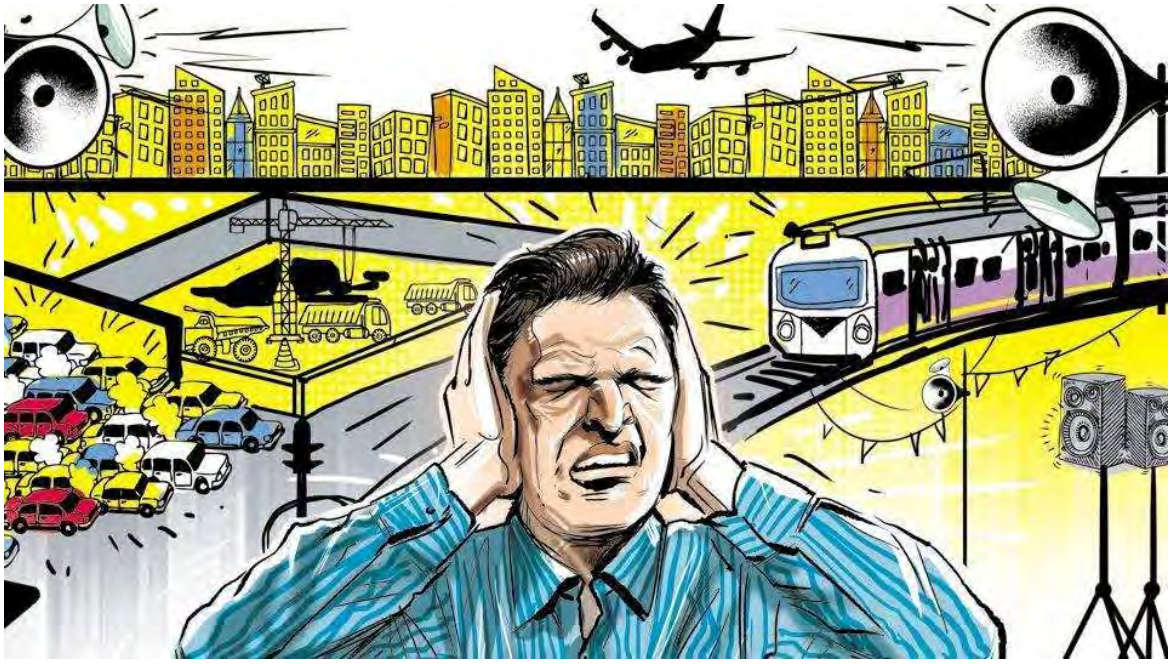


Environmental Engineering Processes & Management

Noise Pollution

Noise Pollution

We hear various types of sounds everyday. Sound is mechanical energy from a vibrating source. A type of sound may be pleasant to someone and at the same time unpleasant to others. The unpleasant and unwanted sound is called *noise*.

Sound can propagate through a medium like air, liquid or solid. Sound wave is a pressure perturbation in the medium through which sound travels. Sound pressure alternately causes compression and rarefaction. The number of compressions and rarefaction of the molecules of the medium (for example, air) in a unit time is described as frequency. It is expressed in Hertz (Hz) and is equal to the number of cycles per second.

There is a wide range of sound pressures, which encounter human ear. Increase in sound pressure does not invoke linear response of human ear. A meaningful logarithmic scale has been devised. The noise measurements are expressed as Sound Pressure Level (SPL) which is logarithmic ratio of the sound pressure to a reference pressure. It is expressed as a dimensionless unit, decibel (dB). The international reference pressure of 2×10^{-5} Pa is the average threshold of hearing for a healthy ear. Decibel scale is a measure of loudness. Noise can affect human ear because of its loudness and frequency (pitch).

The Central Pollution Control Board (CPCB) has recommended permissible noise levels for different location as given in following table.

Area Code	Category of Area	Noise Level in dB	
		Day	Night
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silence zone	50	40

CHARACTERISTICS OF SOUND

Basically sound is a series of alternate compression and rarefaction of air or any other medium, produced by a vibrating body. These longitudinal sound waves travel all around through any material in solid, liquid or gaseous form. These waves travel in air with a velocity of 340 m/sec at normal temperature and pressure. This velocity of sound depends on density. temperature, pressure and nature of medium of transmission. Higher the density, greater will be the sound velocity. In vacuum (with theoretical density of zero), sound cannot be transmitted, i.e. it travels with zero velocity.

Sound waves are characterized by its three properties as below:

- Frequency.

- Intensity, and
- Tone

Frequency or pitch is defined as vibration cycles per second. The highest frequency which an human ear can identify as audible is 20000 cps while the lowest audible frequency is 20 cps. An human ear cannot listen a sound of frequency lower than 20 cps or higher than 20000 cps.

The **sound intensity** measures the flow of sound energy through a unit area normal to the wave direction. The variation range of sound intensity is very large indicating different levels of noise created, normally indicated in decibels, ranging from nearly 140 decibels created by aeroplanes causing pain to barely audible intensity of less than 20 decibels produced by whisper or rustle of leaves. National Building Code gives the intensity levels of different sound sources and acceptable noise levels in buildings from viewpoint of comforts.

Another sound characteristic is called **tone** by which sounds are differentiated from one another.

LEVELS OF NOISE

The sound pressure of the faintest sound that can be heard by a normal healthy individual is about 20 micro-Pascal. The loudest sound produced by a Saturn rocket at the lift off stage is about 200 Pa. This large variation in sound pressure (varying from 20 μ Pa to 200 Pa) is usually avoided by expressing sound pressure on a scale based on the log of the ratio of the measured sound pressure and a reference standard pressure.

Measurement on this scale is called **levels**. The sound level (L) is thus represented as,

$$L = \log_{10} (Q/Q_0) \text{ (Bels)}$$

Where

Q = Measured quantity of sound pressure or sound power or sound intensity.

Q_0 = Reference standard quantity of sound pressure.

L = Sound level in Bels.

A Bel is a *large* unit so for convenience it is divided into 10 subunits called **decibels (dB).**

So when sound level is expressed in decibels.

$$L = 10 \log_{10} (Q/Q_0) \text{ (dB)}$$

According to World Health Organization (WHO) a level of 45 dB is considered a safe noise level in a city. However, a noise level of 65 dB can be tolerable as per the international standards. A report from National Physical Laboratory (India) shows that there is an increase in the background noise level at the rate of 1 dB per year.

ADVERSE EFFECTS OF NOISE

Effects on Human Body Function

Exposure to noise is likely to bring about activation of sympathetic nervous system in a similar way as heat, cold, pain etc. One of the short time reactions is the change in blood circulation. The other effects on brain and other organs are the increased release of insulin in pancreas, increase in the secretion of oxitaxin and ADH from the posterior and it also decreases the detoxifying function of the liver including aromatic substances with carcinogenic effects. Long time noise can produce stomach ulcer, reduced flow of gastric juice and change in acidity neurosis, allergies and circulatory disease, abortion and other congenital defects in children, deafness etc.

Sleep Interference

The main annoying effect of noise is the interruption on sleep. Sleep is a must and even one nights missed sleep may disturb us. One can become short tempered and weary. Noise can interfere with sleep even when the sleeping person is not awakened.

Effect on Working Efficiency

It has been proved that the working efficiency reduces with increase in noise. Reduction in noise from 96 dB to 87 dB has increased the performance by 12%. Reduction of noise either by sound proofing or putting sound obstructing barriers improves the quality of work. It also reduces the industrial accidents. The noise affects communication signals, so reduction of noise increases the efficiency.

Effect on Wild Life

Noise produces physiological effects on human as well as animal health. It has been surveyed that noise has adversely affected the wildlife of the country. It has been observed by the zoo authorities that animals particularly deer, lions, rhino etc. are the worst affected ones by the traffic noise. They become dull, inactive, lesser reproductive and ill. Even the migratory birds are reduced if there is noise. In the forests because of the human activity the noise increases and the animals like lion, tiger and elephants feel segmentation and their reproduction is automatically reduced.

Effects on Non-living Things

Noise affects even the non-living things. High intensity noise may produce cracks into buildings. The noise and vibrations from machinery result in shattering of foundations, loosening of plaster and cracks in walls and house hold crockery.

Psychological and physiological effects

The noise of different levels has different psychological and physiological effects. The following table shows some of them.

Noise level	Effects
65 dB	Noise may create annoyance up to this level, but it is only psychological (nervous effect). Above this level physiological effects such as mental and physical fatigue may occur.
90 dB	Many years of exposure to such noise level would cause permanent hearing loss.
100 dB	With short period of exposure to this noise level the aural acuity may be impaired temporally and prolonged exposure is likely to cause irreparable damage to the auditory organ.
120 dB	Short exposure cause pain and other damages to human beings.
150 dB	Causes instantaneous loss of hearing.

NOISE CONTROL AT SOURCE

In an industry to control the noise at source the machinery should be equipped by effective silencers, properly installed on the designed foundation and well maintained. Use of shock absorbing material, efficient flow technique, reducing fluid jet velocities, restricting sound producing area, reducing peak accelerations are some of the techniques of noise control at source. Use of guards, covers, enclosures and muffler systems, sealing all openings, use of proper cutting speeds and feed rate are other ways of noise reduction. The proper maintenance of machines by lubrication and timely replacement of bearings is the main thing required for the control of noise at source.

NOISE CONTROL ALONG THE PATH

The modification of sound path includes:

- Use of solid high barriers to interrupt the direct transmission. Solid fences and high earth berms can be provided up to attenuation along the highways.
- Increasing distance between the source and the receiver.
- By planting trees. Trees are very good absorber of the sound and otherwise also very much useful as described earlier.

NOISE CONTROL AT RECEIVING END

- To control the noise at receiver level following measures are adopted.
- Double glazing windows in the building for improved sound proofing.
- Gasketing and sealing door and windows openings.
- Providing additional sound insulation for roofs and walls.
- Isolate the operator from the noise.
- By controlling hours of exposure to noise.

- Use of personal protective devices like ear plugs, ear defenders, disposable ear plugs etc.

OTHER WAYS OF NOISE CONTROL

Forming legislation for noise levels for various types of equipment, land use pattern, declaration of silence zone, restricting the use of loudspeakers are some of the ways of noise reduction. Actually, there are rules and regulations but their implementation is difficult without the co-operation of masses. Educating people about hazards of noise pollution and developing awareness at all levels can solve the problem. The social workers should come up to ban the use of bands, orchestras, DJs in the marriages and other functions. The engineers should design the equipment with minimum noise. The industrialists have to install and maintain the equipment & machinery properly. The vehicle drivers should owe to restrict the use of horns of their vehicles unnecessarily. The students should owe to stop the use of crackers on festivals and other moments of joy. The demonstrations should be silent ones. Society in general can reduce the noise pollution if it really wants so.

NOISE MEASUREMENT

Sound level meters are used to measure any type of sound under different conditions and for a variety of reasons. For such applications measurement technique is carefully selected and controlled to obtain valid and consistent results. The measurements are generally taken at the receivers level i.e. 1.2 m above ground (human ear position). The response of the meter depends upon the type of expected sound. The primary components of a sound level meter are microphone, single conditioning electronics and some form of filtering and an analog or digital indicator. The microphone is most important as it converts acoustic signal into electrical signal. The microphone may be a carbon microphone, condenser microphone, piezoelectric microphone or moving coil electrodynamic microphone etc. A good microphone must produce minimum diffraction. This is made possible by keeping its dimensions small compared to the wavelength of sound to be measured. Its output should not be affected by temperature, humidity, wind, atmospheric pressure and magnetic field. It should have low electrical noise and should have flat frequency response. The output should have no distortion. It should have high acoustic impedance and should be strong built.

The human ear has an inbuilt defence mechanism, its sensitivity decreases for higher intensity sounds. Actually, its response is proportionate to the logarithm of intensity. It is measured in decibels. The decibel is the logarithm of the ratio of the measure sound intensity and the reference intensity (audibility). The sound level L is thus represented as,

$$L = 10 \log_{10} I / I_0 \ (dB)$$

where I = measured intensity

I_0 = reference intensity (10^{-12} W/m^2)

SOUND PRESSURE

Sound pressure is dependent on the acoustic environment. The factors involved include the effects of nearby reflecting surfaces, receiver distance, type of space, the amount and location of absorption in the space, the location in the space, the presence of barriers, and the intrusion of ambient sounds.

Sound Power and Sound Pressure are also *different* in that Sound Power is a measure of total energy per unit time emitted by the source in all directions. Sound pressure is a measure of the pressure at the receiver's location.

Typically, manufacturers provide equipment sound power data, in decibels (dB) per octave band.

Sound pressure is the phenomenon we *sense*; it is also the physical property that we can measure with microphones. The sound pressure resulting from a given AHU-generated sound power depends on:

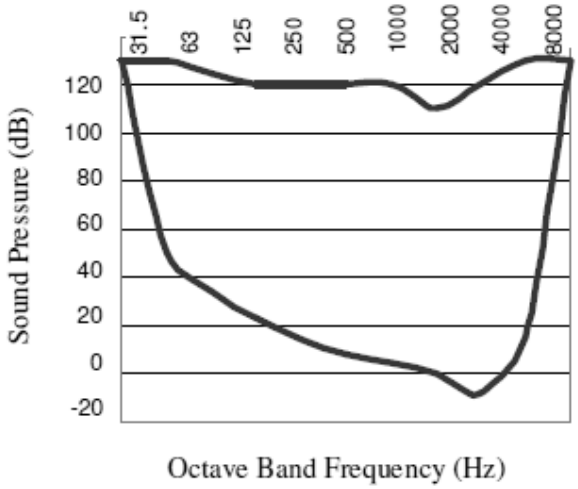
- Distance from the AHU to the room
- The size of the room
- The absorptive properties of interior furnishings
- Attenuating elements such as silencers, duct liner, duct branches, elbows, etc.

Propagating sound creates pressure fluctuations in the air, which vibrate the microphone diaphragm and cause it to make a voltage output proportional to the pressure. We use an RMS (Root Mean Square) value of the pressure fluctuations to obtain a logarithmic measure, expressed as L_p.

OCTAVE BAND ANALYSIS

Sound energy can occur over a broad frequency range, and the human ear is sensitive from about 20 Hertz (Hz) to 20,000 Hz. We can measure the overall level, the sum across all these frequencies, but it is usually helpful to break this down into frequency bands. As in music, an octave band convention was chosen. Each progressive band has double the bandwidth of the previous. The centre frequencies assigned for the bands for the full range of human hearing are: 31.5, 63, 125, 250, 500, 1000, 2000. 4000. 8000. and 16000 Hz. Usually, we disregard the last band.

We can show the range of human hearing in a plot of sound pressure against octave band frequencies.



Range of human hearing

COMMUNITY NOISE

In their Guidelines for Community Noise, the World Health Organization defines community or environmental noise pollution (community noise) *as "noise emitted from all sources except noise at the industrial workplace."*

Sources of Community Noise

- Railroads, Airports and Highways
- Ventilation Systems
- Exhaust Equipment
- Outdoor Construction
- Public Work
- Industrial Premises
- Electrical Installations
- Clubs, Pubs and Concerts
- Oil and Gas Operations

Increasing population, transportation demands, vehicular increase, and congestion of roads are factors that have intensified traffic noise pollution significantly in recent years. Studies assessing noise levels in different settings, week day and holidays, and different zones observed that average noise levels were above the permissible standards.

Another convenient mode of transport in urban areas, the metro trains, were found to generate noise levels, above the permissible levels of 65 dBA (day) and 55 dBA (night) (commercial zone). Although the ambient noise level is reduced due to its predominant underground location, workers are at higher risk, particularly those stationed at the high noise level areas (engine noise, electric generator etc.).

Daily exposure to such noise levels over a long period can have harmful effects. With rapid urbanization, often unmatched by proper layout of roads, highways and buildings, industrial, residential, and commercial areas lie in close proximity. This disturbs the peaceful environment of residential areas. The ambient noise levels in silence zones were found to go even up to 90 dB. Both day time and night time noise levels in these silence zones were above the permissible limits. It causes distractions and annoyance in not only in institutional areas, but also much discomfort and mental disturbance to patients in hospitals. Night time noise levels in residential areas also exceed the prescribed limits of 55 db in day-time and 45 db at night time.

In addition to the continuous traffic noise which people are exposed to, community festivities, public address systems, noise from machines at construction sites, etc, affect the quality of life. According to a study conducted in a residential area in Delhi during **Diwali** festival, the average ambient noise level on Diwali ranged from 76 to 80 dB, which was 1.2-1.3 times higher than on normal days in the area (57-69 dB. Intense high impact noise emitted by fireworks pose a great risk, and can result in damage to the auditory apparatus. Neighbourhood noise can also create an unfriendly atmosphere, misunderstandings, and hostility.

The World Health Organization has listed critical health effects, with corresponding noise levels and exposure time in specific environmental settings.

The adverse health effects of noise are auditory disorders such as hearing impairment, tinnitus, ear ache, noise-induced hearing loss, and non-auditory manifestations which include headache, psychological disturbances manifested by irritability, inability to concentrate on one's work thereby reducing work efficiency, disturbance in sleep and rest, and interference with speech communication.

Studies have also reported hypertension to be associated with noise exposure.

A primary psychological response to noise is annoyance. At a noise level of 50 dB, an adult can get moderately annoyed, and around 55 dB, seriously annoyed.

A study conducted in Orissa found that, though people experienced noise-induced symptoms such as headache, bad temper, hearing problem, loss of concentration, and sleep disturbance, they were unaware of the ill-effects of noise on health.

Awareness of the public and stakeholders is the key component in the prevention and control of community noise pollution. Basic and essential information should be extensively disseminated, such as noise levels created by common sources of noise pollution, adverse health effects on both the person creating noise, and the public preventive measures and conditions punishable under law. Graphic displays in public places are a good medium to spread the message. School campaigns, health education programs, and publicizing through print and electronic media can actively address this issue. Involvement of non-governmental organizations in generating public interest and co-operation, and providing audiological facilities will immensely help the cause.

COMPOSITE NOISE RATING

A U.S. noise measurement system introduced in the early 1960's, and designed to evaluate land use near airports and predict annoyance levels from aircraft operations. Although still in use, the CNR has been superseded in some places by the more recent *Noise Exposure Forecast (NEF)* system (which is similar but adds corrections for duration and pure tones) and the *Community Noise Equivalent Level* (which is based on dBA readings to avoid computer calculation).

The measurement is based on the maximum *Perceived Noise Level* (PNL_{max}) in PNdB plus consideration of the number of flights during the day and night. The basic equation is:

$$CNR = PNL_{\max} + 10\log_{10}(N_D + 16.7N_N) - 12(dB)$$

where PNL_{max} is the approximate energy mean of the maximum perceived noise levels at a given point, and N_D and N_N are the number of flights during the day (0700 to 2200) and night (2200 to 0700) respectively. The factor 16.7 represents a 10-to-1 weighting of night flights over day ones.

ASSIGNMENT

Q.1. (AMIE W11, 4 marks): Define noise and differentiate between "sound pressure levels" and "sound levels."

Q.2. (AMIE S10, 14, 16, 10 marks): Describe the adverse effects of noise pollution and methods of control for the same.

Q.3. (AMIE W10, S16, 10 marks): Describe the sources of noise pollution. What are the adverse effects of noise pollution? State the maximum permissible noise levels in different zones.

Q.4. (AMIE S10, 10 marks): Explain following terms (i) source of noise (ii) noise levels (iii) noise levels standards in India.

Q.5. (AMIE S12, 6 marks): Explain the terms "sound intensity" and "decibels".

Q.6. (AMIE W11, 6 marks): Differentiate between continuous, intermittent and impulsive noise.

Q.7. (AMIE S12, 4 marks): Explain how trees act as barriers in noise control.

Q.8. (AMIE W12, 10 marks): Discuss the method of measurement of sound. Also, explain the methods of prevention of noise pollution.

Q.9. (AMIE S14, 6 marks): Write in brief about the concept and measurement of sound.

Q.10. (AMIE S13, 12 marks): With reference to noise measurement, write a note on "sound pressure", "octave band analysis", "community noise" and "composite noise rating".

Q.11. (AMIE W14, S15, 12 marks): What are the general methods of noise control?

Q.12. (AMIE W13, 6 marks): What are various methods of noise pollution control in industries?