at
sensitive locations, can also prevent noise problems.

**Vehicular measures**

Motor vehicle noise can be reduced at source, for example through
vehicle construction, selection of tires and exhaust systems, as well as vehicle
maintenance. Control of vehicle noise emissions can be attempted using
vehicle design rules and in-use noise regulations and enforcement.

**Surface design and maintenance**

The application of a bituminous surface layer over worn concrete
roadways is effective in reducing frictional noise. The use of open-graded
asphalt and the avoidance of surface dressings may also be effective in
reducing frictional noise in sensitive areas. Some jurisdictions are
experimenting with asphalt made using discarded tires, which appears to
reduce frictional noise as well. Generally, smooth, well-maintained surfaces
such as freshly laid asphalt without grooves and cracks will keep noise to a
minimum.

**Road geometry**

Road design should avoid steep grades and sharp corners to reduce noise
resulting from acceleration, braking, gear changes, and the use of engine brakes
by heavy trucks at critical locations.
Noise barriers

Noise barriers are among the most common mitigative measures used. They are most effective if they break the line of sight between the noise source and the receptors being protected, and if they are thick enough to absorb or reflect often incorporate several of the measures. A busy road passing by a high-rise building, for example, may require specialized surfacing, a barrier or screen to reduce traffic noise at lower levels, and facade insulation for the upper floors of the building, the noise received. Various materials and barrier facade patterns have been extensively tested to provide maximum reflection, absorption, or dispersion of noise. The types of noise barriers most commonly employed consist of earth mounds or walls of wood, metal, or concrete which form a solid obstacle between the road and roadside communities. Noise mounds require considerable areas of roadside land; for narrow alignments, bridges, and roads on embankments, wall-type barriers may be the only viable option. Two or more barrier types are often combined to maximize effectiveness. Plantations of trees and shrubs, for instance, contribute little to actual noise reduction, but they do confer a psychological benefit in reducing the perceived nuisance of traffic noise, and they are often used to ‘soften’ the visual appearance of mounds and walls.

Noise Abatement

If traffic noise impacts are identified, various noise abatement measures are considered to mitigate the adverse impacts. The construction of a noise barrier is the mitigation measure most often associated with the concept of noise abatement.

Traffic management measures can sometimes reduce noise problems. For example, if acceptable alternative truck routes are available, trucks can be prohibited from certain streets and roads, or they can be permitted to use
certain streets and roads only during daylight hours. Traffic lights can be changed to smooth out the flow of traffic and to eliminate the need for frequent stops and starts. Speed limits can be reduced; however, about a 20 mile-per-hour reduction in speed is necessary for a readily noticeable [5 dB (A)] decrease in noise levels.

Buffer zones are undeveloped, open spaces which border a highway. Buffer zones are created when a highway agency purchases land or development rights, in addition to the normal right-of-way, so that future dwellings cannot be constructed close to the highway. This prevents the possibility of constructing dwellings which would otherwise experience an excessive noise level from nearby highway traffic. An additional benefit of buffer zones is improvement of the roadside appearance. However, because of the tremendous amount of land which must be purchased and because in many cases dwellings already border existing roads, creating buffer zones is often not possible.

Vegetation, which is so high, wide, and dense that it cannot be seen over or through, can decrease highway traffic noise. However, it requires a 200-foot width of such vegetation to reduce noise by 10 decibels, which cuts in half the loudness of traffic noise. It is not feasible to plant enough vegetation along a road to achieve such reductions. If vegetation already exists, it can be saved to maintain a psychological relief, if not an actual lessening of traffic noise levels. If vegetation does not exist, it can be planted for psychological relief, not to reduce traffic noise levels.

Insulating buildings can greatly reduce highway traffic noise, especially when windows are sealed and cracks and other openings are filled. Sometimes noise-absorbing material can be placed in the walls of new buildings during construction. However, insulation can be costly, because air conditioning is
usually necessary once the windows are sealed. A noise abatement measure which should always be considered is the possibility of altering the highway location to avoid those land use areas which have been determined to have a potential traffic noise impact. Since sound intensity decays with distance from the source, increased distance between the noise source and receiver will reduce the noise impact. It may also be possible to obtain abatement by depressing the roadway slightly to produce a break in the line of sight from the source to the receiver. Potential noise reduction should be considered with the many other factors which influence the selection of roadway alignment.

1.13 Limiting the noise pollution:

There are some things one can do to help himself while governments get around to tightening the standards for noise pollution, [27] though:

- One can use air conditioning to allow one to keep windows closed during the noisiest times of the day. This is of course only an interim solution, since air conditioning uses more electricity which raises energy costs and also requires more power plants which in turn create more air or other forms of pollution. Furthermore, when rooms are closed up indoor air pollution becomes a problem. But it can be a good short-terms solution.

- One can buy small noise-canceling devices which sample the frequencies of sound and create other sound waves which in essence collide with the noxious sounds and batter them into other, less disturbing sounds. These devices are relatively new and have not been proven to be fully effective, though.

- One can use other sound-generating devices such as stereo systems, which cover up some of the more disturbing sounds with more
pleasurable ones. This short-term solution, however, since the underlying sounds are still present.

- One can learn some of the techniques on Stress to lessen the impact of unpleasant sounds. When we are more relaxed in general, big annoyances become little annoyances and may disappear altogether. When we learn to truly relax, we may find that sounds which were once of great concern simply faded away into the background.

- And of course, if none of the other suggestions works, one can become active in his community to work with local authorities to devise solutions to the problem of noise pollution which may be uniquely suited and to the place we live.

Acoustically similar noise environments are often assumed to cause more annoyance in residential areas during the evening or night hours than they would during the daytime. A night time weighting is therefore included in some noise indexes, such as $L_{dn}$. An analysis of ten studies with a total of 22,000 respondents found some evidence that evening and night time noise may have a somewhat greater impact on annoyance [28-29].

### 1.14 Sound Pressures and their corresponding decibel:

It is interesting to note that threshold of audibility is zero dB. If a pin falls on a hard floor, it gives 10 dB, sound up to 40 dB is encountered in a garden, a bedroom, in libraries. Whisper (30 dB) is usually considered to be pleasant. An average conversation produces 60 dB. Observations shown in Figure 1.2 contain summary of various sound pressures and the corresponding decibel levels, with examples of recognized common indoor and outdoor noises [30].
<table>
<thead>
<tr>
<th>Outdoor Noises</th>
<th>Sound Pressures (µPa)</th>
<th>Sound Pressure Levels (dB)</th>
<th>Indoor Noises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jet Flyover at 300 m</td>
<td>6,324,555</td>
<td>110</td>
<td>Rock Band at 5 m</td>
</tr>
<tr>
<td>Gas Lawn Mower at 1 m</td>
<td>2,000,000</td>
<td>100</td>
<td>Inside Subway train</td>
</tr>
<tr>
<td>Diesel Truck at 15</td>
<td>632,456</td>
<td>90</td>
<td>Food Blender at 1 m</td>
</tr>
<tr>
<td>Noisy Urban Daytime</td>
<td>200,000</td>
<td>80</td>
<td>Garbage Disposal at 1 m</td>
</tr>
<tr>
<td>Gas Lawn Mower at 30 m</td>
<td>63,246</td>
<td>70</td>
<td>Shouting at 1 m</td>
</tr>
<tr>
<td>Commercial Area</td>
<td>20,000</td>
<td>60</td>
<td>Vacuum Cleaner at 3 m</td>
</tr>
<tr>
<td>Quite Urban Daytime</td>
<td>6,325</td>
<td>50</td>
<td>Normal Speech at 1 m</td>
</tr>
<tr>
<td>Quite Urban Nighttime</td>
<td>2,000</td>
<td>40</td>
<td>Large Business Office</td>
</tr>
<tr>
<td>Quite Suburban Nighttime</td>
<td>632</td>
<td>30</td>
<td>Dishwasher Next Room</td>
</tr>
<tr>
<td>Quite Rural Nighttime</td>
<td>200</td>
<td>20</td>
<td>Small Theater, Large</td>
</tr>
<tr>
<td></td>
<td>63</td>
<td>10</td>
<td>Conference Room, Library</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0</td>
<td>Bedroom at night</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Concert hall (background)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Broadcast and Recording Studio</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Threshold of hearing</td>
</tr>
</tbody>
</table>

**Fig. 1.2: Common outdoor and indoor noises**

### 1.15 Literature Review:

V. Krishna Murthy [31] assessed traffic noise pollution in Banepa, a semi urban town of Nepal and found that the overall minimum and maximum levels for the main road are 60.1 dB(A) and 110.2 dB(A). The noise levels produced by different motor vehicles ranged from 121 to 91.2 dB(A). The study observes motor vehicles as main source in the town. S. Sampath [3] studied noise levels in Kerala, and observed that during festival time, the levels exceeds the prescribed limit by 30 to 40 dB. J.K. Datta [32] reported that noise levels in Burdwan town lies within the range of 64-85 dB or above in different time at different places. The locations that belong to the silence zone have the noise level up to 90 dB. C. Ravichandran [33] computed Leq and other noise
descriptors and found that noise levels reached up to 101 dB in Bus stand and Leq was 90.58 dB. In residential areas, L10 values were above 85-90 dB. Dr. S.K. Bhattacharya [34] measured sound pressure levels in platforms of different stations in Calcutta and their results indicated that the averaged A-weighted SPLs in these stations were in the range of 84-87 dB. In the coaches of the moving train Leq values ranged 92-99 dB.

Inga Baubonyte [20] assessed noise levels in Kaunas city, Lithuania, the study result showed that the equivalent noise level at day time was 67.7 dB, in the evening 63 dB, at the night time 57.8 dB and in Eiguliai it was 70 dB, 68.6 dB and 65.1 dB respectively. The noise levels exceeded the hygiene standard from 12.7 to 18.6 dB. M. Malakootian [35] recorded minimum noise level 83.9 dB and maximum noise level 94.5 dB in different stations of Kerman-Iran. Carolina Moura-de-Sousa [36] studied equivalent continuous noise levels in the city of Sao Paulo, Brazil. He observed that Leq for the roads with heavy traffic ranged from 70.88 to 80.18 dB, mean 75.88 dB and the maximum peak ranged from 102.47 to 108.37 dB(C). Mohammed Raza Mehdi’s [37] model research has provided a basis for a comprehensive study on noise pollution in Karachi using GIS techniques. M. Parida [19] studied the noise levels on flyover which is 81.12 dB which is higher than the noise level 80.93 dB due to adjacent road. He also suggested some mitigation measures for the studied flyover in his paper. Shrikanta Naik [38] studied noise levels at Bondamunda area of Rourkela industrial complex. He computed Noise descriptors like L_10, L_50, L_90, L_eq, L_{np}, traffic noise index and found that ambient noise levels in some places exceeded the recommended limit. Stelian Tarulescu [39] studied noise levels in urban areas of Barsov, Romania and concluded that in some intersections the medium level of noise pollution i.e. L_eq is frequently over 70 dB. This is because the evolution of traffic volume in Barsov is continuously increasing.
Maria Patroscu [40] recorded noise levels between the range of 65-75 dB in his study in Bucharest, Romania. Zekry F. Ghatass [41] has made assessment and analysis of traffic noise pollution in Alexandria city of Egypt and recorded the maximum value of noise levels were close to 101 dB. The L\(_{10}\) values were 92, 88.97 dB at Elgish street, Horreya Avenue and Circular Highway respectively. The L\(_{90}\) values were 67, 62 and 57 at the same street. Dhananjay K. Parbat [42] evaluate noise descriptors in the form of L\(_{\text{max}}\), L\(_{\text{min}}\), L\(_{10}\), L\(_{50}\), L\(_{90}\), L\(_{\text{eq}}\), L\(_{\text{np}}\), NC and TNI and found 93.3, 28.1, 77.4, 70.2, 64.5, 73.2, 86.1, 86.9 and 12.8 dB respectively. Ingle [43] made monitoring and assessment of daily exposure of residential population of highway traffic noise in Jalgaon, Maharashtra, India urban centre and found that it affects on hearing capability. D. Banerjee [44] studied the road traffic noise in Asansol, India. He created noise maps for impact analysis and formulation of Noise Risk Zones. Mean L\(_{\text{dn}}\) value ranged between 55.1 and 87.3 dB (A). Day time L\(_{\text{eq}}\) level ranged between 51.2 and 89.0 dB (A), where it ranged between 43.5 and 81.9 dB (A) during night. The study reveals that present noise level in all the locations exceeds the limit prescribed by Central Pollution Control Board. Based on the finding it can be said that the population in this industrial town are exposed to significantly high noise level, which is caused mostly due to road traffic. Mirhossaini [45] has made evaluation and analysis of environmental noise of Arak, Iran and his results indicate that daily average sound levels due to road traffic exceeds environmental standards by about 10 dBA and more than 30% of the residents should be highly disturbed by road traffic noise. West Bengal Pollution Control Board [46] in 2005-2006 had taken various activities to combat noise pollution. The board had taken major steps to tackle noise and other pollution-related problems during Durga puja in 2005. To have a clear idea about the increase of ambient noise level in residential areas in the city of Calcutta and other district
town during the festivals, the West Bengal Pollution Control Board (WBPCB) has undertaken a noise monitoring survey in the year 2005 [47]. Maharashtra Pollution Control Board [48] (MPCB) had taken a survey in the cities of State of Maharashtra during Diwali Festival and found that noise levels at all locations was in the range of 55-75 dB(A). These values are higher than the stipulated limit of 55 dB for day time and 45 dB for night. The noise levels were much higher during 8 and 9 pm. Peak levels of noise were found as high as 118 dB(A) at ground floor at 4m distance from fire cracking area. However, this level was found intermittently only during the fire cracking. MPCB [49] carried out the survey for 5 days during Ganesh Festival in the month of Aug 27-Sept 7, 2006 to assess the situation of noise levels in various cities in the state of Maharashtra and found that noise levels were exceeding the permissible limits during the festival period. In Aurangabad city, it was observed that minimum noise level was ranging from 52 to 82.9 dB(A) and maximum level was ranging from 73.2 to 115 dB(A). MPCB [50] also taken same type of survey in the year 2007 and found that sound level $L_{eq}$ during the survey ranged from 65.2 to 114.1 dB(A). Hans Bendtsen [51] developed the Nordic computational model to calculate outdoor noise levels as a 24-hour average in free field, i.e. in front of the façade of a given building, where reflected noise for the particular building is not included in the calculations. The new version of the model will enable calculation at speeds down to 30 km/hr compared with 50 km/hr previously. Alam [52] studied the level of traffic-induced noise pollution in Sylhet city, Bangladesh and observed that at all the locations the level of noise remains far above the acceptable limit for all the time. The noise level on the main road near residential area, hospital area and educational area were above the recommended level (65dBA). Antonio [53] studied the problems that appear when a model to predict the
environmental noise is the emergence of anomalous sound events. This work is focused in obtaining a method for prediction of anomalous sound events from the flows of different types of vehicles in traffic. Nirjar [54] used different established models to predict the noise level for an urban area. The data collected at different sites in Delhi has been analyzed and compared with the values predicted by each of three models. Also, a regression model for prediction of noise level was developed from the data collection in eight different locations in Delhi. Golmohammadi [55] recognized road traffic noise as the main source of environmental pollution and develop a model to predict noise level from fundamental variables. Alimohammadi [56] examined the reliability of traffic noise estimate and measurement techniques in highways of Tehran, capital of Iran. Traffic flow, traffic composition in terms of heavy vehicles and traffic speed are identified as the key factors influencing the generation of traffic noise. Dragan Cvetkovic [57] studied the noise levels in urban area of Nis and developed a model. In his paper, the results of traffic noise prediction based on NAISS-model obtained by trending of the experimental data collected by systematic noise measurement in urban area of Nis as well as comparative analysis with other models will be shown. Peretti [58] carried out road traffic noise monitoring in forty two different sites of Chioggia, Italy. Traffic flow data have been correlated with the hourly $L_{Aeq}$ levels in order to develop a mathematical model. The classical functional relationships available in literature Burgess [59], Josse [60], Fagoti [61], Pamanikbud [62] have been stated is based on data measured through semi-empirical models, typically using regression analysis.

Also, in Literature review revealed that a number of [63-68] investigators have carried out research on vehicular traffic noise pollution for large metropolitan cities in developing as well as developed countries. A large
cluster of suffering population also resides in cities with intermediate population, for which very limited research has been carried out and reported [69-71].

1.16 Objectives of the study:

In the light of the rapid growth of vehicles and the hazardous effects due to noise pollution, there is a need to study noise pollution from the transportation point of view. Transportation systems are major sources of noise pollution, with road traffic noise being the most prevalent and wide spread source. The main objective is to study and analyze noise pollution due to vehicular traffic in Aurangabad city, India.

No systematic and extensive studies have been conducted on noise pollution in Aurangabad city. So in this study, noise parameters such as \( L_{10} \), \( L_{50} \), \( L_{90} \), \( L_{np} \), Noise Climate and Traffic Noise Index will be studied by collecting necessary data at various locations.

The aim of the study is to develop a suitable model of traffic noise prediction under the various traffic conditions at selected locations. This study will present a tool for dynamic traffic noise prediction and propose a model for noise levels.

There are many other sources of environmental noise that present an ever-increasing burden of noise pollution that affects our well-being. On every occasion from birth to death loud noise or music band is the part of our culture. So to assess the noise levels during the festivals and other religious or public gatherings is part of the objectives of this study.

The analysis of noise using noise power spectrum helps in identifying the various sources of noise that contribute to the noise. As different sources of noise generally produce noise in a certain frequency range; knowledge of the potential components of noise helps in planning of noise pollution control.
measures. So the analysis of recorded audio data from different sources from the point of view of the power levels present at different frequencies is another objective of this study.

The study of different types of noise reveals that noise spectra exhibit a wide variety of characteristics. This study includes finding any distinct patterns or presence of characteristic behavior such as a frequency dependence that is characterized as a peculiar type of noise such as white noise, pink noise etc.
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