NEC license Exam Preparation

Chapter 6: Water Supply, Sanitation and Environment

DAY:6

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Chemical oxygen demand (COD)

- The equivalent amount of oxygen required to oxidize organic matter(non-biodegradable) in a waste water by means of a strong oxidizing agent

- COD analysis is fast in comparison to BOD analysis (3 hours versus 5 days)

- Common oxidizing agent used for determination of COD of wastewater is potassium dichromate ($K_2Cr_2O_7$) in presence of sulphuric acid.

- *Value of COD is more than BOD i.e COD/BOD is >1*

Waste water treatment

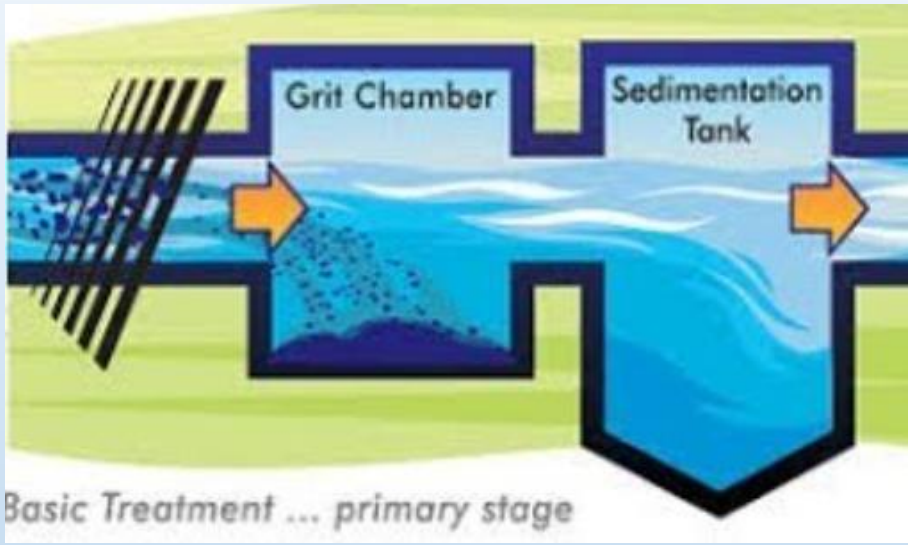
- Wastewater treatment can be broadly classified into following categories

Primary treatment	Secondary treatment/ Biological process
Screening	Intermittent sand filter
Skimming tank (removal of fat, oil, grease, waxes etc.)	Contact bed
Grit chamber (removal of grits like sand, gravel, clinker, etc.)	Trickling filter
Settling tank (sedimentation tank)	Activated sludge process
	Oxidation pond
Also called unit operations (physical operations)	Also called unit process (biological and chemical process)

S.No.	Method	Contact Mechanism	Decomposition
1	Trickling filter	Attached growth	Aerobic
2	Rotating biological contactor	Attached growth	Aerobic
3	Activated sludge process	Suspended growth	Aerobic
4	Oxidation pond	Suspended growth	Aerobic
5	Septic tank	Suspended growth	Anaerobic
6	Imhoff tank	Suspended growth	Anaerobic

Primary treatment: Design of grit chamber

- The grit chamber is designed as normal sedimentation tank.
- The detention time is taken as 45 to 90 seconds.
- The settling velocity of grit particles is calculated using the formula :



$$V = 60.6\ d\ (S-1)\frac{3T+70}{100}$$

- The horizontal velocity of waste water is to be maintained in the range of 0.15 to 0.3 m/s so as to prevent the scouring of settled grit particles.

Secondary treatment

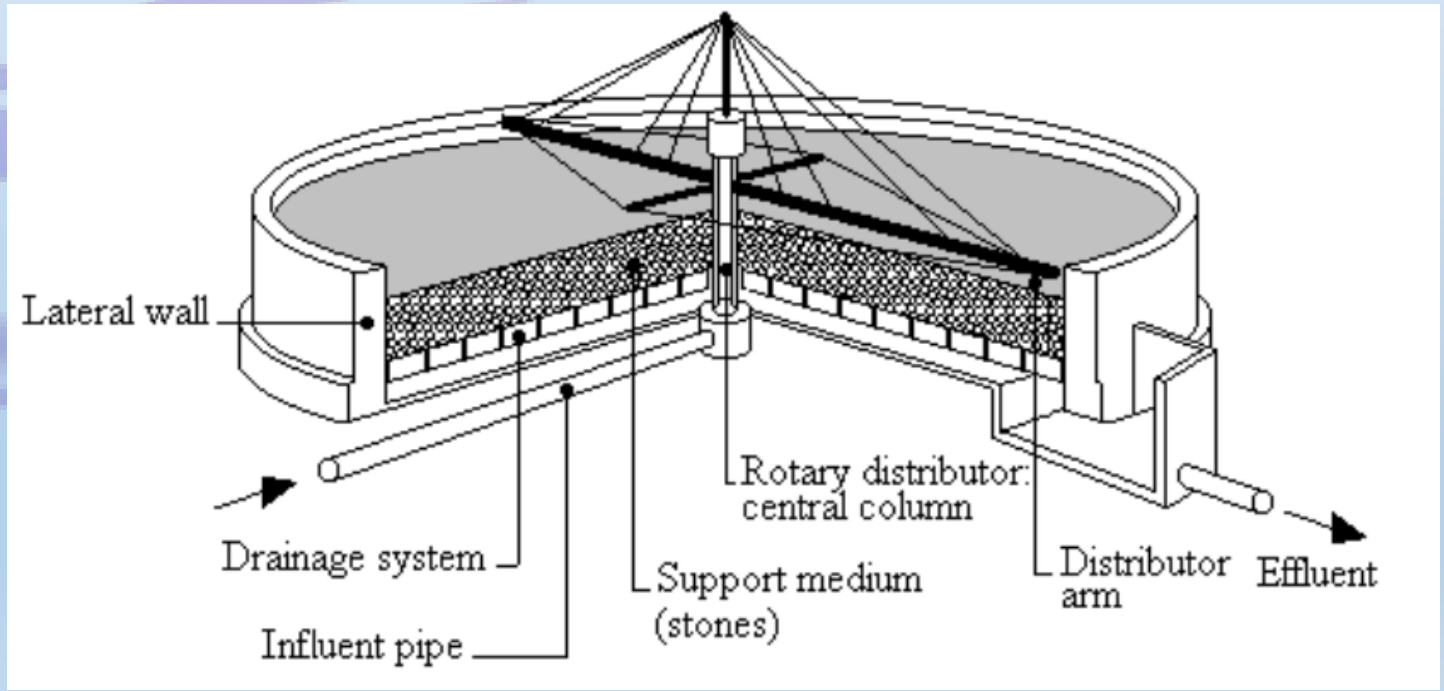
- Biological treatment of wastewater
- Consists of two process

Attached growth process	Suspended growth process
Process in which the bacteria for stabilizing the organic compounds are attached to the filter media	Process in which the bacteria for stabilizing the organic compounds are held in suspension
Intermittent sand filter	Activated sludge process
Contact bed	Oxidation pond
Trickling filter	Aerated lagoons

Secondary treatment: Sewage filtration

Trickling filter

- Filter media consists of high specific surface area material like rock, gravel, shredded pvc bottles etc.
- Mostly circular tank is used
- Ventillation is provided from bottom
- Disposal of sludge is required
- Attached growth process is used



Types of trickling filter

On the basis of whether the filtered water is recirculated or not, the filter is classified into two types:

a. Standard/normal/low rate trickling filter (SRTF/NRTF):

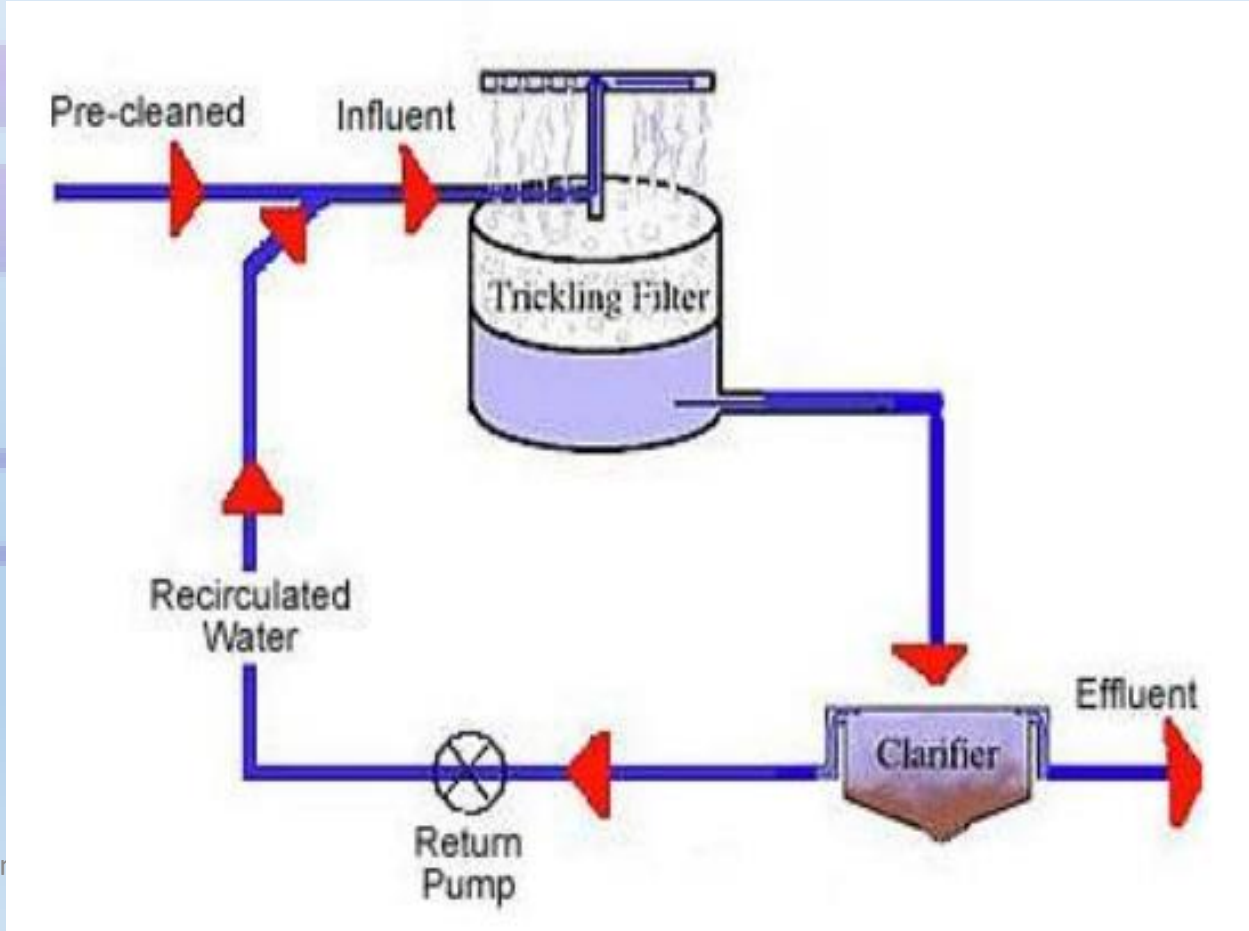
- No recirculation of water

b. High rate trickling filter (HRTF):

- Circulation of water is done.
- It is also classified as:

➢Single stage HRTF

➢Double stage HRTF



Some terms in trickling filters

1. $Recirculation\ Ratio\ (r) = \frac{Recirculated\ Flow\ (R)}{Flow\ of\ Raw\ sewage\ (I)}$
2. $Recirculation\ Factor(F) = \frac{1+r}{(1+0.1r)^2}$
3. $Hydraulic\ Loading\ (H) = \frac{Rate(Q)}{Plan\ Area\ (A)}$
4. $Organic\ Loading\ (U) = \frac{W}{VF} = \frac{influent\ or\ applied\ BOD\ per\ day\ (Q*C_i)}{(Volume\ of\ TF)*F}$

EFFICIENCY FORMULA

$$\frac{100}{1+0.44\sqrt{U_1}}$$

$$\frac{100}{1+\frac{0.44\sqrt{U_2}}{1-E_1}}$$

When organic loading is measured in Kg BOD/ cu. M / day

NOTE: Overall efficiency for two stage trickling filter = E = E1 + E2 (1-E1)

Q. A standard rate trickling filter has following properties:
(i) Volume = 4500 m3
(ii) Organic loading rate = 160 gm/m3/day

What is the efficiency of this filter unit?

a) 79.93%
b) 85.03 %
c) 82.20%
d) 88.15%

The filter over which sewage is sprinkled is called as

Sloughing ?

A. Trickling filter

B. Percolating filter

C. Contact bed

D. Intermittent sand filter

The recirculation factor of low rate trickling filter is

a) 1

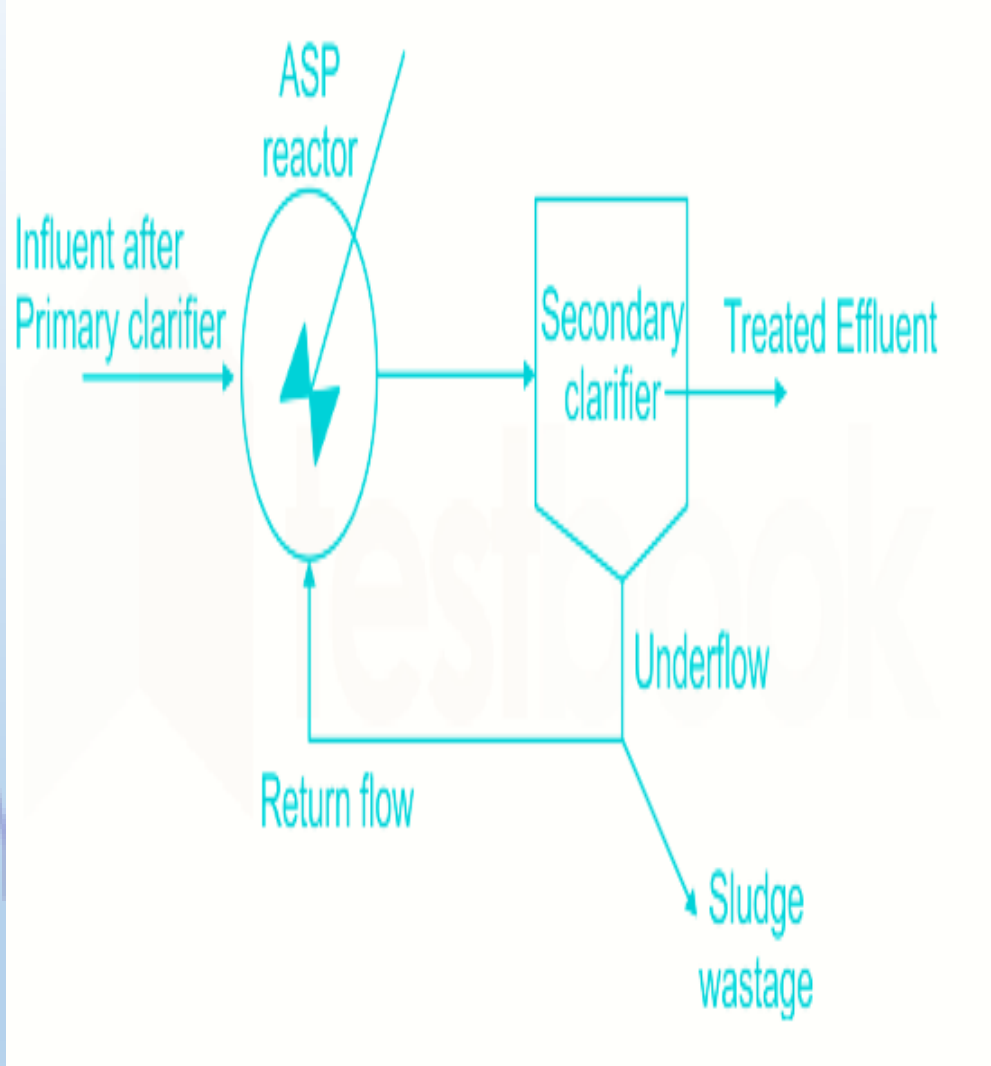
b) 2

c) 0

d) 3

Activated sludge process

- Suspended growth process
- Sewage from PST is mixed with 20-30% of own volume of returned activated sludge
- Mixture of raw sewage and activated sludge is called mix liquor
- Suspended solid in mix liquor is called mixed liquor suspended solids (MLSS)
- Diffused air aeration or mechanical aeration is used or combination of both is used
- Efficiency : BOD removal = 80-90% , Bacteria = 90-95%



Activated sludge process

- Sludge volume index (SVI):

It is the volume in ml occupied by 1 gram of activated sludge suspension after 30 minutes settling.

It is given by :

$$SVI = \frac{Settled\ volume\ of\ sludge\ (\frac{ml}{lit})}{Concentration\ of\ suspended\ solids\ (\frac{g}{lit})}$$

Note: The recommended value of SVI for well settled sludge is 80 -150 ml/gm (IS).

Activated sludge process

SDI=100/SVI

- For good sludge, SDI=1-2
- Poor sludge, SDI<=0.3
- MLVSS/MLSS =0.8
- F/m=0.2-0.6 /day (0.3 typical)

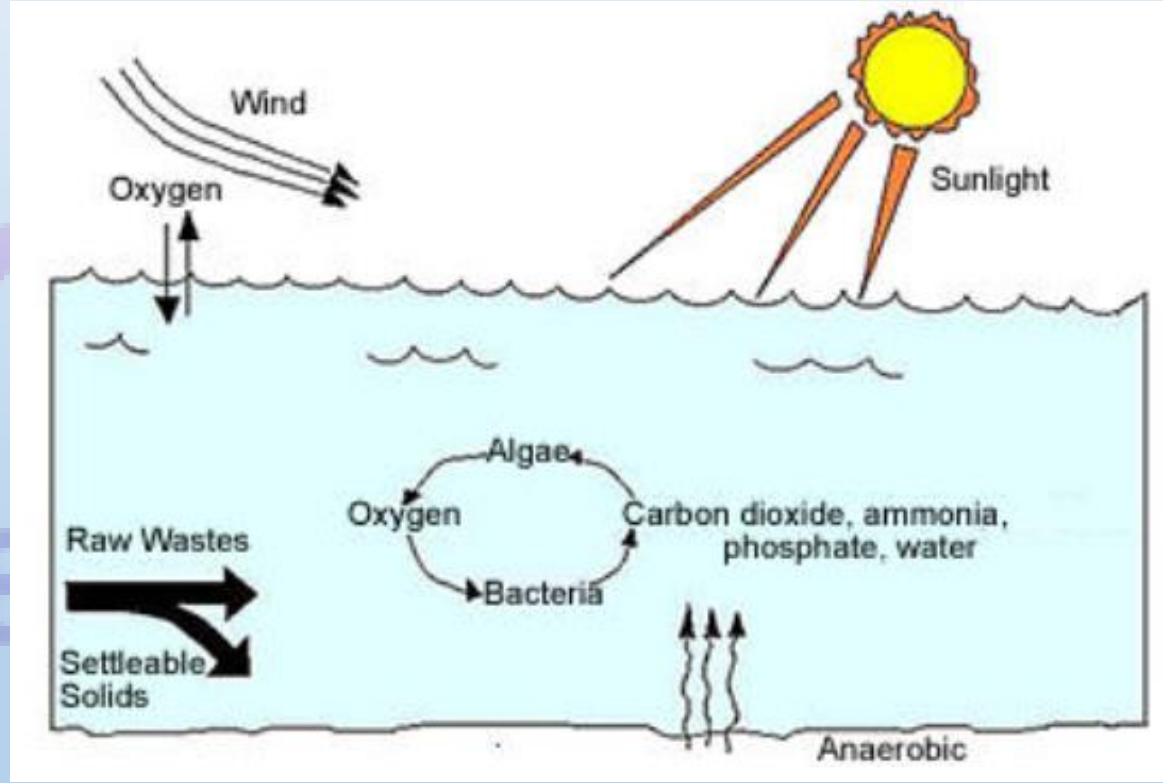
If a sludge has greater SVI value then it is considered as

a) Poor sludge
b) Very good sludge
c) Any
d) none

Sludge bulking?

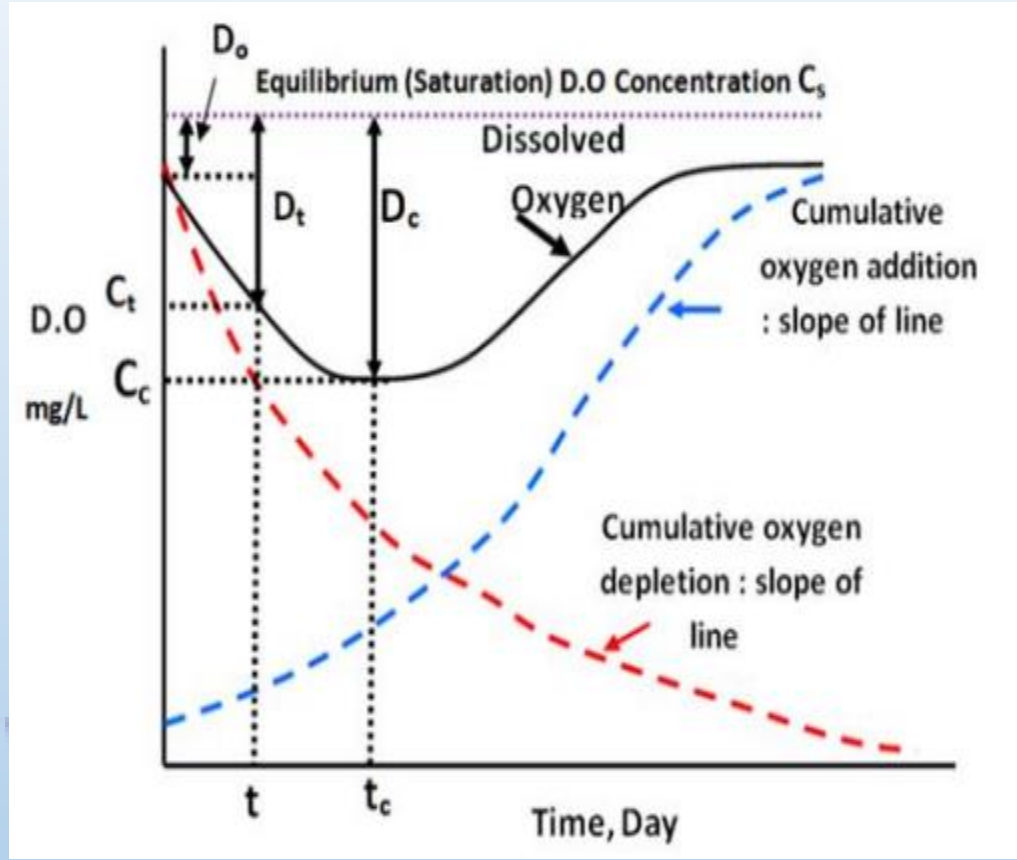
Oxidation pond

- An artificial pond is formed in open space
- Suspended growth process
- Based on the principle of bacterial-algal symbiosis
- Should be constructed at least 300 m away from residential areas
- Provides high quality effluent (BOD > 90% , Suspended solid > 90%)



Self purification of river

- When wastewater is discharged into the river or stream, the BOD of mix increases initially and DO level starts falling.
- As river water travels further BOD gradually reduces and DO increases and reaches its saturation level.
- Thus river gets purified on its own.
- This phenomena is known as Self Purification of Stream/River
- The desirable concentration of DO in water is 6.5 – 8 ppm.
- Minimum DO required for survival of fishes = 4 ppm
- The concentration of water after mixing wastewater is given by :



Oxygen sag curve

$$C_S * Q_S + C_R * Q_R = C\,(Q_S + Q_R)$$

Self purification of river

- Factors affecting self purification of stream

a. Dilution
b. Oxidation /reduction
c. Sedimentation
d. Action of sunlight
e. Water current
f. Temperature

Streeter Phelps equation for oxygen sag curve

Oxygen deficit at any time t is given by

$$D_t = \frac{KL_0}{R-K}(10^{-Kt} - 10^{-Rt}) + D_0 10^{-Rt}$$

The critical time at which the oxygen deficit is maximum is given by

$$t_c = \frac{1}{K(f-1)} Log_{10}\left(f * [1 - (f-1)\frac{D_0}{L_0}]\right)$$

R/K = f is called self-purification factor/constant

Critical oxygen deficit in terms of t_c is given by

$$D_c = \frac{K}{R} * L_0 * 10^{-Kt_c}$$

DO	Dissolved Oxygen
D_0	Initial Deficit (Saturation DO – DO level after mixing sewage at t=0
D_C	Critical Deficit (Maximum Deficit, Minimum DO level)
t_c	Critical Time
L_0	Ultimate first stage BOD at disposal point
D_t	Deficit at any time 't'
K	Deoxygenation Constant (Base 10) ; $K_\theta = K_{20} * (1.047)^{\theta-20}$
R	Re-oxygenation Constant (Base 10) ; $R_\theta = R_{20} * (1.016)^{\theta-20}$

Waste water disposal by land treatment

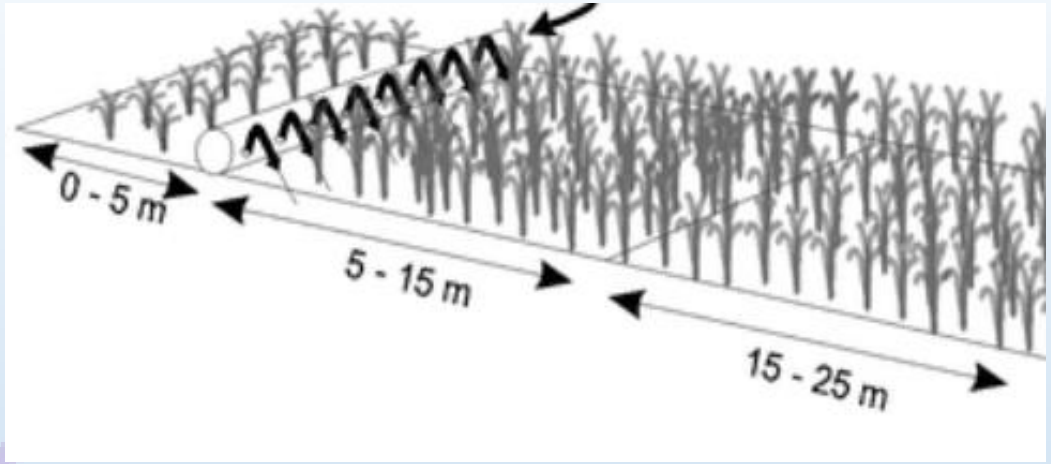
- Method of waste water disposal by controlled application of waste water into land
- Following methods can be used for waste water disposal

A. Irrigation / sewage irrigation

- The wastewater is used for irrigation purpose
- Various methods of irrigation like free flooding, check flooding, sprinkler irrigation, etc. can be used suitably

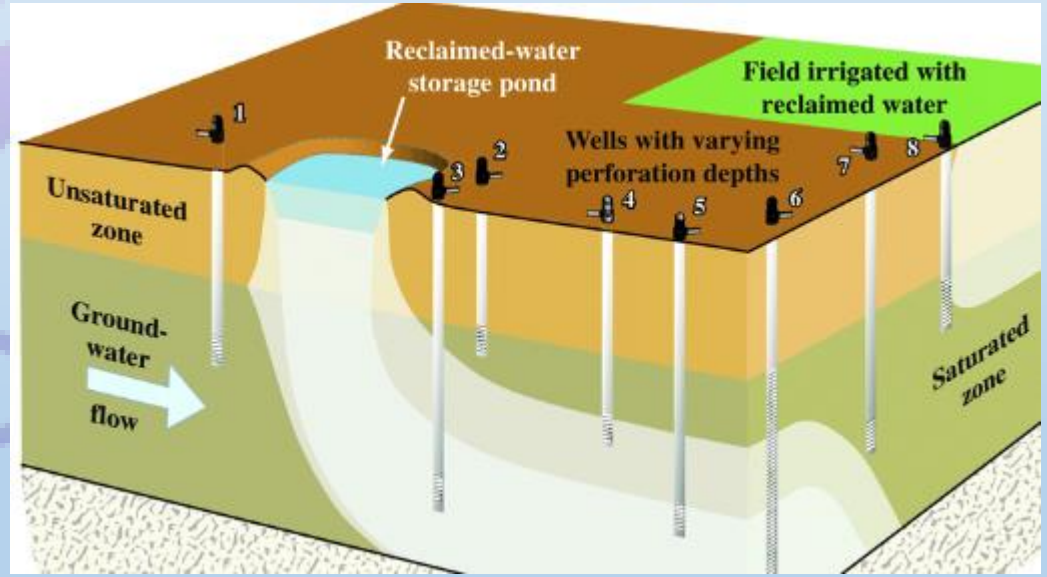
B. Overland flow

- Wastewater is discharged into a sloping land containing vegetation.
- The decomposable organic wastes are taken up by the vegetation and water gets soaked in.



C. Rapid infiltration:

- The waste water is applied into shallow basins mostly containing granular and porous soil
- Useful in ground water recharging



Sludge and solid waste disposal methods

Various methods of sludge and solid waste disposal are:

A. Composting

- It is the process of stabilizing the organic matter present in waste by the aerobic action of bacteria.
- Optimum condition is required to be maintained for composting
- The carbon – nitrogen ratio of waste should be maintained at 25-30
- The moisture should be maintained at 50%
- The temperature should be maintained at 55 degree celcius

Types of composting

Trench composting

Windrow composting

Mechanical composting

B. Incineration

- Incineration involves burning the organic waste at a very high temperature (about or more than 1000°C).
- A small amount of ash produced by incineration can be disposed into a landfill site.
- Incineration is suitable for countries with small land sizes.
- Detrimental for environment
- The most common type: multiple hearth furnance.

C. Dumping

- Releasing of waste materials into open space without any further procedures
- Disposal into abandoned mines , abandoned quarries etc.

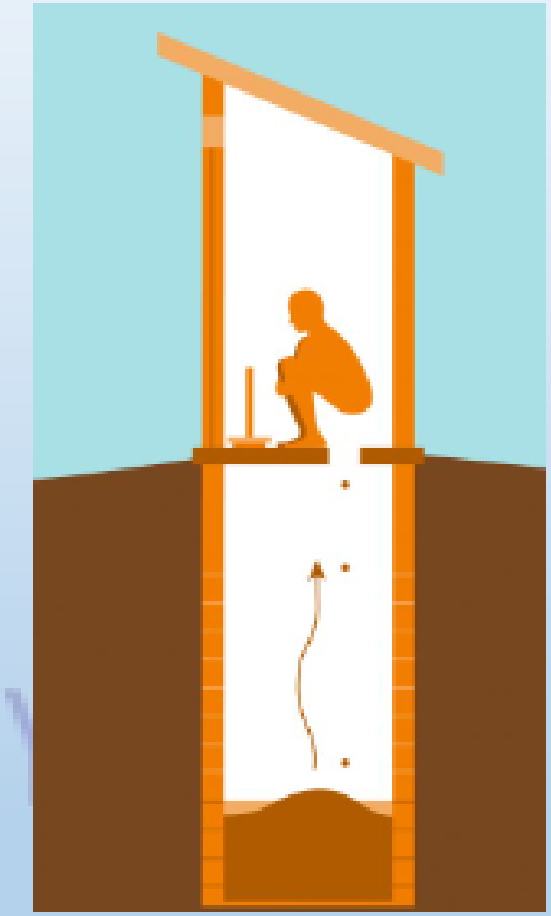
D. Land filling

- Wastes are spread on land in layers and compacted with rollers
- Covered with soil of thickness of about 15-50 cm (usually 30 cm)
- More hygienic than dumping

On-site sanitation /Latrine and septic tank

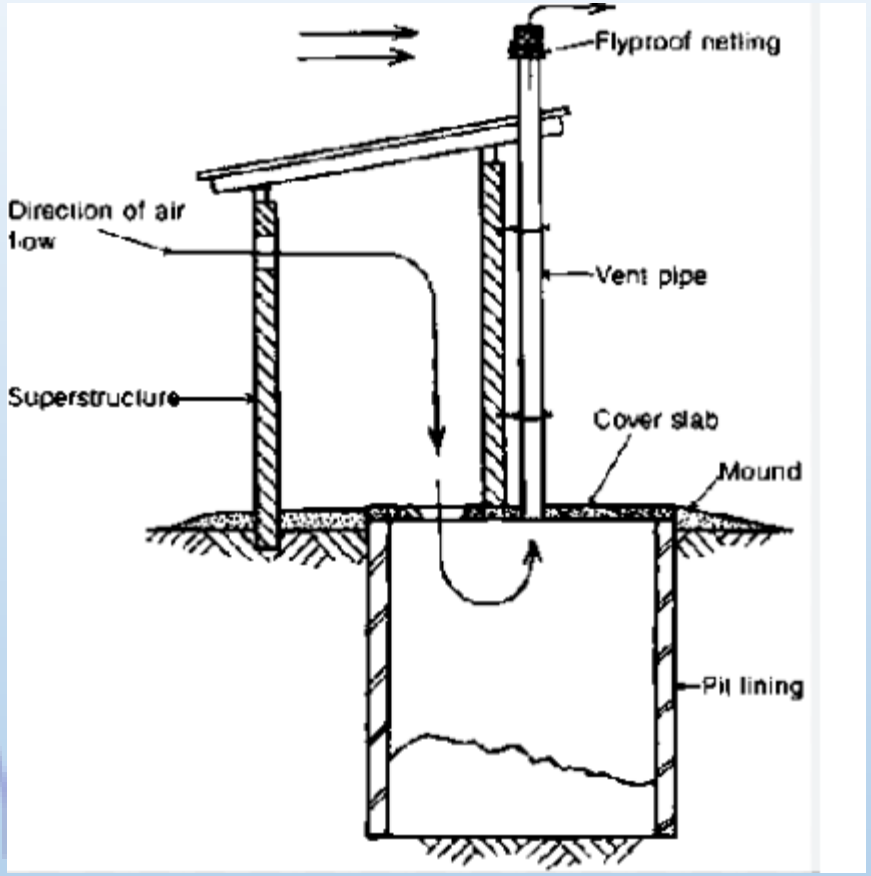
A. Pit privy

- Used for collection and disposal of human excreta
- Consists of pit, a squatting slab and superstructure
- Less hygienic
- More odour
- Should be at least 30 m away from source of water to prevent contamination



B. VIP latrine (Ventilated improved pit latrine)

- Consists of pit, a squatting slab and superstructure along with ventilation pipe for removal of foul odour
- More hygienic than pit privy
- Should be at least 30 m away from source of water to prevent contamination
- Can be either single, double or multiple VIP latrines based on the number of pits used.



Septic tank

- Water tight tank for settling, storage and digestion of human excreta and other solids from waste water.
- Usually tank is of rectangular dimension with length 2-4 times breadth
- Generally two compartments are provided
- Minimum width of septic tank = 75 cm
- Anaerobic decomposition of wastes occur
- Sludge is removed at the interval of 2 to 3 years
- In design the detention time usually used is 24 hours.

Septic tank

- Volume of septic tank consists of three parts:

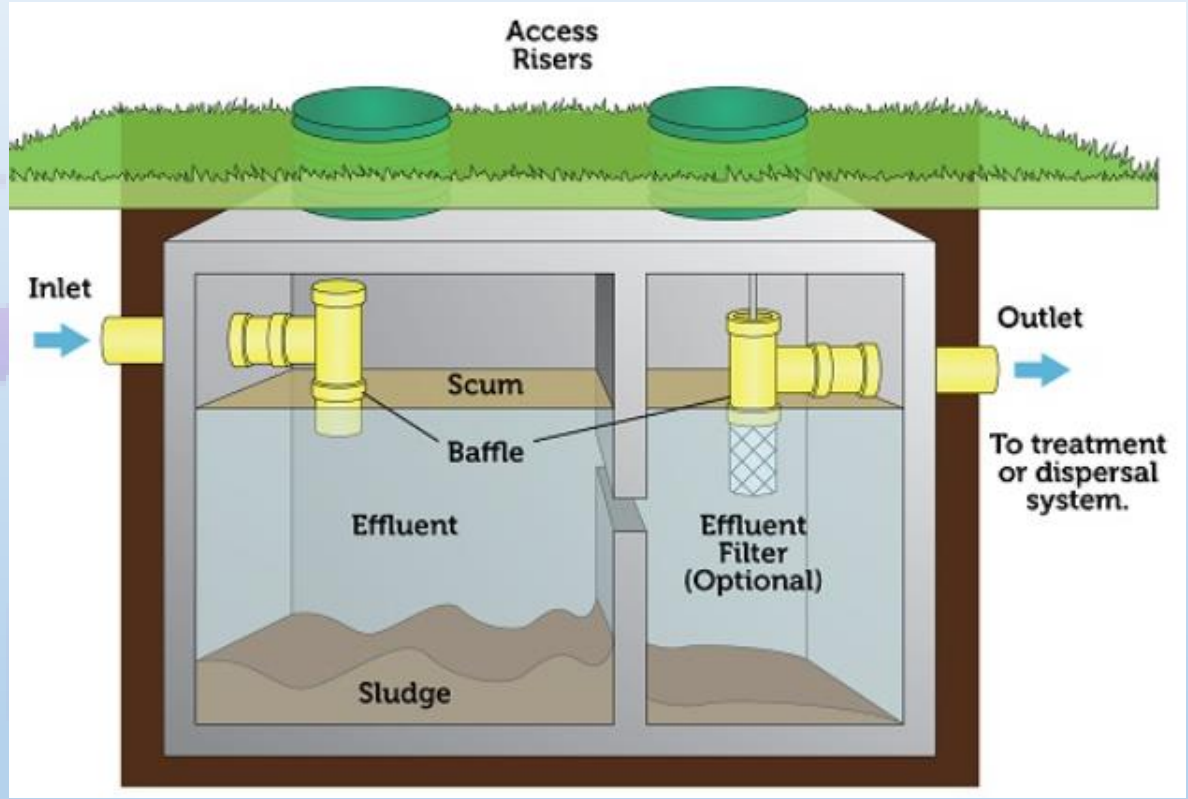
a. Volume for sewage settlement

$V1 = NxQxT$

where N = no. of users

Q = rate of sewage flow

T = detention time



b. Volume for sludge digestion

$V2 = 0.0425$ cu. m / person

Septic tank

c. Volume for sludge storage (V3)

- Depends on the frequency of cleaning
- Value usually adopted for sludge storage is

V3 = 0.085 cu. m / person

(considering cleaning period of 3 years)

Standard values for V3

Sludge Cleaning Period	V_3 (m^3)
6 months	0.0283 N
1 year	0.0490 N
2 years	0.0708 N
3 years	0.0850 N

Soak Pit

- It is a pit of circular plan constructed with a purpose of releasing the waste water coming out of the septic tank.

- The diameter of the soak pit is calculated using the formula

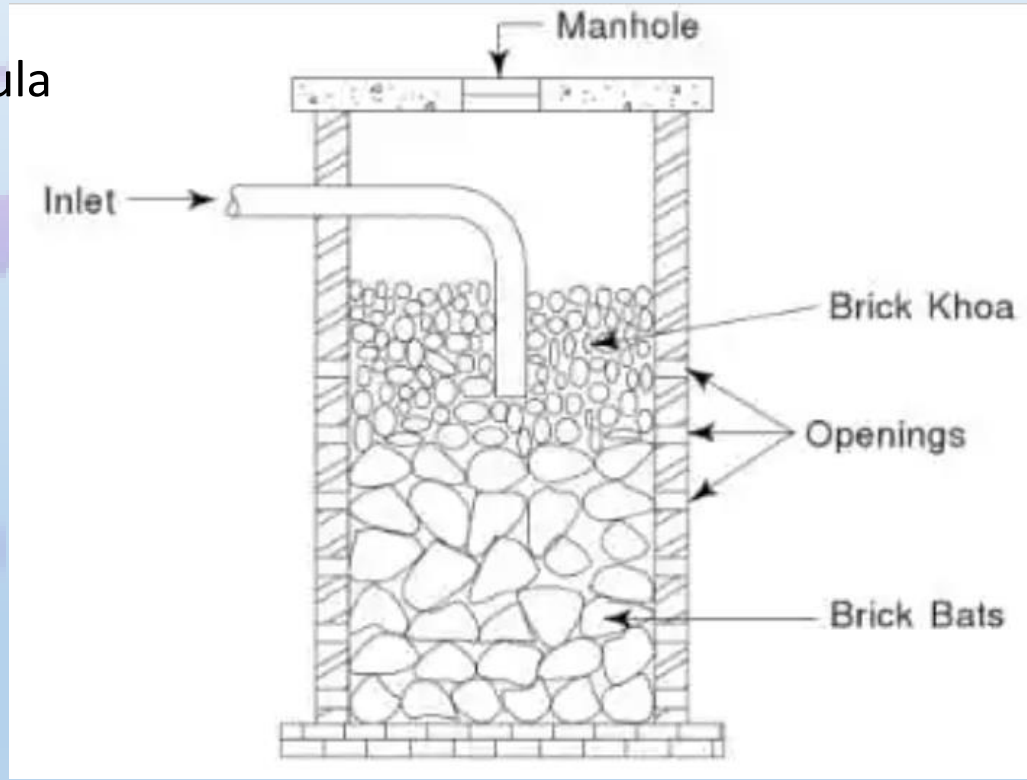
$$D = \frac{Q}{\pi H I}$$

Where

- D = Diameter of soak pit in meter
- Q= design discharge in litres/day
- H= depth of pit (1.5-4 m)
- I = infiltration capacity of soil (litres/ sq. m / day)

Note: Minimum diameter of pit = 1 m

Maximum diameter of pit = 3 m



MCQs

1. Aerobic bacterias
a. flourish in the presence of free oxygen
b. consume organic matter as their food
c. oxidise organic matter in sewage
d. All the above.

2.Pick up the correct statement from the following :
a. pH value indicates acidity and alkalinity of sewage
b. In alkaline sewage, the pH value is more than 7
c. Fresh sewage is generally alkaline
d. All the above.

MCQs

3.Dilution method of disposing off sewage, is not preferred

a. when sewage is fresh
b. when diluting water has high dissolved oxygen content
c. when diluting water is used for water supply near the point of sewage disposal
d. when the diluting water is having flow currents

4.Bio-chemical oxygen demand (BOD) for the first 20 days is generally referred to

a. initial demand
b. first stage demand
c. carbonaceous demand
d. all of these.

MCQs

5.Disposal of sewage in large cities, is done by

a. irrigation
b. dilution
c. oxidation
d. All

6.For the COD test of sewage, organic matter is oxidised by $K_2Cr_2O_7$ in the presence of

a. H_2SO_4
b. HNO_3
c. HCl
d. none of these.

MCQs

7. Which of the following is not secondary treatment process of wastewater?

a. Trickling filter
b. Activated sludge process
c. Grit chamber
d. Oxidation pond

8. The equation describing the oxygen sag curve is given by

a. Streeter phelps equation
b. Camp shield equation
c. Manning equation
d. Horton’s equation

MCQs

Which of the following is suspended growth process of wastewater treatment ?

a. Intermittent sand filter
b. Contact bed
c. Trickling filter
d. Activated sludge process

MCQs

12. Which of the following is the best method for solid waste disposal from environmental point of view?

a. Dumping
b. Incineration
c. Composting
d. All of the above

13. Which of the following latrine is the most hygienic of all?

a. Pit privy
b. VIP latrine
c. Pour flush latrine
d. Normal open pits

Consider the following statements:

1. The quality of waste water is determined on the basis of DO.

2. The BOD test is based on DO.

3. Determination of DO helps in controlling corrosion.

Which of the above statements are correct?

1. 1, 2 and 3
2. 1 and 2 only
3. 1 and 3 only
4. 2 and 3 only

The presence of algae in water indicates that water is

1. Hard
2. Soft
3. Acidic
4. Turbid

The exertion of biochemical oxygen demand (BOD) by microorganisms is called:

1. transpiration
2. eutrophication
3. deoxygenation
4. reoxygenation

Gases formed during aerobic decomposition of sewage

a) $CO_2+NH_3+H_2S$
b) $CO_2+NH_3+H_2S+CH_4$
c) $CO_2+NH_3+SO_2$
d) All the above

Complete through treatment should generally be given to sewage before its disposal in a stream, if the dilution factor available is

a) Less than 350
b) Less than 250
c) Less than 150
d) none

Dilution factor	Standards of purification required
Above 500	No treatment is required.
300-500	Primary treatment required such as plain sedimentation.
150-300	Treatment required such as sedimentation, screening etc.
Below 150	Complete through treatment should be given to sewage.

Which one is correct?

a) COD>BOD>TOD
b) TOD>BOD>COD
c) TOD>COD>BOD
d) None

Grit chamber having higher detention period about 3-4 min. is

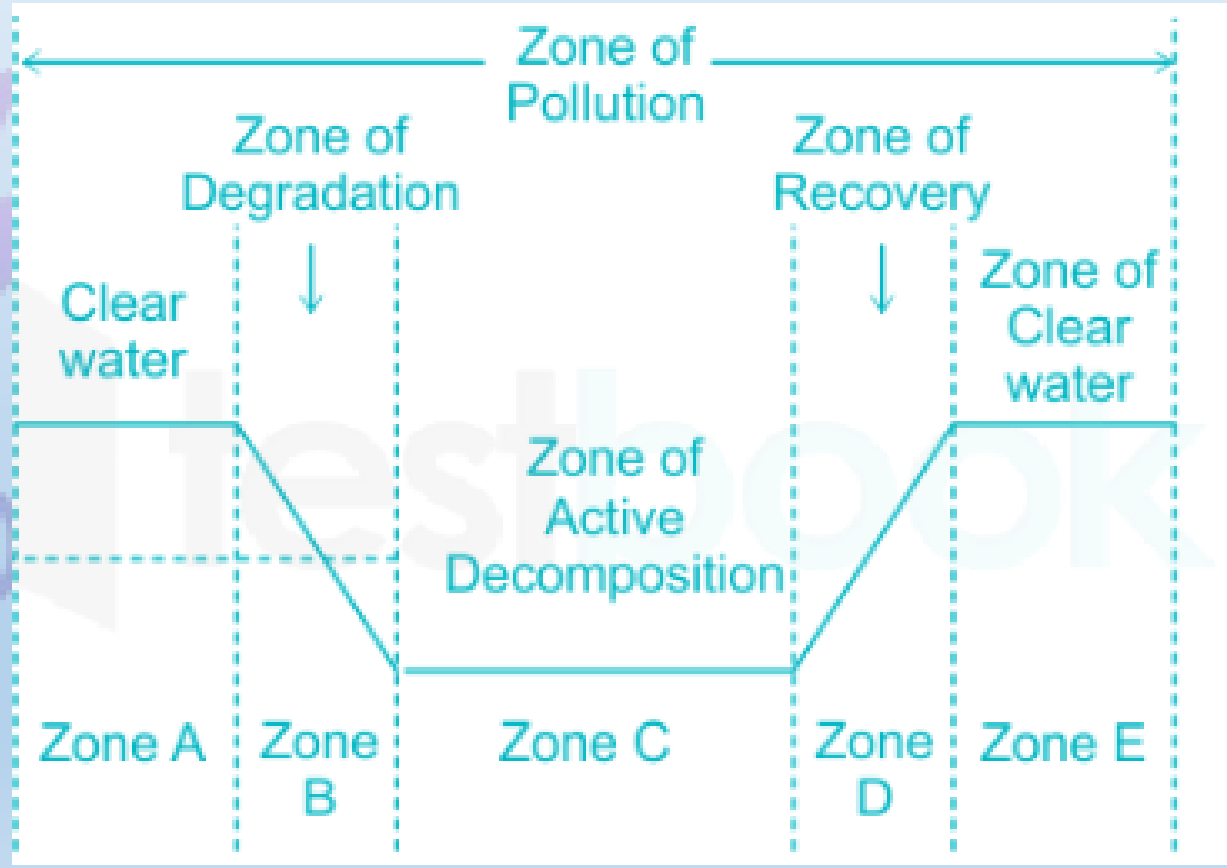
a) Grit basin
b) Grit channel
c) Detritus tank
d) all

The Langelier index is an indication of water's.....

a) Energy potential
b) Conductivity
c) turbidity
d) corrossiveness

If D.O. concentration falls down to zero in any natural drainage, it indicates the zone of

a) degradation
b) active decomposition
c) recovery
d) cleaner water
e) none of these



Assertion (A) : The determination of pH value of sewerage is important.

Reason (R) : The efficiency of certain treatment methods depends upon the availability of pH value.

a) Both A and R are true and R is the correct explanation of A
b) Both A and R are true but R is not a correct explanation of A
c) A is true but R is false
d) A is false but R is true

THANK YOU !