# ENVIRONMENTAL ENGINEERING -1

**Important Questions**

**Unit -1**

1. As per IS: 1172 -1963, water required per head per day for average domestic purposes, is
   a) 50 liters
   b) 135 liters
   c) 85 liters
   d) 105 liters
2. The per capita demand of water for an average Indian as per IS is,
   a) 250 lpcd
   b) 300 lpcd
   c) 270 lpcd
   d) 200 lpcd
3. The water requirement for fire demand is usually derived by various formulae in which it is evident that the water requirement for fire demand depends upon
   a) The population of the city
   b) Size of the city
   c) Climate condition prevailing
   d) Intensity of fine
4. If the average daily water consumption of a city is 24000 cum, the peak hourly demand will be:
   a) 1000 cum/hr
   b) 1500 cum/hr
   c) 1800 cum/hr
   d) 2700 cum/hr
5. The suitable method for forecasting population for a young and rapid developing city is:
   a) Arithmetic mean method
   b) Geometric mean method
   c) Comparative graphical method
   d) None of these
6. Which one of the following practices, causes a reduction in the per capita water consumption?
   a) Good quality water
   b) Hotter climate
   c) Modern living

d) Metering system

7. The multiplying factor, as applied to obtain the maximum daily water demand, in relation to the average i.e per capita daily demand is :
   a) 1.5
   b) 1.8
   c) 2.0
   d) 2.7
8. The growth of the population can be conveniently represented by a curve, which is amenable to a mathematical solution. The type of curve is:
   a) Semi-log curve
   b) Straight-line curve
   c) Logistic curve
   d) Exponential curve
9. The water treatment units may be designed, including 100% reserves, for water demand equals to:
   a) Average daily
   b) Twice of (a)
   c) Maximum daily
   d) Twice of (c)
10. Water losses in water supply system, are assumed as:
    a) 5%
    b) 7.5%
    c) 15%
    d) 25%
11. In two periods, each of 20 years, a city has grown from 30,000 to 1, 70,000 and then to 3, 00,000. Using the above data, determine the saturation population and the equation of the logistic curve for the prediction of future population
12. What do you understand by design period of water-supply scheme?
13. Describe in brief the factors considered in estimating design period of a water supply scheme.
14. Describe, in brief, infiltration galleries and infiltration well with the help of neat sketches.
15. Why tube wells are generally preferred as source of drinking water supply for a relatively larger population over open well?
16. A city has population 25000, 28000, 34000, 42000 and 47000 in the year 1930, 1940, 1950, 1960 and 1970 respectively. Then forecast population in the year 2000, 2010 and 2030 by using arithmetic increase method, geometric increase method and incremental

increase method respectively. Also compare and comment.

17. What are the factors which affect water demand?
18. Explain various method of population forecasting.
19. Explain physical and chemical characteristics of water.
20. A water supply scheme has to be designed for a city having population of 100000. Estimate the important kinds of draft namely average daily draft, maximum daily draft, maximum hourly draft and coincident draft employing 250 lpcd average water consumption.

**Unit -2**

1. Water is said to be contaminated, if it contain:
   a) Pathogens
   b) Undesirable suspended matter, making it unfit for drinking and domestic use
   c) Dissolve salts
   d) None of the above
2. ‘Safe water’ is the one, which does not contain:
   a) Pathogenic bacteria
   b) Turbidity
   c) Any taste
   d) Any colour
3. The measure of the amount, to which light is adsorbed or scattered by the suspended material in water, is called:
   a) Opacity
   b) Turbidity
   c) Celerity
   d) Diffraction
4. The true colour of water is measured on:
   a) Platinum cobalt scale
   b) Silica scale
   c) Nickel scale
   d) All of the above
5. With increase in temperature, the specific conductivity of water:
   a) Decreases
   b) Increases
   c) Remained unchanged
   d) None of the above
6. pH value of water indicates its:

a) Acidity
b) Alkalinity
c) Both (a) and (b)
d) None of the above

7. Waters are considered ‘hard’ if their hardness is the order of :
   a) 50 ppm
   b) 100 ppm
   c) 200 ppm
   d) 300 ppm
8. The maximum allowable concentration of iron in water is:
   a) 1.0 ppm
   b) 0.05 ppm
   c) 0.3 ppm
   d) 0.03 ppm
9. The only metal among the following, which is toxic to human beings, is:
   a) Calcium
   b) Barium
   c) Iron
   d) Magnesium
10. Soap is a sodium salt of :
   a) Acetic acid
   b) Stearic acid
   c) Formic acid
   d) Oxalic acid
11. In water treatment plant, the pH values of incoming and outgoing waters are 7.5 and 8.3 respectively. Assuming a linear variation of pH with time, determine the average pH value of water.
12. Explain the importance chemical and biological analysis of water used for domestic purposes.
13. State the permissible limits of fluorides in water to be supplied for domestic consumption. Mention the ill-effects when they are not in the permissible limits.
14. Explain why bacteriological test should be necessary in handing problems of water supply.
15. Name one water-borne disease under each of bacterial, viral and protozoal origin that can be controlled by proper treatment of water.
16. Enumerate and discuss in brief the various physical, chemical and bacteriological characteristics of testing of raw water supplies.
17. What are the common impurities found in natural sources of water, and explain their effects

upon its quality.

18. Explain the concept of indicator organism in the determination of bacteriological quality of water. What are the reasons for selecting E-coli as indicator organism of water quality?
19. What is hardness in water? Explain various test conducted to find hardness in water.
20. Write short notes on :
    a) pH
    b) E-coli
    c) Nitrogen content
    d) Dissolved gases

**Unit -3**

1. The fine screens are generally not used these days, in water treatment, as the fine suspended impurities are removed in :
   a) Filtration
   b) Sedimentation
   c) Aeration
   d) Disinfection
2. The settling velocity of inorganic particles in a sedimentation tank of a water treatment plant, is governed by:
   a) Darcy's law
   b) Dupuit's law
   c) Stoke's law
   d) None of the above
3. The most widely used coagulant for water treatment is:
   a) Lime and soda
   b) Ferrous sulphate
   c) Chlorinated copperas
   d) Alum
4. Coagulants, used in water treatment, function better when the raw water is:
   a) Acidic
   b) Alkaline
   c) Neutral
   d) None of the above
5. The bacteria which survive in the presence as well as absence of oxygen, are called:
   a) Anaerobic
   b) Facultative

c) B-coli

d) E-coli

6. A pathogenic organism of unicellular/protozoal group is:

a) Escherichia coli

b) Salmonella typhi

c) Entamoeba hystolytica

d) None of the above

7. A harmful organism, which may be present in faecal matter may be:

a) Bacteria-coli

b) Escherichia coli

c) Vibrio cholera

d) None of these

8. The bacteria which survive in the presence of oxygen, are called:

a) Anaerobic

b) Facultative

c) B-coli

d) E-coli

9. A clariflocculator is a:

a) Plain sedimentation unit

b) Aeration unit

c) Coagulation-sedimentation unit

d) None of the above

10. The detention time for water sedimentation tank, using coagulated raw supplies, using coagulated raw supplies, may vary between:

a) 1 - 2 hr

b) 2 – 4 hr

c) 4 – 8 hr

d) 16 – 24 hr

11. Find the settling velocity of a discrete particle in water under conditions when Reynolds's number is less than 0.5. The diameter and specific gravity of the particle is 5 x 10^-3 cm and 2.65, respectively. Water temperature is 20° C (Kinematic viscosity υ of water at 20° C = 1.01 x $10^{-2}$ $cm^2$/sec).

12. 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 6 hours and the velocity of flow as 20 cm per minute.

13. In a continuous flow settling tank 3 m deep and 60 m long, what flow velocity of water would you recommended for effective removal of 0.025 mm particles at 25° C. The specific gravity of particles is 2.65, and kinematic viscosity υ for water may be taken as $0.01 cm^2/sec$.
14. Design a coagulation-cum-sedimentation tank with continuous flow for a population of 70,000 persons with a daily per capita water allowance of 120 litres. Make suitable assumptions where needed.
15. Define "flowing through period" and "detention period" in a sedimentation basin.
16. Describe briefly the various constituent of a coagulation-sedimentation plant.
17. Enumerate and discuss briefly the various methods which are adopted collectively for treating public water supplies drawn from a perennial river.
18. Discuss the various methods which are adopted for treating public supplies in order to remove colour and taste from it.
19. Draw a neat flow diagram for treating drinking water sourced from ground water with justification of each treatment unit employed for the treatment.
20. Describe with chemical reactions any two coagulants used for treatment of drinking water.

**Unit -4**

1. In water treatment, slow sand filters, when compared to rapid gravity filters, produces:
   a) Lesser contaminated effluent
   b) More contaminated effluent
   c) Equally contaminated effluent
   d) None of the above
2. Cleaning of slow sand filters is done by:
   a) Scraping and removal of sand
   b) Back washing
   c) Any of the above
   d) None of these
3. Back washing of rapid filters, may face rough weather, due to:
   a) Air-binding
   b) Mud-balls
   c) Negative head
   d) Cracking of filters
4. Air-binding phenomenon in rapid sand filters may occur due to:
   a) Excessive negative pressure
   b) Mud ball formation
   c) Higher turbidity in the effluent

d) Low temperature

5. A pressure filter is a compact unit, which carries out the job, as accomplished by a :
   a) Flocculation tank
   b) Sedimentation tank
   c) Filtration unit
   d) All of the above in one unit
6. A roughening filter, as used in treating water supplies, is like a :
   a) Slow sand filter
   b) Rapid sand filter
   c) Rapid gravity filter with coarser sand
   d) None of the above
7. Disinfection of water helps in :
   a) Removing turbidity
   b) Removing hardness
   c) Killing pathogenic bacteria
   d) Complete sterilisation
8. The process, which involves chlorination beyond break point chlorination, is known as:
   a) Prechlorination
   b) Super chlorination
   c) Post chlorination
   d) Dechlorination
9. The treatment of water with bleaching powder is known as :
   a) Prechlorination
   b) Dechlorination
   c) Super chlorination
   d) Hypochlorination
10. Activated carbon is added to water to remove tastes and odours:
    a) Before coagulation
    b) After coagulation
    c) Before filtration
    d) Any of the above
11. Describe the difference between slow sand and rapid sand filter with their advantages and disadvantage for treatment of drinking water.
12. Design five slow sand filter beds from the following data:

    Population to be served = 60,000

    Per capita demand = 150 litres/head/day

Rate of filtration = 180 litres/hr/sq. m

Length of each bed = twice the breadth

Assume max. demand as 1.8 times the average daily demand. Also assume that one unit , out of five, will be kept as stand by.

13. Design a rapid sand filter unit of 4 million litres per day of supply, with all its principal components.
14. A filter unit is 4.5 m by 9.0 m. after filtering 10,000 cubic meter per day in 24 hour period, the filter is back washed at a rate of 10 litres/sq. m/sec for 15 minute. Compute the average filtration rate, quantity and percentage of treated water used in washing and rate of wash water flow in each trough. Assume 4 troughs.
15. Chlorine usages in the treatment of 20,000 cubic metres per day is 8 kg/day. The residual after 10 min. contact is 0.20 mg/l. calculate the dosage in milligrams per litre and chlorine demand of the water.
16. The analysis of hard water shows the following compositions:

    Free carbon dioxide = 3 mg/l

    Alkalinity = 68 mg/l

    Non-carbonate hardness = 92 mg/l

    Total magnesium = 15 mg/l

    Assume that it is possible to remove all but 35 mg/l of carbonate hardness with lime and that the treated water is to have a total hardness of 80 mg/l. determine the amount of hydrated lime and soda required for treatment per million litre of raw water.
17. Calculate the requirement of lime and soda for cold softening of 2,00,000 litres of raw water, found to have the following chemical composition:

    Dissolved $CO_2$ = 39.6 mg/l

    $Ca^{++}$ = 44 mg/l

    $Mg^{++}$ = 18 mg/l

    $Na^{+}$ =16 mg/l

    Alkalinity ($HCO_3^-$) = 122 mg/l.
18. What is meant by "Disinfection" in treating public water supply? What is its importance? What are the chemicals which are used as disinfectants and what are their comparative merits and demerits?
19. Explain briefly the following processes:
    a) Break point chlorination
    b) Super chlorination
    c) Desalination
    d) Fluoridation

20. Draw a neat sketch of a rapid gravity filter and describe how it works.
    What are its advantages over the slow sand filter?
    Design a set of rapid sand filters for treating water required for population of 50,000; the rate of supply being 180 litres per day. The filters are rated to work 5,200 litres per square meter.

**Unit -5 & 6**

1. The water-tap of your house is known as:
   a) Sluice tap
   b) Stop cock
   c) Bib cock
   d) Ferrule
2. The design technique, adopted in design of large water supply networks, as an aid to simplify and separate the smaller loops, is:
   a) Hardy cross method
   b) Circle method
   c) Electrical analyser method
   d) Equivalent pipe method
3. The suitable layout for a water supply distribution system, for an irregularly grown town, is:
   a) Dead end system
   b) Grid iron system
   c) Ring system
   d) Radial system
4. Axial flow pumps are of :
   a) Rotodynamic type
   b) Displacement type
   c) Centrifugal type
   d) None of them
5. High lift pumps are generally required to feed water into the:
   a) Treatment plant
   b) Distribution system
   c) Both of them
   d) Neither of them
6. A check valve is also known as:
   a) Relief valve
   b) Reflux valve
   c) Blow off valve

d) None of these

7. The valve, which allows the flow only in one direction, is a :
   a) Reflux valve
   b) Sluice valve
   c) Gate valve
   d) None of these
8. Cast iron pipes having plain ends, are joined by a joint, called:
   a) Flanged joint
   b) Spigot and socket joint
   c) Dresser coupling
   d) None of these
9. Summits are the points of:
   a) High presser
   b) Low pressure
   c) Equal pressure
   d) None of these
10. The commonly used material for water mains, which is strong, non-corrodible, very – very durable (100 years or so), but heavy and brittle, is :
    a) Steel
    b) RCC
    c) Copper
    d) Cast iron
11. Why is the pressure pipes most commonly used for conveying water from distant surfaces to the town of supply? What are the drawbacks of open channels and masonry aqueducts in this respect?
12. Enumerate the various forces which may act on pressure conduits carrying water supplies. Also discuss briefly, any two of these forces.
13. What are the different materials, which are commonly used for water supply pipes? Discuss their comparative merits and demerits.
14. Write short notes on any four of the following:
    a) Cement concrete and RCC water mains
    b) Corrosion of metal pipes
    c) Pipe appurtenance in lying water supply mains
    d) Jointing of cast iron water supply mains
    e) Intake
15. Name the different types of pumps used generally in water supply scheme. What are the

factors on which their selection depends?

16. Explain briefly the general methods of distribution of water employed in municipal water supply schemes.
17. Write short notes on the wastage of water in public water supplies. State various methods of detection and prevention of wastage. Enumerate the causes of such wastage.
18. Compare the merits and demerits of the 'continuous' and 'intermittent' systems of water supply. Under what conditions would you recommend the use of the letter?
19. Write short notes on any four of the following:
    a) Hardy cross method
    b) Fire hydrants
    c) Different types of distribution network
    d) Metering in distribution system
    e) Stand pipes
    f) Waste detection and prevention
    g) Distribution reservoirs
20. Explain the Hardy Cross method used for pipe networks analysis in water distribution system. A pipe network consists of the following pipes:

| Pipe | Length (m) | Diameter (cm) | Friction factor |
|---|---|---|---|
| AB | 400 | 30 | 0.014 |
| BC | 600 | 30 | 0.010 |
| AD | 500 | 40 | 0.012 |
| DC | 500 | 25 | 0.011 |

Inflow at A is 1.0 $m^3$/sec, while outflows at B, C and D are 0.3, 0.5 and 0.2 $m^3$/sec, respectively. Find the flow in each pipe taking only one trial using Hardy Cross method. The pressure at A is 100 m of water.

21. What are the different impacts of noise pollution?
22. Discuss the regulatory guidelines for noise pollution.
23. What are the different impacts of noise pollution on hearing?
24. Define noise pollution. Enumerate the sources and effects of noise pollution.

Q. (20) A water supply scheme has to be designed for a city having population of 100000. Estimate the important kinds of draft namely average daily draft, maximum daily draft Maximum hourly draft and coincident draft employing 250 lpcd average water consumption

Soln:-

(i) Average daily draft = (Per capita average consumption in litre/person/day) × Population

$= 250 \times 1,00,000$ lits/day

$= 250 \times 10^5$ ~~liter~~ lits/day = 25 MLD

(ii) Maximum daily draft may be assumed as 180% of annual average daily draft

∴ Maximum daily draft $= \frac{180}{100} \times 25$ MLD = 45 MLD

(iii) Maximum hourly draft of the Maximum day: It may be assumed as 270 percent of annual average hourly draft

∴ Maximum hourly draft of maximum day $= \frac{270}{100}$ [25 MLD] = 67.5 MLD

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(iv) Fire Flow

where p = in thousand population

$$q = 4637\sqrt{P}\,[1 - 0.01\sqrt{P}]$$

$$= 4637\sqrt{100}\,[1 - 0.01\sqrt{100}]$$

$$= 41733 \text{ lit/min.}$$

$$= \frac{41733 \times 60 \times 24}{10^6} \text{ MLD} = 61 \text{ MLD}$$

Coincident draft = Maximum daily draft + fire draft

$$= 45 + 61 = 106 \text{ MLD}$$ Ans

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Q (11) In water treatment plant, the pH values of incoming and outgoing waters are 7.5 & 8.3 respectively. Assuming a linear variation of pH with time, determine the average pH value of water.

Sol$^n$ By definition of pH value, we have

$$pH = \log\left[\frac{1}{H^+}\right]$$

⇒ using suffix 1 for incoming water & 2 for outgoing water.

$$(pH)_1 = 7.5 = \log_{10}\frac{1}{H_1^+}$$

$$(pH)_2 = 8.3 = \log_{10}\frac{1}{H_2^+}$$

$$\log_{10}\frac{1}{H_1^+} = 7.5$$

(or) $$(-)\log_{10} H_1^+ = 7.5$$

$$H_1^+ = 7.5$$

$$H_2^+ = 8.3$$

Average value of $H^+ = \frac{H_1^+ + H_2^+}{2}$

$$= \frac{10^{-7.5} + 10^{-8.3}}{2}$$

$$= 10^{-8.3}\left[\frac{(10)^{0.8}+1}{2}\right] \doteq 10^{-8.3}\left[\frac{6.309+1}{2}\right]$$

$$\doteq 10^{-8.3} \times 3.654 = 3.654 \times 10^{-8.3}$$

$\therefore$ Average value of PH

$$= \log_{10}\left(\frac{1}{3.654 \times 10^{-8.3}}\right) = \log_{10}\left(\frac{10^{8.3}}{3.654}\right)$$

$$= \log_{10}\left(10^{7} \times \frac{10^{1.3}}{3.654}\right) = \log_{10} 10^{7}\left(\frac{10^{1.3}}{3.654}\right)$$

$$= \log_{10} 10^{7} \times \left(\frac{19.2}{3.654}\right)$$

$$= \log_{10} 10^{7} \times (5.333) \simeq \log_{10} 10^{7} \times 5$$

$$= \log_{10} 50000000 = \underline{7.698}$$

Q(11) Find the settling velocity of discrete particle in water under conditions when Reynold's number is less than 0.5. The diameter and specific gravity of the particle is $5\times10^{-3}$ cm and 2.65 respectively. water Temperature is 20°C (kinematic viscosity $\nu$ of water at $20°C = 1.01\times10^{-2}$ cm²/sec)

Soln:-

using Stoke's equation

$$v_s = \frac{g}{18}(G-1)\frac{d^2}{\nu}, \quad \text{when } d < 0.1\,mm$$

& C.G.S unit

$v_s$ = settling velocity in cm/sec

$$= \frac{g}{18}(G-1)\frac{d^2}{\nu} \quad \text{where } d < 0.1\,mm$$

$G = 2.65$

$d = 5\times10^{-3}$ cm $= 0.05$ mm, which is $< 0.1$ mm

$\nu = 1.01\times10^{-2}$ cm²/sec

$g = 981$ cm²/sec.

$\therefore V_s = \frac{981}{18}(2.65-1) \times \frac{(5\times10^{-3})^2}{1.01 \times 10^{-2}}$ cm/sec

$= 0.2226$ cm/sec — (i)

Also,

$V_s = 418\,(G-1)\cdot d^2 \cdot \left(\frac{3T+70}{100}\right)$ for $d < 0.1$ mm

$G = 2.65$

$d = 5\times10^{-3}$ cm $= 5\times10^{-2}$ mm

$T = 20^\circ C$

$\therefore V_s$ (in mm/sec) $= 418(2.65-1)(5\times10^{-2})^2 \times \left(\frac{3\times20+70}{100}\right)$

$= 418 \times 1.65 \times 25\times10^{-4} \times 1.3$

$V_s = 2.24$ mm/sec

$= 0.224$ cm/sec — (ii)

$V_s = 0.224$ cm/sec [max$^m$ of (i) & (ii)]

Q. (13) In a continous flow settling tank 3m deep and 60m long. what flow velocity of water would you recommended for effective removal of 0.025 mm particales at 25°C. The specific gravity of Particles is 2.65, and kinematic viscosity of water may be taken as 0.01 cm²/sec.

Soln:-

The settling velocity $V_s$ from stoke's equation for d < 0.1mm is

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

$$d = 0.025 mm = 0.0025 cm = \frac{981 \times (0.0025)^2}{18 \times 0.01} (2.65 - 1) \; cm/sec$$

$$d = 0.562 \; mm/s \quad \text{———} \; (I)$$

Also,

$$V_s = 418 (G-1) d^2 \frac{3T + 70}{100}$$

$$= 418 \times (2.65 - 1) \times (0.025)^2 \times \frac{3 \times 25 + 70}{100}$$

$$= 0.625 \; m/s \quad \text{———} \; (II)$$

From (I) & (II)

$$V_s = 0.625 \; m/s$$

from equation, $\frac{V_f}{V_S} = \frac{L}{H}$

where; $V_f$ = Flow velocity
$V_S$ = settling velocity
L = Length of the tank = 60m
H = height of water in the tank.

Assume 0·6m free board out of the total depth 3m of the tank.

∴ water depth in the tank = H = 3 - 0·6 = 2·4m,

$V_H = 0·625 \times \frac{60}{2·4}$ mm/sec = 15·626 mm/sec

∴ effective removal of particles upto 0·025mm the flow velocity in the settling tank should not be more than 15·626mm/sec.

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Q. (14.) Design a coagulation-cum-sedimentation tank with continous flow for a population of 70,000 persons with a daily per capita water allowance of 120 Litres. Make suitable assumptions where needed.

Soln.:-

Average daily consumption = 70,000 × 120

$= 8.40 \times 10^6$ Litres

Maximum daily demand = $1.8 \times 8.40 \times 10^6$ Litres

$= 15.12 \times 10^6$ Litres

Assume detention periods as 4 hours

∴ Quantity of water to be treated during the detention period

$= \frac{15.12 \times 10^6}{24} \times 4 = 2.52 \times 10^6$ Litres.

$= 2.52 \times 10^3$ m3.

Assume an overflow rate of 1000 Litres/hr/m².

$$\frac{Q}{BL} = 1000$$

$q = \frac{15.12 \times 10^6}{24} = 630 \times 10^3$ Litres / hr.

plan area $= B \cdot L = \frac{630 \times 10^3}{1000} = 630 \ m^2$.

Keeping length of the tank 3 times that of width

$\therefore 3B \times B = 630$

$B = \sqrt{630/3} = 14.491 \simeq 14.5$ or $15$ m

~~Length = 14.5 × 3 = 43.5 m~~

Length = 15 × 3 = 45 m.

Hence, tank size may be taken as

45 m × 15 m × 4 m. provided 0.5 m extra depth for sludge and 0.5 of free board.

$\therefore$ size of the tank = 45 m × 15 m × 5 m.

Floc chamber

The length of floc chamber which will be provided at entry will be extra in addition to ~~3~~ 45 m length of settling tank.

Assume

Effective depth in the floc chamber as half the depth in tank near the floc chamber

$\therefore$ Depth of flock chamber $= \frac{4.5}{2} = 2.25$ m.

Assume detention period as 15 minutes.

$\therefore$ capacity of the chamber $= \frac{15.12 \times 10^3}{24} \times \frac{15}{60}$

$= 157.5\ m^3$.

Plan area $= 157.5 / 2.25 = 70\ m^2$

using same width of 15 m, length of flocculation chamber $= 70/15 = 4.66 \simeq 5m$ (say)

Q. (12) Design five slow sand filters beds from the following data:

Population to be served = 60,000

Per capita demand = 150 Litres / head / day

Rate of filtration = 180 Litres / hr / sq.m

Length of each bed = twice the breadth

Assume Max. demand as 1.8 times the average daily demand. Also assume that one unit, out of five will be kept as stand by.

Soln:

Average daily demand = Population × per capita demand

$= 60,000 \times 150 \, l/day$

$= 9 \times 10^6$ Litres/day

Maximum daily demand = $1.8 \times 9 \times 10^6$

$= 16.2 \times 10^6$ Litres/day

Rate of filtration = 180 Litres/$m^2$/hr

$= (180 \times 24)$ litres/$m^2$/day

Total surface area = $\dfrac{\text{Maximum daily demand}}{\text{Rate of filtration per day}}$

$= \dfrac{16.2 \times 10^6 \text{ Litres/day}}{180 \times 24 \text{ Litres/m}^2\text{/day}}$

$$= \frac{16.2 \times 10^6}{180 \times 24} m^2$$

$$= 3750 \, m^2$$

The area of each Filter unit $= \frac{1}{5} \times 3750$

$= 750 \, m^2$.

$L = 2B$

$2B \times B = 750$

or $B^2 = 750/2 = 375 \, m^2$.

$B = 19.36 \simeq 20 \, m$.

$L = 2 \times 20 = 40 \, m$.

Hence,

provide 6 filtres units with one unit as stand by, each unit of size 40m x 20m arrange in series with 3 units on either sides

Q. (13.) Design a rapid sand filter unit of 4 million litres per day of supply, with all its components.

Soln:-

Assume that daily 4% of filtered water is required for washing of the filter

Total filtered water requirement = 4 X 1.04
= 4.16 million litres / day

Assume that,
30 minutes is lost everday in washing the filter

Filterd water requirement per hour = $\frac{4.16}{23.5}$

= 0.177 million litres / hr.

Next, assume that the rate of filtration be 6000 litres / hr / sq.m.

Area of filter required = $\frac{0.177 \times 10^6}{6000}$

= 29.5 $m^2$

Assuming the length of the filter bed (L) as 2 times the width of the filter bed.
provide two beds.

$\therefore$ $2 \times L \cdot B = 29.5 m^2$

$2 \times 2B \times B = 29.5$

$\Rightarrow B = 2.715$

$L = 2B = 2 \times 2.715 = 5.431 \simeq \underline{6m}$

Use the length of the filter as 6.0 m.

$B = \frac{29.5}{2 \times 6} = 2.458 \simeq 3.1m$

Here provided 2 filter unit each of dimension
$= 6 \times 3.1$ m.

<u>under drainage system</u>

<u>Assume</u>
area of perforation to be 0.2% of the total filter area.

Area of perforations $= \frac{0.2}{100} \times (6 \times 3.1)\ m^2$

$= 0.0372\ m^2$

Assume the area of each lateral

= 2 times the area of perforation

Total area of laterals $= 2 \times 0.0372 = 0.0744\ m^2$

Assume

area of Manifold be aroun twice the area of laterals.

Area of Manifold $= 2 \times 0.0744 = 0.1488\ m^2$

Dia of Manifold $= \frac{\pi}{4} d^2 = 0.1488$

$d = \sqrt{\frac{0.1488 \times 4}{\pi}} = 0.435\ m \simeq 0.45 m.$

Hence 45 cm dia manifold pipe will be laid lengthwise at the centre of the filter bottom. Laterals will run perpendicular to the manifold at spacing of (say) 20 cm.

∴ Number of laterals $= \frac{6 \times 100}{20} = 30$ on either side of Manifold

∴ No. of laterals in each unit $= 30 \times 2 = 60$

Length of each lateral $=$ width of Filter $/2$ $-$ Dia of Manifold $/2$

$$= \frac{3.1}{2} - \frac{0.45}{2} = 1.325 \text{ m.}$$

Adopt 15 mm dia perforations in the laterals

Total area of perforation $= 0.0372 \text{ m}^2 = 372 \text{ cm}^2$

$$= n \times \frac{\pi}{4} (1.5)^2$$

$n =$ No of perforation in all 60 laterals.

$$n = 372 \times \frac{4}{\pi} \left[\frac{1}{(1.5)^2}\right] = 210.5 \simeq 211$$

∴ No of perforations in each laterals

$= \frac{211}{60} = 3.52 \simeq 4.$

∴ Area of perforations per lateral $= 4\left[\frac{\pi}{4} \times (1.5)^2\right]$

$= 7.068 \ cm^2$

∴ Area of each lateral = 2 × area of perforations per lateral.

$= 2 \times 7.068 = 14.136 \ cm^2$

∴ Dia of each lateral $= \sqrt{\frac{14.136 \times 4}{\pi}}$

$= 4.24 \ cm \simeq 4.3 \ cm.$

∴ use 60 laterals each of 4.3 cm dia @ 20 cm c/c each having 4 perforations of 15 mm size with 45 cm dia Manifold

## wash water

Assume the rate of washing of the filter be 0.45 m/minute

∴ The wash water discharge

$$= \frac{0.45 \times (6 \times 3.1)}{60} = 0.1395 \ m^3/sec$$

∴ velocity of flow in the lateral for wash water

$$= \frac{0.1395}{60\left[\frac{\pi}{4} \times (4.3 \times 10^{-2})^2\right]} = \frac{0.1395}{0.0871}$$

$= 1.6$ m/s.

velocity flow in the manifold = $\frac{\text{Discharge}}{\text{Area}}$

$$= \frac{0.1395}{\left[\frac{\pi}{4} \times (0.45)^2\right]} = \frac{0.1395}{0.159} = 0.877 \text{ m}$$

$0.88$ m/sec

velocity of flow is less than 1.8 to 2.4 m/sec (maxm permissible), hence is acceptable.

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## Design of Troughs

wash water trough are kept around 1.5 to 2m apart.

∴ In a Length of 6m of filter bed provide 3 troughs at $6/3 = 2.0m$ apart

Total wash water discharge of $0.1395\ m^3/sec$ enters in these 3 trough.

∴ Discharge in each trough $= \frac{0.1395}{3} = 0.0465\ m^3/sec.$

Dimension of flat bottom trough is given by the empirical formula

$$q = 0.76 B' h^{3/2}$$

q = Discharge in litres / min

B' = width of trough

h = water depth in the trough

Assume $B' = 20$ cm

$$0.0465 \times 1000 \times 60 = 0.76 \times 20 \times h^{3/2}$$

$$h^{3/2} = \frac{0.0465 \times 1000 \times 60}{0.76 \times 20} = 183.55$$

$$h = (183.55)^{2/3} = 33.29 \text{ cm}$$

Keep 5 cm freeboard.

Hence depth of trough = 33.29 + 5

= 38.29 ≃ 38 cm

Hence 3 NO wash water ~~the~~ troughs of size 38 cm × 20 cm will be used.

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Q. (15) Chlorine usages in the treatment of 20,000 cubic meters per day is 8 kg/day. The residual after 10 min. contact is 0.20 mg/l. Calculate the dosage in milligrams per litre and chlorine demand of the water.

Soln. :-

water ~~to~~ treated per day = 20,000 m3

= 20000 × $10^3$ Litres

= 20 × $10^6$ Litres

= 20 million Litres

Chlorine consumed per day = 8 kg = 8 million mg

Chlorine used per litre of water = $\frac{8 \text{ million mg}}{20 \text{ million ltrs}}$

= 0.4 mg/l

Residual chlorine left = 0.2 mg/l

∴ Actual chlorine deman

= 0.4 − 0.2 = 0.2 mg/l.

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Q. (16.) The analysis of a hard water shows the following compositions :

Free carbon dioxide = 3 mg/l

Alkalinity = 68 mg/l

Non carbonate hardness = 92 mg/l

Total Magnesium = 15 mg/l

Assume that it is possible to remove all but 35 mg/l of carbonate hardness with Lime, and that the treated water is to have a total hardness of 80 mg/l. Determine the amount of hydrated Lime and Soda required for treatment per million Litre of Raw water.

Soln.

Total hardness to be left = 80 mg/lit

carbonate hardness to be left = 35 mg/l

∴ Non-carbonate hardness to be left

= 80 − 35 = 45 mg/l

Non carbonate hardness of raw water

= 92 mg/l

∴ Non carbonate hardness to be removed from raw water = (92 - 45) mg/l = 47 mg/l

Lime requirment

(I) Lime required for free carbon dioxide.

Molecular weight of $CO_2$ is 44.
and that of lime (CaO) as 56.

44 mg/l of $CO_2$ requires = 56 mg/l of CaO

∴ 3 mg/l of $CO_2$ will required $= \frac{56}{44} \times 33$ mg/l of CaO

CaO is required of 1 ml of water = 3.82 kg. ——(1)

(II) Lime required for carbonate hardness

carbonate hardness = Alkalinity = 68 mg/l.

∴ Molecular weight of $CaCO_3$ is

= 40 + 12 + 48 = 100 gm.

CaO = 40 + 16 = 56 gm.

NCH of 100 mg/l of $CaCO_3$ = 56 mg/l of CaO

∴ NCH of 68 mg/l of $CaCO_3$ = $\frac{56}{100} \times 68$ mg/l of CaO

CaO required for 1 Ml of water = 38.08 kg ——— (2)

(iii) Lime required Magnesium.

24 mg/l of Mg requires = 56 mg/l of CaO

15 mg/l of Mg = $\frac{56}{24} \times 15$ mg/l of CaO

= 35 mg/l of CaO

∴ Lime required of 1 Ml of water

= 35 kg ——— (3)

Hence

Total pure Lime (CaO) = (1) + (2) + (3)

= 3.82 + 38.08 + 35

= 77.90 kg.

56 kg of pure Lime ($CaO$) is equivalent of 74 kg of hydrated lime.

$$Ca(OH)_2 = 77.90 \times \frac{74}{56} = 102.94 \text{ kg.}$$

per ~~million~~ M.l of Raw water

## Quantity of Soda Required

Soda ($Na_2CO_3$) is required for Non-carbonate hardness.

Non-carbonate hardness = 47 mg/l (as $CaCO_3$)

100 mg/l of $CaCO_3$ = 106 mg/l of $Na_2CO_3$

$\therefore$ 47 mg/l of $CaCO_3$ = $\frac{106}{100} \times 47$ mg/l of $Na_2CO_3$

= 49.8 mg/l

$\therefore$ soda required of 1 Ml of water = 49.8 kg.

Q. (17) Calculate the requirement of Lime and soda for cold softening of 200,000 Litres of raw water found to have the following chemical composition.

Dissolved $CO_2$ = 39.6 mg/l

$Ca^{++}$ = 44 mg/l

$Mg^{++}$ = 18 mg/l

$Na^{+}$ = 16 mg/l

Alkalinity ($HCO_3$) = 122 mg/l.

Soln.:-

Total hardness as $CaCO_3$ = $\left(Ca^{++} \times \frac{50}{20} + Mg^{++} \times \frac{50}{12}\right)$

$= 44 \times \frac{50}{20} + 18 \times \frac{50}{12} = 110 + 75 = 185$ mg/litre

(a) Computing quantity of Lime (CaO) required for softening.

Lime (CaO) = Alkanimity ($HCO_3$) + $Mg^{++}$

= [m. eq/l of $HCO_3^-$ + m.eq/l of $Mg^{++}$]

× Eq. mass of CaO

$= (1.6 + 0.8)\ 28\ mg/l = 67.2\ mg/l$

Quantity of impure lime required $= \frac{67.2}{0.9} mg/l$

( ∵ purity = 90% )

$= 74.67\ mg/l$

Total quantity of Lime required to treat 2 Ml/day of raw water

$= ~~74 \times 67~~\ 74.67 \times 2 \times 10^6\ mg/day$

$= 74.67 \times 2\ kg/day$

$= 149.34\ kg/day.$

(6.) computing quantity of soda required of softening ::

Soda ash ($Na_2CO_3$) is required to neutralise non-carbonate hardness.

Non-carbonate $= \underbrace{Ca^{++} + Mg^{++}}_{T.H} - \underbrace{HCO_3^-}_{C.H}$

Soda required = [m/eq/l of $Ca^{++}$ + m.eq/l of $Mg^{++}$ − m.eq/l $HCO_3^-$] × [Eq mass of $Na_2CO_3$]

$= [1.6 + 0.8 - 1.6]\ 53\ mg/l$

$= 42.4\ mg/l$

Quantity of impure soda required

$$= \frac{42.4}{0.95} \ mg/l = 44.63 \ mg/l$$

(∵ purity = 95 %)

Total quantity of soda required 2 M l/day of raw water

$= 44.63 \times (2 \times 10^6) \ mg/day$

$= 44.63 \times 2 \ kg/day$

$= 89.26 \ kg/day$

# Environmental Engineering (Solution)

Unit-I

1) B
2) C
3) A
4) 64800 $m^3$/hr
5) B
6) D
7) D
8) C
9) C
10) A

Unit-II

1) A
2) A
3) B
4) A
5) B
6) C
7) C
8) C
9) B
10) B

Unit-III

1) B
2) C
3) D
4) A
5) B
6) A
7) B
8) B
9) C
10) B

Unit- IV

1) A
2) A
3) C
4) A
5) C
6) C
7) C

8) B
9) D
10) B

Unit-V

1) C
2) A
3) A
4) C
5) B
6) B
7) A
8) C
9) B
10) A