DESIGN OF SEWER

In Sanitary engg., the design of Sewer is most imp., bcz of success of Sewarage System depends on it.

Hydraulic formulas for design of Sewers:-

Following are the some common empirical formula used in design of Sewers.

(1) Chezy's formula :-

$$V = C\sqrt{mi}$$

V = Velocity (m/s)
m = hydraulic mean depth (m)
i = slope
C = chezy constant.

(2) Bazin's formula :-

$$C = \frac{157.6}{1.81 + \frac{K}{\sqrt{m}}}$$

K = Bazin coeff

Surface	K
Very Smooth Surface	0.109
Brick and Concrete surface	.290

(3) Manning formula

$$V = \frac{1}{N} m^{2/3} i^{1/2}$$

Surface	N
Smooth Surface	0.010
Concrete	0.012
stoneware	0.013
Brick or Stone masonry	0.017

(4) Kutter's formula

$$C = \frac{23 + \frac{0.00155}{i} + \frac{1}{N}}{1 + \left(23 + \frac{0.00155}{i}\right)\frac{N}{\sqrt{m}}}$$

⑤ Crimp and burge's formula

$$V = 83.50\, m^{2/3}\, i^{1/2}$$

$m =$
$i =$

⑥ Hazen and william's formula

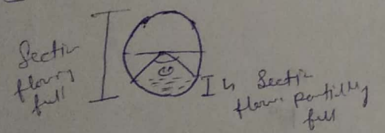
$$V = 0.85\, C\, m^{0.63}\, i^{0.54}$$

$C =$

Type	C
Cast iron pipe	100
Brick sewer	100
Stone ware	110
Cement lined later	110
Smooth surface	140

Variation in flow and velocities:-

The sewage discharge flowing through a sewer does not remain constant at all the times. for most of the period the sewer does not run full. when the sewer does not run full, there is a variation in discharge, depth of flow, hydraulic mean depth, velocity etc.



D = dia of circular sewer
h = depth of flow when the sewer is flowing partially full

① When the section is flowing full, the hydraulic parameters will be as follows:-

Cross sectional area $A = \frac{\pi D^2}{4}$

wetted perimeter $p = \pi D$

V = velocity

discharge $= Q = A \times V$

② When the section is partially full,

depth of partial flow $h = \frac{D}{2}(1 - \cos \theta/2)$

Proportional depth $\frac{h}{D} = \frac{1}{2}(1 - \cos\theta/2)$

Cross sectional area when flowing partial full = a

$$a = \left[\frac{\pi}{4} D^2 \times \frac{\theta}{360}\right)$$

$$a = \frac{D^2}{4}\left[\frac{\pi\theta}{360} - \frac{\sin\theta}{2}\right]$$

$$\frac{a}{A} = \left[\frac{\theta}{360} - \frac{\sin\theta}{2\pi}\right]$$

p - partial wetted perimeter $= \frac{\pi D \theta}{360}$

$$= \frac{p}{P} = \frac{\theta}{360}$$

m = hydraulic mean depth

$$= \frac{\text{area}}{\text{perimeter}}$$

proportionate h.m.d. $\Rightarrow \frac{\text{p. area}}{\text{p. peri}} = \frac{\left[\frac{\theta}{360} - \frac{\sin\theta}{2\pi}\right]}{\theta/360}$

$$= \left[1 - \frac{360^\circ \sin\theta}{2\pi\theta}\right]$$

Acc. to manning formula

$$V = \frac{1}{N} m^{2/3} i^{1/2}$$

proportionate velocity

$$\Rightarrow \left[1 - \frac{360^\circ \sin\theta}{2\pi\theta}\right]^{2/3}$$

proportionate discharge

$$= \frac{q}{Q} = \frac{av}{AV}$$

$\Rightarrow$ (prop. area) prop velocity.

A 60 cm dia sewer is to discharge 0.07 cumecs at a velocity as self-cleansing as a sewer flowing full at 0.85 m/sec. find the depth and velocity of flow and the req. slope. take N = 0.015.

(a) for sewer running full

$$V = \frac{1}{N} R^{2/3} S^{1/2}$$

$N = 0.015 \quad V = 0.85 \text{ m/s}$

$R = D/4 = 0.6/4 = 0.15 \text{ m}$

$$0.85 = \frac{1}{0.015} (0.15)^{2/3} S^{1/2}$$

$$S = 0.00204$$

$$Q = \frac{\pi}{4} (0.6)^2 \, 0.85 =$$

$$\Rightarrow 0.2403$$

(b) for partial depth self cleansing flow

$$q_s = \underline{0.07}$$

$$\frac{q_s}{Q} = \frac{0.07}{0.2403} = 0.2913$$

$$\frac{q_s}{Q} = \frac{N}{n} \left(\frac{a}{A}\right) \left(\frac{r}{R}\right)^{2/3}$$

$$\frac{a}{A} = \left(\frac{\theta}{360} - \frac{\sin\theta}{2\pi}\right)$$

$$= \frac{\theta}{360} \left(1 - \frac{360 \sin\theta}{2\pi\theta}\right)$$

$$\frac{r}{R} = \left[1 - \frac{360° \sin\theta}{2\pi\theta}\right)$$

$$\frac{q_s}{Q} = \frac{N}{n} \times \frac{\theta}{360} \left(1 - \frac{360° \sin\theta}{2\pi\theta}\right) \left(1 - \frac{360° \sin\theta}{2\pi\theta}\right)^{2/3}$$

$$0.2913 = \frac{1 \times \theta}{360} \left(1 - \frac{360° \sin\theta}{2\pi\theta}\right)^{5/3}$$

$\theta = 143.5°$

$$\frac{d}{D} = \frac{1}{2} \left(1 - \cos\frac{\theta}{2}\right) = 0.3434$$

SEWERAGE SYSTEMS UNIT-2

The entire system of conduits and appurtenances for collecting sewage and delivering it to a disposal point is called Sewerage system.

Types of Sewerage system:→

These are of three types:→

(1) Separate system
(2) Combined system
(3) Partially separate system:-

Sewerage system

↓ Separate system
↓ Carrying sanitary sewage in one sewer and storm water in another set of sewer

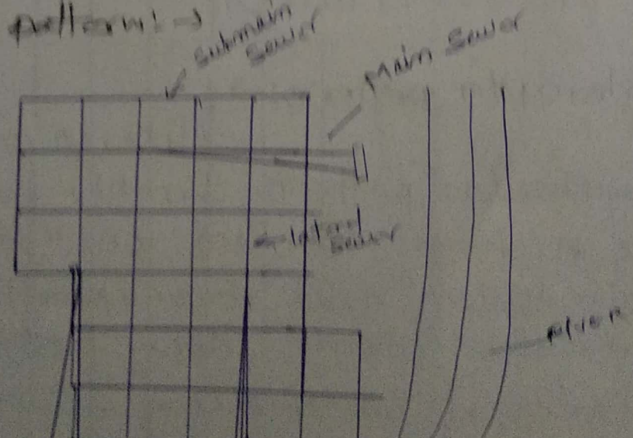
↓ Combined system
↓ Carrying both sanitary sewage and storm water in one sewer

↓ Partially Separate System
↓ Carrying sanitary sewage and a part of storm water in one sewer and remaining storm water in another sewer.

Patterns of Collection system:→

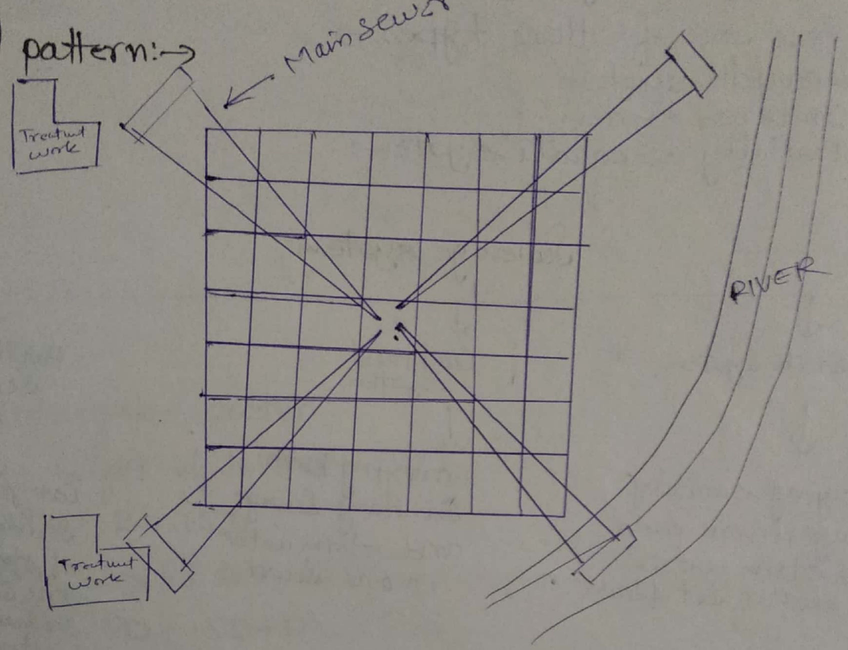
Following are the most commonly used patterns of collection system.

(1) Perpendicular pattern:→



In this pattern the storm water sewers are laid through shortest route to natural water course. The shortest route is acheived if the sewers are laid perpendicular to each other.

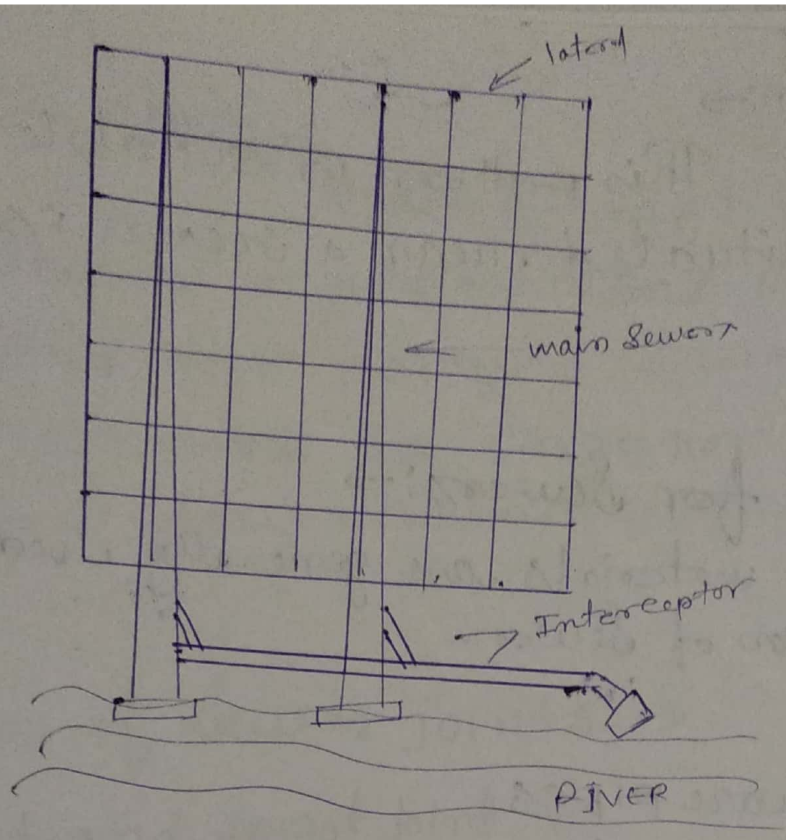
(ii) Radial pattern:→



Radial pattern is employed if the sewage is to be disposed off from the heart of city to outside periphery. This system requires two or more treatment units.

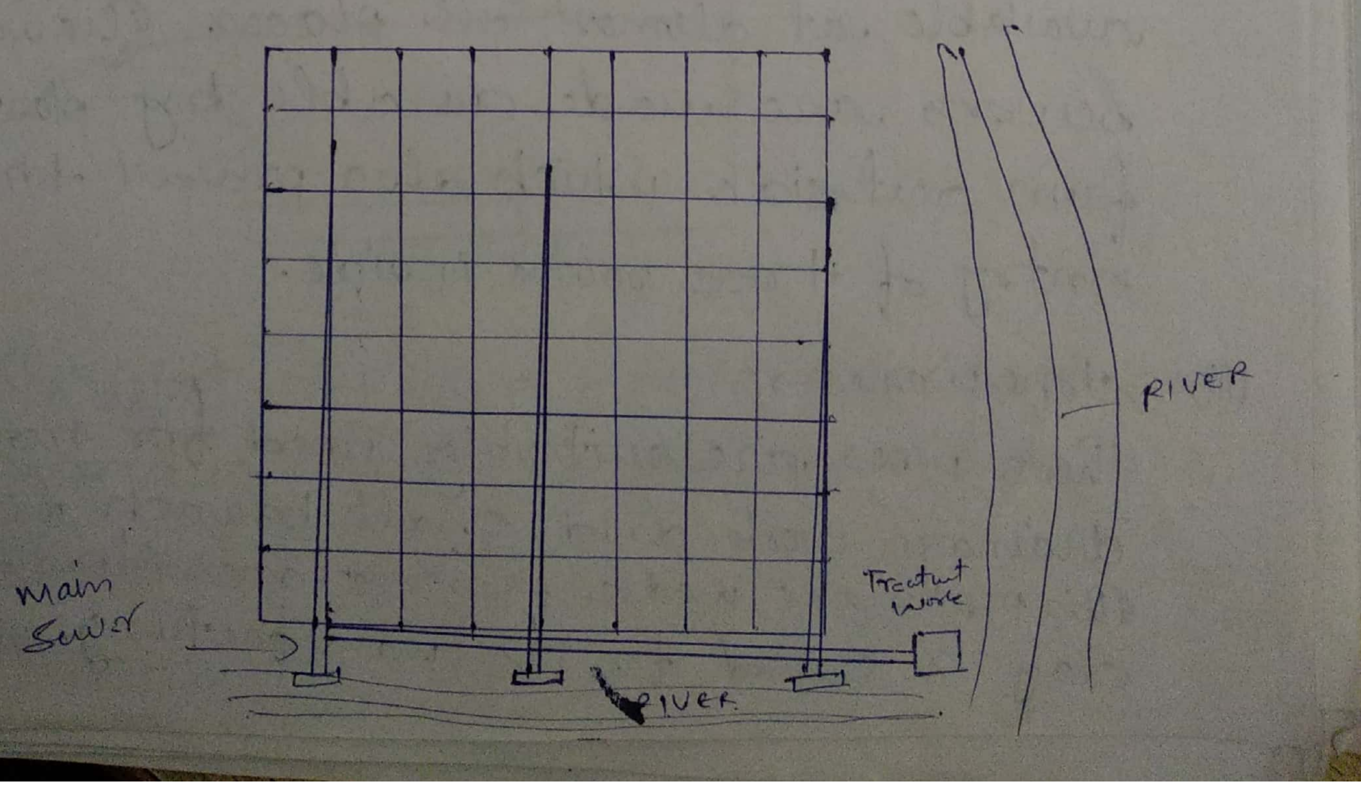
(iii) Interceptor pattern:→

This is an improvement over perpendicular pattern. In this pattern sewers are laid to connect sewage from all the main sewers and transport it either to a treatment plant. during flood season there is chance of backflow of sewers due to overflowing of natural water course.



(iv) Zonal pattern:→

This pattern is suitable for areas of diffrent elevations. The entire area is divided into zones of diffrent elevations and Separate interceptors are provided to collect from each zone.



Comparison b/w Conservancy and water carriage system:-

S.N.	C. S.	W. C. S.
1	Due to putrefication, there is a lot of foul smell.	No chances of putrefication, and hence no foul smell.
2.	large labour force is req.	small labour force is req.
3.	water consumption is small	Req. high water consumption
4.	Acute pollution problems	pollution pro. are rare.
5.	Risk of spread disease	No such risk.
6.	The system is unhygienic	The system is hygienic.
7.	No technical person req.	tech. persons req. for operation and maintanance.
8	Good quality manure available from	The sludge has small manure value. However, treated waste water can be used for irrigation a-
9	The system is more suitable for rural conditions	The system is better suited for urban conditions.

Testing of Sewer lines:→

Sewers are generally subjected to the following tests before they put into service.

(1) Test for straightness of alignment and obstruction:→

It is tested by two methods:→

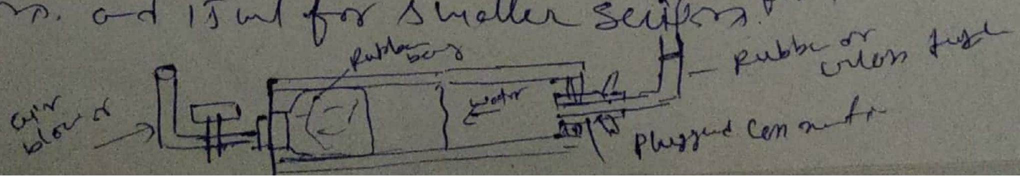
(a) At the high end of the sewer a smooth that ball of dia. 13 mm. less that inserted into pipe. If there is no obstruction, the ball will roll down the invert of the pipe and emerge at the lower end.

(b) A mirror is placed at one end of the sewer line and lamp at the other end. If the pipe line is straight, the full circle of light will be observed.

(2) Water test:→

It is carried out to find out the water tightness of the joints. This is carried out after giving sufficient time for the joints to set. In case of concrete and stoneware pipes with with cement mortar joints, pipes should be tested three days after the cement mortar joints have been made.

The test is carried out by plugging the sewer opening in the lower manhole. plugging is done by a rubber bag equipped with a canvas cover. The rubber bag is connected to an air blower. The bag is tightly fit into the pipe. The other end of the sewer is plugged with a connection to a hose, ending in a funnel. The sewer is filled with water through the funnel. water level in the funnel is allowed to rise to 2 metres above the invert of the upper end of sewer. The quantity of water loss is noted after 30 min. The water loss should not exceed 30 ml for large size sewers. and 15 ml for smaller sewers.



Smoke test:→

It is carried out for drainage pipes located in buildgs. The smoke is produced by burning oil waste tar paper etc. In the combustion chamber of a smoke machine. The pipes are approved gas-tight by the smoke test conducted under pressure of 25 mm of water, maintained for 15 min. after all trap. If the sewer have any leakage than the smoke seen from the leakage.

Appurtenances:→

The different devices required for the efficient working of Sewage System are called appurtenances.

classifications of appurtenances:→

These are classified as under:-

(i) Manholes (ii) Drop manholes

(iii) lamp holes (iv) clean outs

(v) ~~street~~ inlets (vi) flushing tanks

(vii) Grease and oil traps.

viii) Inverted syphon.

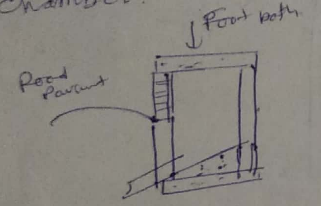
* Manholes:→

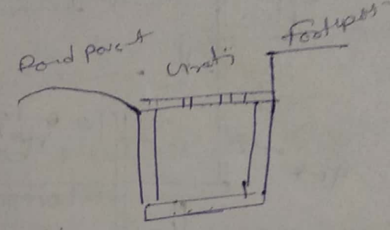
The opening constructed on the alignment of a Sewer line for the purpose of permitting a man to enter for inspection and cleaning of Sewer is called a man hole.

(ST)REET INLET :->

The street inlets are the opening provided by the side of roads to allow the storm water to enter the sewer without accumulating on the road pavement. The spacing of inlets should be 20 m and should be provided on both sides of the road.

This inlets may be vertical or horizontal. A box like compartment is constructed with brick masonry. In vertical type, a grating is provided on the road curb just at the edge of footpath. In horizontal types, a perforated cover is placed on the top of the chamber.

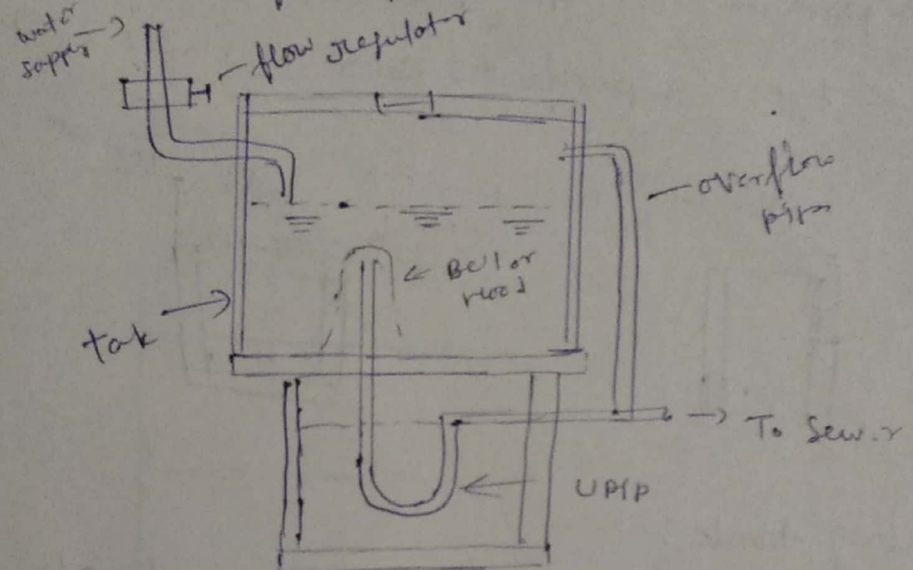




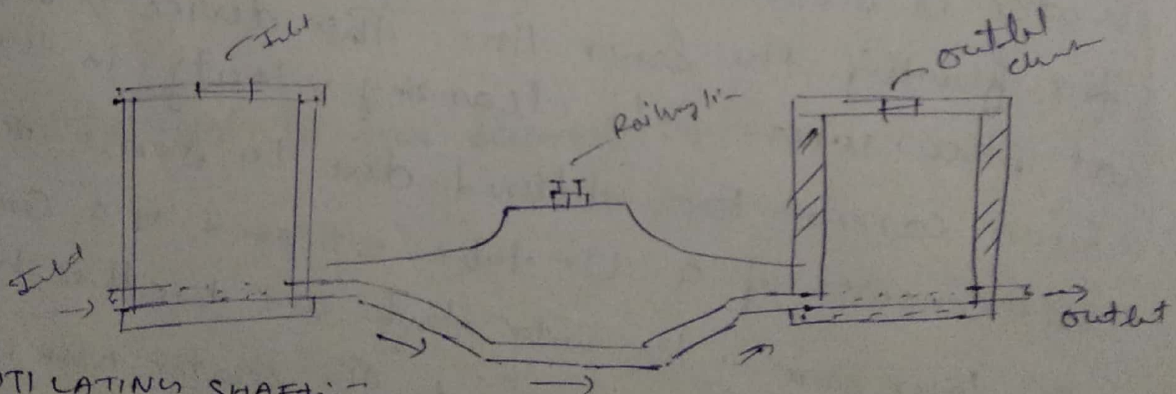
Flushing tank :->

The flushing tank is a device by which the water is released automatically at some interval for flushing the sewer line. This device is required at places where self cleansing velocity in the sewer cannot be obtained due to some reason.

It consists of a U-tube encased in a compartment. The longer arm in the water tank and bell or hood is placed over the free end. The shorter arm is connected to the sewer line through a straight pipe. The water is supplied to the tank through a flow regulator. When the water level in the tank increases, the water level in the bell also increases. Ultimately a stage comes when the siphonic action starts and the water rushes through the sewer clearing all the sediments. the water supply is so regulated that the siphonic action starts at some interval. The siphonic action stops when the water level comes below the bell mouth after discharging water level in the U tube. The capacity of the tank should be quite adequate for flushing the sewer line.

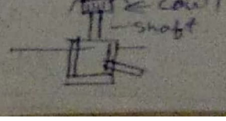


Inverted siphon:→



VENTILATING SHAFT:-

It is provided for the ventilation of sewer. Various gases are produced in sewer due to the decomposition of organic matter. Some gases may be harmful to workers. Some gases may be corrosive and any may cause corrosion to sewer pipes. So, by constructing ventilating shaft in sewer line, these gases are removed. The shaft may be provided at an interval of 100m. The shaft may be made of C.I pipes of dia. 15 cm. A cowl is provided on the top. The base of the shaft is wide and secured in concrete foundation. The shaft is directly connected to sewer.



General terms in waste water engineering:->

Sanitary engineering:-> The branch of engineering which deals with the removal and disposal of the sewage (liquid waste) without causing any nuisance to the community is called sanitary engineering.

Importance of Sanitary engineering:->
(i) General developments of the city
(ii) Protecting water supplies from pollution.
(iii) collecting and disposing off the waste of the city.
(iv) maintaining good environments for public.
(v) Preventing the occurence of disease e.g. malaria, typhoid etc.

WASTE:->
Any thing which is not completely utilized and finally wasted in one or the other form is called waste.
The waste may be in any of the following states
(i) Dry (ii) Semiliquid (iii) liquid.

Dry :-> The waste which does not contain moisture is called dry-waste e.g. rubbish like paper, leaves, broken furniture, waste building material.
Ashes like combustion of coal, Coke, timber.
Garbage like veg.s, peelings of fruits, waste meat etc.
Dry waste never mixed with sewage. It carried away from road sides by carts, trucks to safe places to outside the city.

Semi liquid:-> The Semiliquid waste is that waste which contains organic matter.

liquid waste:-> It mainly consists of water and very less organic matter. It is a discharge from the kitchens, bath rooms, wash basins, w.c the liquid wastes from kitchens, bathrooms and wash-basins is called sullage. It does not include discharge from hospitals, or slaughter-houses. It is only waste water and not very foul-smelling.

Sewage:→ It is liquid waste consisting of sullage discharge from w.c., urinal, and hospitals. It creates foul-smelling gases and so it is conveyed in covered sewers.

Types of sewage:→

(i) Sanitary Sewage (ii) Storm sewage

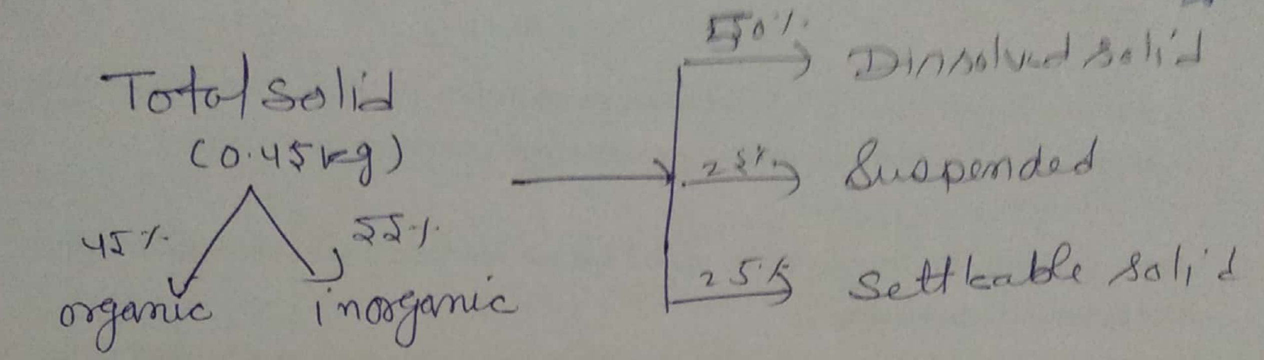
(i) Sanitary Sewage:→ It is divided into two classes

ⓐ domestic sewage:→
It is liquid waste from kitchens and bathrooms and is commonly known as sullage. This is from residential areas, offices, and institutions

ⓑ Industrial waste:→
It is waste from industries and manufacturing processes.

(ii) Storm Sewage:→ It is any surface water including rain water of the city, which may be admitted into underground conduits.

- about 80% of the water supplied in the community enters into the sewer
- Sewage is more than 99.9% water and less than 0.1% Solid such that if thousand kg of sewage sample is Considered it consist of 0.45 kg of Solids.



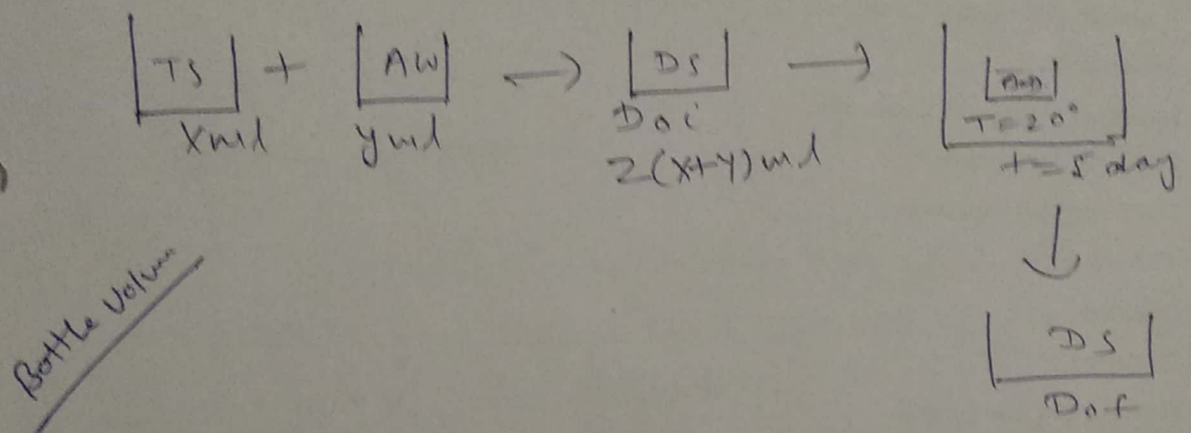
Total Solid present in the Sewage are determine by evaporating a measured volume of sewage at 100°c and weighing the residue

Settleable Solids are Suspended solids which will Settle within one hour to the bottom of the cylinder of Specified height. It is determine by using an imhoff Cone. It is conical glass of one litre volume and. The Cone is filled with the sewage and is allowed to Settle ~~at the bottom~~ for one hour. After one hour the volume of Solid settled at the bottom is directly measured. This gives the volume of settleable solids in the sewage.

Bio-chemical oxygen Demand (BOD)

- Bio-chemical oxygen required to carryout
- The amount of O_2 required to carryout the decomposition of ~~the~~ bio-degradable organic matter preset in the system is termed as bio-chemical oxygen demand.
- BOD during 5 days at 20°c is taken as standard BOD and it is approximately 68% of ultimate BOD.

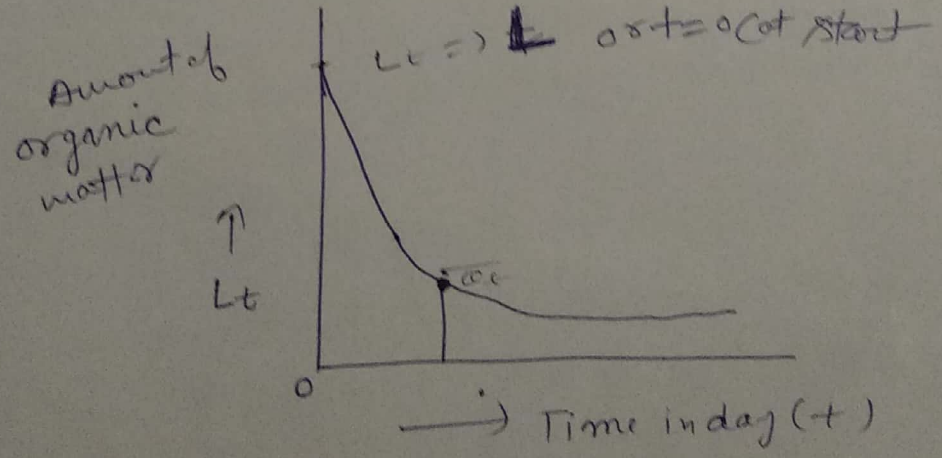
BOD is determined by diluting the known volume of the sample with aerated water sample and noting the dissolved oxygen of diluting sample before and after incubation for 5 days at 20°C. normally 300 ml size bottles are used for incubation and all the source of light must be excluded from the incubator in order to avoid photosynthesis during which oxygen is released which results in lower value of BOD than actual.



$BOD_5/20°C \Rightarrow (D_{oi} - D_{of}) \times$ Dilution factor

$D_f \Rightarrow \frac{\text{final vol of DS}}{\text{total vol of TS}} = \frac{Z}{X}$

mathematical expression of BOD

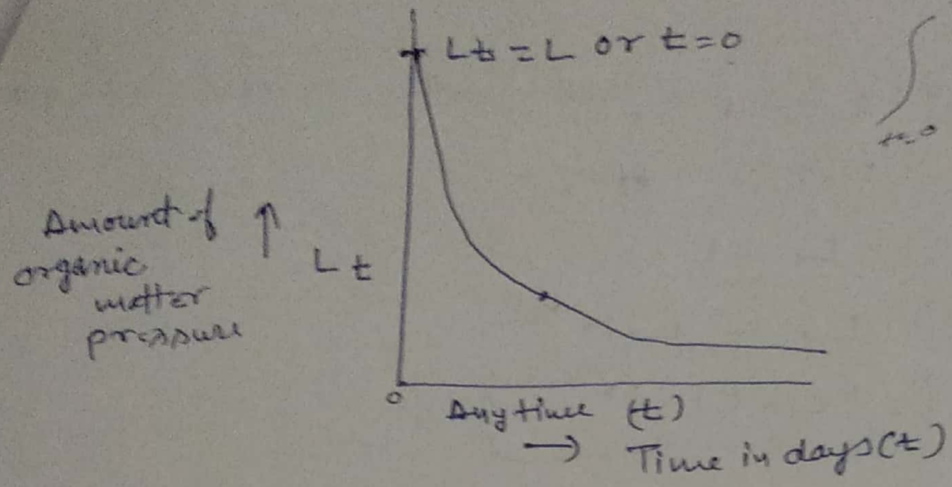


Rate of Deoxygenation :-

At a certain temp., the rate of deoxygenation is assumed to be directly proportional to the amount of organic matter present in decaying

mathematically $\frac{dL}{dt} \propto -L$ slope $= \frac{dy}{dx}$

(Mathe)matical expression of BOD :→



t = 0   t = t

Rate of deoxygenation :→

At a certain temp, the rate of deoxygenation is assumed to be directly proportioned to the amount of organic matter present in sewage.

$$\frac{dL_t}{dt} = -K \cdot L_t \quad \left[\frac{dL_t}{dt} \propto L_t \right] \quad —(1)$$

where L_t = oxygen equivalent of org. matter present at any time 't' in mg/L

K = Rate constant

Integrating eq^n (1)

$$\int_{L_t = L_0}^{L_t = t} \frac{dL_t}{L_t} = -\int_{t=0}^{t=t} K \cdot dt$$

$$\left| \log L_t \right|_{L_0}^{L_t} = -K \cdot t$$

$$\log \frac{L_t}{L_0} = -kt$$

$$2.303 \log \frac{L_t}{L_0} = -kt$$

$$\log_{10} \frac{L_t}{L_0} = \left(\frac{-K}{2.303}\right) t \qquad \frac{K}{2.303} = K_D$$

$$L_t = L_0 \, e^{-Kt}$$

$$L_t = L_0 \, 10^{-K_D t}$$

$\log_e = \ln$

$\log 10^{-K \cdot t}$

∴ quality of organic matter oxidised $L_0 - L_t$ 1

Y_t = total amount of organic matter oxidised in t

⇒ BOD in t days

$Y_t = L_0 - L_t$

$\Rightarrow L_0 - L_0 10^{-k_D t}$

$= L_0 (1 - 10^{-k_D t})$

A domestic sewage having 5-day B.O.D. of 200 mg/l at 20°c calculate the B.O.D. of 1 and 5 days at 12°c. Assume the value of K_D as 0.18 perday at 20°c

(5.11)

$K_D = K_{D(20)} (1.047)^{T-20}$

$\Rightarrow 0.18 (1.047)^{12-20}$

$K_{D(12)} \Rightarrow 0.125$ perday

$Y_t = L_0 (1 - 10^{-K_D t})$

$200 \Rightarrow L_0 (1 - 10^{-.18 \times 5})$

$\Rightarrow L_0 (1 - 10^{-0.9})$

$L = \frac{200}{(1 - 10^{-0.9})} \Rightarrow 230$ mg/l

for 1 day B.O.D. at 12°c

$Y_1 = 230 (1 - 10^{-0.125 \times 1})$

$= 57.50$ mg/l

5 day B.O.D. at 12°c

$Y_5 = 230 (1 - 10^{-0.125 \times 5})$

$= 174.80, 175$ mg/l.

The analysis of an industrial waste indicated its ultimate B.O.D. as 600 mg/l with value of K as 0.15 perday at 20°c. Calculate its 5-days B.O.D. What would be its 5-days B.O.D. If the value of K dropped to 0.10 perday

$K_D = 0.15$ perday

$L = 600$ mg/l

$Y_t = L (1 - 10^{-K_D t})$

$Y_t \Rightarrow 600 (1 - 10^{-0.15 \times 5})$

$Y_5 = 492$ mg/l

value of K_D is dropped to 0.10 perday

$Y_5 = 600 (1 - 10^{-0.10 \times 5})$

$= 408$ mg/l.

5

Q.2:→ If 5 days 20°C BOD of a Sewage Sample is 150 mg/l. What will be its 8 days 15°C BOD. Assume deoxygenation constant at 20°C as 0.23 (base)

Sol. Given BOD_5 ⇒ 150 mg/l. (at 20°C) k = 0.23 base e at 20°C

$$Y_t(20°C) = L(1-(10)^{-k_D \cdot t})$$

$$150 = L(1-10^{-0.1\times5})$$

$$150 \Rightarrow L(1-(10)^{-0.1\times5})$$

$$= L\left[1-\frac{1}{10^{0.5}}\right], \quad = \frac{150}{0.684} \Rightarrow 219.37 \text{ mg/l}$$

$$k_{t(15°)} = k_{1(20°)}[1.047]^{T-20}$$

$$= 0.1[1.047]^{15-20} = 0.0795$$

$\frac{.23}{2.303}$

$$Y_{t\,5°} = 219.37[1-(10)^{-0.0795\times8}]$$

$$= 219.37\left[1-\frac{1}{10^{0.64}}\right] = 168.63 \text{ mg/l}.$$

Q.③ The BOD of a Sewage Sample incubated for 5 days at 30°C is 105 mg/l. Calculate Bod at 20°C

Q.1 for waste water Sample, 5-day BOD at 20°C is 375 mg/l ~~and it is 6~~ what will be the ~~7~~-day BOD at 35°C.

Q.2 Calculate 8 days 37°C BOD of a Sewage Sample whose 5 days 20°C BOD is 150 mg/l

Chemical oxygen demand (COD):→

The BOD test takes a min. of 5 days time, and due to this, it is not useful in the control of treatment processes. An alternative test is the COD test, which can be used to measure content of organic matter of both wastewater as natural. COD. can be determine only in 3 hours. In this test, a strong chemical oxidising agent used in an acidic medium to measure oxygen equivalent to organic matter that can be oxidised. chemical oxidising agent is $K_2Cr_2O_7$.

In general, It can be stated that the C.O.D. of sewage is higher than its B.O.D. bcz of the fact that more compounds can be chemically oxidised than can be biologically oxidised.

The COD test can be carried out to measure organic matter present in industrial wastes having toxic compounds likely to interfere with the biological life.

Advantages of the C.O.D. test over the B.O.D. test:→

(i) When toxic matters are present and conditions are not favourable for the the growth of microbes, B.O.D. cannot be determined accurately.

(ii) The C.O.D. test gives speedy result as it takes about 3hours as against 5days for the B.O.D test.

(iii) The. C.O.D. test determines the strength of certain wastes which cannot be determined by B.O.D. test.

(iv) The C.O.D. test is very easy as compared with the B.O.D. test.

Primary Treatment of Sewage

8.1 INTRODUCTION

The sewage contains various suspended, floating and oily substances. By primary treatments these substances are removed from the sewage so that the working of the sedimentary treatment units may be easy and there is no disturbances in the operation of those units. The units of the primary treatments are as follows:

(a) Screens
(b) Grit chamber
(c) Detritus tank
(d) Skimming tank
(e) Primary sedimentation tank.

8.2 FLOW DIAGRAM OF PRIMARY TREATMENT

The units in Fig. 8.1. are arranged according to the sequence of primary treatment.

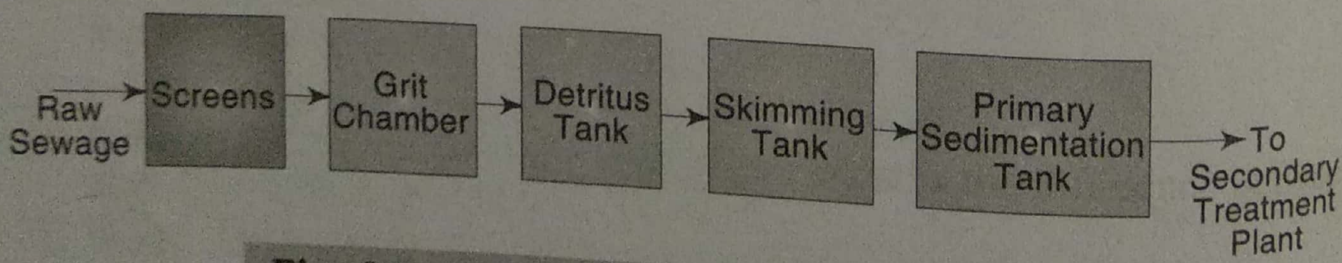


Fig. 8.1 *Flow diagram of primary treatment*

Functions of Units

1. Screens To eliminate large floating matters.

2. Grit Chamber To eliminate large size organic and inorganic matters.

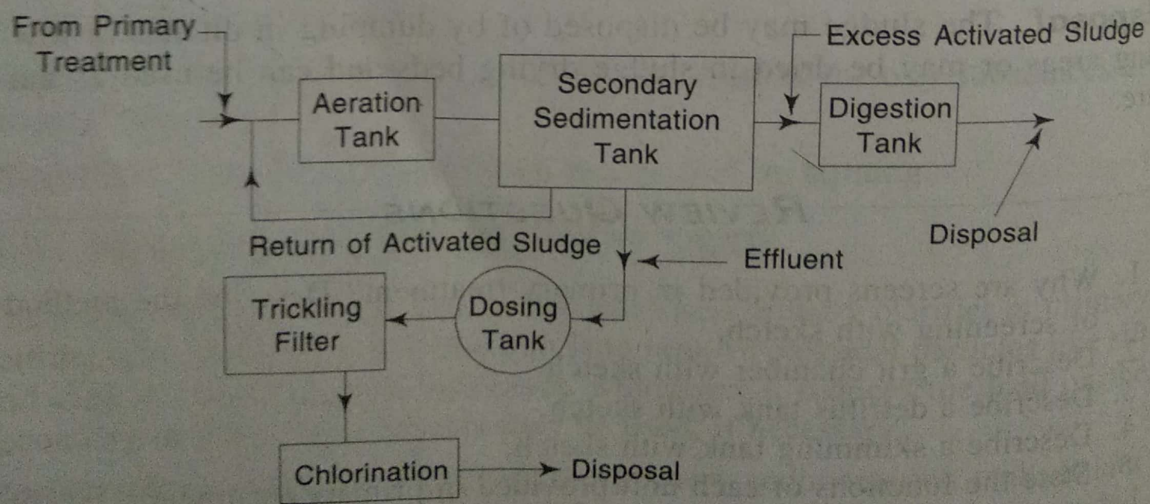
Secondary Treatment of Sewage

9.1 INTRODUCTION

In the primary treatment, the larger solids in sewage are removed. But the effluent still contains organic matters, bacteria, colloidal matters, etc. Such effluent cannot be discharged into the natural water coarse. So secondary treatments are given to the effluent of primary treatment to make it safe in all respects and suitable for discharging into the river. The most important units in this stage are: (a) Activated sludge process and (b) Filtration of sewage.

There are some other units which are allied with these main treatments. The sequence of the secondary treatment is shown in the next section.

9.2 FLOW DIAGRAM OF SECONDARY TREATMENT



culated to the aeration tank by pumping.

Disposal of Excess Sludge The excess sludge is taken to the sludge digestion tank for digestion and final disposal.

9.5 ACTIVATED SLUDGE PROCESS

Definition

The sludge which is made powerful by the process of aeration is known as activated sludge. It contains high content of oxygen and high number of aerobic bacteria. It possesses unusual property to oxidise the organic matters.

Action

The following are the actions of activated sludge:

(i) The activated sludge when mixed with sewage, the microorganisms multiply rapidly.

(ii) The activated sludge oxidises the organic substances rapidly.

(iii) It converts the colloidal matters to settleable size rapidly.

Operational Features

Figure 9.8 shows the various stages of activated sludge process. The activated sludge process consists of the following operations:

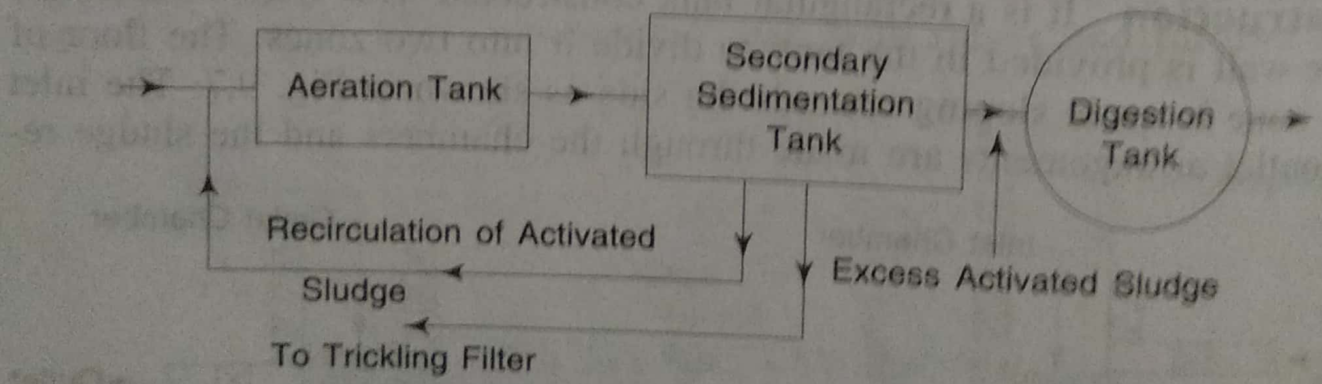


Fig. 9.8 *Activated sludge process*

1. Mixing of Activated Sludge Some portion of the activated sludge settled at the bottom of the secondary settling tank is recirculated and mixed with the effluent of primary settling tank just before its entry to the aeration tank.

ing the complex organic matter by

Elements of Trickling Filter

The following are the elements of trickling filter:

(a) Construction of Filter Figure 9.10 shows a trickling filter. Generally, the trickling filter is circular in shape. It consists of four numbers of rotary distributing arms which have perforations at the bottom. The arms are fitted with a central support which is rotated by a suitable device. The floor of the filter is made of concrete and its slope is made towards the periphery.

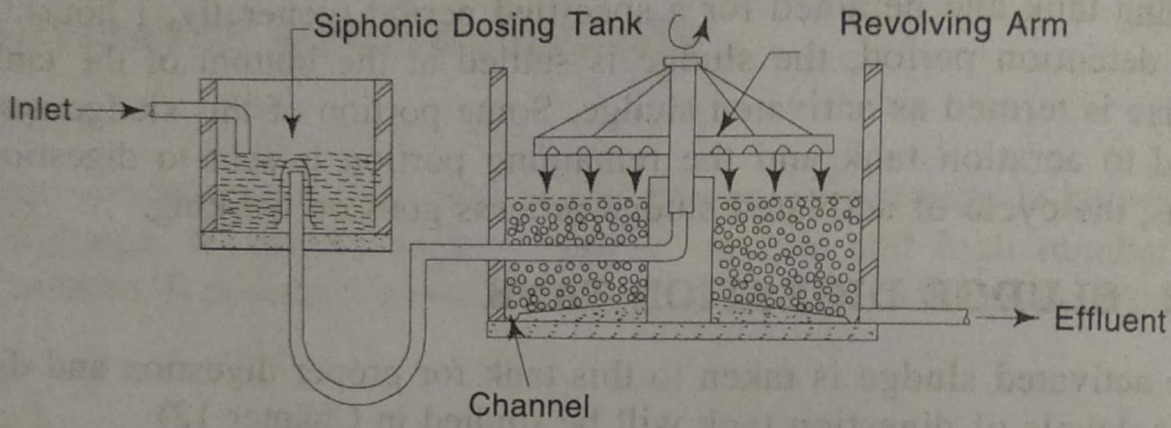


Fig. 9.10 *Trickling filter*

(b) Dosing of Filter A siphonic dosing tank is provided with the trickling filter for intermittent supply of effluent over the filtering media.

(c) Filter Media The filter media consists of broken stones, clinkers, etc. with their size varying from 20 – 50 mm. The larger size stones are placed at the bottom layer and the smaller size stones are arranged towards the top. The stones or clinkers should be of good quality.

(d) Underdrainage System The underdrainage system consists of a channel along the periphery of the filter. The channel again is connected to the outlet pipe.

(e) Ventilation The ventilation of filter is necessary for the smooth working of the filter. The ventilation is achieved by providing vent pipes at the periphery. (not shown in fig.)

(f) Working The effluent is spread over the filtering media of broken stones by rotary arms. The effluent trickles down the media and gets collected in the channel. The channel carries the effluent to the outlet pipe through which the effluent is taken for chlorination.

(g) Cleaning After working for long period, the upper surface of the media may be clogged by sediments. The rate of filtration may be decreased or stopped due to this. At that time, the upper layer of stones are scrapped off and fresh layer of stones of same size are replaced properly.

10.2 CESSPOOL

The cesspool is an isolated method of sewage treatment for individual house, housing estates, etc. It is not suitable for large scale treatment.

Construction It is a rectangular or circular structure constructed with brick work below the ground level. The brick wall is constructed with cement mortar and inner surface is plastered. Sometimes, several holes are provided on the wall in zigzag manner. The depth varies from 3–4 m and it should not go below the water table. An R.C.C. cover is placed over the top of cesspool. The volume of cesspool depends on the number of users. Generally, the capacity varies from 2000 to 5000 lits. The inlet pipes are connected to it with 'T' pipe, as shown in Fig. 10.2. A vent pipe is provided with it for the removal of foul gases. It should be located far away from the locality. The latrines are connected by underground pipe line. (Fig. 10.2)

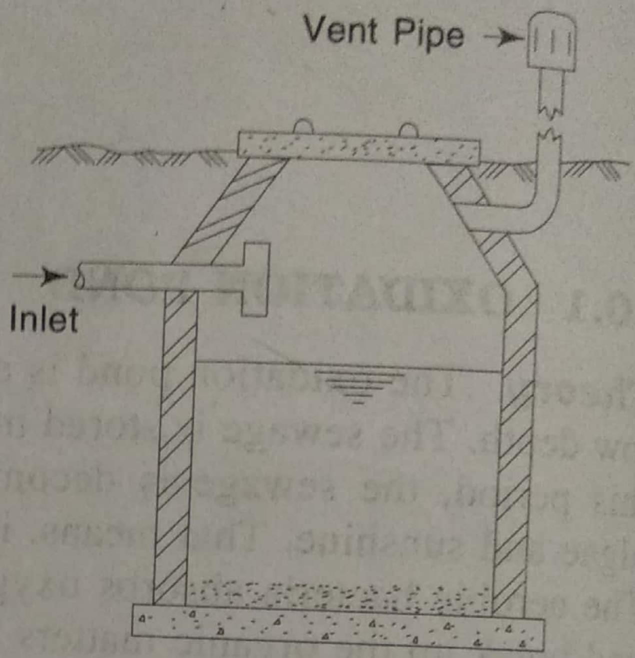


Fig. 10.2 *Cesspool*

Function and Cleaning In cesspool, the decomposition of sewage is achieved by anaerobic bacteria. After decomposition, the sludge is deposited at the bottom and effluent is collected at the top. When the cesspool is filled up, it is removed by pumping and collected in tanker, and disposed of in low-lying barren lands far away from the locality.

10.3 SEPTIC TANK

Theory The theory of septic tank is based on the principle of sedimentation of sewage and digestion of sludge. In this tank, the sewage is detained for some period. During this detention period, the sewage is decomposed by anaerobic bacteria and the sludge is deposited at the bottom (as sedimentation tank). The digestion of sludge is carried out by the anaerobic bacteria (as digestion tank). The effluent is clear and it is discharged into the soak pit constructed at a suitable place.

Use The septic tank is suitable for the towns where it is not possible to establish the water carriage system. It is provided in residential buildings, hostels, hotels, hospitals, schools, colleges, etc.

Constructional Features Figure 10.3 shows a septic tank. The following are the constructional features of septic tank:

(i) It is a rectangular tank constructed with brick masonry over concrete foundation. The length is usually 3 times the breadth.

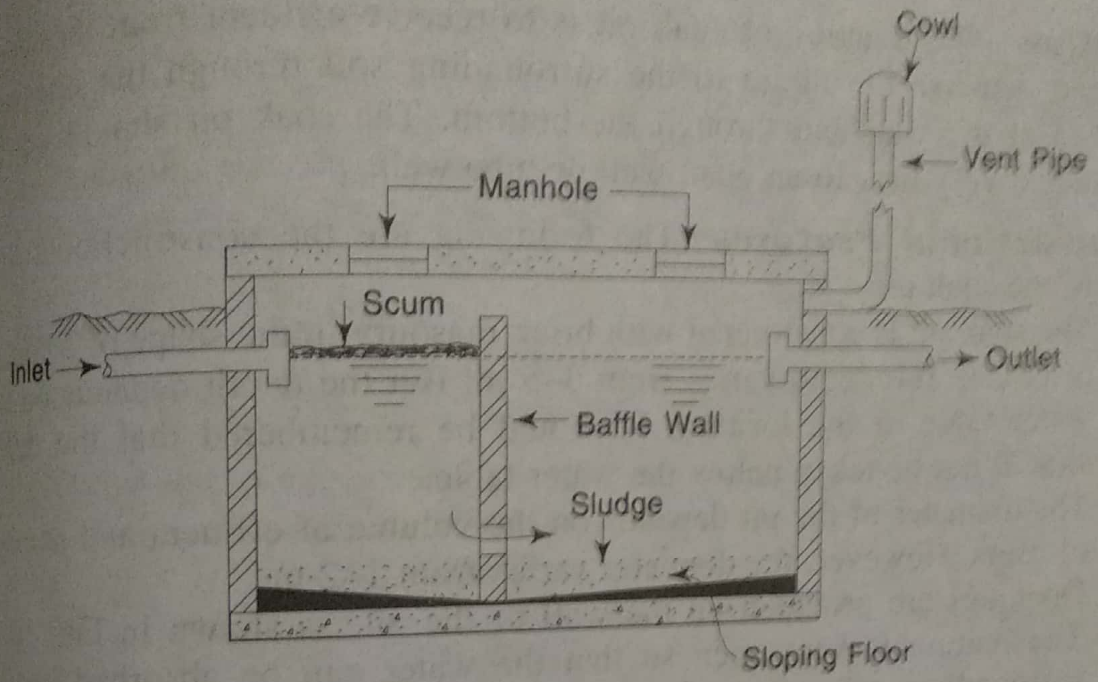


Fig. 10.3 *Septic tank*

(ii) The liquid depth varies from 100–180 cm.

(iii) A free board of 30–50 cm is provided above the liquid level.

(iv) The inlet pipe and outlet pipe consist of 'T' or 'elbow' which are submerged to a depth of about 25 cm below the liquid level.

(v) The outlet level is about 15 cm lower than the inlet level.

(vi) The inside surface of the tank should be plastered and finished with neat cement polish to make it complete watertight.

(vii) For smaller tank single baffle wall should be provided. But for larger tank two baffles should be provided near both the ends.

(viii) The top of the baffle should be at least 15 cm above the liquid level.

(ix) Openings should be provided near the bottom of the baffle for the flow of effluent from first chamber to second chamber. Sometimes, hanging baffles may be provided.

(x) R.C.C. slab with manholes is provided at the top of the tank.

(xi) Ventilation pipe is provided for the removal of foul gases.

Working of Septic Tank The fresh sewage from the latrines enters the first chamber directly where the scum start floating at the beginning. Within few days, the anaerobic bacteria decompose the scum and sludge is formed which is settled down at the bottom of the tank, and it is digested further by those bacteria. The effluent from the first chamber flows to the second

the soak pit. During the decomp... which are released through...
and hydrogen sulphide are formed which are released through the ...

Due to the deposition of sludge, the capacity of the tank goes on reducing gradually. So, the tank should be cleared every year, or at some reasonable period.

10.4 SOAK PIT OR SOAK WELL

Function The function of soak pit is to receive effluent from the septic tank and disperse the liquid to the surrounding soil through the openings provided at the wall and through the bottom. The soak pit should not be constructed very near to an open well or tube well.

Constructional Features The following are the constructional features of the soak pit:

(i) The soak pit is constructed with brick masonry in the shape of a square or circle. The depth varies from 3–5 m. But the depth depends on the water table of the locality. It should be remembered that the depth should not be taken below the water table.

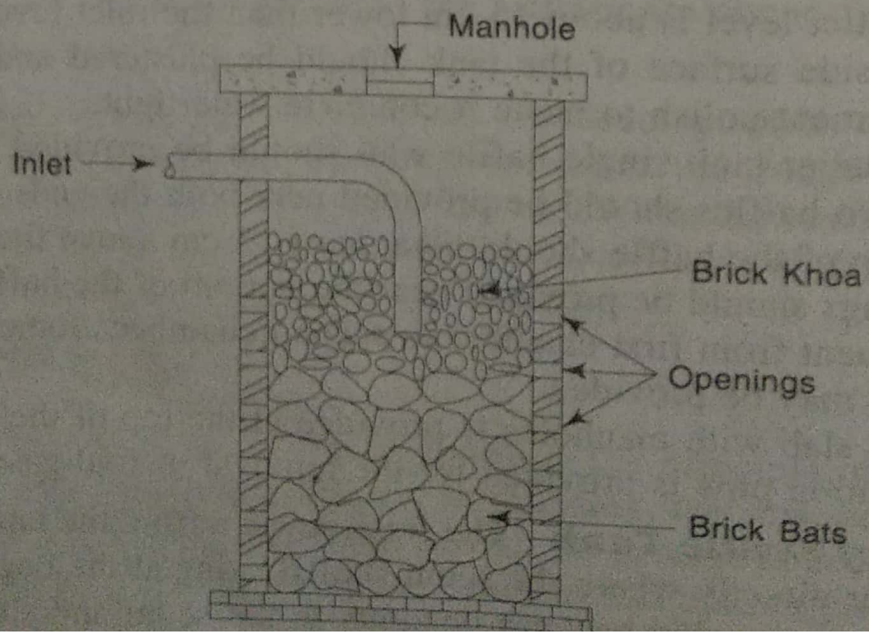
(ii) The diameter of the pit depends on the volume of effluent and number of users. However, the diameter varies from 1–2 m.

(iii) Openings are provided on the wall of the pit, as shown in Fig. 10.4. The bottom is kept open so that the water can be absorbed by the surrounding soil.

(iv) The pit may be hollow or filled up with brick bats and brick khoa.

(v) Sometimes, a packing of coarse sand (15 cm thick) is provided around the pit to increase the percolating capacity of the soil.

(vi) If the soaking capacity of the pit is destroyed, it should be cleaned and filling materials may be replaced. (Fig. 10.4).



...trap is a depressed or bent fitting which, when provided in a drainage system, always remains full of water, thus maintaining a *water seal*. It prevents the passage of foul air or gas through it, though it allows the sewage or waste water to flow through it. The depth of water seal is the vertical distance between the crown and dip of a trap (Fig. 20.1). The depth of water seal represents its *strength* or effectiveness. Greater the depth of water seal, more effective is the trap. The depth of water seal varies from 25 mm to 75 mm.

Causes of breaking of seal . Water seal may break due to the following reasons :

(*i*) faulty joints
(*ii*) crack in the bottom of seal
(*iii*) creation of partial vacuum in the sewer fittings
(*iv*) increase in the pressure of sewer gases, and
(*v*) non-use for a prolonged period.

The breaking of the water seal can be prevented by (*i*) connecting the portion between the soil pipe and trap by a vent pipe, and (*ii*) use of anti-siphonage pipe in the building.

Characteristics of traps. A trap should possess the following characteristics :

1. It should possess adequate water seal at all times, to fulfill the purpose of its installation. However, it should retain minimum quantity of water for this purpose.
2. It should be of non-absorbent material.
3. It should be free from any inside projections, angles or contractions, so that flow is not obstructed or retarded.
4. It should be simple in construction, cheap and readily available.
5. It should be self cleansing.
6. It should be provided with suitable access for cleaning.
7. Its internal and external surfaces should have smooth finish so that dirt etc. does not stick to it.

20.4. CLASSIFICATION OF TRAPS

Traps are classified as follows :

(*a*) *Classification according to shape* (Fig. 20.1)

(*i*) *P-Trap* (Fig. 20.1 *a*). This resembles the shape of letter *P*, in which the legs are at right angles to each other.

(*ii*) *Q-trap* or *half-S-trap* (Fig. 20.1 *b*). This resembles the shape of letter *Q*, in which the two legs meet at an angle other than a right angle.

(*iii*) *S-trap* (Fig. 21.6 *c*). This resembles letter-*S*, in which both the legs are parallel to each other, discharging in the same direction. Fig. 20.1 (*d*) shows the development of all the three types of traps.

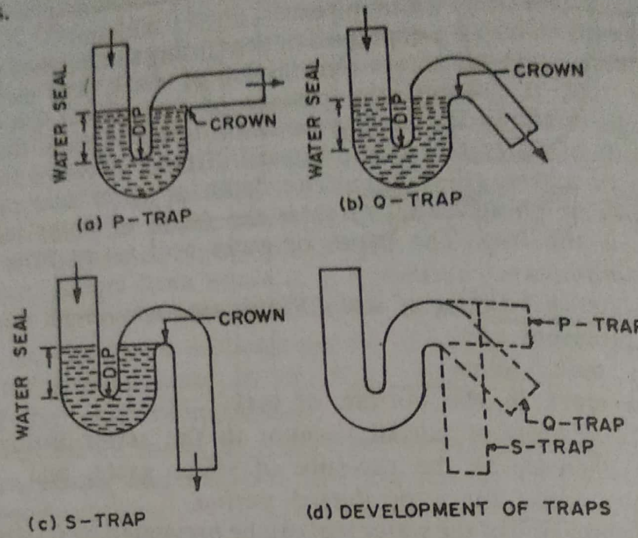


FIG. 20.1. TRAPS ACCORDING TO SHAPES.

(*b*) ***Classification according to use:***

(*i*) Floor trap or nahni trap

(*ii*) Gully trap

(*iii*) Intercepting trap.

20.5. FLOOR TRAP OR NAHNI TRAP

A floor trap, commonly known as a *nahni trap* is used to collect wash water from floors, kitchens and bath rooms. It forms the starting point of waste water floor. It is made of cast iron, with a gravity at top, to exclude entry of solid matter of big size. This cover can be removed to do frequent cleaning of the trap. These traps have small water seal.

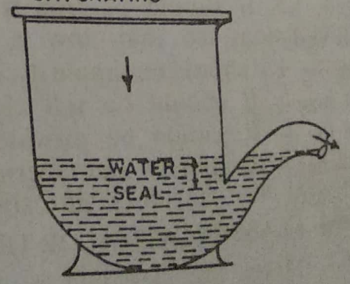


FIG. 20.2. FLOOR TRAP.

20.6. GULLY TRAP

These are special types of traps which disconnect sullage drain (collected from baths, kitchen etc.) from the main drainage system. It is either made of stone-ware or of cast iron. Stone ware gully trap is of square section at the top on which C.I. grating is fitted.

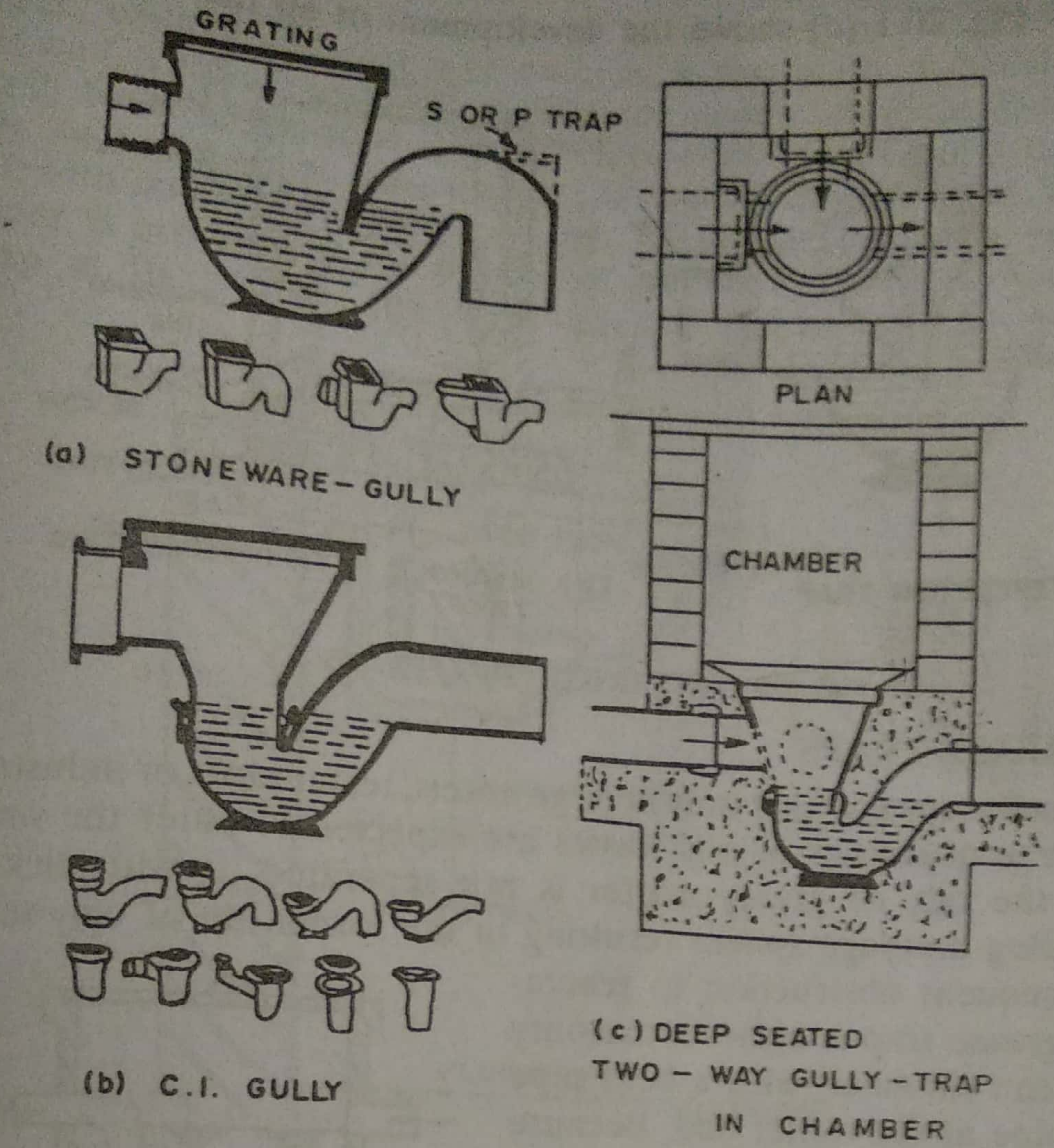


FIG. 20.3. VARIOUS FORMS OF GULLY TRAPS.

Fig. 20.3 (*a*) shows such a gully along with its variations. A C.I. gully is circular in section, as shown in Fig. 20.3 (*b*), along with its variations. It can also be fitted in a masonry chamber as shown in Fig. 20.3 (*c*). A water seal of 60 to 70 mm is usually provided. It may have either a *S*-trap and *P*-trap. A gully trap, is provided at the external face of a wall. It thus receives wastewater from baths, kitchens etc. and pass it on to the house drain carrying excremental discharge from water closets etc. A well designed gully trap may serve two or three connections from nahni traps.

20.7. INTERCEPTING TRAPS

This is a special type of trap provided at the junction of house drain with the public sewer or septic tank. It is thus provided in the last manhole of the house drainage system. It has a deep water seal of 100 mm, so as to effectively prevent the entry of sewer gases from public sewer line into the house drain.

The trap has an opening at the top, called the *cleaning eye* or *rodding arm*, having a tight fitting plug, for frequent cleaning of the trap.

the trap... connected to the...

4. **Two pipe system** (Fig...) ... (W.P.) are provided. The discharge soil pipe (S.P.) and waste pipe (W.P.) are provided. The discharge from W.C. is connected to the soil pipe (S.P.) while the discharge from baths, sinks, lavatory basin etc. are connected to the waste pipe (W.P.). All the traps are competely ventilated by providing separate ventilating pipes. Thus, four pipes are required. The discharge from waste pipe is disconnected from the drain by means of a gully trap.

Anti-siphonage pipe

It is a pipe provided to preserve the water seal of traps. It maintains proper ventilation and does not allow the water seal to get broken due to siphonic action. In the case of a multi- storeyed building, the sudden flush of water in the upper storey results in the sucking of air from the short branch of the pipe connecting the W.C. to the soil pipe of lower storey. This sucking of air causes partial vacuum on the downstream side of the water seal of the lower W.C. The pressure at the upstream side of the water seal is more (atmospheric), which forces the water up the trap and siphons it out in the branch. This results in breaking of the water seal. This can be avoided by connecting the crown of the trap to the atmosphere through an anti-siphonage pipe (Fig. 20.12). A ventilating pipe can therefore be used as an anti-siphonage pipe.

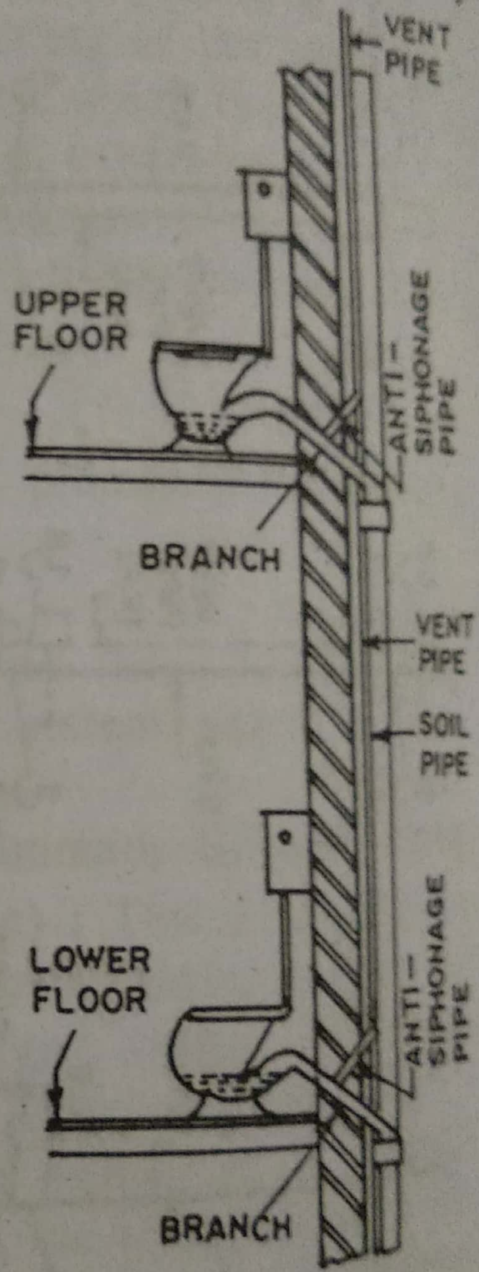


FIG. 20.12.
ANTI-SIPHONAGE PIPE.

20.11. HOUSE DRAINAGE PLANS

For efficient drainage, it is always better to prepare house drainage plan. In some cities, it is statuatory to submit such plans. Fig. 20.13 shows a typical plan for drainage of a small house.

The site plan is drawn to a suitable scale, showing onto it

(iii) Limited types of crops can be grown.
(iv) Public may dislike the crops grown by this method.

11.4 SELF PURIFICATION THEORY

If the sewage is discharged into natural water course, then the organic compounds are oxidised by the dissolved oxygen in water and the water gets purified. Thus, a deficiency of dissolved oxygen is created in flowing water. But, that deficiency is immediately replenished by the atmospheric oxygen. This phenomenon of deoxygenation (i.e. loss of oxygen) and reoxygenation (i.e.) gain of oxygen)for maintaining the purification process is known as self-purification property of natural water.

The process of self-purification occurs in the following ways:

(i) When sewage is discharged into natural water course, the water gets polluted in the beginning.
(ii) After some time, the organic matters are decomposed by aerobic bacteria present in sewage. The dissolved oxygen is consumed by bacteria and a deficiency in oxygen is created.
(iii) The deficiency is immediately replenished by atmospheric oxygen.
(iv) Algae and other organisms consume the mineral foods and supply oxygen to the water to maintain the aerobic condition.
(v) The protozoa eat bacteria for survival.
(vi) Again, fish and other aquatic life eat the protozoa.
(vii) Thus, the natural water becomes free from bacteria and protozoa.
(viii) In this way, the decomposition of organic matters and the process of purification go on in natural water.

Graphical Representation

At the beginning, the oxygen demand of sewage is satisfied by dissolved oxygen in water which is represented by deoxygenation curve in Fig. 11.6. Immediately, the deficit of oxygen is filled up by aeration(i.e. by atmospheric oxygen) which is represented by reoxygenation curve. Finally, the rate of deoxygenation becomes equal to that of reoxygenation.

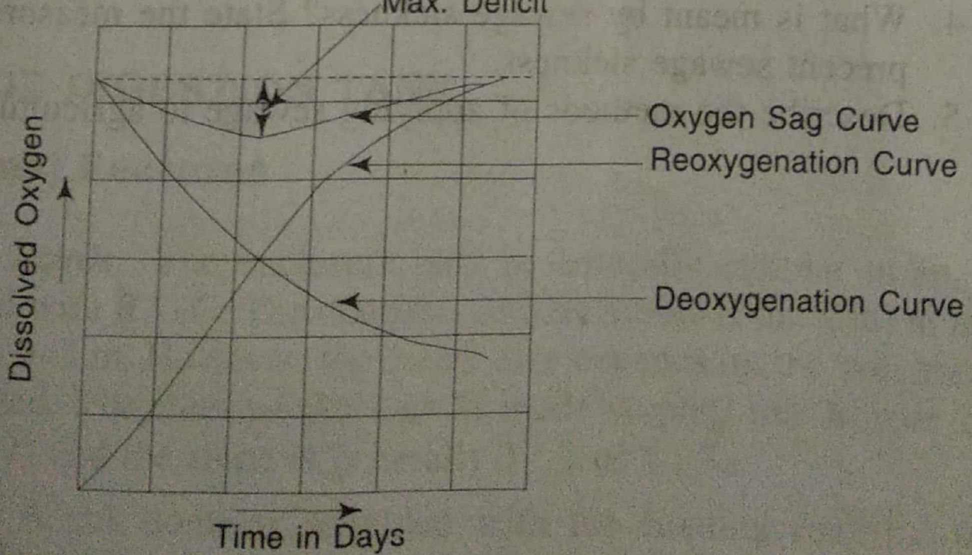


Fig. 11.6 *Self purification process*

By combining both the curves the oxygen sag curve is obtained. When the rates of both the curves are equal, the critical point of maximum deficit is obtained which is indicated by *p*.

11.5 SEWAGE SICKNESS

In sewage farming, when sewage is applied continuously on the agricultural land, the voids of soil go on clogging gradually. A time comes, when the soil voids get completely clogged, air circulation through the soil is totally stopped and sediments get deposited on the surface. An anaerobic condition is developed. At this stage, the soil is unable to absorb further sewage load. An insanitary condition is developed by liberating bad smell. Such condition is termed as sewage sickness.

The following measures may be taken to prevent sewage sickness:

(i) The primary treatment should be given to sewage to eliminate the suspended solids.

(ii) The intermittent supply of sewage should be adopted considering the nature of soil.

(iii) Crop rotation system should be followed so that the different crops may consume different fertilising elements.

(iv) The sub-soil drainage system should be provided to drain out the sub-soil effluent.

(v) Deep ploughing by tractor should be adopted to increase the soaking capacity of soil.

(vi) Time to time, a thin layer of surface soil should be removed by scrapping.

4.4 Acid Rain

Normally, clean air is slightly acidic, with a pH level of about 5.0 to 6.0. This is due to the equilibrium between rainwater and the CO_2 present in the air, which dissolves to a sufficient extent in the water droplets and then give weak carbonic acid solution.

Today, over wide areas of our planet, heavy rainfalls predominate with a pH value of 3.0 to 4.0, which is known as 'Acid rain'. The term acid rain is applicable to both wet and dry acidic deposition.

Acid rain occurs with much of the NO_x and SO_x entering the atmosphere are converted into HNO_3 and H_2SO_4 respectively. The detailed photochemical reactions in the atmosphere are summarized as :

$$NO + O_3 \rightarrow NO_2 + O_2$$

$$NO_2 + O_3 \rightarrow NO_3 + O_2$$

$$NO_2 + NO_3 \rightarrow N_2O_5$$

$$N_2O_5 + H_2O \rightarrow 2HNO_3$$

HNO_3 is removed as a precipitate or as particulate nitrates after reaction with bases (NH_3, particulate lime).

$$SO_2 + 1/2O_2 + H_2O \xrightarrow[\text{Soot particles (Metal oxide)}]{\text{(HC,NO)}} H_2SO_4$$

The presence of hydrocarbons and NO_x step up the oxidation rate of the reaction. In water droplets, ions such as Mn(II), Fe(II), Ni(II) and Cu(II) catalyze the oxidation reaction. Soot particles are also known to be strongly involved in catalyzing the oxidation of SO_2.

HNO_3 and H_2SO_4 combine with HCl emitted by both, natural and anthropogenic sources to generate acidic precipitation which is widely known as ***Acid Rain***. Acid rain is now a major pollution problem in some areas. Fig. 4.12 describes the formation of acid rain.

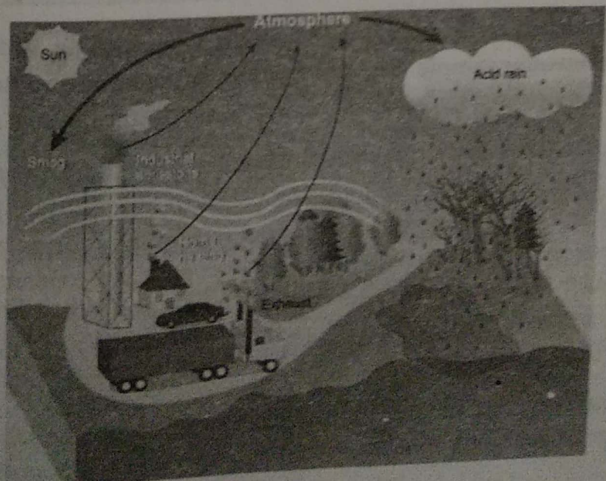


Fig.4.12 : Formation of Acid Rain

... they become joined with water ... In addition, ... rain can also be a problem in areas far from the

4.4.1 Effects of Acid Rain

The most important effects are : damage to freshwater aquatic life, damage of vegetation and damage to buildings and material.

4.4.1.1 Damage to Aquatic Life

The main impact of fresh water acidification is a reduction in diversity and populations of fresh water species. The effect on soil and rock will depend upon the in situ capacity called 'buffering capacity' to neutralize the acids. The soil organisms are killed in acid rain where soils have limited buffering capacity. The acidic leaf litter in forest areas adds to the nutrient leaching effects of acid rain. This scavenging from cloud increases the amount of pollution deposited. Trees are quite effective in intercepting the air borne pollutants than other types of upland vegetation.

In the areas of high acid deposition and poor buffering in the lakes, a pH less than 5 has become common. At pH 5, fish life and frogs begin to disappear. By pH 4, 5, virtua!ly all aquatic life has gone. Acid rain releases metals particularly aluminum from the soil, which can build up in lake water to levels that are toxic to fish and other organisms. A decline in fish and amphibian population will affect the food chain of birds and mammals that depend on them for food.

4.4.1.2 Damage to Trees and Plants

For some years there has been concern about the apparent deterioration of trees and other vegetation. It is not easy to establish the cause of damage: pollution, drought, frost, pests and forest management methods can all affect tree health. SO_2 has a direct toxic effect on trees and in parts of central Europe for example where SO_2 levels are very high, extensive areas of forest have been damaged or destroyed. Picture of forest badly effected by acid rain is shown in Fig.4.13.

Acid deposition may combine with other factors to affect tree health; for instance by making trees more susceptible to attack by pests, or by acidifying soils which may cause loss of essential nutrients such as magnesium, thus impairing tree growth. Nitrogen and sulphur are both plant nutrients and deposition can upset the balance of natural plant communities by encouraging the growth of other plant species. Secondary pollutants like ozone are also known to exacerbate the effects of acid deposition.

Fig.4.13

4.4.1.3 Damage to Buildings and Materials

All historic buildings suffer damage and decay with time. Natural weathering causes some of this but there is no doubt that air pollution, particularly SO_2, also plays an important part. SO_2 penetrated porous stones such as limestone and is converted to calcium sulphates, which causes gradual crumbling. Most building damage happens in urban areas where there are many SO_2 emitters (domestic chimneys, factories and heating plant). The introduction of the Clean Air Acts and the replacement of coal fires by gas and electricity have greatly reduced sulphur dioxide levels in urban areas. Other materials badly affected by pollutant gases include marble, stained glass, most metals and paint. Poorly set or fractured concrete may also allow sulphates to penetrate and corrode the steel reinforcement inside.

Some of the monuments having archeological significance are listed below which are being affected by acid rain in India :

(i) Taj Mahal in Agra (U.P.)
(ii) Red Fort in Delhi
(iii) Jama Masjid in Delhi
(iv) Qutab Minar in Delhi
(v) Konark Temple in Orissa
(vi) Ajanta and Ellora Caves in Maharashtra
(vii) Victoria in Kolkata (W.B.)

4.4.1.4 Effects on Human Health

Acid rain looks, feels, and tastes just like clean rain. The harm to people from acid rain is not direct. Walking in acid rain, or even swimming in an acid lake, is no more dangerous than walking or swimming in clean water. However, the pollutants that cause acid rain SO_2 and NO_x do damage human health. These gases interact in the atmosphere to form fine sulphate and nitrate particles that can be transported long distances by winds and inhaled deep into people's lungs. Fine particles can also penetrate indoors.

... stack gases. An example of FGD is the wet scrubber ...y used in the U.S. and many other countries. A wet scrubber is basically a reaction tower equipped with a fan that extracts hot smoke stack gases from a power plant into the tower. Lime or limestone in slurry form is also injected into the tower to mix with the stack gases and combine with the sulphur dioxide present. The calcium carbonate of the limestone produces pH-neutral calcium sulphate that is physically removed from the scrubber. That is, the scrubber turns sulphur pollution into industrial sulphates.

In some areas the sulphates are sold to chemical companies as gypsum when the purity of calcium sulphate is high. In others, they are placed in landfill. However, the effects of acid rain can last for generations, as the effects of pH level change can stimulate the continued leaching of undesirable chemicals into otherwise pristine water sources, killing off vulnerable insect and fish species and blocking efforts to restore native life.

Since most acid pollution comes from burning of fossil fuels, one way of reducing emissions is to reduce the overall demand for energy by encouraging energy conservation and improving the efficiency of electricity generation. Another option is to develop non-fossil fuel energy sources such as nuclear power or renewable energy (solar, wind, tidal power, etc.). However these have their own environmental problems which must be balanced against those of fossil fuels.

4.5 Global Warming

Global warming is termed to be the increase in the average temperature of Earth's oceans and near surface air. This has been happening in the recent decades and is expected to continue. In fact the term global warming is said to be a specific example of climatic changes. In scientific and common terms, global warming refers to recent warming and also implies a human influence on the same. Global warming is the increase in the average temperature of the Earth's near-surface air and oceans.

The Intergovernmental Panel on Climate Change (IPCC) concludes that most of the observed temperature increases since the middle of the 20^{th} century was caused by increasing concentrations of greenhouse gases resulting from human activity such as fossil fuel burning and deforestation. It also concludes that variations in natural phenomena such as solar radiation and volcanoes produced most of the warming from pre-industrial times to 1950 and had a small cooling effect afterward.

Climate model projections indicate that the global surface temperature will probably rise a further 1.1 to 6.4 °C during the twenty-first century. The warming is expected to continue beyond

2100 even if emissions stop, because of the large heat capacity of the oceans and the long lifetime of carbon dioxide in the atmosphere. An increase in global temperature will cause sea levels to rise and will change the amount and pattern of precipitation, probably including expansion of subtropical deserts. The continuing retreat of glaciers, permafrost and sea ice is expected, with warming being strongest in the Arctic. Other likely effects include increases in the intensity of extreme weather events, species extinctions, and changes in agricultural yields. The available options are mitigation to reduce further emissions; adaptation to reduce the damage caused by global warming. Most national governments have signed and ratified the Kyoto Protocol aimed at reducing greenhouse gas emissions.

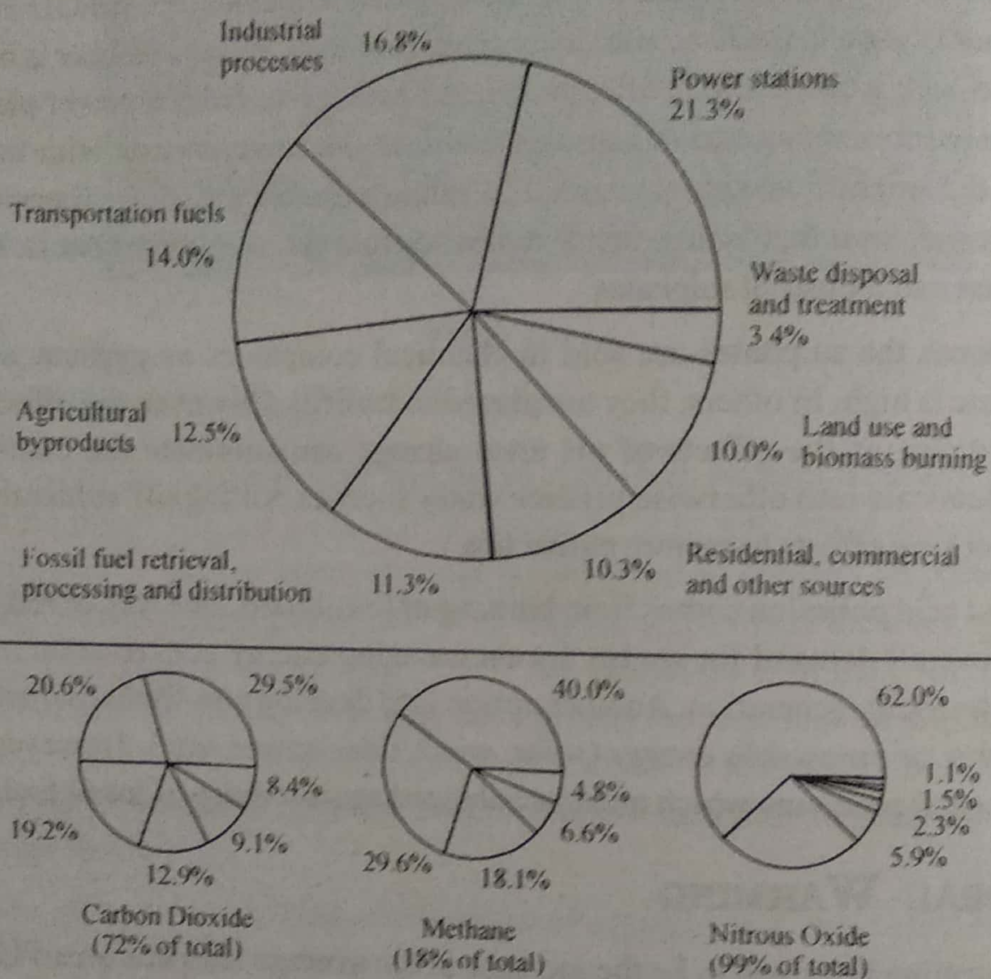


Fig.4.14 : Anual Greenhouses Gas Emissions by Sector

4.5.1 Causes of Global Warming

Global warming is caused by several things, which include man-made or anthropogenic causes, and global warming is also caused by natural causes.

4.5.1.1 Natural Causes

Natural causes are causes that are created by nature. One natural cause is a release of methane gas from arctic tundra and wetlands. Methane is a greenhouse gas and a very dangerous gas to our environment. A greenhouse gas is a gas that traps heat in the earth's atmosphere. Another natural cause is that the earth goes through a cycle of climate change. This climate change usually lasts about 40,000 years.

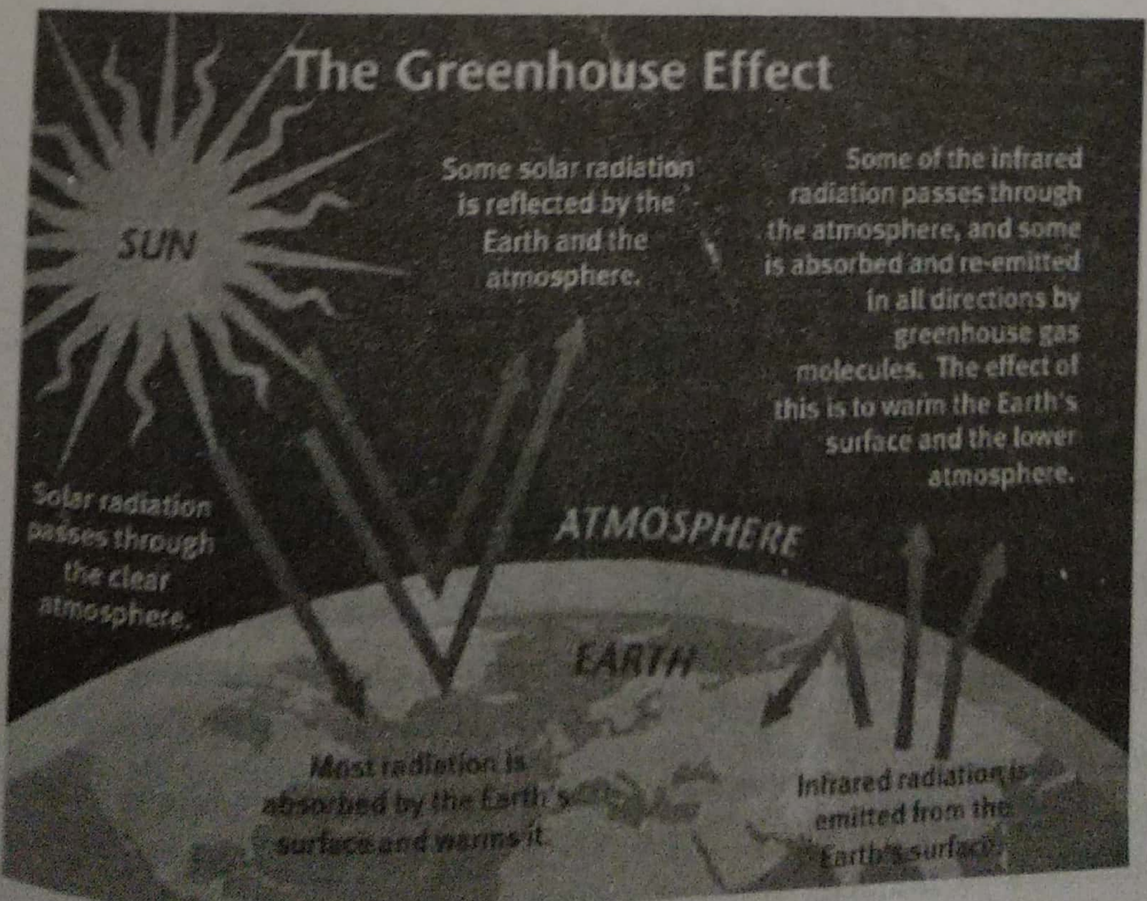
4.5.1.2 Man-made Causes

Man-made causes probably do the most damage to our planet. There are many man-made causes of global warming. Pollution is one of the biggest man-made problems. Pollution comes in many shapes and sizes. Burning of fossil fuels is one thing that causes pollution. Fossil fuels are fuels made of organic matter such as coal, or oil. When fossil fuels are burned they give off a green house gas called CO_2. Also, mining coal and oil allows methane to escape.

Another major man-made cause of Global Warming is population. More people mean more food, and more methods of transportation. That means more methane because there will be more burning of fossil fuels. Another source of methane is manure. Because more food is needed to feed the population we have to raise food. Animals like cows are a source of food which means more manure and hence more methane. Another problem with the increasing population is transportation. More people mean more cars and more cars means more pollution. Also, many people have more than one car. There are definitely ways of raising animals and farming that use no manure and no methane. Once we realized the problem we should have stopped immediately using manure.

4.5.2 Global Warming By Greenhouse Effect

When sunlight reaches Earth's surface some part of it is absorbed and warms the earth and most of the rest is radiated back to the atmosphere at a longer wavelength than the sun light. Some of these longer wavelengths are absorbed by greenhouse gases in the atmosphere before they are lost to space. The absorption of this long wavelength radiant energy warms the atmosphere. These greenhouse gases act like a mirror and reflect back to the Earth some of the heat energy which would otherwise be lost to space. The reflecting back of heat energy by the atmosphere is called the "greenhouse effect".



The major natural greenhouse gases are water vapor, which causes about 36-70% of the greenhouse effect on Earth (not including clouds); carbon dioxide CO_2, which causes 9-26%; methane, which causes 4-9%, and ozone, which causes 3-7%. It is not possible to state that a certain gas causes a certain percentage of the greenhouse effect, because the influences of the various gases are not additive. Other greenhouse gases include, but are not limited to, nitrous oxide, sulphur hexafluoride, hydro fluorocarbons, per fluorocarbons and chlorofluorocarbons. Greenhouse gases in the atmosphere act like a mirror and reflect back to the Earth a part of the heat radiation, which would otherwise be lost to space. The higher the concentration of green house gases like carbon dioxide in the atmosphere, the more heat energy is being reflected back to the Earth. The emission of carbon dioxide into the environment mainly from burning of fossil fuels (oil, gas, petrol, kerosene, etc.) has been increased dramatically over the past 50 years.

Since CO_2 contributes to global warming, the increase in population makes the problem worse because we breathe out CO_2. Also, the trees that convert our CO_2 to oxygen are being cut down because we are using the land that we cut the trees down from as property for our homes and buildings. We are not replacing the trees (trees are a very important part of our eco-system), so we are constantly taking advantage of our natural resources and giving nothing back in return. Fig. 4.16 showing curve indicates how global temperature varies with concentration of CO_2.

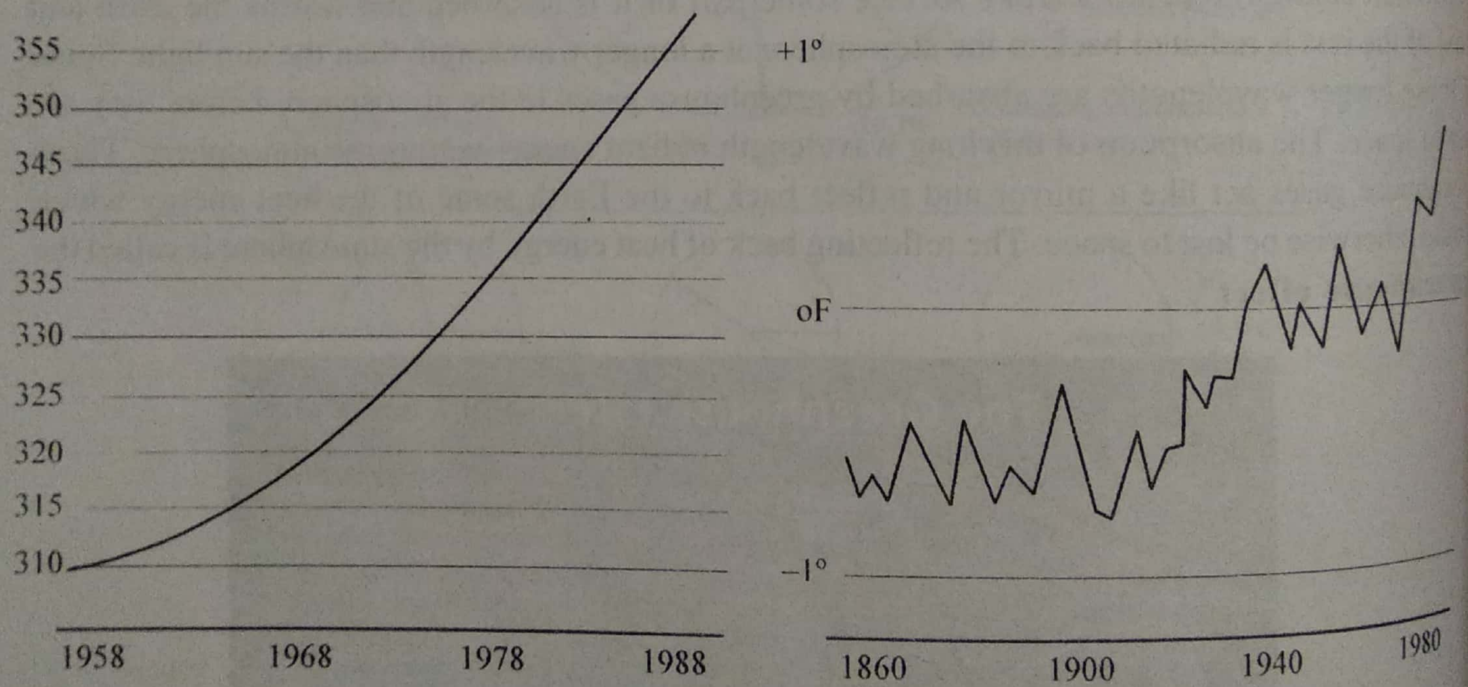


Fig.4.16

4.5.3 Effects of Global Warming

Greenhouse gases can stay in the atmosphere for an amount of years ranging from decades to hundreds and thousands of years. No matter what we do, global warming is going to have some effect on Earth. Here are the 5 deadliest effects of global warming.

1. Spread of Disease : As northern countries warm, disease carrying insects migrate north, bringing plague and disease with them. Global warming has the ability to increase the areas that spread such diseases as malaria, bluetongue disease, Hantavirus infection, Crimean-Congo hemorrhagic fever, tularemia, and rabies. Increases in several of these diseases have already been recorded in the north Mediterranean region and Russia. Indeed some scientists believe that in some countries due to global warming, malaria has not been fully eradicated.

2. Warmer Waters and More Hurricanes : As the temperature of oceans rises, Hurricane draws its energy from the warm ocean waters and it was feared that frequency as well as severity of hurricanes and storms will increase. So will the probability of more frequent and stronger hurricanes.

3. Probability Droughts and Heat Waves : Although some areas of Earth will become wetter due to global warming, other areas will suffer serious droughts and heat waves. It has been feared that global warming is likely to effect delicate balance of the ecosystem. Many species of birds and animals are going to find it difficult to survive in rapidly deteriorating climate, as the environments in which they live are either going to deteriorate fast or are going to be extinct. Even forests are going to be devastated. Alpine forests and many of the mangrove forests are facing extinction. In the Antarctica penguin population has shrunk by 33 % in the last 25 years.

Africa will receive the worst of it, with more severe droughts also expected in Europe. Water is already a dangerously rare commodity in Africa, and according to the Intergovernmental Panel on Climate Change (IPCC), global warming will worsen the conditions and could lead to conflicts and war.

4. Economic Consequences : Most of the effects of anthropogenic global warming was not be good. And these effects spell one thing for the countries of the world : economic consequences. Hurricanes çause do billions of dollars in damage, diseases cost money to treat and control and conflicts exacerbate all of these.

5. Polar Ice Caps Melting : The ice caps melting are a four prolonged danger.

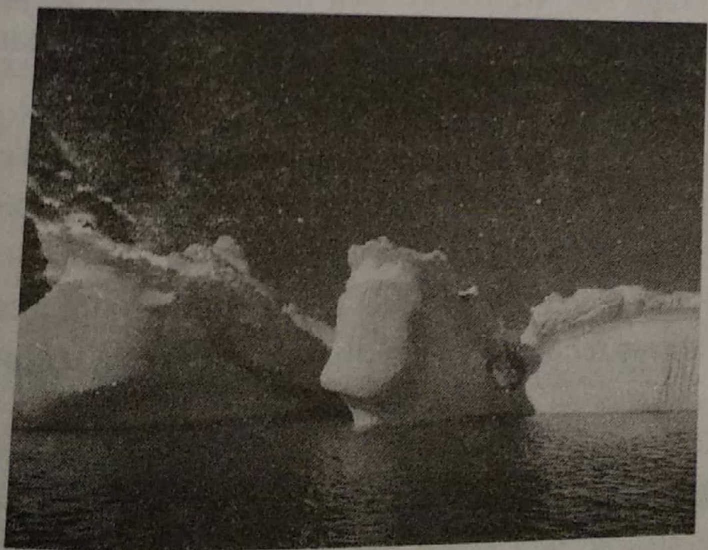


Fig.4.17 : Melting of Ice Caps

First, it will raise sea levels. There are 5,773,000 cubic miles of water in ice caps, glaciers, and permanent snow. According to the National Snow and Ice Data Center, if all glaciers melted today the seas would rise about 230 feet.

Second, melting ice caps will throw the global ecosystem out of balance. The ice caps are fresh water, and when they melt they will desalinate the ocean, or make it less salty.

despite the relatively low concentration of ozone.

4.6.2 Depletion of Ozone Layer

Today, one of the most discussed and a serious environmental crisis is the ozone layer depletion, the layer of gas that forms a protective covering in the Earth's upper atmosphere. Ozone layer depletion first captured the attention of the whole world in the later half of 1970 and since then, many discussions and researches have been carried out to find out the possible effects and the causes of ozone depletion.

The stratospheric ozone layer shields life on Earth from the Sun's harmful ultraviolet radiation. Natural sources contribute to the depletion of the ozone layer, but not nearly as much as human activity. Natural sources can be blamed for approximately 15 to 20 percent of ozone damage. A common natural source of ozone damage is naturally occurring chlorine. Naturally occurring chlorine, like the chlorine released from the reaction between a CFC molecule and UV radiation, also has detrimental effects and poses danger to the earth. Volcanic eruptions are a small contributor to ozone damage, accounting for one to five percent. During large volcanic eruptions, chlorine, as a component of hydrochloric acid (HCl), is released directly into the stratosphere, along with sulphur dioxide. In this case, sulphur dioxide is more harmful than chlorine because it is converted into sulphuric acid aerosols. These aerosols accelerate damaging chemical reactions, which cause chlorine to destroy ozone. Typical picture showing the formation of ozone hole as shown below.

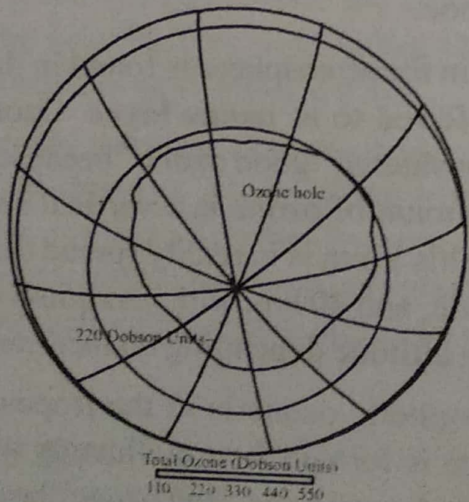


Fig.4.18 : Depletion of Ozone Layers on Global Level

Human activity is by far the most prevalent and destructive source of ozone depletion, while threatening volcanic eruptions are less common. Human activity, such as the release of various compounds containing chlorine or bromine, accounts for approximately 75 to 85 percent of ozone damage.

Chemicals that destroy ozone are formed by industrial and natural processes. With the exception of volcanic injection and aircraft exhaust, these chemicals are carried up into the stratosphere by