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LAB MANUAL
OF
ENVIRONMENTAL ENGINEERING

[BCE 653]

B.TECH (CIVIL)
3RD Year, 6th Semester

Dr. A.P.J. Abdul Kalam Tech. University
Uttar Pradesh

2025-26

Department of Civil Engineering

Faculty Name: Dr. Supriya Phurailatpam

(Associate Professor)

Approved by: (Head of the Department)

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MANUAL CONTENTS

This manual is intended for the **3rd Year students of B.Tech Civil Engineering for the subject of Environmental Engineering Laboratory.** The manual contains practical experiments and laboratory sessions related to various aspects of Environmental Engineering, aimed at enhancing the understanding of fundamental concepts through hands-on practice and observation.

The experiments included in this laboratory manual are designed to develop technical skills, analytical thinking, and professional competence among students in the field of Environmental Engineering. Students should maintain proper observation records, calculations, and interpretations during each laboratory session for better conceptual clarity and academic improvement.

We hope that this laboratory experience will help students gain confidence, practical exposure, and deeper insight into environmental engineering practices and applications.

Best Wishes for a Productive and Enjoyable Laboratory Experience.

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PREFACE

This practical manual will be helpful for the students of Civil Engineering in understanding the subject from the perspective of practical and applied aspects of engineering. The manual has been prepared to enhance the practical knowledge of students and to provide them with hands-on experience related to the course curriculum. Every effort has been made to ensure that the contents of this manual are accurate and error-free; however, some inadvertent errors may still remain. Constructive suggestions and valuable feedback from readers for further improvement of the manual are sincerely welcomed.

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VISION OF THE DEPARTMENT

"To impart academic excellence in Civil Engineering field with emphasis on holistic development of the professional, while inculcating ethics, socially and professionally responsive technocrats."

MISSION OF THE DEPARTMENT

. **Mission-1**. To provide a comprehensive platform for the academic expertise and proficiency.

Mission-2. To develop Civil Engineering professionals with creative skills and leadership qualities in order to face regional and global challenges.

Mission-3. To develop ethics in students in order to promote socially responsible environmental awareness with innovative thinking.

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Program Educational Objectives (PEOs) of the Department

- **PEO 1**: To enhance skill and expertise in field of civil engineering with aim of boosting employability and entrepreneurship.
- **PEO 2**: To develop multidisciplinary approach of civil engineering system with lifelong learning solutions.
- **PEO 3**: To develop the potential to pursue higher education and research in field of civil engineering.

Program Specific Outcomes (PSOs) of the Department

- **PSO 1**: Graduates shall be able to apply critical thinking in Research, design, analysis and implementation of civil engineering problems.
- **PSO 2**: Graduates shall be able to inculcate the idea of sustainability in engineering solution to meet real world challenges.

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Program Outcomes:(PO)

Graduates will be able to achieve

PO 1: **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering

Fundamentals, and an engineering specialization to the solution of complex engineering problems.

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

PO 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.

PO 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.

PO 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.

PO 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.

PO 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.

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

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

PO 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

PO 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.

PO 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

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Course Evaluation Scheme

Sr No	Subject Code	Subject Name	Periods			Evaluation Scheme				Total	Credit
						Sessional Assessment			PE		
			L	T	P	CT	TA	PS			
1.	BCE653	Environmental Engineering Lab	0	0	2	-	-	50	50	100	1

Course Objectives

The teacher will explain:

1.	To provide hands-on training in water and wastewater quality analysis.
2.	To develop skills for environmental monitoring using standard equipment.
3.	To enable students to interpret laboratory data for water treatment design.

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Course Outcomes (COs)

Course Outcomes: The students should be able to:		**Bloom's Level**
CO1	Recall standard procedures for water and wastewater quality analysis.	K1, K2
CO2	Apply standard methods to determine physical, chemical, and biological parameters.	K3, K4
CO3	Analyze environmental data from water and wastewater samples.	K4, K5
CO4	Evaluate water quality against national and international standards.	K4, K5
CO5	Design laboratory protocols for advanced water and wastewater testing.	K5

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	–	1	1	2	2	–	2	2	–	1	1	1
CO2	2	1	–	-	1	1	2	–	2	2	–	1	1	1
CO3	2	2	–	2	1	2	1	–	2	2	–	1	2	2
CO4	2	1	1	1	1	1	1	1	2	2	–	1	1	1
CO5	2	2	2	1	1	2	2	1	2	2	–	1	2	2
Avg.	**2**	**1.4**	**1.5**	**1.25**	**1**	**1.6**	**1.6**	**1**	**2**	**2**	**–**	**1**	**1.4**	**1.4**

The extent of mapping is as follows: 1 for low, 2 for moderate, 3 for high &"-" for No correlation between CO & PO.

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List of Experiments

S. No.	Experiment
1	Determination of pH
2	Determination of Turbidity
3	Determination of Conductivity
4	Determination of Alkalinity & Acidity
5	Determination of Hardness in water
6	Determination of Chloride in water
7	Determination of Residual Chlorine
8	Determination of Total Solids
9	Determination of Total Suspended Solids and Total Dissolved Solids
10	Determination of Dissolved Oxygen
11	Determination of BOD
12	Measurement of noise levels using a sound level meter
13	Field Visit to nearby Water/Sewage Treatment Plant

Beyond Syllabus:

S.No.	Experiment
1	Calculation Of Water Quality Index (WQI) by using the NSF Method
2	Calculation Of Water Quality Index (WQI) by using the Weighted Arithmetic Method (Indian/Brown)

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S.No.	Name of the Experiment	CO	BTL	Lab Conduction Date	Remark/ Grade/ Marks	Faculty Signature with Date
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

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DO'S

- All students must wear appropriate laboratory attire**.**
- Keep your work area clean.
- Enter laboratory with appropriate laboratory uniform and shoes.
- Bring the laboratory manual, observation and record without fail.
- Collect the instruments and check for damage if any before carrying out the experiment.
- Eliminate potentially dangerous chemical reactions by thoroughly washing beakers, test tubes, flasks
- and other glassware before and after use.
- Always add concentrated chemical (e.g. acid or base) to water – NOT water to concentrated chemical.
- Make sure that all equipment is clean and returned to its original place after performing experiments.
- Turn off all heating apparatus, gas valves, and water faucets when not in use.
- Wear disposable gloves, as provided in the laboratory, when handling hazardous materials.
- Remove the gloves before exiting the laboratory.

DON'T

- Do not place glassware near edge of laboratory bench.
- Do not let water drip onto power strips.
- Never point the open end of a test tube containing a substance at yourself or others.
- Do not use mobile phones during laboratory hours.
- Do not fool around in the laboratory.
- Do not come with long hair, dangling jewelry and loose or baggy clothing that may cause accident in the laboratory.

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PREREQUISITES - 1

DEFINITIONS

1. **pH**: It is an indicator of acidity or alkalinity. pH is shown in a logarithmic scale and an increase or decrease of one pH unit is a 10 fold change. Neutral water has a pH of 7, acidic solutions have values less than 7 and alkaline solutions have values more than 7.

2. Temperature: It is a measure of the average energy (kinetic) of water molecules. It is measured on a linear scale of degrees Celsius or degrees Fahrenheit. It is one of the most important water quality parameters. Temperature affects water chemistry and the functions of aquatic organisms. It influences the:

- Amount of oxygen that can be dissolved in water,
- Rate of photosynthesis by algae and other aquatic plants,
- Metabolic rates of organisms,
- Sensitivity of organisms to toxic wastes, parasites and diseases, and timing of reproduction, migration, and aestivation of aquatic organisms

3**. Turbidity:** It is a measure of the cloudiness or haziness in water caused by suspended solids (eg sediment, algae). Turbidity is expressed in Nephelometric Turbidity Units (NTU) and is measured using a relationship of light reflected from a given sample.

4. **Conductivity**: This is a measure of the capability of a solution such as water in a stream to pass an electric current. This is an indicator of the concentration of dissolved electrolyte ions in the water. It doesn't identify the specific ions in the water. However, significant increases in conductivity may be an indicator that polluting discharges have entered the water.

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5. **Total Hardness**: Hardness is predominantly caused by divalent cations such as calcium, magnesium, alkaline earth metal such as iron, manganese, strontium, etc. The total hardness is defined as the sum of calcium and magnesium concentrations, both expressed as $CaCO_3$ in mg/L. Carbonates and bicarbonates of calcium and magnesium cause temporary hardness. Sulphates and chlorides cause permanent hardness.

6. **Dissolved Oxygen (DO)**: Dissolved oxygen is oxygen gas molecules (O_2) present in the water. Plants and animals cannot directly use the oxygen that is part of the water molecule (H_2O), instead depending on dissolved oxygen for respiration. Oxygen enters streams from the surrounding air and as a product of photosynthesis from aquatic plants. Consistently high levels of dissolved oxygen are best for a healthy ecosystem. Levels of dissolved oxygen vary depending on factors including water temperature, time of day, season, depth, altitude, and rate of flow. Water at higher temperatures and altitudes will have less dissolved oxygen. Dissolved oxygen reaches its peak during the day. At night, it decreases as photosynthesis has stopped while oxygen consuming processes such as respiration, oxidation, and respiration continue, until shortly before dawn. Human factors that affect dissolved oxygen in streams include addition of oxygen consuming organic wastes such as sewage, addition of nutrients, changing the flow of water, r aising the water temperature, and the addition of chemicals. Dissolved oxygen is measured in mg/L.

- 0-2 mg/L: not enough oxygen to support life.
- 2-4 mg/L: only a few fish and aquatic insects can survive.
- 4-7 mg/L: good for many aquatic animals, low for cold water fish
- 7-11 mg/L: very good for most stream fish

7. **Phosphates**: It occur in natural or wastewaters as orthophosphates, condensed phosphates and naturally found phosphates. Their presence in water is due to detergents, used boiler waters, fertilizers and biological processes. They occur in solution in particles or as detritus. They are

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essential for the growth of organisms and a nutrient that limits the primary productivity of the water body. Inorganic phosphorus plays a dynamic role in aquatic ecosystems; when present in low concentration is one of the most important nutrients, but in excess along with nitrates and potassium, causes algal blooms. It is calculated by the stannous chloride method. In acidic conditions orthophosphate reacts with ammonium molybdate forming Molybdophosphoric acid, reduced further to molybdenum blue by stannous chloride. The intensity of the blue colour is directly proportional to the concentration of phosphate. The absorbance is noted at 690nm using spectrophotometer.

8. **Chlorides**: The presence of chlorides in natural waters can mainly be attributed to dissolution of salt deposits in the form of ions (Cl-). Otherwise, high concentrations may indicate pollution by sewage, industrial wastes, intrusion of seawater or other saline water. It is the major form of inorganic anions in water for aquatic life. High chloride content has a deleterious effect on metallic pipes and structures, as well as agricultural plants.

9. **Biological Oxygen Demand (BOD)**: Biological Oxygen Demand (BOD) is the amount of oxygen required by microorganisms for stabilizing biologically decomposable organic matter (carbonaceous) in water under aerobic conditions. The test is used to determine the pollution load of wastewater, the degree of pollution and the efficiency of wastewater treatment methods. 5-Day BOD test being a bioassay procedure (involving measurement of oxygen consumed by bacteria for degrading the organic matter under aerobic conditions) requires the addition of nutrients and maintaining the standard conditions of pH and temperature and absence of microbial growth inhibiting substance.

10. **Chemical Oxygen Demand (COD)**: Chemical oxygen demand (COD) is the measure of oxygen equivalent to the organic content of the sample that is susceptible to oxidation by a strong chemical oxidant. The intrinsic limitation of the test lies in its ability to differentiate between the

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biologically oxidisable and inert material. It is measured by the open reflux method.

11. **Sludge Volume Index (SVI)**: SVI is used to describe the settling characteristics of sludge in the aeration tank in Activated Sludge Process. It is a process control parameter to determine the recycle rate of sludge. It is defined as 'the volume (in ml) occupied by 1 gram of activated sludge after settling the aerated liquid for 30 minutes.

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PREREQUISITES - 2

DRINKING WATER QUALITY STANDARDS (Indian Standard: IS: 10500:2012)

S. No.	Parameter	Acceptable limit	Permissible limit in the absence of alternate source
1.	Colour (Hazen units)	5	15
2.	Odour	Agreeable	Agreeable
3.	pH value	6.5–8.5	No relaxation
4.	Taste	Agreeable	Agreeable
5.	Turbidity (NTU units)	1	5
6.	Total dissolved solids (mg/l)	500	2000
7.	Aluminium (mg/l)	0.03	0.2
8.	Ammonia (mg/l)	0.5	No relaxation
9.	Anionic detergents (as MBAS) (mg/l)	0.2	1.0
10.	Barium (as Ba) (mg/l)	0.7	No relaxation
11.	Boron (as B) (mg/l)	0.5	1.0
12.	Cadmium (mg/l)	0.003	No relaxation
13.	Calcium (as Ca) (mg/l)	75	200
14.	Chloramines (as Cl_2) (mg/l)	4.0	No relaxation
15.	Chloride (as Cl) (mg/l)	250	1,000
16.	Copper (mg/l)	0.05	1.5
17.	Fluoride (mg/l)	1.0	1.5
18.	Iron (mg/l)	0.3	No relaxation
19.	Lead (mg/l)	0.01	No relaxation
20.	Magnesium (mg/l)	30	100
21.	Mercury (mg/l)	0.001	No relaxation
22.	Nickel (mg/l)	0.02	No relaxation
23.	Nitrate (mg/l)	45	No relaxation
24.	Phenolic compounds (as C_6H_5OH) (mg/l)	0.001	0.002
25.	Selenium (as Se) (mg/l)	0.01	No relaxation
26.	Sulphate (as SO_4) (mg/l)	200	400
27.	Sulphide (as H_2S) (mg/l)	0.05	No relaxation
28.	Total alkalinity (as $CaCO_3$) (mg/l)	200	600
29.	Total arsenic (mg/l)	0.01	No relaxation
30.	Total chromium	0.05	No relaxation
31.	Total hardness (as $CaCO_3$) (mg/l)	200	600
32.	Zinc (mg/l)	5.0	15.0
33.	Aldrin/Dieldrin (µg/l)	0.03	No relaxation
34.	Chlorpyriphos (µg/l)	30	No relaxation
35.	2,4-D (µg/l)	30	No relaxation
36.	DDT (µg/l)	1.0	No relaxation
37.	Endosulfan (µg/l)	0.4	No relaxation

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EXPERIMENT NO: 1

DETERMINATION OF pH

AIM: TO DETERMINE pH OF A GIVEN WATER SAMPLE

INTRODUCTION:

The term pH refers to measure of hydrogen ion concentration in a solution and defined as the negative log of H^+ ions concentration in water and wastewater. Values of **pH,** 0 to a little less than 7 are termed as acidic and values of **pH** a little above **7** to **14** are termed as basic. When the concentration of **H^+** and **OH^-** ions are equal then it is termed as neutral **pH**.

APPARATUS: pH meter, Beaker

REAGENT: Buffer solutions of known pH value

PROCEDURE:

Three major steps are involved in the experiment.

1. Preparation of Reagents
2. Calibrating the Instrument
3. Testing of Sample

STEPS:

- Perform calibration of pH meter using standard pH solutions. The calibration procedure would depend on pHrange of interest.
- In a clean dry 100 ml beaker take the water sample and place it in a magnetic stirrer, insert the Teflon coatedstirring bar and stir well.
- Now place the electrode in the beaker containing water sample and check for the reading in pH meter. Wait untilyou get a stable reading.
- Take the electrode from the water sample, wash it with distilled water and then wipe gently with soft tissue.

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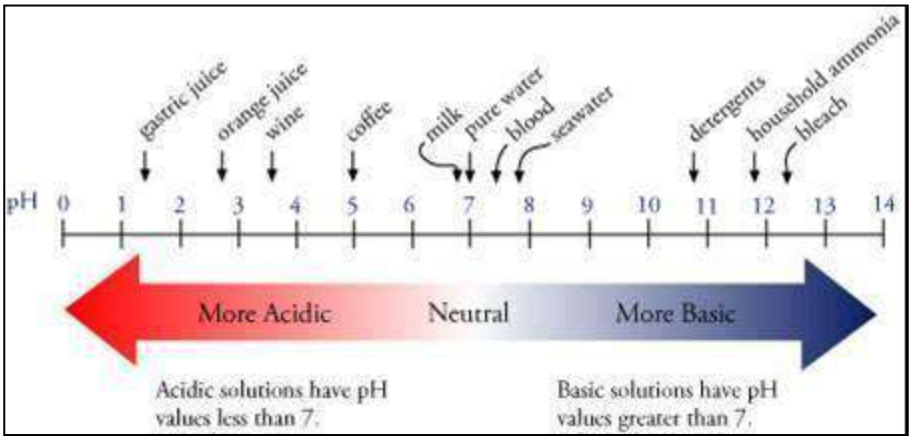
RESULT:

pH of given water sample is _____. .

ENVIRONMENTAL SIGNIFICANCE:

Determination of pH is one of the important objectives in biological treatment of the wastewater. In anaerobic treatment, if the pH goes below 5 due to excess accumulation of acids, the process is severely affected. Shifting of pH beyond 5 to 10 upsets the aerobic treatment of wastewater. In these circumstances, the pH is generally adjusted by addition of suitable acid or alkali to optimize the treatment of the wastewater. pH value or range is of immense importance for any chemical reaction. A chemical shall be highly effective at a particular pH. Chemical coagulation, disinfection, water softening and corrosion control are governed by pH adjustment. Lower value of pH below 4 will produce sour taste and higher value above 8.5 a bitter taste. Higher values of pH hasten the scale formation in water heating apparatus and also reduce the germicidal potential of chlorine. High pH induces the formation of tri- halomethanes, which are causing cancer in human beings.



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EXPERIMENT NO. 2

DETERMINATION OF TURBIDITY

AIM: TO DETERMINE THE TURBIDITY OF THE GIVEN WATER SAMPLE USING A TURBIDITY METER (NEPHELOMETER).

PRINCIPLE:

Turbidity is caused by suspended and colloidal particles present in water. It is measured by the amount of light scattered by these particles when a beam of light passes through the sample.

The turbidity is expressed in NTU (Nephelometric Turbidity Units).

APPARATUS REQUIRED:

- Nephelometer/Turbidity meter
- Sample bottles
- Beakers

PROCEDURE

1. Switch on the turbidity meter and calibrate it using standard solutions.
2. Collect the water sample in a clean sample tube.
3. Remove air bubbles and wipe the outer surface with a soft cloth.
4. Place the sample tube inside the turbidity meter.
5. Record the turbidity value displayed on the meter.

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OBSERVATION TABLE

Sl. No	Sample ID	Turbidity (NTU)

RESULT:

The turbidity of the given water sample is found to be _____ NTU.

PRECAUTIONS

- Use clean and scratch-free sample tubes.
- Avoid formation of air bubbles.
- Calibrate the instrument properly before use.
- Do not touch the optical surface of the tube.

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EXPERIMENT NO. 3

DETERMINATION OF CONDUCTIVITY

AIM: TO DETERMINE THE ELECTRICAL CONDUCTIVITY OF THE GIVEN WATER SAMPLE USING A CONDUCTIVITY METER.

PRINCIPLE:

Electrical conductivity represents the ability of water to conduct electric current due to dissolved salts and ions present in it.

The conductivity is generally expressed in:

- µS/cm (microsiemens/cm) or
- mS/cm (millisiemens/cm)

APPARATUS REQUIRED:

- Conductivity meter
- Conductivity cell/probe
- Beakers
- Distilled water

PROCEDURE:

1. Switch on the conductivity meter and calibrate it if required.
2. Rinse the conductivity probe with distilled water.

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3. Pour the water sample into a clean beaker.
4. Immerse the probe into the sample without touching the sides.
5. Wait until the reading stabilizes.
6. Record the conductivity value displayed on the meter.

OBSERVATION TABLE:

Sl. No	Sample ID	Conductivity (µS/cm)

RESULT:

The conductivity of the given water sample is found to be _____ **µS/cm**.

PRECAUTIONS:

- Rinse the probe before and after use.
- Avoid air bubbles around the probe.
- Ensure proper calibration of the meter.
- Do not touch the electrode surface with bare hands.

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EXPEIMENT NO: 4

DETERMINATION OF ALKALINITIY & ACIDITY

AIM: TO DETERMINE ALKALINITY OF A GIVEN WATER SAMPLE

INTRODUCTION:

Alkalinity is primarily a way of measuring the acid neutralizing capacity of the water. In other words, its ability to maintain a relatively constant pH. The ability of natural water to act as a buffer is controlled in part by the amount of carbonate ion in solution. Carbonate ion and calcium ion both come from calcium carbonate or limestone. So water that comes in contact with limestone will contain high levels of both Ca^{++} and CO^{-} and have elevated hardness and alkalinity.

PRINCIPLE:

The alkalinity of water is a measure of how much acid it can neutralize. When a water sample that has a pH of greater than 4.5 is titrated with acid to a pH 4.5 end point, all OH^-, CO_3^{2-} and HCO_3^- will be neutralized. For pH more than 8.3, add phenolphthalein indicator, the colour changes to pink colour. This pink colour is due to presence of hydroxyl ions. If sulphuric acid is added to it, the pink colour disappears i.e. OH^- ions are neutralized. Then add mixed indicator, the blue colour appears. While adding acid, the colour changes to orange, this colour change indicates thatall the CO_3^{2-} & HCO_3^- has been neutralized. This is the end point.

APPARATUS: Burette, pipette, Conical flask, Beakers, Burette stand and Clamp

CHEMICALS: Sodium carbonate, Standard Sulphuric acid, Phenolphthalein and Methyl orange indicator,Methyl red & Bromocresol green

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PROCEDURE:

The procedure involves two phases.

1. Preparation of reagents
2. Testing of water sample

PREPARTION OF REAGENTS:

The following reagents are required to be prepared.

- Sulphuric acid solution (0.02 N)
- Phenolpthalein Indicator
- Mixed Indicator

Sulphuric acid solution (0.02 N)

Take 500 ml of distilled water in a 1000 ml standard flask. Exactly measure 28 ml of concentrated sulphuric acid andadd slowly along the sides of the standard flask. Then make up the volume up to the mark. The strength of this solution is 1 N. For preparing 0.02 N sulphuric acid solution, exactly measure 20 ml of 1 N solution and make up to1000 ml in a standard flask.

Phenolphthalein Indicator

For preparing 0.02 N sulphuric acid solutions, exactly measure 20 ml of 1N solution and make up to 1000 ml in astandard flask. Weight 1 gm of phenolphthalein and add 100 ml of 95% ethyl alcohol or 100 ml of distilled water.

Mixed Indicator

Dissolve 100 mg bromocresol green and 20 mg methyl red in 100 ml 95% ethyl alcohol or 100 ml of distilled water.

TESTING OF WATER SAMPLE:

Using a measuring cylinder exactly measure 100 ml of sample and pour it in a 250 ml of conical flask.

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Fill the burettewith 0.02N sulphuric acid. Add few drops of phenolphthalein indicator to the conical flask. If the contents in the conical flask turns pink then titrate it against 0.02N sulphuric acid till the pink colour disappears. Note down the titratevalue (V_1). The value of titration is 0.5 ml. This value is used in calculating the phenolphthalein alkalinity. To the same solution in the conical flask add few drops of mixed indicator and the solution turns blue. Continue the titration from the point where stopped. Titrate till the solution become red. The entire volume (V_2) of sulphuric acid noted down and is accountable in calculating the total alkalinity. Repeat the titration from concordant values.

Burette Solution: Sulphuric acid solution

Pipette solution: Sample

Indicator: Phenolphthalein Indicator, Mixed Indicator

CALCULATION:

Calculation of Phenolphthalein Alkalinity

Burette Solution: Sulphuric acid solution

Pipette solution: Sample

Indicator: Phenolphthalein Indicator

End point: Disappearance of pink colour

Sr.No.	Volume of sample (ml)	Burette reading (ml)		Vol. of 0.02N Sulphuric acid (ml)
		Initial	Final	

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Phenolphthalein Alkalinity= Vol of Sulphuric acid (V_1) x Normality x 50 x 1000/ Vol. of sample taken

Calculation of Total Alkalinity

Burette Solution: Sulphuric acid solution

Pipette solution: Sample

Indicator: Mixed Indicator

End point: Appearance of red colour

Sr.No.	Volume of sample (ml)	Burette reading (ml)		Vol. of 0.02N Sulphuric acid (ml)
		Initial	Final	

Total Alkalinity = Vol of Sulphuric acid (V_2) x Normality x 50 x 1000/ Vol. of sample taken

ENVIRONMENTAL SIGNIFICANCE:

Large amount of Alkalinity imparts bitter taste in water. The principal objection of alkaline water is the reactions that can occur between alkalinity and certain cations in water. The resultant precipitate can foul pipes and other accessoriesof water distribution systems.

a. Chemical coagulation of water and waste water – to neutralize acids produced during flocculation, the sample should be alkaline as otherwise further floc formation slowly ceases.
b. Corrosion control: to control the corrosion due to acids, natural water is rendered to alkaline.
c. Effluents of wastewater: wastewater containing excess caustic (hydroxide) alkalinity is not to be discharged into natural water bodies or sewers.

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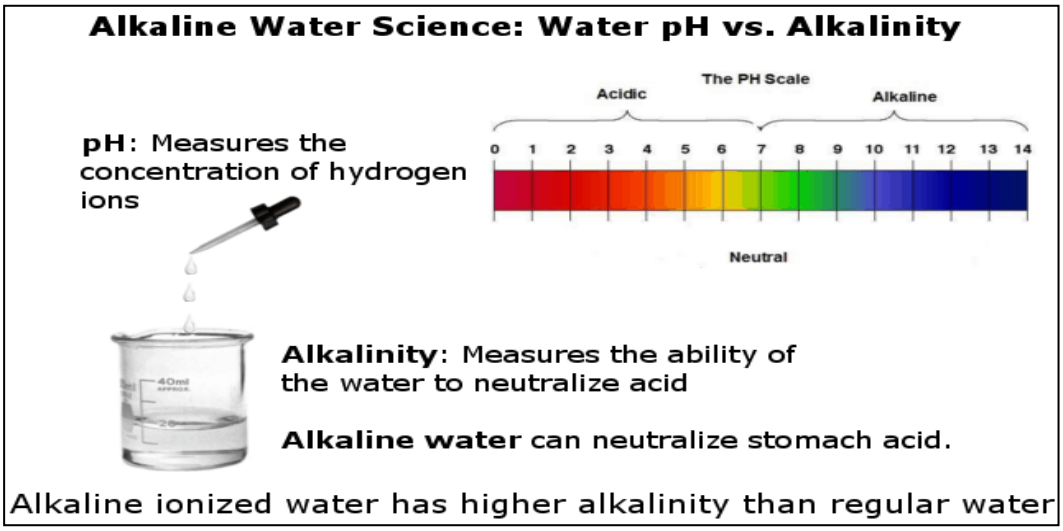

RESULT:

Total Alkalinity present in water sample is _____ .

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EXPERIMENT NO: 5

DETERMINATION OF HARDNESS IN WATER

AIM: TO DETERMINE HARDNESS OF GIVEN WATER

SAMPLE INTRODUCTION:

Hardness is caused by divalent metallic cations. The principal hardness causing cations are calcium, magnesium, strontium, ferrous and manganese ions. The major anions associated with these cations are sulphates, carbonates, bicarbonates, chlorides and nitrates. The hardness of water varies considerably from place to place. In general, surface water is softer than groundwater. The hardness of water reflects the nature of the geological formations with which it has been in contact. The total hardness of water is defined as the sum of calcium and magnesium concentrations, both expressed as calcium carbonate, in mg/l. Hardness are of two types, temporary or carbonate hardness and permanent or non-carbonate hardness. Temporary hardness is one in which bicarbonate and carbonate ion can be precipitated by prolonged boiling. Non-carbonate ions cannot be precipitated or removed by boiling, hence the term permanent hardness. IS value for drinking water is **300 mg/l as CaCO3**.

APPARATUS: 50 ml Burette, 20 ml Pipette, 250 ml Conical flask, 100 ml Beaker, 250 ml beaker, Glassfunnel.

REAGENTS: EDTA solution, Standard CaCO3 solution, Eriochrome Black–T indicator, Buffer solution.

THEORY:

EDTA (Ethylenediamine tetra acetic acid) forms colorless stable complexes with Ca^{2+} and Mg^{2+} ions present in water at pH = 9-10. To maintain the pH of the solution at 9-10, buffer solution

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(NH4Cl + NH4OH) is used. EriochromeBlack-T (E.B.T) is used as an indicator. The sample of hard water must be treated with buffer solution and EBT indicator which forms unstable, wine-red colored complexs with Ca^{2+} and Mg^{2+} present in water.

APPARATUS:

- Beaker
- Burette
- Pipette
- Conical flask
- Measuring cylinder

PROCEDURE:

1. Standardization of EDTA

i. Pipette out 20 ml of standard hard water into a conical flask.
ii. Add 5 ml of buffer solution and few drops of Eriochrome Black-T. The indicator, which is originally bluecolor would acquire a wine-red color.
iii. Titrate with EDTA solution taken in the burette, till the wine red color changes to blue which is the endpoint. Let the burette reading of EDTA be V_2 ml.

2. Determination of Total hardness

Repeat the above titration method for sample hard water instead of standard hard water. Let the burette reading ofEDTA be V_3 ml.

3. Determination of Permanent hardness

Take 100 ml of sample hard water in 250 ml beaker. Boil it to remove temporary hardness to about half of this volumeand cool to room temperature. Filter through filter paper to remove insoluble $CaCO_3$ and $MgCO_3$. Make up the volume to the original 100 ml by adding distilled water. Now pipette out 20 ml of this solution into a clean conical flask. Then repeat the process of titration

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steps as mentioned above. Let the burette reading of EDTA be V_4 ml.

OBSERVATIONS:

1. Standardization of EDTA

Sr.No.	Volume of hard water taken (ml)	Burette reading (ml)		Vol. of EDTA consumed (V_2) (ml)
		Initial	Final	

2. Determination of Total Hardness

Sr.No.	Volume of hard water taken (ml)	Burette reading (ml)		Vol. of EDTA consumed (V_2) (ml)
		Initial	Final	

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3. Determination of Permanent Hardness

Sr.No.	Volume of hard water taken (ml)	Burette reading (ml)		Vol. of EDTA consumed (V_2) (ml)
		Initial	Final	

CALCULATIONS:

1. **Standardization of EDTA $M_1V_1 = M_2V_2$**

Where, M_1 = Molarity of standard hard water

V_1 = Volume of Standard hard water in conical flask

M_2 = Molarity of EDTA

V_2 = Volume of EDTA consumed (Burette reading)

2. Determination of Total hardness

$M_2V_2 = M_3V_3$

Where, M_3 = Total hardness of sample water

V_1 = Volume of sample hard water in conical flask

3. Determination of Permanent hardness

$M_2V_2 = M_4V_4$

Where, M_4= Permanent hardness of sample water

V_4 = Volume of sample hard water in conical flask Note:

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Multiply M_3 and M_4 with 105 to covert hardnessinto parts per million (ppm).

2. **Determination of Temporary hardness Temporary hardness = Total hardness – Permanent hardness**

RESULT:

Total Hardness present is a water sample is _____ .

ENVIRONMENTAL SIGNIFICANCE:

Hard water is as satisfactory for human consumption as soft waters. Because of their action with soap, however, their use for cleansing purpose is quite unsatisfactory, unless soap costs are disregarded. Soap consumption by hard waters represents an economic loss to the water user. Sodium soaps react with multivalent metallic cations to form a precipitate, thereby losing their surfactant properties. In recent years these problems have been largely alleviated by the developments of soaps and detergents that do not react with hardness. Boiler scale, the result of the carbonate hardness precipitation, may cause considerable economic loss through fouling of water heater and hot water pipes. Change in pH in the water distribution systems may also result in deposits of precipitates. Bicarbonates begin to convert to the less soluble carbonates at pH values above 9.0. Magnesium hardness, particularly associated with the sulfate ion has a laxative effect on persons unaccustomed to it. Magnesium concentrations of less than 50 mg/l are desirable in potable waters, although many public water supplies exceed the amount. Calcium hardness presents no public health problem. In fact, hard water is apparently beneficial to the human cardiovascular system.

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Water Hardness Scale		
Grains/Gallon	mg/L & ppm	Classification
Less than 1	Less than 17.1	Soft
1 to 3.5	17.1 to 60	Slightly hard
3.5 to 7.0	60 to 120	Moderately hard
7.0 to 10.5	120 to 180	Hard
10.5 and over	180 and over	Like a stone
Note - one grain per gallon = 17.1 parts per million (ppm)		

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EXPERIMENT NO: 6

DETERMINATION OF CHLORIDE IN WATER

AIM: TO DETERMINE CHLORIDE IN A GIVEN WATER

SAMPLE INTRODUCTION:

Chlorides occur in all natural waters in widely varying concentration, the chloride content normally increases as the mineral content increases. Chloride ion may be present in combination with one or more of the cations of calcium, magnesium, iron and sodium. Chlorides of these minerals are present in water because of their high solubility in water. Each human being consumes about six to eight grams of sodium chloride per day, a part of which is discharged through urine and night soil. Thus, excessive presence of chloride in water indicates sewage pollution. IS value for drinking water is **250 to 1000 mg/l**.

METHOD:

The Mohr Method uses silver nitrate for titration (normality: 0.0141) (method applicability: 0.15 to 10 mg/L chloride ions). This corresponds to **1 ml of 0.0141 equals to 1 mg chloride in solution.** The silver nitrate solution is standardized against standard chloride solution, prepared from sodium chloride (NaCl). During the titration, chloride ion is precipitated as white silver chloride (Eq.1):

$$Ag^+ + Cl^- <=> AgCl \text{ (Solubility product constant, } K_{sp}=3\times10^{-10}) \text{ ---------- (Eq.1)}$$

The indicator (potassium chromate) is added to visualize the endpoint, demonstrating presence of excess silver ions. Inthe presence of excess silver ions, solubility product of silver chromate exceeded and it forms a reddish-brown precipitate (Eq.2). This stage is

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taken as evidence that all chloride ions have been consumed and only excess silver ions have reacted with chromate ions:

$$2Ag^{+} + CrO_4^{2-} <=> Ag_2CrO^4 \ (K_{sp}=5\times10^{-12}) \text{ ---------- (Eq. 2)}$$

APPARATUS: Burette, conical flask, pipette, measuring cylinder.

REAGENTS: Potassium chromate indicator solution, standard silver nitrate titrant.

STEPS:

1. Take 25 ml sample in a conical flask. Measure sample pH.
2. Add 1.0ml potassium chromate indicator solution,
3. Titrate with standard silver nitrate solution to pinkish yellow end point and note down volume of titrant used.Also measure sample pH.
4. Calculate chloride ion concentration using Eq. (3):

Chloride Ion Concentration (mg/L) = (A×N ×35.45)*1000 / V_{sample} --------(Eq. 3)

Where: A = volume of titrant used,

N is normality of silver nitrate (here we used N/71 or 0.0141 N), and

V_{sample} is volume of sample used (ml).

RESULT:

Chloride present in water sample is _____

ENVIRONMENTAL SIGNIFICANCE:

Chlorides in reasonable concentrations are not harmful to human. At concentrations above 250 mg/l they give a salty taste to water, which is objectionable to many people. For this reason, chlorides are generally limited to 250 mg/ l in supplies intended for public use. In many areas of the world where water supplies are scarce, source be containing as much as

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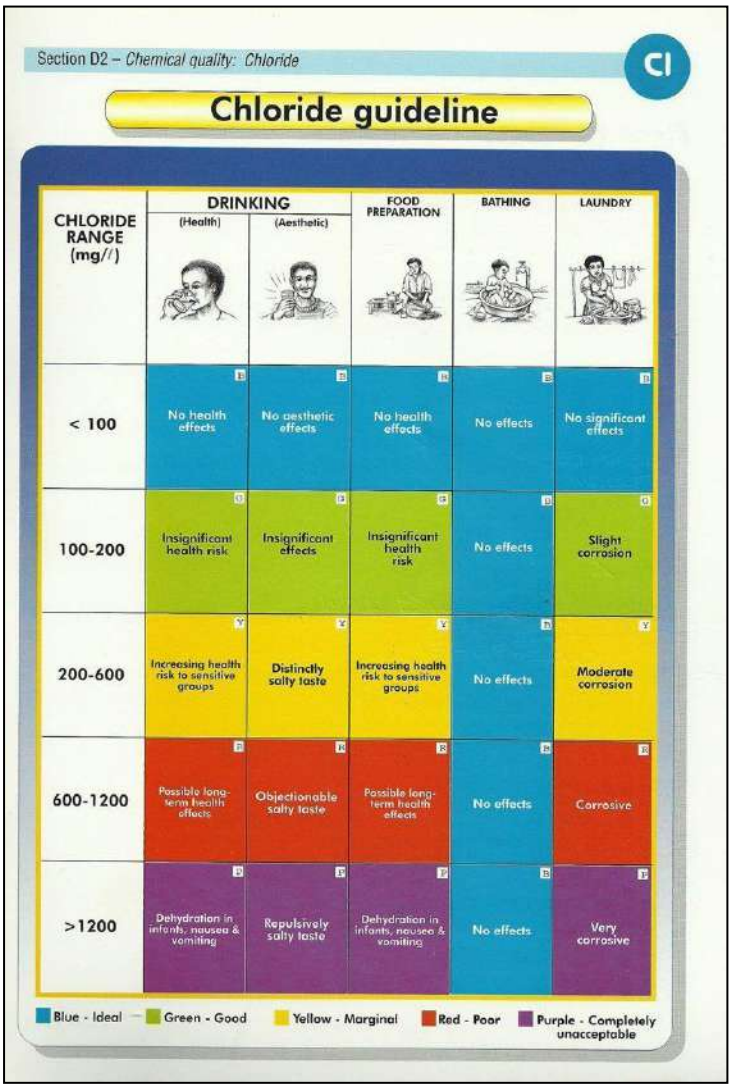
2,000 mg/l are used for domestic purposes without the development of adverse effects, once the human system becomes adapted to the water.



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EXPERIMENT NO. 7

DETERMINATION OF RESIDUAL CHLORINE IN A WATER SAMPLE

AIM: TO DETERMINE THE RESIDUAL CHLORINE IN A GIVEN WATER SAMPLE BY IODOMETRIC METHOD.

APPARATUS:

Burette with Burette stand and porcelain title, pipettes, conical flask (Erlenmeyer Flask) 250 mL, standard flask, wash bottle.

REAGENTS:

Bleaching powder solution, Potassium iodide crystal (KI), Glacial acetic acid, Starch indicator, Sodium thiosulphate (Na 2S2O3)

PRINCIPLE:

Residual chlorine present in water acts as an oxidizing agent. In the iodometric method, the residual chlorine reacts with potassium iodide (KI) in acidic medium and liberates free iodine (I_2). The liberated iodine is then titrated with a standard sodium thiosulphate ($Na_2S_2O_3$) solution using starch as an indicator.

The amount of sodium thiosulphate consumed is equivalent to the amount of residual chlorine present in the sample.

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Chemical Reactions

1. **Liberation of iodine by chlorine:**

$$Cl_2+2KI \rightarrow 2KCl+I_2$$

2. **Titration of iodine with sodium thiosulphate:**

$$I_2+2Na_2S_2O_3 \rightarrow 2NaI+Na_2S_4O_6$$

Initially, iodine imparts a yellow-brown colour to the solution. After addition of starch indicator, a blue colour appears. The disappearance of the blue colour at the end point indicates complete reduction of iodine and completion of the titration.

PROCEDURE:

1. Take 100ml of sample in a conical flask and add a pinch of potassium iodide.
2. Add 5ml of acetic acid and allow the reaction to complete.
3. Titrate the sample against 0.0025N of sodium thiosulphate solution until the yellow colour disappears.
4. Add 1ml of starch solution, blue colour appears then continue the titration until the blue colour disappears(A-B).

OBSERVATION TABLE:

Sl.No.	Sample Taken	Burette Reading (ml)		Difference	Residual Chlorine (mg/l)
		Initial	Final		

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CALCULATION:

Residual chlorine = ((A-B)×0.0025×35.45×1000)/ (volume of sample).

ENVIRONMENTAL SIGNIFICANCE:

• Residual chlorine test checks water quality, especially in treated water for drinking.

• It ensures disinfection effectiveness, preventing waterborne diseases and protecting public health.

• Monitoring residual chlorine levels prevents microbial regrowth in the water distribution system.

• Maintaining appropriate chlorine levels minimizes stress on aquatic ecosystems and protects aquatic organisms.

• Regulatory compliance with residual chlorine testing ensures adherence to drinking water quality standards.

• The test helps optimize disinfection practices while minimizing environmental impacts like disinfection by-product formation.

RESULT:

Residual chorine in the given sample is _____mg/l.

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EXPERIMENT NO: 8

TOTAL SOLIDS (TS)

AIM: TO DETERMINE TOTAL SOLIDS OF GIVEN SAMPLE.

PRINCIPLE:

Total solids are determined by evaporating a well mixed sample and dried to constant weight in an oven at 103 to 105°C and weighing the dry residue left. The increase in final weight than the initial weight of crucible indicates total solids.

APPARATUS: Crucible, Muffle furnace, measuring cylinder, weight balance, oven, desiccators.

PROCEDURE:

1. Take the weight of empty crucible
2. Take 50 ml of given water sample in a crucible.
3. Evaporate the sample at 103 to 105°C for 24 hrs.
4. Again ignite the crucible for 15-20 minutes in a muffle furnace whose temperature is maintained to 550°Cuntil the constant weight is attained. Cool it.
5. Note down the weight of crucible with residue.

OBSERVATION:

1. Weight of empty crucible (B): gm
2. Weight of empty crucible with residue (A): gm.

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CALCULATION:

Total solids (TS) mg/l = {(A-B) x 1000 x 1000} / ml of sample (V),

where, A = Final weight of the crucible with residue in gm

B = Initial weight of the empty crucible in gm.

V = Volume of sample taken in ml.

RESULT:

The amount of total solids determined from the given water sample is _____mg/l.

ENVIRONMENTAL SIGNIFICANCE:

Total solids determination is used to assess the suitability of potential supply of water for various uses.

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EXPERIMENT NO: 9

TOTAL SUSPENDED SOLIDS (TSS) AND TOTAL DISSOLVED SOLIDS (TDS)

AIM: TO DETERMINE TOTAL SUSPENDED SOLIDS FROM GIVEN SAMPLE.

PRINCIPLE:

The residue which remains on filter paper after filtration. The dry weight of this residue is termed as total suspendedsolids.

APPARATUS:

Whatman filter paper no. 44, measuring cylinder, weight balance, oven, desiccator, funnel, tripod stand.

PROCEDURE:

1. Take a tripod stand and put it on the table to which funnel is placed.
2. Take initial weight of Whatman filter paper as (W_1)
3. Now place the Whatman filter paper three folded on the funnel.
4. Pour the well mixed sample on the Whatman filter paper.
5. Wait for some time so as to drain out the water sample completely.
6. Now remove the Whatman filter paper and keep it in the oven. Care should be taken to see that the filterpaper should not be scratched.

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7. Now take the final weight of the filter paper along with residue as (W_2).

OBSERVATIONS:

1. Initial weight of Whatman filter paper (W_1): _____ gm.
2. Final weight of Whatman filter paper with residue (W_2):_____ gm..

CALCULATION:

Total suspended solids (TSS) mg/l = { (W_2-W_1) x 1000 x 1000 } / ml of sample (V)

where,

W_1 = Initial weight of filter paper in gm.

W_2 = Final weight of filter paper with residue in gm

V = Volume of Sample taken

RESULT:

The amount of total suspended solids determined from the given water sample is _____mg/l.

ENVIRONMENTAL SIGNIFICANCE:

1. Suspended solid material may be objectionable in water. Organic suspended are degraded anaerobically mayrelease obnoxious odors.
2. Measures the quality of the wastewater influent and effluent.
3. Extremely valuable in the analysis of polluted waters.

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APPLICATION OF DATA:

1. To evaluate the strength of domestic wastewater.
2. To determine the efficiency of treatment units.

TOTAL DISSOLVED SOLIDS (TDS)

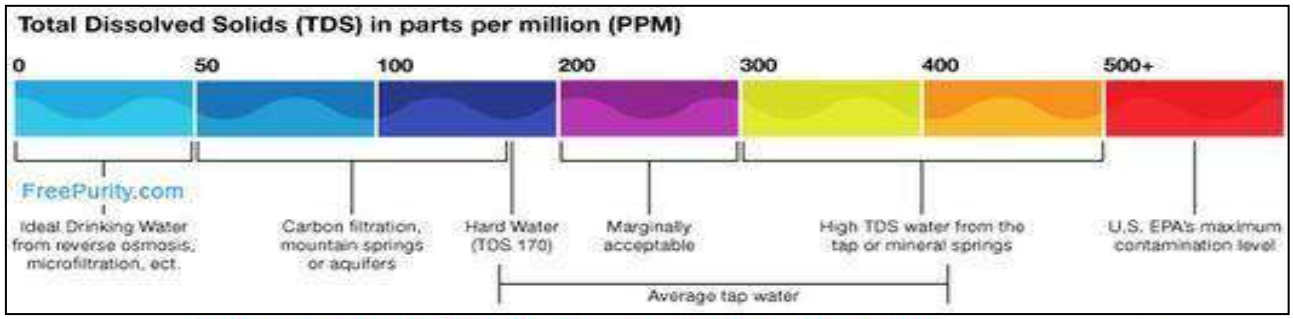
TDS (mg/l) = TS – TSS

RESULT:

The amount of total dissolved solids determined from the given water sample is _____mg/l.

ENVIRONMENTAL SIGNIFICANCE:

1. TDS stands for total dissolved solids, and represents the total concentration of dissolved substances in water.
2. An elevated total dissolved solids (TDS) concentration is not a health hazard. The TDS concentration is a secondary drinking water standard and, therefore, is regulated because it is more of an aesthetic rather than a health hazard.
3. High concentration produces hard water, which leaves deposits and films on fixtures and on the insides of hot water pipes and boilers.



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EXPERIMENT NO: 10

DISSOLVED OXYGEN

AIM: TO DETERMINE DISSOLVED OXYGEN OF GIVEN SAMPLE.

PRINCIPLE:

DO rapidly oxidizes the divalent manganous to its higher valency which forms a brown hydrated oxide precipitate after addition of NaOH and KI. In the presence of iodide ions in an acidic solution the oxidized manganese reverts to the divalent state and liberates Iodine from KI equivalent to the original DO content.

The liberated Iodine is then titrated against Sodium thiosulphate solution with starch as an indicator. $MnSO_4$ reacts with alkali to form white precipitate $Mn(OH)_2$ thus indicating absence of oxygen in the sample.

REACTION:

$$Mn^{2+} + 2(OH^-) \rightarrow Mn(OH)_2 \text{ (white)}$$

$$Mn^{2+} + 2(OH^-) + 1/2\ O_2 \rightarrow$$

$$MnO_2 \text{ (brown)} + H_2OMnO_2 + 2I^-$$

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

APPARATUS:

BOD bottles (capacity 300 ml), burette, pipettes, conical flask, burette stands, tile, measuring cylinder, weight balance, glass rod, beakers.

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REAGENTS:

1. **Winkler's A solution:**

   Dissolve 48 gm tetra hydrate manganous sulphate in 100 ml distilled water. Filter if necessary.

2. **Winkler's B solution:**

   Dissolve 50 gm of NaOH and 15 gm of KI in 100 ml distilled water.

3. **Starch indicator:**

   Make a paste of 2gm L.R grade soluble starch powder in distilled water. Pour this solution in 100 ml distilledwater. Boil for few minutes. Cool the solution and then use.

4. **Concentrated sulphuric acid**

5. **Standard sodium thiosulphate solution:**

   Dissolve 24.82 gm $Na_2S_2O_3$ in distilled water and make up to 1 liter. It becomes 0.1N. Take 250 ml of thissolution and make up to 1 liter with distilled water to prepare 0.025N.

PROCEDURE:

1. Collect the sample in 300ml BOD bottle.
2. Add 2ml of Winkler's A solution and 2ml of Winkler's B solution well below the surface through the walls.
3. Stopper immediately to remove air bubbles and mix carefully by inverting bottle up and down.
4. Allow the brown precipitate to settle down leaving clear supernatant.
5. Add conc. Sulphuric acid drop by drop till precipitate digested.
6. Restopper the bottle and mix by inverting several times for complete dissolution.

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7. A yellow colored solution appears.
8. Take 50 ml samples in conical flask.
9. Add few drops of starch indicator and titrate against 0.025N $Na_2S_2O_3$ solution.
10. Note down the reading until the color changes from blue to colorless.

SOURCE:

1. Drinking water.
2. Tap water.

OBSERVATIONS:

1. In burette: 0.025 N sodium thiosulphate solution.
2. In conical flask: 50 ml sample + indicator.
3. Indicator: starch.
4. End point: blue to colorless.

OBSERVATION TABLE:

Sample	Volume of Sample (ml)	Burette Reading (ml)		Volume of $Na_2S_2O_3$ (Final Value – Initial Value) (ml)
		Initial	Final	

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CALCULATION:

$$\textbf{DO (mg/l)} = \textbf{(V x 70) / u}$$

Where,

V= ml of titrant used for DO determination (B.R.)

u = ml of water sample taken

70 = correction factor

RESULT:

The amount of dissolved oxygen determined from the given sample is _____ mg/l.

ENVIRONMENTAL SIGNIFICANCE:

1. A minimum DO of 4 to 6 mg/l is desirable for the survival of aquatic life; higher values of DO may causecorrosion of iron and steel.
2. High temperature, biological impurities, ammonia, nitrites, ferrous iron, chemicals such as hydrogen sulphideand organic matter reduces DO values.
3. Drinking water should be rich in DO for good taste.

APPLICATION OF DATA:

1. It is necessary to know DO levels to assess the quality of raw water and to check on stream pollution.

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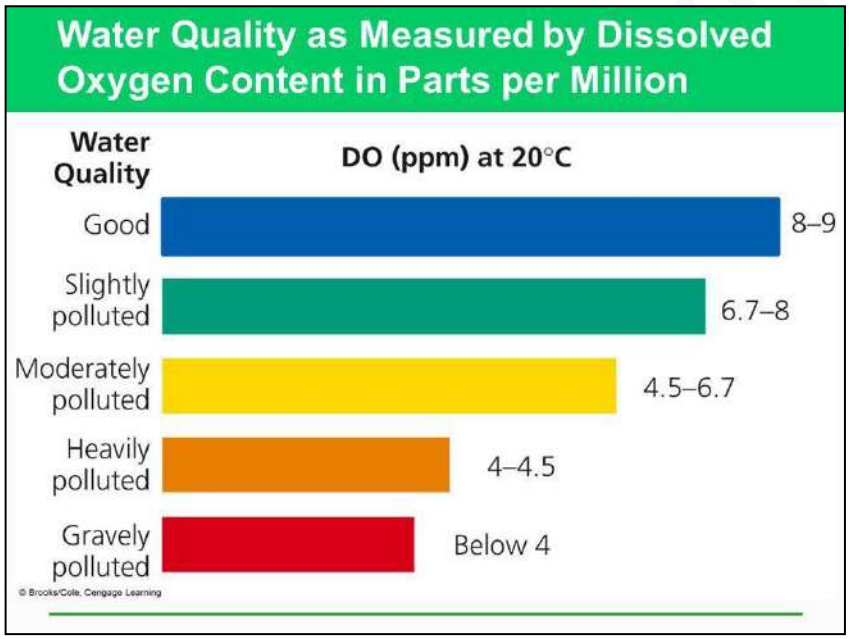
2. DO test is basis for BOD test which is an important parameter to evaluate organic pollution potential of waste.
3. DO test is used to control oxygen in boiler feed water.
4. DO test is used to evaluate the pollution strength of domestic and industrial waste.
5. Determination of DO in waste water is useful to identify the nature of biochemical reactions whether aerobic oranaerobic.



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EXPERIMENT NO: 11

BIOCHEMICAL OXYGEN DEMAND (BOD)

AIM: TO DETERMINE BOD OF GIVEN SAMPLE

PRINCIPLE:

The BOD is an empirical test which measures the oxygen required by the microorganisms for the biochemical degradation of organic matter to carbon dioxide and water at 20°C temperature. The test consists of determination of DO prior to following period of 5 days. The difference between first day DO and fifth day DO is the amount of BOD.

APPARATUS:

BOD bottles (capacity 300 ml), BOD Incubator, burette, pipettes, conical flask, burette stands, tile, measuring cylinder,weight balance, glass rod, beakers.

REAGENTS:

1. **Phosphate buffer solution**

Dissolve 8.5 g KH_2PO_4, 21.75 g K_2HPO4, 33.4 g Na_2HPO_4, and 17.4 g NH_4Cl in1000 ml distilled water.

2. **Magnesium Sulphate Solution**

Dissolve 22.5 g $MgSO_4.7H_2O$ in 1000 ml distilled water.

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3. **Calcium Chloride solution**

Dissolve 27.5 g $CaCl_2$ in 1000 ml distilled water.

4. **Ferric Chloride Solution**

Dissolve 0.25 g $FeCl_3.6H_2O$ in 1000 ml distilled water.

5. **Winkler's A solution**

Dissolve 48 gm tetra hydrate manganous sulphate in 100 ml distilled water. Filter if necessary.

6. **Winkler's B solution**

Dissolve 50 gm of NaOH and 15 gm of KI in 100 ml distilled water.

7. **Starch indicator**

Make a paste of 2gm L.R grade soluble starch powder in distilled water. Pour this solution in 100 ml distilledwater. Boil for few minutes.
Cool the solution and then use.

8. **Concentrated sulphuric acid**

9. **Standard sodium thiosulphate solution**

Dissolve 24.82 gm $Na_2S_2O_3$ in distilled water and make up to 1 liter. It becomes 0.1N. Take 250 ml of thissolution and make up to 1 liter with distilled water to prepare 0.025N.

PROCEDURE:

1. Take the sample in 2 BOD bottles.
2. Fill another two BOD bottles with distilled water.

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3. Add 1 ml each of phosphate buffer, magnesium sulphate, calcium chloride, and ferric chloride solutions in all above bottles.
4. Find immediately DO of the sample and distilled water on 1st day.
5. Incubate at 20°C for 5 days the other two bottles. Tightly stopper to prevent any air entry into the bottles.
6. Determine DO content in the incubated bottles at the end of 5 days by using DO estimation method.

OBSERVATION:

1. In burette : 0.025N sodium thiosulphate solution
2. In conical flask : 50 ml sample + indicator
3. Indicator : Starch
4. End Point : Blue to Colourless

SOURCE:

1. Wastewater
2. Tap water
3. Drinking water
4. Distilled water

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OBSERVATION TABLE:

Sample	Volume of Sample (ml)	Burette Reading (ml)		Volume of $Na_2S_2O_3$ (Final Value – Initial Value) (ml)
		Initial	Final	

CALCULATION:

1. Initial DO of the sample = D_0
2. Final DO after 5 days of the sample = D_5
3. Initial DO of distilled water (Blank) = C_0
4. Final DO after 5 days of distilled water (blank) = C_5
5. DO depletion of the sample = D_0-D_5
6. DO depletion of distilled water = $C_0 - C_5$
7. DO depletion due to microbes = $(D_0-D_5) - (C_0 - C_5)$
8. BOD (mg/l) = (D_0-D_5) x Volume of bottle - $(C_0 - C_5)$/ ml of sample

RESULT:

The amount of BOD determined from the given sample is _____ mg/l.

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ENVIRONMENTAL SIGNIFICANCE:

1. It is the principal test which gives biodegradability of a sample and the strength of waste. Hence the amount ofpollution can be measured.
2. Efficiency of any treatment plant can be judged by considering influent BOD and effluent BOD and so also theorganic loading on the unit.
3. Data from BOD tests are used for the development of engineering criteria for the design of wastewater treatmentplants.

BOD Level *(in ppm)*	Water Quality
1 - 2	**Very Good** There will not be much organic waste present in the water supply.
3 - 5	**Fair: Moderately Clean**
6 - 9	**Poor: Somewhat Polluted** Usually indicates organic matter is present and bacteria are decomposing this waste.
100 or greater	**Very Poor: Very Polluted** Contains organic waste.

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EXPERIMENT NO. 12

MEASUREMENT OF NOISE LEVELS USING A SOUND LEVEL METER

AIM: TO MEASURE THE NOISE LEVEL AT A GIVEN LOCATION USING A SOUND LEVEL METER.

PRINCIPLE:

A sound level meter measures the intensity of sound in decibels (dB). The instrument converts sound pressure variations in air into electrical signals and displays the sound level.

Noise level is generally measured in:

- **dB(A)** for environmental noise assessment.

APPARATUS REQUIRED:

- Sound Level Meter
- Battery/Power supply
- Notebook for observations

PROCEDURE:

1. Switch on the sound level meter.
2. Select the appropriate weighting network, usually **A-weighting**.
3. Select the desired response mode (slow/fast).
4. Hold the meter at arm's length away from the body.
5. Point the microphone towards the sound source.

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6. Record the sound level displayed on the meter.
7. Take multiple readings at different intervals and locations if required.
8. Calculate the average noise level.

OBSERVATION TABLE:

Sl. No.	Location	Noise Level (dB)

RESULT:

The measured noise level at the given location is found to be _____ **dB(A)**.

PRECAUTIONS:

- Calibrate the sound level meter before use.
- Avoid touching or covering the microphone.
- Hold the instrument away from reflecting surfaces.
- Take readings under stable environmental conditions.
- Avoid wind interference during measurements.

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LAB BEYOND SYLLABUS

EXPERIMENT NO. 1

WATER QUALITY INDEX (WQI) USING NSF WQI (BROWN ET AL., 1970) METHOD.

1. AIM:

To test and estimate the **Water Quality Index (WQI)** of a given water sample using laboratory data of selected water quality parameters and applying the **NSF WQI (Brown et al., 1970) method**.

2. Principle:

The **National Sanitation Foundation Water Quality Index (NSF WQI)** is based on the evaluation of nine key water quality parameters. Each parameter is assigned a **weight (Wi)** according to its importance for overall water quality. The measured value of each parameter is converted into a **sub-index (Qi)** using rating curves or standard tables.

The final WQI is calculated as:

$$WQI = \frac{\sum_{i=1}^{n}(W_i \times Q_i)}{\sum_{i=1}^{n} W_i}$$

$W_i =$ Weight of the ith parameter

$Q_i =$ Quality rating (sub-index) of the ith parameter

The **NSF WQI** typically uses the following nine parameters:

i. Dissolved Oxygen (DO)
ii. Fecal Coliform
iii. pH
iv. Biochemical Oxygen Demand (BOD)

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v. Temperature change (ΔT)
vi. Total Phosphate
vii. Nitrate
viii. Turbidity
ix. Total Solids

3. Apparatus Required:

- DO meter / Winkler's titration set
- Incubator (for BOD test)
- COD digester & titration setup (if COD is measured additionally)
- pH meter
- Turbidity meter
- Spectrophotometer (for phosphate, nitrate determination)
- Filtration apparatus
- Measuring cylinders, beakers, conical flasks, burettes
- Distilled water
- Standard reagents (alkaline KI, $MnSO_4$, sulfuric acid, starch, sodium thiosulfate, Nessler's reagent, etc.)
- Sample bottles (sterile for microbiological parameters)

4. Theory:

Water Quality Index (WQI) provides a **single numerical value** that summarizes the overall quality of water based on multiple parameters. This makes it easier for policymakers, scientists, and the general public to interpret water quality.

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The **NSF WQI (Brown et al., 1970)** is widely used as it incorporates multiple parameters with scientifically assigned weights. For instance, **DO has the highest weight (0.17)** since it is most critical for aquatic life, while **nitrates and phosphates** are indicators of eutrophication.

Interpretation of WQI (NSF scale):

- **90–100** → Excellent
- **70–90** → Good
- **50–70** → Medium
- **25–50** → Bad
- **0–25** → Very Bad

5. Procedure:

a) Collect the water sample from the designated site using sterilized bottles.

b) Analyze the following parameters using standard methods (APHA, IS, or BIS):

- **Dissolved Oxygen (DO):** Winkler's method / DO meter
- **Fecal Coliform:** Membrane filtration method (MPN count)
- **pH:** pH meter (standardized)
- **BOD:** 5-day incubation at 20°C followed by titration
- **Temperature Change (ΔT):** Difference between sample and reference (standard) water body temperature
- **Phosphate:** Spectrophotometric molybdenum blue method
- **Nitrate:** UV spectrophotometric method
- **Turbidity:** Nephelometric turbidity meter
- **Total Solids:** Gravimetric method (evaporation at 105°C)

c) Convert each measured parameter value into a **quality rating (Qi)** using NSF rating curves/standard charts.

d) Multiply each sub-index Qi with its respective weight Wi.

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e) Sum up all weighted sub-indices and divide by the sum of weights.

f) Report the final WQI value and interpret the quality class.

6. Observation Table:

The NSF-WQI combines **nine parameters** into a single score:

Sl.No.	Parameter	Typical Unit	Weight (W_i)	Mean Value	Q-Value (Q_i)	W_iQ_i
1	Dissolved oxygen (DO)	mg/L	0.17			
2	Fecal coliform	MPN/100 ml	0.15			
3	pH	Std Unit	0.12			
4	Biochemical oxygen demand (BOD) (5-day)	mg/L	0.1			
5	Nitrates	mg/L	0.1			
6	Phosphates	mg/L	0.1			
7	Water Temperature	°C	0.1			
8	Turbidity	NTU	0.08			
9	Total Dissolved Solids	mg/L	0.08			
		Tota weight =	**1**		$\sum$ **WiQi**	

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7. Result:

The **Water Quality Index (WQI)** of the given water sample (using NSF method) is:

$$WQI = \frac{\sum W_i Q_i}{\sum W_i}$$

$$WQI =$$

Interpretation: The water quality is **(Excellent / Good / Medium / Bad / Very Bad)**.

8. Precautions:

- Collect water samples in sterilized and contamination-free bottles.
- Calibrate instruments (pH meter, DO meter, turbidity meter, spectrophotometer) before use.
- Use freshly prepared reagents for accurate results.
- Maintain incubation temperature accurately during BOD test.
- Avoid spillage and handle acids/bases with care.
- Ensure no air bubbles remain in DO sample bottles before fixation.

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LAB BEYONG SYLLABUS

EXPERIMENT NO. 2

WATER QUALITY INDEX (WQI) USING THE WEIGHTED ARITHMETIC METHOD (INDIAN/BROWN)

1. Objective:

To determine the **Water Quality Index (WQI)** of a water sample by measuring selected physico-chemical parameters (pH, DO, BOD_5, COD, TDS, turbidity, nitrate, etc.) in the laboratory and computing the WQI using the **Weighted Arithmetic Method (Brown)** commonly used in Indian practice.

2. Principle:

The Weighted Arithmetic WQI compresses multiple water-quality parameters into a single index by:

I. Converting each measured parameter into a quality rating (q_i) that expresses how close the observed concentration is to the ideal and permissible value.

II. Assigning each parameter a unit weight (w_i) (usually inversely proportional to its standard permissible value S_i).

III. Calculating the weighted average of the quality ratings to obtain the WQI.

Mathematical summary (when weights are normalized so $\Sigma w_i = 1$):

$$q_i = \frac{V_{actial,i} - V_{ideal,i}}{S_i - V_{ideal,i}} \times 100 \quad (for\ 'higher\ is\ worse'\ parameter)$$

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$$WQI = \sum_{i=1}^{n} q_i w_i$$

Notes: For parameters where higher is better (e.g., DO) or where deviation in either direction matters (pH), use adapted forms so q_i represents deterioration (larger q_i → poorer quality). Use authoritative standards (BIS/WHO/local) for S_i values.

3. Apparatus & Reagents Required:

- **Field sampling**
  - ❖ Clean sampling bottles (amber/clear as required), cooler/ice, sample log, thermometer, GPS.
- **Laboratory**
  - ❖ pH meter & buffers
  - ❖ DO meter or Winkler reagents & burettes
  - ❖ BOD bottles & incubator (20 ± 1 °C)
  - ❖ COD digestion apparatus & reagents (if COD included)
  - ❖ Turbidity meter (nephelometer)
  - ❖ Conductivity/TDS meter or gravimetric TDS apparatus
  - ❖ Volumetric glassware, analytical balance, filtration unit
  - ❖ Reagents: potassium dichromate, sulphuric acid, EDTA, standard buffers, nitrate/phosphate reagents, etc.
  - ❖ PPE: gloves, goggles, lab coat; fume hood for strong reagents

4. Theory:

Key concepts

- **Ideal value (V_{ideal}):** the target/ideal value for the parameter (often 0 for pollutants; for DO use saturation or a biologically meaningful high value; for pH use 7.0).

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- **Standard permissible value (S_i):** the regulatory guideline limit for the intended use (e.g., BIS 10500 for drinking, CPCB/state PCB for surface water). Always state the source and exact S_i used.

Unit weight determination

Preliminary unit weight:

$$w_i' = \frac{1}{S_i}$$

Normalized unit weight:

$$w_i = \frac{w_i'}{\sum w_i'} \; so \; that \; \sum w_i = 1$$

Quality rating (q_i)

For pollutants (BOD, COD, TDS, turbidity, nitrate):

$$q_i = \frac{V_{actial,i} - V_{ideal,i}}{S_i - V_{ideal,i}} \times 100$$

For DO (where higher is better):

$$q_{DO} = \frac{V_{actial,DO} - V_{ideal,DO}}{V_{ideal,DO} - S_{DO}} \times 100$$

(V_ideal,DO = saturation or defined ideal; S_DO = minimum acceptable DO).

- For pH (deviation both sides):

$$q_{pH} = \frac{|V_{actial,pH} - V_{ideal,pH}|}{|S_{pH} - V_{ideal,pH}|} \times 100$$

(pick S_pH as the nearest permissible bound in the direction of deviation).

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Final index

$$WQI = \sum(q_i w_i)$$

Interpret using chosen classification.

Classification example (common)

- 0–25: Excellent
- 26–50: Good
- 51–75: Poor
- 76–100: Very Poor
- 100: Unsuitable / Heavily polluted

  (Adjust classification to institution's convention and state it in the report.)

5. Procedure:

A. Sampling

I. Select representative sampling points and collect grab samples following standard sampling practice. Label bottles with Sample ID, date, time, location, collector.

II. Preserve/transport samples on ice (4 °C) and analyze DO/BOD promptly.

B. Laboratory measurements (recommended sequence)

a. **pH & Temperature:** Calibrate pH meter; measure pH and temperature.

b. **Dissolved Oxygen (DO):** Measure immediately (Winkler fixation or calibrated DO meter).

c. **BOD_5:** Prepare dilution bottles, measure initial DO ($DO_{initial}$ incubate 5 days at 20 °C, measure final DO (DO_{final}).

d. Compute $BOD_5 = (DO_{initial} - DO_{final}) \times$ dilution factor (apply seed correction if necessary).

e. **COD (if used):** Perform standard digestion and titration / colorimetric determination; compute COD mg/L.

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f. **Turbidity:** Measure with nephelometer.

g. **TDS / Conductivity:** Measure conductivity and convert or measure gravimetrically.

h. **Total Hardness / Nitrate / Phosphate:** Perform titrimetric or spectrophotometric methods as required.

i. **Quality controls:** Run blanks, duplicates, standards; record calibration details.

C. WQI calculation

a. Choose parameters to include (typical set: pH, DO, BOD, COD, TDS, Turbidity, Total Hardness, Nitrate, etc.).

b. Obtain S_i (permissible values) and V_ideal for each parameter; list the source (BIS/WHO).

c. Compute preliminary unit weights

   i. $w_i' = \frac{1}{S_i}$ then normalize to obtain w_i.

d. Compute each quality rating q_i using the formulas above (handle DO and pH specially).

e. Compute WQI = $\Sigma(q_i \times w_i)$. Round sensibly (e.g., one decimal place).

f. Interpret the WQI and identify dominant contributors (parameters with large $q_i \times w_i$).

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Parameter	Unit	V_actual	V_ideal	S_i (Std Value) (BIS Standard Value)	q_i	w'_i = 1/S_i	w_i (Normalized)	q_i × w_i
pH	Std. Unit		7.00	8.50				
Dissolved Oxygen (DO)			14.60	5.00				
Biochemical Oxygen Demand (BOD_5)	mg/L		0.00	30.00				
Chemical Oxygen Demand (COD)	mg/L		0.00	250.00				
Total Dissolved Solids (TDS)	mg/L		0.00	500.00				
Turbidity	NTU		0.00	5.00				
Total Hardness	mg/L		0.00	300.00				
Nitrate	mg/L		0.00	45.00				
							WQI =	

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Notes for table

- List the exact numeric S_i used and cite the regulatory source (e.g., BIS 10500:2012).
- Show intermediate values (w'_i and w_i) so students can reproduce calculations.
- If $q_i > 100$ for any parameter, note that it exceeds the permissible level.

7. Result:

The final computed **Weighted Arithmetic WQI** = _____ (dimensionless).

The water quality classification based on chosen scale is _____.

8. Precautions:

- Use approved standards for S_i and document their sources.
- Calibrate instruments before each use and record calibration logs.
- Preserve DO & BOD samples properly; run BOD incubations at constant 20 ± 1 °C.
- Handle strong reagents (acid/dichromate) in fume hood with PPE.
- Ensure no air bubbles in DO bottles before Winkler fixation.