CBCS SCHEME

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BCV304

Third Semester B.E./B.Tech. Degree Examination, Dec.2023/Jan.2024
Water Supply and Waste Water Engineering

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Briefly explain : i) Factors affecting per capita demand of water. ii) Factors affecting design period. iii) Domestic water demand.	12	L2	CO1
	b.	Explain the need and importance of protected water supply to the community.	8	L2	CO1
		OR			
Q.2	a.	The population of 5 decades from 1980 to 2020 are given in below table. Find out the population after 3 decades beyond the last known decades by using arithmetic increase method.	12	L2	CO1

Year	1980	1990	2000	2010	2020
Population	25,000	28,000	34,000	42,000	47,000

	b.	List different methods of population forecasting. Explain briefly Arithmetical and Geometrical Increase method.	8	L2	CO1
		Module – 2			
Q.3	a.	Explain the objectives of Water treatment or Water purification.	4	L2	CO2
	b.	Describe briefly the construction and working of coagulation sedimentation tank with neat sketch.	10	L2	CO2
	c.	Briefly explain the terms : i) Sedimentation ii) Coagulation iii) Flocculation.	6	L2	CO2
		OR			
Q.4	a.	The maximum daily demand at a water purification plant has been estimated as 12 million litres per day. Design the dimensions of a suitable sedimentation tank (fitted with mechanical sludge removal arrangements) for the raw supplies , assuming a detention period of hours and velocity of flow as 20cm per minute.	8	L2	CO2
	b.	List the coagulants used in water treatment.	4	L2	CO2
	c.	Briefly explain the mechanism of Filtration.	8	L2	CO2
		Module – 3			
Q.5	a.	What is Disinfection of water? What are the characteristics of good disinfectant?	6	L2	CO3

	b.	Explain the different types of sewerage system with their merits and demerits of suitability.	12	L2	CO3
		OR			
Q.6	a.	Calculate the velocity of flow and discharge of sewer of a circular section having a diameter of 1m laid at a gradient of 1 in 500. Use Manning's formula taking N = 0.012. Assume that the sewer is running half full.	8	L3	CO3
	b.	Explain the process and objective of sampling with different methods.	6	L2	CO3
	c.	Explain DWF and WWF.	6	L2	CO3
		Module – 4			
Q.7	a.	Illustrate the layout of a conventional municipal treatment plant and infer upon importance of each unit in sanitation.	10	L2	CO4
	b.	Elucidate the working principle of sludge digester, with a neat labeled sketch.	6	L2	CO4
	c.	Explain different types of screens.	4	L2	CO4
		OR			
Q.8	a.	Discuss briefly with a neat sketch Grit Chamber and Oil and Grease removal tank.	10	L2	CO4
	b.	Explain the working of Conventional Activated Sludge Process (ASP) with flow diagram.	10	L2	CO4
		Module – 5			
Q.9	a.	Determine the size of a high rate trickling filter for the following data : i) Sewage flow = 4.5 mld ii) Recirculation Ratio = 1.5 iii) BOD of raw sewage = 250 mg/ltr. iv) BOD Removal in primary settling tank = 30%. v) Final effluent BOD desired = 30 mg/ltr.	10	L3	CO5
	b.	Explain the concept of BoD and CoD. Enumerate their limitation.	6	L2	CO5
	c.	Briefly explain Self – Cleansing Velocity.	4	L2	CO5
		OR			
Q.10	a.	Draw a neat sketch of Skimming tank. Enumerate importance of Skimming tank.	10	L2	CO5
	b.	Draw and explain Oxidation Pond and Oxidation ditch.	10	L2	CO5

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DEC. 2023/ Jan. 2024 QP SCHEME & SOLUTION

Q 1 a) Briefly explain: i) Factors affecting per capita demand of water ii) Factor affecting design period. iii) Domestic water demand.

i) Factors affecting Per capita demand ---- 12 Marks.

Ans: i) Size of the community: water demand is more with increase of size of town because more water is required in street washing, running of sewers, maintainance of parks & gardens.

ii) Living standard of the people: the per capita demand of the town increases with the standard of living of the people because of the use of air conditioners, room coolers etc.

iii) System of sanitation: per capita demand of the towns having water carriage system will be more than the town where this system is not being used.

iv) cost of water: the cost of the water directly affects its demand. if cost is more then there will be less demand. 04 x 4 — 04 M

ii) Factors affecting design Period:

i) Useful life of component structures and the chances of becoming their old and obsolete.

ii) Ease and difficulty that is likely to be faced in expansions, if undes taken at future dates.

iii) Amount and availability of additional investment likely to be incurred for additional provisions.

iv) The rate of interest on the borrowings and the additional money invested

1 × 4 = 04M.

iii) Factors affecting domestic Water demand.

i) the water required for domestic purposes like washing clothes utensils, bathing etc is called domestic water demand which mainly depends on size of the family. If the size increases then there will be increase in domestic water demand.

ii) Type of flushing used in the w/c.

iii) Habit of taking bath.

iv) Size of the house: If size of the house increases there will be increase in the domestic water demand.

1 × 4 = 04M.

~~Total = 12M.~~

Q.1 b Explain the need and importance of the protected water supply to the community --- 08M.

Ans: Protected water supply means the supply of water that is treated to remove the impurities and made safe to public health. water may be polluted by physical and bacterial agents. water is also good carries of disease causing germs. The causes of outbreak of epidemics are traced to pollute water and poor sanitation hospitals are continued to be flooded with sicks due to ignorance about health. However during last few decades, improvement in the public health protection

by supplying safe waters and sanitation to all the people in the developing countries. Pure and wholesome waters is to be supplied to the community alone can bring down the morbidity rates. ---- 08M.

Q.No2 a) The population of Five decades from 1980-2020 are given in below table. Find out the population after 3 decades beyond the last known decades by using arthmatic increase method.

Year	1980	1990	2000	2010	2020
Population	25000	28000	34000	42000	47000.

--- 12M.

Soln Consider the following table.

Year	Population	Increase in population
1980	25000	-
1990	28000	3000.
2000	34000	6000
2010	42000.	8000
2020	47000.	5000.
	Total	22000.
	Average	5500

--- 08M

Now as per arthmatic increase method

$$P_n = P_o + nI$$

$\therefore$ $P_{2050} = 47000 + 3 \times 5500.$

$$\boxed{P_{2050} = 63500.}$$ ---- 04 M

Total 12 M.

Q.2 b) List different methods of population forecasting. Explain briefly Arithmetical & geometrical increase method. 08M

Ans: i) Arthmatic increase method.
ii) Geometric increase method.
iii) Incremental increase method.
iv) Graphical extension method.
v) Graphical comparitive method.
vi) Ratio & correlation method. --- 02 M.

i) Arthmatical Increase method.

In this method, the average increase of population for the last three or four decades is worked out and then for each successive future decades, this average is added.

Following relation is use to forecast the population.

$$P_n = P_o + nI$$

where P_n = Future population in n decades.
P_o = present population
n = no of decades.
I = Avg. increase in population. --- 03M

iii) Geometrical increase method:

In this method, it is assumed that the % age increase in population from decade to decade remains constant. From the available census records, this % age is fixed and then population of each future successive decades is worked out.

The formula used is.

$$P_n = P_o \left(1 + \frac{a}{100}\right)^n$$

where P_n = Population in n^{th} decade.

P_o = Present population

a = Avg % age increase in population.

n = no of decades. --- 03M

Total 08M.

Q3a: Explain the objectives of water treatment or water purification 04M

Some of the main objectives of the water treatment process are:

1) To reduce the impurities to a certain level that does not cause harm to human health

2) To reduce the objectionable color, odor, turbidity and hardness.

3) To make water safe for drinking.

4) To eliminate the corrosive nature of water affecting the pipe. — 1×04 = 04M.

Q3b. Describe briefly the construction and working of coagulation sedimentation tank with neat sketch.

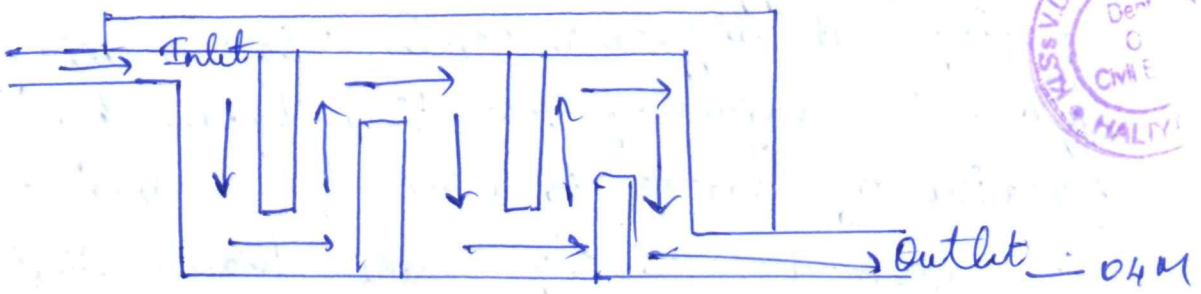
Working of sedimentation tank along with coagulation is simple as shown below in figure The water enters the tank from one end and as it travels towards the outlet at the other end, its velocity is broken or reduced by means of baffle walls. The walls contain openings at different levels. The velocity of the flow is adjusting that time taken by a particle of water to move from one end to the other is slightly more than that required

for the settlement of suspended impurities in water. The entry of impure water from one end and the exit of clear water from the other end are continous.

The flow of water is designed to meet the following two requirements:

a) The velocity of flow is such that suspended impurities of required size settle down at the bottom of tank.

b) The total amount of flow from the tank within 24 hours equals to the daily demand of water. The silt is deposited at the bottom of tank and when it is accumulated in sufficient quantity, the flush valve is opened and the tank is cleaned



Plan.

Q.3 c) Briefly explain the terms.
i) Sedimentation ii) Coagulation iii) Flocculation. 06M

Ans: i) Sedimentation: It is the process of removing the suspended solids present in the waters. In this process the water is allowed to stand still for a given detension time, so that there will be a settlement of suspended solids at the bottom of tank. — 02M

ii) Coagulation: It is a process which is used to accelarate the velocity of settlement of suspended solids present in the water. This is also effective in the removal of colloidal solids. — 02 M

iii) Flocculation: Flocculation in water treatment is a process where small, suspended particles in waters are brought together to form larger, heavier clumps called flocs, which can then be removed through sedimentation or filtration. This process is crucial for improving water clarity and removing impurities. 2×3 = 06M

Q4 a) The maximum daily demand of a water purification plant has been estimated as 12 MLD. Design a dimension of suitable sedimentation tank (fitted with mechanical sludge removal arrangements) for the raw supplies assuming detention period of hours and velocity of flow as 20 cm/min. 08M

Q3A: ~~Explain the objectives of~~

Soln

Given

$Q = 12\ MLD$

$= \frac{12 \times 10^6}{24 \times 60 \times 60}$

$= 8333.33\ lt/min$

$= 0.834\ m^3/min$ ——— 02M

$V = 20 cm/min$

Assuming detension period as T as 8 hrs.

then cubical contents $C = Q \cdot T$

$= 0.834 \times 8$

$= 6.672\ m^3.$

Assuming depth of tank as 2.50 m.

Surface area $= A = \frac{6.672}{2.50}$

$A = 2.67\ m^2.$ ——— 04

$Q = A \times V$

$0.834 = A \times 20.$

$A = 0.417\ m^2$ Not suitable.

Assuming Breath as 1.00 m then

length of tank

$L = 2.67 m$

Provide a tank of dimensions

$L = 3m \quad B = 1.00 \quad d = 2.5m.$ ——— 02

Total 08M.

10

4 b) List the Coagulants Used in Waters treatment. 04 Marks.

Ans:
1) Aluminium Sulphate
2) Chlosinated Copperas.
3) Ferrous Sulphate and lime
4) Magnesium Carbonate.
5) Polyelectrolytes.
6) Sodium aluminates. — 04 Marks

4 c) Briefly explain the Mechanism of filtration. 08M.

Ans: In filtration the water is allowed to pass through thick layers of sand and during the process of filtration the following effects on waters.

1) The suspended and colloidal impurities which are present in waters in a finely devided state are removed to a great extent.

2) The chemical characteristics are altered.

3) The number of bacteria present in waters also considerably reduced. — 04M

The mechanism of filtration can be explained with following four actions.

i) Mechanical straining
ii) Sedimentation

i) Mechanical straining: The suspended Particles which are unable to pass through the voids of sand grains are arrested and removed.

iii) Sedimentation: The voids bet^{n} the sand Particles acts a like small sedimentation tanks, the Particles & impurities will be arrested in these voids. —04

Total: 08M

5a. What is disinfection of water? What are the characteristics of good disinfectant? 06M

The characteristics of good infectant are microorganisms are destroyed or deactivated, resulting in termination of growth and reproduction such that they represent no significant risk of infection. When microorganisms are not removed from drinking water, drinking water usage will cause people to fall ill. When water leaves the filter plant, it is till found to contain some of the impurities. These impurities can be grouped as :- Bacteria, Viruses, Protozoa - dissolved inorganic salts, - colour, odor and taste, - iron and maganese. —06M.

5b. Explain the different types of sewerage system with their merits and demerits of suitability. — 12M.

Out of syllabus

Following are the three systems of sewarage.

i) Separate system.
ii) Combined system
iii) Partially Separate systems.

12

ii) Separate system: In this system two sets of sewers are laid - one for carrying dry weather flow (DWF) and other for carrying storm water.

Merits:

1) The load on the treatment units becomes less.
2) The sewers are small in size
3) The storm waters can be discharged in to natural streams without any treatment.

Demerits:

1) The cleaning sewers is difficult as they are small in size.
2) The maintainance cost are high. — O&M

iii) Combined system: In this system only one set of sewers is laid and it carries both DWF & storm water.

Merits:

i) easy to clean as size of sewers is large.
ii) The maintainance cost are reasonable.

Demerits:

1) The load on treatment plant increases.
2) The storm water is unnecessarily polluted. — O&M

iii) Partially separate system.

In this system the arrangement is made to permit early washings by rain which are foul in nature in to the sewers carrying sewage.

Merits:

1) The entry of rain water avoids silting in sewers.
2) The sewers are of reasonable size.

Demerits:

1) The quantity of storm water admitted in sewers may increase the load and pumping and treatment units.
2) The velocity of flow is low in dry weathers.

— 04M

Total: 12M.

Q.6a) Calculate the velocity of flow and discharge of sewer of circular section having a diameter of 1.00m laid in a gradient of 1 in 500. Use Manning's formula taking $N = 0.012$. Assume that the sewer is running half full. — 08M.

Sol:

OUT OF SYLLABUS

Q.6b) Explain the process and objective of Sampling with different methods. — 06M.

Ans: * Objectives of Sampling

i) Monitor water quality:

Sampling helps to track changes in water quality over time, identify potential pollutants and assess the effectiveness of the treatment processes.

ii) Optimize treatment processes.

Sampling data can be used to fine tune chemical dosages, optimize treatment efficiency and minimize operational cost. — 02M.

* Methods of sampling: 1) Grab Sampling.

This method involves collecting a single sample at a specific location and time. This method is suitable for characterizing the particular point in the wastewater stream. This method is good for identifying localized contamination. — 02M.

2) Composite Sampling:

It involves collecting multiple grab samples over a period and combining them into a single sample. This method provides more representative characterization of the wastewater quality over a longer time period. This method is used when flow or composition varies over time. ——— 02M

Total 06M.

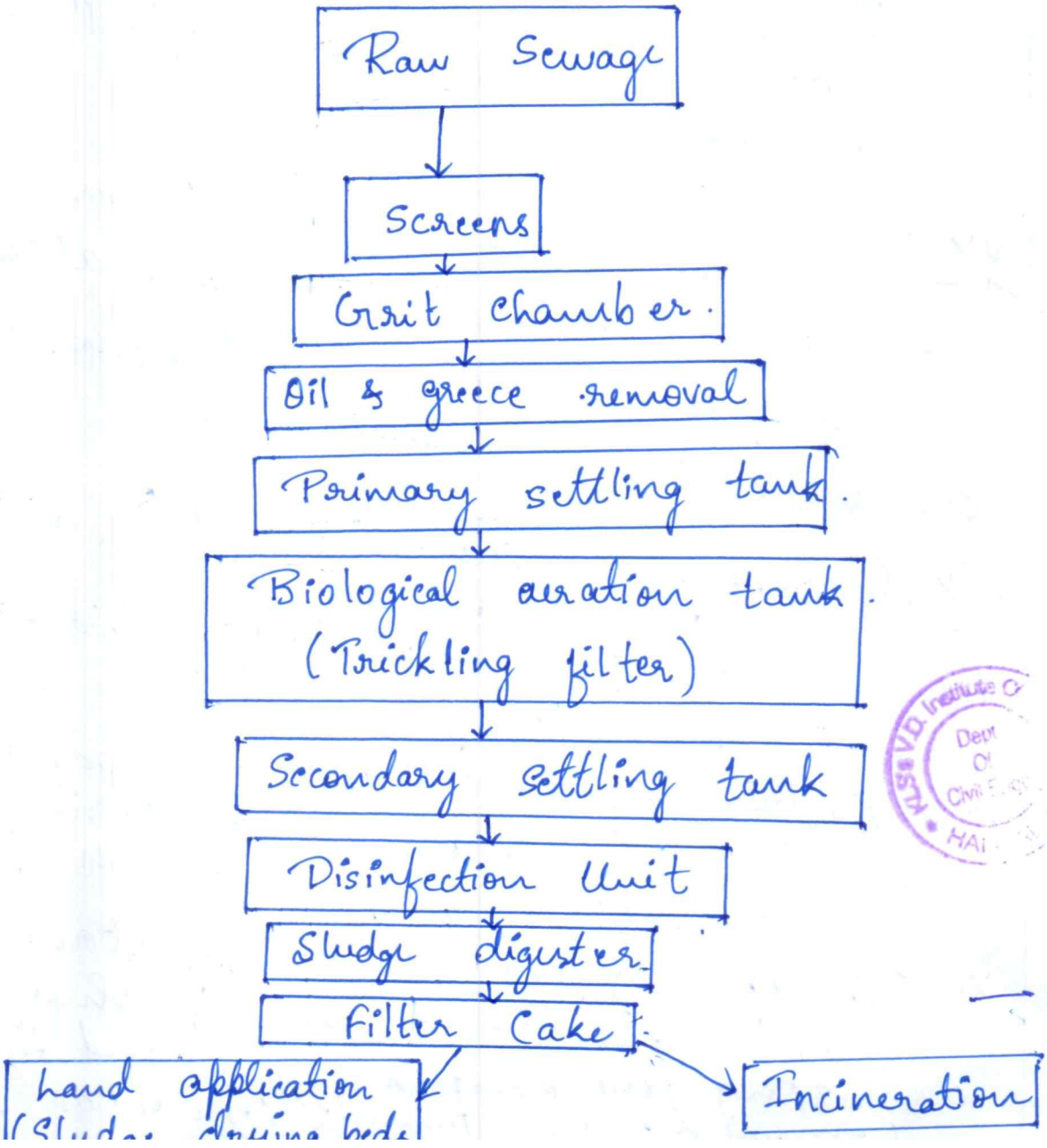
6c) Explain DWF & WWF — 06

Ans: OUT OF SYLLABUS.

Q7 a Illustrate the layout of a conventional municipa treatment plant and infer upon importance of each unit in sanitation. 10M

Sewage treatment or municipal waste water treatment process is a combination of physical, chemical and biological processes to bring the waste water to such a quality that it is not harmful to human health and environment.

* Flow of diagram for municipal Treatment.



— 06M.

i) Screens: These are important in removing floating matter present in the water which impair the future processes.

ii) Grit chamber: It is important to remove the settleable solids.

iii) oil & grease chambers: Important to remove oil & grease concentration which affect the future processes like sedimentation filtration etc.

iv) Primary settling tank: This is important in removing suspended solids present in the water.

v) Trickling filter: This is important to remove colloidal solids and also to reduce the bacterial load of water or wastewater.

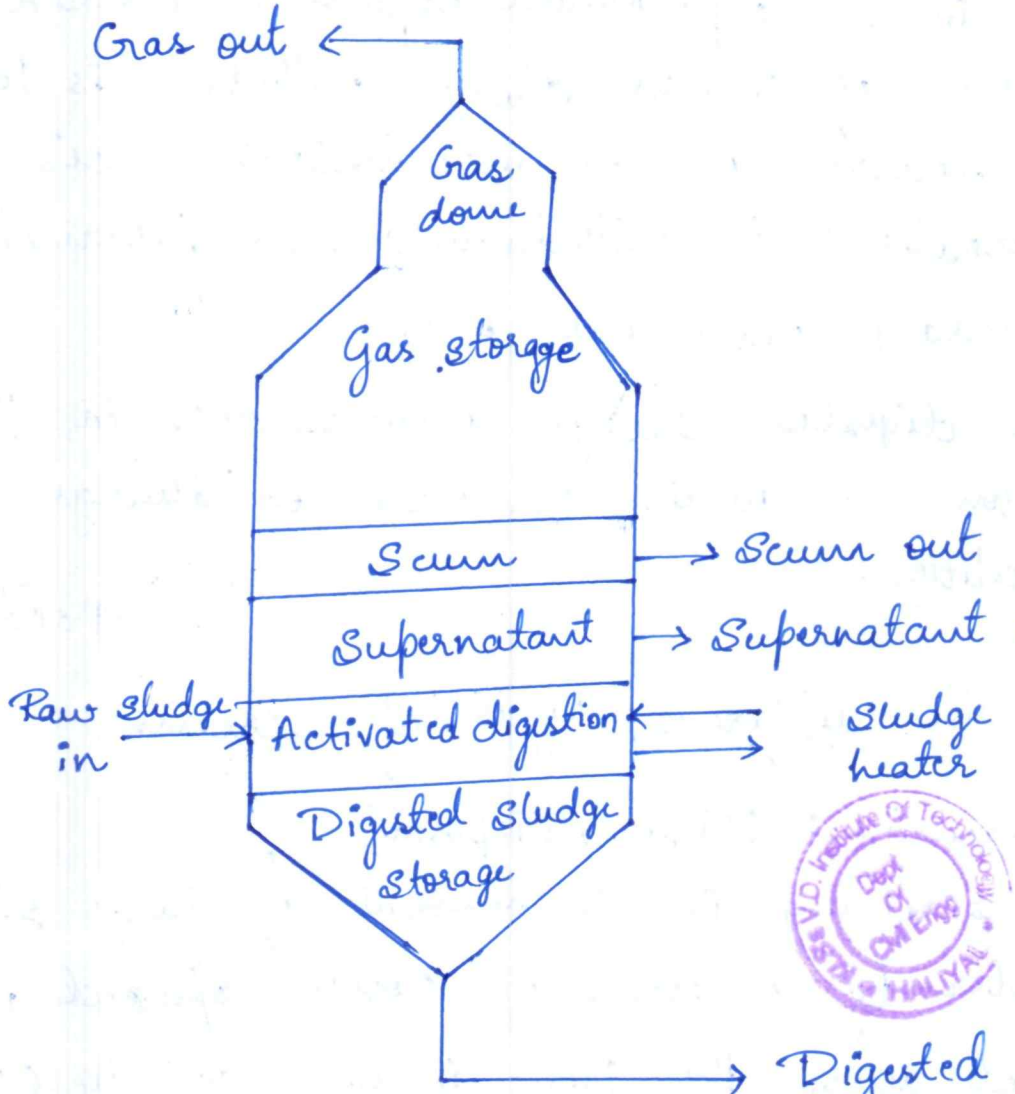
vi) Secondary settling tank: It is important in removing the suspended solid remained after filtration process.

vii) Disinfection unit: This is important to remove pathogenic bacteria present in water or waste water.

viii) Sludge digesters: It is important to reduce the COD & BOD of sludge. by oxidizing the complex organic and inorganic compounds in water.

Q7 b. Elucidate the working principal of sludge digester with a neat labled sketch. 06M.

The sludge digester is as shown below in figure



— 02

Working Principle:

The purpose of the anaerobic sludge digestion process is to convert sludge to end products of liquid & gases while producing as little biomass as possible. The process is economica than aerobic digestion of sludge.

The anaerobic sludge digester consists of closed tanks with air tight covers. Sludge separators in the digester are as shown in fig. Some mixing occurs in the zone of active decomposition and in the supernatant because of withdrawal & return of heated sludge. Sludge is fed to the reactor on an intermitent basis and the supernatant is withdrawn and returned to the secondary treatment unit.

The digested sludge accumulates in the bottom to await removal to sludge disposal facilities. — 03 M

Total 06M.

Q7 c) Explain different types of screens. 04 M

i) Screening : (Types, Disposal)

Screening is the removal of large size floating matter by a series of closely spaced bars placed across the flow inclined 30° to 60°. These floating materials, if not removed, will choke the pipes or adversely affect the working of the sewage pumps.

Screen should be placed before the grit chambers, however, if the quality of the grit is not important, as in the case of land sliding, screens may be placed after the grit chamber or something within the body of grit chamber. 04M.

20

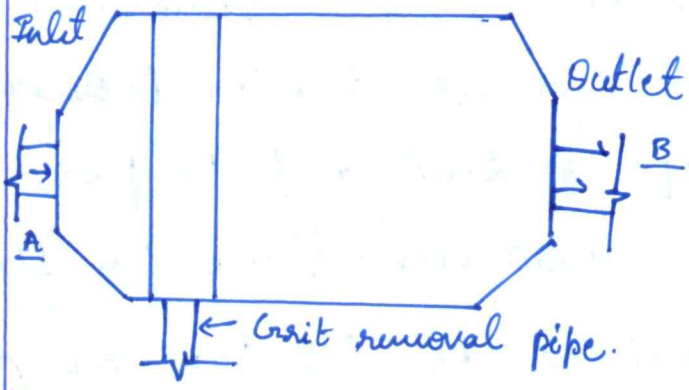
Q8

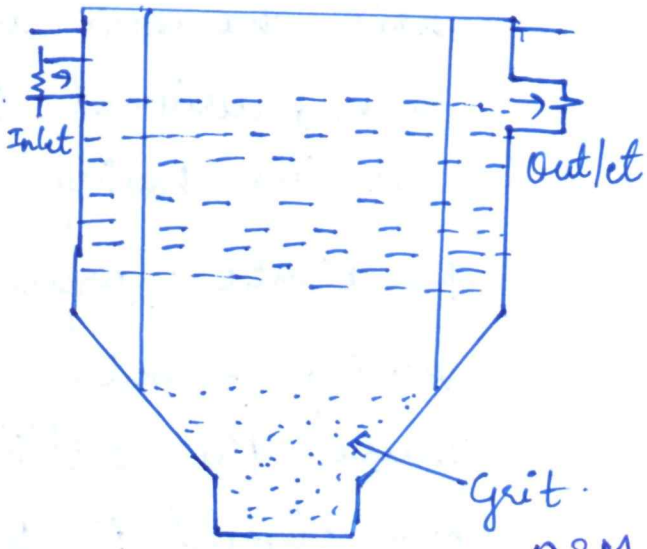
Q8 a) Discuss briefly with a neat sketch, grit chamber and oil and grease removal tank (10M)

Grit chambers are nothing but sedimentation tanks, designed to separate heavies inorganic materials having sp. gr 2.65 and to pass forward the lighter organic materials. Hence the flow of velocity should neither be too low as to cause the settling of lighter organic matter, nor should it be too high as not to cause the settlement of the silt and grit present in the sewage. This velocity is called "differential sedimentation and differential scouring velocity". The scouring velocity determines the optimum flow through velocity. This may be explained by the fact that the critical velocity of flow V_c beyond which particles of certain size and density once settled, may be again introduced into the stream of flow. It should always be less than the scouring velocity of grit particles. The critical velocity of scour is given by Shields formula i.e

$$V = 3 \text{ to } 4.5 \left(g(G-1)\, d\right)^{1/2}$$

The following figure shows the plan of a grit chamber. —— 03 M





* Oil And Grease Removal tank is same as skimming tak which answered in Q. No. 10 a) 05M.

02M

Section on AB.

Total 05 M.

Q8 b) Explain the working of conventional activated Sludge process (ASP) with flow diagram.

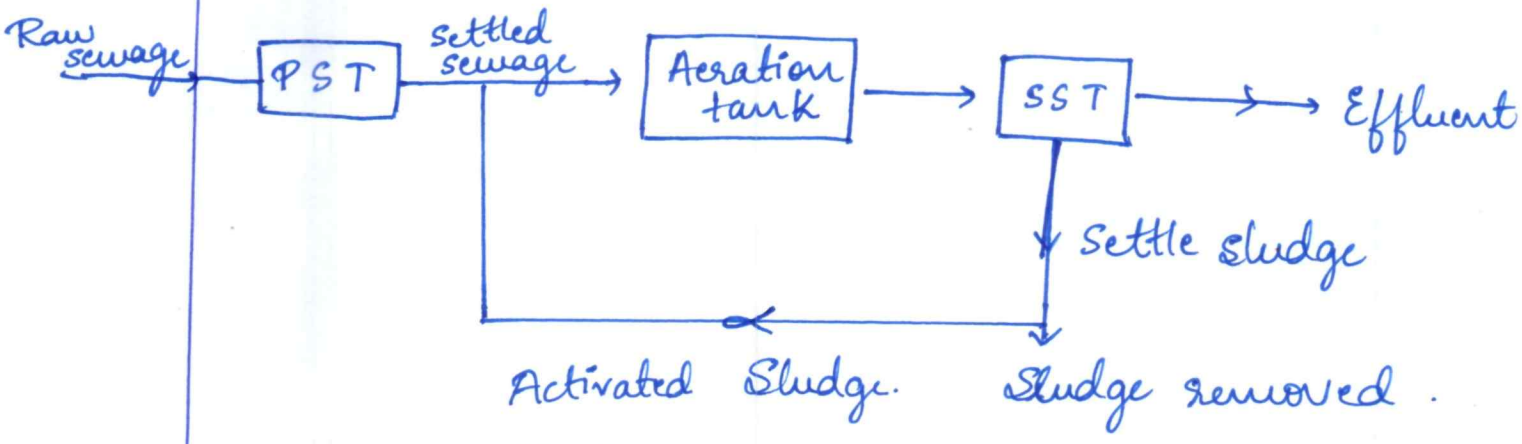
* Activated Sludge Process: (ASP)

"Activated Sludge" may be difined as the sludg which settle down after the sewage has been agitated freely in the presence of abudant atmospheric oxygen. Activated Sludge contains large number of aerobic bacteria and other organism and when it is mixed with raw sewage. containing sufficient O_2, the bacteria perform two functions i.e.

1) It oxidizes organic solids.

2) Promotes coagulation and floculation

Process converts colloidal & dissolved solids into settleable solids. —— 05



The settled sewage from PST is mixed with required amount of activated sludge coming from S.S.T. The resultant mixture is called a mixed liquor Suspended Solids (MLSS).

P.S.T means primary settling tank & S.S.T means secondary settling tank. —05

Total 10M.

Q.9a) Determine the size of a high rate trickling filter for the following data
i) Sewage flow = 4.5 MLd
ii) Recirculation ratio = 1.5
iii) BOD of raw sewage = 250 mg/lt
iv) BOD removal in primary settling tank = 30%
v) Final effluent BOD desired = 30 mg/lt ——— 10M.

Sol) Total BOD present in Sewage
$= \frac{4.5 \times 250 \times 10^6}{10^6}$
$= 1125 Kg.$

BOD removed in the primary settling = 30%.
∴ BOD left in the sewage entering the per day in the trickling filter
$= 1125 \times 0.7$
$= 787.5 Kg.$ ——— 04

Desired effluent BOD = 30 mg/lt.
Total BOD left in the effluent per day $= \frac{4.5 \times 30 \times 10^6}{10^6}$
$= 135 Kg.$
∴ BOD removed by the filter $= 787.5 - 135$
$= 652.5 Kg.$
∴ Efficiency of the filter $= \frac{\text{BOD removed}}{\text{Total BOD}} \times 100$
$= \frac{652.5}{787.5} \times 100$
$= 82.85\%.$ ——— 04

Now NRC equation

$$E_2 = \frac{100}{(1 + 0.4 (F_1 BOD / V_1 R_{f1})^{1/2}}$$

where $R_{f1} = 1.5$ (Given)

$$\therefore 82.85 = \frac{100}{1 + 0.4 (787 / 1.5 \times V_1)^{1/2}}$$

$$\Rightarrow V_1 = 2000 m^3.$$

Assuming the depth of the filter as 1.5m

The surface area $= \frac{2000}{1.5}$

$= 1333.33 m^2$ ——— 03

∴ Now the diameter of TF

i.e $A = \frac{\pi D^2}{4}$

$$\Rightarrow D^2 = \frac{4A}{\pi}$$

$$D = \sqrt{\frac{4 \times 1333.33}{\pi}}$$

$D = 41.2 m$.

Hence use a high rali trickling filter with 41.2 m dia, 1.5m deep filter media and with recirculation ratio 1.5. —— 01M

Total 10M

Q.9b) Explain the concept of BOD & COD. Enumerate their limitations. ——— 06M.

Ans: BOD

Biochemical oxygen Demand (BOD) measures the amount of dissolved oxygen consumed by aerobic microorganisms during the decomposition of organic matter in a water sample over a specific period, typically five days. It serves an indicator of water pollution and the potential for oxygen depletion in aquatic ecosystems.

Limitation: BOD test has a limitation, including its reliance on microbial activity, the time consuming nature of the test, and its inability to account for all types of organic matter & the presence of toxic substances. ——— 03M.

COD:

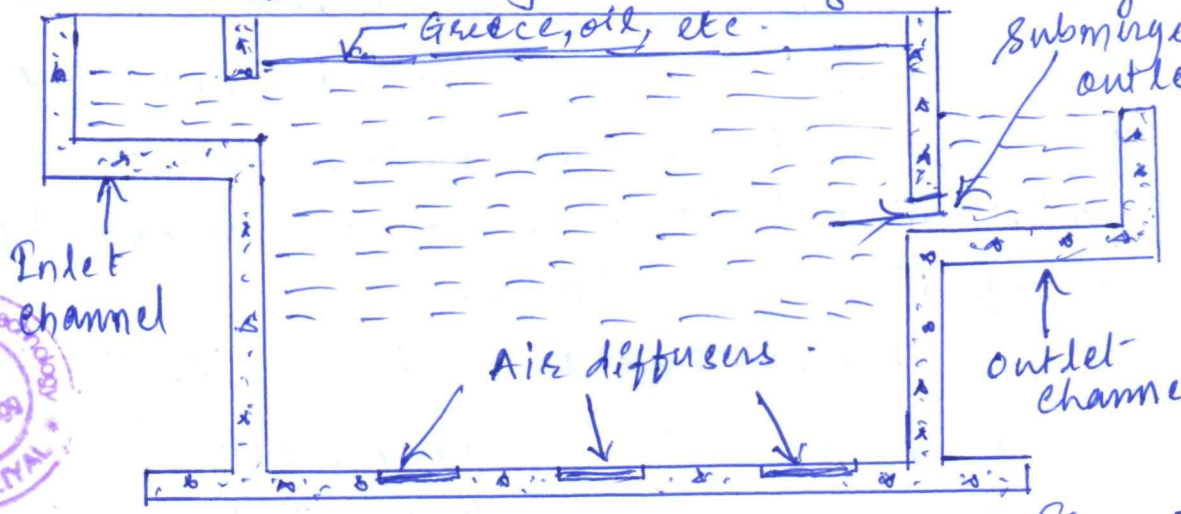
Chemical Oxygen Demand (COD) is the measure of the total amount of oxygen required to oxidize all organic & inorganic compounds in a water sample, using strong chemical oxidant. It's a key indicator of water quality, industrial effluents & efficiency of treatment plants. However COD has limitations including its inability to differentiate between biodegradable and inert organic matter and the use of hazardous chemicals in the testing process. ——— 03M

Total 06M.

Q.9 c) Briefly explain self-cleanishing velocity. — 04M.

OUT OF SYLLABUS.

Q.10 a) Draw a neat Sketch of skimming tank. Enumerate the importance of skimming tanks.



10M

Fig: Skimming tank. — Fig - 05M

The sewage contains floating substances which, if allowed to remain in sewage, seriously affect the working of various treatment units. The object of installing a skimming tank is to remove such floating substances ~~etc~~ which include grease, oil, soap, wood pieces, fruit skins etc. The floating substances are more prominent in the industrial sewage or waste water obtained from kitchen of hotels, motor garages, oil refineries, soap and candle factories etc.

— 05

Total 10M.

Q10 b) Draw and explain oxidation pond or and Oxidation ditch.

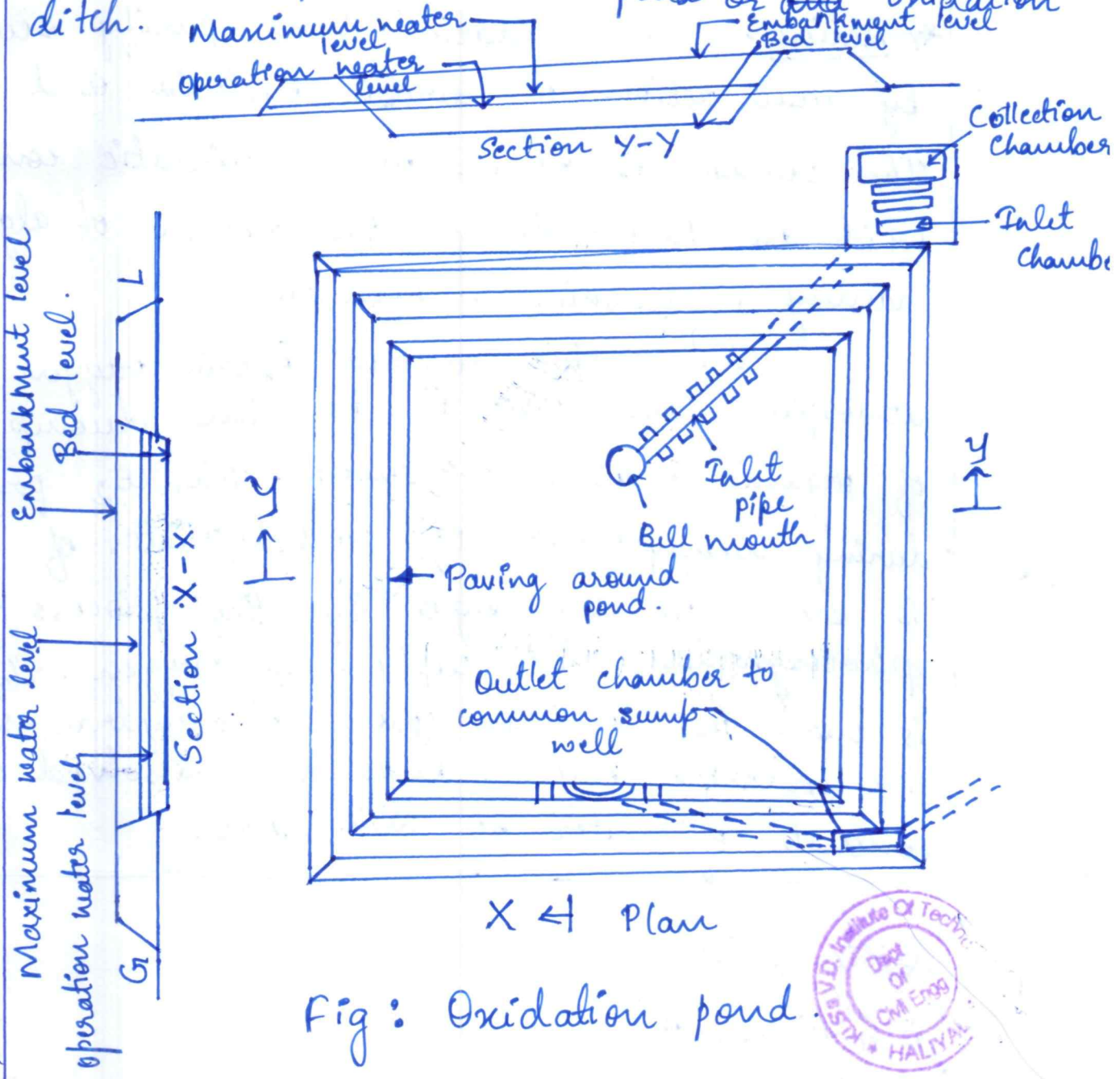


Fig: Oxidation pond.

*) Construction: The oxidation ponds are constructed with shallow depth of about 900mm to 1500mm. The shallow depths permits the penetration of sunlight into the body of sewage and it thus encourages the growth of algae. It is desirable to provide free board of about 1m or so. The pond is constructed into compartments of suitable sizes and the sewage is allowed to flow is zigzag manner through these

compartments.

*) Action: The oxidation pond purify sewage by dual action of aerobic bacteria and algae. The sewage is stored under climatic conditions which are favourable for the growth of algae, namely, sunshine & warmth.

The aerobic bacteria obtain oxygen from atmosphere and use it in the decomposition of organic matter of sewage. The CO_2 produced during decomposition of carbohydrates of sewage is broken up by algae by the process of photosynthesis into carbon & oxygen. The carbon is used in producing more carbohydrates and the released oxygen keeps the dissolved oxygen content of water at high level.

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