

Module - 2Characteristics of Water5th Sem

The raw or treated waters can be checked and analysed by studying and testing their physical, chemical and microscopic / biological characteristics.

Physical Characteristic :-

- Physical analysis of water is carried out in order to determine the physical characteristics of water.
- This includes tests for determining
 - (i) Turbidity
 - (ii) Suspended solids
 - (iii) Colour
 - (iv) Taste or odour
 - (v) Temperature
 - (vi) Specific conductivity

(i) Turbidity :-

- Opqueness of water is called turbidity.
- It is the measure of extent to which light is either scattered or absorbed by suspended matter in water.
- It is also defined the resistance to passage of light through water by the particle.

Impact :-

- Disinfection of turbid water is difficult because suspended solids may partially shield the organism from disinfectants.
- In natural water bodies turbidity interferes with light penetration and hence with photosynthesis reaction.

Measurement :-

- Turbidity is measured by,
 - (i) Turbidity Rod
 - (ii) Jackson's turbidity meter
 - (iii) Baylis turbidity meter
 - (iv) Nephelometer

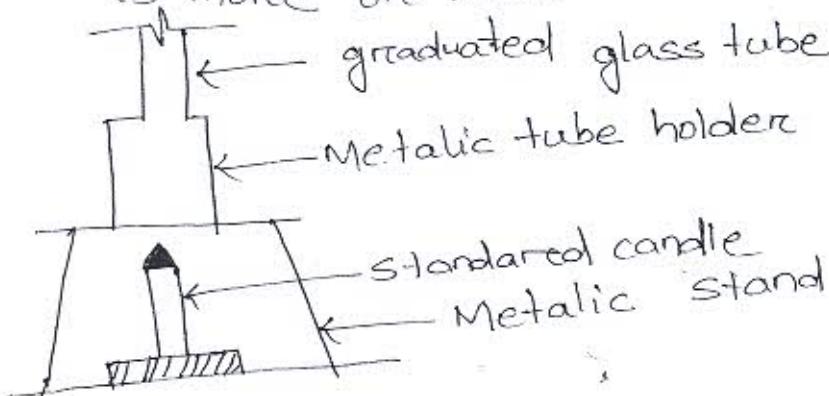
Turbidity Rod :-

It has platinum needle at the depth. The rod is inserted inside the turbid water and the depth at which platinum needle will become invisible gives turbidity in ppm (Parts per meter).

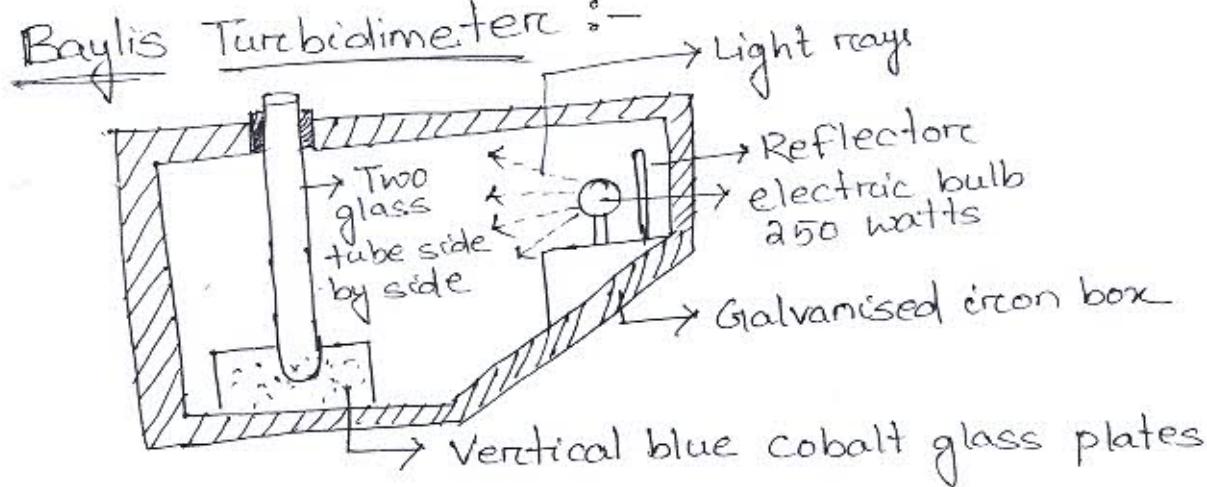
Jackson's Turbidimeter :-

It can be used to measure turbidities in the range between 25-1000 mg/l.

- With the glass tube is placed over a lighted candle the water sample is gradually added to the glass tube.
- The addition of water has stopped as soon as the image of candle flame is invisible.
- This height of water column thus determined the turbidity is more or less.



Baylis Turbidimeter :-



- Light is incident on the sample as well as standard pure water.
- Both tubes are compared by the colour of cobalt glass plates.

- In Baylis turbidimeter light intensity is measured in the direction of light.
 - Whereas in Nephelometer light intensity is measured in perpendicular direction of light.
Accept limit \approx 1 NTU Cause of rejection \Rightarrow 10 NTU
- i) Suspended Solids :-
- It is aesthetically displeasing and may contain disease causing organism.
 - These are measured by gravimetric technique, it means by weighing them.
 - Suspended solids are calculated by filtering the water sample.
 - Acceptable limit \Rightarrow 500 mg/l
Cause of rejection \Rightarrow 2000 mg/l

ii) Colour :-

Two types of colour are visible.

- (a) Apparent colour \Rightarrow due to suspended solids
- (b) True colour \Rightarrow due to dissolved solids

Impact \Rightarrow

Organic compound causing colour must exerted chlorine demand. Hence reduces the effectiveness of chlorine as a disinfectant.

\Rightarrow Some of the colour causing organism when mixed with chlorine, produces carcinogenic.

Tannic acid produces yellow colour

Iron oxide produces reddish colour

Manganese oxide produces brown/blackish colour.

Measurements :-

\Rightarrow Colour is measured by colour matching technique called tintometer.

- The result is expressed as 'TCU' (True color unit).
 - 1 TCU = Colour produced by 1mg/lit of platinum in the form of chloroplatinate ion.
- Acceptable limit \rightarrow 5 TCU
 Cause of rejection \rightarrow 25 TCU

(iv) Taste and odour :-

Taste and odour may be caused by the presence of dissolved gases such as H_2S , CH_4 , CO_2 , O_2 etc.

- For measurement of taste and odour chromatography is used. But this test is very costly, so, somoscope is used for the measurement.

The measurement is expressed as TON

- (Threshold odour Number)
 TON is generally represented by the dilution ratio.



A \Rightarrow Vol. of water sample

B \Rightarrow Vol. of distilled water

$$\text{Dilution ratio} = \frac{C}{A}$$

Acceptable limit \rightarrow 1 TON

Cause of rejection \rightarrow 3 TON

(v) Temperature :-

It affects chemical and biological reactions.

Allowable limit $\rightarrow 10 - 25^{\circ}C$

31st Aug

Chemical Characteristics

- ⇒ Chemical analysis of water is carried out in order to determine the chemical characteristics of water.
- ⇒ This involves tests for determining
 - (i) Dissolved solids
 - (ii) pH value
 - (iii) Chloride content
 - (iv) Nitrogen content
 - (v) Phosphorous content
 - (vi) Fluoride content
 - (vii) Other metals
 - (viii) Iron and manganese
 - (ix) Copper
 - (x) Dissolved gases
 - (xi) Hardness
 - (xii) Alkalinity

Total Dissolved Solids (TDS)

- ⇒ It is determined by electrical conductivity of water.
- ⇒ Electrical conductivity is measured by di-ionic water tester.
- ⇒ Limits $\Rightarrow 500 - 2000 \text{ mg/lit}$

pH
 pH value of water indicates the logarithm of reciprocal of hydrogen ion concentration present in water.

⇒ It is expressed as $\text{pH} = -\log_{10} [\text{H}^+]$

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

$$\boxed{\text{pH} + \text{pOH} = 14}$$

- ⇒ It is measured by potentiometer.
- Permissible value of pH in water is 7 - 8.5

Cause of rejection,

$$\text{pH} < 6.5 \text{ and } \text{pH} > 9.2$$

Impact :-

Acidic water causes corrosion of pipes. and alkaline water causes encrustation / scaling of pipes (ions/ compounds gradually deposits in the inner layers of pipes causing less discharge).

Measurement :-

It is measured by colour indicators which is compared with the standard colour of pH.

→ The indicators used are methyl orange and phenolphthalein.

\Downarrow
pH range 2.8-4.4

\Downarrow
pH range :- 8.6-10.3

Chloride Content :-

Presence of chloride in water in high concentration indicates pollution of water due to sewage or industrial sewage.

Measurement :-

Chlorides are estimated by titrating the water sample with AgNO_3 solution using K_2CrO_4 (Potassium chromate)

Limits :-

Acceptable $\Rightarrow 200 \text{ mg/lit}$

Cause of rejection $\Rightarrow 1000 \text{ mg/lit}$

1st Sept

Nitrogen ~~Meas~~ Content :-

The presence of nitrogen in water is an indication of the presence of the organic matter.

→ It occurs in form of

- (i) free ammonia } combinedly known as Kjedahl nitrogen
- (ii) Organic ammonia
- (iii) Nitrite (NO_2^-)
- (iv) Nitrate (NO_3^-)

→ Free ammonia indicates very recent pollution.

→ Organic ammonia represents quantity of nitrogen present in water in the form of undecomposed organic matter.

→ Nitrates indicates the presence of partly decomposed (not fully oxidised) organic matter.

→ Nitrites indicates the presence of fully oxidised organic matter in water (thus representing the old pollution).

Limits :-

→ Free ammonia should not be more than 0.15 mg/l and it can be measured by simple boiling of water and measuring the liberated ammonia by distillation process.

→ Organic ammonia should not be more than 0.3 mg/lit.

It can be measured by boiling the already boiled water by adding KMnO_4 (Potassium Permanganate)

→ Nitrite is highly dangerous. Its permissible limit should be zero. It is measured by colour matching technique, whereas colour is developed by Sulphonic + Neptumine acid.

→ Nitrate is not harmful because it is fully oxidised but large quantity of nitrates affect infants because it causes blue baby disease (Mathemoglobinemia)

⇒ Nitrate concentration should not be more than 4mg/lit and it is measured by colour matching technique whence colour is produced by phenol-di-sulphonic acid.

Phosphorous Content :-

- ⇒ Phosphorous itself is not toxic but its presence indicate the pollution of water.
- ⇒ It facilitate the growth of aquatic plants and interferes in the water treatment process of coagulation.
- ⇒ Even in low concentration of 0.2 mg/lit it interfere with the process.

Fluoride Content :-

- ⇒ Fluoride upto 1mg/lit helps to prevent dental cavities and also helps in the formation of permanent teeth.
- ⇒ fluoride value greater than 1.5 - 2 mg/lit results in decolorisation of teeth called mottling of teeth.
- ⇒ If its value is greater than 5 mg/lit it causes bone fluorosis.

Limits :-

Acceptable - 1 mg/l
cause of rejection - 1 mg/l.

Other Metals :-

Toxic :- Hg, Arsenic, Cadmium, chromicium, cyanide
↓
mercury

Non toxic :- Calcium, potassium, Manganese, Iron, Zinc, Magnesium.

In a water treatment plant, the pH values of incoming and outgoing waters are 7.2 and 8.4 respectively. Assuming a linear variation of pH with time, determine the average pH value of water.

Given, $\text{pH}_1 = 7.2$

$$\text{pH}_2 = 8.4$$

$$-\log_{10} H_1^+ = 7.2$$

$$\Rightarrow H_1^+ = 10^{-7.2}$$

$$-\log_{10} H_2^+ = 8.4$$

$$\Rightarrow H_2^+ = 10^{-8.4}$$

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

$$= \frac{10^{-7.2} + 10^{-8.4}}{2}$$

$$= 8.42 \times 10^{-8.4}$$

$$\text{pH} = -\log_{10} (8.42 \times 10^{-8.4})$$

$$= 7.474$$

Total alkalinity is equal to 200 mg/lit expressed as CaCO_3 .

$$\text{Ca}^{2+} = 60 \quad \text{Mg}^{2+} = 30$$

Find total hardness, carbonate and non carbonate hardness.

$$\text{Total hardness} = \frac{\text{Ca}^{2+} \times 50 + \text{Mg}^{2+}}{12} \times 50 = \frac{60}{20} \times 50 + \frac{30}{12} \times 50$$

$$= 275 \text{ mg/lit}$$

$$\text{TH} > \text{total alkalinity} = 200$$

$$\text{so } \text{CH} = \text{TA} = 200 \text{ mg/lit}$$

$$\text{NCH} = 275 - 200 \text{ mg/lit}$$

$$= 75 \text{ mg/lit}$$

Sodium :-

- Sodium in excess concentration is harmful for kidney and heart patient.
- It is corrosive for metal surface and imparts bad taste.

Iron and Manganese

- It causes colour problem, if concentration is greater than 0.3 mg/lit and less than 0.05 mg/lit.
- Surface water does not contain iron and manganese whereas as ground and under ground water contains iron and manganese.
- Acceptable limit →
 - for Fe, 0.1 to 1 mg/lit
 - for Mg, 0.05 to 0.5 mg/lit

Copper :-

- It causes lungs and respiratory problem.
- It causes lungs and respiratory problem.
limit :- 0.05 to 1.5 mg/lit.

Dissolved Gases

- H_2S imparts taste and odour.
- CO_2 indicates biological activity also results in corrosiveness.
- CH_4 is toxic.
- If O_2 is less than the saturated level indicates oxygen deficiency.
- Maximum dissolved oxygen should be 0.2 mg/lit at $20^\circ C$.
- Oxygen level less than 4 mg/l is harmful for aquatic elements.

3rd sept :-

Hardness :- Hardness in water is that characteristic which prevents the formation of sufficient foam, when such hard hard water mixed with soap.

→ Hardness is of two types,

- (i) Carbonate
- (ii) Non-carbonate

Carbonate Hardness :-

If carbonate and bicarbonates of calcium and magnesium are present in water, the water have hard temporary, as this hardness can be removed to some extent by simple boiling. Such a hardness is known as temporary hardness or carbonate hardness.

Non-carbonate hardness :-

If sulphides, chlorides and nitrates of calcium or magnesium are present in water, they cannot be removed at all by simple boiling, therefore such hardness is known as permanent hardness or non-carbonate hardness.

Measurement :-

After determining the amount of calcium and magnesium present in the water by titration with Versenate solution (EDTA method), the hardness is measured in mg/l.

$$\text{Total hardness} = \left(\frac{\text{Ca}^{2+}}{20} \times 50 + \frac{\text{Mg}^{2+}}{12} \times 50 \right) \text{ mg/lit of } \text{CaCO}_3$$

Acceptable limit \rightarrow 200 mg/lit

Cause of rejection \rightarrow 600 mg/lit

Hardness

0 - 55

55 - 100

100 - 200

200 - 500

Degree

Soft

Slightly hard

Moderately hard

Very hard

Alkalinity

Alkalinity is defined as quantity of ions in water that will react to neutralise hydrogen ions.
 ⇒ It is the ability to neutralise acid.

⇒ Major constituents of alkalinity are,

- (i) Carbonate alkalinity (CO_3^{2-})
- (ii) Bicarbonate alkalinity (HCO_3^-)
- (iii) Hydroxide alkalinity (OH^-)

Impact :-

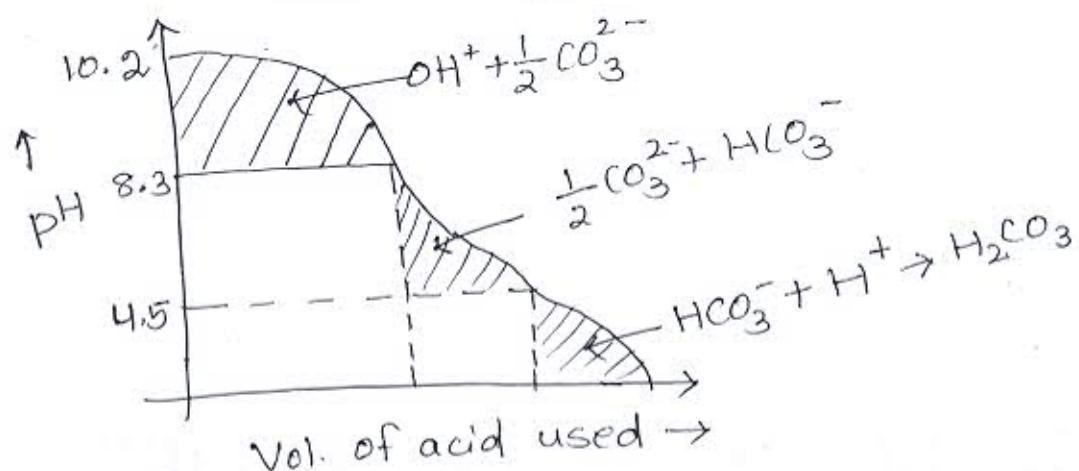
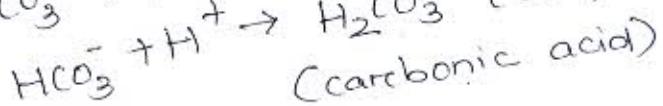
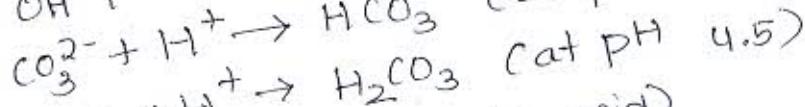
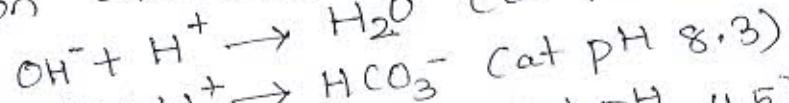
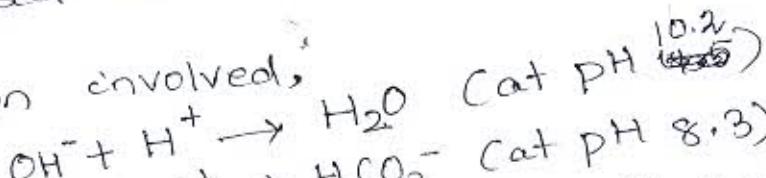
Alkalinity imparts bitter taste to water and excess alkalinity is harmful for irrigation.
 Alkalinity leads to encrustation of pipe.

Measurement :-

It is measured by titrating the water with an acid and determining the hydrogen equivalent of alkalinity.
 If 0.02(N) Normality of H_2SO_4 is used as titrate 1ml of acid used correspondance to 1 mg alkalinity expressed as CaCO_3 .

4th Sept

Reaction involved:



For pH > 8.3, add phenolphthalein indicator, colour of titrate becomes pink, pink colour is due to hydroxyl ion.

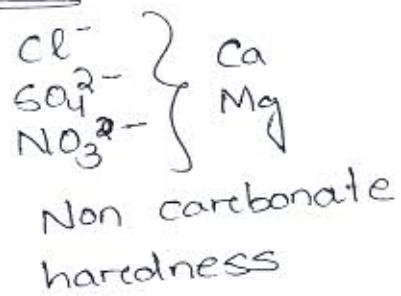
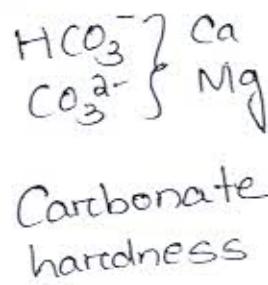
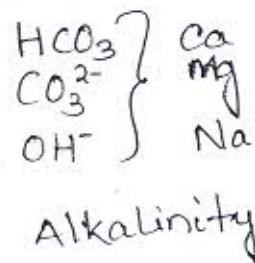
If H₂SO₄ added, pink - colourless
OH⁻ ions are neutralised

→ Then add methyl orange, the presence of CO₃²⁻ HCO₃⁻ changes the colour to yellow.

→ While adding sulphonic acid, the colour changes to red (end point).

→ Colour change indicates the complete neutralisation of CO₃²⁻, HCO₃⁻.

Relation between alkalinity and hardness



→ When total hardness (CH + NCH) is greater than total alkalinity, then carbonate hardness (CH) will be equal to total alkalinity, and non-carbonate hardness (NCH) will be zero. Total hardness minus carbonate hardness

$$TH > TA$$

$$CH = TA$$

$$NCH = TH - CH$$

→ When total hardness is less than total alkalinity, then carbonate hardness is equal to total hardness and non carbonate hardness is zero.

$$TH < TA$$

$$CH = TH$$

$$NCH = 0$$

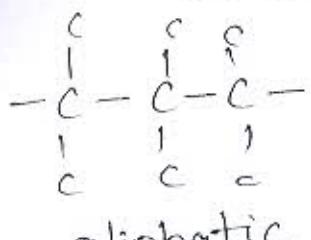
7th Sept

Biological Characteristic :-

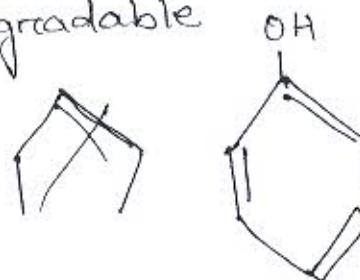
Organic compound are of two types.

(i) Bio degradable

(ii) Non - bio degradable



(Bio degradable)
compound



(Non-biodegradable)

→ Microbial decomposition occurs in two method.

(i) Oxidation reaction

(ii) Reduction reaction

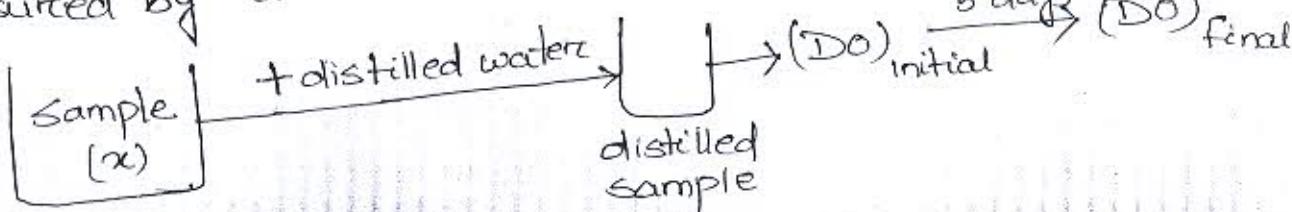
→ Oxidation Reaction :- In presence of oxygen decomposition by aerobic bacteria.

→ Reduction Reaction :- In absence of oxygen by anaerobic bacteria, the decomposition is named as reduction reaction.

BOD (biochemical oxygen demand)

The extent of organic matter present in water sample can also be easily estimated by supplying oxygen to this sample and finding the oxygen consumed by the organic matter present in water. This oxygen demand is known as biochemical oxygen demand (BOD).

→ Measured by dilution method.



$$BOD = [(DO)_I - (DO)_F] \times \text{dilution factor}$$

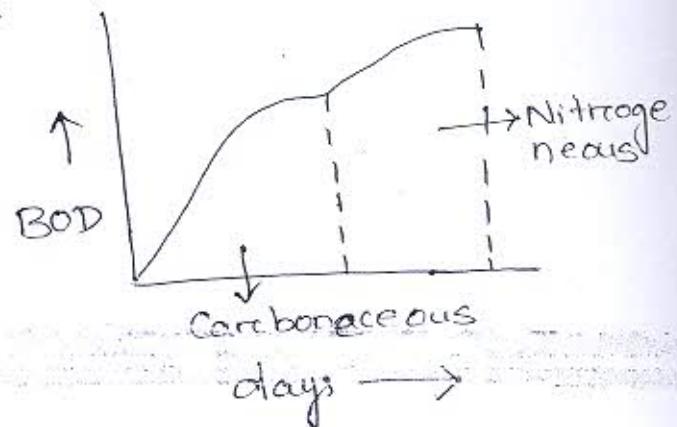
~~DO~~ → dissolved oxygen

DO = Dissolved oxygen

dilution factor = $\frac{\text{Volume of diluted sample}}{\text{Vol. of original sample}}$

→ BOD consists of two stages

- (i) Carboaceous
- (ii) Nitrogenous



Biological Water Quality Test :-

Testing procedure are of two type.

(i) Qualitative tests :- Test whether organisms are present or not.

(ii) Quantitative tests :- Quantify the amount of organic

Qualitative Test :-

(i) Plate count Method :-

Substrate is provided to trigger the growth of micro organism, incubated at 37°C to maintain warm condition. By which the colony becomes visible to naked eye and the no of colonies on a plate can be counted.



↓
substrate food

(ii) Membrane filters technique :-

- Filter paper which can trap even viruses are percolated with food.
- After passing a known vol of water membrane is kept in incubator at 37°C for 24 hrs.
- Presence of purple / black dots show the presence of micro organism.

Quantitative Test :-

(i) E- coli test :-

Escherichia coli

- Escherichia coli form a group of bacteria, non-pathogens are present in warm blooded animals, humans.
- These are responsible for converting food into energy and waste product.
- It is treated as the indicator of organism. It is not harmful but presence of E-coli indicates the presence of pathogen.
- E-coli test is also known as multiple tube fermentation test.

Procedure :-

- Take a water sample with lactose. After fermentation,
if hydrogen sulphide gas is produced then
E-coli is present otherwise not.
- E-coli test results is quantify by two methods
 - (i) E-coli index
 - (ii) Most probable no.

8th Sept

(i) E-coli index :-

Defined as the reciprocal of the smallest quantity of sample that would give +ve results.

Ex:- 100ml 10ml 1ml 0.1ml 0.01ml 0.001ml
+ + + + - -

$$E\text{-coli index} = \frac{1}{0.1} = 10 \text{ nos}/100\text{ml}$$

(ii) MPN :-

→ Represents the bacterial density which is most likely to be present in the given water sample for the given test results.

Experiments :-

→ Mix different dilution of sample of water with lactose broth, incubate at 37°C, 24 hrs.

Lactose + Coliform → Acid + Gas
(Indicate presence of +ve -ve coliform)

100ml	{ 5 tubes }	4	1
10 ml		3	2
1 ml		2	3
0.1 ml		1	4
0.01 ml		0	5

MPN for 100ml is obtained corresponding to 3-2-1 from standard table.

(Q) 5ml of sample is taken, whence BOD is to be tested and it is made to 300ml sample, by adding distilled water. $(D_O)_1 = 7.8 \text{ mg/lit}$

$$(D_O)_f = 3.4 \text{ mg/lit}$$

After 5 days find BOD.

$$\Rightarrow (BOD)_5 = [(D_O)_1 - (D_O)_f] \times \text{dilution ratio}$$
$$= (7.8 - 3.4) \times \frac{300}{5}$$
$$= 264 \text{ mg/lit}$$

10th Sept

Ultimate BOD:-

The total amount of oxygen consumed when the biochemical reaction is allowed to proceed to complete is called ultimate BOD.

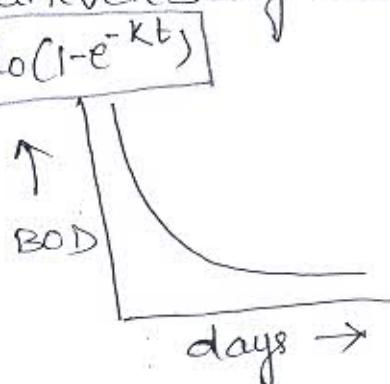
→ 5-day BOD has been almost universally adopted

$$(BOD)_5 = (BOD)_U (1 - e^{-Kt}) \Rightarrow lt = \ln(1 - e^{-Kt})$$

Where, $(BOD)_U$ = Ultimate BOD

K = reaction const

t = days



$$K_{DT} = K_{20} (1.047)^{T-20}$$

Q) For a waste water the $(BOD)_5$ at $20^\circ C$ is 200 mg/lit. for same water find $(BOD)_5$ at $30^\circ C$

Where $K = 0.2 \text{ / day}$.

$$\rightarrow (BOD)_5 = (BOD)_U (1 - e^{-Kt})$$

$$\rightarrow 200 = (BOD)_U (1 - e^{-0.2 \times 5})$$

$$\rightarrow (BOD)_U = 316.39 \text{ mg/lit}$$

$$K_{DT} = 0.2 (1.047)^{30-20}$$

$$= 0.2 (1.047)$$

$$= 0.3165$$

$$(BOD)_5 \text{ at } 30^\circ C = 316.39 (1 - e^{-0.3165 \times 5})$$

$$= 251.384 \text{ mg/lit}$$

Water borne Diseases :-

- Water borne diseases which spread primarily through contaminated water.
- The important of these water borne diseases are
 - 1) Caused by bacterial functions :
 - (i) Typhoid and para typhoid fever
(caused by salmonella typhi)
 - (ii) Cholera
(caused by vibrio-cholera bacteria)
 - (iii) Bacillary dysentery
(caused by shiga bacillus)
 - 2) Disease caused by viral infections :
 - (i) Infectious hepatitis or jaundice
(caused by hepatitis virus)
 - (ii) Poliomyelitis
(caused by polio virus)
 - 3) Caused by protozoal infections :
 - (i) Amoebic dysentery (caused by entamoeba histolytic germs)

Natural Purification

Natural purification of water is done by various method such as ,

- (i) Aeration
- (ii) Oxidation
- (iii) filtration through layers of soil
- (iv) Aquatic animals.
- (v) Evaporation