is removed manually or mechanically. Chlorine is sometimes added which helps to remove effectively the oils and grease. Grease and oils may be removed by addition of chemicals including sulphuric acid.

Floating substance is disposed off by filling up the low lying areas or burnt along with sludge.

Detention periods of about 3 to 5 minutes is usually sufficient, and amount of compressed air required is about 300 to 6000 m^3 per millions litres of sewage.

Surface area required for the tank,

$$A = 0.00622 \frac{q}{V_r}$$

where, q = rate of flow of sewage in m^3/day.

V_r = minimum rising velocity of grease material to be removed = 0.25 m/minutes (mostly)

II. Primary Treatment

It removes large suspended organic solids. This is accomplished by sedimentation in settling besins. The effluent contains a large amount of suspended organic material and has a high BOD / about 6% of original.

Finaly divided suspended solids in the sewage are made to settle down by the sedimentation process.

Sedimentation in sewage works are corried out for following :

(*i*) To remove 80 – 90% of settleable solids

(*ii*) To reduce strength of sewage by 30—35%

1. Sedimentation Tanks

Classification of sedimentation tanks

(*i*) According to Use

(*a*) Primary sedimentation tank : When a sedimentation tank is used for settling suspended solids before biological treatment *i.e.,* soon after the grit chamber, it is called *primary sedimentation tank.*

(*b*) Secondary sedimentation tank : When a sedimentation tank is used for settling suspended solids after biological treatment, it is called *secondary sedimentation tank.*

(*ii*) According to Flow type

(*a*) Vertical flow type : These have rectangular, circular or hopper bottom shapes.

(*b*) Horizontal flow type : *These are further classified as follows :*

(*a*) Radial flow type

(*b*) Circumferential flow type

Note : The liquid sewage coming out of tanks after sedimentation process is called *effluent*. The thick viscous liquid settled at the bottom of the tank is called *sludge*.

Design of Primary Sedimentation Tank

Sedimentation tanks are desinged to remove a part of the organic matter from the sewage effluent coming out from the grit chambers.

In a complete sewage treatment, the sedimentation is carried twice

(*i*) Before the biological treatment (*i.e.* primary sedimentation)

(*ii*) After the biological treatment (*i.e.* secondary sedimentation).

Settling velocity

For $d < 0.1$ mm, $V_s = \frac{1}{18} . g . d^2 \left[\frac{G_s - 1}{v}\right]$

For $d > 0.1$ mm, $V_s = 418\,(G_S - 1) d^2 \left(\frac{3T + 70}{100}\right)$

For $d > 1$ mm, $V_s = 1.8\,\sqrt{gd(G_S - 1)}$

For d between 0.1 to 1 mm,

$$V_s = 418\,(G_S - 1) d \left(\frac{3T + 70}{100}\right)$$

where, d = diameter of particle (in mm)

T = temperature (in°C)

G_s = specific gravity of particle

V_s = settling velocity (in cm/sec)

Hazen equation for transition zone :

$$V_s = 60.6\, d\,(G_S - 1) \left(\frac{3T + 70}{100}\right)$$

For inorganic solids $V_s = d\,(3T + 70)$

For organic solid $V_s = 0.12d\,(3T + 70)$

$$\text{Flow velocity } V = \frac{Q}{BH}$$

From geometric consideration

$$\frac{V}{V_s} = \frac{L}{H}$$

But, $V = \frac{Q}{BH}$, hence $V_s = \frac{Q}{BL}$

Discharge per unit plan area $\frac{Q}{BL}$, is an important term for the design of flow type of settling tanks. It shows that all those particles with a settling velocity equal to or greater than $\frac{Q}{BL}$ will settle down and be removed.

Overflow rate : Selting velocity in tanks is also called **overflow rate** or **surface loading** or **overflow velocity**

Normal value of overflow rates ranges between:

40 to 50 cum/m^2/ day 1650 to 2100 l/h m^2 - for plain primary sedimentation tanks

50 to 60 /m^2/day - for sedimentation tanks using coagulants. as aid

about 25 to 35 cm/m^2/day - for secondary sedimentation tanks.

Note : Smaller particles will also settle down, if overflow rate is reduced.

Effective depth : Usual value of effective depth (*i.e.* depth excluding bottom sludge zones) range between 2.4 to 3.6 m.

Detention time

For rectangular tank, detention time = $\dfrac{\text{BLH}}{\text{Q}}$

For circular tank,

$$\text{detention time} = \frac{(0.011/d + 0.785\ \text{H})d^2}{\text{Q}}$$

Dimensions of tank

- Width of tank is usually kept about 6 m, and not allowed to exceed 7.5m or so.
- Length of the tank is generally not allowed to exceed 4 to 5 times the width.

Flow velocity : Generally taken as 0.3 m/minute.

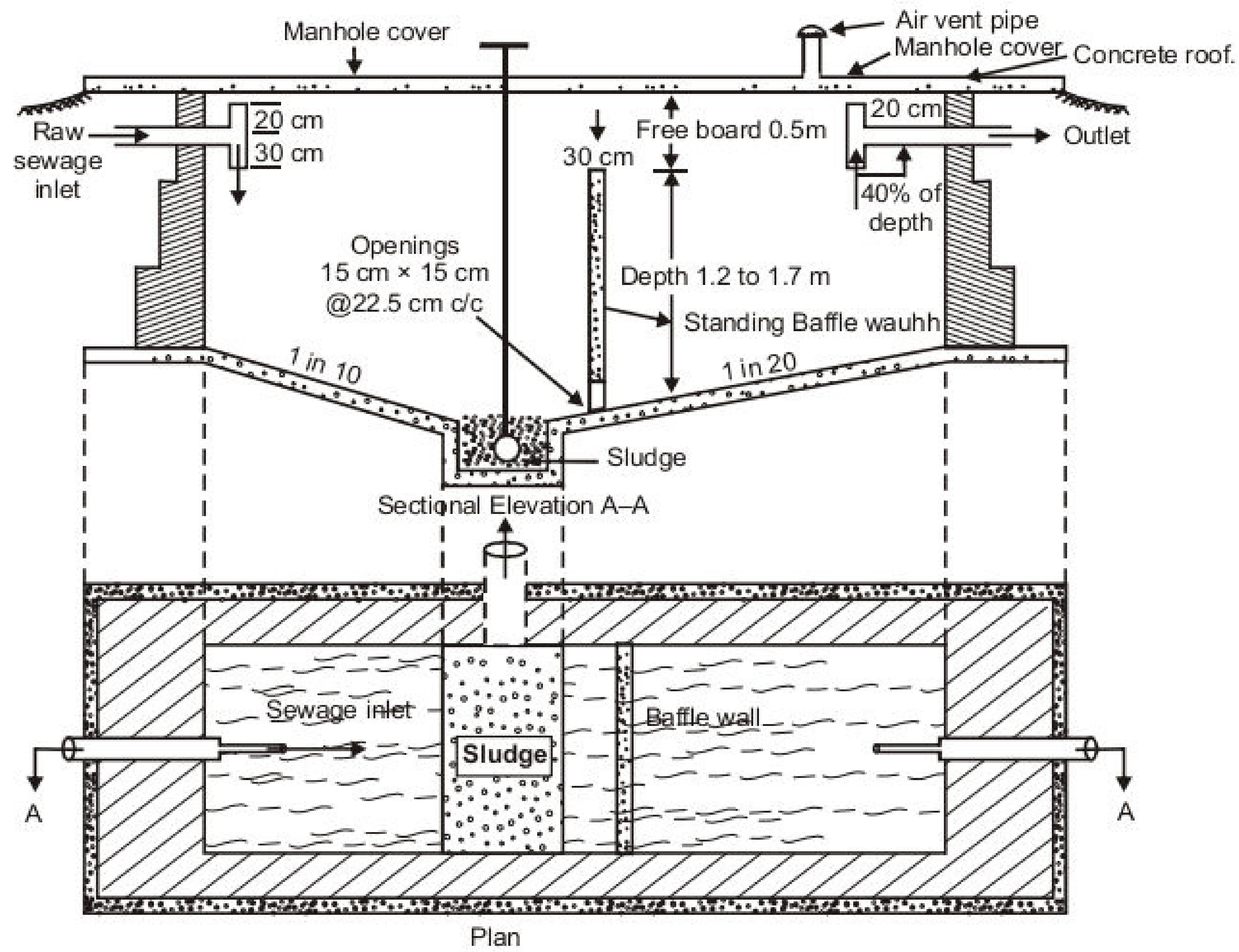
Displacement efficiency

$$= \frac{\text{flowing through period}}{\text{detention period.}}$$

Sludge zone : For tanks without mechanical sludge removal equipment, an additional minimum depth of about 0.8 to 1.2 m should be provided for storage of settled materials, and is called *sludge zone*.

2. Septic Tanks

It may be defined as a primary sediment-ation tank, with a longer detention period (12 to 36 hr.) and with extra provisions for digestion of the settled sludge.



Septic tank unit is generally classified under the units which work on the principle of anaerobic decomposition. It is completely covered and provided with a high vent shaft for escape of gases.

It is a horizontal continuous flow type of a sedimentation tank, directly admitted raw sewage, and removing about 60 to 70% of the dissolved matter from it. Effluent from such a tank will be sufficiently foul in nature, and will have to be disposed off either for sub-surface irrigation or in cess-pools or soakpits or to be treated in trickling filter before disposed it off in water courses.

These are generally provided in areas where sewers have not been laid.

Design criteria

(*i*) Capacity of septic tanks = Quantity of sewage produced during detention periocs

+ Volume of sludge for 6 months to 3 years, depending upon periodicity of cleaning.

Rate of accumulation of sludge has been recommended as 30 lit./person/years.

A free board of about 0.3 m. may be provided above the top sewage line in the tank.

(*ii*) *Inlet and outlet baffles :* Inlet should penetrate by about 30 cm below the top sewage line, and the out let should penetrate to about 40% of the depth of sewage.

(*iii*) *Detention period :* It for septic tank generally varies between 12 to 36 hr. but is commonly adopted as 24 hours.

(*iv*) *Length to width ratio :* L/B = 2 to 3. Width should not be less than 90 cm. Depth of the tank generally ranges between 1.2 to 1.8m.

Methods of disposal of Effluent from Septic tanks

(*i*) Sub-surface irrigation method using dispersion trenches

(*ii*) Disposal in soak-pits

(*iii*) Disposal in a leaching cess–pool.

Design of soak-well

Soak-well or soak-pit can be designed by assuming percolating capacity of the filtering media, say as 1250 lit/m^3 /day.

3. Imhoff Tanks or Two-storey Digestion Tanks

It is a two storeyed tank in which upper portion is called *sedimentation tank* and lower portion is called *digestion chamber.*

Design criteria

(*i*) *Sedimentation tank :* *It is rectangular in shape with the following specifications :*

(*a*) Detention period = 2 to 4 hours (usually 2 hours).

(*b*) Flowing through velocity should not be more than 0.3 m./minute.

(*c*) Surface loading should not exceed 30, 000 litres/m^2 of plan area/day.

(*d*) $L \leq 30$ m, $\frac{L}{B} = 3$ to 5.

(*e*) Total depth = 9 to 11 m, Depth of sedimentation chamber is about 3 to 3.5 or so.

Free-board = 45 cm.

(*ii*)*Digestion chamber:* This chamber is generally designed for a minimum capacity of 57 litres per capita.

Note: Working conditions in imhoff tanks are **anaerobic in lower** compartment and **aerobic** in upper compartment.

Clarigesters : These are small patented circular imhoff type double storey tanks, without bottom hoppers, and fitted with mechanical sludge and scum breaking equipment.

Aerobic and Anaerobic Biological Units

Aerobic Biological Units : These are treatment reactors, in which organic matter decomposes (oxidised) by aerobic bacteria.

These consist of following :

(*i*) Filters

(*ii*) Aeration tanks

(*iii*) Oxidation ponds and Aerated lagoons.

Since all these aerobic units, generally make use of primary settled sewage, they are easily classified as *secondary units*.

Anaerobic biological Units : These are reatment reactors, in which organic matter is destroyed and stabilised by anaerobic, bacteria.

These consists of following :

(*i*) Anaerobic lagoons

(*ii*) Septic tanks

(*iii*) Imhoff tanks

Out of these units, only an aerobic lagons make use of primary settled sewage, and hence only they can be classified as *secondary units.*

Thus septic tanks and imhoff tanks using raw sewage are not classified as *secondary units*.

Note : Sewage treatment is usually confined upto *secondary treatment only.*

Anaerobic Pond

In these stabilisation of waste is mainly brought about by usual anaerobic conversion of organic water to CO_2, CH_4, and gaseous end products, with erruption of foul odours and pungent smells.

Facultative Pond

In these, upper layers work under aerobic conditions, while anaerobic conditions prevail in the bottom layers. The upper aerobic layer of the pond acts as a good check against the evolution of the foul odours from such a pond.

Aerobic Ponds

These are practically difficult to construct and use. The facultative ponds, with depth (1 to 1.5 m.) are thus most widely used for treatment of sewage.

End products of the aerobic pond are carbon dioxide, NH_3 and phosphates, which are required by the algae to grow and continue to produce oxygen.

Oxidation Pond

It was originally referred to that stabilisation pond which received *partially treated sewage* ; whereas pond that received *raw sewage* was called *sewage lagoon*. Oxidation pond has been widely used as a collective term for all types of ponds, and most particularly the facultative stabilisation ponds.

Effluents from oxidation ponds can be easily used for land irrigation, particularly at places, where they cannot be discharged into river streams.

Design criteria : Oxidation ponds works on algal-symbiosis. in which the algae while growing in the precede of sunlight, presence oxygen by the action of photosynthesis and this oxygen is utilised by the bacteria for oxidising the waste organic water. End products of the process are CO_2, NH_3 and phosphates, which are required by the algae to grow and continue to produce oxygen.

- *Organic loading :* 300 – 150 kg/hectars/day. In India to about 90 – 60 kg./ha./day.
- Each unit may have an area ranging between 0.5 to 1 hectare.
- L/B = 2, depth = 1 to 1.5 m., free board = 1 m.
- *Detention time :* 20 – 30 days.

$$\text{Detention period in days} = \frac{1}{k_D} \log_{10}\left(\frac{L}{L-Y}\right)$$

where, L = BOD of the effluent entering the pond

Y = BOD removed, say 90% of L or 95% of L etc.

k_D at 20°C = 0.1/day,

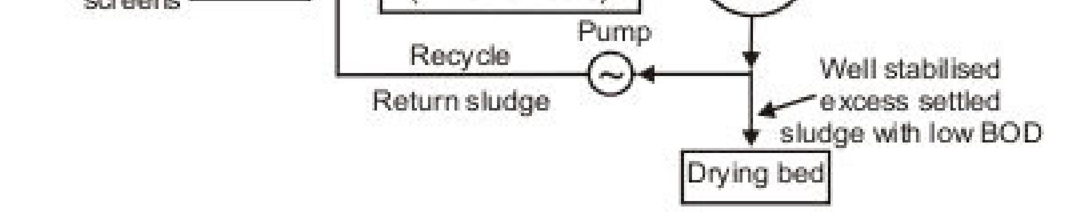
- Properly operated ponds may be as effective as trickling filters in reducing BOD of the sewage. BOD removal is upto 90%, and coliform removal is upto 99% or so.

Advantage of an oxidation pond treatment : It is very cheap; capital cost being 10 to 30% of that of the conventional plant.Their maintenance cost is also very minor, and no skilled supervision is required at any stage of construction and operation.

Disadvantage of oxidation ponds : Nuisance due to mosquito breeding and bad odours.

Order may also be kept under control by avoiding the over-loading. The algae growth may be stimulated by adding sodium nitrate, which is both a plant food and an oxidising agent.

Oxidation ditches (Pasveer type) or Extended Aeration Lagoons



The normal activated sludge plant has been modified to eliminate primary sedimentation tank and sludge digestion tank, in a process, called *extended aeration*, which aims at providing an aeration tank with a longer aeration time.

METHODS OF SLUDGE DISPOSAL

Dewatering

Digested sludge is first of all dewatered or dried up before disposal (burning or dumping).

Methods of Dewatering

(*i*) Dewatering of sludge by Sludge Drying Beds.

(*ii*) Mechanical Methods of Dewatering sludge.

Dried sludge from the drying beds is either use as a manure or is used for filling low lying areas.

Disposal of Row Sludge

1. Disposal on Land

In this method, sewage effluent is generally disposed off by throwing it away on land. The percolating water may either raise the water table or is collected below by a system of underdrains.

When sewage is applied on the ground, a part of it evopartes and remaining portion percolates through soil. Suspended particles are caught in the soil voids. If proper aeration of voids is maintained, the organic matler will get oxidised by aerobic process. But in fine grained soils like clays, pores get clogged up developing non-aerobic condition, which result in evaluation of foul gases and clogging makes the area water logged causing problem of mosquito breading. Application of the sludge sewage will also have some problem, hence primary treatment is necessary before land disposal.

Sewage Farming and Effluent Irrigation

Both these terms are synonyms and means use of sewage effluents for irrigating crops, i.e. direct application of effluent to lands. The basic difference is, in *effluent irrigation* main consideration is the successful disposal of sewage while in *sewage farming* main consideration is successful growing of crops.

Methods of Land Disposal

(*i*) **Irrigation :** It involves application of effluent to the land for treatment and meeting the growth needs of plants. Effluent is treated by physical, chemical and biological means as it seeps in to the soil. Where water for irrigation is valuable, crops can be irrigated as consumptive use rates of 2.5 to 7.5 cm/week depending on the crop and economic return from the crop.

(*ii*) Rapid infiltration : In this system, effluent is applied to the soil at high rates (10 to 20 cm/ week) by spreading in basins or by sprinkling. Treatment occurs as the water passes through the soil matrix.

System objectives are following :

(*a*) Ground water recharge

(*b*) Natural treatment followed by pumped withdrawl or underdrain recovery.

(*c*) Natural treatment with renovated moving vertically and laterally in the soil and recharging a surface water course.

Rapid infiltration is suitable for percolation rate of 6 to 25 mm/minute. The degree of water renovation by rapid infiltration is difficult to predict.

(*iii*) Overland Flow : It is available only for slopping sites with relatively impervious soils. It is essentially a biological treatment process in which waste water is applied over upper reaches of sloped (2 to 8%)terrain and allowed to flow across the vegetated surface to runoff collection ditches. Renovation is accomplished by physical, chemical and biological means as waste water flows in a thin sheet down the relatively impervious slope.

It is suitable for percolation rate below 2mm/ min. Plant or tree cover is essential to minimize errosion and assist in nutrient removal.

In this method there is difficulty in maintaining consistant quality in the runoff and site preparation. Since process is exposed to weather, biologically activity and degree of treatment are adversely affected by lack of sun- shine and cold temperature.

Fundamental Considerations in Land Treatment systems

(*i*) Knowledge of waste water characteristics and treatment mechanisms.

(*ii*) Vegetation and public health requirements.

(*iii*) Waste water characteristics and treatment mechanisms.

NOISE POLLUTION

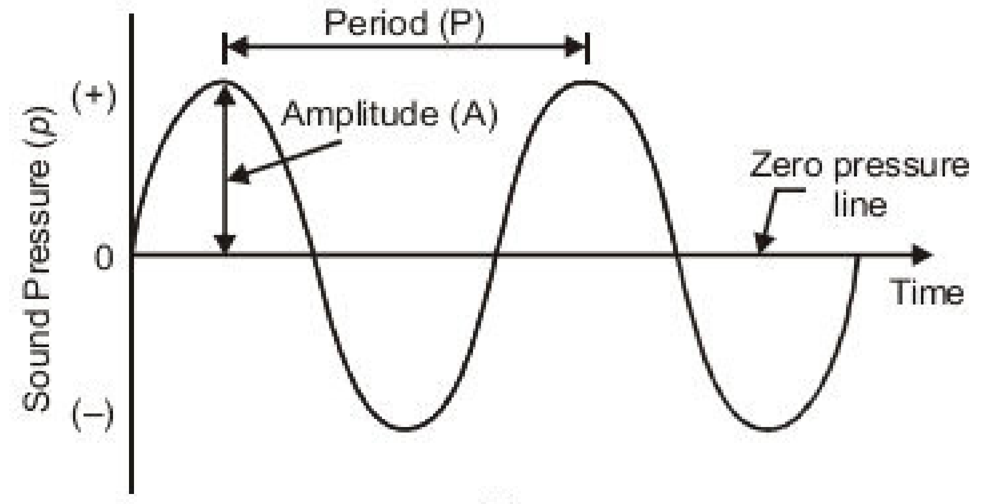
Noise is a characteristic of an environment, and is usually defined as unwanted sound. The unwanted sound certainly produces several undesirable effects on our body health, and therefore, called *pollutant*.

Noise can also be defined as that unwanted sound pollutant which produces undesirable physiological and psychological effects in an individual, by interferring with one's social activities like work, rest, recreation, sleep, etc.

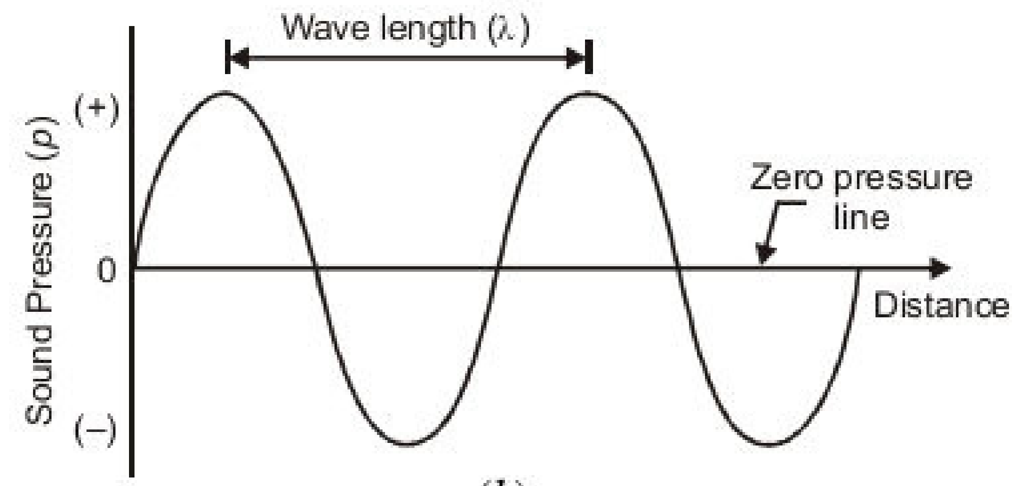
It is a generalised fact that noise of sufficient intensity and duration can induce health problems like temporary and some-times permanent hearing loss, besides causing several other diseases like general annoyance, irritation, disturbance, headaches, insomnia, fatigue, mental torture, nausea, high blood pressure, high pulse rate, greater perspiration, etc.

CHARACTERISTICS OF SOUND AND ITS MEASUREMENT

Sound is produced in the environment by alternating pressure changes in the air, and is caused by vibrations of solid objects or separation of fluids, as they pass over, around, or through holes in solid objects. These vibrations cause the surrounding air to undergo compression, then rarefaction, again compression, then rarefaction, and so on. Such alternating compression and rarefaction of the surrounding air produces sound waves which propagate in the form of sinusoidal path, as shown in Fig. (a) and (b).



(*a*)



(*b*)

Fig. *(a)* shows time between successive peaks or troughs of oscillation called **period** (P), and its inverse, which represents the number of times a peak arrives in one second, is called **frequency** *(f)*.

$$\therefore \qquad P = \frac{1}{f}$$

Fig. *(b)* shows distance between successive peaks or troughs is called **wave length** (λ), which is related to frequencey (*f*) by the relation

$$\lambda = C.\ \frac{1}{f}$$

where C = velocity of the sound wave.

Amplitude (A) of the wave is height of the peak sound pressure measured above or below the zero pressure line.

Equivalent pressure of such a sine wave is represented by root mean square pressure (p_{rms}) as

$$p_{rms} = \sqrt{p_{(t)}^2} = \sqrt{\frac{1}{T} \cdot \int_0^T p_{(t)}^2 dt}$$

where $p_{(t)}$ = pressure at any time t.

Thus r.m.s. sound pressure is obtained by adding squares of amplitude values at small time intervals, and dividing total by averaging time, and finally taking square root of the total. This works out equal $\frac{A}{\sqrt{2}}$ for a regular sine wave.

Sound pressure is related to the atmospheric pressure and barometric pressure as

Sound pressure = Total atmospheric pressure — Barometric pressure

Power of Sound (W)

It is defined as the rate of doing work by a travelling sound wave in the direction of propagation of the wave. Thus energy transmitted by a sound wave in the direction of its propagation is defined as its power, and is represented in watts in S.I. units.

Sound Intensity (I)

It is defined as sound power averaged over the time per unit area normal to the direction of propagation of the sound wave.

Intensity and Power of a sound wave are related by the equation

$$I = \frac{W}{a}$$

where, I = intensity of sound wave in watt/m^2

W = power of sound wave in watts

a = unit area perpendicular to the direction of wave motion.

Sound intensity (I) is further related to r.m.s. sound pressure by the equation

$$I = \frac{p_{rms}^2}{\rho . C}$$

where, p_{rms} = r.m.s. sound pressure in pascals (Pa)

ρ = density of air or medium in which sound wave is travelling in kg/m^3

C = velocity of sound wave in m/s.

Density of air (ρ) and speed of sound (C) used in the above equation can be known if temperature of air is known. In other words, given the temperature and pressure of air, density of air can be determined from standard tables; and speed of sound in air at 101.325 kPa may be determined by the equation

$$C = 20.05\sqrt{T}$$

where, T = absolute temperature in kelvin (K) and C is in m/s.

LEVELS OF NOISE

Sound pressure of the faintest sound that can be heard by a normal healthy individual is about 20 micro-pascal (μ - Pa), and loudest sound produced by a Saturn rocket at the lift off stage is about 200 Pa. This astronomical 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. Measurements on this scale are called **levels**.

$$\text{Sound level, } L = \log_{10} \frac{Q}{Q0} \text{ (bels)}$$

where, Q = measured quantity of sound pressure, or sound power, or sound intensity

Q_0 = reference standard quantity of sound pressure, or sound power, or sound intensity, as case may be

L = sound level in bels (B)

The unit of sound level turns out to be a rather large unit, a smaller unit of **decibels (dB)** is generally used.

$$1 \text{ dB} = \frac{1}{10} \text{B}$$

Hence, when sound level is expressed in decibels, above equation reduces to

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

In this equation reference standard quantity Q_0 is taken as to 20 μPa, when sound pressure is measured.

$$\text{Sound pressure level : } L_p = 10 . \log_{10} \left(\frac{p_{rms}}{20\mu Pa}\right)^{2*}$$

$$\Rightarrow \quad L_p = 20 \log_{10} \left(\frac{p_{rms}}{20\mu Pa}\right)$$

Sound pressure levels so measured are reported as dB *re* : 20 μPa.

Similarly, reference standard quantity Q_0 in the above equation is taken to be equal to 10^{-12} watts, when sound power is measured.

$$\text{Sound power level : } L_w = 10 \log_{10} \left(\frac{W}{10^{-12}}\right)$$

The sound power levels so computed are reported as dB *re* : 10^{-12} W.

Similarly, reference standard quantity Q_0 is taken to be equal to 10^{-12} W/m^2, when sound intensity level is measured.

Sound intensity level : $L_I = 10 \log_{10}\left(\frac{I}{10^{-12}}\right)$

Out of three terms given above, *sound pressure level* on reference scale of 20 μP*a*, is usually adopted to express sound levels in decibels.

AVERAGING SOUND PRESSURE LEVELS

Average value of various recorded sound pressure levels (L_p) at a particular place over a given period cannot be computed by simple averaging due to log scale involved in their values.

$$\text{Average pressure level, } \overline{L}_p = 20 \log \frac{1}{N} \sum_{n=1}^{n=N} (10)^{L_n/20}$$

where, $\overline{L}_p$ = Average sound pressure level in dB re : 20 μP*a*

N = Number of measurement readings.

L_n = *n*th sound pressure level in dB *re*. 20 μP*a*.

n = 1, 2, 3......... N.

Types of Sound

1. **Continuous Noise**

   It is an uninterrupted sound level that varies less than 5 dB during entire period of observation.

   e.g. running fan

2. **Intermittent Noise**

   It is a noise which continues for more than 1 second and is then interrupted for more than 1 second.

   e.g. drilling machine used by a dentist

3. **Impulse Noise**

   It is characterised by a change of sound pressure of atleast 40 dB within 0.5 second with a duration of less than one second.

   e.g. firing of a weapon

NOISE RATING SYSTEMS

A noise may consist of different types of sounds with different pressure levels operating for different time intervals. The frequencies of these sounds may also vary. The combined resultant noise will infact be responsible for determining human response and degree of annoyance caused by it. Therefore combined impact of different sound pressures lasting for different periods is attempted to be worked out by using some statistical measures, such as L_N and L_{eq} systems.

1. L_N concept

L_N is a statistical measure indicating how frequently a particular sound level is exceeded. Value of L_N will represent the sound pressure level that will exceed for N% of the gauging time.

When L_N is plotted against N (where N = 1, 2, 3, ... 100%), a cumulative distribution curve, is obtained.

2. L_{eq} concept

It is defined as constant noise level, which over a given time, expands the same amount of energy, as is expanded by the fluctuating levels over the same time. This value is expressed by the equation:

$$L_{eq} = 10 \log \sum_{i=1}^{i=n} (10)^{\frac{L_i}{10}} \times t_i$$

where, *n* = total number of sound samples

L_i = noise level of any *i*th sample

t_i = time duration of *i*th sample, expressed as fraction of total sample time.

L_{eq} constitutes an important parameter for evaluating impact of fluctuating noises of all kinds, such as from aircraft, street and road traffic, rail traffic, industrial machines, sports stadiums, play grounds, etc.

Moreover, duration in hours, over which L_{eq} is worked out for a given site, is further mentioned in bracket, such as $L_{eq(8)}$ which means that L_{eq} is based on 8-hour measurement; when, no such time is mentioned, then L_{eq} always corresponds to one hour measurement.

NOISE LEVEL STANDARDS

The prescribed noise standards generally put a limit either on L_{eq} or L_N values. Different such limiting values are then prescribed for different areas.

e.g. VIP and silence areas will impose lower limiting values as compared to those for commercial or industrial areas within a city. Usually prescribed limiting L_{eq} values for different areas of a city is of the order of 40 to 70 decibels.

Table show two sets of noise standards : These levels are above those that would be absolutely harmless, but are below those of many existing highways.

Table : Noise standards laid down by U.S. federal highway administration for highways in new developments

Land use category	*Exterior design noise level dB(A)**		*Description of land use category*
	L_{eq} or L_{10}		
A	57	60	VIP and other protected areas, where serenity and quietness is to be maintained
B	67	70	Residence, hotels, schools, hospitals, picnic areas, play grounds, parks, etc.
C	72	75	Developed lands and properties not included in A and B category, such as commercial and industrial areas.
D	No limit	No limit	Undeveloped lands
E	52 (interior)	55 (interior)	Public meeting halls, schools, libraries, churches, hospitals, etc.

*Either L_{eq} or L_{10}, based on 1 hour samples, is to be used.

Table (*b*) has been evolved by U.S. *Environmental Protection Agency* and shows the limiting noise levels for different types of areas for indoor as well as outdoor noises, that should be maintained for adequately safeguarding public health over long periods (accounting annual average levels in L_{eq} values).

Table : Average yearly energy levels (L_{eq}) identified as requisite to protect public health and welfare with an adequate margin of safety.

Types of areas	Measure	Indoor		To protect against both effect (*b*)	Outdoor		To Protect against both effects (*b*)
		Activity interference	Hearing loss consideration		Activity Interference	Hearing loss consideration	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Residential without side space and farm residences	L_{dn} $L_{eq}(24)$	45	70	45	55	70	55
Residential with no outside space	L_{dn} $L_{eq}(24)$	45	70	45			
Commercial	$L_{eq}(24)$	(*a*)	70	70(*c*)	(*a*)	70	70(*c*)
Inside transportation	$L_{eq}(24)$	(*a*)	70	70(*c*)			
Industrial	$L_{eq}(24)$(*d*)	(*a*)	70	70(*c*)	(*a*)	70	70(*c*)
Hospitals	L_{dn} $L_{eq}(24)$	45	70	45	55	70	55
Educational areas	L_{dn} $L_{eq}(24)$	45	70	45	55	70	55
Farm land and general	$L_{eq}(24)$	(*a*)	70	70(*c*)	(*a*)	70	70(*c*)
Farm land and general unpopulated land	$L_{eq}(24)$				(*a*)	70	70(*c*)

Codes:

(***a***) Since different types of activities appear to be associated with different levels, identification of a maximum level for activity interference may be difficult except in those circumstances where speech communication is a critical activity.

(***b***) Based on lowest level.

(***c***) Based only on hearing loss.

(***d***) An $L_{eq(8)}$ of 75 *d*B may be identified in these situations so long as the exposure over the remaining 16 hour per day is low enough to result in negligible contribution to the 24-hour average, that is, no greater than an L_{eq} of 60 *d*B.

- Explanation of identified level for hearing loss. The exposure period that results in hearing loss at the identified level is a period of 40 years.

Table : Acceptable noise levels for residential areas, as per I.S. (4954-1968) code.

S. No.	Acceptable outdoor noise levels in residential areas		S. No.	Acceptable indoor levels for various types of buildings	
	Location	Noise levels dB(A)		Location	Noise levels dB(A)
1.	Rural areas	25 – 35	1.	Radio and TV studios	25 – 30
2.	Suburban areas	30 – 40	2.	Music rooms	30 – 35
3.	Urban residential areas	35 – 45	3.	Hospitals, class rooms, auditorium	35 – 40
4.	Residential and business urban areas	40 – 50	4.	Apartments, hotels, homes Conference rooms, small offices	35 – 40
5.	City areas	45 – 55	5.	Court rooms, private offices, libraries	45 – 50
6.	Industrial areas	50 – 60	6.	Large public offices, banks, stores, etc.	45 – 50
			7.	Restaurants	50 – 55

In order to legally enforce control on noise levels, GOI has notified **Noise Pollution (Regulation and Control) Rules 2000,** under *the Environment (Protection) Act, 1986*. Under these rules,

Table : Ambient air quality standards in respect of noise.

Area Code	Category of Area/Zone	Limits 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 shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 a.m.
3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority.
4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

SOURCES OF NOISE

1. Traffic Noise

It including air traffic, road traffic, and sea-shore and inland water traffic

Amount and type of noise produced by traffic is largely dependent upon type of traffic.

Table : Noise levels of different sources of traffic.

S.No.	*Source of Noise*	*Noise level in dB*
1.	Air traffic	
	(*i*) Jet aircraft at take off stage at about 300m	100 – 110
	(*ii*) Propeller type aircraft at take off stage at about 300 m	90 – 100
2.	Rail traffic (at about 30 m)	90 – 110
3.	Heavy road traffic (highway)	80 – 90
4.	Medium road traffic (main streets)	70 – 80
5.	Light road traffic (side streets)	60 – 70

Table : GOI noise standards for different types of vehicles.

S. No.	*Type of vehicles*	*Noise level in dB*
1	Two wheelers	80
2	Cars	82
3	Passenger or commercial vehicles	
	(*i*) upto 4 MT (Tonnes)	85
	(*ii*) between 4 MT to 12 MT	89
	(*iii*) More than 12 MT	91

2. Industrial Noise

Noise is the essential by-product of industry; its intensity and nature being dependent upon type of the industry. Industrial noises are usually produced by rotating, reciprocating or any other types of machinery, or by high pressure high velocity gases, liquids or vapour involved in the industrial processes. The usual noise level of the industries is of the order of 60 to 95 decibels.

3. Noise produced by Other sources.

Several other human activities, such as blarring of loud-speakers and sirens, shouting of hawkers, playing of children, general life and activity, ringing of temple and church bells, etc. do produce noises of different levels, tones and spectra.

NOISE ABATEMENT AND CONTROL

Exposure of mankind day-by-day is increasing noise. Nuisance must be reduced and abated, if its adverse effects on human health are to be controlled. The society must therefore be protected from harmful effects of noise by devising and implementing ways and means for the abatement of noises.

There are certain noises which can be kept under control by legal laws and ordinances, and there are others which have to be damped and attenuated by the use of good technology and town planning.

e.g., the noises produced by motor vehicles can be controlled to some extent by proper maintenance of vehicles, which can be ensured only by prescribing maximum permissible noise levels for different types of automobiles, through Motor Vehicles Act. Similarly, industrial noises can be brought under the control of Factories Act by specifying maximum permissible noise levels and other checks.

Similarly, public blarring of loud-speakers and playing of radio sets at loud levels can be prevented by general legal laws of public nuisance or laws specifically made for noise pollution. Yet however, there exist several other noises which have become part and parcel of our modern life. All such noises are to be reduced by better design technology to be used in the modern day gadgets like fans, air-conditioners, washing machines, refrigeratiors, mixers and grinders, etc.

Another very important method for abating noise effects on mankind is to use proper town planning techniques, and thus, to ensure construction of houses and offices away from the major sources of noise. Proper segregation, zoning and separation of residential complexes from the commercial and industrial ones, by means of physical barriers, roads, railway lines, parks or green belts, do constitute an important aspect of such good town-planning.

The noises produced by automobiles and trains, being the biggest noise nuisance in a modern city life, can be abated by construction of walls on both sides of roads and railway lines. Raising of such obstructions and barriers in between the noise sources (automobiles) and residences, may considerably reduce the noise levels reaching the residences.

Attenuation of up to 15 decibels is possible in this manner.

When $D \geq R$ and $R >> H$, the noise reduction may also be calculated by the equation:

$$\text{Noise reduction (dB)} = 10 \log_{10}\left(\frac{20\,H^2}{\lambda R}\right)$$

where, H = height of the barrier wall.

λ = wavelength of sound.

D = distance between barrier and the receiving point.

Raising of thick and high vegetation and tree growing along sides of roads and railway lines, offers cheaper barriers to cause such noise reductions.

Locating the noisy sources on the downwind side of the residences may be another important consideration in good town planning, because noise will then travel farther in the downwind direction away from the residences.

Noise levels in residential buildings can be reduced to some extent by offsetting the building from the main or street roads by a suitable distance. The farther is this distance, the better will be the attenuation, because the intensity of noise gets reduced with increase in distance.