ATME College of Engineering

13th KM Stone, Mysore - Bannur Road , Mysore – 570 028

DEPARTMENT OF CIVIL ENGINEERING

(ACADEMIC YEAR 2025 - 2026)

LABORATORY MANUAL

SUBJECT: Environmental Engineering Laboratory

SUBJECT CODE: BCV504

SEMESTER: V

Vision of the Institute :

Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

Mission of the Institute :

To keep pace with advancements in knowledge and make the students competitive and capable at the global level.

To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations and shine as torchbearers of tomorrow's society.

To strive to attain ever-higher benchmarks of educational excellence.

Vision of the Department :

To develop globally competent Civil Engineer who excel in academics research and are ethically responsible for the development of the society.

Mission of the Department :

To provide quality education through faculty and state of the art infrastructure To identify current problems in the society pertaining to Civil Engineering disciplines and to address them effectively and efficiently

To inculcate the habit of research and entrepreneurship in our graduates to address current infrastructure needs of society

PEO’s :

Graduates who complete their UG course through our institution will be,

PEO l- Engaged in professional practices, such as construction, environmental, geotechnical, structural, transportation, or water resources engineering by using technical, communication and management skills.

PEO 2- Engaged in higher studies and research activities in various Civil Engineering fields and a life time commitment to learn ever changing technologies to satisfy increasing demand of sustainable infrastructural facilities

PEO 3- Serve in a leadership position in any professional or community organization, or local/state engineering board

PEO 4- Registered as a professional engineer or developed a strong ability leading to professional licensure being an entrepreneur.

PROGRAM OUTCOMES :

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. 44

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and

write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO's :

PSO1: Provide the necessary infrastructure for all situations through competitive plans, maps and designs with the aid of a thorough Engineering Survey and Quantity Estimation.

PSO 2: Assess the impact of anthropogenic activities leading to environmental imbalance on land, in water & in air and provide necessary viable solutions revamping water resources and transportation for a sustainable development.

Environmental Engineering Laboratory

Subject Code	:	**BCV504**	**CIE Marks**	:	**50**
Hours/Week	:	**2P**	**Exam Hours**	:	**02**
Total Hours	:	**20**	**Exam Marks**	:	**50**
Credits - 01			**Total Marks**	:	**100**

COURSE SYLLABUS:

1. Preparation chemical solutions required for analysis and sampling methodologies

2. Determination of pH, Conductivity, TDS and Turbidity.

3. Determination of Acidity and Alkalinity

4. Determination of Calcium, Magnesium and Total Hardness.

5. Determination of Dissolved Oxygen

6. Determination of BOD.

7 Determination of Chlorides

8 Determination of percentage of % of available chlorine in bleaching powder sample, Determination of Residual Chlorine and chlorine demand.

9 Determination of Solids in Sewage: i) Total Solids, ii) Suspended Solids, iii) Dissolved Solids,

iv) Volatile Solids, Fixed Solids v) Settleable Solids.

10. Determination of optimum coagulant dosage using Jar test apparatus.

11. Determination Nitrates and Iron by spectrophotometer

Demonstration Experiments (For CIE)

12 Determination of COD (Demonstration)

13 Air Quality Monitoring (Demonstration)

14 Determination of Sound-by-Sound level meter at different locations (Demonstration)

REFERENCE BOOKS:

1. Lab Manual, ISO 14001 Environmental Management, Regulatory Standards for Drinking Water and Sewage disposal

2. Clair Sawyer and Perry McCarty and Gene Parkin, “Chemistry for Environmental Engineering and Science” , McGraw-Hill Series in Civil and Environmental Engineering

Scheme of Examination:

Question paper pattern:

1. Two experiments shall be asked from the above set
2. One experiment to be conducted and for the other student should write detailed procedure.

CONTENT LIST

Environemental Engineering Laboratory Manual

DETERMINATION OF HARDNESS

AIM

To determine the total hardness of the given sample

APPARATUS REQUIRED

Burette, Pipette, Conical flask

PRE-REQUISITE QUESTIONS

What is hardness? List the types of hardness.

Differentiate between temporary and permanent hardness.

PRINCIPLE

In alkaline condition, EDTA reacts with Ca and Mg to form a soluble chelated complex, Ca and Mg ions develop wine-red color with Eriochrome black T. When EDTA is added as a titrant, Ca and Mg divalent ions get complexed resulting in sharp color change from wine-red to blue, which indicates end point of the reaction.

Ca^{2+} Ca
} + Eriochrome black ------------> } Eriochrome black T complex Mg (wine
T Mg^{2+} red color)

Ca Ca
} Eriochrome black T complex + -----------> } EDTA + Eriochrome black T
EDTA Mg Mg (to blue color)

REAGENT PREPARATION

a. Buffer Solution:
Dissolve 6.75 gm of Ammonium Chloride in 75ml of liquid Ammonia and dilute to 100ml with distilled water.

b. Eriochrome Black T:
Dissolve 0.2 gm of pure solid of EBT in 15ml of distilled water (or) 0.1gm of EBT in 20ml of ethyl alcohol.

c. Standard EDTA Solution (0.01N):
Dissolve 3.723 gm of EDTA Sodium salt in distilled water to make up to one litre and standardize against standard Calcium solution such that 1ml of EDTA is titrated is equal to 1gm of $CaCO_3$ is obtained.

PROCEDURE

- **TOTAL HARDNESS**
  a. Take 25ml of sample in a conical flask.
  b. Add 2ml of Ammonia buffer solution
  c. Add 2 drops of Eriochrome Black T indicator when the solution becomes wine red in color.
  d. Titrate the above solution against EDTA solution taken in the burette. The end point is the appearance of blue color.
- **PERMANENT HARDNESS**
  a. Take 25 ml of sample and boil it for a few minutes to remove Carbonates and Bicarbonates.
  b. Repeat the above procedure to get concordant values and calculate Permanent Hardness.

TABULATION

- **TOTAL HARDNESS**

Burette : EDTA solution

Conical Flask : given water sample

Indicator : Eriochrome Black T

End point : Wine red to steel blue

Sl. No.	**Volume of sample (ml)**	**Burette reading (ml)**		**Volume of EDTA(ml)**
		Initial	Final	

FORMULA

- **TOTAL HARDNESS**

$$\text{Total Hardness as } CaCO_3 \text{ in mg/L} = \frac{\text{Volume of EDTA in ml} \times \underset{(0.02)}{N} \times \underset{(50)}{\text{Eq. Wt. of } CaCO_3} \times 1000}{\text{Volume of sample in ml}}$$

- **PERMANENT HARDNESS**

Burette : EDTA

Conical Flask : given water sample

Indicator : Eriochrome Black T

End point : Wine red to steel blue

Sl. No.	**Volume of sample (ml)**	**Burette reading (ml)**		**Volume of EDTA (ml)**
		Initial	Final	

FORMULA

- **PERMANENT HARDNESS**

$$\text{Permanent Hardness as } CaCO_3 \text{ in mg/L} = \frac{\text{Volume of EDTA in ml} \times \underset{(0.02)}{N} \text{ x } \underset{(50)}{\text{Eq. Wt. of } CaCO_3} \text{ x } 1000}{\text{Volume of sample in ml}}$$

CALCULATIONS

Amount of Total hardness present in the sample =

Amount of Permanent hardness present in the sample =

Temporary hardness = Total hardness - Permanent hardness =

RESULT

The amount of Total Hardness present in the given sample =--------mg/L

VIVA VOCE QUESTIONS

1) What is the expansion of EDTA?

A: Ethylene di-amine tetra acetic acid

2) What is hardness of water?

A: The property of water which restricts or checks the lather formation with soap

3) What is temporary or carbonate hardness?

A: It is caused by the presence of carbonates and bicarbonates of calcium and magnesium.

4) What is permanent or non-carbonate hardness?

A: It is the amount of hardness in excess of alkalinity expressed as $CaCO_3$.

5) Which indicator is employed in EDTA titration?

A: Eriochrome black T

6) What is complexometric titration?

A: Titration depending upon the combination of ions other than H^+ or OH^- ions to form soluble slightly dissociated ions or compounds is called complexomteric titration.

7) Name the complexing agent used in this complexometric titration.

A: Ethylene dyamine tetra acetic acid (EDTA)

8) How the equivalent point is detected in complexometric titration?

A: The equivalent point is indicated by the use of metal ion indicator such as Eriochrome black T.

9) Which type of ligand is EDTA?

A: It serves as a hexadentate ligand and acts as a chelating agent.

10) What is buffer solution?

A: A buffer solution is defined as solution which resists in its pH value even when small amount of the acid or base are added to it.

STIMULATING QUESTIONS

1) What consequences will the public face if hard water is consumed by them regularly?
2) Is hard water really a health problem?
3) Is water softener a best solution?

APPLICATION OF HARDNESS DATA

Hardness of water is an important consideration in determining the suitability of water for domestic and industrial uses. The environmental engineer uses it as a basis for recommending the need for softening processes. The relative amounts of calcium and magnesium hardness and of carbonate and non carbonate hardness present in water are factors in determining the most economical type of softening process to use, and become important considerations in design. Determinations of hardness serve as a basis for routine control of softening processes.

DETERMINATION OF pH

AIM

To determine the pH value of a given sample using pH meter

APPARATUS REQUIRED

pH meter- pen type

PRE-REQUISITE QUESTIONS

How are hydrogen and hydroxyl ions related to each other?

What do you mean by conductivity of water?

PRINCIPLE

A pH meter is an electronic device used for measuring the pH (acidity or alkalinity) of a liquid (though special probes are sometimes used to measure the pH of semi-solid substances). A typical pH meter consists of a special measuring probe (a glass electrode which generates a potential varying linearly with the pH of the solution in which it is immersed.) connected to an electronic meter that measures and displays the pH reading.

REAGENT PREPARATION

Standard buffer solution of pH 4, pH 7 and pH 10

PROCEDURE

a. The protective cover of the pH meter is removed and pH meter is turned on by the switch

b. Calibrate the pH meter with at least two standard buffer solutions among of pH 7, 4 & 9.

c. Rinse the pH meter thoroughly with de-ionized water and carefully wipe with a tissue paper.

d. Dip the pH meter in the sample solution, and swirl the solution and wait up to one minute for steady reading.

e. The reading is taken after the indicated value remains constant for about a minute

RESULT

The pH value of given sample is...........................

VIVA VOCE QUESTIONS

1) What is pH?

A: The pH of a solution is the potentiality of hydrogen ions in a solution in mol / litre expressed as the negative logarithm of the hydrogen ion concentration.

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

2) What is the effect of temperature on pH?

A: The pH of the solution is increasing with temperature.

3) What is the pH of pure water at 25^0C?

A: 7.0

4) What is the effect of dilution on pH of an acidic solution?

A: pH increases towards 7.0

5) What does pH of a solution signify?

A: It signifies the $[H^+]$ ion concentration in moles per litre.

6) What is the range of a solution if it is highly acidic?

A: Nearly 2-3

7) What is the acid-base indicator?

A: An acid-base indicator is an organic compound which changes its color within certain pH range.

8) What is the ionic product of water?

A: $Kw = [H^+][OH^-]$

9) What is the range of pH for sewage?

A: 5.5-9.0

10) What is the pH of rain water?

A: 5.6

STIMULATING QUESTIONS

1) Why do we test pH of soil and water?
2) Why it is not advised to drink milk immediately after taking meals with curd?
3) Alcohol sconsumption is strictly prohibited for people having acidity problem. Why?

DETERMINATION OF ACIDITY

AIM

To determine the acidity of a given sample

APPARATUS REQUIRED

Burette, Pipette, Conical flask

PRE-REQUISITE QUESTIONS

What does pH indicate?

How is it related with acidity?

PRINCIPLE

The mineral acids present in the sample which are contributing to mineral acidity can be calculated by titrating or neutralizing samples with strong base NaOH to pH 4.3.The CO_2 and bi-Carbonate that are present and contribute to CO_2 acidity in the sample can be neutralized completely, by continuing the titration to pH 8.2.

REAGENT PREPARATION

a. NaOH Solution (0.02 N):

Dissolve 8 g of NaOH in distilled water and dilute to 1000 ml.

b. Methyl Orange Indicator:

Dissolve 50 mg of Methyl Orange powder in distilled water and dilute to 100 ml.

c. Phenolphthalein Indicator:

Dissolve 1 g of Phenolphthalein in 100 ml of 95% ethyl alcohol or isopropyl alcohol, and add 100 ml of distilled water to it and add 0.02 N NaOH solution drop wise until faint pink color appears.

PROCEDURE

a. Take 20 ml of sample in a conical flask

b. Add 2 drops of methyl orange and the sample turns to brick red color.

c. Titrate the sample until the color changes to yellow indicating pH 3.7.

d. Note down the volume of NaOH added (V_1).

e. Add 2-3 drops of Phenolphthalein indicator to it and continue the titration with NaOH until pink color appears indicating pH 8.3.

f. Note down the volume of NaOH added (V_2) from V_1.

OBSERVATION

Burette : 0.02N NaOH solution

Conical Flask : Given Water Sample

Indicator for Mineral Acidity : Methyl Orange

End point : Brick Red to Orange Yellow

Indicator for CO2 alkalinity : Phenolphthalein

End point : Colourless to pink

TABULATION

Sl No	Volume of sample (ml)	Methyl orange indicator			Phenolphthalein indicator		
		Burette reading (ml)			Burette reading (ml)		
		Initial	Final	NaOH V_1(ml)	Initial	Final	NaOH V_2 (ml)

CALCULATIONS

Mineral acidity due to mineral acids as $CaCO_3$, in mg/L =

$$\frac{V_1 \times \underset{(0.02)}{N} \times \underset{(50)}{\text{Eq.wt. of } CaCO_3} \times 1000}{\text{Volume of sample taken}}$$

CO_2 Acidity due to CO_2 and HCO_3 as $CaCO_3$, in mg/L =

$$\frac{V_2 \times \underset{(0.02)}{N} \times \underset{(50)}{\text{Eq.wt. of } CaCO_3} \times 1000}{\text{Volume of sample taken}}$$

Total acidity due CO_2, HCO_3 and mineral acids as $CaCO_3$ in mg/L $CaCO_3$ = Mineral acidity + CO_2 acidity

RESULT

Methyl Orange Acidity = ----------- mg/L

Phenolphthalein Acidity = ----------- mg/L

Total Acidity = ----------- mg/L

VIVA VOCE QUESTIONS

1) Crystalline NaF is added to a dilute solution of hydrofluoric acid. What happens to the

hydrogen ion concentration as a result of this addition?

A: Decreases

2) In general, for a diprotic acid, $Ka_1 >> Ka_2$. Why?

A: It is more difficult to remove a proton from the -1 ion that it is from the neutral acid.

3) What is the pH of a 1.25×10^{-3} M NaOH solution?

A: 11.10

4) According to Bronsted-Lowry, what is a base?

A: Proton acceptor

5) What are the two products when an acid and base react together?

A: Salt and water

6) What gas is produced when hydrochloric acid reacts with calcium carbonate?

A: CO_2

7) A soil sample is found to have a pH value of 5.5. What step would you suggest to neutralize the soil?

A: Adding lime

8) What is the pH of a 0.00001 molar HCl solution?

A: 5

9) Given the equation: $[H^+] + [OH^-] <-> [H_2O]$. Which type of reaction does the equation represent?

A: Neutralization

10) What is an Arrhenius acid?

A: By definition an Arrhenius acid yields hydrogen ions as the only positive ions in aqueous solution.

STIMULATING QUESTIONS

1) Can you suggest a method to test the strength of the acid in a car battery?
2) Acid waste from a factory is found to be killing fish in a nearby river. Can you name a chemical if added to the water which would help prevent the fish kill?
3) Why would universal indicator be a better choice of acid-base indicator than litmus?

APPLICATION OF ACIDITY DATA

Carbon dioxide determinations are particularly important in the field of public water supplies. In the development of new supplies, it is an important factor that must be considered in the treatment method and the facilities needed. Many underground supplies require treatment to overcome corrosive characteristics resulting from carbon dioxide. The amount present is an important factor in determining whether removal by aeration or simple neutralization with lime or sodium hydroxide will be chosen as the treatment method. The size of equipment, chemical requirements, storage space, and cost of treatment all depend upon the amounts of carbon dioxide present. Carbon dioxide is an important consideration in estimating the chemical requirements for lime or lime-soda ash softening.

Most industrial wastes containing mineral acidity must be neutralized before they may he discharged to rivers or sewers or subjected to treatment of any kind. Quantities of chemicals, size of chemical feeders, storage space, and costs are determined from laboratory data on acidity.

DETERMINATION OF ALKALINITY

AIM

To determine the alkalinity of a given sample

APPARATUS REQUIRED

Burette, Pipette, Conical flask

PRE-REQUISITE QUESTIONS

How pH is related with alkalinity?

Why titration is preferred over litmus test?

PRINCIPLE

Alkalinity can be obtained by neutralizing OH^-, CO_3^{2-}, and HCO_3^- with standard H_2SO_4. Titration to pH 8.3 or decolourization of phenolphthalein indicator will show complete neutralization of OH^- and of CO $^{2-}$ w3hile to pH 4.4 or sharp change from yellow to pink of methyl orange indicator will indicate total alkalinity i.e. OH^- , CO_3^{2-} , and HCO_3^-.

REAGENT PREPARATION

a. Standard Sulfuric Acid (0.02 N):

   Dilute 2.8 ml of Con. H_2SO_4 to one litre (0.1 N) . From that, take 200ml of 0.1N H_2SO_4 and dilute to one litre (0.02 N)

b. Phenolphthalein Indicator:

   Add 1 gram of phenolphthalein in 200 ml of distilled water or ethyl alcohol. Then add 0.02 N NaOH in drop wise till faint pink colour disappears.

c. Methyl orange Indicator:

   Dissolve 0.1gram of methyl orange in 200 ml of distilled water.

PROCEDURE

Phenolphthalein or Partial Alkalinity:

a. Take 20 ml of sample in a clean conical flask.
b. Add one drop of phenolphthalein indicator and the sample turns pink in colour.
c. Titrate the sample with standard H_2SO_4 (0.02 N) taken in a burette and note the volume V_1.
d. The end point is the disappearance of pink color.

Total Alkalinity:

a. Add one drop of methyl orange indicator to the solution in which phenolphthalein alkalinity has been determined.
b. Continue the titration for same above sample against standard H_2SO_4 (0.02 N) and note the total volume consumed from zero, V_2.
c. The end point is the change from orange to brick red colour.
d. Repeat the titration to get concordant values.

OBSERVATION

Titration : Standard H_2SO_4 (0.02 N) Vs Water Sample

Burette : H_2SO_4 solution

Pipette : Given Water Sample

Indicator for phenolphalein alkalinity : Phenolphthalein

End point : Disappearance of pink colour

Indicator for total alkalinity : Methyl orange

End point : Change from orange to brick red colour.

TABULATION

Sl. No.	**Volume of sample (ml)**	**Phenolphthalein indicator**			**Methyl orange indicator**		
		Burette reading V_1 (ml)			**Burette reading V_2 (ml)**		
		Initial	Final	H_2SO_4 (ml)	Initial	Final	H_2SO_4 (ml)

CALCULATIONS

$$\text{Phenolphthalein or Partial alkalinity as } CaCO_3, \text{ in mg/L} = \frac{V_1 \text{ of } H_2SO_4 \times \underset{(0.02)}{N} \times \underset{(50)}{\text{Eq.wt. of } CaCO_3} \times 1000}{\text{Volume of sample taken}}$$

$$\text{Total alkalinity as } CaCO_3, \text{ in mg/L} = \frac{V_2 \text{ of } H_2SO_4 \times \underset{(0.02)}{N} \times \underset{(50)}{\text{Eq.wt. of } CaCO_3} \times 1000}{\text{Volume of sample taken}}$$

Carbonate and bi-carbonate alkalinity as $CaCO_3$, in mg/L = Total alkalinity - Partial alkalinity

RESULT

Total alkalinity present in the given sample ------------mg/L

VIVA VOCE QUESTIONS

1) When HCl(aq) is exactly neutralized by NaOH(aq), what will be the hydrogen ion concentration in the resulting mixture compared to hydroxide ions?

A: Always equal than the concentration of the hydroxide ions

2) Is the alkaline water suitable for drinking purpose?

A: No

3) What is the permissible limit of alkalinity in potable water as per IS?

A: 600ppm

4) In what form is the nitrogen present in water?

A: Free Ammonia

5) What is the pH of a solution with a hydronium ion concentration of 0.01 mole per liter?

A: 2

6) A bottle of hydrochloric acid contains the hazard symbol shown. What does this symbol mean?

A: Corrosive

7) What are the components in acid rain?

A: H_2CO_3, HNO_3, and H_2SO_4

8) A student mixes 0.080 moles of nitric acid in water to form 1.0 liter of solution. What will be the pH of the resulting solution?

A: 1.10

9) A student is nervous for a big exam and is breathing rapidly. What could be the problem?

A: Respiratory alkalosis

10) What happens when you titrate a classic buffer solution (eg: carbonic acid and sodium bicarbonate) with the (strong) acid of your choice?

A: In any buffer system, the boost in $[H^+]$ increases the reaction rate H^+ + salt => weak acid and takes some H^+ out of circulation.

STIMULATING QUESTIONS

1) Why baking soda is used to rub on the skin when you get a sting from a bee?
2) Why it is recommended to keep our body slightly alkaline in order to prevent cancer?
3) Can you correlate your emotional reactions to the imbalance in acid-base equilibrium in your body?

APPLICATION OF ALKALINITY DATA

Information concerning alkalinity is used in a variety of ways in practice:

Chemical Coagulation

Chemicals used for coagulation of water and wastewater react with water to form insoluble hydroxide precipitates. The hydrogen ions released react with the alkalinity of the water. Thus, the alkalinity acts to buffer the water in a pH range where the coagulant can be effective. Alkalinity must be present in excess of that destroyed by the acid released by the coagulant for effective and complete coagulation to occur.

Water Softening

Alkalinity is a major item that must be considered in calculating the lime and sodaash requirements in softening of water by precipitation methods. The alkalinity of softened water is a consideration In terms of whether such water meet drinking water standards.

Corrosion Control

Alkalinity is an important parameter involved in corrosion control. It must be known in order to calculate the Langelier saturation index. Buffer Capacity Alkalinity measurements are made as a means of evaluating the buffering capacity of wastewaters and sludges. They can also be used to assess a natural waters ability to resist the effects of acid rain.

Industrial Wastes

Many regulatory agencies prohibit the discharge of wastes containing caustic (hydroxide) alkalinity to receiving waters. Municipal authorities usually prohibit the discharge of wastes containing caustic alkalinity to sewers. Alkalinity as well as pH is an important factor in determining the amenability of wastewaters to biological treatrnent.

DETERMINATION OF CHLORIDES

AIM

To determine the amount of chlorides present in water sample

APPARATUS REQUIRED

Burette, Pipette, Conical flask, Measuring jar, Standard flask, Beakers

PRE-REQUISITE QUESTIONS

What are the available forms of chloride?

What is organic pollution?

PRINCIPLE

The water sample is titrated with standard Silver Nitrate in which Silver Chloride is precipitated at first. Potassium Chromate is used as an indicator. The end of titration is indicated by formation of red Silver Chromate from excess Silver Nitrate.

$Ag\,NO_3 + Cl \text{-------}> AgCl + NO_3^-$

$2Ag\,NO_3 + K_2CrO_4 \text{---------}> Ag_2CrO_4 + 2\,KNO_3$

REAGENT PREPARATION

a. Standard Silver Nitrate (0.0141 N):

Dissolve 2.396 g of Silver Nitrate in 1000 ml of distilled water.

b. Potassium chromate indicator:

Dissolve 5 g of Potassium Chromate in 100 ml of water and add few drops of Silver Nitrate solution until red precipitate is formed.

PROCEDURE

a. Take 20 ml of the given sample in a conical flask.

b. Add 2 to 3 drops of Potassium Chromate indicator to get light yellow color.

c. Titrate the sample against silver nitrate solution until the color changes from yellow to brick red.

d. The above procedure is repeated until consistent values are obtained.

OBSERVATION

Burette solution : Silver Nitrate

Conical Flask : Given water sample

Indicator : Potassium Chromate

End point : Yellow to brick red

TABULATION

Sl. No.	**Volume of sample (ml)**	**Potassium Chromate indicator**		
		Burette reading (ml)		
		Initial	Final	Vol. of $AgNO_3$ (ml)

CALCULATIONS

$$\text{Amount of chlorides in the given sample as } Cl^- \text{ in mg/L} = \frac{\begin{array}{c}\text{Vol. of } AgNO_3 \text{ in ml} \times N \times \text{Eq.wt. of } Cl^- \times 1000 \\ (0.0141)\_\ (35.45)\end{array}}{\text{Volume of sample taken}}$$

RESULT

Amount of Chloride present in the given sample =---------- mg/L

VIVA VOCE QUESTIONS

1) What is the solubility of NaCl in (a) cold water and (b) hot water?

A: 357g/L and 391g/L

2) What are the major sources of chloride in surface water and groundwater?

A: Chloride in surface and groundwater from both natural and anthropogenic sources, such as run-off containing road de-icing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas.

3) What is the average amount of chloride excreted by a human being?

A: 4g per day

4) What is the EPA secondary standard for chlorides in drinking water?

A: 250mg/L

5) What is the average chloride concentration of seawater?

A: 19000mg/L

6) What is the largest source of chloride in earth's crust?

A: Halite (mineral form of NaCl)

7) What is the difference between chloride and salinity?

A: Chloride [Cl^-] is the binary compound of chlorine and is one of the major inorganic anions in saltwater and freshwater. It originates from the dissociation of salts, such as sodium chloride or calcium chloride, in water. Salinity is the total of all non-carbonate salts dissolved in water. This is comprised mostly by Cl^- and Na^+ ions. Seawater may have other ions, such as K^+, Mg^{2+}, or $SO4^{2-}$.

8) How chloride is formed naturally?

A: When hydrochloric acid reacts with any metal in water, chloride is naturally formed.

9) What is the normal range of chloride in the groundwater?

A: 35-125mg/L

10) What are the treatment options for saline water?

A: Reverse osmosis and distillation

STIMULATING QUESTIONS

1) Why do we tempt to take lots of water if consumed very salty food?
2) Why the water supply pipelines made of galvanized iron getting corroded?
3) If you have a brackish aquarium, how would you maintain the salinity in the tank?

APPLICATION OF CHLORIDE DATA

In many areas the level of chloride in natural waters is an important consideration in the selection of supplies for human, industrial, and agricultural uses. Where brackish waters must be used for domestic purposes, the amount of chloride present is an important factor in determining the type of desalting apparatus to be used. The chloride determination is used to control pumping of groundwater from locations where intrusion of seawater is a problem.

In areas where the discharge of salt-water brines and industrial wastes containing high concentrations of chloride must be controlled to safeguard receiving waters, the chloride determination serves to excellent advantage for regulatou purposes. Chloride interferes in the determination of chemical oxygen demand (COD). A correction must be made on the basis of the amounts present or else a complexing agent such as HgSO, can bc added.

Sodium chloride has a considerable history as a tracer. One of its principal applications has been in tracing pollution of wells. It is admirably suited for such purposes for five reasons:

1. Its presence is not visually detectable.
2. It is a normal constituent of water and has no toxic effects.
3. The chloride ion is not adsorbed by soil formations.
4. It is not altered or changed in amount by biological processes.
5. The chloride ion is easily measured.

It is to be expected that chloride will continue in limited use as a tracer where other methods are not applicable.

DETERMINATION OF TOTAL SOLIDS, SUSPENDED SOLIDS AND DISSOLVED SOLIDS

AIM

To determine the amount of solids present in a given sample

APPARATUS REQUIRED

Evaporating dishes, Water bath, Hot air oven,
Desiccators, Weighing balance, Filter paper

PRE-REQUISITE QUESTIONS

What is evaporation?

What is the difference between the 3 different types of solids?

PRINCIPLE

Total solids are determined as the residue left after evaporation and drying of the unfiltered sample.

PROCEDURE

Total Solids:

a. Wash and wipe the silica dish and dry it in a hot air oven for dryness.

b. Take the initial weights of dish by using electronic balance.

c. Take 20 ml of sample in the silica dish and evaporate in a water bath at 103°C to 105°C

d. Cool the container to dryness in a desiccator and weigh the dish again.

e. Note the increase in weight.

Dissolved Solids:

a. Wash and wipe the silica dish and dry it in a hot air oven for dryness.

b. Measure the initial weights of dish by using Electronic balance.

c. Take 20 ml of filtered sample in the silica dish and evaporate in a water bath at 103°C to 105°C.

d. Cool the container to dryness in a desiccator and weigh the dishes again.

Suspended Solids:

The difference between the Total solids and the Dissolved Solids gives the Suspended Solids in the sample.

CALCULATIONS

Total Solids:

Initial weight of the container W1 =---------g

Final weight of the container W2 =---------g

Weight of residue, (W1 - W2) ie., Amount of total solids= --------- g

$$\frac{\text{mg of residue}\times 1000}{\text{volume of sample}}$$

=.........................mg/L

Dissolved Solids: =

Initial weight of the container W1 =--------- g

Final weight of the container W2 =----------g

Weight of residue, (W1 – W2) = ---------- g

$$\text{Amount of Dissolved Solids} = \frac{\text{mg of residue}\times 1000}{\text{Volume of sample}}$$

=.........................mg/L

Suspended Solids:

Amount of suspended solids = = Total Solids – Dissolved Solids

=..................mg/L

RESULT

Amount of Total solids present in the sample = -----------mg/L

Amount of Dissolved solids present in the sample = --------- mg/L

Amount of Suspended solids present in the sample = -----------mg/L

VIVA VOCE QUESTIONS

1) What is the pore size of the filter paper used?
A: 2.0μ m or smaller
2) Turbidity in water caused by what type of solids?
A: Suspended solids
3) What is the chemical substance used in the desiccators?
A: CaCl
4) Can you suggest another method to determine the dissolved solids in water?
A: By measuring specific conductance
5) What is the acceptable limit of TDS as per IS code?
A: 500mg/L
6) What part of dissolved solids can directly impose BOD of water?
A: Volatile solids
7) What happens if the oven temperature is too high, or sample is kept for long time?
A: There may be decomposition of some of the heat-sensitive components in the food. This will cause a change in the mass of the solids and lead to errors in calculation.
8) What is the necessity to determine suspended solids concentration of wastewater?
A: Wastewater having high suspended solids contains large concentration of contaminants which affect the treatment capacity of the treatment plant by adding more settleable solids in clarifier as well as clogging the filters Also the effluent quality is characterized by the limit on suspended solids.
9) What you mean by fixed and volatile solids?
A: Fixed solid is the term applied to the residue of total, suspended, or dissolved solids remaining after combustion at 500°C. The weight lost during combustion is referred to as volatile solids.
10) What is the meaning of setteable solids?
A: It is the term applied to the material settling out of suspension within a defined period of time. Settleable solids are not directly related to total solids, total suspended solids or total dissolved solids.

STIMULATING QUESTIONS

1) Why RO water is not highly recommended for drinking?
2) Can you explore the possible errors that can be encountered while conducting this experiment in the lab?
3) Why this method is not suitable for water containing biomass?

APPLICATION OF SOLIDS DATA

In the realm of public and industrial water supplies, the total-dissolved-solids determination is the only one of importance. It is used to determine the suitability of potential supplies for development. In cases in which water softening is needed, the type of softening procedure used may be dictated by the dissolved-solids content, since precipitation methods decrease, and exchange methods increase, the solids. Corrosion control is frequently accomplished by the production of stabilized waters through pH adjustment. The pH at stabilization depends to some extent upon the total solids present as well as the alkalinity and temperature.

The settleable-solids determination has two significant applications. First, it is used extensively in the analysis of industrial wastes to determine the need for and design of primary settling tanks in plants employing biological treatment processes. The test is also widely used in waste-treatment-plant operation to determine the efficiency of sedimentation units: It is fully as important in the operation of large as well as small treatment plants.

The suspended- and volatile-suspended-solids determinations are used to evaluate the strength of domestic and industrial wastes. The tests are particularly valuable in determining the amount of suspended solids remaining after settleable solids have been removed in primary settling units, for the purpose of determining the loading of remaining materials on secondary biological treatment units. In the larger treatment plants, suspended-solids determinations are used routinely as a measure of the effectiveness of treatment units. From the viewpoint of stream pollution control, the removal of suspended solids is usually as important as BOD removal. Both suspended- and volatile-suspended-solids determinations are used to control the biological solids in the aclivated-sludge process.

The total- and volatile-solids tests are the only solids determinations normally applied to sludges. They are indispensable in the design and operation of sludge digestion, vacuum-filter, and incineration units.

ESTIMATION OF AVAILABLE CHLORINE IN BLEACHING POWDER

AIM

To determine the available chlorine in the given sample of bleaching powder

APPARATUS REQUIRED

Burette, Pipette, Conical flask

PRE-REQUISITE QUESTIONS

What is the composition of bleaching powder?

Outline disinfection.

Recall chlorine demand

PRINCIPLE

Chlorine is a strong oxidizing agent and liberates iodine from iodide ion.

$$Cl_2 + 2I^{--} \text{------------------------------} > I_2 + 2Cl^{--}$$

Starch gives blue color with Iodine.

$$I_2 + \text{starch} \text{-----------------} > \text{blue color.}$$

The liberated Iodine is titrated with standard Sodium-thio-Sulphate a reducing agent.

$$I_2 + 2\,Na_2S_2O_3 \text{------------} > Na_2S_4O_6 + 2Na\,I$$

The disappearance of blue color indicates the completion of reaction with free iodine is converted in to iodide.

REAGENT PREPARATION

a. Sodium thio Sulphate: (0.025N)
Dissolve 1.9748 g of Sodium thio Sulphate in water & make up to 1000 ml.

b. Starch indicator:
Dissolve 2 g of soluble starch and pour 100 ml of water in it and allowed to boil for few minutes. After boiling cool the solution, filter & then use.

c. Potassium Iodide solution:
Dissolve 0.425 g of Potassium Iodide in 250 ml distilled water.

PROCEDURE

a. Take 5 g of fresh bleaching powder and add a small quantity of water. Break the lumps with a glass rod and allow this to settle for few minutes. After settling, take the supernatant of the solution and make up to 100 ml.
b. Take all the 100 ml of the above bleaching powder solution in a conical flask and add a pinch of KI.
c. Add 10 ml of Acetic acid in to it and allow the reaction to complete.
d. Titrate the solution with standard $Na_2S_2O_3$ solution until the yellow color of liberated Iodine is almost faded out.(Pale yellow color)
e. Add 1 ml of starch solution and continue the titration until the blue color disappears.
f. Note down the quantity of Sodium thio Sulphate added in ml.

OBSERVATION

Burette : Sodium thio sulphate solution.

Conical flask : Water sample

Indicator : Starch

End point : Disappearance of blue color.

TABULATION

Sl..No.	**Volume of sample (ml)**	**Burette reading (ml) =**		**Volume of $Na_2S_2O_3$ (ml)**
		Initial	Final	

CALCULATIONS

Amount of chlorine present in 5 gms of
Bleaching Powder in mg = Volume of $Na_2S_2O_3 \times$ N (0.025)$\times$ Eq.wt. of Cl^- (35.45)

$$\text{\% age of chlorine content in the bleaching powder} = \frac{\text{Amount of } Cl^- \text{ in bleaching powder x 100}}{\text{Weight of bleaching powder taken}}$$

RESULT

Percentage of Chlorine in the given sample of Bleaching Powder = ------------

VIVA VOCE QUESTIONS

1) What is the chemical formula for bleaching powder?

A: Calcium oxychloride ($CaOCl_2$)

2) How the bleaching happens with bleaching powder?

A: The available chlorine, produced by the action of dilute acid on bleaching powder, acts as a bleaching agent due to its oxidizing property and it can decolorize the colored substances.

3) What are the uses of bleaching powder?

A: It is used for bleaching cotton and linen in textile industry and for bleaching pulp in paper industry. It is used for disinfecting drinking water supply. It is generally used as an oxidizing agent in many chemical industries, especially for the production of chloroform.

4) How can you find the percentage of available chlorine in a given bleaching powder sample using HCl?

A: You cannot use HCl directly because it is a strong acid. It will produce chlorine from the perchlorites in bleaching powder. Acetic acid can be used instead of HCl.

5) What are the ingredients required for preparing household bleach?

A: Chlorine, caustic soda and water

6) What is the normal chlorine content in bleaching powder?

A: About 35%

7) What is the other common name for bleaching powder?

A: Chlorinated lime

8) What are the forms of chlorine available in market?

A: Gaseous chlorine in cylinder, Calcium hypochlorite as bleaching powder in solid form and Sodium hypochlorite in liquid form.

9) How shock chlorination in performed in swimming pools?

A: Shock chlorination is performed by mixing a large amount of sodium hypochlorite, which can be in the form of a powder or a liquid such as chlorine bleach, into the water. Water that is being shock chlorinated should not be swum in or drunk until the sodium hypochlorite count in the water goes down to 3.0 mg/L or less.

10) What you mean by disinfection byproducts (DBP)?

A: Chlorine can react with naturally occurring organic compounds found in the water supply to produce compounds known as disinfection byproducts (DBPs). The most common DBPs are trihalomethanes (THMs) and haloacetic acids (HAAs) which are potential carcinogens.

STIMULATING QUESTIONS

1) What happens when bleaching powder is treated with an excess of dilute acid?
2) Can you obtain bleaching powder from lime?
3) Can you think of the major drawbacks of chlorination?

APPLICATION OF CHLORINE DATA

The prime purpose of disinfecting public water supplies and wastewater effluents is to prevent the spread of waterborne diseases. The practice of disinfection with chlorine has become so widespread and generally accepted that the real reason is frequently taken very much for granted.

MEASUREMENT OF CHLORINE DEMAND

The chlorine demand of a water is the difference between the amount of chlorine applied and the amount of free, combined, or total available chlorine remaining at the end of the contact period. The chlorine demand is different with different waters, and even with a given water will vary with the amount of chlorine applied, the desired residual, time of contact, pH, and temperature. The test should be conducted with chlorine or with hypochlorite, depending upon the form that will be used in practice. Measurement of chlorine demand can be readily made by treating a series of samples of the water in question with known but varying dosages of chlorine or hypochlorite. The water samples should he at a temperature within the range of interest, and after the desired contact period, determination of residual chlorine in the samples will demonSstrate which dosage satisfied the requirements of the chlorine demand, in terms of the desired residual.

DETERMINATION OF TURBIDITY

AIM

To determine the turbidity of a given sample using Nephelo meter

APPARATUS REQUIRED

Nephelometer with accessories

PRE-REQUISITE QUESTIONS

What are suspended solids?

What is the principle of scattering of light?

Define absorption.

PRINCIPLE

The method is based on a comparison of the intensity of light scattered by the sample in specific conditions with the intensity of light scattered by standard reference suspension under the same condition. The higher the intensity of scattered lights, higher the turbidity. Formazine polymer, which has gained acceptance as the turbidity standard reference suspension is used as a reference turbidity standard suspension for water. It is easy to prepare and is more reproducible in its lights scattering properties than the clay or turbid natural water standards previously used. The turbidity of a given concentration of formazine has an approximate turbidity of 100 NTU, when measured on candle turbidity meter. Nephelometric turbidity units based on formazine preparation will have approximate units derived from Jackson candle turbidimeter but will not be identical to them.

REAGENT PREPARATION

a. Turbid free distilled water (for setting zero)

Pass distilled water through a membrane filter having a precision pore size of less than 10 microns (Whatman filter No. 42). Rinse collecting flask atleast twice with such filtered water and discard the next 200 mL. Use this filtered water for setting zero of the instrument.

b. Formazine turbidity concentrate (hydrazine sulphate + hexamine)

Solution I

Weigh accurately 2.5 g of ‘Anal–R’ quality hydrazine sulphate $(NH_2)_2H_2SO_4$ into a 500 mL volumetric flask and add distilled water to make up to the mark. Leave the mixture to stand for 4 hours.

Solution II

Weigh accurately 25g of ‘Anal–R’ quality hexamethylene tetramine $(CH_2)_6N_4$ (hexamine) into a 250 mL volumetric flask and add distilled water to make up to the mark.

Mix equal volume of solution I and II to form formazine turbidity concentrate. Allow it to stand in a closed container at 25°C to 30°C for 48 hours to produce insoluble white turbidity corresponding to 2000 NTU.

Note: Once prepared, formazine turbidity concentrate (which corresponds to 10000 ppm SiO_2*) is stable for 2 to 3 months.*

c. Formazine standard (for setting 100 of the instrument)

Dilute 25mL of the formazine turbidity concentrate to 1 litre with turbidity free distilled water to obtain 250 ppm or 100 NTU for setting '100' of the instrument.

Note: Formazine standard 100 NTU should be prepared weekly.

PROCEDURE

a. Switch the instrument on.
b. Open the lid of the sample compartment.
c. Insert a test tube filled with distilled water into the sample compartment. Close the lid.
d. Adjust 'SET 0' control to get '0' displayed on the read out.
e. Open the lid. Replace the test tube filled with distilled water with a test tube filled with formazine standard. Close the lid.
f. Adjust the 'SET 100' control to get '100' displayed on the read out.
g. Repeat the above operation to get consistent values of 0 to 100 within 1% to 2%.

Measurement of turbidity less than 100 NTU

a. Thoroughly shake the sample.
b. Wait until air bubbles disappear and pour the sample into the nephelometer tube.
c. Read the turbidity directly from the instrument.

Measurement of turbidity above 100 NTU

Dilute the sample with one or more volume of turbidity free distilled water until the turbidity fall below 100 NTU.

TABULATION

NTU of sample $= \frac{A(B+C)}{C}$

where,

A = NTU found in diluted sample

B = volume of dilution water in ml

C = sample volume taken for dilution in ml

0-100 NTU		>100 NTU			
Sample no.	NTU	A (ml)	B (ml)	C (ml)	NTU = A(B + C)C

Sl.No	Sample	Turbidity

RESULT

Turbidity of the given sample = ------------- NTU.

VIVA VOCE QUESTIONS

1) Where do you find the adverse effects of turbidity in environmental engineering? Mention two instances.

A: (a). In natural water bodies turbidity may impart a brown or other colour to water and may interfere with light penetration and photosynthetic reaction in streams and lakes.

(b). It increases the load on slow sand filters. The filter may go out of operation, if excess turbidity exists.

2) Discuss the significance of determination of turbidity in sanitary engineering.

A: (a). To evaluate the performance of treatment plants

(b).To determine the optimum dosage of coagulants to treat the domestic and industrial wastes

(c). To estimate the quantity of coagulants needed for treatment of water and wastewater

3) What is the permissible limit of turbidity in drinking water?

A: 10 units

4) What are NTU and JTU?

A: NTU- Nephelometric Turbidity Unit

JTU – Jackson Turbidity Unit

5) What is the range of the turbidity that can be normally seen through naked eye?

A: Greater than 5 units

6) On what principle does a Nephelometer work?

A: Based on the principle of scattering of light.

7) What is the working principle of Jackson turbidity meter?

A: Light absorption

8) What is the effect of turbidity in oxidation ponds?

A: Turbidity reduces light penetration into the euphotic zone causing a reduced rate of photosynthetic production of oxygen.

9) What causes turbidity in water?

A: Turbidity is caused by particles suspended or dissolved in water that scatter light making the water appear cloudy or murky. Particulate matter can include sediment -especially clay and silt, fine organic and inorganic matter, soluble colored organic compounds, algae, and other microscopic organisms.

10) What is the significance of turbidity to human health?

A: Turbidity can provide food and shelter for pathogens. If not removed, turbidity can promote re-growth of pathogens in the distribution system, leading to waterborne disease outbreaks. Although turbidity is not a direct indicator of health risk, numerous studies show a strong relationship between removal of turbidity and removal of protozoa.

STIMULATING QUESTIONS

1) Can you correlate increased BOD with increase in the turbidity?
2) What are the practical problems in the measurement techniques?
3) How can you remove turbidity of water at your home?

APPLICATION OF TURBIDITY DATA

Turbidity measurements are of particular importance in the field of water supply. They have limited use in the field of domestic and industrial waste treatment. Knowledge of the turbidity variation in raw-water supplies is of prime importance for water treatment plant operation. Such measurements are used in conjunction with other information to determine whether a supply requires special treatment by chemical coagulation and filtration before it may he used for a public water supply.

Many large cities, such as New York, Boston, and San Francisco, have upland or mountain supplies whose turbidities are so low that treatment other than chlorination is not required, although this may change because of growing concerns with protozoan pathogens. Water supplies obtained from rivers usually require chemical flocculation because of high turbidity. Turbidity measurements are used to determine the effectiveness of the treatment produced with different chemicals and the dosages needed. Thus, they aid in selection of the most effective and economical chemical to use.

Such information is necessary to design facilities for feeding the chemicals and for Turbidity measurements help to gauge the amount of chemicals needed from day to day in the operation of treatment works. This is particularly important on "flashy" rivers where no impoundment is provided. Measurement of turbidity in settled water prior to filtration is useful in controlling chemical dosages so as to prevent excessive loading of rapid sand filters. Finally, turbidity measurements of the filtered water are needed to check on faulty filter operation, and to conform to regulatory requirements.

Domestic and Industrial Waste Treatment

The suspended-solids determination is usually employed in waste treatment plants to determine the effectiveness of suspended-solids removal. The determination is slow and time-consuming, and in plants employing chemical treatment, changes in chemical dosages have to be made rather frequently. Turbidity measurements can be used to advantage, because of the speed with which they can be made, to gain the necessary information. By their use, chemical dosages can be adjusted to use the minimum amount of chemical while producing a high-quality effluent.

DETERMINATION OF IRON

AIM

To determine the amount of iron present in a given sample

APPARATUS REQUIRED

Spectral Colorimeter (510nm)

PRE-REQUISITE QUESTIONS

PRINCIPLE

In water supplies the amounts present are normally so small that colorimetric procedure adopting phenanthroline is more satisfactory. The colorimetric procedures have a major advantage in that they are usually highly specific for the ion involved, and a minimum of pretreatment is required.

Phenanthroline Method

The phenanthroline method is the preferred standard procedure for the measurement of iron in water at the present time, except when phosphate or heavy-metal interferences are present. The method depends upon the fact that 1.10-phenanthroline combines with Fez+ to form a complex ion that is orange-red in color. The color produced conforms to Beer's law and is readily measured by visual or photometric comparison.

REAGENT PREPARATION

a. Concentrated Hydrochloric acid

b. Hydroxylamine solution:
Dissolve 10 gm of the salt in 100 ml distilled water.

c. Ammonium acetate buffer solution:
Dissolve 250 gm ammonium acetate in 150 ml distilled water. Add 700-ml con. (Glacial) acetic acid

d. Phenanthroline solution:
Dissolve 100 mg of the 1, 10 phenanthroline monohydrate salt in 100 ml distilled water.

e. Stock iron solution:
Dissolve 1.404 gm of ferrous ammonium sulphate in a mixture of 20 ml of con.. Sulphuric acid and 50 ml distilled water. Dilute to 1 litre. 1 ml of the stock solution = 200 μg iron. From the stock dilute iron standards can be made.

PROCEDURE

a. Mix the sample and take 50 ml of the water sample.

b. Add 2 ml Con.HCL and 1 ml Hydroxylamine solution and boil the solution so as to reduce the volume to 20 ml.

c. Add 10 ml ammonium acetate buffer and 2 ml ortho-phenanthroline solution and make up to 100 ml.

d. Allow 10 to 15 minutes for maximum colour development.

e. Run distilled water blank along with samples.

f. Take the absorbance readings by setting the distilled water blank to 100 % transmission or zero absorb taking the readings of the colour developed in the sample at 510 nm.

g. Carry out a calibration graph by using the iron standards ranging from 0-100 µg Fe / 100 ml by using 2 ml to 10 ml iron standards solution

1 ml = 10 µg of Fe and following the procedure as mentioned above.

h. From the calibration curve determine the Iron content.

TABULATION

Sample description	Volume of sample (ml)	Iron (mg/L)

RESULT

The Iron content present in the given water sample is =-----------mg/L

VIVA VOCE QUESTIONS

1) What is the permissible limit of iron in drinking water as per IS standards?

A: 0.3mg/L

2) What does the presence of iron in natural waters indicate?

A: Dissolution of rock and minerals, acid mine drainage, land fill leachates, sewage and industrial effluents.

3) What are the consequences of high iron content in potable water?

A: Form red spots on clothes, causes stains to wash basin and steel containers

4) What is the result of long time consumption of drinking water with high concentration of iron?

A: Liver diseases (Hemosiderosis)

5) What is the environmental fate of iron?

A: Aeration of iron-containing layers in the soil can affect the quality of both groundwater and surface water if the groundwater table is lowered or nitrate leaching takes place. Dissolution of iron can occur as a result of oxidation and decrease in pH.

6) How can you determine iron concentration?

A: Atomic absorption spectrometry (detection limit 1 μ g/L) and colorimetric methods (detection limit 5 μ g/L)

7) How to remove iron from drinking water?

A: If iron is primarily soluble, as would be expected from reducing environments common to natural waters (particularly low-oxygen containing groundwater), then an oxidation step before filtration is needed. The two main ways of oxidizing iron is by aeration or chlorine, with chlorine being the most common choice. The chlorine is injected before filtration (with some lag time) which oxidizes the soluble iron into a precipitate which can be removed with regular cartridge filters.

8) What is the normal limit on concentration of iron in filter system?

A: 3mg/L

9) What are iron bacteria?

A: These are the bacteria that derive the energy they need to live and multiply by oxidizing dissolved ferrous iron.

10) What happens in aerating water having high iron content?

A: Soluble ferrous iron (Fe^{2+}) is oxidized to a ferric iron (Fe^{3+}), which readily forms the insoluble iron hydroxide complex $Fe(OH)_3$.

STIMULATING QUESTIONS

1) Can excessive iron in water harm our health?
2) What is the success of using natural adsorbents in removing iron from drinking water?
3) What are the criteria to select minimum concentration level allowed to pass in the house hold water purification system?

APPLICATIONS OF IRON AND MANGANESE DATA

In explorations for new water supplies, particularly from underground sources, iron and manganese determinations are an important consideration. Supplies may be rejected on this basis alone. When supplies containing amounts in excess of 0.3 mgL iron or 0.05 mgL manganese are developed, the engineer must decide whether treatment is justified and, if so, the best method of treatment. The ratio of iron to manganese is a factor that determines the type of treatment used, as well as the amount of organic matter present in the water. The efficiency of treatment units is determined by routine tests for iron and manganese. They are also used to aid in the solution of problems in distribution systems where iron-oxidizing bacteria are troublesome. Corrosion of cast-iron and steel pipelines often produces "red-water" troubles in distribution systems. The iron determination is helpful in assessing the extent of corrosion and aiding in the solution of these problems. Research on corrosion and methods of corrosion control require the use of many types of tests to evaluate the extent of metal loss. The iron determination is one of them.

ESTIMATION OF DISSOLVED OXYGEN

AIM

To determine the quantity of dissolved oxygen present in a given sample

APPARATUS REQUIRED BOD bottles

Burette, Conical flasks, Measuring cylinder, Pipette

PRE-REQUISITE QUESTIONS

What you mean by oxygen sag curve?

What is the maximum solubility of oxygen in water at room temperature?

PRINCIPLE

Manganese Sulphate reacts with the alkali to form a white precipitate of Manganese Hydroxide which in presence of Oxygen gets oxidized to a brown color compound. In the strong medium, Manganese ions are reduced by Oxide ions, which get converted into Iodine, equivalent to original concentration of oxygen in sample.

$$Mn^{2+} + 2(OH)^{-} \dashrightarrow Mn(OH)_2$$

$$Mn^{2+} + 2(OH^{-}) \rightarrow MnO_2 + H_2O$$

$$MnO_2 + 2I^{-} + 4H^{+} \rightarrow Mn^{2+} + I_2 + 2H_2O$$

REAGENT PREPARATION

a. Sodium thio Sulphate(0.025N) :
Dissolve 24.82 grams of Sodium thio sulphate in 1 litre of water. Add one pellet of NaOH in to it and dilute the solution 4 times to prepare 0.025N.

b. Alkaline KI solution:
Dissolve 100 grams of KOH and 50 grams of KI in 200 ml of water.

c. Manganese Sulphate Solution:
Dissolve 100 ml of $MnSO_4.4H_2O$ in 200 ml of boiled water.

d. Starch indicator:
Dissolve 2 grams of soluble starch and pour 100 ml of water in it and allow boiling for few minutes. After boiling cool the solution filter & then use.

PROCEDURE

a. Fill the Sample in a glass-stoppered bottle (BOD Bottle) of known volume. Avoid any kind of bubbling and trapping of air bubbles.

b. Add 1ml of each MnSO4 and KI solution. Pour the Reagents to bottom of bottle with help of pipette to ensure better mixing.

c. Place the stopper and shake the contents well by inverting the bottle. Keep the bottle for some time to settle.

d. Add 1-2ml of conc. H_2SO_4 and shake the bottle well to dissolve the precipitate.

e. Take 200 ml of sample from the solution and titrate it against Sodium thio Sulphate using starch as indicator. End point is change of color from blue to colourless solution.

TABULATION

Sl. No.	Volume of sample (ml)	Burette reading (ml)		Volume of Sodium thio Sulphate (ml)
		Initial	Final	

CALCULATIONS

$$\text{Amount of dissolved oxygen (mg/L)} = \frac{\text{Volume of sodium thiosulphate} \times \underset{(0.025\text{N})}{\text{N}} \times \underset{(8)}{\text{Eq. wt. of O}} \times 1000}{\text{Volume of sample from bottle (200 ml)}}$$

RESULT

The amount of dissolved oxygen in the given water sample is = -----------mg/L

VIVA VOCE QUESTIONS

1) Why it is desirable to maintain a significant DO concentration in rivers and streams?

A: For self-purification

2) What is the basic limit of DO that is needed in water for self purification?

A: 14.8mg/L

3) What does a rapid fall in DO level in river water indicate?

A: Organic pollution

4) Whether the solubility of atmospheric oxygen increases or decreases with increase in temperature?

A: Increases

5) In to how many zones is a stream classified?

A: Four

6) What do you mean by oxygen sag curve?

A: Difference between saturation DO content and actual DO content

7) What is the normal saturation DO value for fresh water at zero degrees Celsius?

A: 14.62mg/L

8) How the salinity is affecting DO measurement?

A: As the salinity of water increases, its ability to dissolve oxygen decreases.

9) What is the solubility of oxygen in water at 0-2^{0}C?

A: 10mg/L

10) Why DO is the most important parameter for water quality?

A: Oxygen is measured in its dissolved form as dissolved oxygen (DO). If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken, or die.

STIMULATING QUESTIONS

1) What changes do you expect in the value of DO when temperature and salinity are increased?
2) Warmer water is capable of holding less dissolved oxygen than colder water. Why?
3) When do you expect your DO measurement in a river gives maximum value?

APPLICATION OF DISSOLVED OXYGEN DATA

All living organisms are dependent upon oxygen in one form or another to maintain the metabolic processes that produce energy for growth and reproduction. Aerobic processes are the subject of greatest interest because of their need for free oxygen. Humans are vitally concerned with the oxygen content of the air that they breathe, since they know from experience that an appreciable reduction in oxygen content will lead to discomfort and possibly death. For this reason, the number of occupants within enclosures must be carefully restricted to the ventilating capacity.

The solubility of atmospheric oxygen in fresh waters ranges from 14.6 mg at 0°C to about 7 mg/L at 35°C under 1atmospheric of pressure.

In liquid wastes, dissolved oxygen is the factor that determines whether the biological changes are brought about by aerobic or by anaerobic organisms. The former use free oxygen for oxidation of organic and inorganic matter and produce innocuous end products, whereas the latter bring about such oxidations through the reduction of certain inorganic salts such as sulfate, and the end products are often very obnoxious. Since both types of organisms are ubiquitous in nature, it is highly important that conditions favorable to the aerobic organisms (aerobic conditions) be maintained; otherwise the anaerobic organisms will take over, and development of nuisance conditions will result. Thus, dissolved-oxygen measurements are vital for maintaining aerobic conditions in natural waters that receive pollutional matter and in aerobic treatment processes intended to purify domestic and industrial wastewaters.

Dissolved-oxygen determinations are used for a wide variety of other purposes. It is one of the most important single tests that environmental engineers and scientists use. In most instances involving the control of stream pollution, it is desirable to maintain conditions favorable for the growth and reproduction of a normal population of fish and other aquatic organisms. This condition requires the maintenance of dissolved-oxygen levels that will support the desired aquatic life in a healthy condition at all times.

Determinations of dissolved oxygen serve as the basis of the BOD test; thus, they are the foundation of the most important determination used to evaluate the 1pollutional strength of domestic and industrial wastes. The rate of biochemical oxidation can be measured by determining residual dissolved oxygen in a system at various intervals of time.

All aerobic treatment processes depend upon the presence of dissolved oxygen, and tests for it are indispensable as a means of controlling the rate of aeration to make sure that adequate amounts of air are supplied to maintain aernbic conditions and also to prevent excessive use of air and energy.

Oxygen is a significant factor in the corrosion of iron and steel, particularly in water distribution systems and in steam boilers. Removal of oxygen from boiler feed waters by physical and chemical means is common practice in the power industry. The dissolved-oxygen test serves as the means of control.

DETERMINATION OF BIOCHEMICAL OXYGEN DEMAND

AIM

To determine the value of BOD for a given sample

APPARATUS REQUIRED

BOD bottles

Incubator

Conical flasks

Measuring cylinder

Pipette

PRE-REQUISITE QUESTIONS

What are the necessary and sufficient conditions for biodegradation of organic matter?

How BOD is related to DO?

PRINCIPLE

The dissolved oxygen content of the sample is determined before and after 5 days incubation at 20° C. The amount of oxygen depleted is calculated as BOD. Samples devoid of oxygen or containing less amount of oxygen are diluted several times with a special type of oxygen dilution water saturated with oxygen, in order to provide sufficient amount for oxidation.

REAGENT PREPARATION

a. Calcium Chloride solution:

Dissolve 27.5 g of anhydrous calcium chloride in distilled water and dilute to 1000ml.

b. Magnesium Sulphate solution:

Dissolve 22.5 g of magnesium sulphate in distilled water and dilute to 1000ml.

c. Ferric Chloride solution:

Dissolve 0.15 g $FeCl_3.6H_2O$ in distilled water and dilute to 1000 ml.

d. Phosphate buffer solution

e. Dissolve 42.5 g of Di Hydrogen Phosphate in 700 ml distilled water and add 8.8 g of Sodium Hydroxide and 2g of Ammonium Sulphate and the solution is make up to 1000 ml.

f. Dilution Water:

High quality organic free water must be used for dilution water. Aerate the required volume of water with a supply of clean compressed air. Add 1 ml each of Calcium Chloride, Magnesium Sulphate, Ferric Chloride, and Phosphate buffer solution to 1 litre of aerated distilled water and mix thoroughly. This is the standard dilution water.

PROCEDURE

a. Take the sample, dilute it with dilution water.
b. Take the diluted sample in 2 BOD bottles.
c. Fill another two BOD bottles with dilution water alone.
d. Immediately find DO of the diluted wastewater sample and dilution water.
e. Incubate the other 2 BOD bottles at 20°C for 5 days. They are to be tightly stoppered to prevent any air entry in to the bottles.
f. Determine the DO content in the bottles at the end of 5 days.

TABULATION

Initial day:

Sl. No.	**Volume of sample (ml)**	**Burette reading (ml)**		**Volume of Sodium thio Sulphate (ml)**
		Initial	Final	

Final day:

Sl. No.	**Volume of sample (ml)**	**Burette reading (ml)**		**Volume of Sodium thio Sulphate (ml)**
		Initial	Final	

CALCULATIONS

$$\text{BOD (mg/L)} = \frac{(D_o - D5) \times BC \times \text{volume of diluted sample}}{\text{volume of sample taken}}$$

where D_0 is the initial DO of the diluted sample, D_5 is the DO at the end of 5 days for the diluted sample, BC is the blank correction ($BC=C_0-C_5$), C_0 is the initial DO of the Dilution water (Blank) and C_5 is the DO at the end of 5 days for the dilution water (Blank).

RESULT

The BOD of the given water sample is =----------- mg/L

VIVA VOCE QUESTIONS

1) What you mean by BOD?

A: Biochemical oxygen demand is a measure of the oxygen utilized by microorganisms during biological oxidation of organic matter contained in the liquid waste under specified experimental conditions.

2) What is the permissible limit of BOD in drinking water?

A: Zero

3) Why BOD is taken in 5 days?

A: Because in 5 days the oxidation is completed around 60 % to 70 %.

4) While conducting BOD test light must be excluded. Why?

A: Presence of light enhances the growth of algae.

5) What should be percentage removal of BOD in plain sedimentation tank?

A: 30-35%

6) What should be percentage removal of BOD in septic tank?

A: 20-30%

7) What is difference between carbonaceous BOD and nitrogenous BOD?

A: CBOD is a method defined test measured by the depletion of dissolved oxygen by biological organisms in a body of water which is a measure of the carbon content. NBOD is accounting for the later utilization of dissolved oxygen due to the demand from the nitrogen compounds.

8) What is the difference between COD, BOD and TOC?

A: BOD is based on the principle that if sufficient oxygen is available, aerobic biological decomposition (i.e., stabilization of organic waste) by microorganisms will continue until all waste is consumed. The COD test uses a chemical (potassium dichromate in a 50% sulfuric acid solution) that “oxidizes” both organic (predominate) and inorganic substances in a wastewater sample, which results in a higher COD concentration than BOD concentration for the same wastewater sample. In the TOC test, organic carbon is converted to carbon dioxide (CO2) and typically measured with an infrared analyzer.

9) What is NBOD?

A: BOD related to chemical oxidation is called NBOD. The source materials for NBOD include organic matter that decays to ammonia. Nitrification, the process of oxidizing ammonia to nitrates by microorganisms, requires almost 5 mg/L of DO (NBOD) for every mg/L of ammonia that is oxidized.

10) What is the rough contribution of CBOD and NBOD for 1mg/L of algal biomass?

A: The CBOD from the decomposition of 1 mg/L of algal biomass is 0.9 mg/L, or 75% of the total oxygen demand, while the NBOD is 0.3 mg/L, or 25% of the total oxygen demand.

STIMULATING QUESTIONS

1) How the DO is maintained in a flowing river even after receiving so much of pollution loads?
2) Why the oxygen demand at the river bed (sediments) is always higher?
3) How does the DO requirement achieved in oxidation pond and oxidation ditch?

APPLICATION OF BOD DATA

BOD data have wide application in practice. It is the principal test applied to domestic and industrial wastes to determine strength in terms of oxygen required for stabilization. It is the only test applied that gives a measure of the amount of biologically oxidizable organic matter present that can he used to determine the rates at which oxidation will occur, or BOD will be exerted, in receiving bodies of water.

BOD is therefore the major criterion used in stream pollution control where organic loading must be restricted to maintain desired dissolved-oxygen levels. The determination is used in studies to measure the purification capacity of streams and serves regulatory authorities as a means of checking on the quality of effluents discharged to such waters.

Information concerning the BOD of wastes is an important consideration in the design of treatment facilities. It is a factor in the choice of treatment method and is used to determine the size of certain units, particularly trickling filters and activated-sludge units. After treatment plants are placed in operation, the test is used to evaluate the efficiency of various processes.

Many municipalities and sewer authorities finance wastewater treatment operations through sewer rental charges. Industries contributing wastes to municipal systems are often required to contribute a fair share of the operation and maintenance costs. BOD is one of the factors normally used in calculating such charges, particularly where secondary treatment employing biological processes is employed.

PROCEDURE FOR TESTING THE POTABILITY OF GIVEN WATER SAMPLE AS PER INDIAN STANDARDS

AIM

To examine whether the given water sample is potable as per Indian Standards for pH, turbidity, hardness, total dissolved solids, dissolved oxygen, chlorides, sulphate, iron, manganese, nitrates and fluorides

APPARATUS

As required for each parameter (based on previous experiments)

PRINCIPLE

According to Indian Standards, the quality of drinking water is safe only when the concentrations of potential pollutants are within the specified limit. The value of Maximum Permissible Limit (MPL) can be obtained from the Manual for Water and Wastewater Analysis prepared by the Central Pollution Control Board.

PROCEDURE

The procedure for each parameter has to be followed as per the manual guidelines.

TABULATION

Sl No.	Description of sample	Observed value of the parameter	Recommended value as per Indian Standard	Remarks
1.		1. 2. 3.		

RESULT

The quality of the given water sample is SAFE/UNSAFE as per the Indian Standards.

VIVA VOCE QUESTIONS

1) What are the critical parameters for given water sample?
2) What is/are the reason (s) for the exceeding value of certain parameters?
3) What is the sampling technique you have used?
4) Which parameters are mostly affected by the delay between sampling and analysis?
5) What is the significance of performing the analysis in triplicate?
6) How you feel the interference of certain parameters affect your results?
7) What are the steps to avoid interference among various parameters while analyzing?
8) What are the additional tests you recommend for ensuring the quality of given sample?
9) How do you interpret the results if your sample is having (i) high TDS and low BOD; (ii) low TDS and high BOD; (iii) high TDS and high BOD and (iv) low TDS and low BOD?
10) How do you interpret the results if your sample is having (i) low pH and high iron; (ii) high turbidity and low chlorides; (iii) high TDS and high nitrate and (iv) high alkalinity and low DO?

STIMULATING QUESTIONS

1) How does the experimental method affect your result?
2) What is the purest source of water and why?
3) What is your recommendation for treatment to this water sampl

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