NEC license Exam Preparation

Chapter 6: Water Supply, Sanitation and Environment

DAY:5

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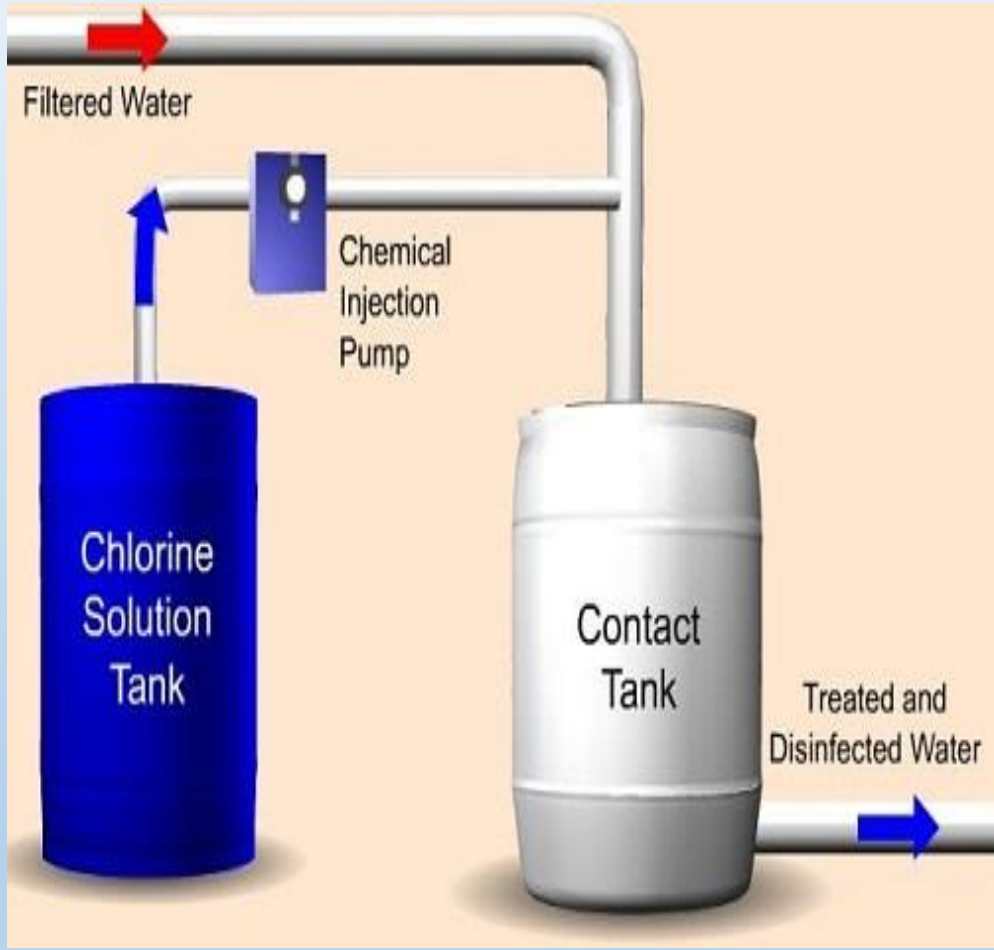
4. Disinfection

- After filtration, the next step of the water treatment process is disinfection.
- Disinfection includes the inactivation of pathogenic bacteria and other microorganisms that can cause diseases.
- This step is essential to control water-borne diseases.



Forms of Chlorines for disinfection;

1. Bleaching powder/hypochlorite form:

- It was used when chlorination was first introduced.
- It contains 30-35% chlorine.
- It is not stable when stored or exposed to air. (सिमेन्ट जस्तै property)
- HTH(HIGH TEST HYPOCHLORITE): 65-70%

2. Chloramines:

- Discovered to overcome the instability of bleaching powder.
- Ammonia is added to water before the addition of chlorine.

3. Chlorine:

- It can be applied in liquid, gaseous, or even solid form.
- It is the *most popular form.*

4. Chlorine Dioxide:

- Chlorine dioxide is more effective than chlorine to kill microorganisms.
- However, it is unstable, so only used in special water treatment processes.

5. Water Softening

- Water softening is done to make the water soft.
- Ground water is more hard than surface water.

1. Temporary hardness

i. Boiling:

$Ca(HCO_3)_2 \rightarrow CaCO_3\downarrow + H_2O + CO_2$

$Mg(HCO_3)_2 \rightarrow MgCO_3\downarrow + H_2O + CO_2$

ii. Clark's Method:

Calcium hydroxide is Clark's reagent.

$Ca(OH)_2 + Ca(HCO_3)_2 \rightarrow 2CaCO_3\downarrow + 2H_2O$

2. Permanent Hardness

i. By adding washing Soda:

- $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$

- $MgSO_4 + Na_2CO_3 \rightarrow MgCO_3 + Na_2SO_4$

ii. **Zeolite method/ion exchange method:**

- In this method, a Permutit called zeolite (Sodium Aluminum Silicate) is added to the water.

- $Na_2Al_2Si_2O_8 .xH_2O + Ca^{++} \rightarrow 2Na^{+} + CaAl_2Si_2O_8.xH_2O$
- REGENERATION?

6. Miscellaneous Treatments

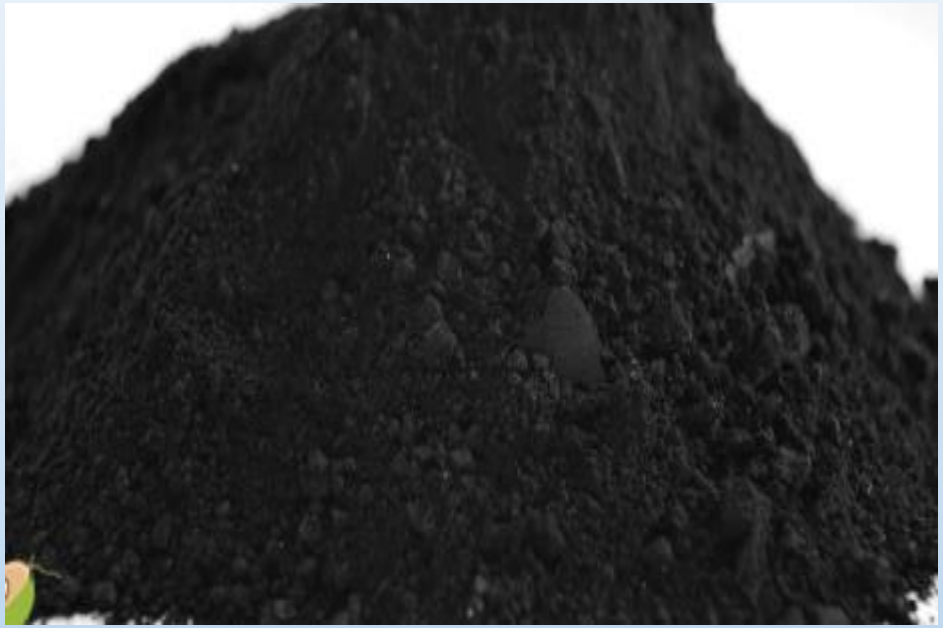
A. Removal of color, odor, and taste

1. Aeration

- In aeration, air and water are mixed intimately.
- It mostly removes the taste because of dissolved gases.
- Increase the dissolved oxygen content
- Removes H_2S gas thus removing the odour
- Decreases the CO_2 content and thus reduces the acidity/corrosion.

Other methods for removal of colour, taste and odour

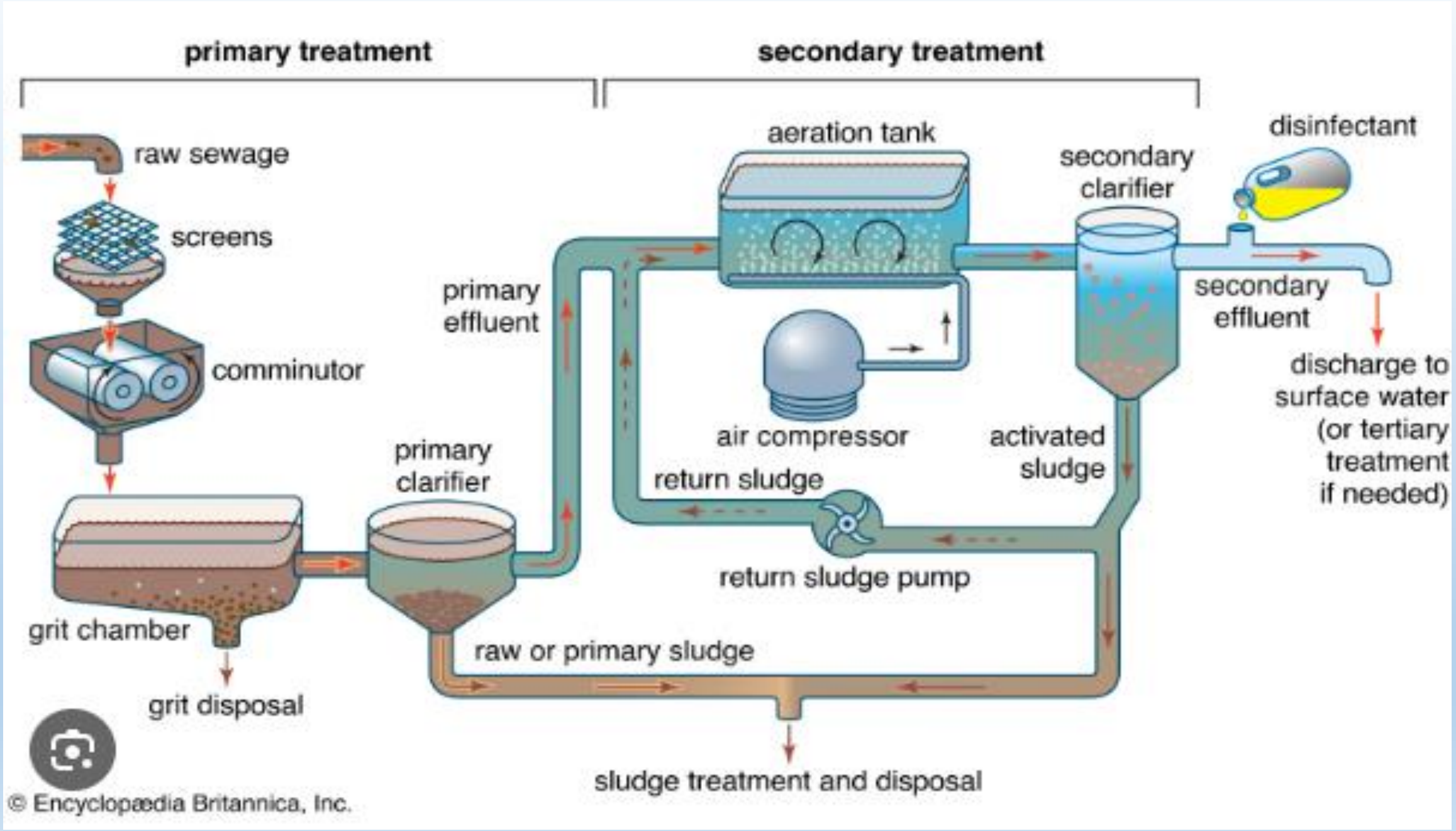
- CuSO4: also removes eutrophication.
- Activated carbon
- Sedimentation with coagulation
- Chlorination
- Ozone treatment
- Ion exchange method
- Removal of iron and manganese



6.5 Chapter Outline

Treatment and disposal of wastewater

- Characteristics and examination of sewage
- Decomposition of wastewater
- BOD and COD
- Primary treatment process and design of grit chamber
- Secondary or biological treatment process
- Sewage filtration
- Activated sludge process
- Oxidation ponds
- Waste water disposal by dilution (oxygen sag curve; Streeter Phelp's equation)
- Waste water disposal by land treatment
- Sludge and solid waste disposal methods
- Latrine and septic tank


primary treatment
secondary treatment
raw sewage
screens
comminutor
grit chamber
grit disposal
primary clarifier
primary effluent
aeration tank
air compressor
return sludge
return sludge pump
activated sludge
secondary clarifier
disinfectant
secondary effluent
discharge to surface water (or tertiary treatment if needed)
raw or primary sludge
sludge treatment and disposal
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Characteristics and examination of wastewater

a. Physical characteristics

b. Chemical characteristics

c. Biological characteristics

Physical characteristics

a. Color:

- Fresh sewage has light brown color
- With passage of time it changes into grey, dark grey and black

b. Odour

- Fresh sewage is odourless, but as the anaerobic decomposition progresses, smell of rotten egg is formed due to H2S.

c. Temperature:

- Excessive temperature of sewage indicates the mixture of industrial wastes.
- Avg temp. of sewage: around 20 degree C.
- *The dissolved oxygen content decreases with high temperature.*

d. Turbidity:

The sewage has varying degree of turbidity depending on colloidal, suspended and dissolved solids.

Chemical characteristics

a. pH:

- Fresh sewage is alkaline in nature (pH 7.3 to 7.5)
- With progress of time, the pH decreases due to formation of acids.

b. Nitrogen content

- They are available in the form of nitrogen gas, ammonia, ammonium compounds, nitrates , nitrites , proteins , etc.
- Dichloro diphenyl trichloroethane indicates excessive growth of algae.

Examination of wastewater

a. Turbidity :

- The turbidity is measured by the turbidimeters

b. Color : By naked eye/spectrophotometer.

c. Odour : By casual smelling. (Not for industrial waste)

d. Temperature: By thermometer

e. Solids :

- Volatile solids, fixed solids and total solids (By heating)
- For total solids, water is heated at temperature of 103 to 105 degree celcius for 24 hours
- For volatile and fixed solids water is heated to 600 degree celcius for 30 minutes

f. BOD : Dilution method is used

Decomposition of wastewater

The decomposition by bacteria can be classified as aerobic and anaerobic decomposition

Parameters	Aerobic decomposition	Anaerobic decomposition
Bacteria	Aerobic / facultative	Facultative / anaerobic
Use of dissolved oxygen	Yes	No
End products	Unobjectionable	Objectionable
Hydrogen converted into	Water	Methane
Carbon converted into	Carbondioxide	Methane
Nitrogen converted into	Nitrates	Ammonia
Sulphur converted into	Sulphates	Hydrogen sulphide
Phosphorus	Phosphates	Phosphene

BOD and COD

- BOD is the amount of oxygen required for micro-organisms to carry out biological decomposition under aerobic condition at standard temperature.
- BOD indicates the strength of sewage.
- BOD is measured in two stages:

1st stage BOD (carbonaceous BOD):

- Consists breaking down of carbonaceous matter.
- Lasts for 7 to 20 days
- Most of the BOD demand of wastewater

2nd stage BOD (nitrogenous bod):

- Consists breaking down of nitrogenous matter.
- Lasts for longer perioid
- Less than 1st stage BOD

1st stage BOD

- 5 day BOD is taken as standard Bod value
- Some expressions on BOD

$$L_t = L_0 10^{-Kt}$$

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

$$K_\theta = K_{20} * (1.047)^{\theta-20}$$

1.135 for θ<20°C

Where,

L_0	BOD remaining at t=0, Ultimate BOD
	Time
	BOD remaining at 't' time Or Oxygen e after time 't'
r BOD_t	BOD exerted at time 't'
	BOD constant (Base e)
	BOD constant (Base 10)
	Temperature

The relative stability of sewage is the ratio of the amount of oxygen available in sewage (dissolved form only) to the amount of oxygen required to satisfy the first-stage BOD of sewage. It is expressed in percentages.

Mathematically, it is given as:

$$S = 100(1 - (0.794)^{t_{20}})$$

$$S = 100(1 - (0.630)^{t_{37}})$$

Laboratory method of determination of BOD

- The water sample is taken.
- The sample is diluted with specially prepared dilution solution
- The DO present in diluted sample is found out
- The diluted sample is incubated at 20 degree celcius for 5 days
- After 5 days, the DO of sample is found out
- Loss of oxygen = Initial DO – Final DO
- BOD = Oxygen consumed x Dilution ratio

$$Dilution\ ratio = \frac{volume\ of\ diluted\ sample}{volume\ of\ undiluted\ sample}$$

If 2% solution of a sewage sample is incubated for 5 days at 20°C and depletion of oxygen was found to be 5 ppm, BOD of the sewage is

(a)200 ppm

(b)225 ppm

(c)250 ppm

(d)None of these

For discharging sewage and industrial effuents into stream, 5 day BOD at 20°C should not exceed

a) 30 mg/L
b) 50 mg/L
c) 100 mg/L
d) 200 mg/L

Say a raw waste water sample from a WWTP has 5-day BOD equals to 2000 mg/L (reaction constant k base e = 0.23/day at 20°C). Calculate value of ultimate BOD?

a) 1996 mg/L
b) 2826 mg/L
c) 2926 mg/L
d) 2000 mg/L

- The purpose of equalization tank in waste water treatment plant is to

a) Filter oils
b) Absorb fluctuation of flow rate
c) Equalize amount of organic matters
d) Remove sludge

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

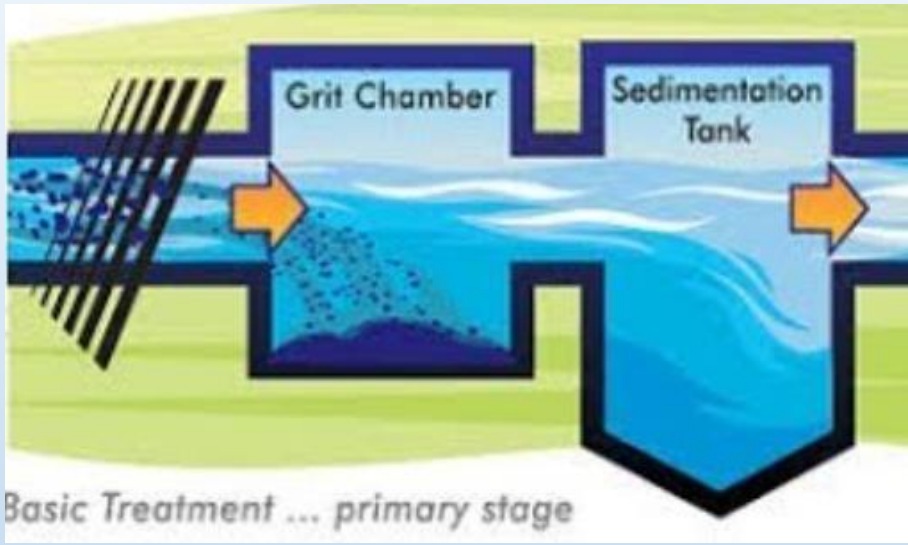
- Phenomenon of removing impurities from wastewater.
- Wastewater treatment can be broadly classified into following categories

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

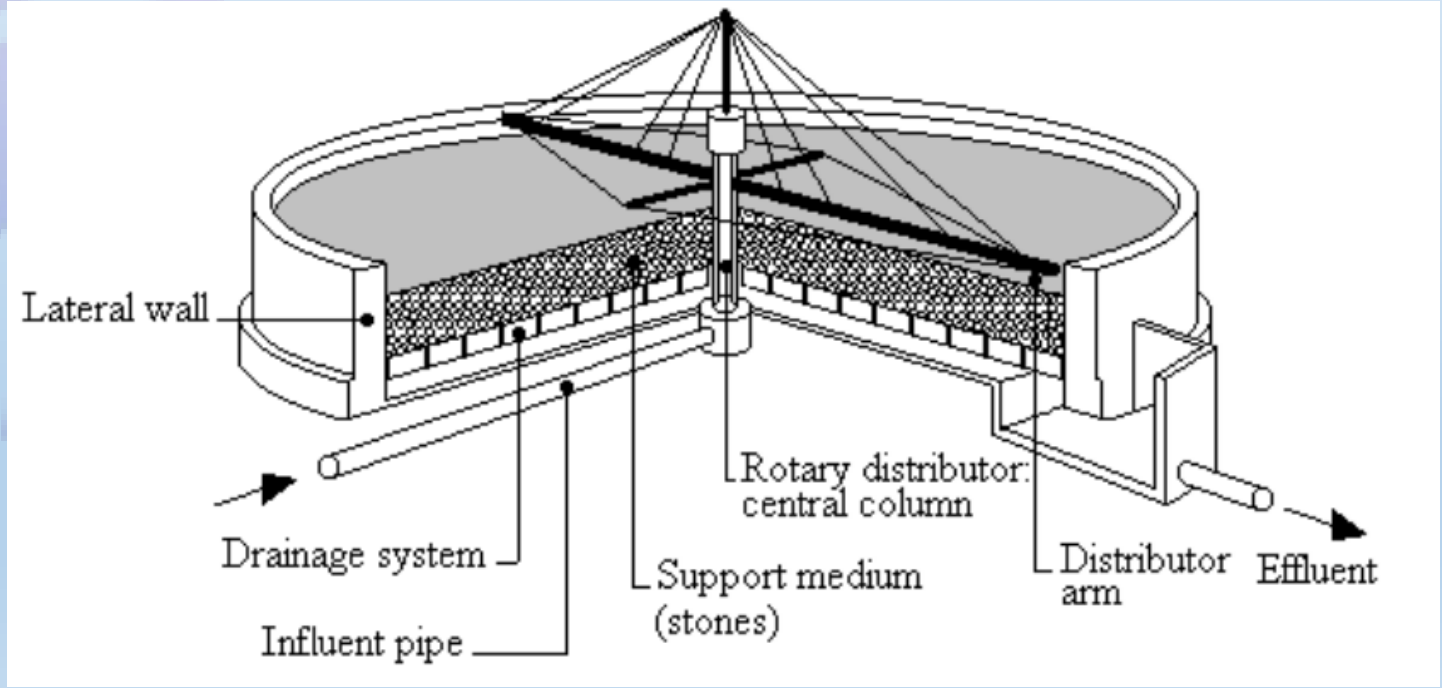
- Biological treatment of wastewater
- Consists of two process

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):

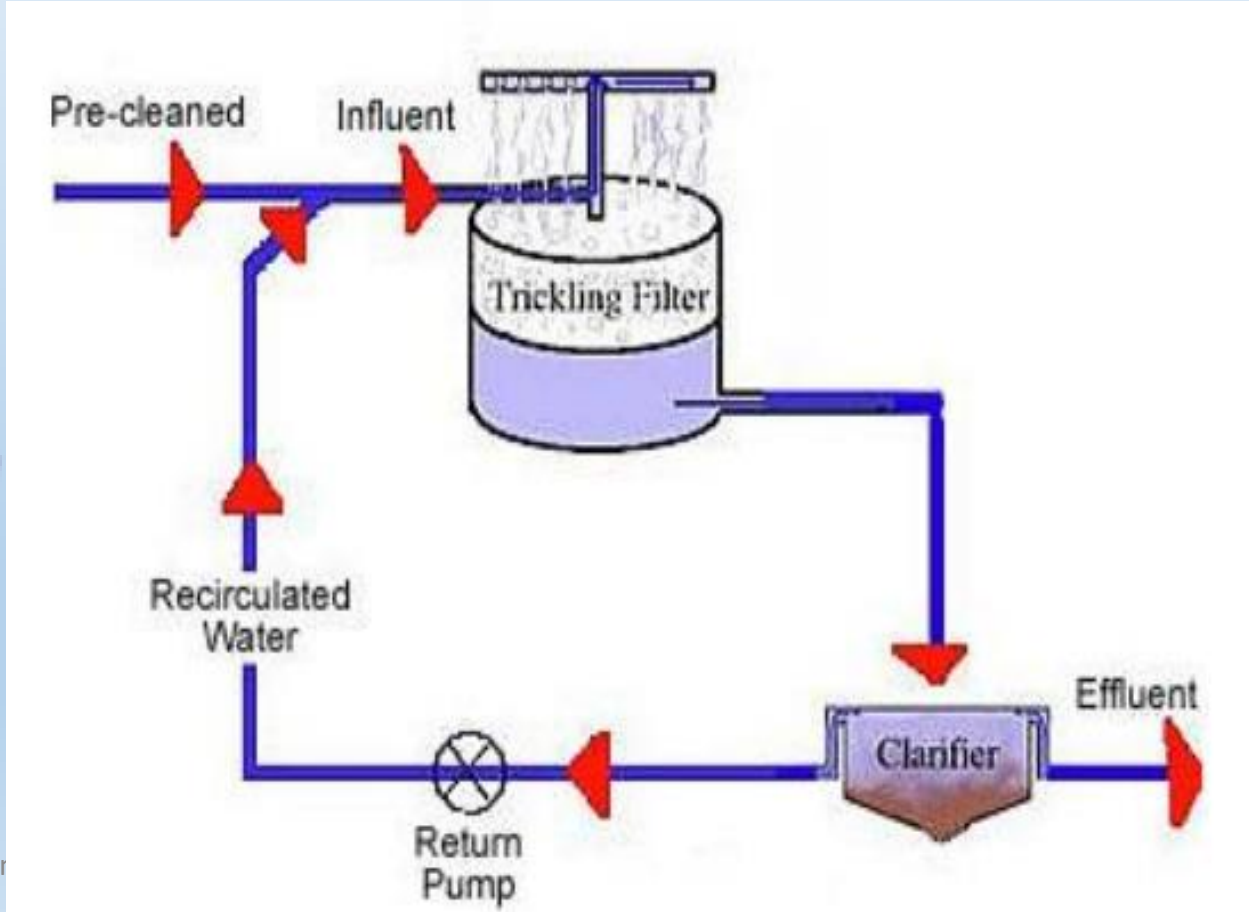
- No recirculation of water

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

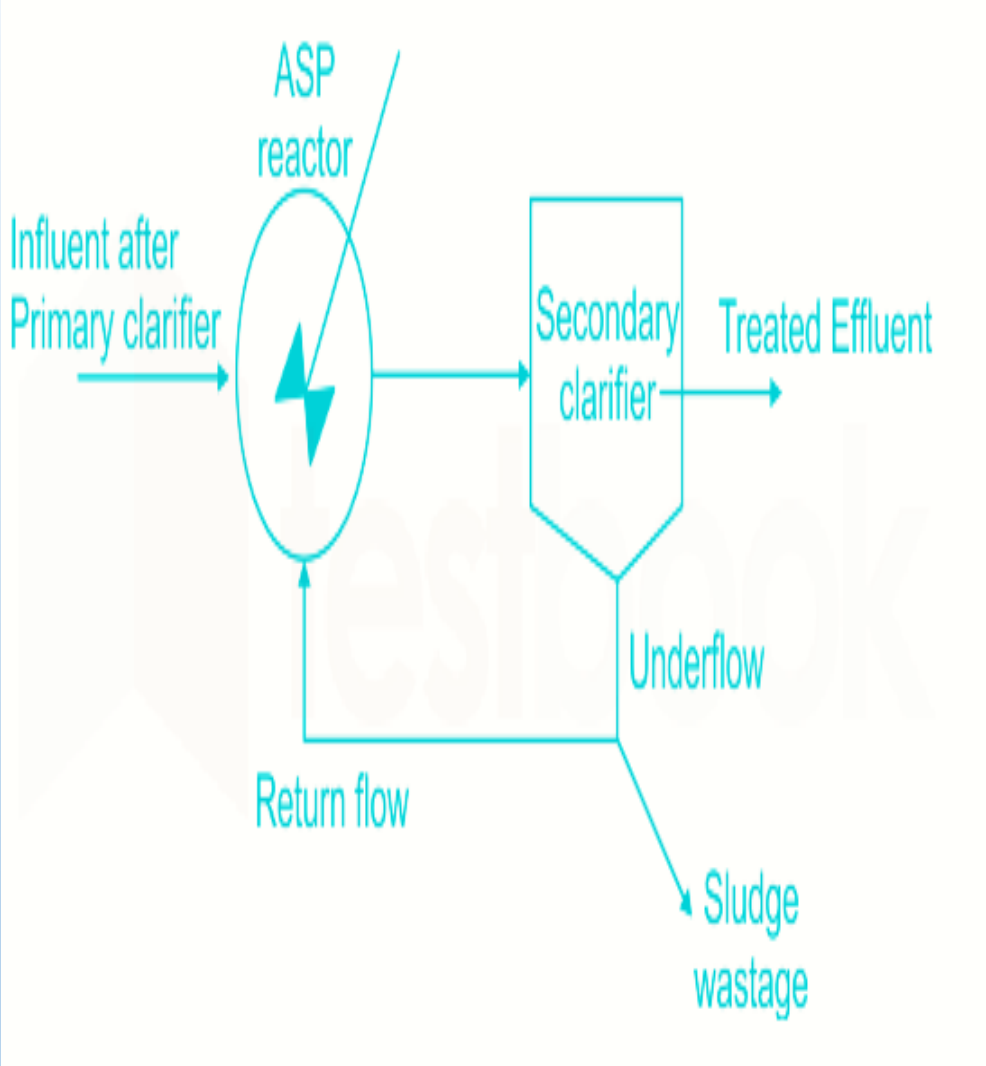
b) 2

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 :

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

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)

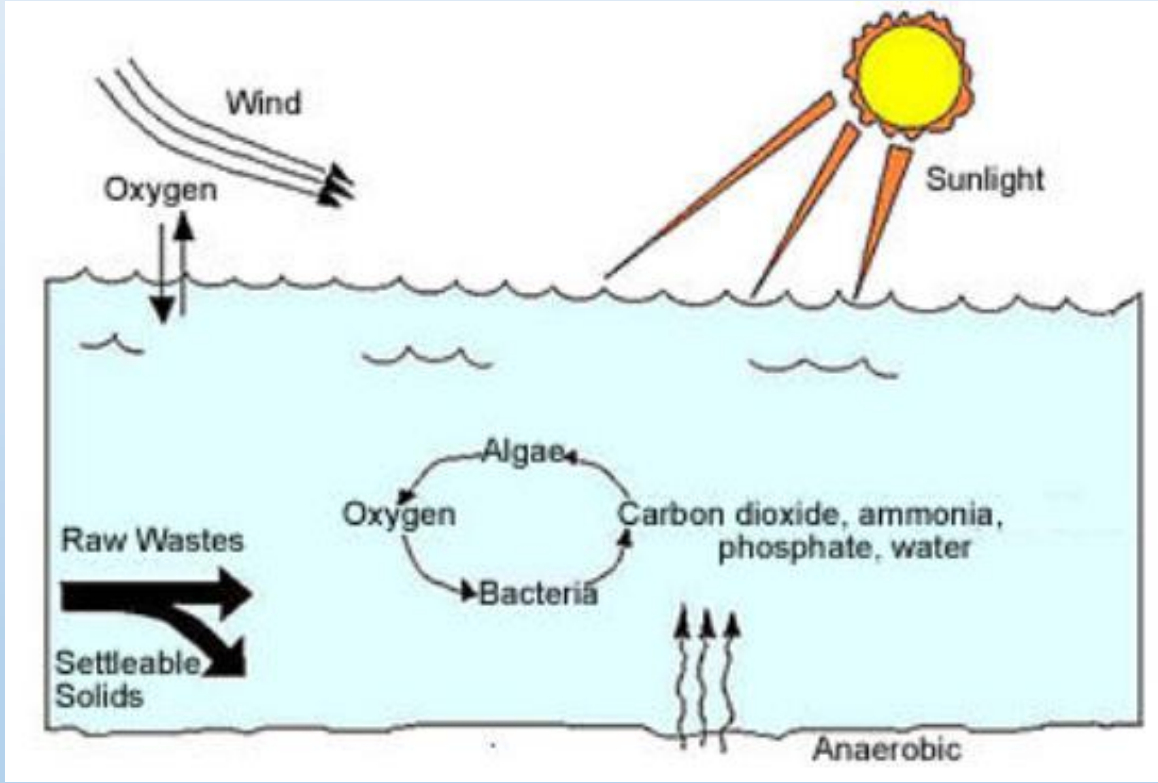
If a sludge has greater SVI value then it is considered as

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

Sludge bulking?

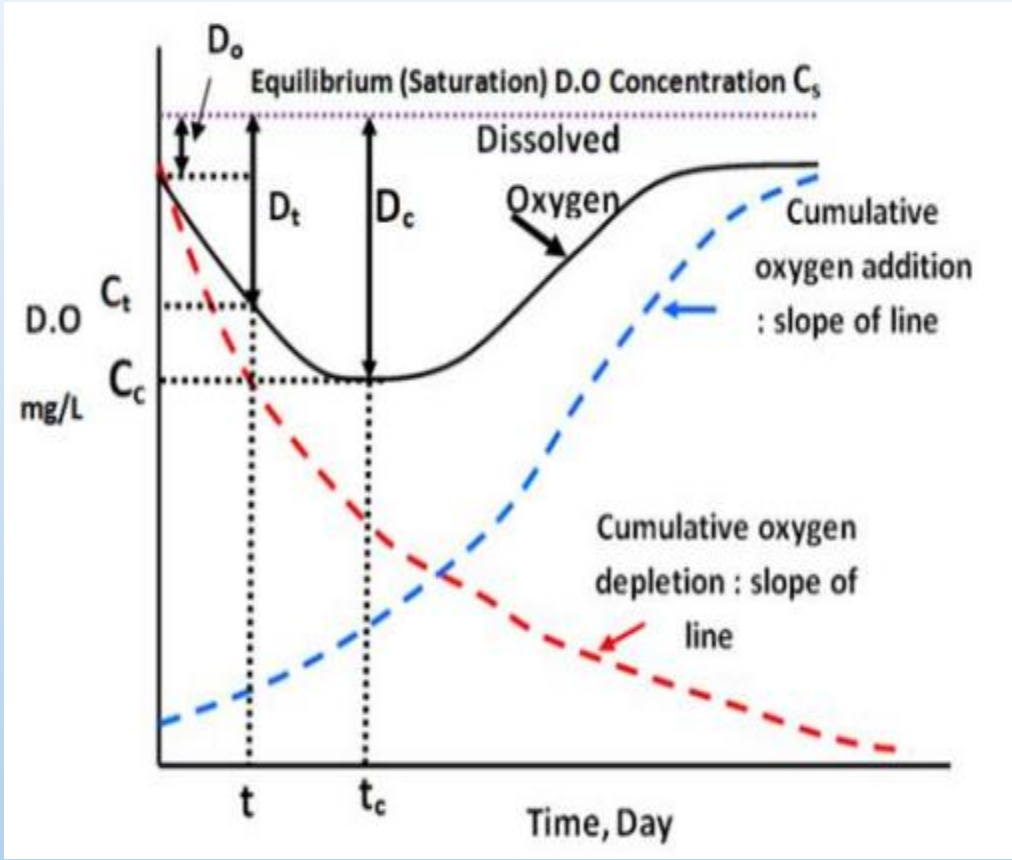
Oxidation pond

- 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

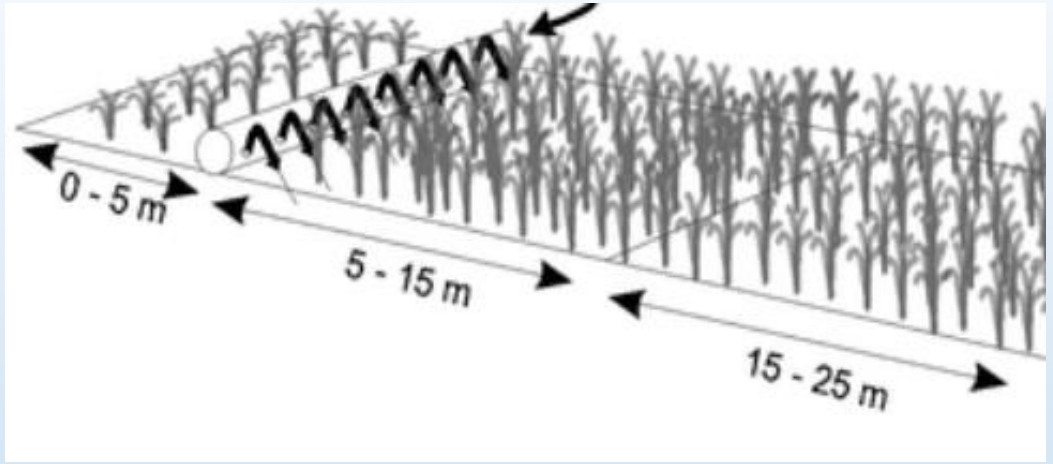
- Method of waste water disposal by controlled application of waste water into land
- Following methods can be used for waste water disposal

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

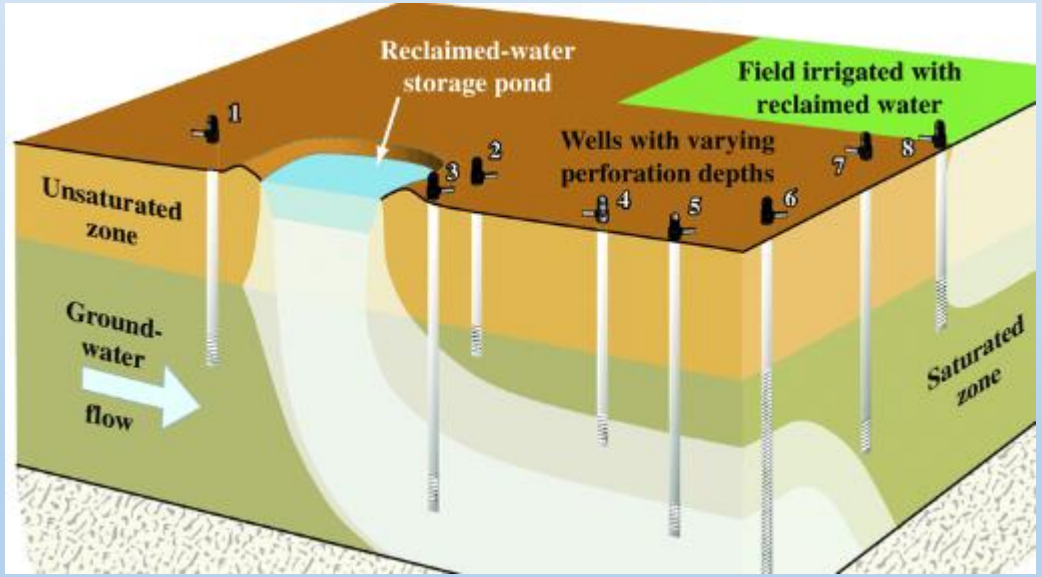
B. Overland flow

- 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.

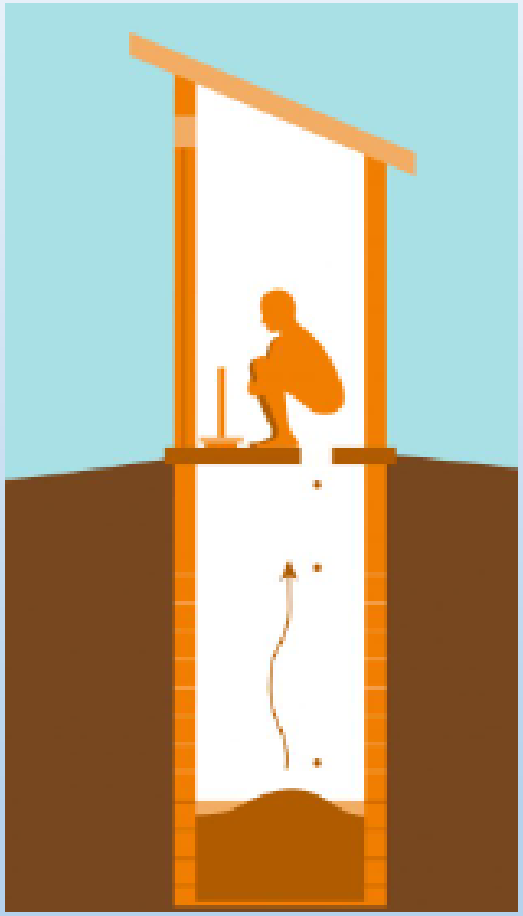
D. Land filling

- 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

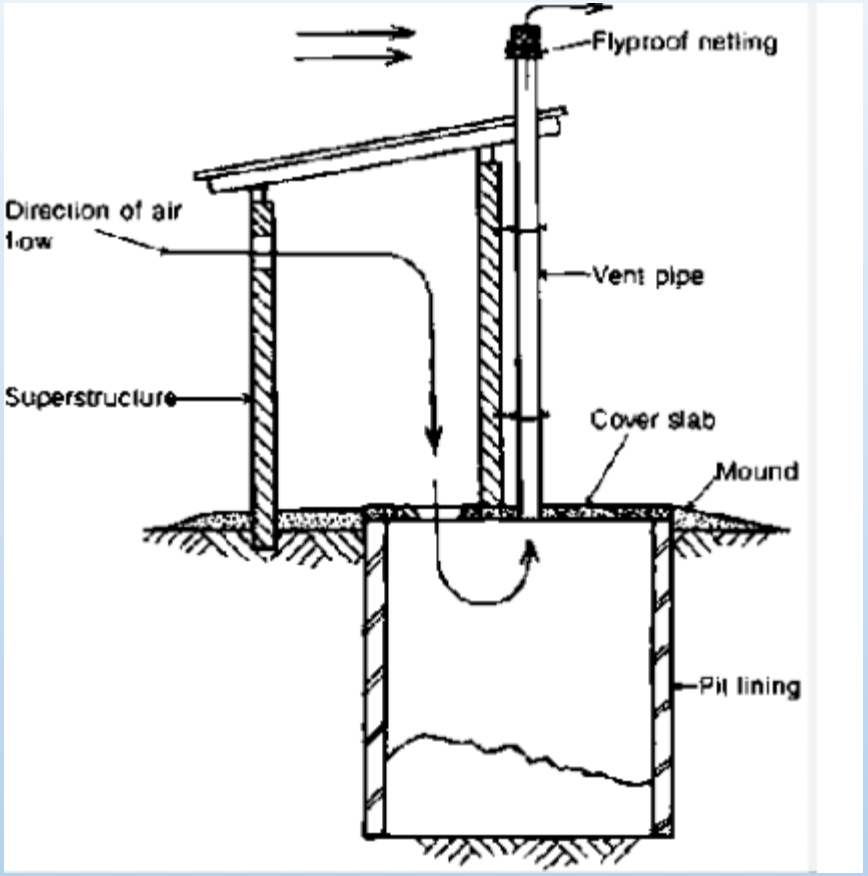
A. Pit privy

- 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:

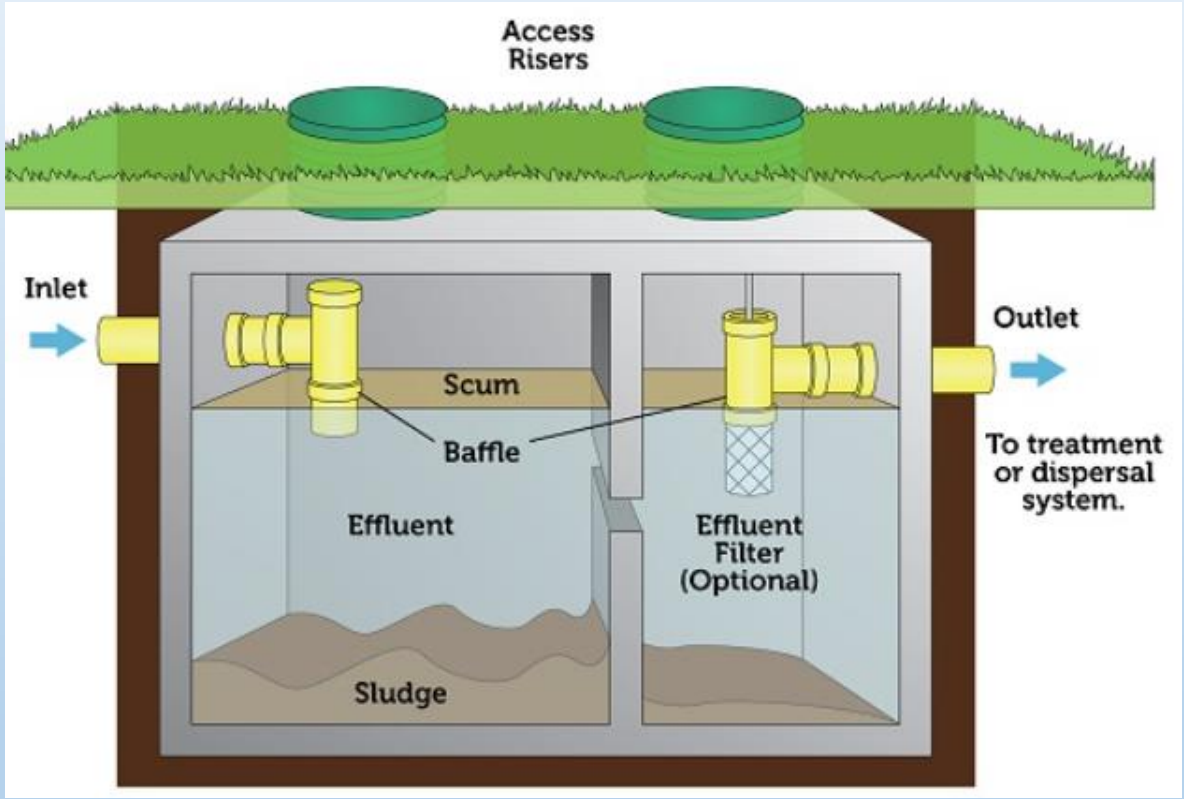
a. Volume for sewage settlement

$V1 = NxQxT$

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

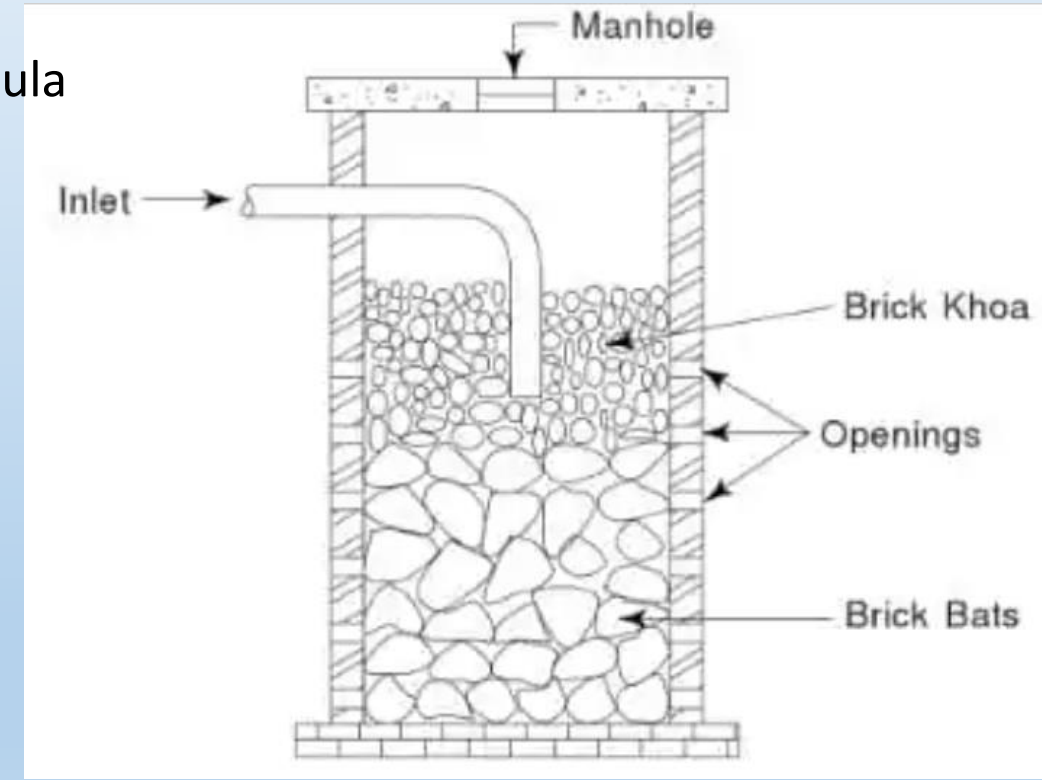
$$D = \frac{Q}{\pi H I}$$

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

Study the given statement with respect to unit operations employed in water treatment and select the correct answer

Statement A: Objectionable gases such as carbon dioxide and hydrogen sulphide present in water can be removed by bubble aeration technique.

Statement B : Chemical coagulation technique removes only the colloidal impurities present in water but not the suspended impurities.

1. Statement B is correct, but A is incorrect
2. Statement A is correct, but B is incorrect
3. Both the statements are correct
4. Both the statements are incorrect

Select the correct option with regard to the activated sludge plant.

1. Activated sludge process offers secondary treatment with minimum area requirement, and effluent of high quality is one of the disadvantages.

2. The advantages of activated sludge plants are that they are easy to operate and do not require supervision.

1. Both are correct.
2. Both are incorrect.
3. Statement 1 is correct, and statement 2 is incorrect.
4. Statement 1 is incorrect, and statement 2 is correct.

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.

TOD for 300 mg/l of glucose is…..mg/l

a) 320
b) 360
c) 340
d) 300

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

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

If the quantity of sludge with moisture content of 97% is x litres, then the quantity of sludge with moisture content of 94% will be…… litres

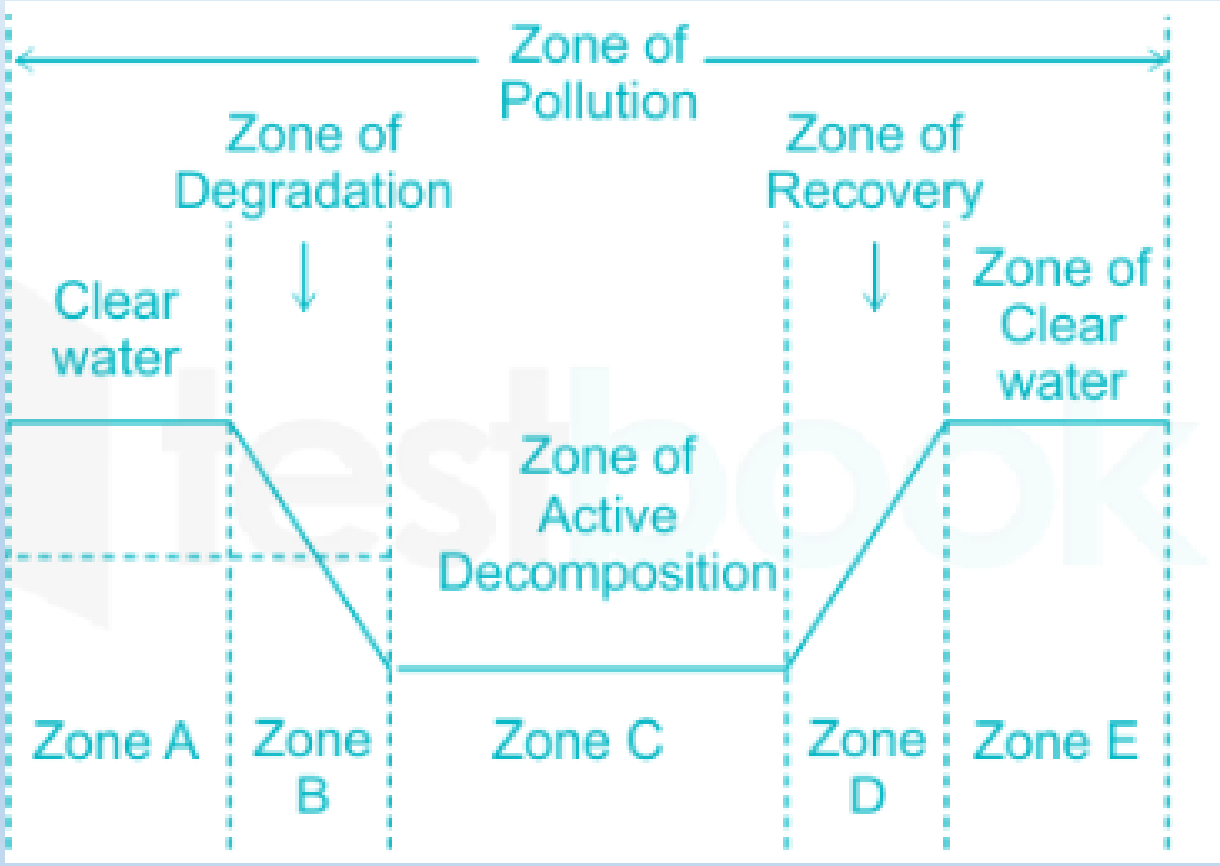
a) x/2
b) x/3
c) 2x
d) 3x

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 !