12th JULY
S_TURDAY

ENVIRONMENTAL ENGINEERING

[10-12 marks]

Objective :

(i) To protect human against environmental factors

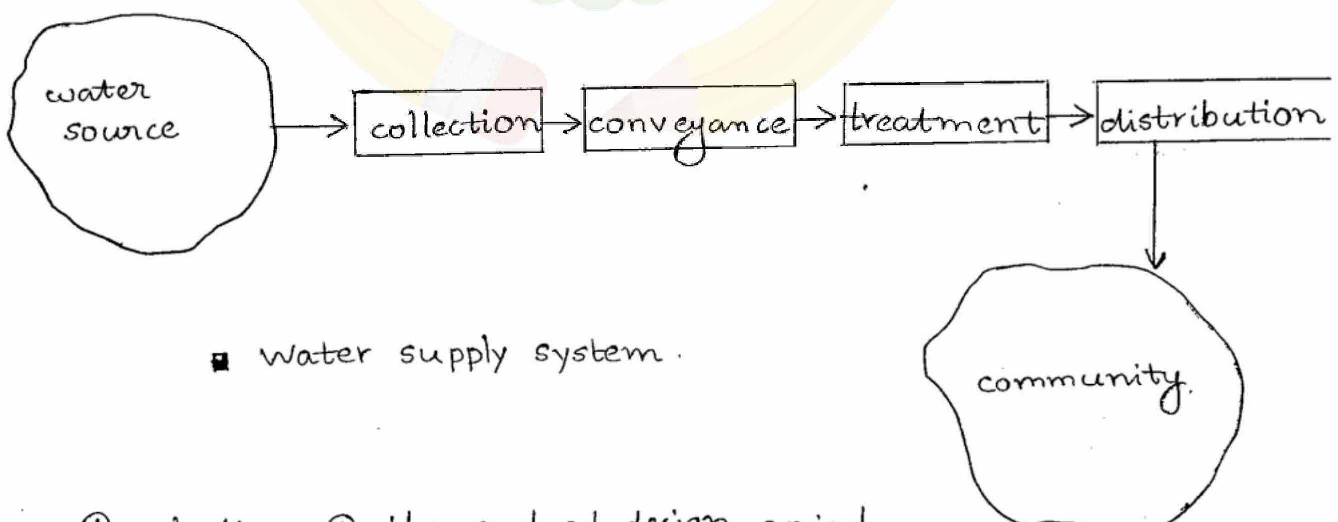
(ii) To protect environments against human actions.

1. Water Supply Engg. – 5 to 6 marks
2. Waste Water Engg. – 4 to 5 marks
3. Solid Waste management
4. Air pollution Control.
5. Noise pollution Control.

} 1 to 2 marks.

WATER SUPPLY ENGINEERING :

Objective: To supply right quality water as per needs of the public (quantity).

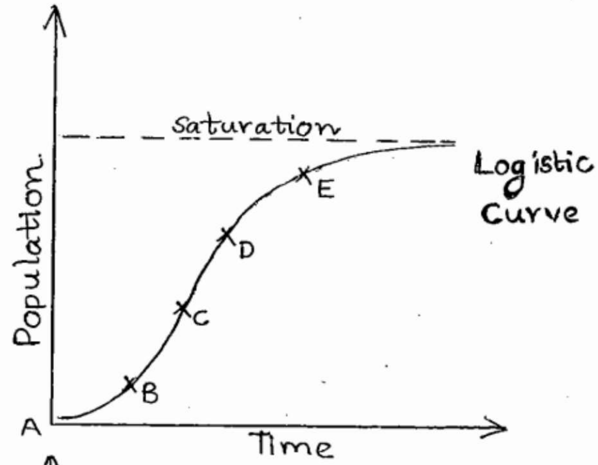


■ water supply system.

Q = Population @ the end of design period × per capita water demand.

13th July,
SUNDAY

Population Forecasting Methods :



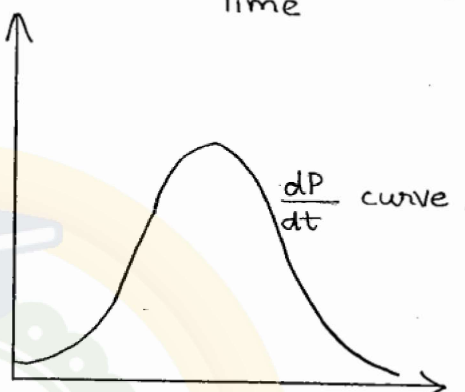
AB → early growth.

BC → exponential or logarithmic growth.

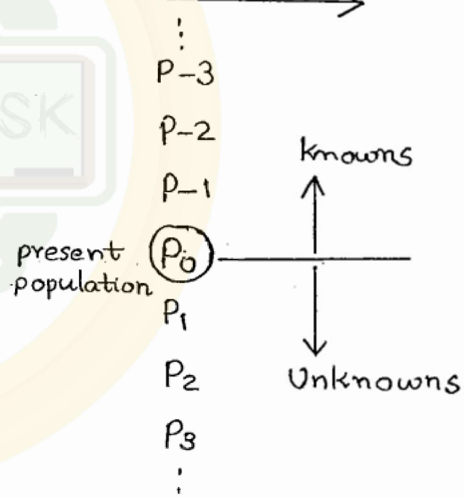
CD → constant growth

DE → late growth.

Slope of the curve = $\frac{dP}{dt}$.



1. Arithmetic Increase method.
2. Geometric Increase method.
3. Incremental Increase method.
4. Decrease in growth rate method.
5. Logistic Curve method.
6. Simple Graphic method.
7. Comparative graphical method.
8. Master plan method.
9. Ratio method.



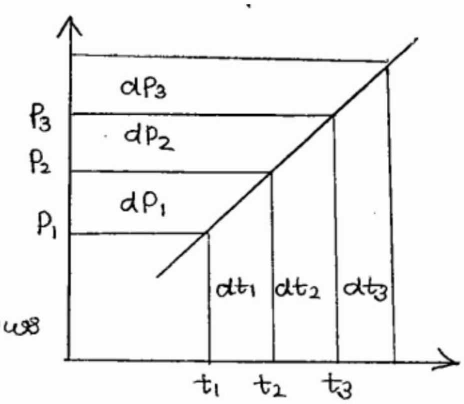
Arithmetic Increase Method:

[Const. Growth Method]

$dP_1 \simeq dP_2 \simeq dP_3$

$dt_1 : dt_2 : dt_3$

$\frac{dP}{dt}$ is constant.



Old and settled communities follows this trend.

Per decade increase in population is assumed to be constant in population forecasting using Arithmetic Increase method.

Let 'P_0' be the latest known last decade population data.
'$\bar{x}$' be the arithmetic avg. of per decade increase in population

Population after 1 decade, $P_1 = P_0 + 1\bar{x}$

Population after 2 decade, $P_2 = P_1 + \bar{x}$
$= P_0 + 2\bar{x}$

$$\boxed{\text{Population after 'n' decades, } P_n = P_0 + n\bar{x}}$$

P-6

Level 2 : Q-01 Ans: (c)

Year	Population	Per decade ↑ in popl^n (dP)
1970	40,000	
		6000 (dP_1)
1980	46,000	
		7000 (dP_2)
1990	53,000	
		5000 (dP_3)
2000	58,000.	

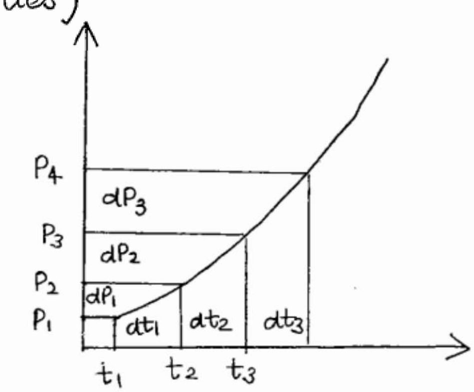
$[dP_1 \simeq dP_2 \simeq dP_3]$

$P_{2010} = P_{2000} + \bar{x}$ $\qquad n = \frac{2010 - 2000}{10} = \underline{\underline{1}}$

$= 58000 + \frac{18000}{63} = \underline{\underline{64000}}$

Geometric Increase Method: [Exponential / Logarithmic Growth Method]

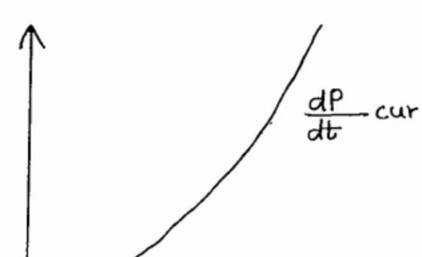
$dP_1 < dP_2 < dP_3$ (fast growing communities)



$\frac{dP}{dt} \propto P_t$ (population at a time 't').

In Geometric increase method, per decade '% increase' in population is assumed to be constant.

$\frac{dP}{dt} = k\,P_t.$



$\frac{dP}{P_t} = k\,dt.$

$$[\ln P_t]_{P_1}^{P_2} = k[t]_{t_1}^{t_2}$$

$$\ln\left(\frac{P_2}{P_1}\right) = k\left(t_2 - t_1\right).$$

$$\Rightarrow \frac{P_2}{P_1} = e^{k(t_2-t_1)}$$ $\Rightarrow$ exponential growth.

$$P_2 = P_1 e^{k(t_2-t_1)}.$$

Similarly,

$$\boxed{P_{tn} = P_{to}\, e^{k(t_n - t_0)}.}$$

k $\rightarrow$ percentage increase per unit time
(r)

Level 2 : Q - 03.

$$P_{2020} = P_{2000}\, e^{\frac{1.6}{100}(2020-2000)}.$$

$$= 10^9 \times e^{\frac{1.6}{100}(20)}.$$

$$= 1.377 \text{ billion.}$$

$$P_{2050} = P_{2020}\, e^{\frac{1.2}{100}\times 30}$$

$$= \underline{\underline{1.974}} \text{ billion}$$

Ans : (a).

Q - 08

$$P_2 = P_1\, e^{\frac{20}{100}\times n}.$$

$$2 = e^{\frac{20}{100}n}. \qquad P_2 = 2P_1$$

$$n = \frac{\ln 2}{0.2} = \underline{\underline{3.46 \text{ years}}}$$

Method 2 : If k (or r) not given, then it can be worked out using the past population data.

Let $\bar{r}$ (or k) be the geometric average of per decade percentage increase in population (assume to be constant)

To find future population, $\bar{r}$ is compounded with existing population

$$\text{Population after 1 decade} = P_0 + \frac{\bar{r}}{100} P_0 = P_0\left(1+\frac{\bar{r}}{100}\right)$$

$$\text{Population after 2 decade} = P_1 + \frac{\bar{r}}{100} P_1 = P_1\left(1+\frac{\bar{r}}{100}\right) = P_0\left(1+\frac{\bar{r}}{100}\right)^2.$$

$$\boxed{\text{Population after 'n' decades} = P_0\left(1+\frac{\bar{r}}{100}\right)^n}$$

$$\bar{r} = (r_1 \times r_2 \times r_3 \times \ldots r_n)^{1/n}$$

$$r_n = \left(\frac{P_n - P_{n-1}}{P_{n-1}}\right) \times 100$$

Q-02 Ans : (c)

$r_1 = 40$, $r_2 = 20$

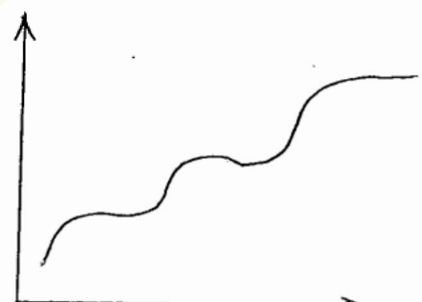
$\bar{r} = (40 \times 20)^{1/2} = \underline{20\sqrt{2}}$

$P_4 = P_3\left(1+\frac{r}{100}\right) = 1.68\left(1+\frac{20\sqrt{2}}{100}\right)$

$= \underline{\underline{2.155 \text{ lakhs}}}$

4th JULY, SUNDAY.

Incremental Increase Method



$dP_1 < dP_2 > dP_3$

$dP_1 > dP_2 < dP_3$

This is an extension of Arithmetic increase method. This method forecast population based on past growth without making any assumptions. To find future populati[on] average of increments over increases are worked out

Let '$\bar{y}$' be the avg of the increments over increasing population. This $\bar{y}$ is to be added to arithmetic increase once for 1st decade, twice for 2nd decade and n times for nth decade. to arrive at

Population after 1 decade, $P_1 = P_0 + 1\bar{x} + 1\bar{y}$

$$= P_0 + 1\bar{x} + \frac{1(1+1)}{2}\bar{y}$$

Population after 2 decade, $P_2 = P_1 + 1\bar{x} + 2\bar{y}$

$$= P_0 + 2\bar{x} + 3\bar{y}$$

$$= P_0 + 2\bar{x} + \frac{2(2+1)}{2}\bar{y}$$

$$\boxed{\text{Population after 'n' decades, } P_n = P_0 + n\bar{x} + \frac{n(n+1)}{2}\bar{y}} \quad \bar{y} = \pm v$$

P-6

Level 2: Q-04.

$P_0 = 50000$, $\bar{x} = 5000$, $\bar{y} = 500$, $n = \frac{2020-1990}{10} = 3$

$$P_{2020} = 50000 + 3\times5000 + \frac{3(4)}{2}\times500$$

$$= 68000$$

Q-05

Year	Population	dP	Increment over Increase in popln.
1940	250000		
		230500	
1950	480500		−160700
		69800	
1960	550300		+18500
		88300	
1970	638600		−31700
		56600	
1980	695200		
		$\bar{x} = 111300$	$\bar{y} = -57966.66$

Ans: (a)

$dP_1 > dP_2 < dP_3 > dP_4$ (confusing trend, ∴ incremental increase method)

$$P_{2000} = 695200 + \frac{2}{2}\times111300 + \frac{2\times3}{2}\times-57966.66$$

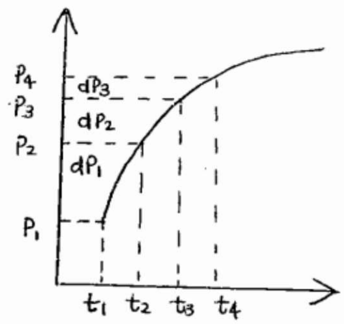
$$= 743900$$

Total water requirement $= 743900\times200$ lpcd

$= 148.78$ MLD $\quad (1\ \text{ML} = 10^6\ \text{L})$

Decreasing Growth Rate Method.

$dP_1 > dP_2 > dP_3$



This trend shown by communities fast moving towards saturation..
Eg: Mumbai, Chennai etc.

$$\frac{dP}{dt} \propto (P_s - P_t)$$

'Rate of increase' decreases. ~~Later~~

Let $\bar{D}$ be the average decrease in percentage increases.

r_0 be the latest known last decade % increase.

This method is an extension of geometric increase method.

Population after 1 decade, $P_1 = P_0 + \left(\frac{r_0 - \bar{D}}{100}\right) \times P_0$

$$= P_0\left(1 + \frac{r_0 - \bar{D}}{100}\right)$$

Population after 2 decade, $P_2 = P_1 + \left(\frac{r_0 - 2\bar{D}}{100}\right) P_1$

$$= P_1\left(1 + \frac{r_0 - 2\bar{D}}{100}\right)$$

$$\boxed{\text{Population after } n \text{ decades, } P_n = P_{n-1}\left(1 + \frac{r_0 - n\bar{D}}{100}\right)}$$

$$P_n = P_0\left(1 + \frac{r_0 - \bar{D}}{100}\right)\left(1 + \frac{r_0 - 2\bar{D}}{100}\right)\left(1 + \frac{r_0 - 3\bar{D}}{100}\right)\cdots\left(1 + \frac{r_0 - n\bar{D}}{100}\right)$$

P-7 : Q-14

14.

Year	Population	% increase.	decrease in % increase
1970	25000		
		12	−9.43 ~~−5.65~~
1980	28000		
		21.43 ~~17.65~~	−2.1 ~~−1.39~~
1990	34000		
		23.53 ~~19.05~~	11.63 ~~8.4~~
2000	42000		
		11.9	

$r_0 = 11.92$

$\bar{D} = 0.033$

$n = 2$

$$P_{2030} = P_{2010}\left(1+\frac{r_0 - \bar{D}}{100}\right)\left(1+\frac{r_0 - 2\bar{D}}{100}\right).$$

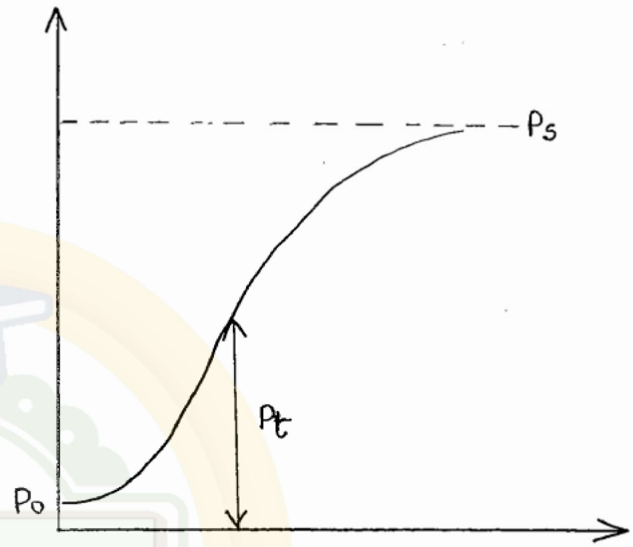
$$= 47000\left(1+\frac{11.62-0.033}{100}\right)\left(1+\frac{11.62-2\times0.033}{100}\right)$$

$$= \underline{\underline{58800}}$$

Logistic Curve Method (Logistic Growth Method):

$$\ln\left(\frac{P_s - P_t}{P_t}\right) - \ln\left(\frac{P_s - P_0}{P_0}\right) = -KP_s t.$$

$$\boxed{P_t = \frac{P_s}{1+me^{nt}}}$$



If three population data spreaded at equal intervals are known, ie

At $t_0 = 0$, P_0

$t_1 = t_1$, P_1

$t_2 = 2t_1$, P_2.

Saturation population, $P_s = \dfrac{2P_0P_1P_2 - P_1^2(P_0+P_2)}{P_0P_2 - P_1^2}$

$$m = \frac{P_s - P_0}{P_0}$$

$$n = \frac{1}{t_1}\ln\left[\frac{P_0(P_s - P_1)}{P_1(P_s - P_0)}\right]$$

Q-13

$t_1 = 20$, $P_0 = 30000$, $P_1 = 170000$, $P_2 = 300000$

$P_s = \cancel{463869.346}.\ \underline{\underline{325478}}$

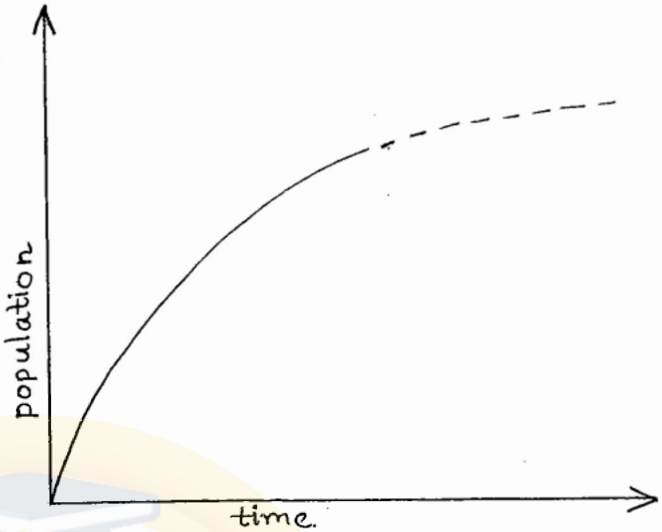
$m = P_s - P_0$ ... 9.85 ... -0.118

$$P_t = \frac{P_s}{1+me^{nt}} = \frac{325\,478}{1+9.85e^{-0.118\times60}} = \underline{\underline{322931}}$$

Simple Graphical Method :

Based on data from past, Population vs Time plot is made.

It is then extrapolated based on experience to obtain the future population

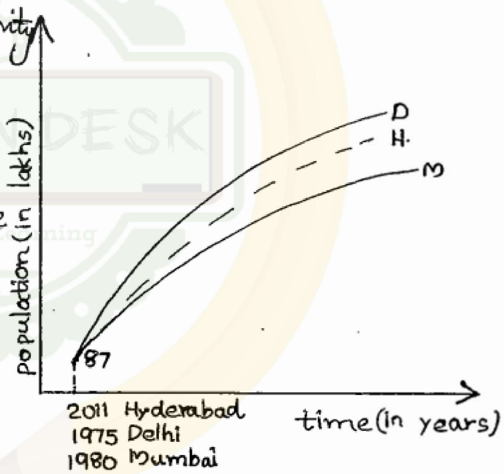


15 JULY
TUESDAY

Comparative Graphical Method :

Population of present community is forecasted based on the population growth trend of some other communities which've developed in a similar manner.

Enhancement of simple graphical method.



Master Plan Method (Zoning Method):

P-6 : Q-06.

400 000		39.62	
5 58 500	158500 dP_1	~~37.24~~	$dP_1 < dP_2 < dP_3$
776 000	217500 dP_2	38.94	(geometrical increase)
1098 500.	322500 dP_3	~~48.28~~ 41.56.	

$\bar{x} =$

$$\bar{r} = (39.62\times38.94\times41.56)^{1/3}$$

$$= \underline{\underline{40.07}}$$

$$P_1 = P_0 \left(1 + \frac{\bar{r}}{100}\right)^1$$

$$= 1098500 \left(1 + \frac{40.07}{100}\right) = 1537944 \approx \underline{\underline{1540,000}}$$

07. At $t = 0$, $P_0 = 28000$, $Q_0 = 4200$ m^3/day

$P_D = ?$ $Q_D = 6000$ m^3/day

At $t = 20$ $P_{20} = 44000$

Q = Population × per capita demand.

* For a given community, per capita demand is always constant

$$\frac{Q_0}{P_0} = \frac{Q_D}{P_D} = \frac{Q_D}{P_0 + t\bar{x}}$$

$$P_{20} = P_0 + 20\bar{x}$$

$$\bar{x} = \frac{44000 - 28000}{20} = \cancel{8000/d}\ 800/yr$$

$$\frac{4200}{28000} = \frac{6000}{28000 + t \times 800}$$

$$t = \underline{\underline{15 \text{ years}}}$$

Level 1 : Q – 26.

$$P_{20} = P_0 + 20\bar{x}$$

$$\bar{x} = \frac{48000 - 28000}{20} = 1000/yr$$

$$Q_0 = 28000 \times 150$$

$$= 28 \times 150 \ m^3/day$$

$$\frac{28 \times 150}{28000} = \frac{6000}{28000 + t \times 1000}$$

$$t = \underline{\underline{12 \text{ years}}}$$

Per capita Water Demand:

$$\text{Per capita water demand (litre/capita/day)} = \frac{\text{total annual average water consumption of community}}{\text{Population} \times 365}$$

Water Demands of a Community: (IS 1172:1993)

1. Domestic water demands. (50–60%)
2. Industrial water demands.
3. Institutional / Commercial water demands.
4. Demand for public use.
5. Fire demands
6. Demands to compensate losses & theft (15–20%)

* Min 135 lpcd is required to meet the domestic demands of a community. It can vary upto 200 lpcd.
* Min. 50 lpcd required to meet industrial demands
* 20 lpcd required for institutional and commercial demands like railway stations, airports, temples, mosques, restaurants, hospitals, schools etc.
* 10 lpcd needed to address the demands for public use.
* 55 lpcd required to compensate losses and thefts.

Empirical Formulae to Find Fire Demands:

1. Kuichling's formula.

$$\boxed{Q = 3182\sqrt{P}}$$

P → population in thousands.

Q → fire demand in litres/minute (lpm).

2. Freemen's Formula

$$\boxed{Q = 1136\left(\frac{P}{5}+10\right)}$$; Q in lpm & P in thousands.

3. National Board of Fire underwriter's Formula.

Insurance company in USA. Equation is used for populations less than 2 lakhs. Widely accepted formula.

$$\boxed{Q = 4637\sqrt{P}\,(1-0.01\sqrt{P})}$$

4. Buston's Formula.

$$\boxed{Q = 5663\sqrt{P}}$$

P-7 : Q-12

$$P = \frac{100000}{1000} = 100.$$

$$Q = 4637\sqrt{100}\,(1-0.01\sqrt{100}).$$

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

$$\text{lpm} = \frac{1\text{ l}}{\frac{1}{24\times60}\text{ day}}$$

$$= \frac{41733\times24\times60}{1,00,000} = 600 \text{ lpcd}$$

Volume of water used to put off fire = Q × duration of fire fighting

$$= 41733\times 4 \times 60.$$ ← duration of fire fighting

Fire demand (in lpcd) = $\dfrac{\text{vol. of water consumed per month during fire accident}}{\text{Population}\times30}$

$$= \frac{41733\times4\times60}{10^5\times30} = 3.33 \text{ lpcd}$$

* As per IS code, total demand of a community vary from 270 to 335 lpcd.

Factors Affecting Water Demand :

(i) Size of the community (iv) Pressure (vii) Cost of water.

(ii) Climatic conditions (v) Method of supply (viii) Quality of water

Variation's in Water Demand :

Average daily water demand, Q = Population * per capita water demand

Max. daily water demand = 1.8 times the avg. daily demand.

ie $\boxed{Q_{max\ daily} = 1.8Q.}$

Max. hourly water demand = 1.5 times max daily water demand

$\boxed{Q_{max\ hourly} = 2.7Q.}$

* Coincident draft (draft = depth of water = demand)

= max. daily water demand + fire demand.

* Total demand (or total draft) = max. hourly water demand OR Coincident draft } whiche is max

Component of water supply scheme	Design rate.	Design Period.
1. Dams	max. daily water demand.	50 years
2. Intakes	max daily water demand.	30 years
3. Conveying main (pipe)	max. daily water demand.	30 years.
4. Pumps.	2 × $Q_{max\ dai}$	15 years.
5. Treatment units (except rapid sand).	1.8 × $Q_{max\ daily}$.	30 years.
6. Rapid sand filters	2 × avg daily demand	15 years.
7. Water distribution system	Total demand.	30 years.

P-06: Q-09.

$Q = 300 \times 4 \times 10^5 = 120$ ~~m³/day~~ MLD.

Q_{max} hourly $= 2.7 \times Q = 324$ MLD

Q_{max} daily $= 1.8 \times Q = 216$ MLD

Q-10

$Q = 250 \times 10^{5} = 25$ MLD.

Filters and lift pumps are designed for $= 2 \times Q$

$= 2 \times 25 = \underline{50 \text{ MLD}}$

Q-11

$Q = 25$ MLD.

Fire demand $= 61$ MLD.

Total demand $=$ Q_{max} hourly or Coincident draft.

$= 2.7\,Q$ or $(1.8\,Q + 61)$

$= 67.5$ or $(61 + 45)$

$\therefore$ Capacity of distribution system $= \underline{106 \text{ MLD}}$

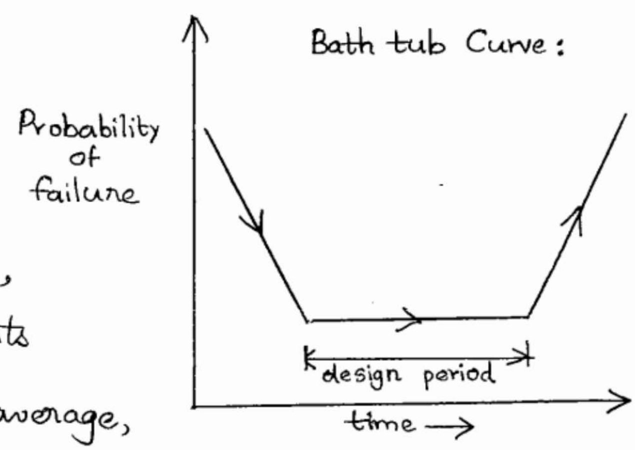
Design Period:

Design period is the utility period or useful life period.

By knowing the design period, we can replace the components

Water supply scheme, on an average, has a period of 30-40 years

Bath tub Curve:

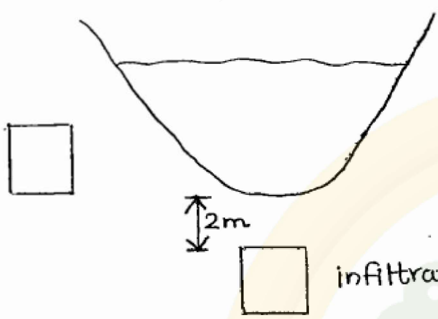


17th JULY,
THURSDAY

2. SOURCES & CONVEYANCE OF WATER

Surface Sources – Quality bad but large quantity. (Ponds, streams, reservoirs)
Subsurface Sources – high quality but less quantity (ground water) springs, wells, infiltration gall

springs – best quality water

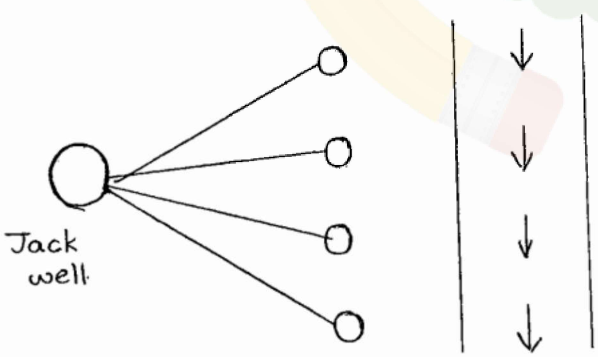


Good quality water due to natural filtration by sand.

infiltration galleries – hollow tunnels made at bed or base of river.

$$Q = \frac{KL(H^2-h^2)}{2R}$$; if infilt. gallery collects water from only one side (bank)

$$Q = \frac{KL(H^2-h^2)}{R}$$; if IG collects water from both sides (bed



Vertical holes made to extract ground water – Wells.

Horizontal holes made to extract seepage water – infiltration galleries

Intakes:

Structure constructed within the surface water body (bed to comfortably collect water from source, stores them temporari and conveys it to distribution pipe.

Collects + store + delivers ⟶ Wet Intakes (River intake)

WATER CONVEYANCE :

1. Gravity Conveyance
2. Pressure Conveyance - using pipe and pump.

17th JULY
THURSDAY

3. QUALITY OF WATER

Raw water → Treatment → Wholesome water

Quality of water (testing) | Quality of water (testing)

Quality of Water (Testing of water):—

1. To know the extent of impurities present in water, based on this method and degree of treatment is decided.
2. To ensure the quality of treated water before supply.

Impurities in Water

1. Based on size of impurities.

macro ← (i) Suspended impurities... 10^{-1} mm to 10^{-3} mm [100 µm – 1 µm]

micro { (ii) Colloidal impurities... 10^{-3} mm to 10^{-6} mm [1 µm – 10^{-3} µm]
(iii) Dissolved impurities... 10^{-6} mm to 10^{-8} mm [10^{-3} – 10^{-5} µm]

2. Based on nature of impurities

(i) Organic impurities – if present in water, they promote growth of micro-organisms. Hence objection

(ii) Inorganic impurities – of natural origin are harmless, but that induced by humans are hazardo[us]
Eg: Cadmium, chromium, nickel, lead, zinc, mercury etc are toxic.

3. State of matter

(i) Physical impurities.
(ii) Chemical impurities
(iii) Biological impurities.

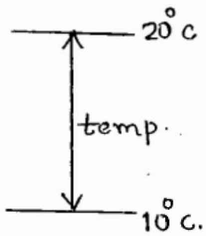
Physical Water Quality:

Assessed by knowing the extend of physical impurities in water. Physical water quality parameters are those which respond to human senses

1. Temperature. ($10^\circ c$ to $20^\circ c$)

2. Colour. (i) Warm temperature is ideal for microbial growth

(ii) Solubility of gases dependent of temperature. Higher the temperature, lower will be solubility.



(iii). Chemical reactions are temperature controlled.

(iv) $\mu_{water} \propto \frac{1}{\text{temperature}}$ $\therefore$ temp should not be less than $10^\circ c$.

2. Colour. (5 TCU to 20 TCU)

Apparent colour $\rightarrow$ suspended solids.

True colour $\rightarrow$ dissolved substances.

Colour in water measured on Burgess scale (Platinum scale) and expressed in terms of True colour Units (TCU) by using device known as "Tintometer."

1 TCU = 1 mg of Platinum as a chloroplatinate ion mixed in 1 litre of distilled water, then the colour produce is taken as 1 standard TCU.

Eg: if 4 mg mixed in 8 L, TCU = 0.5 TCU (mass ÷ volume)

Drinking water standard wrt colour = 5 to 20 TCU (mg/L). Less than 5 TCU is not easily achievable. Colour > 20 TCU is perceptable, so anything above 20 TCU is rejected.

3. Turbidity (5 TU to 10 TU)

Opaqueness in water is known as turbidity. It

Turbidity in water is caused by suspended & colloidal substances.

Smaller particles – high turbidity (more will be the surface area)

Larger particles – large turbidity

Surface area governs turbidity. Turbidity is a surface phenomenon

* Dissolved particles do not possess any surface area. They go into molecular level. So turbidity is offered by suspended and colloidal particles.

Turbidity is the measure of resistance offered by particles in water to the passage of light through water.

* Turbidity is measured on 'Silica Scale' and expressed in terms of 'Turbidity Units' (TU)

1 TU = 1 mg of finely divided silica mixed in 1L of distilled water, then the turbidity produced is taken as 1 standard turbidi unit.

It is also known as 'Jackson Turbidi Unit' (JTU

* Turbidity is measured by:

(i) Devices working on the principle of light absorption.

(ii) Device working on the principle of light scattering.

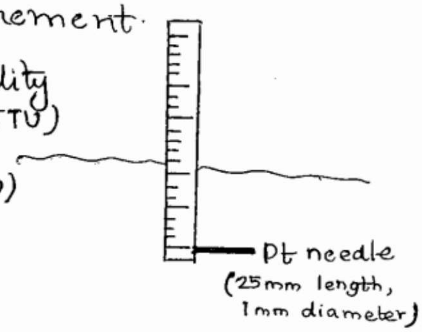
* Turbidimeters (Light Absorption)

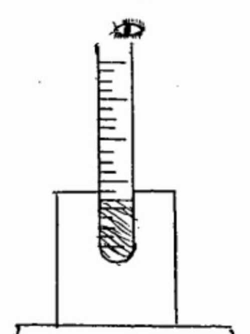
(i) Jackson Turbidi rod — field measurement.

(ii) Jackson Turbidimeter – for high turbidity (> 25 JTU)

(iii) Baylis meter – low turbidity (0 – 2 JTU upto 5 JTU)

(iv) Hillege meter (upto 50 JTU)



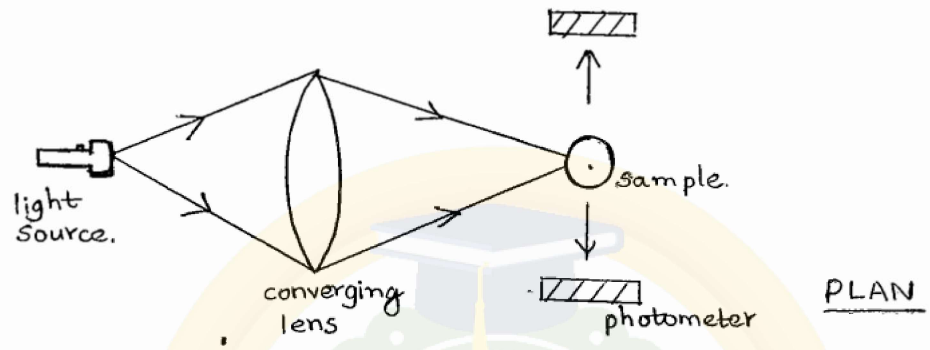


* Nephlometer (light scattering)

Nephlometer measure turbidity in terms of NTU (Nephlometric Turbidity Unit)

1 NTU ≈ 1 mg of formezyn polymer mixed in 1L of distilled water.

It's also expressed in FTU as formezyn is used as a polymer



Nephlometer measures amount of light scattered ⊥ to incident light and the measure is electronically displayed. Hence its almost free from human errors.

Drinking water std. wrt turbidity = 5 NTU to 10 NTU.

18th JULY FRIDAY

4. Odour & Taste (<3 TON)

Odour in water is measured by a device known as "Osmoscope". It is an inhaler with capacity 200 mL.

To ensure the safety of the person who conducts test, diluted samples are always used.

Odour is expressed in terms of 'TON' (Threshold Odour Number). TON is a dilution ratio at which odour is just detectable.

$$TON = \frac{A+B}{A} \quad ; \quad A+B = 200\ mL \text{ (capacity of device)}$$

A → vol. of water sample used in dilution (mL).

A B TON = 200

Drinking water standards for Odour = less than 3 TON

TON = 1 can be observed only by trained persons.

TON = 2 can be sensed by avg. individuals if told.

There are no such tests to measure taste. Generally a sample with bad odour is expected to taste bad.

FTN — Flavoured Threshold Number.

P-23

43. $\text{TON} = \frac{200}{12.5} = \underline{\underline{16}}$

-19

5.8. $\text{FTN} = \frac{200}{25} = \underline{\underline{8}}$

Chemical Water Quality:

1. Solids.

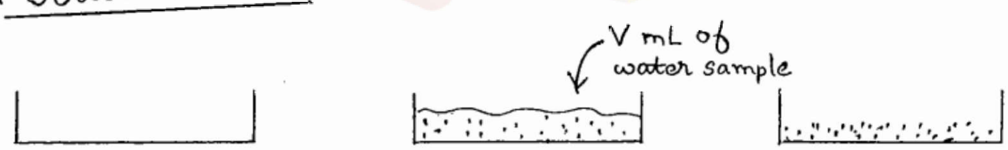
Residue left on evaporation is called Solids in water.

(i) Total Solids
(ii) Suspended Solids
(iii) Total dissolved solids (TDS)

} Gravimetry (weight measurement). Expressed in mg/L or ppm.

NOTE: For water $1\ \text{mg/L} \simeq 1\ \text{ppm}$.

* Total Solids:-



Initial weight, W_1

Hot air oven @ 103°c for 4-5 hrs

Final weight after oven drying } W_2

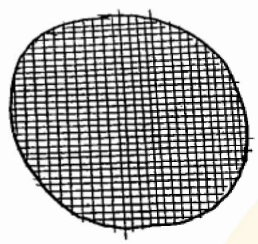
$$\text{Total solids} = \frac{W_2 - W_1}{V}\ \text{mg/L}$$

Q A 50 mL of water sample drawn on to an empty dry container whose initial wt. found to be 92.436 g. After oven drying, the final wt. of container found to be 92.468 g. Find total solids in

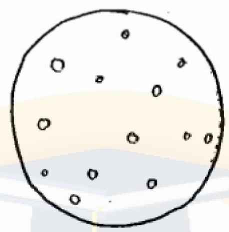
$$\text{Total solids} = \frac{(92.468 - 92.436)\,10^3}{50 \times 10^{-3}} = 0.064 \times 10^4$$
$$= \underline{\underline{640\ mg/L}}$$

* Suspended Solids :-

Filter papers of pore size smaller than the smallest suspended particle is used for filtration. Weight of solids retained on filter paper are measured.



Initial wt. of empty dry filter paper, W_1



Hot air oven @ 103°c for 4-5 hours

Final wt. of filter paper $= W_2$

$$\text{Suspended solids (mg/L)} = \frac{W_2 - W_1}{\text{Vol. of water filtered.}}$$

Q. A 50 cc of water sample passed through empty dry filter paper whose initial wt. found to be 1.248 g. After oven drying its final wt. measured to be 1.262 g. Find suspended solids in water in mg/L.

$1\ m^3 = 1000\ L$
$10^6\ cm^3 = 1000\ L$

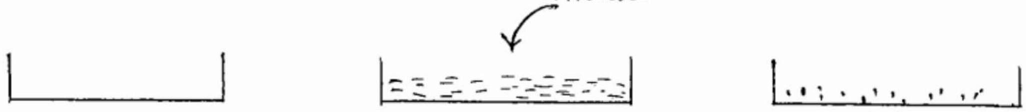
$$\text{Suspended solids} = \frac{(1.262 - 1.248)\,10^3}{50 \times 10^{-3}} = \underline{\underline{280\ mg/L}}$$

$\boxed{1\ m^3 = 1000\ L \quad 1\ cm^3 = 1\ mL}$

* Total Dissolved Solids (TDS) [< 500 mg/L]

TDS includes both colloids and dissolved particles.

V mL of filtrate



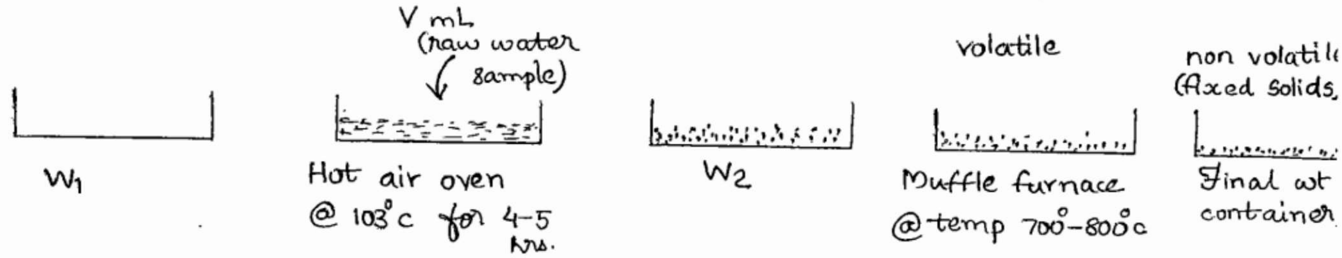
W_1 W_2

TDS (mg/L) = $W_2 - W_1$

* Volatile & Non Volatile (fixed) Solids.

$TS = \frac{W_2 - W_1}{V}$; Volatile solids $= \frac{W_2 - W_3}{V}$;

Non volatile solids $= \frac{W_3 - W_1}{V}$ (mg/L).



Q-23

47. $V = 100$ mL, $W_1 = 98.42\,g$, $W_2 = 98.484\,g$, $W_3 = 98.462\,g$.

$$TS = \frac{64}{100 \times 10^{-3}} = 640 \text{ mg/L}$$

$$\text{Volatile solids} = \frac{W_2 - W_3}{V} = \frac{22 \times 10^{+3}}{100} = 220 \text{ mg/L}$$

$$\text{Non volatile solids} = \frac{W_3 - W_1}{V} = \frac{42 \times 10^{3}}{100} = 420 \text{ mg/L}$$

2. pH (6.5 to 8)

pH is a measure of potential of hydrogen ion concentration.

$$H_2O \longrightarrow H^+ + OH^- \quad \text{(Ionisation)}$$

$$\text{Ionisation constant, } k = \frac{[H^+][OH^-]}{H_2O}$$

For pure water @ 4°c, $H_2O = 1 \Rightarrow K = 10^{-14}$ mol/L

$$\therefore \boxed{[H^+][OH^-] = 10^{-14} \text{ mol/L}}$$

Applying $\log_{10}$ on either side,

$$\log_{10}[H^+] + \log[OH^-] = \log_{10} 10^{-14} = -14$$

$$\log_{10}\frac{1}{H^+} + \log\frac{1}{OH^-} = 14$$

$$pH = \log_{10} \frac{1}{H^+} = -\log_{10} [H^+]$$

$$pOH = \log_{10} \frac{1}{OH^-} = -\log_{10} [OH^-]$$

P-19
Q-6. Whether its strong acid/base or weak acid/base, product of $[H^+]$ and $[OH^-]$ is always constant (14)

Q. If $[OH^-] = 10^{-8.25}$ mol/L, then find pH of water

$$p\,OH = -\log_{10} 10^{(-8.25)} = 8.25$$

$$pH = 14 - 8.25 = \underline{\underline{5.75}} \text{ mol/L}$$

P-22
Q.36. $pH = 4.1$

$$-\log [H^+] = 4.1$$

$$[H^+] = 10^{-4.1} = \underline{\underline{7.94 \times 10^{-5}}} \text{ mol/L}$$

P-23
Q.44. $[OH^-] = 17 \text{ mg/L} = \frac{17}{17 \times 1000} = 10^{-3} \text{ mol/L}$ $\quad 17 \times 10^{-3} \times 6.024 \times 10^{-24}$ —$^{1}/_{L}$

$$\text{mol/L} \rightleftarrows \text{mg/L}$$

$$\boxed{x \text{ (in mg/L)} = x \text{ (in mol/L)} * \text{mol. wt of } x * 1000}$$

$$p(OH^-) = 3$$

$$p[H^+] = 14 - 3 = \underline{\underline{11}}$$

$$\boxed{x_{(mg/L)} = x_{(equ/L)} * \text{Eq. wt. of } x * 1000}$$

$$\text{Eq. wt. of } x = \frac{\text{Mol. wt of } x}{\text{Valency}}$$

$$\boxed{x_{(mg/L)} = x_{(m.equi/L)} * \text{Eq. wt. of } x}$$

P-22

Q.37. $[OH^-] = 10^{-5.6}$ m mol/L $= 10^{-8.6}$ mol/L m mol/L = milli mol/L $= 10^{-3}$ mol/L

$pOH = 8.6$

$\therefore pH = 5.4$

P.23

Q.42. $pH = 9.25$; $pOH = 4.75$.

$[OH^-] = 10^{-4.75}$ mol/L

$= 10^{-4.75} \times 1000 \times 17 = 0.302$ mg/L

P-20

Q-15. $(pH)_I = 7.2$ $(pH)_O = 8.4$.

$(pH)_{avg} = -\log_{10}[H^+]_{avg} = 7.47$

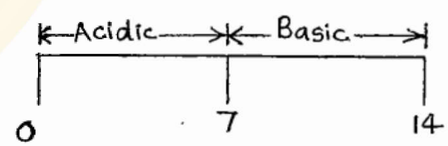
$[H^+]_I = 10^{-7.2}$ mol/L

$[H^+]_O = 10^{-8.4}$ mol/L

$[H^+]_{avg} = \dfrac{10^{-7.2} + 10^{-8.4}}{2} = 3.35 \times 10^{-8}$ mol/L

Q.16. $[pH]_A = 4.4$ $[pH]_B = 6.4$.

Sample A more acidic than Sample B.



$\dfrac{[H^+]_A}{[H^+]_B} = \dfrac{10^{-4.4}}{10^{-6.4}} = 10^2$

$\Rightarrow [H^+]_A = 100[H^+]_B$.

Q.17. A : Vol is 300 mL, $pH = 7$, $[H^+] = 10^{-7}$.

B : Vol is 700 mL, $pH = 5$, $[H^+] = 10^{-5}$.

$[H^+]_{(mixture)} = \dfrac{10^{-7} \times 300 + 10^{-5} \times 700}{1000} = 7.03 \times 10^{-6}$.

$pH_{(mixture)} = -\log[7.03 \times 10^{-6}] = 5.15$

$$\boxed{C_{mix} = \frac{V_A C_A + V_B C_B + V_C C_C + \cdots}{V_A + V_B + V_C + \cdots}}$$

* Chemicals required to treat water depends on pH.
* Extreme high pH and low pH affects the property.

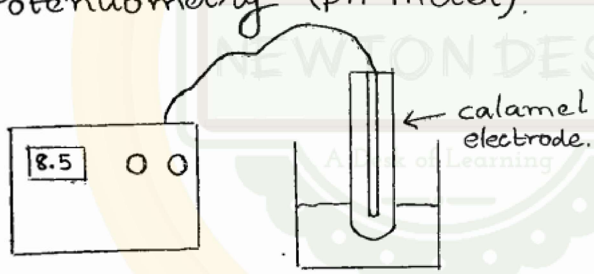
  Eg:- acids cause corrosion
  alkali causes scaling.
* Water treatment is pH sensitive.

Measurement of pH:-

(i) Colorometry (pH paper)
Field determination of pH.

(ii) Titrometry

(iii) Potentiometry (pH meter).



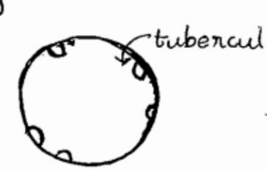
Drinking water standards wrt pH = 6.5 – 8.

3. Acidity

Acidity is the ability of water to neutralise the base

(i) Mineral Acidity. (strong acid)
caused by minerals; pH in the range 0 to 4.2

(ii) Carbonic acidity (weak acid)
caused by CO_2; pH in the range 4.2 to 8.3.



Acidity causes :

(i) Corrosion.

* Water used in construction should have acidity less than or equal to 50 mg/L as $CaCO_3$

$$\boxed{\text{Acidity} \leq 50\ \text{mg/L as } CaCO_3}$$

$$\boxed{x \text{ interms of mg/L of } y = x_{(mg/L)} * \frac{\text{Eq.wt of } y}{\text{Eq.wt of } x}}$$

* Acidity is estimated by Titrometry

Titrant = NaOH.

Indicators : 1. Methyl Orange (Pink – yellow)

2. Phenolphthalein (Yellow – pink)

Q. 20 mL of 0.02 N NaOH soln is consumed in titrating 50 mL water sample. Find acidity in water sample as mg/L of $CaCO_3$.

$$\text{Concentration of 'x'}_{(mg/L)} = \frac{V * N * \text{Eq.wt. of } x * 1000}{\text{mL of water sample tested}}$$

$$\boxed{\text{Conc. of 'x' in terms of 'y'} = \frac{V * N * \text{Eq.wt. of } y * 1000}{\text{mL of water sample tested.}}}$$

$$\text{Acidity} = \frac{20 \times 0.02 \times \left(\frac{40+12+3\times16}{2}\right) \times 1000}{50} = \underline{\underline{400}} \text{ mg/L}$$

4. Alkalinity (TA < 200 mg/L as $CaCO_3$).

Ability of water to neutralise ~~base~~ acids is called alkalinity.

* Alkalinity cause bitter taste to water.
* High alkalinity causes scaling (reduces carrying capacity
* Incrustation.

* Alkalinity in water is caused by:

(i) OH^- (pH: 14-10.2) (ii) CO_3^{2-} (pH: 8.3-10.2) (iii) HCO_3^- (pH : 4.2 to 8.3)

Both CO_3^{2-} & HCO_3^- cause alkalinity.
Alkalinity caused by OH^- negligible

* Total alkalinity

$$\underset{(mg/L\ of\ CaCO_3)}{TA} = \underset{(mg/L)}{OH^-} * \frac{Eq.wt.\ of\ CaCO_3}{Eq.wt.\ of\ OH^-}$$

$$\underset{(mg/L\ of\ CaCO_3)}{TA} = \underset{(mg/L)}{CO_3^{2-}} * \frac{Eq.\ wt\ of\ CaCO_3}{Eq.\ wt\ of\ CO_3^{2-}} + \underset{(mg/L)}{HCO_3^-} * \frac{Eq.wt\ of\ CaCO_3}{Eq.\ wt.\ of\ HCO_3^-}$$

$$\boxed{\begin{aligned} TA &= \underset{(mg/L)}{OH^-} * \frac{50}{17} \\ TA &= CO_3^{2-} * \frac{50}{30} + HCO_3^- * \frac{50}{61} \end{aligned}}$$

19th JULY, SATURDAY

P-20

18 $TA = CO_3^{2-} * \frac{50}{30} + HCO_3^- * \frac{50}{61}$

$= 90 * \frac{50}{30} + 61 \times \frac{50}{61} = \underline{\underline{200}}$ mg/L as $CaCO_3$

P-21

21. $pH = 9$

$\therefore pOH = 14 - 9 = 5$

$[OH^-] = 10^{-5} \times 17 \times 1000 = 17 \times 10^{-2}$ mg/L.

$TA = 17 \times 10^{-2} \times \frac{50}{17} = \underline{\underline{0.5}}$ mg/L as $CaCO_3$ (this can be neglected as pH < 10.2)

P-22

33. $CO_3^{2-} = 5 \times 30 = 150$ mg/L [x(mg/L) = x m.equi/L * Eq.wt. of x

pH = 8.5 , pOH = 5.5

$OH^- = 10^{-5.5} \times 17 \times 1000 = 0.0537$

$TA = 0.0537 \times \frac{50}{17} = 0.158$ mg/L as $CaCO_3$ (neglected).

* Alkalinity is estimated by Titrometry.

Titrant used – H_2SO_4

Indicators used : 1. Phenolphthalein (Pink – Colourless)

2. Methyl Orange (Yellow – Pink)

First end point is called P–Alkalinity

Second end point is called Methyl Orange Alkanity. It's also called as Total Alkalinity (M– Alkalinity or T–alkalinity)

Relation b/w P & T	OH^-	CO_3^{2-}	HCO_3^-	
P = 0	0	0	T	(Sum will be T)
$P < \frac{1}{2}T$	0	2P	T−2P	
$P = \frac{1}{2}T$	0	2P	0	$(2P = 2 \times \frac{1}{2}T =$
$P > \frac{1}{2}T$	2P−T	2T−2P	0	
P = T	T	0	0	

Q. If TA of water 300 mg/L as $CaCO_3$ and P-Alkalinity is 200 mg/L as $CaCO_3$, then find OH^-, CO_3^{2-}, HCO_3^- in mg/L

P=200 mg/L , T = 300 mg/L

$\Rightarrow P > \frac{1}{2}T$.

$OH^- = 2P - T = 400 - 300 = 100$ mg/L as $CaCO_3$

$CO_3^{2-} = 2T - 2P = 600 - 400 = 200$ mg/L as $CaCO_3$

* Drinking water standard wrt Alkalinity:-

Total alkalinity $\leq$ 200 mg/L as $CaCO_3$.

5. Hardness ($TH < 300$ mg/L)

Hardness is caused by the reaction of divalent metallic cations present in water with anions.

Eg:- Ca^{2+}, Mg^{2+}, Sr^{2+}, Fe^{2+}, Mn^{2+}.

Hardness caused by Sr^{2+}, Fe^{2+}, Mn^{2+} are too small to consider.

CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-} are the anions causing hardness

$$\underbrace{\begin{bmatrix} Ca^{2+} \\ Mg^{2+} \\ Sr^{2+} \\ Fe^{2+} \\ Mn^{2+} \end{bmatrix}}_{\text{cations}} + \underbrace{\begin{bmatrix} CO_3^{2-} \\ HCO_3^- \\ Cl^- \\ SO_4^{2-} \end{bmatrix}}_{\text{anions}} \longrightarrow \text{Hardness.}$$

* Total Hardness (TH) = Carbonaceous Hardness (CH) + Non carbonaceous Hardness (NCH)

$$\boxed{TH = CH + NCH}$$

$$TH \text{ in water} = \underset{(mg/L)}{Ca^{2+}} * \frac{Eq.wt \text{ of } CaCO_3}{Eq.wt \text{ of } Ca^{2+}} + Mg^{2+} * \frac{Eq.wt. \text{ of } CaCO_3}{Eq.wt \text{ of } Mg^{2+}}$$

$$\boxed{TH = \underset{(mg/L)}{Ca^{2+}} * \frac{50}{20} + Mg^{2+} * \frac{50}{12}}$$

if $TH > TA$	very important	if $TH \leq TA$ $CH = TH$

P-22.

34 $Ca^{2+} = 100$ mg/L $\quad CO_3^{2-} = 0$

$Mg^{2+} = 6$ mg/L $\quad HCO_3^- = 250$.

$$TH = 100 \times \frac{50}{20} + 6 \times \frac{50}{12} = \underline{\underline{275}} \text{ mg/L as } CaCO_3$$

$$TA = 0 + 250 \times \frac{50}{61} = 205 \text{ mg/L as } CaCO_3$$

$TH > TA \Rightarrow (CO_3^{2-} + HCO_3^-)$ hardness, $CH = TA$

$= 205$ mg/L as $CaCO_3$.

32. $Ca^{2+} = 12$ m.eq/L $= 12 \times 20 = 240$ mg/L

$Mg^{2+} = 18$ m.eq/L $= 18 \times 12 = 216$ mg/L.

$$TH = 240 \times \frac{50}{20} + 216 \times \frac{50}{12}$$

$$= \underline{\underline{1500}} \text{ mg/L as } CaCO_3$$

31 $Ca^{2+} = 55$ mg/L, $Mg^{2+} = 10$ mg/L.

$$\text{Hardness} = 55 \times \frac{50}{20} + 10 \times \frac{50}{12.2} = \underline{\underline{179}} \text{ mg/L as } CaCO_3$$

P-21

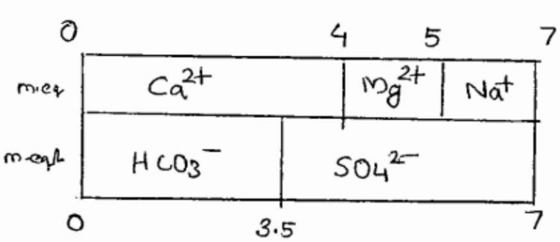
30 TA $= 250$, TH $= 350$ $\Rightarrow$ TH > TA. Ans: (d)

Carbonate hardness $=$ TA $= 250$ mg/L as $CaCO_3$

NCH $=$ TH $-$ CH $= 100$ mg/L as $CaCO_3$.

P-23

45.



$Ca^{2+} = 4 \times 20 = 80$ mg/L $\quad HCO_3^- = 3.5 \times 61 = 213.5$ mg/L.

$Mg^{2+} = 1 \times 12 = 12$ mg/L

$$TH = 4 \times 20 \times \frac{50}{20} + 1 \times 12 \times \frac{50}{12} = 250 \text{ mg/L}.$$

$CH = TA = 175 \ mg/L$

$NCH = 250 - 175 = \underline{\underline{75 \ mg/L}}$

$$\boxed{TH = Ca^{2+}_{(m.eq/L)} * 50 + Mg^{2+}_{(m.eq/L)} * 50}$$

P-19

1. $TH = 160 \times \frac{50}{20} + 40 \times \frac{50}{12} = \underline{\underline{567}} \ mg/L$ as $CaCO_3$

12. $TH = 200 \ mg/L$, $TA = 250 \ mg/L \Rightarrow TH < TA$

$CH = TH = \underline{\underline{200}} \ mg/L$

13. $NCH = 0$.

19. $TH = 65 \times \frac{50}{20} + 51 \times \frac{50}{12} = \underline{\underline{375}} \ mg/L$

$TA = 248 \times \frac{50}{61} = 203 \ mg/L$

$TH > TA$

$CH = TA = \underline{\underline{203}} \ mg/L$

$NCH = \underline{\underline{172}} \ mg/L$

* Hardness in water estimated by '<u>Versanate method</u>' (EDTA method).

Titrant : EDTA (Ethylene Diamene Tetra Acetic acid).

Indicator : Erichrome Black ~~Tea~~ (EBT).

Colour change : Wine red to Blue.

NOTE: When titrating with EDTA, colour changes to blue on addition of EBT, there is no hardness in water.

* Hardness in water causes :

a) Bitter taste d) Increased soap consumption.

b) Corrosion

c) Scaling

Hardness (mg/L of $CaCO_3$).	Nature of water.
< 75	Soft.
75–150	moderately hard.
150–300	Hard.
>300	Very hard.

{ TH upto 200 mg/L remains unnoticed

* Drinking water standards, TH < 300 mg/L

6. Chlorides (≤250 mg/L).

* If chlorides are present in water along with sodium, it cause kidney and cardiac problems

* Seawater intrusion into groundwater is verified with chlorides estimation.

* Chlorides in water estimated by Mohr's Method.

Titrant : silver nitrate.

Indicator: Potassium chromate.

Colour: yellow to brick red.

* Drinking water standard ≤ 250 mg/L

7. Sulphates (< 250 mg/L)

* "Laxative" problems (loose motion → diarrhea)

* Sulphates estimated by 'Turbidimetry' using Barium.

* Drinking water standards < 250 mg/L

8. Dissolved Oxygen (3 – 4 mg/L)

* dissolved oxygen keeps water fresh for long period

* It improves taste of water
* DO in water estimated by 'Winkler's Method'

Reagents : 1. Manganous Sulphate + Alkali Iodide Azide } Brown ppt (DO present) / White ppt (DO absent)

Titrant : Sodium Thiosulphate.

Indicator : starch

H_2SO_4 + brown ppt = Yellow colour.

If V is the volume of titrant consumed,

$$\text{Amount of DO} = \frac{V * 0.025 * 8 * 1000}{200} = \underline{\underline{V\ mL}}$$

$$\boxed{DO \propto \frac{1}{temp}}$$

9. Fluorides (1 to 1.5 mg/L)

* Fluorides are only found in groundwater
* Fluorides < 1 mg/L → Dental caries (dental cavities

Fluorides (in water) + Enamel (in teeth) → strong teeth.

Fluorides > 1.5 mg/L → (i) mottling of teeth (teeth stain, yellow patch

(ii) Fluorosis (for very high Fl conc of 2, 2.5 mg/L
a) Dental fluorosis
b) Skeletal fluorosis (Bone fluorosis

* Drinking water standard = 1 to 1.5 mg/L

* Fluorides in water estimated by 'Colourometry' using Zirconium.

10. Nitrogen Compounds

* Indicate organic contamination of water. ∴ no amou of nitrogen compounds are allowed in drinking water.

Kjedahal Nitrogen { (i) Ammonia nitrogen — indicates recent pollution.
(ii) Organic nitrogen (Albuminoid nitrogen) — indicates old pollution (vegetative and animal waste).

(iii) Nitrites — intermediate stage of pollution.

(iv) Nitrates — oxidized organic matter.

* Nitrogen compounds are estimated by Colourometry

* Drinking water standards :-

Ammonia nitrogen < 0.15 mg/L

Organic nitrogen < 0.3 mg/L

Nitrites $\simeq$ nil.

Nitrates < 45 mg/L.

If nitrates > 45 mg/L, it leads to 'Blue Baby Disease' known scientifically as 'Methemoglobinoemea'. Haemoglobin in blood has more affinity towards 'nitrates' than oxygen. So nitrates in water are carried to different body parts instead of oxygen. When this happens, body turns blue for infants as a first symptom.

11. Iron & Manganese. (Fe < 0.3 mg/L ; Mn < 0.05 mg/L).

* Iron — reddish colour to water. } when present in high conc.
* Manganese — purple to brown colour }

* Estimated by 'Colorometry'

* Drinking water standards :

Iron < 0.3 mg/L

Manganese < 0.05 mg/L

12. Toxic Chemicals (Heavy Metals)

(i) Damage central nervous system.
(ii) Damage blood cells.
(iii) Damage blood vessels
(iv) cancerogenic (carcinogenic)

Toxic Chemical Substances	Drinking water Standards.
Lead	< 0.1 mg/L
Arsenic	<0.05 mg/L
Barium	< 1 mg/L
Boron	<0.01 mg/L
Cadmium	<0.01 mg/L
Chromium	<0.05 mg/L
Phenols	< 0.001 mg/L
Mercury	<0.001 mg/L.
Cyanide.	<0.05 mg/L

P-21
Q.22 $NaCl$ (mg/L) $= 2\times10^{-3}$ mol/L $*$ molecular wt.

$$= 2\times10^{-3}\,(23+35.5)\times1000 = 117 \text{ mg/L}$$

$NaCl$ in mg/L as $CaCO_3$ $= 117\times\dfrac{\text{Eq.wt of } CaCO_3}{\text{Eq.wt of } NaCl}$

$$= 117 * \frac{50}{\left(\frac{23+35.5}{1}\right)} = \underline{\underline{100 \text{ mg/L}}} \text{ as } CaCO_3$$

P-23
Q.40 $CaCl_2$ as mg/L of $CaCO_3$ $= 110\times\dfrac{50}{\left(\frac{40+71}{2}\right)} = \underline{\underline{100 \text{ mg/L}}}$ $\quad Ca + CO_3 \rightarrow$

Q.41. $A + B \longrightarrow C + D$

$$Ca + CO_3 \longrightarrow CaCO_3$$

Mol. wt. of Ca = 40

Mol. wt of CO_3 = 12 + 3×16 = 60

60 parts of CO_3 react with 40 part of Ca.

1 part $CO_3 \longrightarrow \frac{40}{60}$ part Ca.

90 g $CO_3 \longrightarrow \frac{40}{60} \times 90 = \underline{\underline{60 \text{ gm}}}$ Ca.

29th JULY, TUESDAY

Biological Water Quality. (Microbial Examination of Water)

(MPN ≤ 1 no./100 mL)

Testing Procedures:

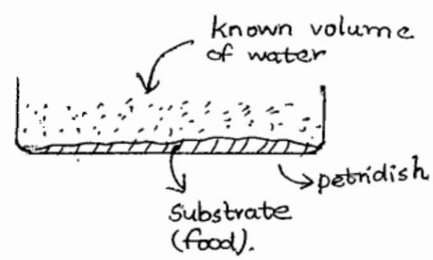
(i) Qualitative Tests → tests whether organisms are present or not.

(ii) Quantitative Tests → quantify the amount of organisms present.

(i) Qualitative Tests –

a) Plate Count Method.

Substrate is provided to trigger growth in petridish. Petridish is kept in incubator at 37°c to maintain warm conditions for growth. Min. time period of 24 hours is provided for growth.



b) Membrane filter Technique.

Filter papers which can trap even viruses is precoated with food. After passing known volume of water sample (sucked), the membranes (filter papers) are placed in incubator @ 37°c for a minimum duration of 24 hours. Presence

(ii) Quantitative Tests.

a) <u>E-coli Test</u> (Escheiricha coli) ← German Biologist

E-coli organism belongs to Coliform group of Bacteria. It is non pathogen. E-coli organism is present in intestines of all warm blooded animals including humans. They are responsible for converting food into energy and waste products. But E-coli organism is treated as indicator organism. Presence of E-coli indicates presence of pathogens.

E-coli test is conducted in 3 stages :

E-Coli test is also known as <u>Multiple Tube Fermentation Tes</u>

1. Presumptive Test.
2. Confirmed Test.
3. Completed Test

E-coli organisms ferment lactose and in doing so they release ga

Innoculate fermentation tubes with Lactose Broth as a culture medium and incubate tubes @ 37°c for 24 hours.

↓

If gas is formed
+ve TEST

↓

confirmed test

↓

Replace lactose broth with Brilliant green Lactose bile.

↓

Gas formed

If no gas is formed.
–VE TEST

↓

no organisms present in water.

E-coli test results are finally expressed interms of :

1. E-coli Index
2. MPN (Most Probable Number).

1. E-coli Index.

It's defined as the reciprocal of the smallest qty of sample that would give +ve results.

Eg:- ①

100 mL	10 mL	1 mL	0.1 mL	0.01 mL	0.001 ml
+	+	+	+	—	—

$$\text{E-coli Index} = \frac{1}{0.1} = 10 \text{ no.s}/100 \text{ mL}$$

②

100 mL	10 mL	1 mL	0.1 mL	0.01 mL	0.001 mL
+	+	+	—	—	—

$$\text{E-coli Index} = \frac{1}{1} = 1 \text{ no.}/100 \text{ mL}$$

2. MPN. - Most Probable Number.

Laws of Statistical Probability are applied for E-coli test results and results are expressed in terms of MPN. M.P.N represents the bacterial density which is most likely to be present. in the given water sample for the given test results.

MPN Tables

	10 — 1 — 0.1
5-5-5	25
5-5-4	24
⋮	⋮
3-2-1	10.

	+ve	-ve.
100 mL — 5 tubes	4	1
10 mL — 5 tubes	3	2
1 mL — 5 tubes	2	3
0.1 mL — 5 tubes	1	4
0.001 mL — 5 tubes	0	5

F-121

20. 1 — 0.1 — 0.01 (test dilution)

4 — 3 — 1.

10 — 1 — 0.1 (table dilution ∴ For test dilution,

P-23

Q.39

10	+ve 4
1	2
0.1	1
0.01	0

⇒ critical sample.

∴ 1 — 0.1 — 0.01 (test dilution.

For table dilution of 10 – 1 – 0.1

MPN = 7. (for 2–1–0 +ve).

∴ For test dilution,

$$MPN = 7 \times 10 = \underline{\underline{70}} \text{ no.}/100\text{mL}$$

* Drinking water standard wrt Microbial water quality:

E-coli Index = 0 $\left(\frac{1}{100} = 0.01\right)$

MPN = 1 no./100 mL

MPN ≯ 1 no./100 mL

6th Aug, WEDNESDAY

Water Borne Diseases:

Name of the disease.	Organism causing the disease	Category.
1. Cholera	Vibrio cholerae or Vibrio comma.	Bacteria.
2. Typhoid.	Salmonella typhi	Bacteria.
3. Paratyphoid.	Salmonella paratyphi	Bacteria.
4. Dysentry	Shigella dysenteria.	Bacteria.
5. Amebiasis (intestine)	Entamoeba & Hystolytica.	Protozoa.
6. Giadiasys (intestine)	Giardia Lamblia.	Protozoa.
7. Jaundice (liver)	Infectious Hepatitis	Virus
8. Polio.	Polio myelitis	Virus.

Entozal Diseases – diseases caused due to physical contact with wrong water.

Eg:- Yellow fever, Hook worm, Guniea. worm, tape worm infecti Hay fever etc.

People who work in sewage, paddy fields, drawing water from open wells are exposed to this disease.