Questions

1. "Providing horizontal plates in settling basins increases the removal efficiency but provision of vertical baffles may even decrease the removal efficiency"– explain. **(02)**

Removal efficiency depends upon surface overflow rate. If horizontal plates are provided, the surface area increases. As a result, the SOR decreases and SOR is numerically equal to settling velocity. Thus, small size particles having lower settling velocity can settle completely.

However, providing vertical baffles don't change the surface area and doesn't change SOR. Apart from that vertical baffles causes turbulence and results in increasing horizontal velocity. Hence, removal efficiency may even decrease.

2. Estimate the minimum diameter of discrete particles whose removal efficiency will be 100 % in a circular tank receiving water at 100 MLD with height of settling zone 5 m, diameter at the end of inlet zone 3 m, and diameter at the start of the outlet zone 30 m. What would be the length of trajectory of settling for such particles. Specific gravity of suspended solids may be taken as 2.65 and kinematic viscosity of water as 1 centipoise. **(06)**

$$S.O.R = \frac{Q}{A}$$

$$\Rightarrow S.O.R = \frac{100\times10^3}{86400\times\pi\times(15^2-1.5^2)} = 1.654\times10^{-3}\ m^3/m^2 \text{ per sec}$$

equating SOR to settling velocity

$$\frac{gd^2}{18\nu}(G-1) = 1.654\times10^{-3}$$

$$\Rightarrow \frac{9.81\times d^2}{18\times10^{-6}}(2.65-1) = 1.654\times10^{-3}$$

$$\Rightarrow d = 4.28\times10^{-5}\ m.$$

$$Re = \frac{vd}{\nu} = \frac{1.654\times10^{-3}\times4.28\times10^{-5}}{10^{-6}} = 0.07 < 1$$

$\therefore$ Laminar

$$\text{trajectory length} = \sqrt{5^2+(15-1.5)^2} = 14.39\,m$$

3. A canal takes off from a river having 1000 m^3/s discharge and is designed to withdraw 5 % of the river flow. The canal cross-section is rectangular having a width 50 m. The TSS in the river water is 300 mg/l with particle size distribution as given below. A water supply intake, which collects the overflow from the canal, is located at 2.58 km from the canal take-off point. Estimate the TSS concentration with weight fraction of different particle sizes to the inlet of the Water Treatment Plant. Make suitable assumptions and state them clearly. **(10)**

Particle Size, µm	:	100	80	70	60	40	20	10
Weight Fraction, %	:	10	05	25	20	10	15	15
Terminal Settling Velocity, (mm/sec)	:	1.081	0.689	0.527	0.388	0.172	0.043	0.011

the canal acts as a plain sedimentation tank of L = 2.58 km and B = 50m

$$S.O.R = \frac{Q}{A} = \frac{\frac{5}{100}\times 1000}{(2.58\times 10^3)\times 50} = 3.87\times 10^{-4}\ m^3/m^2 \text{ per sec}$$

$$= 0.388\ mm/sec.$$

60% particles, that are above 60µm will be completely removed

$$\text{Extra removal} = \left(\frac{0.172}{0.388}\times 10\right) + \left(\frac{0.043}{0.388}\times 15\right) + \left(\frac{0.011}{0.388}\times 15\right)$$

$$= 4.43 + 1.66 + 0.425$$

$$= 6.51\%.$$

total removal = 60 + 6.51 = 66.51%.

$$\therefore \text{TSS concentration} = \left(\frac{100 - 66.51}{100}\right)\times 300$$

$$= 100.47\ mg/L$$

4. Briefly explain Crown Corrosion in Sewer and its consequences. What measures can be taken to deal with consequences of the problem of Crown Corrosion. **(03)**

(a) Anaerobic conditions prevail in the ~~sewage~~ sewer. Desulpho vibrio bacteria reduces SO_4^{2-} present in sewage to S^{2-}. These sulfides are released into the ~~sewage~~ sewer atmosphere as H_2S gas. In the crown micro oxidising conditions exist and H_2S is converted to SO_2 and the SO_3, and finally to H_2SO_4 in presence of thiobacillus. As a result crown corrosion occurs.

(b) Consequences: As a ~~per~~ crown becomes weaker the sewage may escape the sewer. Also the road above the sewer may collapse.

(c) Remedies

- Good ventillation to ensure aerobic condition
- Regular flushing of sewer line
- Providing pipes made of inert materials & provide lining

5. What is the purpose of gentle mixing as part of coagulation process? How is power required for this provided in non-mechanical flocculator? Other than flow, what information is required to compute power dissipated in such kind of flocculators. **(03)**

(a) Gentle mixing is done in coagulation process to ensure orthokinetic ~~settl~~ flocculation.

(b) $P = \gamma_w Q H$. The power is provided in the form of head loss.

(c) Apart from flow, we need information of headloss.

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6. During coagulation operation in water treatment plant, rapid mixing is carried out for 0.5-1 minutes and slow/gentle mixing is carried out for 20-30 minutes. In water treatment plant hydraulic jump is used for mixing chemicals quickly (flash mixer) **(03)**

7. Describe how coagulation of colloidal particles in water treatment is achieved under the following conditions:

a) Low colloid concentration and high alkalinity
b) Low colloid concentration and low alkalinity
c) High colloid concentration and low alkalinity
d) High colloid concentration and high alkalinity

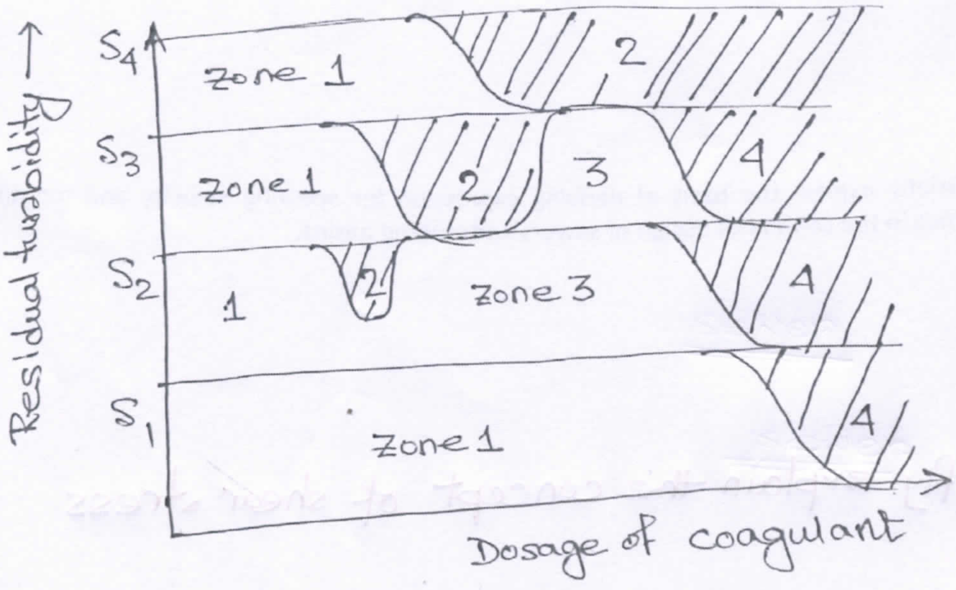
Give your answer under the heads: (i) Nature of residual turbidity versus the addition of coagulant dose plot, (ii) Mechanism of destabilization of colloidal suspension, (iii) Necessity of coagulant aid, and (iv) Sludge characteristics in terms water content and/or bulkiness. **(08)**

(a) Low colloid - High alkalinity: The small no of colloids make coagulation difficult, zone 1 will be formed. At very high alkalinity, zone 4 will be observed. The mechanism will be enmeshment into sweep flocks. Sludge will have high volume and will be bulky in nature. If we add colloids, zone 2 will be observed and it will decrease the amount of coagulant needed.

(b) Low colloid - Low Alkalinity: It is very difficult to remove the particles as the small number of colloids make coagulation difficult and low alkalinity prevents settling by enmeshment. Additional alkalinity can be added to convert it to a Group 3 type or additional turbidity can be added to convert it to zone 1 → it is advantageous to add both.

(c) High colloid - Low Alkalinity: Easiest system — zone 1 and zone 2 will be formed — no restabilisation. Particles will destabilise easily. Coagulant addition is not necessary. Sludge will be less bulky.

(d) High Colloid - High Alkalinity: High Alkalinity — zone 2 will be formed. Mechanism is enmeshment into sweep flocks. Coagulant addition is not necessary. Sludge will be bulky in nature



8. Determine the pump horsepower to raise the water from a river with reduced level of water surface 120 m during the lean season to treatment plant whose inlet water surface reduced level is 140 m. The water treatment plant needs to cater to a population of 2 lakhs having per capita daily demand of water of 150 litres and the water is conveyed through a rising main of 1 m diameter. The total head loss due to friction, etc. and pumping efficiency is estimated at 2 m and 70% respectively. **(03)**

Water pumped daily = 200000 × 150 lt
= $30 \times 10^3\ m^3$

discharge pumped = $\frac{30 \times 10^3}{24 \times 3600} = 0.347\ m^3/sec$

water power required = $\gamma_w Q H$

where, H = total head lift = 20 + 2 = 22 m

∴ water power required = $9.81 \times 0.347 \times 22 = 74.94$ kW

water HP = $\frac{74.94}{0.735} = 101.96$ HP

pumping efficiency = 70%

HP of motor required = $\frac{101.96}{0.7} = 145.66$ HP

9. Briefly explain the basis of deriving expression for scouring velocity and mention its significance in the context of design of sewers and settling basins. **(<u>03</u>)**

Briefly explain the concept of shear stress

<u>Sewers</u>: Minimum velocity = Scouring velocity should be achieved atleast once in a day so that the deposited particles get resuspended.

<u>Settling Basin</u>: Horizontal velocity should be less than the scouring velocity because here we don't want resuspension of already settled particles.

10. Table below gives the analysis of the frequency of the storms of stated intensity and duration during 26 years for which the rainfall data was available for a given town.

A storm sewer is to be designed which drains a part of the town having an area of 5 hectares. A survey of the area indicated that 50 % of the area is densely populated (I = 65-75 %), 30 % is occupied by industrial and commercial installations (I = 70-90 %), and the remaining 20 % consists of an open area, greenery, etc. (I = 10-20 %). Further based on economic considerations and calculated risk, it is decided to design the storm sewer for one-year frequency. The sewer has a length of 120 m and is designed for 1 m/s velocity when flowing half full. Assume an inlet time of 12 minutes. The ground conditions dictate that slope should not be more than 6.05 m per 1000 m. Compute the diameter of the sewer and the difference in invert levels between the two manholes. **(<u>10</u>)**

Duration in Minutes	Number of Storms of Stated Intensity (mm/h) and Duration for a								
	30	35	40	45	50	60	75	100	125
05	-	-	-	-	100	40	18	10	2
10	-	-	90	72	41	25	10	5	1
15	-	82	75	45	20	12	5	1	-
20	83	62	51	31	10	9	4	2	-
30	73	40	22	10	8	4	2	-	-
40	34	16	8	4	2	1	-	-	-
50	14	8	4	3	1	-	-	-	-
60	8	4	2	1	-	-	-	-	-
90	4	2	-	-	-	-	-	-	-

Use following data for choosing runoff coefficient values.

Runoff Coefficient for Imperviousness, I = 60 —65 %	0.365	0.427	0.477	0.531	0.569
Storm Duration, Minutes	10.0	20.0	30.0	45.0	60.0

Avg imperviousness co-efficient $= 0.5\times70+0.3\times80+0.2\times15$
$= 62$

1year design frequency → 26 times in 26years

storm duration = 12 min

run off co-efficient, $C = 0.365+\left(\frac{0.427-0.365}{10}\right)\times2 = 0.3774$

10min duration:

intensity for 26 storms $= -\left(\frac{60-50}{41-25}\right)\times1+60 = 59.375$ mm/hr

15min duration

intensity for 26 storms = $\cancel{-6\left(\frac{31-10}{50-45}\right)+50}$

$= -\left(\frac{50-45}{45-20}\right)\times6+50 = 48.8$ mm/hr

12min duration

$I = 59.375+2\times\left(\frac{48.8-59.375}{15-10}\right) = 55.145$ mm/hr

$Q = CIA = 0.3774\times(55.145\times10^{-3})\times5\times10^4$

$Q = 1040.58$ m³/hour

$Q = 0.289$ m³/sec

$Q = V.A$

$\Rightarrow (0.289) = 1\times\frac{\pi D^2}{8}$

$\Rightarrow D = 0.857$m

provide, D = 0.86m

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

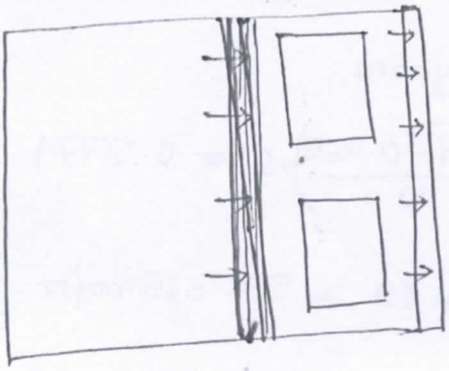
$1 = \frac{1}{0.013}\times\left(\frac{D}{4}\right)^{2/3}\sqrt{S}$

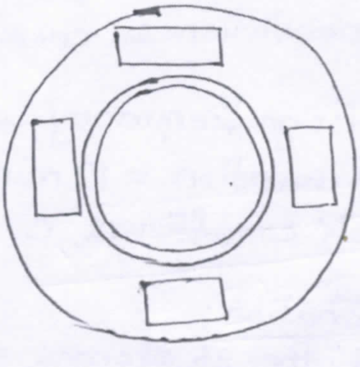
$S = 1.312\times10^{-3}$

= 1.312 in 1000

(okay)

11. The maximum length of effluent launders in settling Basin A (30 m long, 10 m wide and 5 m deep) and B (30 m diameter and 5 m deep) without additional provision can be 10 m and 30π m respectively. Explain below giving sketch how additional length of the effluent launders can be provided for rectangular and circular settlings basins. **(04)**

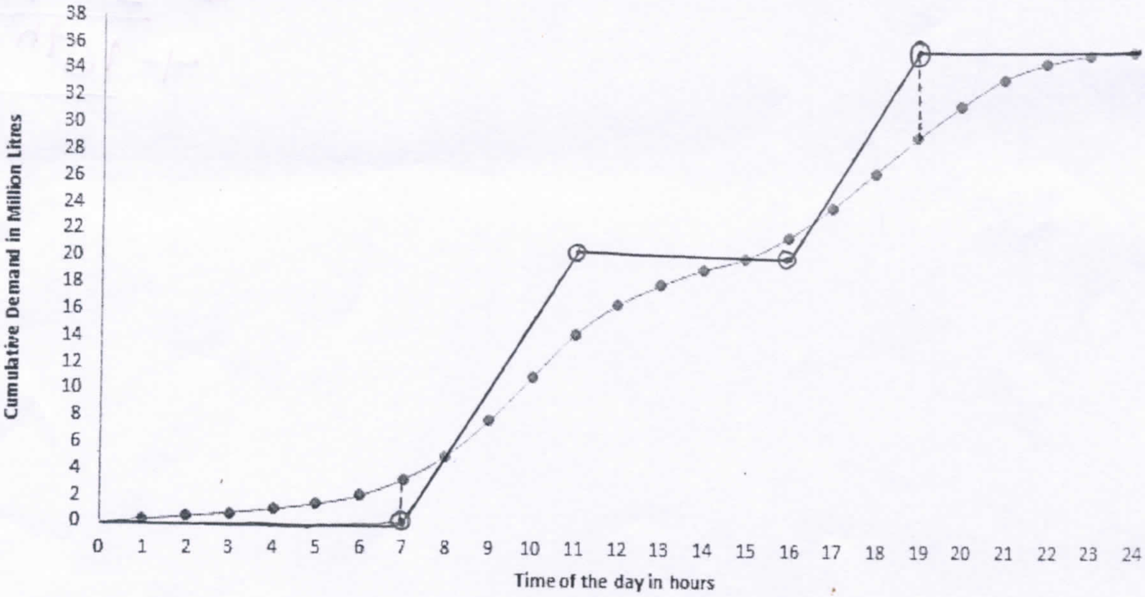




12. A city with a population of 2 lakhs has to be supplied with water at 180 L per person per day. The probable 24 h variation in demand as percentage of average daily demand and cumulative demand are given below in the Table and Figure respectively. Water is supplied for four hours in the morning between 07:00 to 11:00 h and three hours during 16:00 to 19:00 h in the evening. Determine (i) duration in which reservoir will get emptied, (ii) duration in which reservoir will get filled, (iii) instance when the reservoir will be full, and (iv) how much water the reservoir should hold when full?

(05)

Time, Hour	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08
% of Average Daily Demand	15	15	15	20	25	40	80	120
Time, Hour	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16
% of Average Daily Demand	180	220	220	150	100	80	60	110
Time, Hour	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
% of Average Daily Demand	150	180	180	16	14	80	45	15



Avg daily supply = 180×200000 lt = 36 million lt

Pumping done for 7AM to 11 AM and 4PM to 7PM

∴ rate of supply = $\frac{36}{7}$ = 5.14 ML/hour

time		cumulative supply
	8	5.14
AM	9	10.28
	10	15.42
	11	20.56
	12AM – 4PM	– same –
	5	25.70
PM	6	30.84
	7	36

(ii) Get ~~emptied~~ filled in: 7 – 11 AM, 4 – 6 PM

(i) (ii) Get ~~filled~~ emptied in: 0 – 7 AM, 11AM – 4PM, 6PM – Midnight

(iii) Full at: 8AM, 3PM, 4:30PM, Midnight

(iv) Volume of reservoir = 6.25 + 3
= 9.25 ML