11 CHAPTER
Treatment of Sewage

Q.1 Unit operations involve contaminant removal by
(a) Biological treatment
(b) Chemical reactions
(c) Physical forces
(d) Both (a) and (b)

Q.2 Which of the following does not use suspended growth process?
(a) Activated sludge process
(b) Bio-towers
(c) Aerated lagoon
(d) Oxidation pond

Q.3 Match List-I (Contaminant) with List-II (Unit operation, process or treatment system) and select the correct answer using the codes given below the lists:

List-I
A. Suspended solids
B. Pathogens
C. Phosphorus
D. Refractory organics

List-II
1. Metal-salt addition
2. Flotation
3. Carbon adsorption
4. Chlorination

Codes:

	A	B	C	D
(a)	2	4	1	3
(b)	1	4	2	3
(c)	2	3	1	4
(d)	1	3	2	4

Q.4 Oils and greases are removed in
(a) Detritus tank (b) Skimming tank
(c) Grit chamber (d) Screening

Q.5 Consider the following statements:
1. Oxygen in oxidation pond is supplied by algal photosynthesis.
2. Oxygen in oxidation pond is supplied by surface re-aeration.
3. Solids at the bottom of oxidation pond are decomposed anaerobically

Which of the these statements are correct?
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

Q.6 Flow measurement devices are generally included in the
(a) Primary system (b) Secondary system
(c) Tertiary system (d) None of these

Q.7 **Assertion (A):** There is a limit placed on velocity of flow through screens.
Reason (R): This limit on velocity limits the head loss through the screens and thus, reduces the opportunity of materials to be pushed through the screens.
(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

Q.8 What is the head loss through screen if the velocity through screen is not allowed to exceed 0.9 ms^{-1} and velocity above the screen is 0.71 ms^{-1}? Assume the screen openings get half clogged.
(a) 0.17 m (b) 0.2 m
(c) 0.22 m (d) 0.25 m

Q.9 Commutators are installed
(a) after grit removal tank
(b) before fine screen
(c) after fine screen
(d) after sedimentation

Q.10 Incineration of screening is carried out at a temperature of about
(a) 600-675°C (b) 675-750°C
(c) 760-815°C (d) 820-875°C

Q.11 Match List-I (Type of settling) with List-II (Expression for C_D) and select the correct answer using the codes given below the lists:

List-I
A. Streamline settling
B. Transition settling
C. Turbulent settling

List-II
1. 0.34 to 0.4
2. $\frac{24}{R_e}$
3. $\frac{24}{R_e}+\frac{3}{\sqrt{R_e}}+0.34$

Codes:

	A	B	C
(a)	2	3	1
(b)	2	1	3
(c)	1	3	2
(d)	1	2	3

Q.12 Consider the following data in the design of grit chamber:
1. Specific gravity of grit particle = 2.65
2. Size of grit particle = 0.19 mm
3. Viscosity of water = 1×10^{-2} cm²/s

The settling velocity (in cm/s) of the grit particle will be
(a) 1.5 - 1.7 (b) 1.8 - 3.6
(c) 3.1 - 4.2 (d) > 4.2

Q.13 Critical scouring velocity for grit channels given by modified Shield's formula, $V_H = K\sqrt{gd(G-1)}$

Here, the value of K is
(a) 1.5 to 3.0 (b) 3.0 to 4.5
(c) 4.5 to 6.0 (d) 6.0 to 7.0

Q.14 Consider the following statements:
1. Grit chamber should allow for settlement of some heavy organic materials.
2. Velocity control devices are provided at the end of channel.
3. Grit chamber is provided in the form of channel of longer length and smaller section area.
4. If proportional weir is used, parabolic channel is provided and when Parshall flume is used, rectangular section is provided in grit chamber.

Which of these statements is/are correct?
(a) 1, 2 and 3 (b) 2 and 3
(c) 1, 2 and 4 (d) 1, 2, 3 and 4

Q.15 **Assertion (A):** The efficiency of skimming tank can be increased considerably by passing chlorine gas along with the compressed air.
Reason (R): The action of chlorine is to destroy the protective colloidal effect of protein, which holds the grease in emulsified form.
(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

Q.16 Match List-I (Name of coagulant) with List-II (pH value required for proper functioning in sewage treatment) and select the correct answer using the codes given below the lists:

List-I
A. Ferric chloride
B. Ferric sulphate with lime
C. Alum
D. Chlorinated copperas

List-II
1. 5.5 to 7.0
2. 6.0 to 8.5
3. 8.0 to 8.5
4. 5.5 to 7.0 and 9.0 to 9.5

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	1	3	2	4
(c)	4	3	2	1
(d)	4	2	3	1

Q.17 The biological film over the filtering media particles in trickling filter will have
(a) aerobic layers
(b) anaerobic layers
(c) facultative layers only
(d) both (a) and (b)

Q.18 Consider the following statements related to trickling filters:
1. They are self-cleansing
2. Cost of construction of trickling filter is low
3. Working of trickling filters is simple and does not require any skilled supervision
4. Primary sedimentation is a must

Which of these statements is/are correct?
(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 2, 3 and 4 (d) 3 and 4

Q.19 Design of trickling filter is to be done for
(a) peak flow
(b) average flow
(c) intermittent flow
(d) peak flow and checked for average flow

Q.20 What is the efficiency of a trickling filter for an organic loading of 160 gm/m³/day?
(a) 82.37% (b) 83.51%
(c) 84.27% (d) 85.63%

Q.21 What is the value of recirculation factor if the recirculation ratio is 2?
(a) 1.92 (b) 2.08
(c) 2.35 (d) 2.59

Q.22 The characteristics and quantity of a sludge depends on
(a) the initial water and waste water composition
(b) the water and waste water treatment processes
(c) the degree of treatment
(d) All of these

Q.23 A combination of sludge, scum and liquid pumped from septic tank or cesspool is known as
(a) Septage (b) Tertiary sludge
(c) Sullage (d) None of these

Q.24 Under oxidizing conditions, volatile solids are removed when sludge is heated to
(a) 400°C (b) 500°C
(c) 600°C (d) 1200°

Q.25 Consider the following statements:
1. Heat content of methane is 7300 k cal./m³.
2. Volatile solids are measured by an equipment called muffle furnace.
3. Supernatant liquor includes the liquefied and finely divided solid matter.
4. Out of the total volatile solids, approx 60-70% are reduced to gases in digestion tank.

Which of these statements are correct?
(a) 1, 2 and 3 (b) 1, 2, 3 and 4
(c) 2 and 3 (d) 2, 3 and 4

Q.26 The depth of sludge digestion tank is usually kept at about
(a) 2 m (b) 4 m
(c) 6 m (d) 8 m

Q.27 What should be the weir overflow rate for secondary sedimentation tank with trickling filter?
(a) 125 m³/m/day (b) 150 m³/m/day
(c) 185 m³/m/day (d) 210 m³/m/day

Q.28 Consider the following methods of sludge concentration:
1. Gravity method
2. Basket centrifuge
3. Dissolved air-floation
4. Solid bowl centrifuge

Which of these methods can be used for waste activated sludge?
(a) 1 and 2 (b) 1 and 3
(c) 1, 3 and 4 (d) 1, 2, 3 and 4

Q.29 The design discharge for the separate sewer system shall be taken as equal to
(a) DWF
(b) 2 × DWF
(c) 3 × DWF
(d) 6 × DWF
where DWF is Dry Weather Flow.

Q.30 The maximum efficiency of BOD removal is achieved in
(a) oxidation pond
(b) oxidation ditch
(c) aerated lagoons
(d) trickling filters

Q.31 The detention period for oxidation pond is usually kept as
(a) 4 - 8 hours (b) 24 hours
(c) 10 to 15 days (d) 3 months

Q.32 For normal sludge, the value of sludge volume index for Indian conditions is
(a) 0 to 50 (b) 50 to 150
(c) 150 to 350 (d) 350 to 500

Q.33 The following steps are involved in laying a sewer in a trench :
1. Transferring the centre line of the sewer to the bottom of the trench.
2. Setting sight rails over the trench.
3. Driving pegs to the level of the invert line of the sewer.
4. Placing the sewer in the trench.
The correct sequence of these steps is
(a) 1, 2, 3, 4 (b) 2, 3, 4, 1
(c) 4, 2, 3, 1 (d) 2, 3, 1, 4

Q.34 The sewers
(a) must be of adequate size to avoid over flow
(b) must flow under gravity $\frac{1}{2}$ to $\frac{3}{4}$ full
(c) must be laid at least 2 to 3 m deep to collect water from the basements
(d) All the above

Q.35 The small sewers are cleaned by
(a) flushing (b) cane rodding
(c) wooden pills (d) none of these

Q.36 Pick up the correct statement from the following:
(a) Hydrogen sulphide gas in excess, may cause corrosion of concrete sewers
(b) 4 ppm of dissolved oxygen (D.O.) is ensured before discharging the treated sewage in river
(c) Solubility of oxygen in sewage is about 95% of that in distilled water
(d) All of the above

Q.37 The digested sludge from septic tank is removed after a maximum period of
(a) 3 years (b) 3.5 years
(c) 4 years (d) 5 years

Q.38 The clarigesters are
(a) circular septic tanks
(b) rectangular septic tanks
(c) circular imhoff double storey tanks with bottom hoppers
(d) circular imhoff double storey tanks without bottom hoppers

Q.39 Anaerobic bacteria derive oxygen in a combined state for their metabolism, which means
1. they decompose radicals of nitrates and phosphates
2. prefer light and running water
3. their end products are odorous
4. their reactions take place slowly
Indicate which of the above are correct?
(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 3, 2 and 4 (d) 1, 2 and 4

Q.40 Quantity of methane produced in a sludge digester is
(a) 1 to 5 m^3/1000g solids
(b) 15 to 22 m^3/1000g solids
(c) 15 to 30 m^3/1000g solids
(d) 25 to 50 m^3/1000g solids

Q.41 Match List-I (Terms/Description) with List-II (Treatment operation process) and select the correct answer using codes given below the lists:

List-I	List-II
A. Sludge volume	
B. Thickening of sludge	
C. Scum removal	
D. Recycling effluent	

List-II
1. Settling in primary sedimentation tank
2. Settling in secondary sedimentation tank
3. Filtration in trickling filter
4. Activated sludge process

Codes:

	A	B	C	D
(a)	2	4	1	3
(b)	4	2	3	1
(c)	2	4	3	1
(d)	4	2	1	3

Q.42 Match List-I with List-II and select the correct answer using codes given below the lists:

List-I	List-II
A. Sludge disposal	1. Seeding
B. Sludge digestion	2. Biofilters
C. Aerobic action	3. Legging
D. Recirculation	4. Contact bed

Codes:

	A	B	C	D
(a)	3	1	4	2
(b)	3	1	2	4
(c)	1	3	2	4
(d)	1	3	4	2

Q.43 Which of the following are claimed as advantageous in respect of aerobic sludge digestion as compared to anaerobic sludge digestion?
1. Lower BOD concentration in supernatant liquor
2. Production of a sludge with excellent denaturing property
3. Greater production of methane
4. Lesser operation cost
5. Lesser capital cost
Which of these statements are correct?
(a) 1, 2 and 4 (b) 2, 3, 4 and 5
(c) 3, 4 and 5 (d) 1, 2 and 5

Q.44 Treatment units which work on oxidation alone are
1. aeration tanks and contact beds
2. intermittent sand filters
3. trickling filters
4. oxidation ponds
Which of these statements are correct?
(a) Both 1 and 3 (b) Both 2 and 4
(c) 1, 3 and 4 (d) 1, 2, 3 and 4

Q.45 Treatment units which work on putrefaction alone are
1. septic tanks
2. imhoff tanks
3. sludge digestion tanks
4. anaerobic lagoon
Which of these statements are correct?
(a) Both 1 and 3
(b) Both 2 and 4
(c) 1, 2 and 3
(d) 1, 2, 3 and 4

Q.46 Consider the following statements with reference to skimming tanks :
1. A detention period of about 3 to 5 minutes is adopted.
2. 300 to 6000 m^3 of compressed air is required per million litres of sewage.
3. The surface area of the tank is equal to 0.00622 q/v, where 'q' is rate of flow of sewage in m^3/day and v is the minimum rising velocity of greasy material to be removed in m/minute.
Which of these statement/s is/are correct?
(a) Only 3
(b) Both 1 and 3
(c) Both 2 and 3
(d) 1, 2 and 3

Q.47 An aeration basin with a volume of 400 m^3 contains mixed liquor with suspended solids concentration of 1000 mg/l. The amount of mixed liquor suspended solids in the tank is
(a) 500 kg (b) 250 kg
(c) 600 kg (d) 400 kg

Q.48 Symbiosis, the beneficial association between algae and bacteria is used for treatment of waste water in which of the following unit?
(a) Activated Sludge
(b) Rotating Biological Disc

(c) Anaerobic Digester
(d) Oxidation Pond

Q.49 A township is to treat 5,00,000 litres of sewage per day which has a 5 day BOD of 150 ppm. An oxidation pond is used for the purpose. The effluent can have a BOD of 15 ppm. The loading is to be 40 kg of 5 day BOD per hectare per day. The required area of the pond is
(a) 1.6875 ha (b) 1.875 ha
(c) 1.975 ha (d) 2 ha

Q.50 If the efficiencies of BOD removal of first-stage and second-stage trickling filters are each 65.0%, then what is the overall BOD removal efficiency of these filters?
(a) 65% (b) 77.25%
(c) 87.75% (d) 92.6%

Q.51 The spacing of bars in coarse screens is generally more than
(a) 6 mm (b) 10 mm
(c) 25 mm (d) 50 mm

Q.52 The ratio of 'flowing through period' to 'detention period' in a sedimentation tank, is called.
(a) surface loading
(b) displacement efficiency
(c) theoretical efficiency
(d) settling velocity

Q.53 Activated sludge is the
(a) aerated sludge in the aeration unit
(b) sludge settled in the humus tank
(c) sludge in the secondary tank after aeration and rich in microbial mass
(d) sludge in the secondary tank after aeration and rich in nutrients

Q.54 Which of the following statements related to C/N (Carbon/Nitrogen) ratio is not correct?
(a) Lower initial C/N ratio leads to loss of nitrogen and slows down the rate of decomposition
(b) Higher initial C/N ratio leads to cell destruction to obtain nutrition
(c) Higher initial C/N ratio leads to lower conservation of nitrogen in the finished compost
(d) An initial C/N ratio of 30 to 50 is optimal for composting

Q.55 Which one of the following is considered as the thermophilic range of sludge digestion?
(a) 60°C to 70°C (b) 50°C to 57°C
(c) 29°C to 40°C (d) 20°C to 30°C

Q.56 Where does sloughing occur?
(a) Grit chamber
(b) Biological treatment unit
(c) Trickling filter
(d) Septic tank

Q.57 A grit chamber of divisions 12 m × 1.5 m × 0.8 m liquid depth has a flow of 720 m^3/hr. Its surface loading rate and detention time are, respectively
(a) 4000 $m^3/hr/m^2$ and 1.2 minutes
(b) 40000 $l/h/m^2$ and 40 minutes
(c) 40 $m^3/h/m^2$ and 12 minutes
(d) 40000 $l/h/m^2$ and 1.2 minutes

Q.58 Which of the following waste disposal tasks are achieved by a septic tank with its dispersion trench?
1. Aerobic sludge digestion.
2. Settling and anaerobic sludge digestion.
3. Anaerobic sewage stabilization.
4. Bio-oxidation of effluent.
Select the correct answer using the codes given below:
(a) 1 and 3 (b) 3 and 4
(c) 2 and 4 (d) 1 and 4

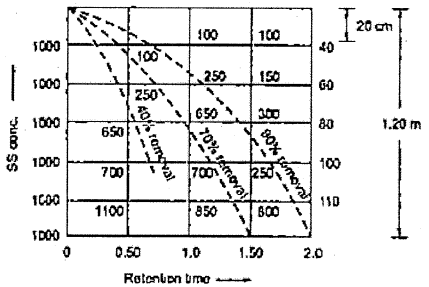
Q.59 In the oxidation ditch, the excess sludge is taken to
(a) anaerobic digestor
(b) aerobic digestor
(c) drying beds
(d) incinerator

Q.60 The function of algae in oxidation pond is to
(a) provide a mat over the surface of the oxidation pond so as to prevent evaporation of water
(b) provide oxygen for bacteria to degrade organic matter.
(c) provide a greenish appearance to the pond.
(d) prevent the odour nuisance.

Q.61 Assertion (A): The effluent of a septic tank needs further treatment before it is discharged into any receiving body.
Reason (R): The organic strength of effluent is high.
(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

Q.62 What is the order of BOD_5 removal efficiency of a septic tank for isolated houses?
(a) 10 to 20% (b) 45 to 55%
(c) 70 to 80% (d) Above 90%

Common Data Question 63-64:
A chemical waste at an initial SS concentration of 1000 mg/l and flow rate of 200 m^3/hour to be settled in a tank, H = 1.2 m deep, W = 10 m wide and L = 31.4 m long. The results of laboratory test are shown in figure.



Q.63 The hydraulic retention time and critical velocity of the particle is
(a) 2.18 hour, 0.614 m/h
(b) 1.99 hr, 0.624 m/hr
(c) 2.08 hour, 0.624 m/h
(d) 1.88 hr, 0.614 m/hr

Q.64 The fraction of solids removed are
(a) 86.90% (b) 88.90%
(c) 90.90% (d) 92.90%

Q.65 The BODs of the liquid from the classifier (primary) is 120 mg/l at flow rate of 0.05 m^3/sec. The dimensions of aeration tank is 20 × 10 × 20 m and MLSS = 2000 mg/l. The F/M ratio is
(a) 0.032 d^{-1} (b) 0.065 d^{-1}
(c) 0.048 d^{-1} (d) 0.086 d^{-1}

Q.66 A sample of sludge has an SS concentration of 4000 mg/l. After settling for 30 min in a 1 L cylinder, the sludge occupies 400 mL. The sludge volume index of sludge is
(a) 100 (b) 1×10^4
(c) 1×10^3 (d) 1×10^5

Common Data Question 67-68:
An activated sludge system operates at flow rate of 400 m^3/day. With incoming BOD (S_0) of 300 mg/l. A pilot plant showed the kinematic constant to be Y = 0.5 kg SS kg/BOD, K_s = 200 mg/l, u = 2/day. We need to design a treatment system that will produce efficient BOD of 30 mg/l.
90% removal (Assume X = 4000 mg/L)

Q.67 The sludge age in days is
(a) 2.8 days (b) 3.8 days
(c) 4.8 days (d) 5.8 days

Q.68 The sludge wasted daily is
(a) 473 kg/day (b) 723 kg/day
(c) 384 kg/day (d) 543 kg/day

Q.69 Raw primary and waste activated sludge containing 4% solids is to be anaerobically digested at a loading of 3 kg/m^3 day. The total sludge produced in the plant is 1500 kg of dry solids per day. The hydraulic retention time for primary digester is
(a) 11.20 days (b) 12.20 days
(c) 13.30 days (d) 11.90 days

Q.70 A binary separator, a magnet is to separate a product, ferrous materials from a feed stream of shredded refuse. The feed rate to the magnet is 1000 kg/h and contains 50 kg of ferrous materials. The product stream weight 40 kg, of which 35 kg are ferrous materials. The overall efficiency of binary separator is
(a) 88% (b) 70%
(c) 92% (d) 80%

71. A laboratory runs a solid test. The weight of the crucible = 486212 g. A 100 ml sample is placed is crucible and water is evaporated. The weight of crucible and dry solids = 48.6432 g. The crucible is placed in 600°C furnace for 24 hr and cooled. The weight of cooled crucible, residues and unburned solids = 48°630 g. The total volatile solids are:
(a) 220 mg/l (b) 88 mg/l
(c) 132 mg/l (d) 308 mg/l

■■■■

Answers Treatment of Sewage

1. (c)	2. (b)	3. (a)	4. (b)	5. (d)	6. (a)	7. (a)	8. (b)	9. (b)	10. (c)
11. (a)	12. (b)	13. (b)	14. (b)	15. (a)	16. (b)	17. (d)	18. (b)	19. (b)	20. (c)
21. (b)	22. (d)	23. (a)	24. (b)	25. (d)	26. (c)	27. (a)	28. (d)	29. (d)	30. (b)
31. (c)	32. (b)	33. (d)	34. (d)	35. (a)	36. (d)	37. (a)	38. (d)	39. (b)	40. (b)
41. (d)	42. (a)	43. (d)	44. (d)	45. (d)	46. (d)	47. (d)	48. (d)	49. (a)	50. (c)
51. (d)	52. (b)	53. (c)	54. (c)	55. (b)	56. (c)	57. (d)	58. (c)	59. (c)	60. (b)
61. (a)	62. (b)	63. (d)	64. (c)	65. (b)	66. (a)	67. (b)	68. (d)	69. (c)	70. (b)
71. (c)									

Explanations Treatment of Sewage

1. (c)
Unit operations involve contaminant removal by physical forces. The major treatment methods falling under this category are screening, mixing, sedimentation, grit chamber, etc.

2. (b)
Examples of suspended growth process: Activated sludge process, aerated lagoon, oxidation pond, aerobic and anaerobic sludge digester etc.
Example of attached growth process: Trickling filter, rotating biological contractors, bio-towers, etc.

8. (b)
Head loss through screen
$= 0.0729 (V^2 - v^2)$
Here, $V = 2 \times 0.9$
(∵ Screen openings are half clogged)
$= 1.8\ ms^{-1}$
$v = 0.71\ ms^{-1}$
So, head loss
$= 0.0729 (1.8^2 - 0.71^2)$
$= 0.2\ m$

12. (b)
Particle size (0.19 mm) is between 0.1 mm and 1 mm so the settling velocity in transition region will be given by,

$$V^2 = \frac{4}{3} g \frac{(\rho_p - \rho_w) d}{C_D \rho_w}$$

Where, $C_D = \frac{24}{R_e}$ when $R_e > 1$

$$C_D = \frac{24}{R_e} + \frac{3}{\sqrt{R_e}} + 0.34$$

when $1 < R_e < 10^3$

$C_D = 0.4$ when $R_e > 10^3$

Finding the settling velocity in transition region is a trial and error process. However, the velocity of particle can be calculated by assuming laminar flow and the velocity in transition will be less than the calculated value

$$V = \frac{g}{18}(G_S - 1)\frac{d^2}{\nu}$$

$$= \frac{9.81}{18} \times (2.65 - 1) \times \frac{(0.19 \times 10^{-2})^2}{10^{-2} \times 10^{-4}}$$

$= 0.0325\ ms^{-1} = 3.25\ cm/s$

Best option is (b)

14. (b)
Grit chambers should never allow settlement of organic material, because no further treatment of removed grit is provided.
If proportional weir is used, rectangular section is provided and if Parshall flume is useo, parabolic channel is provided.

17. (d)
Aerobic layer will be at the surface whereas anaerobic layer will be deep inside the film where oxygen cannot penetrate.

18. (b)
Cost of construction of trickling filter is high. These filters cannot treat raw sludge and primary sedimentation is a must.

20. (c)
Organic loading,
$\mu = 180\ gm/m^3/day$
$= \frac{180}{1000} \times 10^4 = 1800\ kg/ha\text{-}m/day$
So, efficiency of filter,

$$\eta = \frac{100}{1 + 0.0044\sqrt{\mu}}$$

$$\Rightarrow \quad \eta = \frac{100}{1 + 0.0044\sqrt{1800}} = 64.27\%$$

21. (b)
Recirculation factor,

$$F = \frac{1 + \frac{R}{I}}{\left(1 + 0.1\frac{R}{I}\right)^2}$$

Where, $\frac{R}{I}$ is recirculation ratio

So, $F = \frac{1+2}{(1+0.1\times2)^2} = 2.08$

25. (d)
Heat content of methane is 8600 k cal./m^3

30. (b)
Oxidation ponds & aerated lagoons - 90% BOD removal
Oxidation ditch - 98% BOD removal
Trickling filters - 80 to 90 % BOD removal

31. (c)
Usually the detention period of oxidation pond varies in between 7 to 42 days.

32. (b)
For good settling, value of sludge volume index should lie between 50-150.

35. (a)
Small sewers are cleaned by flushing, while medium sewers are cleaned by cane rodding or by wooden piles & large sized sewers are generally cleaned by manual labour.

37. (a)
Digested sludge from septic tank is periodically removed between 6 months to 3 years. In no case greater than 3 years.

38. (d)
Clarigesters are small patented circular imhoff type double storey tanks, without bottom hoppers.

40. (b)
In the process of sludge digestion, gases like methane, carbon dioxide and traces of other inert gases like nitrogen, hydrogen sulphide etc. are evolved.
The amount of gas produced on an average is about 0.9 m^3 per kg of volatile solids reduced in digestion. The gas produced thus varies with the sewage produced and works out to about 14 to 18 litres per capita per day (usually 17*l*/c/d).

47. (d)
Volume of basin = 400 m^3
Suspended solids concentration = 1000 mg/l
∴ MLSS = $1000 \times 10^{-6} \times 400 \times 10^3$ kg
= 400 kg

48. (d)
In a totally aerobic pond, the stabilisation of waste is brought about by aerobic bacteria, which flourish in the presence of oxygen. The oxygen demand of such bacteria in such a pond is met by the combined action of algae and other microorganisms, (such as bacteria and protozoa), called as algal photosynthesis, or algal-symbiosis. In this symbiosis, the algae (which are microscopic plants) while growing in the presence of sunlight, produce oxygen by the action of photosynthesis; and this oxygen is utilized by the bacteria for oxidizing the waste organic matter.

49. (a)
BOD to be treated by oxidation pond
$= 150 - 15 = 135$ ppm
$\therefore BOD_5 = 135 \times 10^{-6} \times 5 \times 10^5$ kg/day
$= 67.5$ kg/day
Area of the pond $= \frac{67.5}{40} = 1.6875$ ha

50. (c)
Overall BOD removal efficiency
$= 65 + (100 - 65) \times \frac{65}{100}$
$= 65 + 22.75 = 87.75\%$

51. (d)
Coarse screens: Spacing is 50 mm or more
Medium screens: Spacing is 6 to 40 mm
Fine screens: Spacing is 1.5 to 3 mm

54. (c)
Initial Carbon-Nitrogen ratios (by mass) between 30 to 50 are optimum for aerobic composting. At lower ratio (C/N) nitrogen in the form of ammonia is given off. Biological activity is also impeded at lower ratios. At higher ratios nitrogen may be a limiting nutrient and cell destruction becomes necessary to obtain nutrients.

55. (b)
The process of sludge digestion is greatly influenced by temperature, i.e. rate of sludge digestion is more at higher temperatures and vice versa. There are two distinct temperature zones:
(i) Thermophilic digestion: In this zone of high temperature, digestion is brought about by heat loving thermophilic organisms. The temperature in this zone ranges between 40° to 60°C with 54°C being optimum.
(ii) Mesophilic digestion: In this zone of moderate temperature, digestion is brought about by common mesophilic organisms. The temperature in this zone ranges between 25° to 40°C with 29°C being optimum.

56. (c)
With continuous growth of microbes on the surface of filtering media, the inner layer organisms die due to deficiency of food and loose contact with the surface of media. The shearing stress of flowing sewage remove these layers of organisms. This is called sloughing in trickling filters.

57. (d)
Flow through grit chamber
$= 720$ m³/hr
Surface area of grit chamber
$= 12 \times 1.5 = 18$ m²
So, surface loading rate
$= \frac{720}{18} = 40$ m³/hr/m²
$= 40000$ l/hr/m²
Liquid depth= 0.8 m
So, detention time
$= \frac{0.8}{40}$ hr $= \frac{0.8}{40} \times 60$ min $= 1.2$ min

63. (d)
Surface area of tank
$WL = 31.4 \times 10 = 314$ m²
Overflow rate,
$= \frac{Q}{A} = \frac{200}{314} = 0.614$ m³/hm²
Critical velocity = 0.614 m/hr
Hydraulic retention time,
$\tau = \frac{V}{Q} = \frac{AH}{Q} = \frac{314 \times 2}{200} = 1.88$ hr

64. (c)
In figure, 85% removal line approximately intersects the retention the total amount removed ignoring bottom most portion.
$$R = P + \sum_{L=1}^{n-1}\left(\frac{h}{H}\right)(P_1 - P)$$
$$= 85\% + \frac{20}{120}[11+9+5+4] = 90.90\%$$

65. (b)
BOD/day
$= 120 \times 0.05 \times \frac{mg}{l} \div \frac{m^3}{S}$
$= \frac{120 \times 0.05 \times 1000 \times 24 \times 60 \times 60}{10^6}$
$= 518.40$ kg/day
MLSS $= VX_t$
$= (20 \times 10 \times 20) \times \frac{2000 \times 10^{-16} \times 10^3}{10^3}$
$= 8000$ kg
$\therefore \frac{F}{M} = \frac{518.40}{8000}$ day^{-1} $= 0.065$ d^{-1}

66. (a)
$SVI = \frac{1000 \times 400}{4000} = 100$

67. (b)
Given, $X = 4000$ mg/l, the hydraulic retention time
$\bar{t} = \frac{0.5(300-30)(200+30)}{2 \times 30 \times 4000}$
$= 0.129$ day $= 3.1$ hr
Sludge age,
$\theta_c = \frac{4000 \times 0.129}{0.5 \times (300-30)} = 3.8$ days

68. (d)
$$\frac{1}{\theta_c} = \frac{\text{kg sludge wasted/day}}{\text{kg sludge in aeration tank}}$$
$$X_r Q_w = \frac{XV}{\theta}$$
$V = \bar{t}Q = 4000 \times 0.129 = 516$ m³
$\Rightarrow V = \frac{4000 \times 516 \times 10^3 \times 1}{10^6 \times 3.8} = 543$ kg/day

69. (c)
Production of sludge requires
$= \frac{1500 \text{ kg/day}}{0.04 \text{ kg/m}^3\text{day}} = 500$ m³
Total mass of wet sludge pumped to the storage is
$= \frac{1500 \text{ kg/day}}{0.04} = 37,500$ kg/day
Since 1 L of sludge weighs about 1 kg, the volume of sludge is 37,500 L/day or 37.5 m³/day and hydraulic retention time is
$t = 500$ m³/37.5 m³/day
$= 13.3$ days

70. (b)
$x_0 = 50$ kg $\quad y_0 = 1000 - 50 = 950$ kg
$x_1 = 35$ kg $\quad y_1 = 40 - 35 = 5$ kg
$x_2 = 50 - 35 = 15 \quad y_2 = 950 - 5 = 945$ kg
$$E_{(x,y)} = \eta_c = \left(\frac{35}{50}\right) \times \left(\frac{945}{950}\right) \times 100 = 70\%$$

71. (c)
Total solids $= \frac{48.6432g - 48.6212}{100mL} \times 10^6$
$= 220$ mg/l
Fixed solids $= \frac{48.630g - 48.6212g}{100mL} \times 10^6$
$= 88$ mg/l
Volatile solids $= 220 - 88 = 132$ mg/l

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