Quality of Water

Pure Water: It is a chemical compound H_2O

Potable Water: Water which is fit for drinking no matter how it tastes or looks.

Palatable Water: Not only is safe for drinking but also free from objectionable tastes, odors, colors and turbidity. Aesthetically looks good

Wholesome Water: chemically may not pure but doesn't contain anything harmful to human beings.

Mineral Water: It contains useful minerals like calcium, magnesium & iron in required proportion

Following are the requirements of potable water for domestic use - or wholesome water

(i) It should be clear, odorless & colorless

(ii) It should be free from harmful & disease producing bacteria

(iii) It should be free from all objectionable substances.

(4) It should be fresh & cool

(5) It should be palatable i.e. aesthetically attractive

(6) It should be tasty

(7) It should not cause corrosion to the pipes & other fittings.

Characteristics of Water

Physical Characteristics: (যিবোৰক কোনো পৰিষ্কাৰ চকুৰে চালি চোৱাতে ব্যৱহাৰ হয় বা অনুমান কৰা হয়।)

(1) **Turbidity:** (অস্বচ্ছতা)

→ Turbidity is the measure of resistance to the passage of light through water.

→ It is caused by suspended materials such as clay, silt or some other finally divided organic & inorganic matter. Turbidity is also due to presence of bacteria, algae, protozoa, fungi etc.

Jackson Turbidity Unit (JTU) →

→ Used to measure high turbidity (>25ppm)

Nephelometric Turbidity Unit (NTU)

→ Small turbidity (even smaller than one) can be measured. Hence used for domestic water supply

→ based on scattering light principle

Formazin Turbidity Units (FTU)

→ Same as NTU

→ when formazin was initially adopted as the primary reference standard then FTU is used.

(ii) Color:

⇒ It is caused by dissolved organic matter from decaying vegetation or some inorganic colored soils, growth of algae, metallic ions (Fe & Mn)

⇒ Iron (Fe) gives reddish & Mn gives brown or blackish color

(iii) Taste & Odor:

⇒ due to dissolved organic matter or inorganic salts, dissolved gases (H_2S, Methane etc)

⇒ Taste measurement unit = Flavor Threshold Number (F

⇒ Odor measurement Unit = Threshold Odor Number (TON)

(iv) Temperature: $10°C$ is desirable for drinking water

(5) Specific conductivity: To know the dissolved salt content.

Chemical Properties:

(i) Total Solids, Suspended Solids & dissolved Solids:

⇒ Total solids can be found by evaporating a sample of water and weighing the dry residue left

⇒ Suspended solids can be found by filtering water sample. SS comes from inorganic particles like silt, clay, oils & organic particles

⇒ Total dissolved solids (TDS) = TS − SS

⇒ Sources of Total dissolved solids –

Major	Minor
Na, Ca, Mg, HCO_3^-, SO_4^{2-}, Cl^-	Fe, K, CO_3^{2-}, NO_3^-, Fluoride, Boron, Silica

(ii) pH value

⇒ It indicates hydrogen ion concentration in water

⇒ $pH = \log\left[\frac{1}{H^+}\right] = -\log[H^+]$; where $[H^+]$ is in moles/litre

⇒ Permissible limit of pH = 6.5 to 8.5

⇒ If pH > 7 it is alkaline, If pH < 7 it is acidic

⇒ $pOH = -\log[OH^-] = \log\left[\frac{1}{OH^-}\right]$

$pH + pOH = 14$; $[H^+] \times [OH^-] = 10^{-14}$

(iii) Alkalinity: is the ability to neutralise acids of the solution

⇒ Most common constituents of alkalinity are CO_3^{2-}, HCO_3^-, OH^- → [very rare, not considered in practical calculation]

⇒ effects of alkalinity

→ Incrustation (জমাট) & sediment deposition in pipe line.

→ difficulties in chlorination

⇒ Alkalinity is calculated as amount of $CaCO_3$ in mg/l or ppm

⇒ if amount of $CaCO_3$ is not given,

Total alkalinity, TA

$$= \left[HCO_3^- (mg/L) \times \frac{\text{equivalent wt. of } CaCO_3}{\text{equivalent wt. of } HCO_3^-} \right]$$

$$+ \left[CO_3^{2-} (mg/L) \times \frac{\text{eq. wt. of } CaCO_3}{\text{eq. wt. of } CO_3^{2-}} \right]$$

$$= HCO_3^- (mg/L) \times \frac{50}{61} + CO_3^{2-} \times \frac{50}{30}$$

*** equivalent weight $= \frac{\text{Molecular weight}}{\text{valance}}$

equi. weight of $CaCO_3 = \frac{100}{2} = 50$

eq. wt. of $HCO_3^- = \frac{61}{1} = 61$

*** **Equivalent weights of Different matter**

[redacted]; $CaCO_3 = 50$, $CO_3^{2-} = 30$, $Ca^{++} = 20$, $Mg^{++} = 12$, $HCO_3^- = 61$,

*** **Molecular weights of different matter**

$Ca^{++} = 40$, $Mg^{++} = 24$, $OH^- = 17$

(iv) Hardness

⇒ A characteristics which prevents formation of lather or foam with soap

⇒ Effects of hardness
→ scaling of boilers
→ greater soap consumption
→ corrosion & incrustation of pipe lines
→ food becomes tasteless

⇒ Type of hardness → Carbonate hardness (CH)
→ Non-carbonate hardness (NCH)

*** ⇒ Temporary / carbonate Hardness
→ Caused by HCO_3^- (bicarbonate) & CO_3^{2-} (carbonate) of Ca & Mg
→ can be removed by boiling / addition of lime. Thats why it is called temporary hardness

*** ⇒ Permanent / Non-carbonate Hardness
→ Caused by SO_4^{2-}, Cl^-, NO_3^- of Ca & Mg
→ water softening methods are required to remove

⇒ Hardness is measured in terms of ppm or mg / litre of $CaCO_3$

⇒ Total Hardness, $TH = \left[Ca^{++}(mg/L) \times \frac{eq.\ wt.\ of\ CaCO_3}{eq.\ wt.\ of\ Ca^{++}} \right] + \left[Mg^{++}(mg/L) \times \frac{eq.\ wt.\ of\ CaCO_3}{eq.\ wt.\ of\ Mg^{++}} \right]$

$= Ca^{++}(mg/L) \times \frac{50}{20} + Mg^{++}_{(mg/L)} \times \frac{50}{12}$

⇒ TH = CH + NCH

If TH > alkalinity, then CH = alkalinity

∴ NCH = TH − alkalinity (TA)

⇒ If TH ≤ alkalinity, then CH = TH

NCH = 0

* If 100mg of H_2SO_4 is added to 1L of water, what is the final pH? [NPCBL'19]

Soln: H_2SO_4 concentration $= \frac{100 \times 10^{-3} g}{98 g} = 0.00102$ mole/L

$H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$

molar ratio; $H_2SO_4 : H^+ = 1:2$

$\therefore [H^+] = [2 \times 0.00102] = [0.00204]$

$\therefore pH = -\log[0.00204] = 2.69$ Ans

* If $[H_3O^+] = 7.1 \times 10^{-2} M$, calculate the $[OH^-]$ concentration.

$pH = -\log(7.1 \times 10^{-2}) = 1.149$

$\therefore pOH = 14 - 1.149 = 12.851$

$[OH^-] = 10^{-pOH} = 10^{-12.851} = 1.41 \times 10^{-13} M$

or,

~~again~~, $[H_3O^+][OH^-] = 10^{-14}$ [for water]

$\Rightarrow [OH^-] = \frac{10^{-14}}{7.1 \times 10^{-2}} = 1.41 \times 10^{-13} M$

* If pH = 9.5, what is the $[OH^-]$ concentration? [PGCB'19]

Soln: $pH + pOH = 14$

$\Rightarrow pOH = 14 - 9.5 = 4.5$

$[OH^-] = 10^{-pOH} = 10^{-4.5}$

$= 0.03 \times 10^{-3}$ M
↓
mole

* The $[OH^-]$ is 10^{-4} mole/l concentration is given, find the pH ___10___ [GICL'16]

Soln: $[OH^-] = 10^{-pOH}$

$\Rightarrow 10^{-4} = 10^{-pOH}$

$\Rightarrow \therefore pOH = 4$

$pH + pOH = 14$ $\therefore pH = 14 - 4 = 10$ A

* The measured pH values of incoming and outgoing water at a water treatment plant are 7.3 and 8.5 respectively. What is the average pH of water, assuming a linear variation of pH with time?

[CAAB 2022]

$[H^+]$ of incoming water, $[H^+]_i = 10^{-7.3}$

$[H^+]$ of outgoing water $[H^+]_o = 10^{-8.5}$

$$\therefore [H^+]_{avg} = \frac{10^{-7.3} + 10^{-8.5}}{2} = 2.664 \times 10^{-8}$$

$$\therefore pH_{(avg)} = -\log[2.664 \times 10^{-8}] = 7.574$$

(2) For a water sample, the total alkalinity is 200 mg/l as $CaCO_3$. The Ca^{2+} is 120 mg/l, Mg^{2+} is 60 mg/l. What is total hardness, carbonate hardness, Non-carbonate hardness. [DNCC'20]

Sol^n: Given, TA = 200 mg/l

$$TH = Ca^{2+} * \frac{50}{20} + Mg^{2+} * \frac{50}{12}$$

$$= 120 * \frac{50}{20} + 60 * \frac{50}{12} = 550 \text{ mg/l as } CaCO_3$$

$\because$ TH > TA

CH = TA = 200 mg/l as $CaCO_3$

NCH = TH − CH = 550 − 200 = 350 mg/l as $CaCO_3$

CamScanner

* In a water sample, the concentrations of Ca^{2+}, Mg^{2+} and HCO_3^- are 100mg/L, 36mg/L and 122mg/L respectively. Calculate the total hardness and the temporary (carbonate) hardness.

Soln: Total hardness $= Ca^{2+} * \frac{50}{20} + Mg^{2+} * \frac{50}{12}$

$= 100 * \frac{50}{20} + 36 * \frac{50}{12}$

$= 400$ mg/l as $CaCO_3$

Total Alkalinity $= HCO_3^- * \frac{50}{61} = 122 \times \frac{50}{61} = 100$ mg/l

∴ Temporary (carbonate) Hardness = TA = 100mg/l

∴ Non-carbonate hardness = 400 − 100

= 300 mg/l as $CaCO_3$

(3) The chemical analysis of water sample indicates the presence of cations as follows follows –

$Na^+ = 20 mg/L$, $Ca^{2+} = 45 mg/L$, $Mg^{2+} = 60 mg/L$,

$HCO_3^- = 248 mg/L$, $SO_4^{2-} = 220 mg/L$, $Cl = 79.2 mg/L$.

Compute, TH, CH, NCH equivalent to $CaCO_3$.

Soln:

$$\text{Alkalinity} = HCO_3^- \times \frac{50}{61}$$

[এখানে CO_3^{2-} দেয়া নাই, তাই শুধু এটার হিসাব করছি]

$$= 248 \times \frac{50}{61}$$

$$= 203.3 mg/L \text{ as } CaCO_3$$

$$TH = Ca^{2+} \times \frac{50}{20} + Mg^{2+} \times \frac{50}{12}$$

$$= 48 \times \frac{50}{20} + 60 \times \frac{50}{12} = 362.5 mg/lit \text{ as } CaCO_3$$

TH > Alkalinity

$\therefore$ CH = Alkalinity = 203.3 mg/lit as $CaCO_3$

$$NCH = 362.5 - 203.3$$

$$= 159.2 mg/l \text{ as } CaCO_3$$

* meq = milli equivalent
mg/L = meq/L * equivalent weight.

(7) Laboratory test shows Ca^{2+} = 40mg/L. Total carbonate hardness = 3 meq/L. Assume carbonate hardness only due to HCO_3^-. Non carbonate hardness = 1 meq/L. Determine total hardness, Mg^{2+} & HCO_3^- as mg/L. [BWDB'19]

Soln: TH = CH + NCH
$= 3 + 1 = 4$ meq/L
$= 4 \times 50$ mg/L of $CaCO_3$
$= 200$ mg/L of $CaCO_3$

HCO_3^- alkalinity = CH
$= 3$ meq/L
$= 3 \times 50$ mg/L of $CaCO_3$
$= 150$ mg/L of $CaCO_3$

$TH = Mg^{2+} * \frac{50}{12} + Ca^{2+} * \frac{50}{20}$

$\Rightarrow 200 = Mg^{2+} * \frac{50}{12} + 40 * \frac{50}{20}$

$\Rightarrow Mg^{2+} * \frac{50}{12} = 100$

$\therefore Mg^{2+} = 24$ mg/l

(8) Alkalinity of a water sample is 200 mg/L as $CaCO_3$. The sample has 160 mg/L of Ca^{2+} & 40 mg/L of Mg^{2+}. The pH is 8.1. Find TH, CH, NCH (PGCB'19)

Soln:

$$TH = Ca^{2+} * \frac{50}{20} + Mg^{2+} * \frac{50}{12}$$

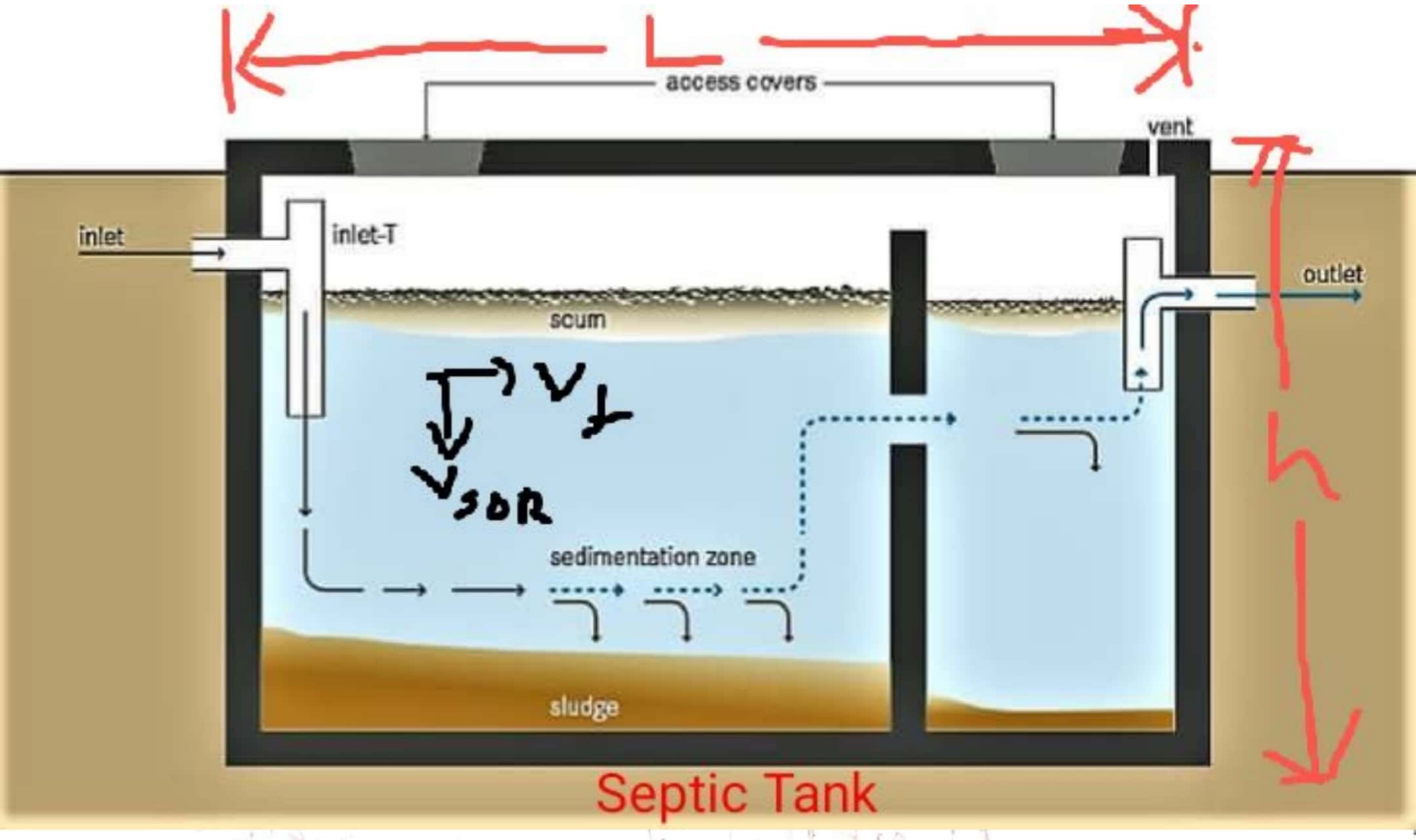
$$= 160 * \frac{50}{20} + 40 * \frac{50}{12}$$

$$= 564 \text{ mg/L as } CaCO_3$$

TH > Alkalinity

$\therefore$ CH = Alkalinity = 200 mg/L as $CaCO_3$

$\therefore$ NCH = 564 - 200 = 364 mg/L as $CaCO_3$ Ans



B= width of the tank

Vs=Settling Velocity

Approach Flow velocity, $V_f = \frac{Q}{BH}$

Surface loading/overflow rate,

$$V_{SOR} = \frac{Q}{BL}$$

if settling velocity $V_s \geq V_{SOR}$, then the particle can be removed (i.e as sludge) from water.

If $V_s < V_{SOR}$; will not get 100% removed.

$\therefore$ sedimentation efficiency, $\eta = \frac{V_s}{V_{SOR}} \times 100$

Detention time, D_t: Theoritical average time for which water is detained in the tank.

$$D_t = \frac{\text{Vol. of tank}}{\text{discharge}} = \frac{LBH}{Q} = \frac{H}{\frac{Q}{LB}} = \frac{H}{V_{SOR}}$$

$\therefore$ Length, $L = \frac{Q \times D_t}{BH} = D_t \times V_f$

*** In order to increase the efficiency, the D_t should be increased, therefore smaller size of particles can also be settled.

(BUET)

(4) 1 ~~MGD~~ million gallon per day water passage through a sedimentation tank of 50'×20'×10'. Find detention time.

Solⁿ:

$$T = \frac{BLH}{Q}$$

$$= \frac{50 \times 20 \times 10}{134.05 \times 10^3}$$

$$= 0.0746 \text{ days}$$

$$= 1.8 \text{ hr}$$

*** 1 gallon = $7.46 ft^3$

~~Q = 1 MGD~~

~~= 10^6 L/D~~

~~= $10^3 m^3$/day~~

$Q = 1 \times 10^6$ gallon/day

$= \frac{10^6}{7.46} ft^3/day$

$= 134.05 \times 10^3 ft^3/day$

* One million gallon water passes through a sedimentation tank of 50'x 20'x 10' size per day. What will be the detention time? [DPDC'16] [GTCL'18]

Soln:

$$\text{Detention time} = \frac{50\times20\times10\ ft^3}{\frac{1\times10^6}{7.485\times24}\ ft^3/hr} = 1.8\ hr$$

$1ft^3 = 7.485$ gallon

* A horizontal flow grit chamber, having flow rate $30ft^3/sec$, 6ft deep, width is 15 times of its length. Approach is 1ft/sec. Determine the width of the grit chamber. [EGCB'20] [CPGCBL'21] [BPDB'23]

Soln:

~~$Q = AV$~~

~~$\Rightarrow 30 = (x * 15x) * 1$~~

~~$\Rightarrow x = 1.42\ ft$~~

~~$\therefore$ Length $= 1.42$ ft; width $= 15\times1.42 = 21.21$ ft~~

*

Approach velocity, $V_a = \frac{Q}{BH}$ [width x height]

$Q = AV$ $\Rightarrow 30 = 15x \times 6 \times 1$	Take, length is x ft

$\Rightarrow x = 0.33ft$

$\therefore$ width $= 0.33\times15$ ft

$= 5ft$ Ans

* Design a sedimentation tank for 3hrs of detention period with discharge 125 lit/hr, where the ratio of length, breadth & height is 1:1:3 ? [BWDB'13]

<u>Solⁿ:</u> $T = \frac{BLH}{Q}$

$\Rightarrow 3 = \frac{x \cdot x \cdot 3x \cdot m^3}{125 \times 10^{-3} m^3/hr}$

$\Rightarrow 0.375 = 3x^3$

$\Rightarrow x^3 = 0.125$

$\therefore x = 0.5$

$\therefore$ length = 0.5m breadth = 0.5m

height = 3×0.5 = 1.5m Ans

* A sample waste water plant has a raw water inflow rate of 0.6 m^3/sec and it has been found through experiment that all particles settle at a rate of $V_s = 0.004 m/sec$. A proposed rectangular settling tank has an effective zone of L = 20m, D = 2m, width = 6m. Calculate
(i) surface overflow (SOR)
(ii) what fraction of particles expected to be removed from the tank ? [SGFL'21]

Solⁿ: (i) $SOR = \frac{0.6}{20 \times 6} = 5 \times 10^{-3} m/s = 18 m/h$

→ SOR বের করতে depth লাগবে না

SOR এর unit সাধারণত velocity এর মত হয়, m/s or m/hr [$SOR = \frac{discharge}{BL} = m/s$]

> Surface overflow $= \frac{discharge}{surface\ area\ (b \times h)}$

(ii) $\eta = \frac{0.004}{5 \times 10^{-3}} \times 100\%$

$= 80\%$

therefore, 80% of particles expected to be removed from the tank.

* Unit of noise is expressed as <u>dB</u> [BPDB'21]

[BPDB'16]

(5) one million gallons of water per day (1mgd) passage through a sedimentation tank which is 20ft wide, 50ft long & 10ft deep. Find (a) Detention time (b) Average velocity of flow through basin (c) If the suspended solids content of the water averages 40ppm, what weight of dry solids will be deposited every 24 hours assuming 75% removed in the basin. d) Surface overflow rate (SOR)

Solⁿ:

(a) $D_t = \dfrac{20 \times 50 \times 10}{\dfrac{10^6}{7.46}}$ = ~~1.8 hrs~~ 0.0746 days = 1.8 hrs

(b) $V_f = \dfrac{L}{D_t}$ $[\because L = D_t \times V_f]$

$= \dfrac{50}{1.8} = 27.78$ ft/hrs

(c) Total suspended solids = (40 parts/million gallon × 1 million gallon)

$= 40 \times 1 \times 0.75$

$= 30$ gallons

$= \dfrac{30}{7.46}$ ft^3

$= 4.02\ ft^3 \times \underset{\text{Sp. Gr of solid}}{2.65} \times 62.43\ lb/ft^3 \rightarrow \gamma_w$

$= 665.3\ lb$

(d) $\underset{(SOR)}{v_s} = v_f \times \frac{H}{L}$

$= 27.78 \times \frac{10}{50}$

$= 5.5\ ft/hrs$

(6) Calculate the dimension of a settling tank if discharge is $45\ m^3/hr$, surface overflow rate $0.5\ m/hr$. detention period 3 hrs. (BB, AD 2011)

Soln:

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

$\Rightarrow BL = \frac{45}{0.5} = 90\ m^2$

Again, $D_T = \frac{BHL}{Q}$

$\Rightarrow H = \frac{Q \times D_T}{BL} = \frac{45 \times 3}{90} = 1.5\ m$

Let, $L = 4B$

$\therefore 4B \times B = 90$

$\Rightarrow B^2 = \frac{90}{4}$

$\Rightarrow B^2 = 22.5$

$\Rightarrow B = 4.75$

$\therefore L = 4B = 4 \times 4.75 = 19$

take B = 5m, L = 20m

Provide an extra depth of 1m for sludge and 0.5m for free board making total depth = ~~3+1.5 = 4.5~~

= 1.5 + 1.5 = 3m

Hence Settling tank dimension 20m × 5m × 3m

~~Check~~ :

~~Surface overflow rate = 45m³/hr / 7.5~~

~~= 3m³/hr/m²~~

(7) Calculate the dimension of a rectangular settling tank to treat 120m³/hr when the over flow rate is 0.75 m/hr & detention time is 2hr. (31st BCS)

Soln: $SOR = \frac{Q}{BL}$

$\Rightarrow BL = \frac{120m^3/hr}{0.75m/hr} = 160m^2$

Again, $D_T = \frac{BHL}{Q}$

$\Rightarrow H = \frac{Q \cdot D_T}{BL} = \frac{120 \times 2}{160} = 1.5$

Not necessary ↓

Let, $L = 4B$

$\therefore 4B^2 = 160$

$\Rightarrow B \approx 6.5\ m$

$\therefore L = 26\ m$

Check, surface loading rate

$= \frac{120\ m^3/hr}{26 \times 6.5\ m^2}$

$= 0.71\ m^3/hr/m^2$

$= 710\ m^3/hr/m^2$ which is satisfactory

Provide an extra depth of 1m for sludge & 0.5m for free board making total depth

$= 1.5 + 1 + 0.5 = 3m$

Hence settling tank dimension $26 \times 6.5 \times 3\ m$

WBPDCL'19

(8) A water supply project has to supply water to a town having population of 50,000. Design a suitable sedimentation tank with the following data:

(i) Per capita demand = 150 lits/day

(ii) Velocity of flow = 30cm/min

(iii) Detention time = 4 hrs

Soln: Max^m daily flow = 1.8 × Avg daily flow

$= 1.8 \times 150 \times 50,000$

$= 13.5 \times 10^6\ l/day$

$= 13.5 \times 10^3\ m^3/day$

Volume of water in 4 hrs $= \frac{13.5 \times 10^3 \times 4}{24}$

$= 2.25 \times 10^3\ m^3$

Length of tank, $L = D_t \times V_f$

$= 0.3 m/min \times (4 \times 60) min$

$= 72 m$

$\therefore BH = \frac{Q}{L} = \frac{2.25 \times 10^3}{72}$

$= 31.25 m$

Assume, depth, $H = 3m$

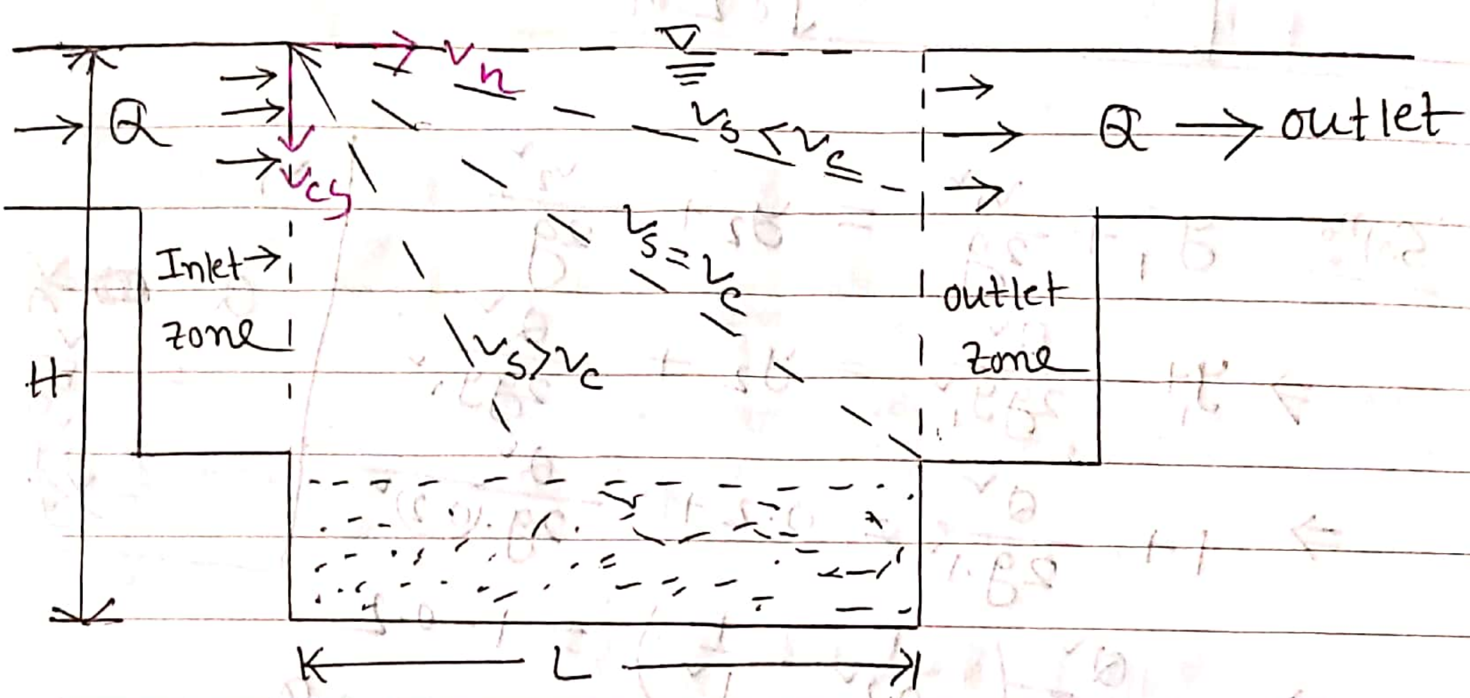
$\therefore$ Width, $B = \frac{31.25}{3} \approx 10.5 m$

Provide an extra depth of 1m for sludge storage and 0.5m for free board making total depth $= 3 + 1.5$

$= 4.5m$

Hence provide a settling tank of size $72m \times 10.5m \times 4.5m$

* Draw the settling trajectories of different types of particles in water in a sedimentation tank. [RRI '21]



V_n = flow velocity = $\frac{Q}{BH}$

V_{cs} = Surface over flow (SOR) = $\frac{Q}{BL}$

V_s = Resultant velocity = $\sqrt{V_n^2 + V_{cs}^2}$

V_c = Critical velocity

* When,

$V_s \geq V_c \Rightarrow$ particles get settled i.e. removed

* Design an aerated grit chamber installation for an average flow of $0.30 m^3/sec$ and a peak flow rate of $1 m^3/sec$. The average depth is 3m, the width to depth ratio is 1.5:1 and the detention time at peak flow is 3.5 min. The aeration rate is $0.4 m^3/min$ per meter of tank length. Determine the dimensions of the grit chamber ~~required~~ and the total air required.

Soln: Volume of chamber, $V = \frac{Q_p \times t}{n}$

n = number of chamber = 1

$= \frac{1 \times 3.5 \times 60}{1}$

$= 210 m^3$

Width of chamber, $w = 1.5 \times 3 = 4.5m$

Length of chamber, $L = \frac{V}{w \times d}$

$= \frac{210}{4.5 \times 3} = 15.55m$

detention time at average flow ~~depth~~ rate,

$t_{avg} = \frac{nV}{Q_{avg}} = \frac{1 \times 210}{0.30} = 700 sec$

$= 11.66 mins$

Total air supply = (Length) x air supply rate

$= 15.55 \times 0.4$

$= 6.22 m^3/min/m$ of tank length

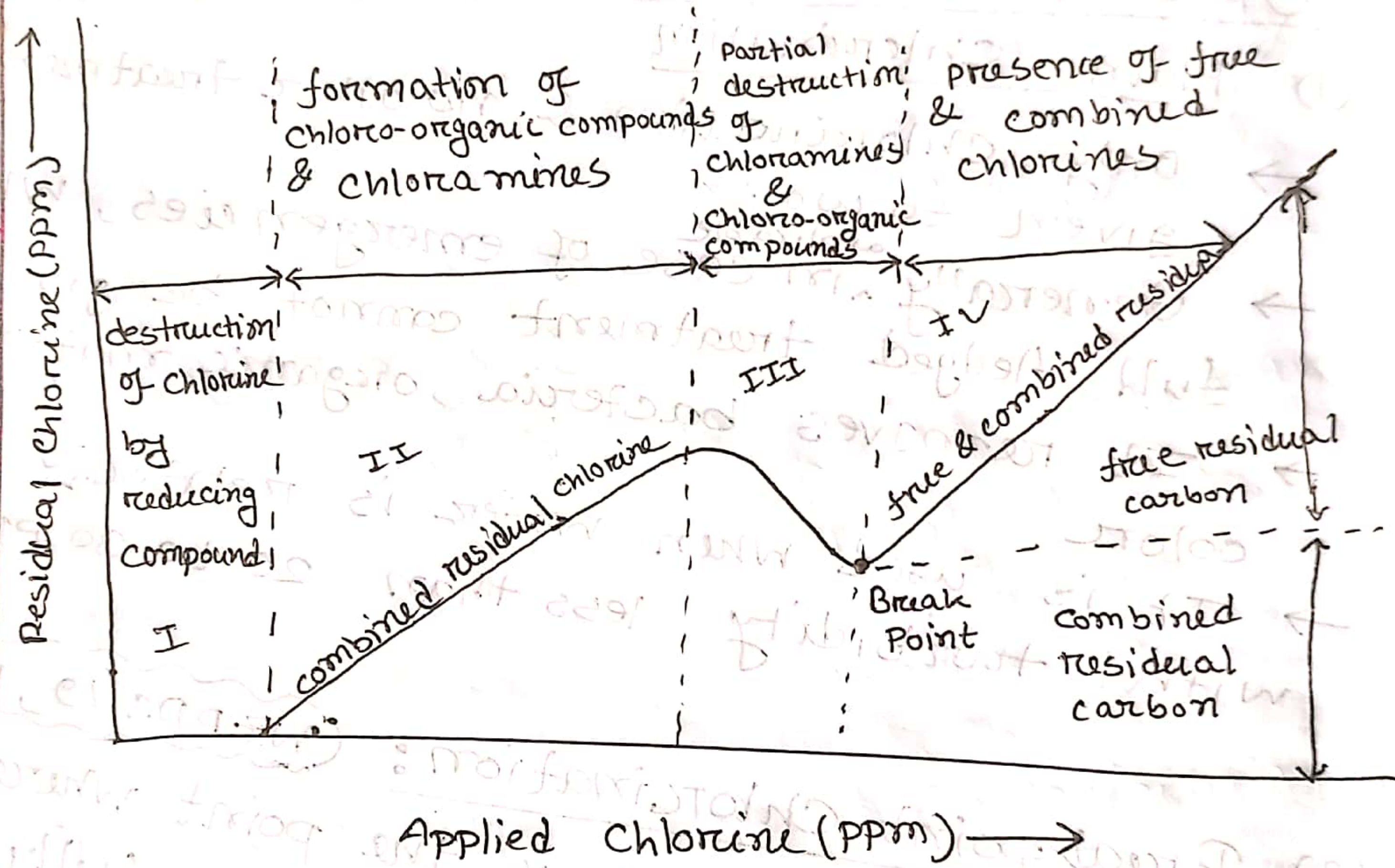
(2) Breakpoint Chlorination: (WZPDC'19, DPDC'14) MSc'19

Breakpoint chlorine is the point where demand for chlorine has been fully satisfied in terms of chlorine addition to water.

or,

Breakpoint chlorination indicates the maximum amount of chlorine required in raw water to kill all microorganisms & destroy it completely by oxidation. Any futher addition of chlorine beyond this point will appear as free residual chlorine.

To ensure safety against future contamination some extra chlorine is added beyond breakpoint chlorination to result in residual chlorine as 0.2 to 0.3 mg/l.



DNCC'20

Solved Problems:

(1) Find Cl_2 demand, if Cl_2 dose of 0.6 mg/l is added to have Cl_2 residual of 0.2 mg/l. Find dose of Bleaching powder required, if it contains 30% of Cl_2. Also find monthly bleaching powder requirement in kg to treat 10 MLD of water.

Sol^n:

Cl_2 demand = Cl_2 dose − Cl_2 residual

$= 0.6 - 0.2$

$= 0.4 \text{ mg/L}$

$$\text{Bleaching powder dose} = \frac{Cl_2 \text{ dose}}{\% \, Cl_2 \text{ in BP}}$$

$$= \frac{0.6}{0.3}$$

$= 2 \text{ mg/l}$ (mg to kg)

Monthly BP required $= 30 \times 10 \times 10^{6} \times 2 \times 10^{-6}$

$= 600 \text{ kg}$

*** [illegible] Chlorine required to disinfect [illegible] (or Cl_2 demand [illegible]) 0.2 mg/l residual [illegible] Cl_2 dose [illegible]।

Cl_2 dose = Cl_2 demand + Cl_2 residual

(ii) In a village 5000 litres water is required daily. If 0.05 mg/l chlorine is required to disinfectent the water and 0.10 mg/l remains as residual, determine the amount of bleaching powder required if it contains 25% Cl_2. [BB AD 2017]

Solⁿ: Cl_2 dose = Cl_2 demand + Cl_2 residual

= 0.05 + 0.1

= 0.15 mg/l

∴ Bleaching powder dose required = $\frac{Cl_2 \text{ dose}}{\% Cl_2 \text{ in BP}}$

= $\frac{0.15}{0.25}$

= 0.6 mg/L

∴ Total BP required = 0.6 × 5000

= 3000 mg

= 3 gm/day Ans

(iv) A slow sand filtration unit produces 900 m³ of water per day. How much bleaching powder with 30% available Cl_2 will be required per day to treat this water with a Cl_2 dose 0.5 mg/L? [DPDC]

Solⁿ: BP dose $= \frac{0.5}{0.3} = 1.67$ mg/l

BP required per day $= 900 \times 10^3 \times 1.67 \times 10^{-6}$
$= 1.5$ kg

(v) The Population of two individual years 1990 & 2000 is given 200,000 & 300,000 respectively. Determine the population of 2010. If per capita water demand 90 lpcd, Chlorine content of 0.5 mg/l is to be added in water to disinfect, how much water bleaching powder will be needed in 2010. Given % of Cl_2 in BP is 20%.
[BWDB, PGCB, DPDC, DESCO, Ashuganj, ----]

Solⁿ: $1+r = \frac{P_{2000}}{P_{1990}} = \frac{300,000}{200,000} = 1.5$

∴ $P_{2010} = P_{2000} \cdot (1.5)^1$ | n = 1 decade
$= 300,000 \times (1.5)^1$
$= 450,000$

এখানে precisely বলা আছে যে 0.5 mg/L add করতে হবে।
তাই তো extra 0.2 mg/L add করা লাগবেনা।

BP dose $= \dfrac{0.5}{0.2} = 2.5$ mg/l

$\therefore$ BP required per day in 2010

$= 2.5 \times 10^{-6} \times 90 \times 450{,}000$

$= 101.25$ kg Ans.

*** অনেক সময় BP এর পরিমাণ পাউন্ডস এ চায়।

1 kg = 2.2 lb (2.205 lb more precise)

* $500 m^3/day$ water is to be supplied from a water treatment plant with chlorine concentration of 0.5 mg/L, if bleaching power that is used for chlorine contains 30% available Cl_2, find the amount of bleaching powder in kg/day? [BIFPCL'21]

Soln:

Sol^n: Bleaching powder required

$$= \frac{500 m^3/day * \frac{0.5\times10^{-6} kg}{10^{-3} m^3}}{0.3}$$

$$= 0.83 kg/day$$

Ans

* The population of a city in year 2000 is 100,000 and year 2015 is 195,000. What will be the water demand in 2025? Given, water demand is 90lpcd. Chlorine content of 0.5mg/L is to be added in water for disinfection. How much bleaching powder is required (ton/day) if bleaching powder contains 25% of chlorine? [PGCL'21] [DESCO'15] [GTCL'16] [DMTCL'22]

Sol^n: ~~Population at 2025, P_{2025} = 195,000 x~~

~~$P_{2025} = P_{2015} * (1 + \ldots)$~~

Population at 2025 $$P_{2025} = P_{2015} * \left(\frac{P_{2015}}{P_{2000}}\right)^{\frac{\text{year gap betn 2025 to 2015}}{\text{year gap betn 2015 to 2000}}}$$

$$= 195000 * \left(\frac{195000}{100,000}\right)^{\frac{10}{15}}$$

$$= 304362$$

∴ Amount of bleaching required

$$= \frac{304362 \times 90 \text{ L/day} \times 0.5 \times 10^{-6} \text{ kg/L}}{0.25}$$

$$= 54.78 \text{ kg/day}$$

$$= 0.055 \text{ ton/day}$$ Ans

Solved problems

***① Population of two individual years 1990 & 2000 is given 200,000 & 300,000 respectively. Determine the population of 2010.
[DESCO'15] [GTCL'16]

Solⁿ:

$$r + 1 = \frac{P_{2000}}{P_{1990}} = \frac{300,000}{200,000} = 1.5$$

| decade, n = 1

$$\therefore P_{2010} = P_{2000}(1+r)^1$$

$$= 300,000 \times 1.5$$

$$= 450000$$

***(3) The population of a community was 200,000 in 1955 & 233,000 in 1965. Find the probable population in 1990.

Solⁿ:

$$1 + r = \frac{P_{1965}}{P_{1955}} = \frac{233,000}{200,000} = 1.65$$

1990 to 1965 = 2.5 decades

$$\therefore P_{1990} = P_{1965}(1+r)^{2.5}$$

$$= 233000(1.65)^{2.5}$$

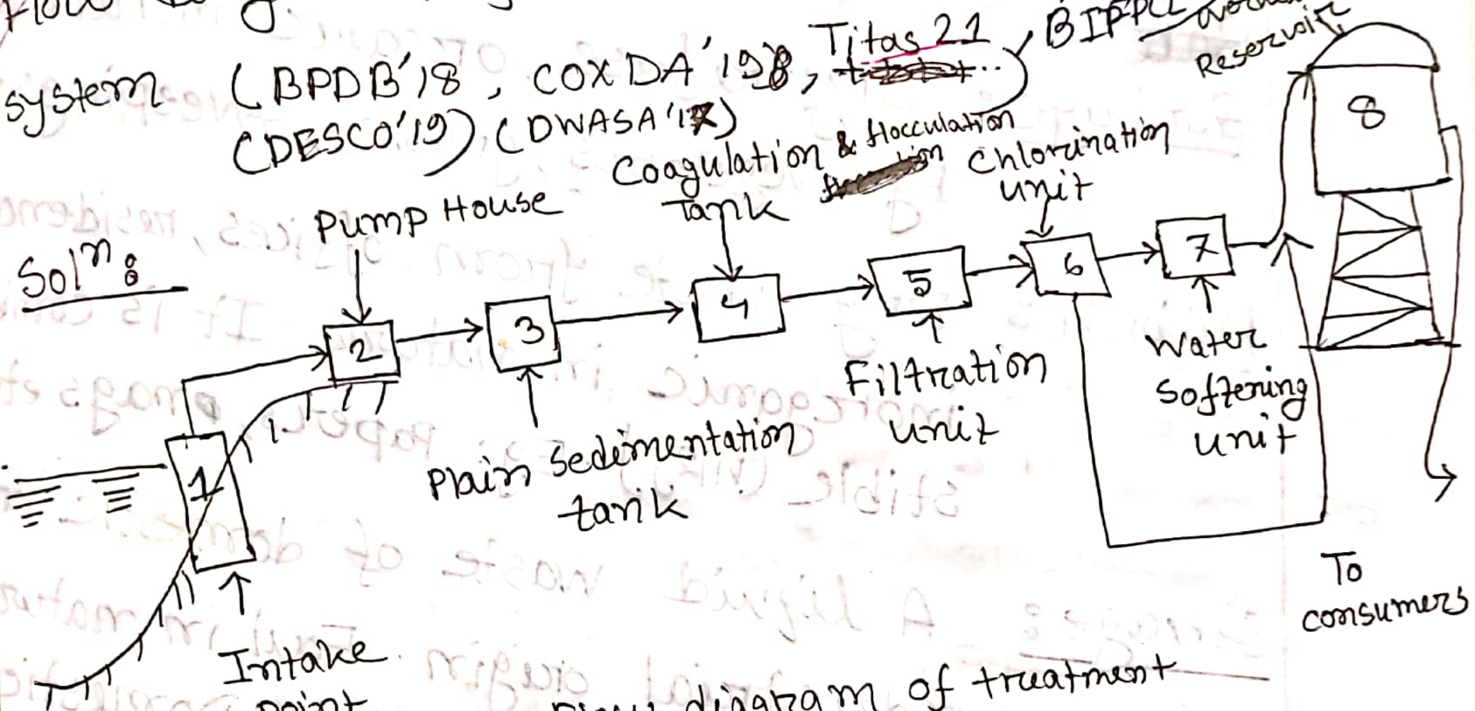
$$= 341327$$ Ans

=

VVI Draw the flow diagram of water treatment of a river water [DWASA'21]

Flow diagram of water treatment/ water supply system (BPDB'18, COXDA'18, Titas 21, BIFPCL'21) (DESCO'19) (DWASA'17)

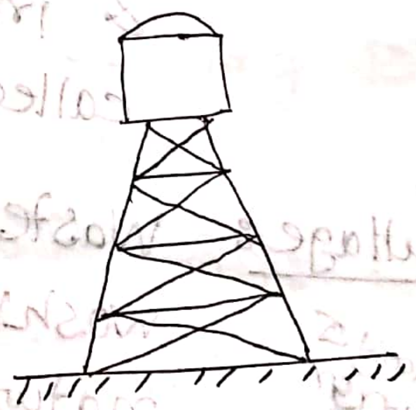
Soln:



Flow diagram of treatment Plant

Sequence of units

1. Intake points
2. Pump house
3. Plain sedimention tank
4. Coagulation tank
5. Filtration unit
6. Chlorination unit
7. Water softening plant
8. Overhead reservoir



Formula for the design of Sewers:

Generally Manning's formula is used to design sewers.

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$ [ft এ দেওয়া থাকলে $\frac{1.486}{n} R^{2/3} S^{1/2}$]

R = hydraulic radius of sewer $= \frac{A}{P}$.

S = bed slope

n = Manning's roughness coefficient

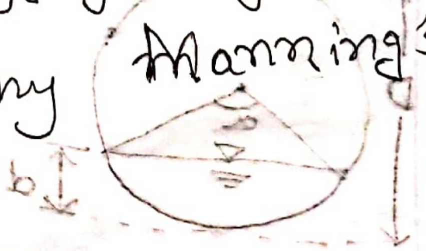
*** for circular sewage with full flow,

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

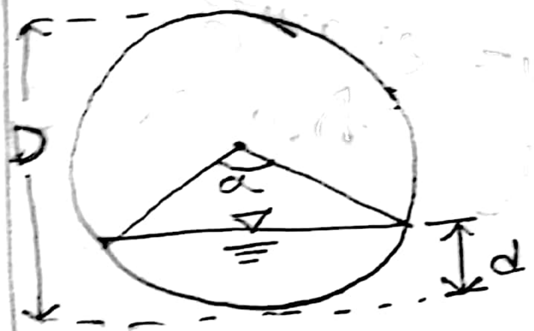
*** for a circular sewage with running half full flow,

$$R = \frac{A}{P} = \frac{\frac{\pi}{8} D^2}{\frac{\pi D}{2}} = \frac{D}{4} \quad \text{(same)}$$

* sewers act like open channel flow, as they are designed as partial flow condition (i.e. flow under gravity, no ~~partial~~ pressure flow). That's why Manning's equation is used.



Partial flow Characteristics of circular sewer



$$\frac{d}{D} = \frac{1}{2}\left(1 - \cos\frac{\alpha}{2}\right)$$

d = depth of flow

D = dia of ~~sewage~~ sewer

$$\frac{a}{A} = \frac{\alpha}{360} - \frac{\sin\alpha}{2\pi} \quad [\text{a = partial flow area}]$$

$$\frac{p}{P} = \frac{\alpha}{360} \quad [\text{p = partial perimeter}]$$

$[P = \pi D]$

$$\frac{r}{R} = \frac{a/A}{p/P} = 1 - \frac{360\sin\alpha}{2\pi\alpha}$$

r = partial hydraulic radius

~~$v = \frac{1}{n} R^{2/3} S^{1/2}$~~

$$\frac{v}{V} = \frac{\frac{1}{n} r^{2/3} s^{1/2}}{\frac{1}{n} R^{2/3} s^{1/2}} \quad [\text{v = partial flow velocity}]$$

$$\frac{v}{V} = \left(\frac{r}{R}\right)^{2/3}$$

(2) A 20cm dia sewer is laid at a slope of 0.004 & is designed to carry a discharge at a depth of 10cm with manning's n = ~~0.01~~ 0.014. Calculate design discharge. [DWASA '21]

Soln: $\frac{d}{D} = \frac{10}{20} = \frac{1}{2}$

running half-full $\therefore$ $R = \frac{D}{4}$.

Now, $Q = AV$

$= \frac{\pi}{8} D^2 \times \frac{1}{n} \times R^{2/3} \times S^{1/2}$ (half full area)

$= \frac{\pi}{8} \times (0.2)^2 \times \frac{1}{0.014} \times \left(\frac{0.2}{4}\right)^{2/3} \times (0.004)^{1/2}$

$= 9.6 \times 10^{-3} m^3/sec$

$= 9.6$ litre/sec Ans

(3) Determine the size of a circular sewer for a discharge of 500 litre/sec running half full. Assume, $S = 0.0001$ & $n = 0.015$

Soln: half full $\therefore$ $R = \frac{D}{4}$

we know, $Q = AV$

$\Rightarrow Q = \frac{\pi D^2}{8} \times \frac{1}{n} R^{2/3} S^{1/2}$

$\Rightarrow 0.5 = \frac{\pi}{8} \times D^2 \times \frac{1}{0.015} \times \left(\frac{D}{4}\right)^{2/3} \times (0.0001)^{1/2}$

$\Rightarrow 0.5 = 0.104 \times D^{\frac{8}{3}}$

$\Rightarrow D^{8/3} = 4.81254$ Ans

$\therefore D \approx 1.8m$

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radius জায়গায় হবে dia

* A pipe has a radius 0.6m and flow is $2m^3/sec$. If the bed slope is 1:50, determine n if pipe flow is half. [KGDCL'21]

Sol^n:

$$Q = \frac{1}{n} * \frac{A}{2} * \left(\frac{D}{4}\right)^{2/3} * \sqrt{S}$$

radius to dia

$$\Rightarrow 2 = \frac{1}{n} * \frac{\pi * 0.6^2}{2} * \left(\frac{0.6 \times 2}{4}\right)^{2/3} \times \sqrt{\frac{1}{50}}$$

$\Rightarrow$ for solving in calculator

$$\Rightarrow n = 0.018$$

Ans.

CamScanner

* A sewer of dia 400mm is laid on a grade 0.015 with manning's $n = 0.013$. What will be the velocity & discharge when the depth of flow is 100mm [SGCL'20] [GTCL'22] [BGDCL'21] [ERL'22] [BWDB'19]

Soln:

$$\frac{d}{D} = \frac{100}{400} = \frac{1}{2}\left(1-\cos\frac{\alpha}{2}\right)$$

$$\Rightarrow \frac{1}{4} = \frac{1}{2}\left(1-\cos\frac{\alpha}{2}\right) \quad \therefore \alpha = 120^\circ$$

$$\frac{r}{R} = 1 - \frac{360 \times \sin 120^\circ}{2\pi \times 120^\circ} = 0.5865$$

$R = \frac{D}{4}$ for full flow

$$\therefore \frac{v}{V} = \left(\frac{r}{R}\right)^{2/3} = 0.7$$

$\therefore$ partial velocity, $v = 0.7V$

$$= 0.7 * \frac{1}{0.013}\left(\frac{0.4}{4}\right)^{2/3} * (0.015)^{1/2}$$

$$= 1.42\ m/s$$

~~discharge, Q = flow area x velocity~~

~~$= \frac{\pi \times 0.2^2}{4} \times 1.42$~~

~~$= 0.045\ m^3/s$~~

$$\frac{a}{A} = \frac{\alpha}{360} - \frac{\sin\alpha}{2\pi}$$

$$\therefore a = \left(\frac{120}{360} - \frac{\sin 120}{2\pi}\right) \times \frac{\pi}{4} \times 0.4^2 = 0.0246\ m^2$$

P.T.O

$\therefore$ discharge $= 0.0246 \times 1.42$

$= 0.035\ m^3/s$

Date: ___/___/___

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* A circular cross-section sewer pipe dia 20" Manning's roughness coefficient = 0.013, laid on a grade = 0.0015. Calculate velocity and discharge when the depth of flow is 5". [ELBL 2022]

Soln: $\frac{d}{D} = \frac{5}{20} = \frac{1}{2}\left(1 - \cos\frac{\alpha}{2}\right)$

$\Rightarrow \frac{1}{4} = \frac{1}{2}\left(1-\cos\frac{\alpha}{2}\right)$

$\therefore \alpha = 120^\circ$

$\frac{r}{R} = 1 - \frac{360^\circ \sin\alpha}{2\pi\alpha} = 0.5865$

20 inch = 1.67 ft

$\therefore \frac{v}{V} = \left(\frac{r}{R}\right)^{2/3} = (0.5865)^{2/3} = 0.7$

$\therefore \text{velocity} = 0.7 * \frac{1.486}{0.013} * \left(\frac{1.67}{4}\right)^{2/3} * \sqrt{0.0015}$

$R^{2/3} = \left(\frac{D}{4}\right)^{2/3}$

$= 1.73 \text{ ft/sec}$

ft এ দেওয়া তাই $= \frac{1.486}{n}$
D = 20" আছে তাই অবশ্যই ft এ নিতে হবে, inch এ কোন হিসাব নাই

$\frac{a}{A} = \frac{\alpha}{360} - \frac{\sin\alpha}{2\pi}$

$\Rightarrow a = \left(\frac{120}{360} - \frac{\sin 120}{2\pi}\right) \times \frac{\pi}{4} \times \left(\frac{20}{12}\right)$

$= 0.4265 \text{ ft}$

$\therefore \text{discharge} = 1.73 \times 0.4265$

$= 0.738 \text{ ft}^3/\text{sec}$

* Determine the size of a circular drainage outlet of a 6 hectare drainage system if the discharge coefficient is 1cm and the tile grade is 0.3%. Assume, n = 0.011 [JGTDSL'21]

Soln:

discharge coefficient 1cm অর্থ হচ্ছে 1cm/day

$$\therefore \text{Discharge, } Q = \frac{1\times10^{-2}\text{m}}{\text{day}} \times 6\times10^4 \text{m}^2$$

$$= 600 \text{m}^3/\text{day}$$

$$= \frac{600}{24\times3600} = \frac{1}{144} \text{m}^3/\text{sec}$$

for a full flow circular dia outlet,

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$$\Rightarrow \frac{1}{144} = \frac{1}{0.011} \times \frac{\pi}{4} \times D^2 \times \left(\frac{D}{4}\right)^{2/3} \times \sqrt{\frac{0.3}{100}}$$

$$\Rightarrow D^{\frac{8}{3}} = 4.475\times10^{-3}$$

$$\therefore D = 0.1315 \text{m} = 13.15 \text{cm} \quad \text{Ans}$$

* একটি 3m*3m*3m size tank এবং এটি 2.5m উচ্চতার পর্যন্ত পানি আছে। tank এর সাথে 400mm dia এর 2m লম্বা একটি pipe যুক্ত আছে। কোন ধরনের loss consider না করে pipe flow বের করুন। [DMTCL'22]

Solⁿ:

pipe flow, $Q = AV$

$$= \frac{\pi}{4} \times \left(\frac{400}{1000}\right)^2 \times \sqrt{2 \times 9.81 \times 2.5}$$

$$= 0.88 \, m^3/sec$$

* The area of metro rail station is $600m^2$. Intensity of rainfall 100mm/hr. Slope of pipe 1 in 100. Calculate the size of PVC pipe required. [DMTCL'22]

Solⁿ: $Q = 600m^2 \times \frac{100 \times 10^{-3} m}{3600 sec} = 0.0167 \, m^3/sec$

For PVC pipe, $n = 0.009$***

Taking full flow condition,

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$$\Rightarrow 0.0167 = \frac{1}{0.009} \times \frac{\pi}{4} \times D^2 \times \left(\frac{D}{4}\right)^{2/3} \times \sqrt{\frac{1}{100}}$$

$$\Rightarrow D^{2+\frac{2}{3}} = \frac{0.0167 \times 0.009 \times 4 \times 4^{2/3} \times \sqrt{100}}{\pi}$$

$$\Rightarrow D^{\frac{8}{3}} = 4.82 \times 10^{-3}$$

$\therefore D = 0.135m$

$\therefore D = 135mm$ Ans

(6) 18 inch sewer with $n = 0.013$ is laid on a grade of 0.015

(i) find capacity when flowing full

(ii) velocity when depth of flow is 4.5 inch

[BCS] [Bakhrabad'21] [GTCL'22]

$18'' = 1.5 ft$

Soln: $Q = AV$ (full flow)

$= \frac{\pi}{4} \times (1.5)^2 \times \frac{1.49}{n} \times R^{2/3} \times S^{1/2}$

$= \frac{\pi}{4} \times (1.5)^2 \times \frac{1.49}{0.013} \times \left(\frac{1.5}{4}\right)^{2/3} \times (0.015)^{\frac{1}{2}}$

$= 1.767 \times 7.29$

$= 12.9 \ ft^3/sec$

> $\frac{1.49}{n}$ দিলে R অবশ্যই ft হবে

(ii) full flow velocity, $V = 7.3 \ ft/sec$

> Slope & n দেয়া থাকলে এবং Manning's formula use করে থাকলে এই formula দ্বারা use হবে।

$\frac{d}{D} = \frac{4.5}{18} = \frac{1}{2}\left(1 - \cos\frac{\alpha}{2}\right)$

$\Rightarrow \frac{1}{4} = \frac{1}{2}\left(1 - \cos\frac{\alpha}{2}\right)$

$\Rightarrow \alpha = 120°$

$\frac{r}{R} = 1 - \frac{360° \times \sin 120°}{2\pi \times 120°} = 1 - \frac{3 \times 0.866}{2\pi} = 0.586$

$\frac{v}{V} = \left(\frac{r}{R}\right)^{2/3}$

$\Rightarrow \frac{v}{V} = (0.586)^{2/3} = 0.7$

$\Rightarrow v = 0.7V$

$= 0.7 \times 7.3$

$= 5.11 \ ft/sec$ Ans

* Define BOD, COD. Why COD is always greater than BOD? [GTCL'22] [BIFPCL'21] [PGCB'18] [PGCB'20] [Titas'19] [DWASA'17] [DESCO'18] [WRGCL'19]

Soln: **BOD:** Biochemical oxygen demand (BOD) is the amount of dissolved oxygen (DO) needed by bacteria and other microorganisms to ~~break down~~ decompose organic material present in a given water sample under aerobic conditions at certain temperature over a specified time period.

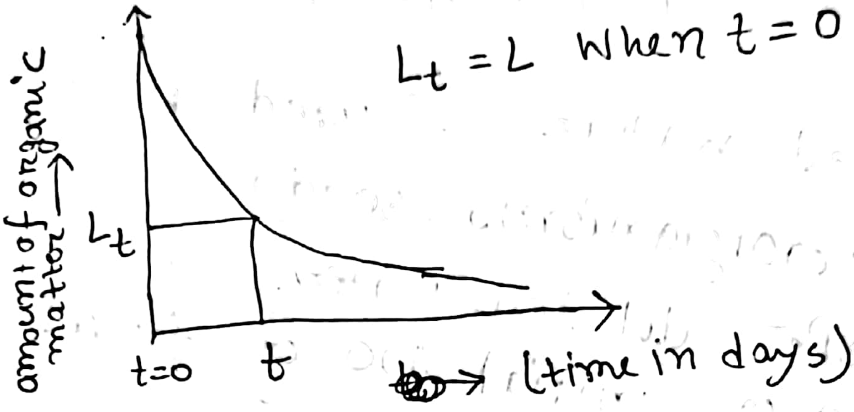
COD: The amount of oxygen that is required for the chemical oxidation of the organic and inorganic ~~chemicals~~ substances present in the wastewater by utilising oxidising agents like potassium permanganate ($KMnO_4$) and potassium dichromate ($K_2Cr_2O_7$) etc is called as chemical oxygen demand (COD).

COD is always greater than BOD because—

(i) more organic compounds can be chemically oxidized than biologically oxidized in a given period.

(2) COD includes both biodegradable and non-biodegradable substances whereas BOD contains only bio-degradable substances.

BOD at different days & ultimate BOD



$L_t = L$ when $t = 0$

L_t = amount of organic matter present at time t

L = total amount of organic matter present in waste water

$$L_t = L e^{-kt}$$
$$= L \cdot 10^{-k_d t}$$

$$BOD_t = L(1 - e^{-kt}) \quad \text{--- (i)}$$

$$BOD_t = L(1 - 10^{-k_d \cdot t}) \quad \text{--- (ii)}$$

K = rate constant

$K_{20^\circ C} = 0.23/\text{day}$ (constant)
(Not temp. dependent)

K_d = deoxygenation constant

K_d changes with temperature

$K_{d(20^\circ C)} = 0.1/\text{day}$ (standard)

~~when t = ∞~~, $L = BOD_u$

maximum K_d for sewage in 20°C is 0.15/day. প্রশ্নে K_d ও k এর একইভাবে দেওয়া না থাকলে সর্বোচ্চ 0.15~0.18 হলে দেওয়া থাকলে, k এর মান

K_d হিসেবে মান দিলে (ii) নং সমীকরণ প্রয়োগ করবে।
$k = 0.27$ হলে (i) নং সমীকরণ ব্যবহার করবে।
** $K_T = K_{20}(1.047)^{T-20^\circ C}$

Solved Problems

(1) In a BOD test the initial DO of the 2% diluted sample is 6 mg/l and it's find after 5 day incubation at 20°C is 2 mg/l. Then find 5-day BOD of sewage sample.

Soln: BOD = $[6-2] \times \frac{100}{2} = 200$ mg/l

(2) If 5 day BOD at 20°C is 200 mg/l, find 3 day BOD at 15°C and 8 day BOD at 30°C. Take $k_{20} = 0.23$/day

Soln: $k_{15} = k_{20}(1.047)^{T-20} = 0.23 \times (1.047)^{15-20} = 0.183\ day^{-1}$

$k_{30°} = 0.23 \times (1.047)^{30-20} = 0.364$/day

$BOD_5 = L_0 [1 - e^{-k_{20} t}]$

$\Rightarrow 200 = L_0 [1 - e^{-0.23 \times 5}]$ [$L_0 = BOD_u$]

$\Rightarrow L_0 = 292.67$ mg/l

$\therefore BOD_3$ at 15°C $= L_0 [1 - e^{-k_{15} t}]$

$= 292.67 [1 - e^{-0.183 \times 3}]$

$= 123.65$ mg/l

BOD_8 at 30°C $= 292.67 [1 - e^{-0.364 \times 8}]$

$= 276.76$ mg/l

* The 5-day BOD of water is 200 mg/L at 20°C, with constant rate 0.21/day. Determine the 10 day BOD of waste water at 20°C.

[[redacted] [RPGCL'22] [NESCO'2] [GTCL'22] [DWASA '21]

Soln:

$$BOD_u = \frac{BOD_5}{1-e^{-kt}}$$

$$= \frac{200}{1-e^{-0.21*5}} = 307.66 \text{ mg/L}$$

Now, $BOD_{10} = BOD_u (1-e^{-kt})$

$$= 307.66 * (1-e^{-0.21*10})$$

$$= 270 \text{ mg/L} \quad \underline{A}$$

$$BOD_{10} = BOD_5 * \frac{1-e^{-k*10}}{1-e^{-k*5}}$$

*** $$BOD_{10} = 200 * \frac{1-e^{-0.21*10}}{1-e^{-0.21*5}}$$

$$= 270 \text{ mg/L} \quad \underline{A}$$

Date: ___ / ___ / ___

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* Initial and final dissolved oxygen in a BOD bottle after 3 days is 7 mg/L and 3 mg/L and k is 0.2/day. Determine BOD_5 and ultimate BOD. [DMTCL'22]

Soln:

$$BOD_3 = (DO_i - DO_f) \times DF$$

$$= (7-3) \times 1$$

$$= 4 \text{ mg/L}$$

dilution factor = 1 (প্রশ্নে দেওয়া নাই)

$$BOD_5 = \frac{1-e^{-0.2\times5}}{1-e^{-0.2\times3}} \times 4 = 5.6 \text{ mg/L (Ans)}$$

$$BOD_u = \frac{4}{1-e^{-0.2\times3}} = 8.865 \text{ mg/L (Ans)}$$

* Initial and final DO of a sample for 5 days is 7.5 mg/L and 3.4 mg/L. Dilution factor is 50. Calculate the ultimate BOD if k=0.2/day

[CPGCBL'22] [PGCB'22]

<u>Soln:</u> $BOD_5 = (7.5 - 3.4) \times 50 = 205$ mg/L

$\therefore BOD_5 = BOD_u(1 - e^{-kt})$

$\therefore BOD_u = \dfrac{205}{1 - e^{-0.2 \times 5}} = 324.305$ mg/L

Ans

direct এই মানটা বসবে

(3) The wastewater having an organic concentration of 54mg/l is flowing at a steady rate of $0.8 m^3/day$ through a detention tank of dimensions ~~2m×2m~~ 2m×4m×2m. If the decay constant is 0.1/day. the outlet concentration is what? [DMTCL MTSP]

10 base
2.10
or 2.3
0.250
0.25

Soln: Detention time, $t = \frac{4 \times 2 \times 2 \ m^3}{0.8 \ m^3/day} = 20 days$

BOD consumed $= 54(1 - 10^{-0.1 \times 20}) = 53.46 mg/L$

$\therefore$ outlet concentration $= (54 - 53.46) mg/L$

$= 0.54 mg/l$

Date: / /

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(3) A river water temperature is 10°C. Calculate the percentage of oxygen consumption after 4 days of the initial amount of oxygen. The BOD rate constant is 0.115/day at standard condition. [SEFL 23]

Soln: Let, initial oxygen content $= L_0$

Remaining O_2 after 4 days $= L$

at standard condition, $k_{20} = 0.115/\text{day}$

$$\therefore k_{10} = k_{20} \times (1.047)^{T-20}$$

$$= 0.115 \times (1.047)^{10-20}$$

$$= 0.0726/\text{day}$$

$$\therefore L = L_0 \times e^{-k_{10} \times t}$$

$$= L_0 \times e^{-0.0726 \times 4}$$

$$= 0.748\, L_0$$

$\therefore$ Oxygen consumption in 4 days

$$= L_0 - L$$

$$= (1 - 0.748) L_0$$

$$= 0.25\, L_0$$

$\therefore$ oxygen consumption is 25% of initial oxygen content.

* Find BOD_5. Initial DO of a soil sample is 8mg/L and final DO is 2mg/L. If 30ml waste sample is mixed with 270ml water. [DPDC'16]

Soln:

$$BOD_5 = (DO_i - DO_f) \times \frac{\text{Total volume}}{\text{Waste water volume}}$$

$$= (8-2) \times \frac{(270+30)}{30} \rightarrow 300ml$$

$$= 60mg/L \quad \underline{A}$$

* Ten 5mL samples of waste water are placed in 300mL BOD bottles and diluted to full volume. Half bottles are titrated immediately and initial DO is 7.9mg/L. The remaining bottles are incubated for 5days after which DO is 4.5mg/L. Calculate BOD_5

Soln:

$$BOD_5 = (7.9-4.5) \times \frac{300}{5 \times 10}$$

$$= 20.4 mg/L$$

(Half bottle নিলে ২ দিয়ে)

* If 2% solution is used from sewage of 5 days at 20°c and dissolved oxygen depletion was 5ppm, determine BOD_5? [PGCB'17]

Soln: $BOD_5 = 5 \times \frac{100}{2}$

$$= 250mg/L$$

($DF = \frac{100}{2}$)

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* The BOD_5 of a sample is 180 mg/L. Find out the dilution factor if the volume of the bottle is 300 ml. Also find out the volume of the sample of sewage mixed with water if the consumption of DO is 4 mg/L.

Solⁿ: BOD_5 = consumed DO × DF

$$\Rightarrow DF = \frac{180}{4} = 45$$

$$DF = \frac{\text{volume of bottle}}{\text{volume of sewage}}$$

$$\Rightarrow \text{volume of sewage} = \frac{\text{volume of bottle}}{DF}$$

$$= \frac{300}{45}$$

$$= 6.67 \text{ ml}$$

* The Waramururungudi tannery with a wastewater flow of $0.011 m^3/s$ and a BOD_5 of 590 mg/L discharges into the Djanggawul Creek. The creek has a 10-year, 7-day low flow of $1.7 m^3/s$. Upstream of the Waramururungudi tannery, the BOD_5 of the creek is 0.6 mg/L. The BOD rate constant, k are $0.115\ day^{-1}$ for the Waramururungudi tannery and $3.7\ day^{-1}$ for the creek. Calculate the initial ultimate BOD after mixing. [BWDB'20]

Soln:

Ultimate BOD of tannery waste water,

$$BOD_{u_1} = \frac{590\ (BOD_5)}{(1-e^{-0.115\times 5})} = 1349.2\ mg/L$$

Ultimate BOD of creek water,

$$BOD_{u_2} = \frac{0.6}{1-e^{-3.7\times 5}} = 0.6\ mg/L$$

∴ Initial ultimate BOD after mixing

$$= \frac{0.011\times 1349.2 + 1.7\times 0.6}{0.011+1.7} = 9.27\ mg/L$$

(correct)

e base হবে না 10 base হবে?

ট্যানারির ক্ষেত্রে k = 0.115/day হওয়ায় 10 base হবে মনে হয়, ক্রিকের ক্ষেত্রে, k = 3.7/day হওয়ায় base হবে e.

N.B.- আমি দুইটার জন্যই e base নিছি।

* Waste water flowing from a city at a rate of 1.35 MGD treated by primary sedimentation & secondary trickling filters with total surface area 70000 ft^2. The influent BOD_5 concentration = 300 mg/L and suspended solids concentration 220 mg/L. The primary treatment process removes 33% of the BOD_5. Calculate the required organic loading rate in kg/ft^2/day. [DPDC'20] [Jalalabad Gas'21]

__Soln:__ organic loading =

(33% remove হয়ে যায় বলে)

$$= \frac{300 \times (1-0.33) \times 10^{-6}\, kg/L \times 1.35 \times 10^{6} \times 3.785\, L/day}{700{,}000}$$

$= 0.0147\ kg/ft^2/day$ (Ans)

1 Gallon = 3.785 litre

* organic BOD loading বললে অবশ্যই অবশ্যই শুধুমাত্র primary effluent count হবে। আর দিবো না, যদি না recycle বা secondary effluent ও হবে।

* In BOD test, dilution wastewater sample (1:50 dilution), initial dissolved oxygen = 8mg/L, final dissolved oxygen after 5 days = 4mg/L. Find 5 days BOD. If wastewater discharged into river at a rate 10ft^3/sec through 24 hrs, estimate yearly BOD5 load. (metric tons/year) [NHA'19]

Soln:

$BOD_5 = (8-4) \times 50 = 200 \, mg/L$

yearly BOD_5 loading

$$= \left[\frac{10}{(3.28)^3} * 3600 * 24 * 365\right] m^3/year * \left[200 \times 10^{-9} * 10^3\right] ton/m^3$$

$= 1787.37$ ton/year

Sub: Disposal of Sewage Effluent

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$DF = \frac{\text{amount of river water}}{\text{amount of sewage}}$

Disposal by Dilution :

If dilution factor above 500, then sewage requires no treatment before disposal

Disposal by dilution is the process whereby the treated sewage or the raw sewage is discharged into a river stream or a large body of water such as a lake or sea.

The discharge sewage, in due course of time, is purified by self purification process of natural water.

Final concentration of DO or BOD is

$$C = \frac{C_S Q_S + C_R Q_R}{Q_S + Q_R}$$

C_S = Sewage concentration

C_R = river concentration

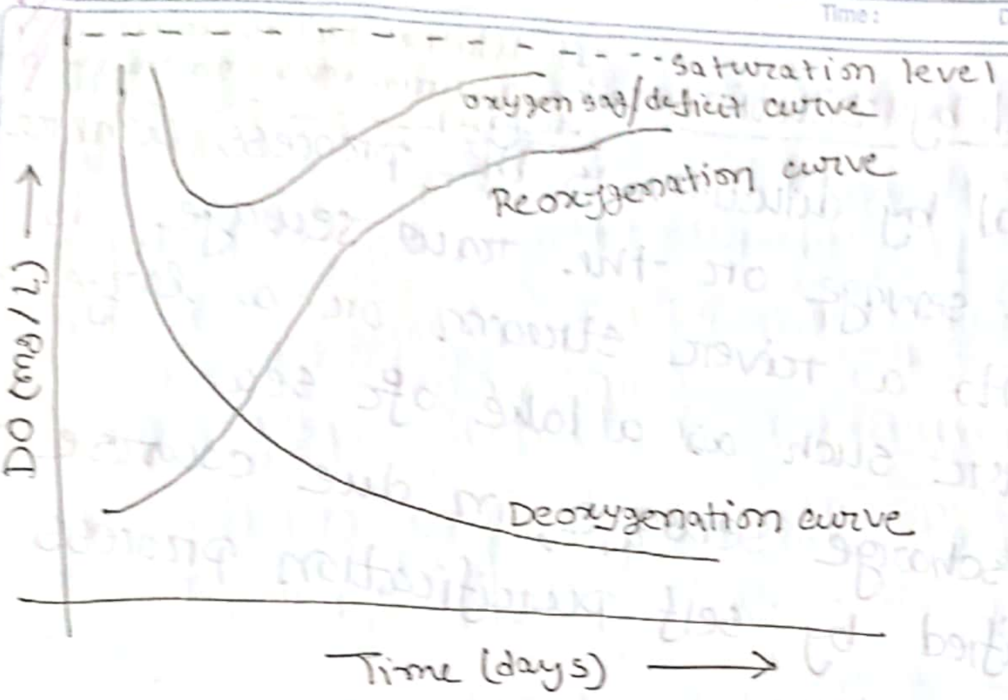
Q_S / Q_R → flow rate of sewage/river

*** at higher temperature, DO is low, as the rate of bio-chemical activities are high at higher temperature causing rapid depletion of dissolved oxygen.

The oxygen deficit of a polluted river-stream

i.e. oxygen deficit (D) = Saturation DO − Actual DO

* saturated DO = amount of DO if river is fully saturated with oxygen.



In a polluted stream, the DO content goes on reducing due to decomposition of organic matter.

Re-oxygenation curve : In order to counter-balance the consumption of DO due to deoxygenation, atmosphere supplies oxygen to the water and the process is called re-oxygenation. The rate of ~~receives~~ receiving oxygen is more in shallow depth than deep water body.

Oxygen Deficit Curve / Sag Curve

Reoxygenation < Deoxygenation

Streeter-Phelps equation:

To calculate DO deficit after t days,

$$D_t = \frac{k_d \cdot L}{k_r - k_d}\left[(10)^{-k_d \cdot t} - (10)^{-k_r \cdot t}\right] + \left[D_o \times 10^{-k_r \cdot t}\right] \quad \text{when } k_d \leq 0.2$$

$$= \frac{k_d \cdot L}{k_r - k_d}\left[e^{-k_d t} - e^{-k_r t}\right] + \left[D_o \times e^{-k_r \cdot t}\right] \quad \text{when } k_d \geq 0.2$$

where,

L = Ultimate first stage BOD / BOD_u

k_d = de-oxygenation coefficient

(k_d is always 10 base) [*k is e base]

k_r = Re-oxygenation coefficient

D_o = initial oxygen deficit / oxygen deficit at the point of mixing sewage into river

** self purification constant, $f = \frac{k_r}{k_d}$

⇒ Maximum DO deficit / Minimum DO presents in stream = D_c (critical DO), $D_c = \frac{BOD_u}{f}[10]^{-k_d \cdot t_c}$

$= \frac{BOD_u}{f} e^{-k_d \cdot t_c}$

time to reach DO deficit = t_c (critical time)

$$t_c = \frac{1}{k_d(f-1)} \log\left[\left\{1 - (f-1)\frac{D_o}{L}\right\} f\right] \quad \text{when } k_d < 0.2$$

$k_d > 0.2$ হলে log এর জায়গায় ln হবে।

(2) A municipal waste water treatment plant discharge $1.2 m^3/sec$ of effluent having BOD of 60 mg/l into a stream that has a flow of $9.3 m^3/sec$ and BOD of ~~its~~ 6 mg/l. Estimate the mixing BOD of the river just down-stream of flow. [BUET]

Soln:

$$\text{mixed BOD} = \frac{C_S Q_S + C_R Q_R}{Q_S + Q_R}$$

$$= \frac{1.2 \times 10^3 \times 60 + 9.3 \times 10^3 \times 6}{1.2 \times 10^3 + 9.3 \times 10^3}$$

m³ এবং litre এ কোন conversion এর দরকার নেই

$$= \frac{1.2 \times 60 + 9.3 \times 6}{1.2 + 9.3}$$

$$= 12.17 \text{ mg/l} \quad \text{Ans}$$

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(3) A waste water Treatment plant discharges 17360 m^3/day of treated effluent into a small stream having a flow rate of 0.43 m^3/sec and ~~an ultimate~~ BOD_5 of 5 mg/l. The treated effluent has a BOD_5 of 12 mg/l and BOD decay constant is 0.12/day at 20°c. stream water temperature is 18°c. compute Ultimate BOD immdiately after mixing.

Soln: 0.43 m^3/sec = 0.43 × 86400 = 37,152 m^3/day

$$BOD_{mix} = \frac{17360 \times 12 + 37152 \times 5}{17360 + 37152} = 7.23 \text{ mg/l}$$

$$K_{d_{18}} = K_{20} (1.047)^{T-20°c}$$

$$= 0.12 \times (1.047)^{18-20}$$

$$= 0.1095$$

$BOD_{mix} = BOD_5$

$$BOD_{mix} = BOD_u [1 - 10^{-k_{18} \cdot t}]$$

$$\Rightarrow 7.23 = BOD_u [1 - 10^{-0.1095 \times 5}]$$

$$\Rightarrow BOD_u = 10.09 \text{ mg/l}$$

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(4) The minimum flow of a river is 50 m^3/sec having a DO content of 7.0 mg/l (80% saturation) and BOD_5 of 8 mg/l. It receives a waste water discharge of 5 m^3/sec with BOD_5 of 200 mg/l and no DO. If the rate constants of deoxygenation and reaeration are 0.5/day and 1.0/day respectively and velocity of river flow is 0.8 m/s, calculate the distance in kilometers d/s from the point of discharge where min DO occurs?

Solⁿ:

$$DO_{mix} = \frac{50 \times 7 + 5 \times 0}{50 + 5} = 6.36 \text{ mg/l}$$

$$\text{saturation } DO = \frac{7}{0.80} = 8.75 \text{ mg/l}$$

$$DO \text{ deficit}, D_0 = 8.75 - 6.36 = 2.39 \text{ mg/l}$$

$$BOD_{mix} = \frac{50 \times 8 + 5 \times 200}{50 + 5} = 25.45 \text{ mg/l}$$

$$BOD_5 = BOD_u [1 - 10^{-k_d \cdot t}]$$

$$\Rightarrow 25.45 = BOD_u [1 - 10^{-0.5 \times 5}]$$

$$\Rightarrow BOD_u = 25.53$$

We know,

$$t_c = \frac{1}{k_r - k_d} \ln\left[\frac{k_r}{k_d}\left(1 - \frac{k_r - k_d}{k_d} \times \frac{D_o}{L_o}\right)\right]$$

$= 0.517$ days

Distance = velocity × time

$$= \frac{0.8 \times 24 \times 3600 \times 0.517}{1000}$$

$= 35.71$ km (Ans)

(5) A waste water is discharged there an out-fall to a fresh water stream of mean velocity 1.2 m/s ~~50m³/sec~~. The DO & BOD_5 of the stream after receiving the waste water are 8.5 mg/l & 25 mg/l. Determine the time and distance downstream where DO concentration is minimum. given, $k_d = 0.25$/day, $k_r = 0.4$/day. Fully saturated DO = 9.2 mg/l. [DMTCL'19]

Soln:

DO deficit, D_o = $DO_{saturated} - DO_{mix}$

$= 9.2 - 8.5$

$= 0.7$ mg/l

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$BOD_{mix} = BOD_u [1 - e^{-k_d \cdot t}]$ $f = \frac{0.4}{0.25} = 1.6$

$\Rightarrow 25 = BOD_u [1 - e^{-0.25 \times 5}]$

$\Rightarrow BOD_u = L = 35.04$

We know, $t_c = \frac{1}{k_d(f-1)} \ln\left[\left\{1 - (f-1)\frac{D_o}{L}\right\} f\right] = 3.05$ days

$$\text{Distance} = \frac{1.2\, m/s \times 24 \times 3600 \times 3.05}{1000} \text{ km}$$

$s = vt$

$= 316.224$ km Ans

(6) A city discharges 100 cumecs of sewage into a river which is fully saturated with oxygen and flowing at the rate of 1500 cumecs during its lean days with a velocity of 0.1 m/sec. The 5 days BOD of sewage at the given temperature is 280 mg/l. Find when and where the critical DO deficit will occur in the d/s and what is its amount. Assume, f = 4 & K_d = 0.1,

saturated DO = 9.2 mg/l (coefficient of purification)

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Solⁿ: $DO_{mix} = \frac{9.2 \times 1500 + 0 \times 100}{1500 + 100}$ [assuming DO of sewage is nill]

$= 8.62 \, mg/l$

Initial DO deficit, $D_o = 9.2 - 8.62 = 0.58 \, mg/l$

$BOD_{mix} = \frac{280 \times 100 + 0 \times 1500}{100 + 1500}$ [∵ fully saturated ∴ BOD = 0]

$= 17.5 \, mg/l$

$f = 4, \; k_d = 0.1$
$\therefore k_r = 0.4$

$BOD_5 = BOD_u [1 - 10^{-k_d \times t}]$

$\Rightarrow 17.5 = L [1 - 10^{-0.1 \times 5}]$

$\Rightarrow L = 25.58 \, mg/L$

$\therefore t_c = \frac{1}{0.4 - 0.1} \log \left[\frac{0.4}{0.1} \left(1 - \frac{(0.4 - 0.1)}{0.1} \times \frac{0.58}{25.58} \right) \right]$
$= 1.905$ days

distance $= \frac{0.1 \times 24 \times 60 \times 60 \times 1.905}{1000}$

$= 16.5024$ km Ans

Amount of Critical DO, $D_c = \frac{0.1}{0.4} \times 25.58 \times 10^{-(-0.1 \times 1.905)} = 4.124 \, mg/L$

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(7) A city discharges 1500 l/s of sewage into a stream whose minimum rate of flow is 6000 l/sec. The 5 day BOD for sewage is 200 mg/l and that of river water is 1 mg/l. If maximum permissible BOD of the mix is 14.45 mg/l, find out the degree of sewage treatment required.

Soln:

Lets find out permissible sewage BOD$_5$ for mix

BOD of 14.45

$$14.45 = \frac{C_s \times 1500 + 1 \times 6000}{1500 + 6000}$$

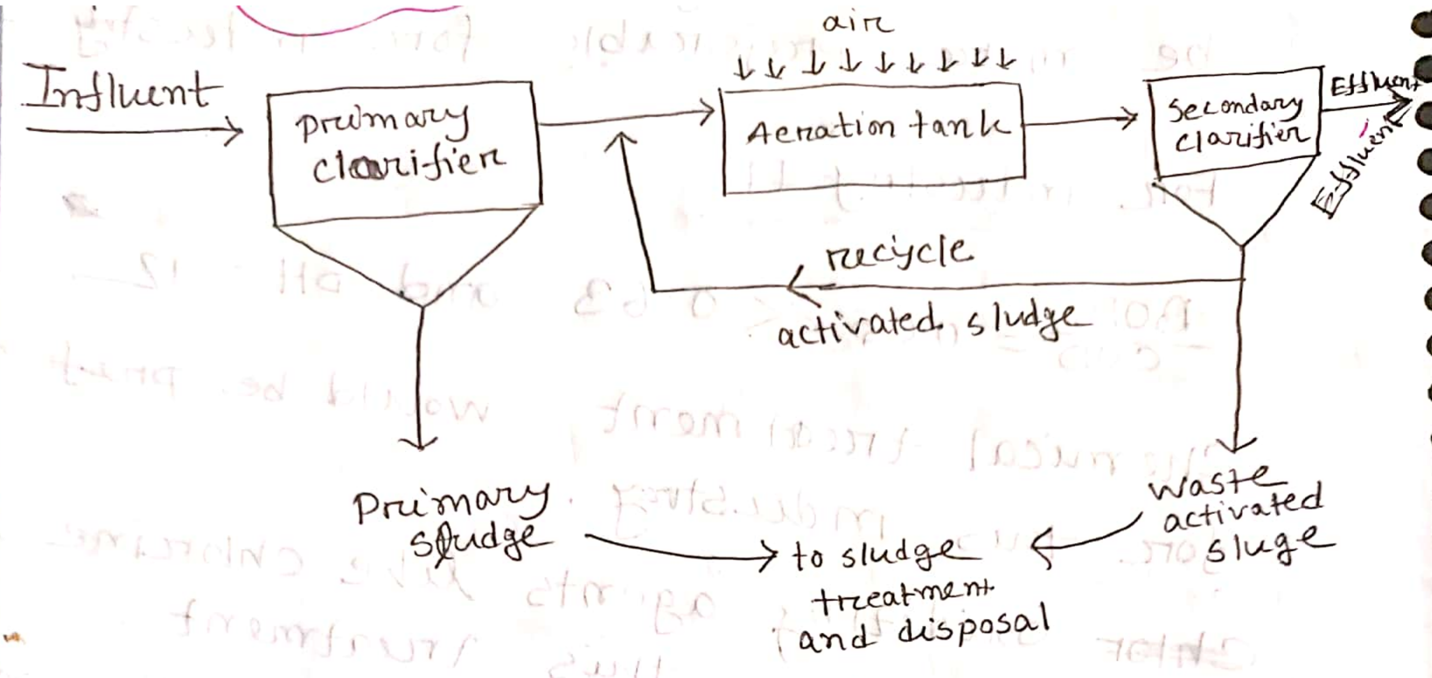
$$\therefore C_s = 68.25$$

$\therefore$ Degree of treatment required

$$= \frac{\text{Original BOD of Sewage} - \text{Permissible BOD of sewage}}{\text{original BOD}}$$

$$= \frac{200 - 68.25}{200} \times 100$$

$$= 65.875\ \%$$ Ans



Activated Sludge Process

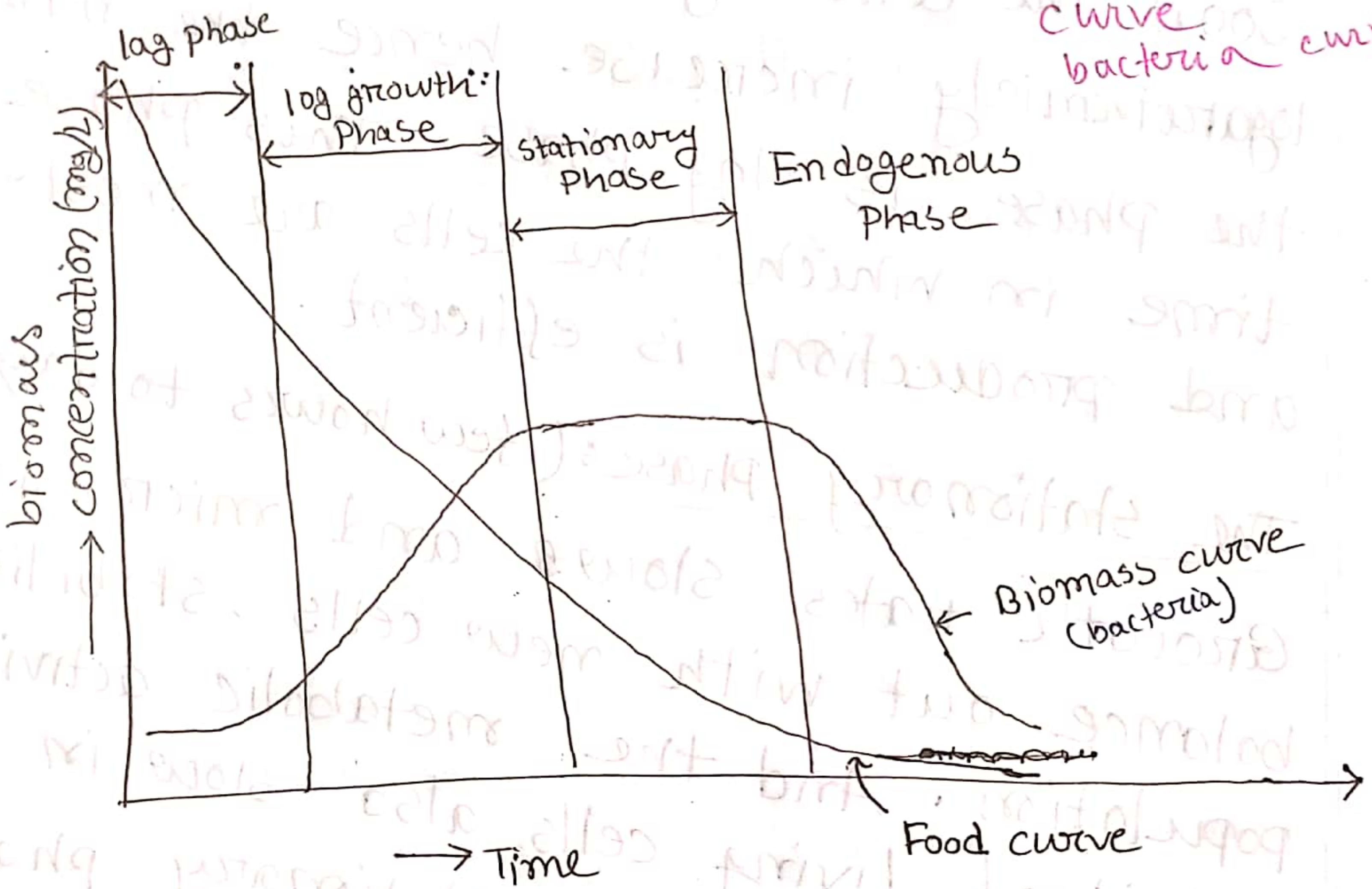
* Mechanisms of removal of heavy metals [DPDC'19]

Soln: (i) Precipitation
(ii) Adsorption
(iii) Ion exchange
(iv) Electro-coagulation
(v) Electro-winning
(vi) cementation
(vii) Reverse osmosis & Electro-dialysis

(bacteria)

Q. Draw a figure showing biomass growth and food utilization with time in a batch reactor. [BWDB'16] [MSc'16]

biomass growth curve
bacteria curve



Solⁿ:

Coagulation: Coagulation is a process of destabilizing colloidal and fine suspended perticles presents in waste water by adding chemical coagulants.

The positive charges of coagulants neutralize the negative charge of suspended perticles. Neutralization causes suspended perticles to bind together to make flocs of relatively higher spacific gravity which eventualy sattle down to the bottom and filtered out from water.

P.T.O

* For drinking water treatment, alum is the mostly used coagulant. For wastewater treatment,

→ Aluminium sulphate [$Al_2(SO_4)_3 \cdot 18H_2O$] ← ফিটকিরি (alum)

→ Ferric sulphate [$Fe_2(SO_4)_3$]

→ Ferric Chloride $FeCl_3$

→ Aluminium chloride $AlCl_3$

→ Sodium Aluminate $Na_2(Al_2O_4)$

are used.

Flocculation: Flocculation is the aggregation of micro-flocs, ~~which~~ formed in coagulation process, into macro-flocs to enhance their settling by gravity sedimentation.

micro-flocs + Flocculent → macro-flocs

* coagulation process এ coagulant chemicals rapid mixing অর্থাৎ অনেক জোরে ~~(flash) mix~~ করা হয়, কিন্তু flocculation প্রসেসে mixing হয় gentle (ধীরে ধীরে).

* flocculation টি last করে. 30-45 mins

* When alum is added to water as coagulant, it decreases pH value [BPDB'15]

* If temperature increases, the dissolved oxygen decreases [DWASA'14]

* The BOD value found from the first order reaction is approximately the value of NBOD T/F (BWDB'16)

Soln: False.

$BOD_5 \approx CBOD$

$BOD_u \approx NBOD + CBOD$

→ 2nd order

* In a gravity waste water pipe line system, the self cleansing velocity should be attained at least twice a day. T/F (BWDB'16)

Soln: False. once a day

*** The only disinfectants chemicals that can be used for waste water treatment are chlorine & ozone T/F [BWDB'16]

Soln: False

C/A: Three (3) most commonly used primary disinfectants are Chlorine, chlorine dioxide (ClO_2), Ozone (O_3)

also chloramine is used as a residual disinfectant for water distribution.

** Trickling filter system needs more skilled operation and maintenance than activated sludge process T/F [BWDB'16]

Soln: False

Activated Sludge Process	Trickling Filter
(1) Need skilled supervision and maintenance	(1) No need skilled supervision
(2) Low cost of installation	(2) high cost of installation
(3) small area required	(3) large area required
(4) No fly or odor nuisance	(4) fly and odor nuisance exists
(5) Only useful in certain types of industries	(5) প্রায় সব কারখানায় ই ব্যবহার করা যায়

* What is environmental impact assessment (EIA)? Why is it done? [CPGCBL'15]

Soln: Environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both benificial & adverse.

Importance/Benifits of Environmental Impact Assessment (EIA):

→ Through EIA, project managers know which project need full screening to prevent any damage to the environment.

→ Helps to assess potential impacts relevant to the environmental legislation based on the legislative requirements.

→ Identifies problems and helps through mitigation process in advance to anticipate disasters likely to happen.

→ Protects the biodiversity environment by suggesting alternative safe project designs and methods.

→ Predict the impact rate for proposed projects, this can be negative or positive.

→ Highlights possible alternative safer to the environment and methods with less impact.

* The Barapukuria Coal is burned at a rate of 1kg/sec. Analysis of BUET lab shows that coal release a sulphur content of 3%. What is the annual rate of emission of SO_2. Assume that 5% of the sulphur in the coal ends up in the ash. [APSCL'20] + DESCO'15]

Soln:

(3% এর মধ্যে 5% অ্যাশে চলে যায়)

The mass of sulpher available to convert into SO_2 = $0.95 \times 0.03 \times 1kg/s \times 24 \times 3600 \times 365$ kg/year

= 898776 kg

~~S + O2 → 2 SO2~~

~~32gm~~ → ~~64~~

~~1mole~~ ~~2mole~~

$S + O_2 \rightarrow SO_2$

32g   64g

1 · 898776 $2\ \frac{64}{32} \times 898776 = 2$

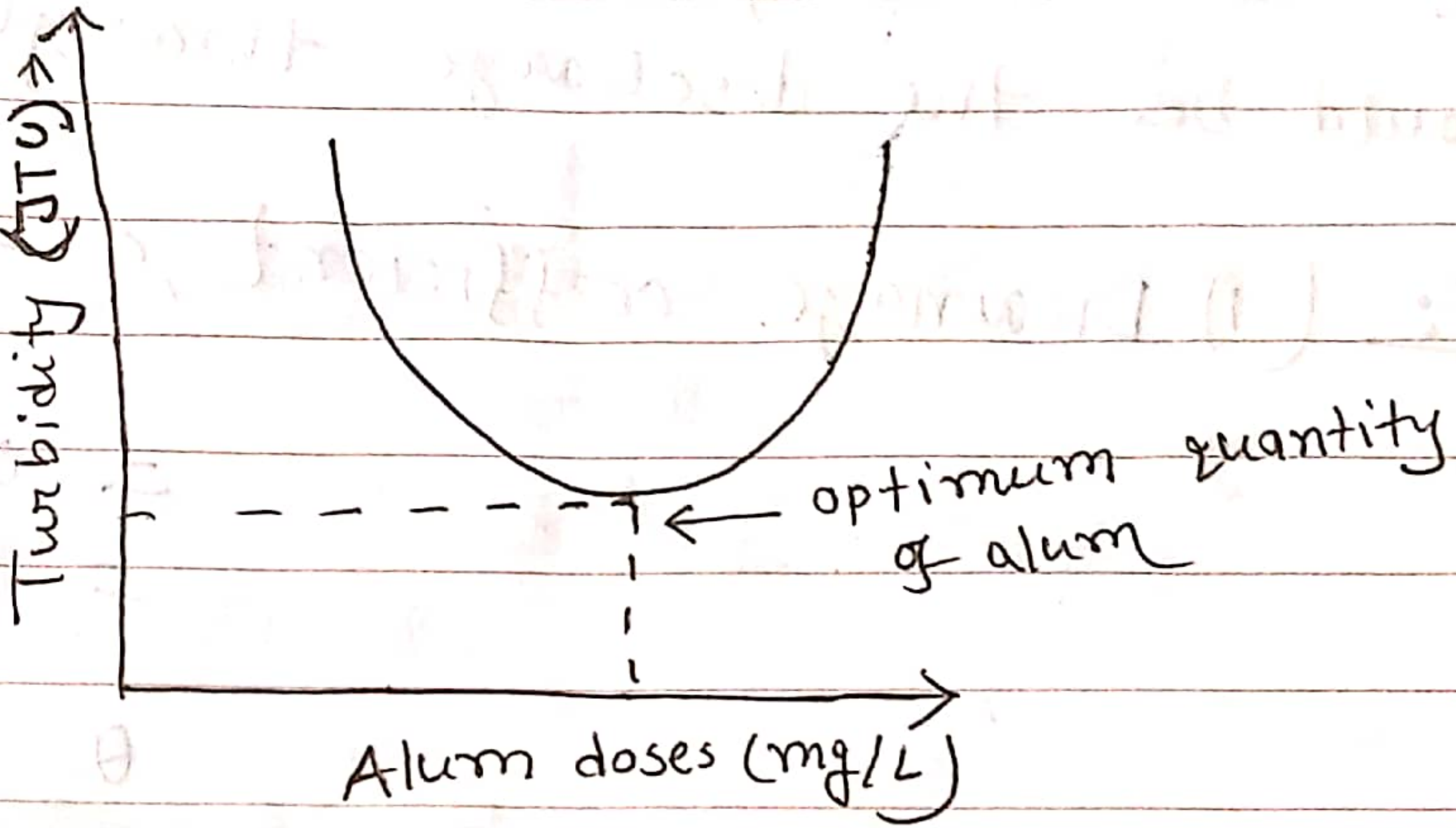
∴ from 898776 kg sulfer, SO_2 produces

$= \frac{2}{1} \times (898776)$

$= 1.797 \times 10^{6}$ kg/year

* Draw a typical qualitative diagram for alum does v/s residual turbidity in a coagulation-flocculation jar test ~~at~~ of surface water sample.

[NESCO'21] [BIWTA'22]



* A power plant burns its coal at a rate of 1000kg/sec. The analysis of the coal reveals a ~~sulfur~~ sulfur content at 3%. Calculate the emission of SO_2 in million kg/year. [BIWM 23]

Soln:
$$S + O_2 \rightarrow SO_2$$
$$32g \qquad (32+16\times2)g = 64g$$

So Sulfur emission rate $= 0.03 \times 1000 \times 60 \times 60 \times 24 \times 365 \times 10^{-6}$
$= 946.08$ million kg/year

$\therefore$ SO_2 emission rate $= \frac{64}{32} \times 946.08$ million kg/years

$= 1892.16$ million kg/years

An

[ELBL'22]

* Abbreviation: [PGCL'17] [APSCL'21] [BCMCL'21]

ETP = Effluent Treatment Plant

STP = Sewage Treatment Plant

ECR = Environment Conservation Rules

PIT = Pile Integrity Test

DCPT = Dynamic Cone Penetration Test

VST = Vane Shear Test

RQD = Rock Quality Designation

OCR = Over Consolidation Ratio.

* Drinking water standards according to ECR'97:

(1) Arsenic = 0.05 ppm / 50 ppb [PGCB'21] [CPGCBL'22] [Titas'21] [SGCL'20] [BPDB'15] [WRGCL'14] [PGCL'21] [GTCL'22] [BPDB'21],

* Lead = 0.05 ppm

(2) Iron = 0.3 ~ 1.0 ppm [NHA'19] [Titas'18]

(3) BOD_5 = 0.2 mg/L [Titas'18] [PGCB'21] [CPGCBL'21] [ERL'22]

(4) COD = 4 mg/L

(5) DO = 6 mg/L

(6) Chlorine (residual) = 0.2 mg/L

(7) Coliform = 0 [CPGCBL'22] [JGTDSL'21] [NHA'19] [MGMCL'22] [PGCB'21]

(8) Color = 15 Hazen

(9) Hardness (as $CaCO_3$) = 200-500 mg/L

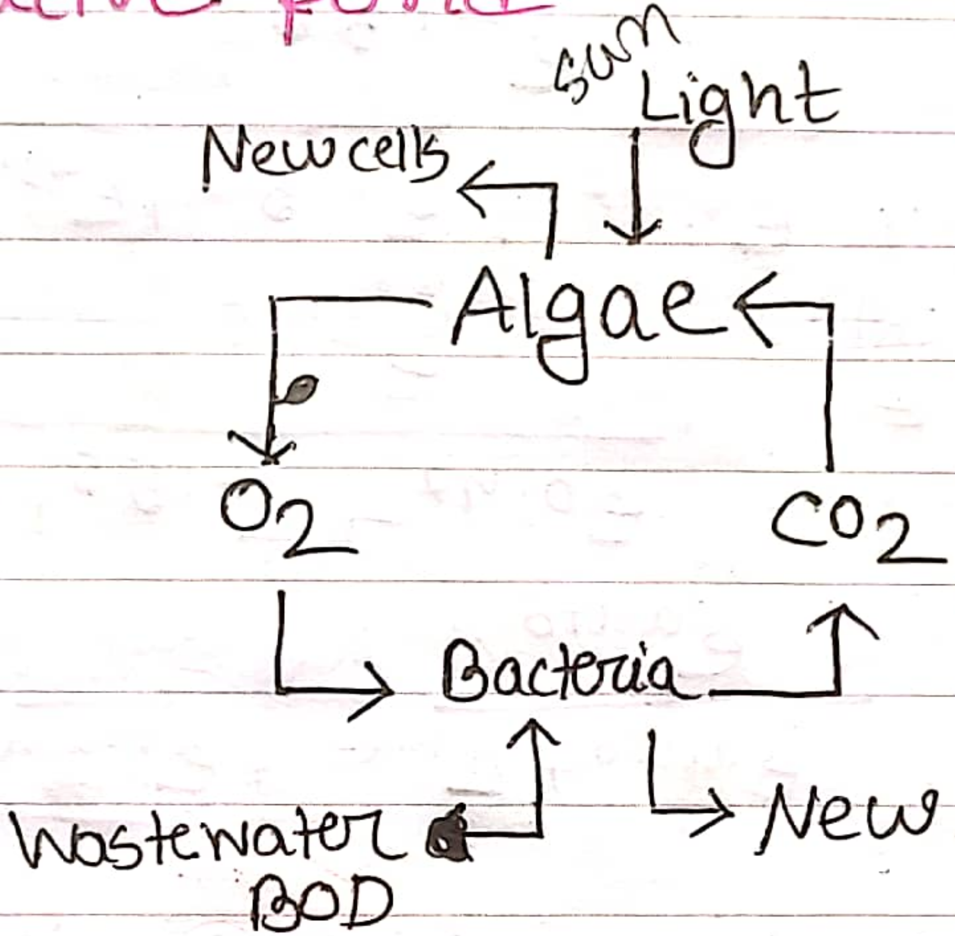
(10) Turbidity = 10 JTU [Titas'18] [GTCL'16]

(11) Total dissolved solids (TDS) – 1000 mg/L [Titas'18]

(12) pH = 6.5 – 8.5 [Titas'18] [CPGCBL'22] [PGCB'21]

* Algae- bacteria symbiosis in a facultative pond

Solⁿ:



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Write down the full meaning:

ETP = Effluent Treatment Plant

COD = Chemical oxygen Demand

BOD = Biochemical Oxygen Demand

UNICEF = United Nations Internation Children's Emergency Fund

SPT = Standard Penetration Test

STP = Sewage Treatment Plant

ECR = Environment Conservation Rules

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What is stabilizing pond? Write down the names of different kinds of waste water stabilizing ponds. Also enlist primary functions [DNCC 22]

⇒ Wastewater stabilization ponds are large, man-made water bodies in which waste water sludge are treated by natural occuring process and ~~as~~ the influence of solar light, wind, ~~micro~~ microorganisms and ~~bacteria~~ algae.

⇒ WSPs are used when high quality effluents are not required and when a large area of land is available for such treatment.

⇒ Three main types
- → anaerobic
- → facultative
- → maturation

⇒ These can be used individually or linked in a series for improved treatment.

(anaerobic → facultative → maturation)

P.T.O

Date:

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Anaerobic Ponds:

→ generally 2.5m-5m deep in which anaerobic conditions prevails.

→ Formation of scum at the surface of the pond helps in reducing the possibility of entering of oxygen inside the pond

→ The main function of anaerobic pond is BOD removal (40 to 85%)

→ Settle undigested material and non-degradable solids as bottom sludge.

→ Dissolve organic materials

→ Breakdown biodegradable materials

Facultative Ponds:

→ generally 1.5-2m deep and divided into three zones. Aerobic at surface, anaerobic zone at the bottom & facultative zone at mid depth.

→ BOD removal efficiency is 80 to 95%

→ Further treat wastewater through sedimentation & oxidation.

→ Reduce odour

~~→ Reduce some disease-causing microbes~~

→ Store residues as bottom sludge.

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Maturation Ponds

→ generally 1-1.5m deep and are normally designed for 3-10 days of hydraulic retention time.

→ whereas anaerobic and facultative ponds are designed for BOD removal, maturation ponds are primarily designed for pathogen removal.

→ It also removes suspended stabilised solids.