Wastewater Engineering (Environmental Engg.-II)

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Achievement:

- **Selected Scientist, NEERI-CSIR, Govt. of India.**
- **GATE Qualified Three Times.**
- **UGC - NET Qualified in First Attempt.**
- **In 2020, Recognized by SWAYAM, NPTEL & IIT:**

  1) Discipline Star 2) NPTEL Believer 3) NPTEL Motivated Learner

- **Topper of PhD Course Work at UGC-HRDC, RTMNU Nagpur.**
- **Selected Junior Engineer, ZP Washim.**
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  1) Assistant Professor, PCE, Nagpur.

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UNIT-III

1) Characteristics of wastewater.

2) Flow sheet of conventional sewage treatment plant.

3) **Preliminary & Primary Treatment:** Screens, Grit chambers, Primary settling tank. Design of bar screens, Grit chambers and Primary settling tanks**.**

Types of Wastewater According to Strength :-

1) Strong sewage:
2) Medium sewage:
3) Weak sewage:

Strength of wastewater is expressed in terms of pollution load

Parameter	Strong Sewage	Medium Sewage	Weak Sewage
COD	1000 mg/L	500 mg/L	250 mg/L
BOD	400 mg/L	200 mg/L	110 mg/L
TS	1200 mg/L	750 mg/L	350 mg/L
SS	350 mg/L	200 mg/L	100 mg/L
DS	300 mg/L	200 mg/L	70 mg/L

TABLE 8.1 TYPICAL COMPOSITION OF DOMESTIC WASTEWATER.

	Constituent		*Concentration*		
			Strong	*Medium*	*Weak*
1.	Solids : Total	(mg/l)	1200	720	350
	Dissolved, total	(mg/l)	850	500	250
	Fixed	(mg/l)	525	300	145
	Volatile	(mg/l)	325	200	105
	Suspended, total	(mg/l)	350	220	100
	Fixed	(mg/l)	75	55	20
	Volatile	(mg/l)	275	165	80
2.	Settleable solids	(mg/l)	20	10	5
3.	Biochemical oxygen damand (BOD_5, 20°C)	(mg/l)	400	220	110
4.	Total organic carbon (TOC)	(mg/l)	290	160	80
5.	Chemical oxygen demand (COD)	(mg/l)	1000	500	250
6.	Nitrogen (total as N)	(mg/l)	85	40	20
	Organic	(mg/l)	35	15	8
	Free ammonia	(mg/l)	50	25	12
	Nitrites	(mg/l)	0	0	0
	Nitrates	(mg/l)	0	0	0
7.	Phosphorus (Total as P)	(mg/l)	15	8	4
	Organic		5	3	1
	Inorganic		10	5	3
8.	Chlorides	(mg/l)	100	50	30
9.	Alkalinity (as $CaCO_3$)*		200	100	50
10.	Grease	(mg/l)	150	100	50

*Depends upon its amount in domestic water supply.

Effluent Standards for Disposal :

	PCB		EPA		WHO
Parameter	Water body	Land	Water body	Land	Land
COD	-	-	-	-	250
BOD	30	100	20	100	100
TS	-	250	400	1000	1000
SS	40	100	25	50	100
pH	6-9	6-9	6-9	6-9	6.5-8

Need of study of characteristics of wastewater ?

Information about strength, composition & characteristics of wastewater is important in the design of treatment system & the amount of pollutants to be removed up to prescribed level set by the local authority.

Characteristics of Wastewater:-

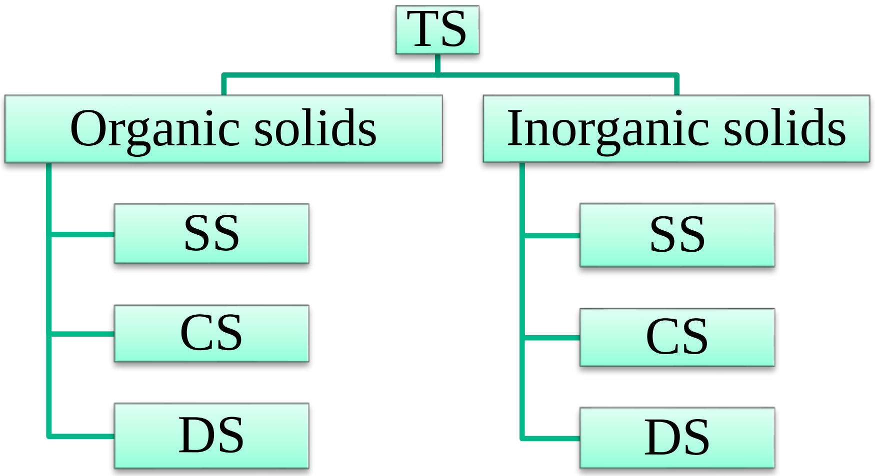
Wastewater contains organic & inorganic matters which may be suspended, colloidal & dissolved form.

- **Characteristics depends on**
  1) Source of generation
  2) Quality of water used
  3) Culture of population
  4) Conservation practice
  5) Types of industries present
  6) Treatment given by industries

- **The characteristics can be classified as:**
  1) Physical
  2) Chemical
  3) Biological

Solids :-

➢ Very small amount of solids in relation to huge amount of liquid (99.9% water & 0.1% solids)



Color :-

1) It can be detected by the naked eye
2) Yellowish, Grey, or light Brown color indicates fresh sewage.
3) The color of the septic & stale sewage is more or less black.
4) The color of the Industrial sewage depends on the chemical process used.

Odor :-

1) Fresh sewage has a slightly soapy or earthy or oily odor.
2) After 3 to 4 hour sewage start omitting offensive odors.

Temperature :-

1) The temp. is slightly higher than the water
2) The avg. temp. of sewage is 37^0 c in India & 20^0 c in US.
3) Addition of Industrial sewage increases the temp.
4) Change in temp. affects the Bacteriological activities, treatment system, self purification of stream & aquatic life.

BOD :-

The amount of oxygen required for microorganisms to carry out biochemical decomposition of biodegradable organic matter under aerobic conditions at specified temp. & duration.

BOD_5 at 20^0C= 68% of total BOD

BOD_5 at 37^0C= 70% of total BOD

The consumed oxygen is related to the amount of decomposable organic matter.

Aerobic decomposition of organic matter is done in two stages carbonaceous and nitrogenous stage.

The first stage BOD is about 90% of the total BOD.

COD :-

1) The amount of oxygen required for chemical oxidation with help of strong chemical oxidant.
2) Determine in 3 to 5 hours.
3) Toxic metal can’t interfere with COD test like BOD test.
4) Useful in determining the strength of industrial wastewater.
5) COD are generally higher than BOD values.
6) COD/BOD of typical sewage =1.25 to 2.5.
7) Higher ratio indicate the sewage is difficult to biodegrade.

pH:

1) The pH value indicates the –ve log of hydrogen ion conc. present.
2) Indicator of the alkalinity of sewage.
3) A very high or low pH indicates of Industrial wastewater.
4) The activities of some microorganism are more in a specific pH value & similarly the chemical precipitation also depends on pH value.
5) Fresh & treated sewage is alkaline and partially treated sewage is acidic.

Other parameters

1) Oil & grease
2) Nitrogen
3) Chloride
4) Heavy metals
5) Gases like oxygen, methane , hydrogen sulfide, etc.

Biological Characteristics:

- Related to the presence of microorganisms.
- The presence of pathogens indicates the degree of pollution.
- The presence of microorganisms affects the self purification of water

1. **Bacteria**: convert the complex organic matter into simpler form.
2. **Algae:** utilize the radiant energy, & absorb CO_2 and release oxygen by photosynthesis.
3. **Fungi**: fully depended on organic matter for obtaining their energy.
4. **Protozoa**: bacteria eaters and destroy the pathogens.

Significance of BOD :-

1) Determining the strength of sewage.
2) Help in selection of required treatment methods.
3) To know the amount of treatment required for disposal.
4) Help in comparing various results, analysis & test.

Determination of BOD :-

1) Sample is diluted in 1:100 ratio
2) First determine the DO in diluted sample before incubation.
3) Keep the diluted sample in incubator at temp. 20^oc for 5 days.
4) Again determine the amount of DO after incubation.
5) Now difference between two is the amount of oxygen consumed by the sewage ie BOD_5 at 20^oc.

Limitation of BOD Test :-

1) Essential to have a high concentration of active bacteria present
2) Sample should not contain toxic waste.
3) The effects of nitrifying organisms should be reduced before BOD test.
4) Measure only the biodegradable organic matter.
5) Long time is required.
6) Utilization of soluble organic matter also affects the BOD determination.

Treatment of Wastewater :-

- Procedure of partial or complete removal of excessive impurities from wastewater for final disposal or suitable reuse.

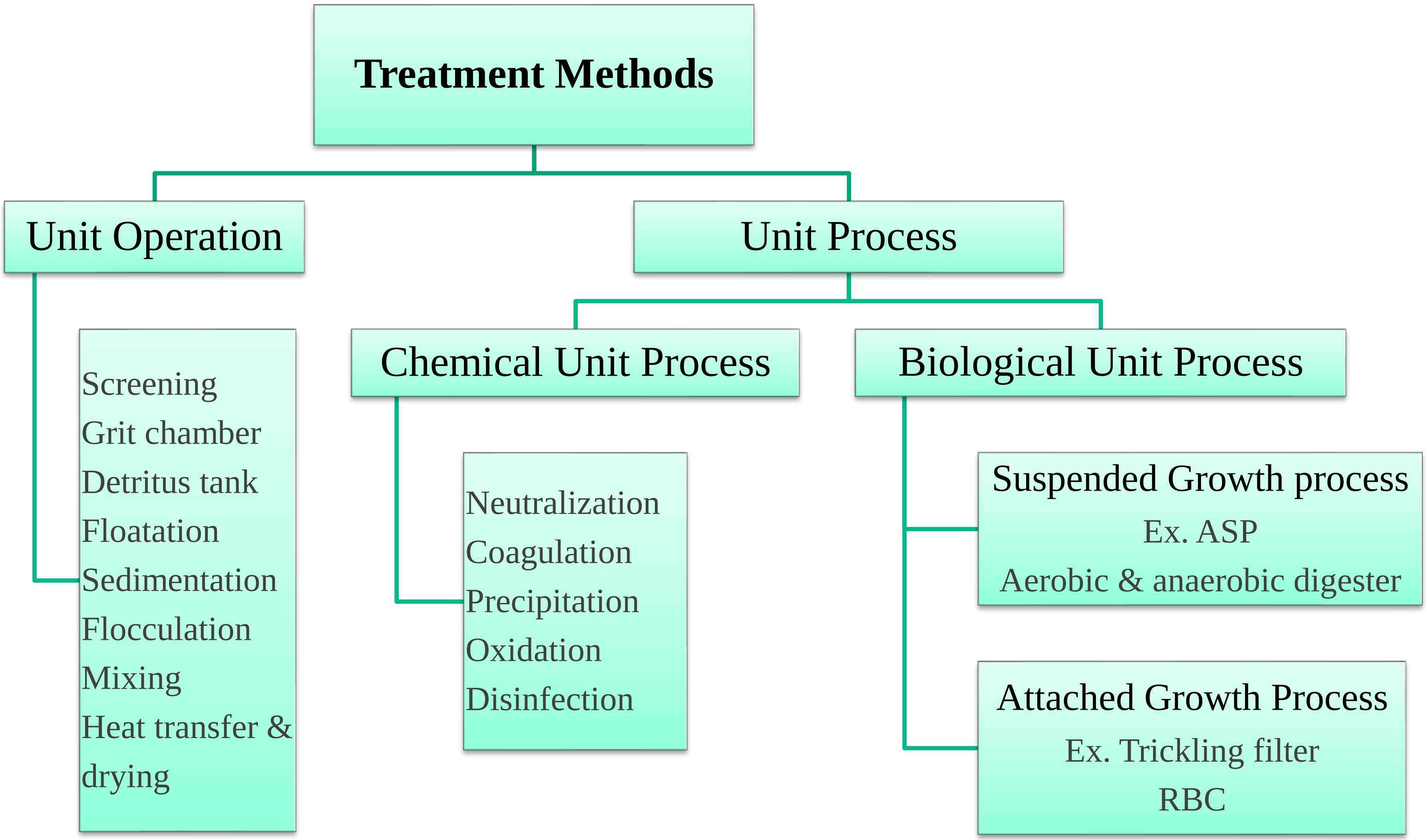
Need of Treatment :-

1) If the quantity of sewage is more then receiving water body will be polluted or land will be sewage sick because of limited self purification capacity of nature.
2) Discharge of large volume high strength sewage affects the environment adversely.
3) Therefore it is necessary to treat the sewage before disposal.

Objective of Treatment of Wastewater:

1) The main objective is to remove nuisance causing excessive impurities so that sewage can be safely discharged or reused.
2) Should not create unhealthy or unhygienic conditions.
3) Should not pollute the water body.
4) Should be useful for agriculture or any other purpose without any adverse effect.
5) All pathogenic bacteria should be killed.

Classification of Treatment Methods :-



Unit operation is the method in which physical forces are predominant

Unit Operations :-

- The removal of contaminates is brought about by application of physical forces or physical forces predominate.
  1) Screening
  2) Mixing
  3) Grit chamber
  4) Detritus tank
  5) Sedimentation tank
  6) Floatation
  7) Flocculation
  8) SDB

Unit Processes :-

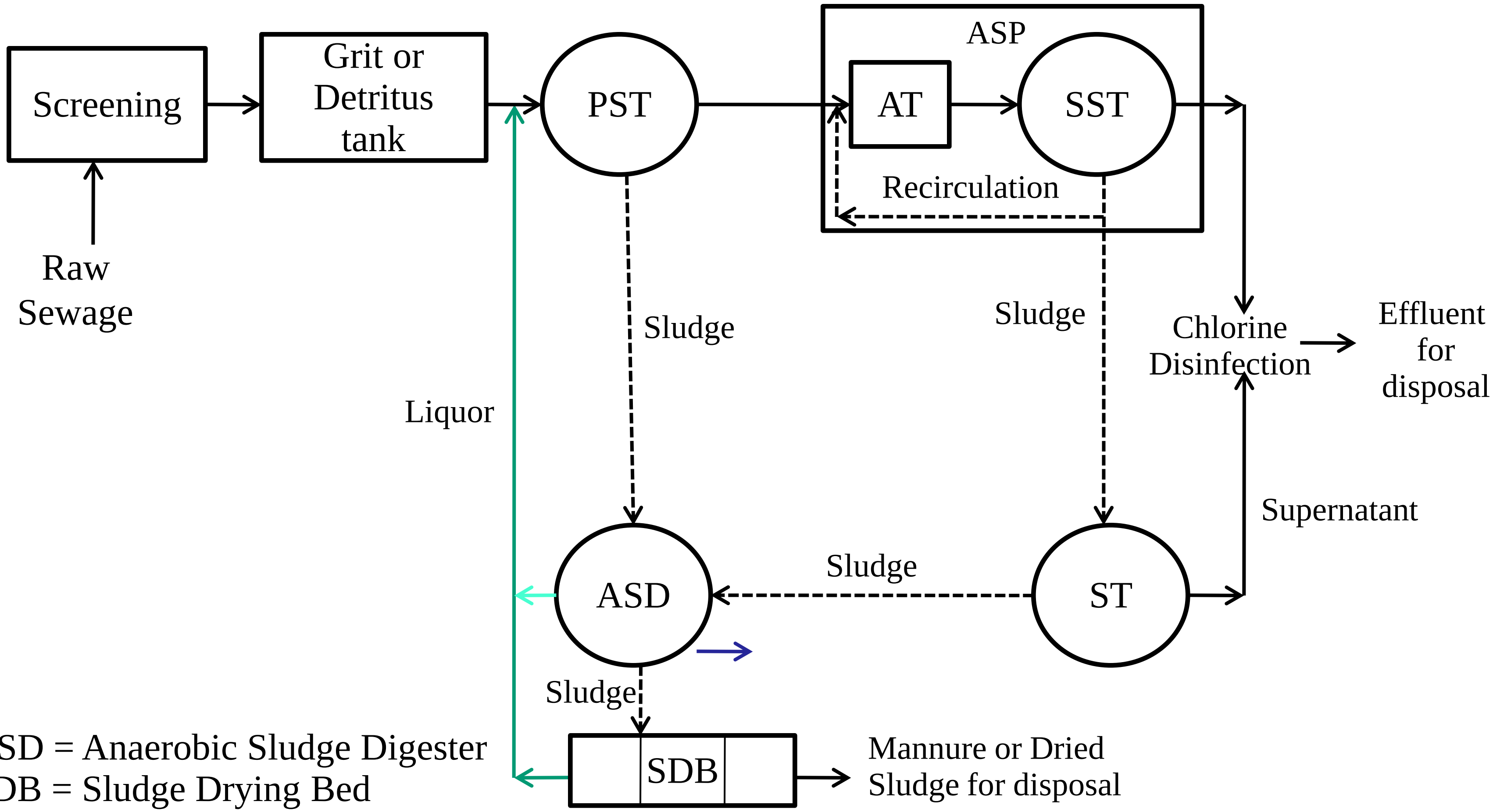
- The removal of contaminates is brought about by chemical or biological reaction
- Based on type of agent used they are again classified

1. **Chemical Unit Process:** reduction or removal is brought about by chemical reaction by adding chemicals.
2. **Biological Unit Process:** reduction or removal is brought about by microorganisms.

A. **Suspended Growth Process:** The microorganisms are maintained in suspension by appropriate mixing technique. Ex. ASP, Lagoons, Oxidation ponds, Anaerobic digester, etc.

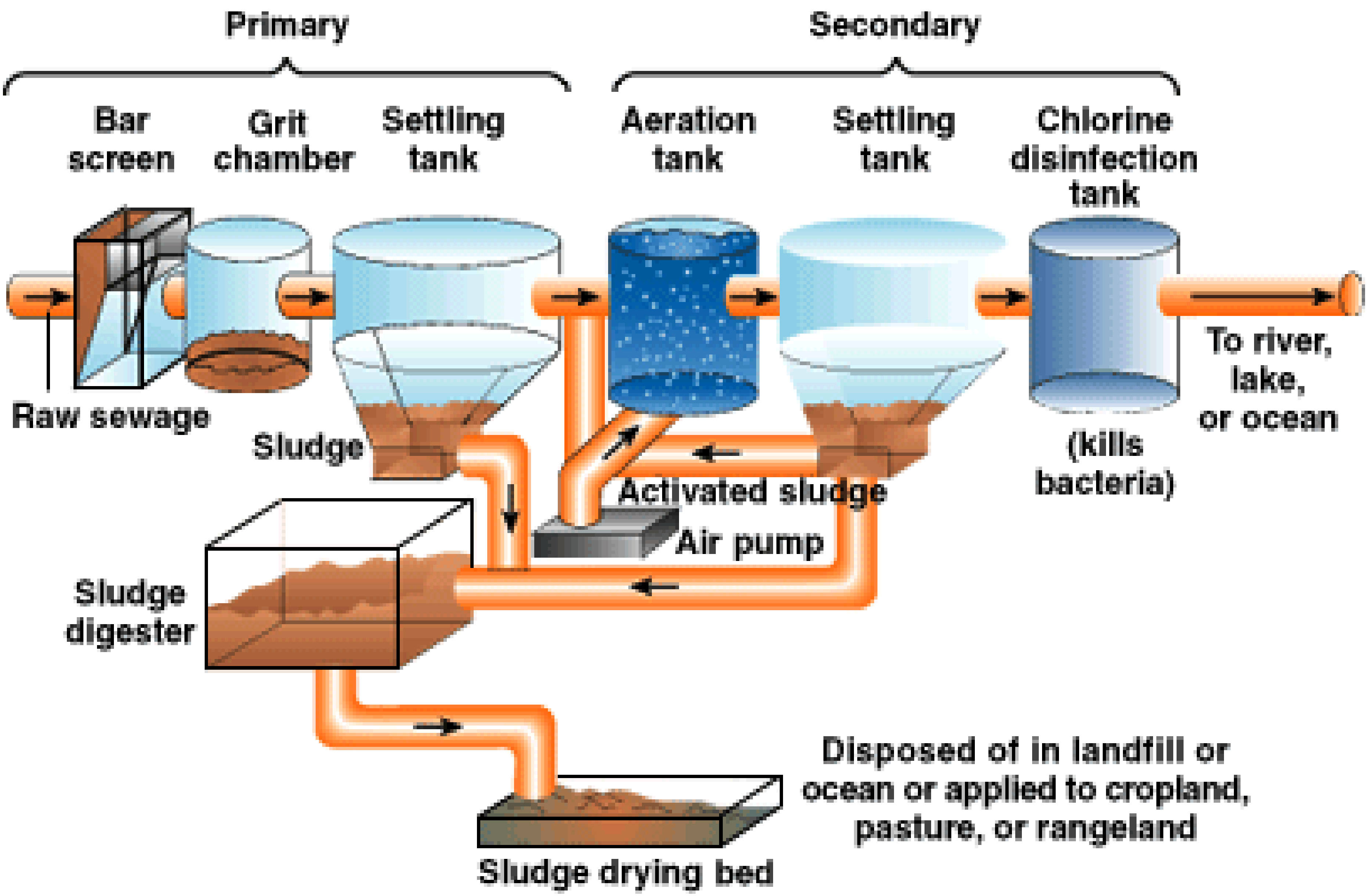
B. **Attached Growth Process:** The microorganisms are attached to an inert packing materials Ex. Trickling Filter, RBC, etc.

Schematic Flow Diagram of a Typical Conventional Sewage Treatment Plant



ASD = Anaerobic Sludge Digester
SDB = Sludge Drying Bed
AT = Aeration Tank
ASP = Activated Sludge Process
SST = Secondary Sedimentation Tank
PST = Primary Sedimentation Tank
ST = Sludge Thickner

The Wastewater Treatment Process



Functions of Treatment Units:-

- **Sump & Pump Well:-** To collect wastewater in sump well & to pump the sewage to treatment units from pump wells.
- **Approach Channel:-** To dampen the wastewater flow before it is applied to subsequent treatment units so that wastewater flow remain as uniform as possible in the following units.
- **Screen Chamber:-** To remove large size & floating material in wastewater. To protect the following units getting damaged by abrasion & clogging.
- **Grit Chamber:-** To remove small & heavy inorganic solids (size 0.2 mm & specific gravity 2.6) from the wastewater.
- **Skimming Tank:-** To collect & remove lighter particles, oil & grease from wastewater. (Oil & Grease Trap)
- **Detritus Tank:-** To remove heavy organic & inorganic natter from wastewater.
- **Primary Settling Tank / Sedimentation Tank:-** To remove fine suspended inorganic & settleable organic solids.

Functions of Treatment Units:-

- **Biological Treatment Units:-** To remove colloidal & soluble organic solids by aerobic & anaerobic process.

- **Secondary Sedimentation Tank / Settling Tank:-** To allow the microorganisms and other solids to settle & segregate sludge from wastewater.

- **Sludge Thickener:-** To thicken the biological or settled sludge by separation or removal of liquid or moisture content.

- **Sludge Digester:-** To treat the sludge by stabilizing before final disposal. To reduce the amounts of sludge to dewater or dispose.

- **Sludge Drying Bed:-** To dry & reduce the volume of the treated sludge by dewatering before final disposal.

Treatment System :-

- The type of combination used from the available unit operation and processes for treatment of a particular wastewater is known as the treatment system.

Types of treatment system:

1. Preliminary Treatment
2. Primary Treatment
3. Secondary Treatment
4. Tertiary or Advanced or Final Treatment

Preliminary Treatment :-

- To remove floating material, large size particles & heavy inorganic contents of wastewater that cause operational problems in primary & secondary treatment.
- It is also known as **pretreatment** in conventional treatment system.
- The preliminary Treatment includes:
  1. Screen Chamber: to remove large size floating materials.
  2. Grit Chamber: to remove grit & sand.
  3. Skimming tank: to remove oil & grease.
  4. Detritus Tank: to remove heavy organic & inorganic matter

Primary Treatment :-

- To remove settleable suspended solids.
- The preliminary treatment unit as well as primary settling tank are included in the primary treatment system.
- Primary settling tank is also known as primary clarifier.
- Removal of organic matter in conventional treatment takes place in two steps.
- The settleable suspended organic matter is removed by PST while colloidal & soluble organic fraction is removed in secondary treatment system like SST.

Secondary Treatment :-

- To remove colloidal & soluble organic matter.
- Biological processes are used to remove remaining contents.
- Different treatment units are available:

1. ASP
2. Trickling filter
3. SST
4. RBC
5. Oxidation Pond or Waste Stabilization Pond
6. Oxidation Lagoons or Aerated lagoons
7. Oxidation ditches

Tertiary Treatment :-

- To remove the concentration of residual impurities after secondary treatment.
- Heavy Metals, Nutrient, TDS, etc
- Used for treatment for industrial wastewater.
- Very expensive.
- Different treatment units are available:

1. Ultra and Micro Filtration
2. Ion Exchange
3. Reverse Osmosis
4. Electro dialysis
5. Adsorption
6. Chemical Precipitation
7. Nitrification / Denitrification

Selection of Treatment System :-

- Mainly depends on the quality of raw wastewater and degree of treatment required.
- Other factors:
    1. Availability of fund & land
    2. Availability of equipment
    3. Availability of skilled labor
    4. Topography of land

Points to be Considered While Selecting Site of Treatment Plants :-

1) Availability of foundation strata should be good.

2) Slope of the ground.

3) Site should be at Lowest area of the city.

4) Availability of area for future.

5) Safe from floods.

6) Near from city.

7) Subsoil water level remain low even during mansoon.

8) Situated on the leeward side of wind.

Points to be Considered During Design of Treatment System/Plant :-

1) Design period should be taken between 15-20 years
2) Design should be done on the avg. domestic flow plus max industrial flow
3) More number of smaller units
4) Self cleansing velocity
5) Economical
6) Easy in maintenance and flexible in operation
7) By-pass should be provided

Effects of Impurities :-

1) **Suspended solids** – can cause sludge deposits and anaerobic conditions in the environment

2) **Biodegradable organics** – can cause anaerobic conditions in the environment

3) P**athogens** – transmit disease

4) **Nutrients** – can cause eutruphication

5) **Heavy metals** – toxicity to biota and humans

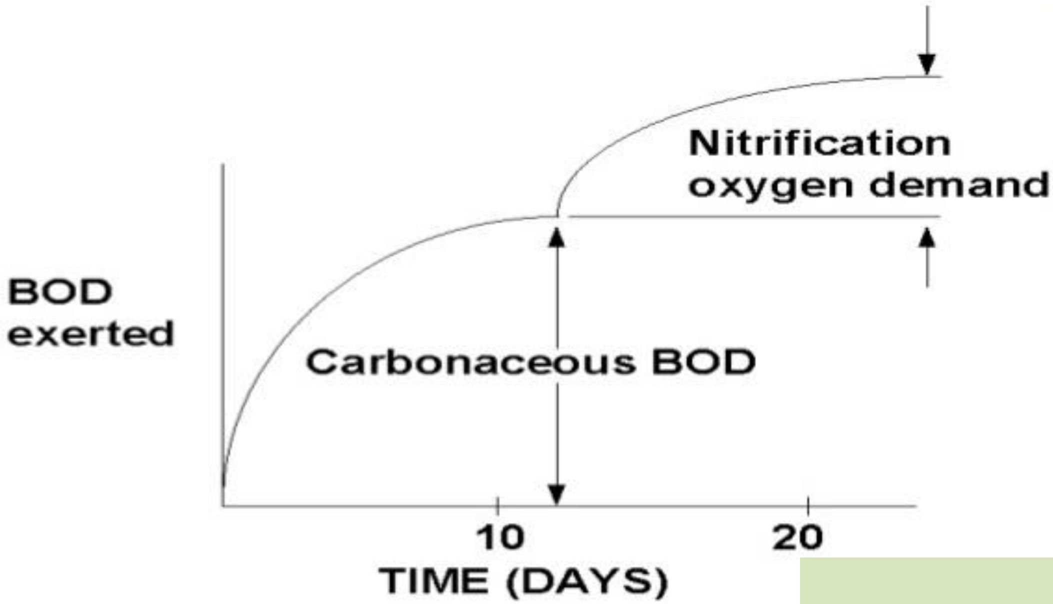
6) **Dissolved solids** – interfere with reuse

TABLE 10.7. UNIT OPERATIONS/PROCESSES AND TREATMENT SYSTEMS USED TO REMOVE MAJOR CONTAMINANTS OF WASTEWATER

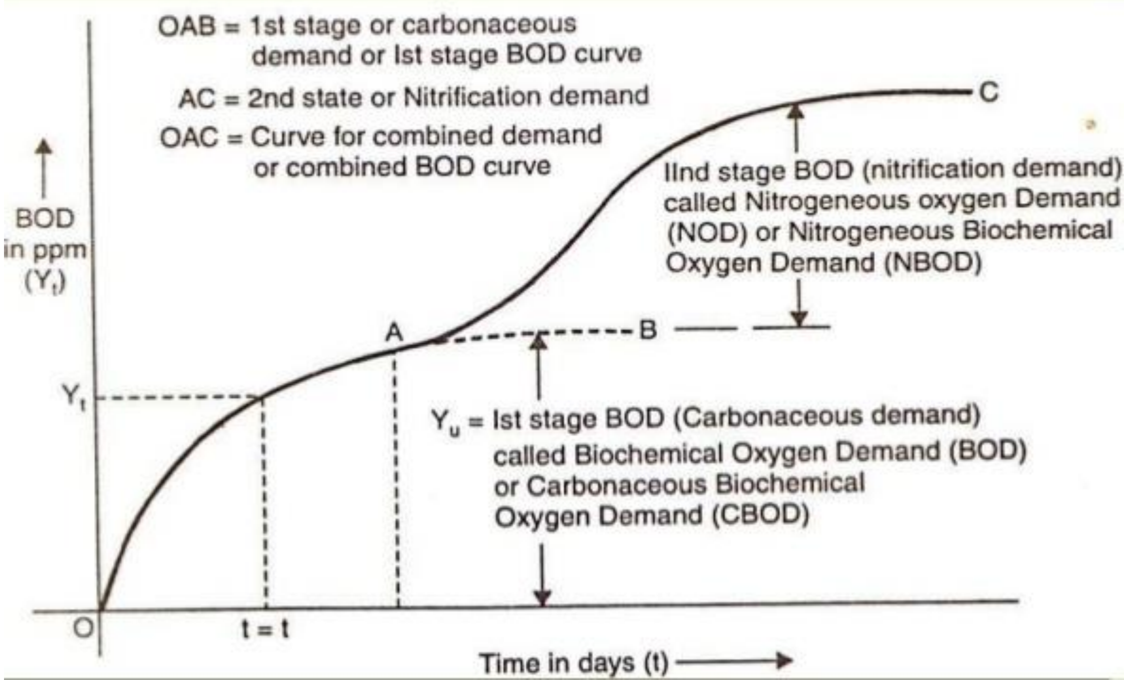
Contaminant	*Unit operations/processes or treatment systems.*
1. Suspended solids	(i) Plain sedimentaton (ii) Screening and comminution (iii) Filtration (various types) (iv) Floatation (v) Coagulation/sedimentation (vi) Land treatment systems
2. Biodegradable organics	(i) Activated sludge processes (ii) Trickling filters (iii) Rotating biological contactors (iv) Lagoons (v) Intermittent sand filtration (vi) Land treatment systems (vii) Physical-chemical systems.
3. Pathogens	(i) Chlorination (ii) Hypochlorination (iii) Ozonation (iv) Land treatment systems

4.	Nitrogen	(i) Nitrification and denitrification Variations of suspended-growth and fixed-film processes (ii) Ammonia stripping (iii) Ion exchange (iv) Break point chlorination (v) Land treatment systems.
5.	Phosphorous	(i) Carbon adsorption (ii) Lime coagulation/sedimentation (iii) Biological-chemical phosphorus removal (iv) Land treatment systems
6.	Refractory organics	(i) Carbon adsorption (ii) Tertiary ozonation (iii) Land treatment systems
7.	Heavy metals	(i) Chemical precipitation (ii) Ion exchange (iii) Land treatment systems
8.	Dissolved inorganic solids	(i) Ion exchange (ii) Reverse osmosis (iii) Electrodialysis

BOD Curve



BOD Curve



BOD exerted or removed is given by, $\mathbf{Y_t = Lo\ (1 - e^{-k\ t})}$

Rate of BOD removal with time is directly proportional to BOD remained at any time.

$(dL / dt)\ \alpha\ L$

Lt = BOD remained at any time.

k = BOD rate constant to the base e, d^{-1}

K = BOD rate constant to the base 10, d^{-1} K = 0.1 at 20 ^{0}c

Y_t = BOD exerted or removed after any time.

Lo = Ultimate BOD. Mg/L

t = Time in days

$(dL / dt) = -k\ L$

$dL / L = -k\ dt$

Integrate it, $\int_{Lo}^{Lt} dL / L = -k \int_{o}^{t} dt$

$(\mathrm{Log}_n L)^{Lt}_{Lo} = -k\ (t + c)^t_o$

$\mathrm{Log}_n Lt - \mathrm{Log}_n Lo = -k\ t$

BOD exerted or removed is given by, $\mathbf{Y_t = Lo\ (1 - e^{-k\ t})}$

$Log_n\ Lt - Log_n\ Lo = -k\ t$

$Log_n\ (Lt / Lo) = - k\ t$

$Lt / Lo = e^{-k\ t}$

$Lt = Lo\ e^{-k\ t}$

Now, Ultimate BOD = BOD remained + BOD exerted

$Lo = Lt + Y_t$

$Y_t = Lo - Lt$ Put $Lt = Lo\ e^{-k\ t}$

$Y_t = Lo - Lo\ e^{-k\ t}$

$Y_t = Lo\ (1 - e^{-k\ t})$ $k = 0.23$ / day

$Y_t = Lo\ (1 - 10^{-K\ t})$ $K = 0.1$ / day

Temp. correction factor, $K_T = K_{20}\ \Theta^{(T-20)}$

Temp coeff. Factor, Θ =1.047 when temp. is greater than or equal to 20 ^{0}c

Temp coeff. Factor, Θ =1.135 when temp. is less than 20 ^{0}c

Que. (1) For a 5 day BOD test, a sample of sewage was diluted with water with dilution factor 100. If the conce. of DO in the begining and at the end of test are 13 and 8 mg/L respectively. Calculate the 5-day BOD. Remark on the nature of sewage.

Ans :-

$$BOD_5 = \text{Loss of Oxygen in mg/L} \times (D.F.)$$

$$= (13-8) \times 100$$

$$\boxed{BOD_5 = 500 \text{ mg/L}}$$

The sewage is strong and it requires heavy or more treatment before disposal.

Que. ② A 2.5 ml of wastewater sample is diluted to 250 ml for BOD test. The initial D.O. for the diluted sample is 7.8 mg/L and final DO after 5 days of incubation is 3.2 mg/L. Find out the BOD of wastewater.

Solⁿ :-

$$DO_{Initial} = 7.8 \text{ mg/L}$$

$$DO_{final} = 3.2 \text{ mg/L}$$

$$\text{Dilution Factor} = \frac{\text{Total Vol}^m \text{ of Diluted Sample}}{\text{Vol}^m \text{ of Raw Sample}}$$

$$= \frac{250}{2.5}$$

$$D.F. = 100$$

$$BOD_5 = [DO_I - DO_F] \times D.F.$$

$$= [7.8 - 3.2] \times 100$$

$$\boxed{BOD_5 = 460 \text{ mg/L}}$$

Que. (3) In a BOD test, 6 ml of wastewater sample is mixed with 294 ml of dilution water. A dilution water contain 8.6 mg/L of DO. After 5 day incubation at 20°c, The DO of the mixture is found to be 5.4 mg/L. Calculate the BOD of wastewater. Assume that the DO content of wastewater initially is zero.

Solⁿ :-

V_m = Volume of mixture = 300 ml

C_m = DO conce. of mixture = ?

V_s = Volume of sample = 6 ml

C_s = DO conce. of Sample = 0 mg/L

V_D = Volume of Dilution water = 294 ml

C_D = DO conce. of Dilution water = 8.6 mg/L

(*) DO conce. of mixture :-

$$V_M \times C_M = V_s \times C_s + V_D \times C_D$$

$$[300 \times C_M] = [6 \times 0] + [294 \times 8.6]$$

$$\therefore C_M = 8.428 \text{ mg/L}$$

(*) 5 Day BOD at 20°c :→

$$BOD_5 = [DO_I - DO_F] \times D.F.$$

$$= [8.428 - 5.4] \times \left[\frac{300}{6}\right]$$

$$\boxed{BOD_5 = 151.4 \text{ mg/L}}$$

Que. (4) A sewage sample has 4 days BOD at 15°c, 87 mg/L. Calculate 5 days BOD at 30°c, K at 20°c = 0.1/day

Solⁿ :→

$$Y_t = Y_4^{15°c} = 87 \text{ mg/L}$$

$$K_{20°c} = 0.1/\text{day}$$

$$Y_5^{30°c} = ?$$

(I) $K_{15°c}$ ⇒

$$K_{15°c} = K_{20°c} (\theta)^{T-20°c}$$

$$K_{15°c} = 0.1 (1.135)^{15-20}$$

$$K_{15°c} = 0.053/\text{day}$$

(II) Ultimate BOD (Lo) ⇒

$$Y_t = Lo(1-10^{-k \cdot t})$$

$$Y_4^{15°c} = Lo(1-10^{-0.053 \times 4})$$

$$87 = Lo(1-10^{-0.053 \times 4})$$

$$\boxed{Lo = 225.25 \text{ mg/L}} \text{ at } 15°c$$

(III) $K_{30°c}$ ⇒

$$K_{30} = K_{20} (\theta)^{T-20}$$

$$= 0.1 (1.047)^{30-20}$$

$$K_{30} = 0.158 \quad \text{at } 30°c$$

(IV) BOD at any time (Yt) ⇒

$$Y_t = Lo(1-10^{-k \cdot t})$$

$$Y_5^{30°c} = 225.25 (1-10^{-0.158 \times 5})$$

$$\boxed{Y_5^{30°c} = 188 \text{ mg/L}}$$

If BOD_5 of a sample measured at 20^0C is 250 mg/L. Determine the 3 days BOD at 27^0C.

Assume reaction rate constant k (base 'e') k = 0.23 /day at 20^0C.

Que. ⑤ If BOD_5 of a sample measured at $20^{\circ}C$ is 250 mg/L, Determine the 3 day BOD at $27^{\circ}C$. Assume a reaction constant K (base 'e') $k = 0.23\ d^{-1}$ at $20^{\circ}C$

Solⁿ:- $Y_5^{20^{\circ}C} = 250$ mg/L

$k_{(base\ 'e')} = 0.23\ d^{-1}$ at $20^{\circ}C$

(I) Ultimate BOD at $20^{\circ}C$ (L_o) ⟹

$$Y_t = L_o(1 - e^{-kt})$$

$$Y_5^{20^{\circ}C} = L_o(1 - e^{-0.23\times5})$$

$$250 = L_o(1 - e^{-0.23\times5})$$

$$\boxed{L_o = 365.8\ mg/L}$$

(II) Reaction Rate constant at $27^{\circ}C$:⟹

$$K_T = K_{20}(\theta)^{T-20}$$

$$K_{27} = 0.23(1.047)^{27-20}$$

$$K_{27} = 0.34\ /day$$

(III) 3 Day BOD at $27^{\circ}C$ ($Y_3^{27^{\circ}C}$) ⟹

$$Y_t = L_o(1 - e^{-kt})$$

$$Y_3^{27} = 365.8(1 - e^{-0.34\times3})$$

$$\boxed{Y_3^{27} = 233.8\ mg/L}$$

Que. 6: Determine the ultimate BOD and 1 day BOD for a sewage having 5 day at 20°c as 200 mg/L. Assume $K_{20} = 0.1/day$.

Solⁿ :- The ultimate BOD is given by, $Y_t = L_o(1-10^{-k.t})$

$$Y_5^{20°c} = L_o(1-10^{-0.1\times5})$$

$$\boxed{L_o = 292.5 \text{ mg/L}}$$

BOD at any time is given by, $Y_t = L_o(1-10^{-kt})$

$$Y_1^{20°c} = L_o(1-10^{-0.1\times1})$$

$$Y_1^{20°c} = 292.5(1-10^{-0.1\times1})$$

$$\boxed{Y_1^{20°c} = 60.16 \text{ mg/L}}$$

3 days BOD of a wastewater sample at 37^0C is 300 mg/l. Calculate its 10 days BOD at 20^0C and 5 days BOD at 30^0C. Assume BOD rate constant at 20^0C as 0.23 per day.

Que. ⑦ 3 day BOD of a wastewater sample at 37°c is 300 mg/L. Find out its 10 days BOD at 20°c and 5 day BOD at 30°c. Assume BOD rate constant at 20°c is 0.23 per day.

Sol^n :–

$$Y_3^{37°c} = 300 \text{ mg/L}$$

$$k = 0.23 \text{ / day.}$$

(I) BOD rate constant at 37°c :–

$$K_{37°c} = K_{20} (1.047)^{37-20}$$

$$K_{37°c} = 0.23 \ (1.047)^{37-20}$$

$$K_{37°c} = 0.502 \text{ / day}$$

$$K_{30°c} = 0.36 \text{ / day.}$$

(II) Ultimate First stage BOD :–

$$Y_t = L_0 (1 - e^{-kt})$$

$$Y_3^{37} = L_0 (1 - e^{-0.502 \times 3})$$

$$300 = L_0 (1 - e^{-0.502 \times 3})$$

$$\boxed{L_0 = 385.5 \text{ mg/L}}$$

(III) $$Y_{10}^{20°c} = L_0 (1 - e^{-k \cdot t})$$

$$= 385.5 (1 - e^{-0.23 \times 10}) = 346.81 \text{ mg/L}$$

(IV) $$Y_5^{30°c} = 385.5 (1 - e^{-0.36 \times 5}) = 322.32 \text{ mg/L}$$

Screening:-

1) It is the process of trapping and removing larger & coarser floating materials like pieces, cloth, plastic, wood, etc.
2) Done by allowing a wastewater to flow through the screens.
3) Screens may consists of parallel bars, rods, wiremeshes, etc.
4) First unit operation encountered in wastewater treatment plants.
5) Frequently required to be cleaned, otherwise head loss will increase across the screen by clogging the screen.

- Coarse screen- Opening Size > 20 mm
- Medium screen- Opening size 10 to 20 mm
- Fine screen – Opening < 10 mm
- Micro screen – Opening < 0.5 μm

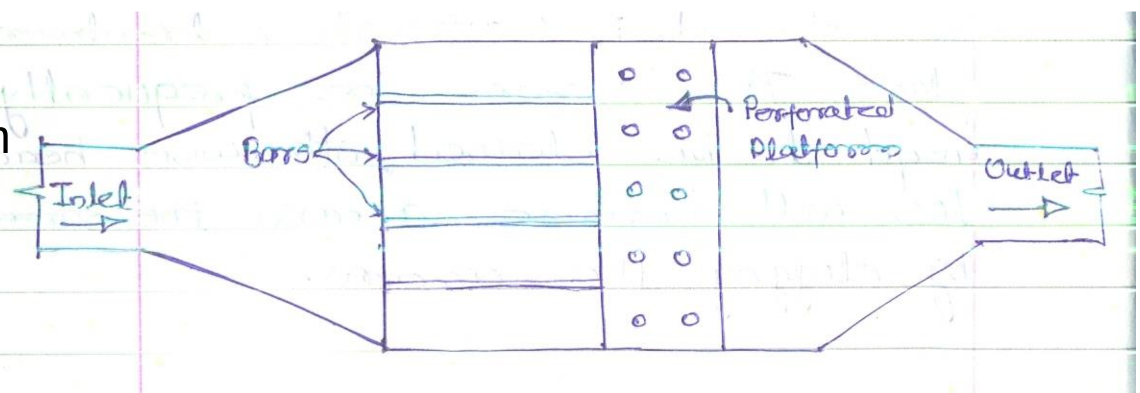
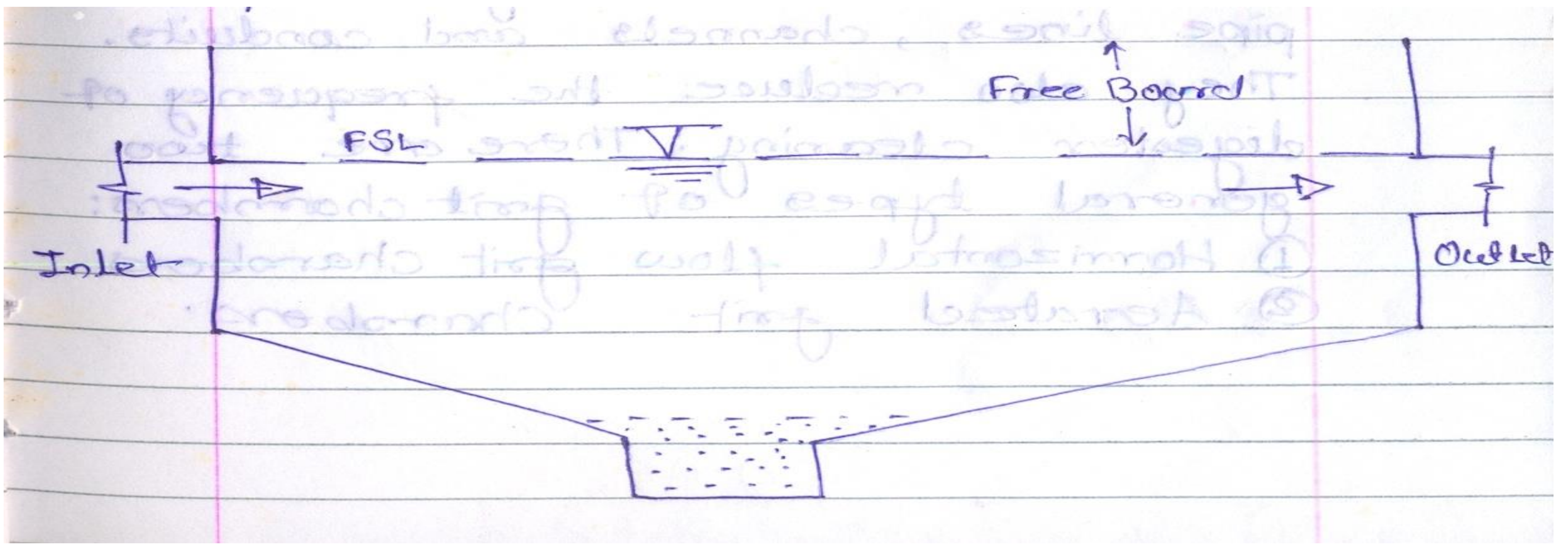


Fig: Top View of Screen.

Grit Chamber:-

1) Grit or inorganic material is removed by grit chamber.
2) **Velocity of flow is reduced** to such an extent that **heavier inorganic materials** settle down at bottom of grit chamber.
3) It has a lesser **detention time of 1 minute** and flow **velocity 0.2 to 0.3 m/s**
4) Flow velocity should neither far low to cause settling of lighter organic matter nor should so high not to cause the settlement of the grit.
5) Provided to protect moving mechanical equipment from abrasion & wear.
6) There are two types of grit chamber :- **Horizontal flow & aerated grit chamber.**



Que. 8 Design a grit chamber of rectangular c/s if the maximum wastewater flow rate is 8000 m^3/day to remove particles upto 0.2 mm diameter with specific gravity of 2.65.

Max. flow rate = 8000 m^3/day = 0.0926 m^3/s

Assume flow velocity. v_H = 0.25 m/s

Assume Detention Time, t = 60 seconds

Length of Girt chamber, L = v_H x t = 0.25 x 60 = **15 m**

c/s area of chamber, A = (Q / v_H) = 0.0926 / 0.25 = **0.37 m^2**

Settling velocity, v_s = d (3T +70)

T = Temp. 20 ^{0}C & d = 2 x 10^{-4} m

Settling velocity, v_s = d (3T +70) = 2 x 10^{-4} (3 x 20 +70) = **0.026 m/s**

Depth of chamber, = v_s x t = 0.026 x 60 = **1.56 m**

Width of chamber, B = (c/s Area) / Depth = 0.37 / 1.56 = **0.24 m**

Assume F.B. = 0.2m & Sludge depth = 0.2m

Overall depth = 1.56 + 0.2 + 0.2 = **1.96 m** say = 2m

Hence Provide a grit chamber of **size 15m x 0.24m x 2m**

Que. 9 Design a grit chamber for a maximum wastewater flow of 8000 m^3/day to remove particles upto 0.2 mm diameter with specific gravity of 2.65. The settling velocity of these particles is found to range from 0.018 to 0.02 m/s. Maintain a constant flow through velocity of 0.3 m/s through the provision of a proportional flow weir?

Max. flow rate = 8000 m^3/day = 0.0926 m^3/s

Assume Flow Velocity, v_H = 0.3 m/s

c/s Area of Chamber, A = (Q / v_H) = 0.0926 / 0.3 = **0.31 m^2**

Assume Detention Time = 60 seconds

Length of Tank, L = v_H x t = 0.3 x 60 = **18m**

Depth of Tank = v_s x t = 0.02 x 60 = **1.2 m**

Width of Chamber, B = (c/s Area) / Depth = 0.31 / 1.2 = **0.26 m**

Overall Depth = Depth + FB + Sludge Depth = 1.2m + 0.2m + 0.2m = **1.6 m**

Hence Provide a grit chamber of **size 18m x 0.26m x 1.6m**

Detritus Tank:-

1) Detritus = mixture of grit & organic matter

2) These are rectangular or square continuous flow settling.

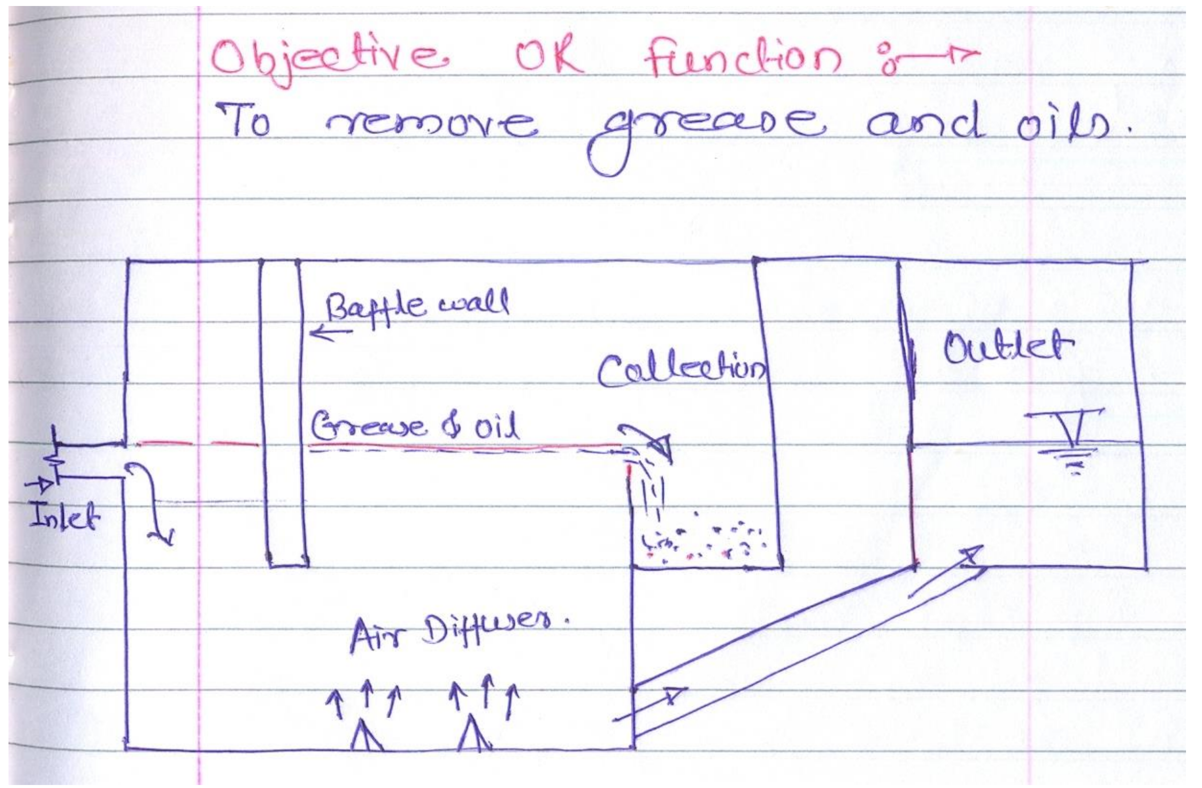
3) Flow velocity = 0.2 m/s to 0.4 m/s

4) Detention time = 3 to 4 hours

5) Sides of the bottom so as to form trough for the collection of detritus.

Skimming Tank:-

1) This tank is in the form of long trough shaped structure.
2) Detention time should be 3 to 5 minutes
3) Efficiency can be increased by passing chlorine gas.
4) Greases & oils interfere with biological treatment processes.
5) Inhibit the biological growth in trickling filter.



Typical Questions :-

1) Write a short note on characteristics of wastewater?
2) Define and explain BOD with its significance? How will you determine the BOD?
3) Define and explain COD? Show the relation between the BOD and strength of sewage? What are the limitations of BOD test? Write a short note on BOD curve?
4) What are the objectives and various methods of wastewater treatment?
5) What is primary treatment system and secondary treatment system of sewage?
6) Draw a neat flow diagram of conventional wastewater treatment plant & state the function of each unit?
7) What is screening? Mention the objectives and types of screening?
8) What is sedimentation? Mention the objectives and types of sedimentation?
9) What points should be considered during the design of sewage treatment units?
10) What points should be kept in mind while locating the site of treatment plants?
11) Explain the grit chamber and detritus tank and what is the difference between them?
12) Design a grit chamber if the maximum wastewater flow rate is 8000 cum/day to remove particles up to 0.2 mm diameter with specific gravity of 2.5.
13) Design a bar screen chamber for max. flow of 12 MLD. Assume suitable data.
14) Design a suitable primary sedimentation tank to treat wastewater of 10 MLD.