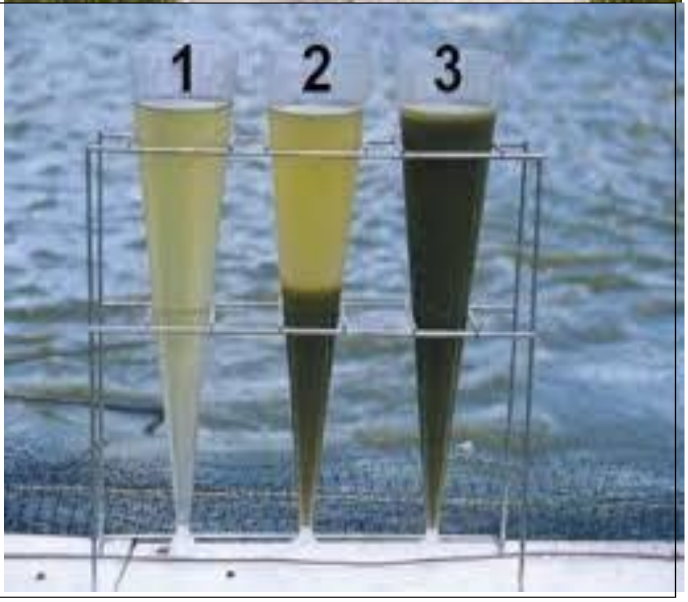
SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

S.R.M NAGAR, KATTANKULATHUR - 603203.

CE3664 - WATER AND WASTE WATER ANALYSIS LABORATORY MANUAL (SIXTH SEMESTER)



DEPARTMENT OF CIVIL ENGINEERING

REGULATION 2023

Academic year 2025-26 (Even)

PREFACE

This instruction manual has been prepared by the DEPARTMENT OF CIVIL ENGINEERING to facilitate instruction during practical classes and further to be used as a reference manual by the Civil Engineering students of this college. This manual covers explanation of experiments included in the syllabus as per Autonomous Regulation 2023 in Environmental Engineering Laboratory for the B.E Degree Course. Any suggestions for the improvement of the manual will be gratefully received.

Prepared by

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Staff-Incharge

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. To produce graduates who can understand their ethical, environmental as well as professional responsibilities so that they appreciate the impact of the engineering solutions which have sustainability over society and the nation.
2. To develop the graduates who will exhibit strong technical ability to create & synthesize data using relevant tools and concepts, for providing sustainable solutions to civil engineering problems and projects.
3. To equip the graduates with suitable skills making them industry ready when they leave the portals of the Institute and to become a competent distinguished Professional Civil Engineer.
4. To produce students who can exhibit attitude, professionalism, ability to communicate with team members and adapt to the latest technology by engaging themselves in life-long learning

2. PROGRAMME OUTCOMES (POs):

After going through the four years of study, our Civil Engineering Graduates will exhibit ability to:

PO	Graduate Attribute	Programme Outcome
1	Engineering knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.
2	Problem analysis	Identify, formulate, research literature, and analyse 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 public health and safety, and 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 modelling 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
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 the 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

3. PROGRAM SPECIFIC OUTCOMES (PSOs):

By the completion of Civil Engineering program the student will have following Program specific outcomes

1. Establish a Civil Engineering career in industry, government or academic field and achieve professional expertise as appropriate.
2. Execute innovation and excellence in Civil engineering problem solving and design in global and societal contexts.
3. Commit to lifelong learning and professional development in the Civil Engineering field to stay updated in technology, research topics and contemporary issues.
4. Understand the fundamentals of Civil Engineering in commercial contexts and in expediting construction projects.

LABORATORY SAFETY PROCEDURES

DO'S

- Wear Mask and follow the COVID precautionary measures.
- Know the potential hazards of the materials used in the laboratory.
- Wear personal protective apparel when working with chemicals. This includes eye protection, lab coat, gloves.
- Wash skin promptly if contacted by any chemical, regardless of corrosivity or toxicity.
- Shoes must cover the entire foot. Open toed shoes and sandals are inappropriate footwear in laboratories.
- Restrain and confine long hair and loose clothing. Pony tails and scarves used to control hair must not present a loose tail that could catch fire or get caught in moving parts of machinery.
- Understand the Hazards of Your Chemicals - Read all labels.
- Read the level of the curve (Miniscus) in all volumetric glass coarse with the eye approximately the same level as the curve of the solution.
- Clean all the apparatus used with distilled water before and after the experiment.
- Have your Lab manual, Observation and record note for every lab classes.

DON'T

- Eat, drink, chew gum, or apply cosmetics in rooms or laboratories where chemicals are used or stored.
- Drink water from laboratory water sources.
- Smell chemicals, taste chemicals, or pipette by mouth.
- Put hazardous chemicals down the drain
- Use squirt/wash bottles over the sink
- Allow waste to accumulate.
- Add water to concentrated acid. A concentrated acid should be added carefully to water

CE3664	WATER SUPPLY AND WASTE WATER ANALYSIS LABORATORY	L	T	P	C
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OBJECTIVES:

- This subject includes the list of experiments to be conducted for characterization of water and municipal sewage. At the end of the course, the student is expected to be aware of the procedure for quantifying quality parameters for water and sewage.

LIST OF EXPERIMENTS: ANALYSIS OF WATER SAMPLE

1. Sampling and preservation methods for water and wastewater (Demonstration only)
2. Measurement of Electrical conductivity, TDS, pH and turbidity
3. Determination of fluoride in water by spectrophotometric method /ISE
4. Determination of iron in water (Demo)
5. Determination of Sulphate in water.
6. Determination of Optimum Coagulant Dosage by Jar test apparatus.
7. Determination of available Chlorine in Bleaching powder and residual chlorine in water.
8. Determination of Alkanity and Acidity.

ANALYSIS OF WASTEWATER SAMPLE

9. Estimation of suspended, volatile and fixed solids
10. Determination of Sludge Volume Index in waste water
11. Determination of Dissolved Oxygen
12. Estimation of B.O.D.
13. Estimation of C.O.D.
14. Determination of TKN and Ammonia Nitrogen in wastewater
15. Determination of total and fecal coliform (Demonstration only)

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the student should be able:

1. Calibrate and standardize the equipment
2. Collect proper sample for analysis
3. To know the sample preservation methods
4. To perform field oriented testing of water, wastewater
5. To perform coliform analysis

REFERENCES:

1. APHA, "Standard Methods for the Examination of Water and Waste water", 22nd Ed. Washington, 2017.
2. "Laboratory Manual for the Examination of water, wastewater soil Rump", H.H. and Krist, H. – Second Edition, VCH, Germany, 3rd Edition, 1999.
3. "Methods of air sampling & analysis", James P.Lodge Jr (Editor) 3rd Edition, Lewis publishers, Inc., USA, 2020.
4. Metcalf & Edd., "Wastewater Engineering: Treatment and Resource Recovery" McGraw-Hill Education,2014.
5. Manual of Water Supply and Treatment., "Central Public Health and Environmental Engineering Organization (CPHEEO"), Ministry of Urban Development, Government of India, 2024.

CE3664	**PO**												**PSO**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
CO1	2	1	1	1	2	1	2	2	1	1	1	3	1	1	1	2
CO2	2	1	1	1	1	2	2	2	1	1	2	3	2	2	2	1
CO3	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
CO4	3	3	3	3	3	2	2	3	3	2	3	2	3	2	2	1
CO5	2	3	3	3	3	2	2	3	2	2	2	3	2	3	3	2
Average	**2.0**	**1.8**	**1.8**	**1.8**	**2.0**	**1.8**	**2.0**	**2.4**	**1.8**	**1.6**	**2.0**	**2.6**	**2.0**	**2.0**	**2.0**	**1.6**

Basic Conversions:

Percent by weight: To make up a solution based on percentage by weight, one would simply determine what percentage was desired.

Weight percentage= (Weight of solute/ weight of solution) x100%

Percent by volume: Solutions based on percent by volume are calculated the same as for percent by weight, except that calculations are based on volume. Thus one would simply determine what percentage was desired

Volume percentage= (Volume of solute/ Volume of solution) x100%

Percent by weight/volume: Another variation on percentage concentration is weight/volume percent or mass/volume percent. This variation measures the amount of solute in grams but measures the amount of solution in milliliters.

Weight/Volume percentage= (Weight of solute/ Volume of solution) x100%

Dilution: Dilution is the mixing of a small accurately measured sample with a large volume of sterile water or normal saline called (diluents or dilution blank).

Dilution= Volume of sample/ total volume of (sample+ Diluent) Dilution Factor=Total

Volume of (Sample+ Diluent)/Volume of sample

For drinking water the following standards should be strictly maintained.

S.NO	PARAMETER	MAXIMUM ALLOWABLE CONCENTRATION
1.	Colour	5 Units
2.	Taste	Unobjectionable
3.	Odour	Unobjectionable
4.	Turbidity	5 Units
5.	Total Soilds	500 mg/l
6.	Carbonate Alkalinity	120 mg/l
7.	Chlorides	200 mg/l
8.	Residual Free Chlorine	0.20 mg/l
9.	BOD	Nil
10.	Iron	0.20 mg/l
11.	Lead	0.10 mg/l
12.	Selenium	0.01 mg/l
13.	Chromium	0.05 mg/l
14.	Cyanide	0.01 mg/l
15.	Nitrates	45 mg/l
16.	Copper	1.0 mg/l
17.	Zinc	5.0 mg/l
18.	Calcium	75 mg/l
19.	Magnesium	50 mg/l
20.	Sulphate	200 mg/l
21.	Phenolic Substances	0.001 mg/l
22.	Manganese	0.01 mg/l
23.	Cadmium	0.01 mg/l
24.	Silver	0.05 mg/l

25.	Barium	1.00 mg/l
26.	Mercury	0.001 mg/l
27.	Pesticides	Nil
28.	B-coli	Nil in 100 ml
29.	Most probable number(MPN)	1 in 100 ml

S.NO	PARAMETER	PERMISSIBLE RANGE OF CONCENTRATION
1.	pH	7 to 8.5
2.	Dissolved Oxygen	5 to 8.5 mg/l
3.	Hardness	75 to 115 mg/l
4.	Fluorides	0.8 to 1.0 mg/l

CONTENTS

Ex.No: 1
Date:

Sampling and preservation methods for Water and Wastewater
(Demonstration only)

Aim

To study about the sampling, preservation methods and significance of characterization of water and wastewater.

Sampling

Random samples or grab samples are mostly collected manually from pipes, reservoirs, rivers, streams or drains. However, random samples can also be taken automatically. Each sample provides data on waste water quality at the collection time of sampling and cannot represent average conditions. Hence it should not be used as a basis for design parameter of treatment.

Grab samples are useful in determining the effects of extreme conditions of the waste during the time composite samples are being collected or when the waste water flow is intermittent. Composite samples or pooled samples can be obtained from an automatic sampler according to times or quantities. Such samples enable conclusions to be drawn about the water quality over longer periods. However, in most cases, peak concentrations cannot be identified in such pooled samples.

In quantity proportional sampling, volumes proportional to flow are collected at constant time intervals. Where the flow is continuously monitored, an almost quantity proportional pooled sample can be prepared by mixing relevant amounts from various single samples.

Sampling techniques

1. Topographic and specialized maps
2. Aerial photographs
3. Waterway plans, drainage plan

Preservation

During sampling, the water is removed from its natural environment. Due to this change, the chemical composition of water may not remain same, but may tend to adjust itself according to its new environment. The contents of water samples can alter at very different rates. These steps allow tests to be carried out even after longer period of time have elapsed.

Many ingredients are so stable that no special precaution for transport and storage are necessary. These are mainly the inorganic components. Water which are absolutely free of organics and micro-organisms show no microbiological degradation processes. The physic- chemical changes possible, where large amounts of organics materials are present and the conditions are suitable for growth of micro-organisms, the water contents can change in a very short time.

The following changes are possible in water samples

(i) Oxidation of components via dissolved oxygen

(ii) Precipitation and co-precipitation of inorganics through milieu changes ($CaCO_3$, metal hydroxides)

(iii) Adsorption of dissolved trace components on the container walls.

(iv) Changes in parameters as a result of microbiological activity (e.g. pH value, oxygen, carbondioxide, BOD, trace organics).

General Information

In water and wastewater analysis, the results are usually reported in terms of mg/L of some particular ion, element or compound. It is most convenient to have the standard titrating agent of such strength, that 1mL is equivalent to 1mg of material being measured. Thus 1 litre of the standard solution is usually equivalent to 1g of the standard substance.

Normality

The desired normality of the titrant is obtained by the relationship of 1 to the equivalent weight of the measured material. Thus normality of acid solution to measure ammonia, ammonia nitrogen, and alkalinity as $CaCO_3$

Ammonia — 1/eq. wt. = 1/17 = N/17 = 0.0588N
Ammonia N — 1/eq. wt. = 1/14 = N/14 = 0.0715N
Alkalinity — 1/eq. wt. = 1/50 = N/50 = 0.020N

The normality of basic solution to measure mineral acidity as $CaCO_3$ is

Acidity — 1/eq. wt. = 1/50 = N/50 = 0.020N

The normality of silver nitrate to measure chloride and sodium chloride is

Chloride — 1/eq. wt. = 1/35.45 = N/35.45 = 0.0282N
Sodium chloride — 1/eq. wt. = 1/58.44 = N/58.44 =0.071N

Thus the substance measured is calculated as follows

$$= \frac{\text{mL of titrant used} \times 1,000}{\text{mL of sample}} \ \text{mg / L}$$

Most materials subjected to the analysis of water and wastewater fall in the realm of dilute solutions i.e., a few mg in a litre. So the results are normally expressed in mg/L or ppm. Parts per million (ppm) is a weight ratio; but mg/L is a weight by volume ratio. The relationship is given as follows

$$\text{ppm} = \frac{\text{mg / L}}{\text{Sp.gr.}}$$

If concentrations are less than 0.1 mg /L, express them in µg/L (micrograms per litre). If concentrations are more than 10,000 mg/L, they are expressed in percentages.

Plotting of Graphs

Rules listed by Worthing and Geffner are to be followed while plotting graphs. They are

1. The independent and dependent variables should be plotted on abscissa and ordinate respectively.

2. The scale should be so chosen that the value of either coordinate could be found quickly and easily.
3. The curve should cover as much of the graph sheet as possible.
4. The scales should be so chosen that the slope of the curve approach unity as nearly as possible.
5. The variables should be chosen to give a plot that will be as nearly a straight line as possible.

STANDARDS OF WATER QUALITY

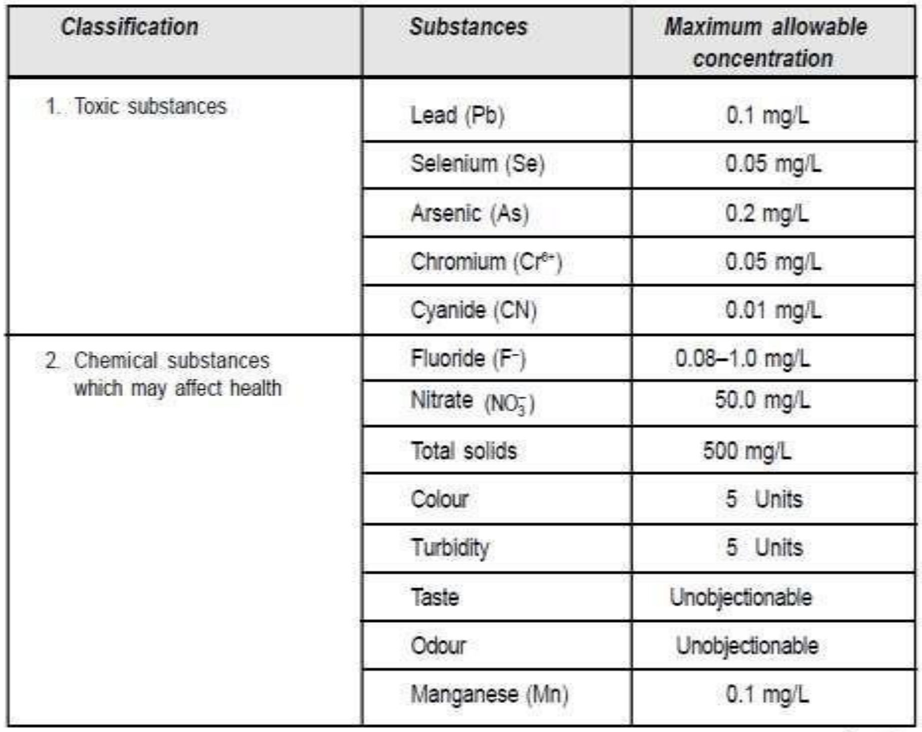
Standards of water quality are presented as follows

Bacteriological Quality

1. Treated water In 90% of the samples examined throughout the year, the coliform bacteria shall not be detected or the MPN index shall be less than 10. None of the samples shall have an MPN index of coliform bacteria in excess of 10. An MPN index of 8–10 shall not occur in consecutive samples.

2. Untreated water In 90% of the samples examined throughout the year, the MPN index of coliform organisms should not be less than 10. None of the samples should show an MPN index greater than 20. An MPN index of 15 or more should not be permitted in consecutive samples.

Chemical and Physical Quality



Classification	*Substances*	*Maximum allowable concentration*
1. Toxic substances	Lead (Pb)	0.1 mg/L
	Selenium (Se)	0.05 mg/L
	Arsenic (As)	0.2 mg/L
	Chromium (Cr^{6+})	0.05 mg/L
	Cyanide (CN)	0.01 mg/L
2. Chemical substances which may affect health	Fluoride (F^-)	0.08–1.0 mg/L
	Nitrate (NO_3^-)	50.0 mg/L
	Total solids	500 mg/L
	Colour	5 Units
	Turbidity	5 Units
	Taste	Unobjectionable
	Odour	Unobjectionable
	Manganese (Mn)	0.1 mg/L

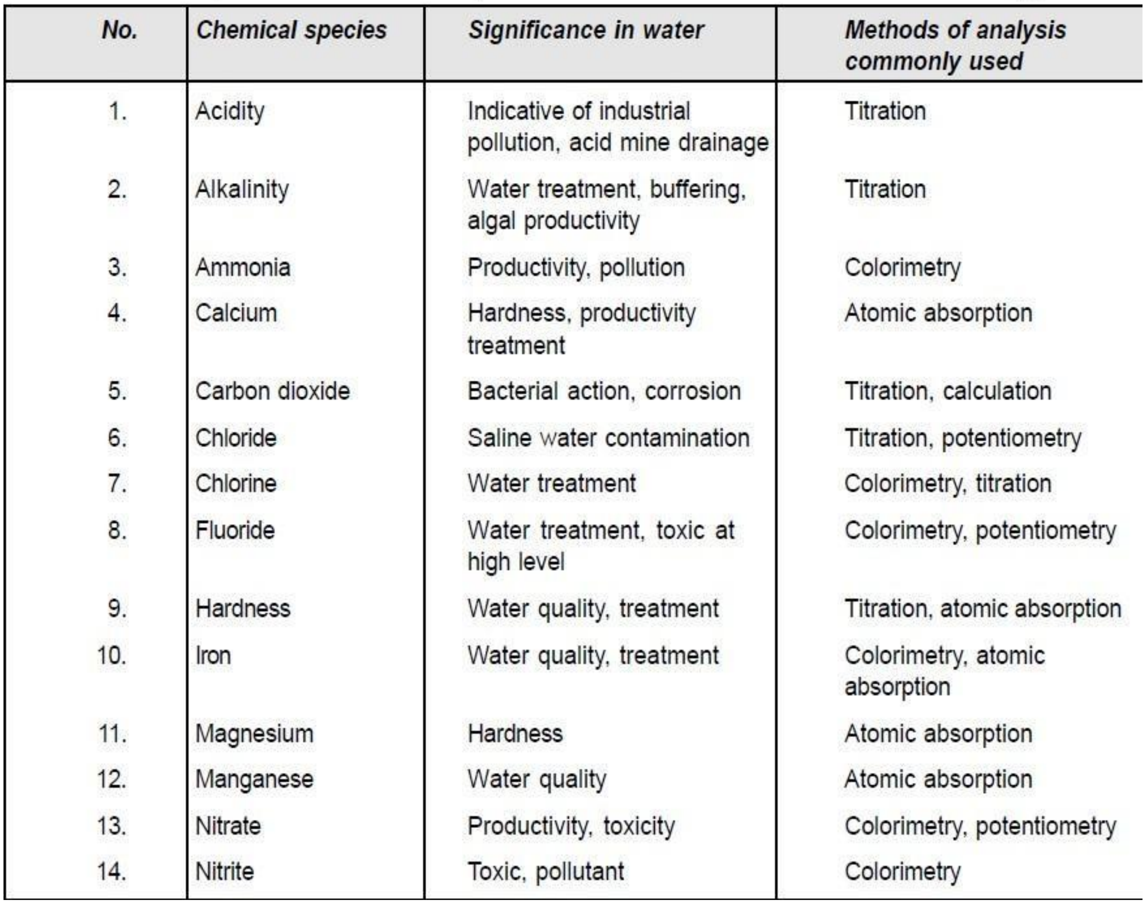
Contd...

3. Chemical substances affecting the potability of water	Iron (Fe)	0.3 mg/L
	Copper (Cu)	1.0 mg/L
	Zinc (Zn)	5.0 mg/L
	Calcium (Ca)	75 mg/L
	Magnesium (Mg)	50 mg/L
	Sulphate	200 mg/L
	Chloride (Cl^-)	200 mg/L
	pH range	7.0–8.5
	Phenolic substances	0.001mg/L

Significance, characterization and determination of Chemical Parameters

Chemical parameters and their significance are presented as follows. The methods of the analysis adopted are also presented. However, only simple methods will be dealt within this manual.

Chemical parameters commonly determined in natural waters and water supplies



No.	*Chemical species*	*Significance in water*	*Methods of analysis commonly used*
1.	Acidity	Indicative of industrial pollution, acid mine drainage	Titration
2.	Alkalinity	Water treatment, buffering, algal productivity	Titration
3.	Ammonia	Productivity, pollution	Colorimetry
4.	Calcium	Hardness, productivity treatment	Atomic absorption
5.	Carbon dioxide	Bacterial action, corrosion	Titration, calculation
6.	Chloride	Saline water contamination	Titration, potentiometry
7.	Chlorine	Water treatment	Colorimetry, titration
8.	Fluoride	Water treatment, toxic at high level	Colorimetry, potentiometry
9.	Hardness	Water quality, treatment	Titration, atomic absorption
10.	Iron	Water quality, treatment	Colorimetry, atomic absorption
11.	Magnesium	Hardness	Atomic absorption
12.	Manganese	Water quality	Atomic absorption
13.	Nitrate	Productivity, toxicity	Colorimetry, potentiometry
14.	Nitrite	Toxic, pollutant	Colorimetry

15.	Nitrogen (albumin.)	Proteinaceous material	Colorimetry
16.	Nitrogen (organic)	Organic pollution	Colorimetry
17.	Oxygen	Water quality	Titration, electrochemical
18.	BOD	Water quality, pollution	Microbiological titration
19.	COD	Water quality, pollution	Chemical oxidation-reduction
20.	pH	Water quality, pollution	Potentiometry
21.	Phosphate	Water quality, pollution	Colorimetry
22.	Sulphate	Water quality, pollution	Gravimetry, turbidimetry
23.	Sulphide	Water quality, pollution	Colorimetry, potentiometric titration

Ex.No:2A Determination of Conductivity in water sample

Date:

Aim:

To determine the Conductivity of the given sample

Apparatus required:

Conductivity Meter, Flask, Beaker, Wash Bottle

Principle:

Conductivity is the capacity of water to carry an electrical current and varies both with number and types of ions the solution contains, which in turn is related to the concentration of ionized substances in the water. Most dissolved inorganic substances in water are in the ionized form and hence contribute to conductance. Conductivity measurement gives rapid and practical estimate of the variations in the dissolved contents of water.

Environmental Significance:

Electrical conductivity measurements are often employed to monitor desalination plants. It is useful for detection of impurities in water. Used for quantitative measurement of ionic constituents dissolved in water, which are important for boiler feed water and cooling water etc.; Used for checking correctness of water analysis as there is a distinct relationship between conductivity and total dissolved solids (TDS). Conductivity data is useful in determining the suitability of water and wastewater for disposal on land. Irrigation waters up to 2 millisiemens/cm conductance have been found to be suitable for irrigation depending on soils and climatic characteristics.

Reagents:

0.01 N, KCL solution: Dissolve 0.746 grams of potassium chloride in 1 litre of distilled water.

Procedure:

1. Rinse the electrode thoroughly blot and dry.
2. Immerse the electrode in 0.01 N KCL solution and the conductivity should be 1413 micro mhos at 25°C Temperature.
3. Now the instrument is calibrated.
4. Remove the cell from KCL solution and wash it thoroughly with distilled water.
5. Immerse the electrode/cell in the unknown sample whose conductivity is to be determined.
6. Note down the instrument reading. If the cell constant is given on the cell itself, then the measured value of conductivity = Cell Constant C X Screen reading

Tabulation:

Sl.No	Sample	Conductivity(mS/cm)	Temperature(^oC)

Result:

Ex.No:2B Determination of pH by using pH meter

Date:

Aim:

To find the pH present in the given water sample.

Apparatus Required:

pH meter, Electrode, Buffer solutions, filter papers etc.

Principle:

pH refers to the hydrogen ion activity and is expressed as the logarithm of reciprocal of hydrogen ion activity in molar per litre. It can be measured by calorimetric methods using various indicators or electrometrically by using pH meter employing hydrogen ion-sensitive electrodes. The basic principle of electrometric pH measurement is determination of activity of the hydrogen ion by potentiometric measurement using a standard hydrogen electrode and a reference electrode.

Interference:

pH measurements are affected by temperature. In the pH meter, provision is made for setting the instrument to room temperature before taking the pH readings. The Buffer solutions used for standardization must be kept in the refrigerator. Always report the temperature at which pH is measured.

Procedure:

1. Connect the pH electrode to the pH meter input terminal. Adjust the manual temperature setting to room temperature.
2. Wash the pH electrode with distilled water and wipe dry using filter paper. Insert the pH electrode into a known buffer of 7.0 pH. If it is different from 7.0 pH, adjust the reading to 7.0 pH by varying the AP control.
3. Wash the electrode with distilled water and wipe dry. Insert the electrode into another known buffer, 4.0 pH.If it is different from 4.0 pH, adjust the reading to 4.0 pH.
4. Wash the electrode with distilled water and wipe dry. Repeat the procedure with 7.0 pH and 4.0 pH until consecutive correct readings are obtained.
5. Now the pH electrode and the pH meter have been matched calibrated.
6. Wash the electrode with distilled water and wipe dry. Insert the electrode into the unknown sample and take the displayed reading.

Tabulation:

S.NO	SAMPLES	pH

Result:

The pH of the given water sample is -------------------

Ex.No:2C Determination of Turbidity in water sample

Date:

Aim:-

To determine the turbidity of the given sample water by Nephelometric method.

Apparatus required: - Nephelo turbidity meter.

Principle: -

Turbidity is a measure of the extent to which light is either absorbed or scattered by suspended material present in the water. Turbidity is surface waters results from the erosion of colloidal material such as clay, slit, rock fragments and metal oxides from soil, vegetable fibers and micro-organisms may also contribute to turbidity. Drinking water supplies requires special treatment by chemical coagulation and filtration before it may be used for public water supply.

This turbidity can be brought down to required level by adding coagulants. Coagulants when added to water it will form a geletaneous substance known as floc and this will arrest the fine suspended and colloidal particles. These arrested particles will settle down rapidly because of increase in their size.

Interference: -

Turbidity waters are aesthetically displeasant and are not accepted for domestic use. The colloidal matter associated with turbidity provides adsorption sites for chemicals and biological organisms that may be harmful or cause undesirable tastes and odour. Disinfection of the turbid waters is difficult and unsatisfactory, since the colloids partially shield organisms from the disinfectant. This IS values for drinking water is 10 to 25 NTU.

Reagents: -

1. Turbidity free water: - Pass distilled water through a lower turbidity than distilled water, discard the first 200ml, collected. If filtration does not reduce turbidity use distilled water.
2. Stock turbidity solutions:

   i) **Solution 1**: - Dissolve 1.0 grams hydrazine suplate $(NH_2)_2.H_2SO_4$ in distilled water and dilute it to 100 ml in a makeup flask.

   ii) **Solution 2**: - Dissolve 10.0 grams hexamethylene tetramine (CH2)6N4 in distilled water and dilute it to 100ml.

   iii) **Solution 3**: - In a 100ml flask, mix 5ml. each of solution 1 and 2. Allow it to stand 24 hours, then dilute it to 100ml and mix thoroughly. The turbidity of this solution is 400 NTU.

   iv) **Standard Turbidity Solution**: - Take 10.0ml of solution 3 in a 100ml make up flask and dilute it to 100ml with turbid free water. The turbidity of this suspension is 40 NTU.

PROCEDURE:-

a) Calibration of Nephelometer:-

i) Select proper range of NTU on Nephelometer.

ii) By placing distilled water in Nephelometer test tube, set the Nephelometer reading to zero by using the knobs provided for zero setting.

iii) Using the standard turbid solution (i.e. 40 NTU), calibrate the Nephelometer (i.e. adjust the Nephelometer reading to 40 NTU using calibration knob).

OBSERVATIONS:-

S.No	SAMPLE	NTU

b) Determination of turbidity of sample water:

i) For samples having turbidities less than 40 NTU: Thoroughly shake the sample so as to remove any air bubbles and pour it into meter cell. Read out the turbidity of the sample from the digital display.

ii) For samples having turbidities above 40 NTU: Dilute sample with 1,2 or 3 volumes of turbidity free water and convert the value obtained as below.

If five volumes of turbidity free water were added to one volume of sample and the diluted sample showed a turbidity of 30 NTU, then the actual value is equal to 180 units. i.e.

Nephelometric turbidity units (NTU) = $(A (B + C)) / C$

Where

A = Turbidity found in diluted sample,
B = Volume of dilution water in ml
C = Sample volume for dilution in ml.

RESULTS: -

Ex.No: 3 Determination of fluoride in water by spectrophotometric method

Aim

To Determine the quantity of iron present in the given sample of water by spectrophotometric method

Apparatus

- Spectrophotometer (set at **570 nm**)
- Cuvettes (1 cm path length)
- Volumetric flasks (10, 25, 50, 100 mL)
- Pipettes and burettes
- Beakers, wash bottle

Reagents

1. **SPADNS Reagent**
    - Prepared by dissolving SPADNS dye in distilled water and filtering.
2. **Zirconyl–Acid Reagent**
    - Zirconyl chloride + concentrated HCl + distilled water.
3. **Color Reagent (SPADNS–Zirconyl Complex)**
    - Mix SPADNS reagent and zirconyl–acid reagent in correct proportion (usually 1:1).
4. **Fluoride Standard Solution (100 mg/L F^-)**
    - Prepare from dried sodium fluoride (NaF).
5. **Diluted Working Standards**
    - Typically prepare standards of 0, 0.2, 0.5, 1.0, 1.5, 2.0 mg/L F^-.
6. **Distilled or deionized water**

Sample Preparation

- Collect water in clean polyethylene bottles.
- If residual chlorine is present, neutralize with a tiny amount of sodium thiosulfate.
- Bring sample to room temperature.
- If sample contains turbidity, filter through Whatman filter paper.

Procedure

A. Preparation of Calibration Curve

1. Pipette **50 mL** of each fluoride standard into labeled volumetric flasks.
2. Add **10 mL** of SPADNS–Zirconyl color reagent to each.
3. Mix thoroughly.
4. Let stand for **10 minutes**.
5. Measure absorbance at **570 nm** using a spectrophotometer.
6. Plot **Absorbance vs. Fluoride concentration (mg/L)** to make a calibration curve.

B. Determination in Water Sample

1. Measure **50 mL** of sample into a volumetric flask.
2. Add **10 mL** of SPADNS–Zirconyl color reagent.
3. Mix well and allow to stand for **10 minutes**.
4. Read the **absorbance at 570 nm**.
5. Determine fluoride concentration using the calibration curve or instrument display.

OBSERVATION

SAMPLE TAKEN	CONCENTRATION	ABSORBANCE

Calculation

Fluoride (mg/L) = (mg F determined photometrically / mL sample used) x 1000 x B / C

The ratio B/C applies only when a sample is diluted to a volume B and a portion C taken from it for colour development.

<table>
<tr><th colspan="4">Preparation of Fluoride standard solutions
(Fluride stock solution 1mL = 10 µg F (Final Volume : 50mL)</th></tr>
<tr><td>F Stock Solution in mL</td><td>F Stock Solution in mL</td><td>F Stock Solution in mL</td><td>F Stock Solution in mL</td></tr>
<tr><td>F in µg</td><td>F in µg</td><td>F in µg</td><td>F in µg</td></tr>
<tr><td>Distilled Water in mL</td><td>Distilled Water in mL</td><td>Distilled Water in mL</td><td>Distilled Water in mL</td></tr>
<tr><td>F conc, mg F/L</td><td>F conc, mg F/L</td><td>F conc, mg F/L</td><td>F conc, mg F/L</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>10</td><td>10</td><td>10</td><td>10</td></tr>
</table>

Result

The amount of Fluoride present in given sample is

Ex. No: 4 DETERMINATION OF IRON (DEMO)

Date:

Aim

To Determine the quantity of iron present in the given sample of water using 1, 10 - phenanthroline method

APPARATUS:

1. Nessler tube
2. Measuring cylinder
3. Dropper

REAGENTS:

1. Hydrochloric acid
2. Potassium permanganate solution
3. Potassium thiocyanate solution
4. Standard iron solution

THEORY:

Iron may be present in two forms, namely the reduced form (ferrous, Fe2+) and the fully oxidized form (ferric, Fe3+). Ferric iron is seldom found in true solution in natural waters, unless they are highly acidic, because of the formation of insoluble ferric hydroxides. Ferrous iron is more likely to be found in true solution, although it is easily oxidized to the ferric state and precipitated in alkaline waters as ferric hydroxide.

Since some iron may exist as iron hydroxide precipitates, therefore it is necessary to bring precipitated form(s) of iron back in 'to solution before oxidizing total iron content in water. For this hydrochloric acid is added to the test sample to dissolve the insoluble ferric forms.

For determination of total iron by the following procedure, it must be ensured that all iron exists in ferric form (Fe3+). This is most readily accomplished by using potassium permanganate, an oxidizing agent.

$$5Fe^{2+} + MnO_4^{-} + 8H^{+} = 5\ Fe^{3+} + Mn^{2+} + 4H_2O$$

Ferric iron is determined by producing a red-colored iron compound, ferric thiocyanate, by the addition of potassium thiocyanate

$$Fe3+ + 3\ KCNS = Fe(CNS)3 + 3\ K^{+}$$

The quantity of ferric iron is determined by comparison with the red color produced by standard iron solutions.

ENVIRONMENTAL SIGNIFICANCE:

As far as is known, human suffer no harmful effects from drinking waters containing iron and manganese. Such waters, when exposed to the air so that oxygen can enter, become turbid and highly unacceptable from the aesthetic' viewpoint owing to the oxidation of iron and manganese to the Fe3+, and Mn4+ states which form colloidal precipitates. The rates of oxidation are not rapid, and thus reduced forms can persist for some time in aerated waters. This is especially true when the pH is below 6 with iron oxidation and below 9 with manganese oxidation. The rates may be increased by the presence of certain inorganic catalysts through the action of microorganisms. Both iron and manganese interfere with laundering operations, impart objectionable stains to plumbing fixtures and cause difficulties in distribution systems by supporting growths of iron bacteria. Iron also imparts a taste to water, which is detectable at very low concentrations.

PROCEDURE:

1. Place 100 mL of the water sample in a Nessler.
2. Add 5 mL of dilute hydrochloric acid
3. Add two drops of potassium permanganate solution
4. Add 5 mL of potassium thiocyanate solution. The solution would turn brown if iron is present.
5. Compare the brown color formed with the standard prepared as follows:
    a. Add 100 mL of distilled water in a Nessler tube
    b. Add 5 mL of the dilute hydrochloric acid.
    c. Add two drops of potassium permanganate solution.
    d. Add 5 mL of potassium thiocyanate solution.
    e. Add 0.2 mL at a time of the standard iron solution until the color of the standard and the sample match.

CALCULATION:

Total iron concentration of test sample (mg/L) =
(Standard iron solution added in distilled water (mL) x Conc. of standard iron solution(mg/L)) / mL of sample taken.

Sample No.	Source of Sample	Temperature of Sample (^oC)	Total iron Concetntration (mg/L)

RESULT:

1. The quantity of ferrous iron present in the given sample is __ppm.
2. The quantity of Total Iron present in the given sample is ____ppm.
3. The quantity of Ferric Iron present in the given sample is____ppm.

Ex.No:5 Determination of Sulphate in water

Date:

Aim:

To find the amount of Sulphates present in the given water sample.

Apparatus Required:

Conical Flask, Watt-man filter paper (No 42), crucibles, Measuring Jar, Beaker.

Principle:

Sulphate is precipated as Barium sulphate in the hydrochloric acid medium by the addition of Barium Chloride solution. The reaction is carried out near the boiling temperature. The precipitate is filtered and then washed to remove the chlorides and ignited and weighed as Barium Sulphate.

Many substances interfere in performing this test. Suspended matter, silica, Nitrate and sulphate lead to the positive errors where the results are on the higher side. Alkali metal sulphates causes the low results. Presence of other metals such as iron and chromium also yield low results due to the formation of metal sulphate.

Reagents:

1. Methyl orange Indicator
2. Barium chloride solution
3. Concentrated Hydrochloric acid.

Procedure:

1. Take 100 ml of sample in a conical flask. Add 2 drops of Methyl orange Indicator to the sample. Adjust pH between 4.5 – 5 by adding few drops of conc Hcl until the colour changes to pink.

2. Add 1 ml of Conc.Hcl heat at 40^0 C until vapour appears and add Barium chloride Solution until the precipitate forms. This precipitate is heated at 90^0 C allowing it to boil for 1 hour. Filter it, wash the precipitate with distilled water and filter it with dry ash less filter paper and ignite it in a crucible at 500-800^0 C for 1 hour.

3. Cool it in desiccator and weigh the precipitate of Barium sulphate.

Tabulation:

Sl.No	Description	Weight of crucible		Sulphates
		Empty weight (g)	Empty weight (g) + Filtrate	

Calculation:

$$\text{Amount of Sulphate} = \frac{\text{Mg. of Sulphate} \times 411.5}{\text{ml of Sample}}$$

Result:

The amount of Sulphates present in the given water sample is ----------------

Inference:

The presence of sulfate in drinking-water can also result in a noticeable taste; the lowest taste threshold concentration for sulfate is approximately 250 mg/litre as the sodium salt. Sulfate may also contribute to the corrosion of distribution systems.

Ex.No: 6 Determination of Optimum Coagulant dosage by Jar test apparatus.

Date:

Aim:

To find out the optimum coagulant required to precipitate turbid particles present in the water.

Apparatus Required:

Jar test apparatus, Beakers, Turbid water, alum, pipettes.

Principle:

Metal salts hydrolyse in the presence of the natural alkalinity to form metal hydroxides. The divalent cation can reduce the zeta potential while the metal hydroxides are good absorbents and hence remove the suspended particles by enmeshing them.

Reagents:

Alum solution

Procedure:

1. 200 ml of water sample is taken in each jar. Increasing dose of alum solution is added to each jar i.e., 2,4 and 6…ml and stirred at maximum speed for 1 min. Then stirred slowly for 15 min and allowed to stand for 15 min.
2. The jars are observed and the settling of sediments is noted. The quality of alum added to the jar containing the clearest solution is noted.
3. Take the sample out of the beaker and test for turbidity in each trial. Plot the curve on x and y axis of the graph sheet.
4. Take the alum dosage in ml along x-axis and turbidity along y-axis

Tabulation:

Sample detail/Jar No	Dosage of Coagulant (ml)	Residual Turbidity in NTU

Result:

The optimum dosage of coagulant required to remove turbidity in the given water sample is_______________ml of alum.

Ex.No:7A Determination of available chlorine in bleaching powder

Date:

Aim:

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

Apparatus Required:

Conical flask, Burette, Pipettes .

Principle:

Chlorine is a strong oxidizing agent and liberates Iodine from Iodide ions.

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

Starch gives blue colour with Iodine i.e.,

I_2 + starch $\longrightarrow$ Blue Colour

The liberated Iodine is titrated against standard Sodium Thiosulphate-reducing agent

$I_2 + 2Na_2S_2O_2 \longrightarrow Na_2S_4O_6\ 2NaI$

The disappearance of blue colour indicates the completion of reaction with free iodine converted black to iodine.

Reagents:

1. Conc.Acetic Acid
2. Potassium Iodide Crystals
3. Sodium Thiosulphate, 0.025N
4. Starch Indicator

Procedure:

1. 1 gm of fresh bleaching powder is taken and is added to a small quantity of water and made into a fine paste. Some more water is added, stirred well and allowed to settle for a few minutes. It is diluted with distilled water to make upto 1 L and the container is stoppered.
2. 25 ml of the bleaching powder solution is taken in a conical flask and a pinch of Potassium Iodide is added.
3. 2 ml of acetic acid is added and is allowed for the reaction to complete.
4. 1 ml of starch solution is added and the titration is continued till the disappearance of blue colour.

Tabulation:

Sl.No	Volume of water sample (ml)	Burette Reading (ml)		Concurrent Burette Reading (ml)	Volume of Sodium Thiosulphate (ml)
		Initial Reading	Final Reading		

Calculation:

$$\text{Concentration of chlorine, mg/l} = \frac{(V_1\text{-}V_2) \times \text{Normality of titrant} \times 1000 \times \text{Eq.wt of chlorine}}{\text{Volume of Sample}}$$

$$\text{Percentage of chlorine} = \frac{\text{Concentration of chlorine} \times 100}{12}$$

Result:

1. The available chlorine in the given sample of bleaching powder is = ------------- mg/l
2. Percentage of chlorine content in bleaching powder is = ---------------------

Inference:

If the bleaching powder consisted wholly of Ca(OCl)Cl it contains 55% of available chlorine—that is, chlorine which can be liberated by treatment with dilute acid; but the commercial variety generally contains other substances, and does not yield more than 36% available chlorine.

Ex.No:7B Determination of residual chlorine in bleaching powder

Date:

Aim:

To find the amount of residual chlorine present in the given water sample.

Apparatus Required:

Burette, Conical flask, Pipette, Measuring jar.

Principle:

Chlorine is primarily added to the water for destroying the harmful micrororganisms. Presence of excess chlorine intensifies the taste and odour of any other compounds in combination with ammonia.

Chlorine is a strong oxidizing agent and liberates Iodine from Potassium Iodide. The liberated Iodine is equivalent to the amount of chlorine and can be titrated against Sodium thiosulphate using starch as an indicator.

Reagents:

1. Acetic Acid
2. Potassium Iodide
3. Sodium Thiosulphate, 0.025N.

Procedure:

1. Take 100ml water sample in a conical flask and add 5ml acetic acid. The pH after addition of acetic acid should be between 3 and 4.
2. Add approximately 1 gm of KI crystals and mix thoroughly with a stirring rod for about 15 minutes keeping it away from the direct sunlight.
3. Add a few drops of starch indicator and titrate against 0.025N sodium thiosulphate until the contents turn colourless from blue.

Inference:

Residual chlorine is the low level amount of chlorine remaining in the water after a certain period or contact time after its initial application. It constitutes an important safeguard against the risk of subsequent microbial contamination after treatment—a unique and significant benefit for public health.

Tabulation:

Sl.No	Volume of water sample (ml)	Burette Reading (ml)		Concurrent Burette Reading (ml)	Volume of Sodium Thiosulphate (ml)
		Initial Reading	Final Reading		

Calculation:

$$\text{Residual chlorine ,mg/l} = \frac{\text{ml of titrate X Normality of Titrate X 1000 X Eq.wt of chlorine}}{\text{Volume of Sample}}$$

Result:

The amount of residual chlorine present in the given water sample is ----------------

Ex.No:8A Determination of Alkalinity in water sample

Date:

Aim:

To determine the Alkalinity present in water sample

Theory:

Alkalinity of water is its quantitative capacity to neutralize a strong acid to a designated pH. Alkalinity is significant in many uses and in treatment of natural acid and wastewater. It is significant in determining suitability of water for drinking as well as irrigation purpose. Alkalinity measurements are used in interpretation and control of water and wastewater treatment process. Alkalinity is primarily due to salts of weak acids and bicarbonates. Major part of alkalinity is because of the action of Carbon dioxide on basic materials.

Environmental Significance:

- Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes. Higher alkalinity levels in surface waters will buffer acid rain and other acid wastes and prevent pH changes that are harmful to aquatic life.
- 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 in waters. The resultant precipitate can corrode pipes and other accessories of water distribution systems.
- Wastewaters containing excess caustic (hydroxide) alkalinity are not to be discharged into natural water bodies or sewers.
- Alkalinity as carbonate and bicarbonate of saline water is very important in tertiary recovery processes for recovering petroleum. Alkaline water offers better wetting to the formation rock and improve oil release. As an additional benefit, ions that provide alkalinity absorb on rock surfaces occupying adsorption sites and decrease the loss of recovery chemical by adsorption.
- The alkalinity value is necessary in the calculation of carbonate scaling tendencies of saline waters.
- The alkalinity acts as a pH buffer in coagulation and lime-soda softening of water.
- In wastewater treatment, alkalinity is an important parameter in determining the amenability of wastes to the treatment process and control of processes such as anaerobic digestion, where bicarbonate alkalinity, and any fraction contributed by volatile acid salts become considerations.

Apparatus:

Titration Stand with Burette, Conical Flask, Beaker, Measuring Cylinder, Pipette, Funnel, Wash Bottle etc.

Observation:

1. Titrant :
2. Indicators : Phenolphthalein and Methyl Orange Indicator
3. End Point : a) Pink to Colourless
   b) Yellow to Faint Orange Color

Table: 1 Phenolphthalein Alkalinity: (Phenolphthalein Indicator)

S.No	Volume of sample ml (V)	Burette Reading(ml)		Volume of H_2SO_4 (ml) (A)
		Initial	Final	

Table: 2 Methyl orange Alkalinity: (Methyl orange Indicator)

S.No	Volume of sample ml (V)	Burette Reading(ml)		Volume of H_2SO_4 (ml) (B)
		Initial	Final	

Calculations:

$$\text{Phenolphthalein Alkalinity as } CaCO_3 \text{ in mg/L} = \frac{\text{Volume of } H_2SO_4 \text{ (A)} \times N \times 50 \times 1000}{V}$$

$$\text{Methyl orange Alkalinity as } CaCO_3 \text{ in mg/L} = \frac{\text{Volume of } H_2SO_4 \text{ (B)} \times N \times 50 \times 1000}{V}$$

$$\text{Total Alkalinity as } CaCO_3 \text{ in mg/L} = \frac{\text{Volume of } H_2SO_4 \text{ (A)} + \text{(B)} \times N \times 50 \times 1000}{V}$$

Reagents:

- 0.02N H_2SO_4:3 ml. Conc. H_2SO_4 in 1 L distilled water to get 0.01 N H_2SO_4. Take 100 ml of 0.01 N H_2SO_4 + 500 ml distilled water

- Phenolphthalein Indicator: Dissolve 0.5 gm of Phenolphthalein Indicator in 500 ml 95% of ethyl alcohol. Add 500 mL distilled water.

- Methyl orange Indicator: Dissolve 0.5 g of Methyl orange Indicator & dilute to 1000 ml with distilled water.

Procedure:

A. Phenolphthalein Alkalinity:

1. Take suitable volume of sample (25, 50 or 100 ml) in a conical flask. Add 2-3 drops of phenolphthalein indicator.
2. If the sample turns pink in colour, then titrate with 0.02 NH_2SO_4, till the pink colour disappears. Note the volume of acid required as (A).
3. If the pink colour does not exist it indicates that, phenolphthalein Alkalinity is absent. Then continue the titration with Methyl Orange indicator

B.Methyl Orange Alkalinity:

1. Add 2-3 drops of methyl orange to the same flask; continue titration till colour becomes orange. Note down volume of H_2SO_4 consumed as 'B'.

2. If there is no pink colour after adding phenolphthalein, continue according to step 3.

   Calculate alkalinity in mg/l

Alkalinity Relationship (P and T)

The values obtained from Phenolphthalein and Total alkalinity determination for a given sample of water are used to estimate three forms of alkalinity shown below.

Results of Titration	**Hydroxide Alkalinity/Caustic Alkalinity as CaCO3**	**Carbonate Alkalinity as CaCO3**	**Bicarbonate Alkalinity as CaCO3**
P=0	P=0	P=0	M
P= ½ M	0	2P	0
P= M	P= M	0	0
P<1/2 M	0	2P	M-2P
P>1/2 M	2P-M	2M-2P	0

Where: P: Phenolphthalein Alkalinity, T: Total Alkalinity

Result:

Sample Used			
Phenolphthalein Alkalinity (mg/L)			
Methyl Orange Alkalinity (mg/L)			
Total Alkalinity (mg/L)			
Hydroxide Alkalinity			
Carbonate Alkalinity			
Bicarbonate Alkalinity			

Inference:

High alkalinity waters may also have a distinctly flat, unpleasant taste. Based on the testing, it is found that the alkalinity of the sample is_mg/L. As per the provisional code, alkalinity should not exceed 200 mg/L for potable water. For the fresh water alkalinity ranges between 20 – 100 mg/L. Alkalinity of tested sample is within/exceeding the limits specified in the standards. Hence the water sample is fit /unfit for drinking.

Ex.No:8B Determination of Acidity in water sample

Date:

Aim:

To determine the acidity present in water & Wastewater sample

Theory:

Acidity of water is its quantitative capacity to neutralize a strong base to a designated pH. Acidity of water is significant in many water supply systems, because acidity influences certain chemical and biological process in water. Acidity of water is due to Hydrogen ions (H+) present in a sample of water. As a result, dissociation of Hydrogen ions is neutralized by titration with standard solution of a strong base in presence of an indicator. Dissolved Carbon dioxide is usually the major acidic component of surface water. Acidity is usually determined by titration with 0.02N solution of Sodium Hydroxide. The amount of Sodium Hydroxide required for the sample to reach the pH 4.5 in a measure of Methyl orange acidity and amount to reach pH 8.3 is a measure of total acidity.

Environmental Significance:

- Acidity is interferes in the treatment of water. Carbon dioxide is of important considerations in determining whether removal by aeration or simple neutralization with lime / lime soda ash or NaOH will be chosen as the water treatment method.
- The size of the equipment, chemical requirements, storage spaces and cost of the treatment all depends on the carbon dioxide present.
- Aquatic life is affected by high water acidity. The organisms present are prone to death with low pH of water.
- High acidity water is not used for construction purposes. Especially in reinforced concrete construction due to the corrosive nature of high acidity water.
- Water containing mineral acidity is not fit for drinking purposes.
- Industrial wastewaters containing high mineral acidity is must be neutralized before they are subjected to biological treatment or direct discharge to water sources.

Apparatus:

Titration Stand with Burette, Conical Flask, Beaker, Measuring Cylinder, Pipette, Funnel, Wash Bottle etc

Reagents:

- 0.02 N NaOH Solution: Dissolve 0.8 grams of NaOH in 1 liter of distilled water.
- Phenolphthalein Indicator: Dissolve 0.5 gm of Phenolphthalein Indicator in 500 ml .95% of ethyl alcohol. Add 500 ml distilled water.
- Methyl orange Indicator: Dissolve 0.5 g of Methyl orange Indicator & dilute to 1000 ml with distilled water

Observation:

1. Titrant:
2. Indicators: Phenolphthalein and Methyl Orange Indicator
3. End Point:

a) Yellow to Faint Orange

b) Colorless to Faint Pink Color

Table: 1 Mineral Acidity: (Methyl Orange Indicator)

S.No	Volume of sample ml(V)	Burette Reading(ml)		Volume of NaOH (ml)(A)
		Initial	Final	

Table: 2 Phenolphthalein Acidity: (Phenolphthalein Indicator)

S.No	Volume of sample ml (V)	Burette Reading(ml)		Volume of NaOH (ml) (B)
		Initial	Final	

Calculations:

Mineral Acidity as $CaCO_3$ in mg/L= $\dfrac{\text{Volume of NaOH (A)x N x 50 x 1000}}{V}$

Phenolphthalein Acidity as $CaCO_3$ in mg/L= $\dfrac{\text{Volume of NaOH (B) x N x 50 x 1000}}{V}$

Total Acidity as $CaCO_3$ in mg/L= $\dfrac{\text{Volume of NaOH (A) + (B) x N x 50 x 1000}}{\text{ml of sample}}$

Procedure:

A. Methyl Orange Acidity

i. Take suitable volume of sample (25, 50 or 100 ml) in a Conical flask. (V)

ii. Add 2 drops of methyl orange and see the colour. If color turns yellow, methyl orange acidity is absent. If colour turns orange, titrate with 0.02 N NaOH till colour changes to faint orange. Characteristic of pH 4.3-4.4. Note the volume of NaOH required (A).

B. Phenolphthalein Acidity

i. Take suitable volume of sample (25, 50 or 100 ml) in a Conical flask. (V)

ii. Add 2-3 drops of phenolphthalein indicator, If the sample turns pinks color it means that, phenolphthalein acidity is absent and stop the experiment.

iii. If there is no color change, titrate with 0.02N Standard NaOH solution till faint pink color appears indicating pH 8.3. The end point is colorless to faint pink color. Note additional volume of NaOH required (B).

Results:

Sample Used	Mineral Acidity (mg/L)	Phenolphthalein Acidity (mg/L)	Total Acidity (mg/L)

Inference:

Total Acidity/Phenolphthalein Acidity measures the neutralizing effects of essentially all the acid species present both strong and weak.

Methyl orange acidity primarily measures acidity due to dissolved CO_2 and other weak acids that are present.

Strong Mineral Acids contribute to the mineral acidity whereas weak acids such as carbonic acid, acetic acid present in the water contributes to Phenolphthalein Acidity.

Ex.No: 9 Determination of Suspended, Volatile and Fixed solids

Date:

Aim:

To determine the amount of total solids, suspended solids and dissolved solids in given sample.

Apparatus and equipment:

a) Electrically heated temperature controlled oven
b) Weighing balance
c) Evaporating dish
d) Pipettes
e) Measuring cylinder (100mL)
f) Muffle furnace
g) Whatmann filter paper (No. 42)

Introduction:

The term 'solid' refers to the matter either filtrable or non-filtrable that remains as residue upon evaporation and subsequent drying at a defined temperature. Further categorisation depends upon depends upon the temperature employed for drying and ignition. Different forms of solids are defined on the basis of method applied for their determination. Solids may affect water or effluent quality adversely in number of ways. Water with high dissolved solids may include an unfavourable physiological reaction in the transient consumer and generally are of inferior palatability. Highly mineralized waters are unsuitable for many industrial applications. High suspended solids in waters may be aesthetically unsatisfactory for such purposes as bathing. Analysis of total solids are important to decide upon the various unit operations and processes in physical and biological wastewater treatment and to assess its performance evaluation. For assessing compliance with regulatory agency, wastewater effluent limitations for various forms of solids act as indicating parameters.

A. Total solids

Principle

Residue left after the evaporation and subsequent drying in oven at specific temperature 103-105°C of a known volume of sample are total solids. Total solids include "Total suspected solids" (TSS) and "Total dissolved solids" (TDS). Whereas loss in weight on ignition of the same sample at 500°C, in which organic matter is converted to CO2 volatilisation of inorganic matter as much as consistent with complete oxidation of organic matter, are volatile solids.

Sample collection, preservation and storage

The water samples may be collected in resistant glass or plastic bottle. Water has considerable solvent property. There is possibility of increase in mineral content of sample, if water is collected and stored in non-resistant glass bottle. The effect is pronounced with alkaline water. Exclude particles such as leaves, sticks, fish and lump of feacal matter in the sample. Begin analysis as soon as possible due to impracticality of preservation of sample.

Procedure

1. Take the empty weight of the thoroughly cleaned dish.(W_1)
2. Take 20 ml of a well-mixed sample in the same dish.
3. Evaporate the sample to dryness at 103-105°C in hot air oven.(4-5h)
4. Cool in desiccator, weigh and record the reading (W_2)
5. Take the same crucible and ignite the dish for 30 minutes in a muffle furnace maintained at 550°C.
6. Cool the dish in a desiccator and record final weight (W_3).
7. The concentration is to be calculated in percent by weight.

Procedure for dissolved solids

1. Take the empty weight of the dish (W_4)
2. Take 25 ml of sample and filter it using whatmann filter paper (No. 42) using the filtration assembly.
3. Pour the filtrate into the dish and . Evaporate the sample to dryness at 103-105°C in hot air oven.(4-5 h).
4. Cool in desiccator, weigh and record the reading (W_5)

Procedure for settleable solids

1. Fill an Imhoff cone to the H mark with a well-mixed sample.
2. Settle for 45-min, gently agitate sample near the sides of the cone with a rod or by spinning, settle 15 min longer, and record volume of settleable solids in the cone as mL/L.
3. If the settled matter contains pockets of liquid between large settled particles, estimate volume of these and subtract from volume of settled solids.
4. The practical lower limit of measurement depends on sample composition and generally is in the range of 0.1 to 1.0 mL/L. where a separation of settleable and floating materials occurs, do not estimate the floating material as settleable matter.
5. Replicates usually are not required.

Observation:

S.No	Details	Notations	Weight(g)
1	**Weight of empty crucible**	**W1**	
2	**Weight of crucible with water sample after ovendrying**	**W2**	
3	**Weight of crucible with water sample after taking it from muffle furnace.**	**W3**	
4	**Weight of empty crucible**	**W4**	
5	**Weight of crucible with filtrate after ovendrying**	**W5**	

Calculation:

Total solids (**TS**) = (w_2-w_1)*1000/volume of sample
Total dissolved solids (**TDS**)= (w_5-w_4)*1000 /volume of sample
Total suspended solids (**TSS**) = **TS-TDS**
Total fixed solids (**TFS**) = (w_3-w_1) / volume of sample
Total volatile solids = (**TVS**) = **TS- TFS** =

Results:

The solids present in the given wastewater are reported below

1. Total solids =
2. Dissolved Solids =
3. Suspended solids =
4. Fixed solids =
5. Volatile solids =

Inference:

Water can be classified by the amount of TDS per litre:

- Fresh water < 1500 mg/l TDS
- Brackish water = 1500 to 5000 mg/l TDS
- Saline water > 5000 mg/l TDS

Ex.No: 10 Determination of Sludge Volume Index in waste water

Date:

Aim:

To determine Sludge Volume Index in waste water

Sludge Volume Index (SVI)

Sludge volume index is a common measurement that we use to determine sludge quality. In wastewater treatment processes, a good quality sludge will generally produce a good quality effluent. SVI takes into consideration the mixed liquor suspended solids concentration (MLSS) and the volume that a certain amount of sludge takes up. Generally, a good quality sludge has an SVI in the range of 50-150 mL/gram.

Apparatus Required:

Measuring Cylinder**,** Distilled water**,** Whatman filter paper, Funnel, Hot air oven.,Weighing Balance

Procedure:

(A) Measurement of Sludge Volume Index

In order to calculate sludge volume index (SVI), you will need two numbers. The first number comes from a 30-minute settleability test, where 1 liter of the mixed liquor sample from the aeration tank is poured into a container called a settleometer. The sludge is allowed to settle for 30 minutes, and the volume of the settled sludge is measured in mL/L.

(B) Measurement of MLSS

The other number used in the sludge volume index (SVI) calculation comes from a MLSS test. It simply determines the suspended solids concentration of the sample from the aeration tank, in mg/L.

1. Take a Whatman filter paper and make it as a cone shaped. Keep it in oven for drying. Then measure the initial weight of the filter paper(W_i).

2. Take a funnel and keep it on the measuring cylinder. Then place the dried filter paper in the funnel. Now pour the 25 ml sample in the filter paper. Allow it to settle for 10-15 min.

3. Keep the filter paper with residue in the hot air oven for 2 hrs @ 100^{o}C.After cooling measure the final weight of the filter paper(W_f).

Sludge volume index (SVI) is calculated by dividing the settleability by the MLSS concentration. The SVI is always expressed in mL/g. Finally the microscopic examination is to be done for SVI.

Calculation:

$$\text{SVI (mL/g)} = \frac{(\text{Settled sludge volume mL/L})\text{x}(1000\text{mg/g})}{(\text{MLSS mg/L})}$$

$$\text{MLSS (g/L)} = \frac{(W_f - W_i)}{\text{Volume of sample}}$$

$$\text{MLSS (mg/L)} = \frac{(W_f - W_i) \text{ x } 10^6}{\text{Volume of sample}}$$

Results:

The SVI of given Biological sludge is_______.

Interpreting Results:

The higher the SVI, the slower the sludge settles. If the sludge is settling too slow, this can result in loss of suspended solids over the clarifier weirs. If the SVI settles too quickly, and the SVI is <50 this can be due to pin floc, which is commonly (but not always) caused by old sludge. It is recommended to perform the SVI test every day. It is beneficial to determine the SVI for 30 minute as well as occasionally for 60 minute settling. The majority of the settling should occur within the first 30 minutes. If there is a change in your SVI, it is recommended to perform a microscopic evaluation to determine the cause. It is also useful to leave the settled sludge in the container and observe if there is a rise time, in which the sludge floats. This indicates denitrification. If the rise time is <2 hours, there is risk of floating sludge in the clarifier and steps need to be taken to reduce nitrate, BOD, and increase oxygen going into the clarifier.

Ex.No:11 & 12 Determination Dissolved Oxygen and BOD for the given sample

Date:

Aim:

To determine the BOD in the given wastewater sample.

Apparatus Required:

BOD incubator BOD bottle (300ml)

Principle:

If sufficient oxygen is available in wastewater, the useful aerobic bacteria will flourish and cause the aerobic biological decomposition of wastewater which will continue until oxidation is completed.

The amount of oxygen consumed in this process is the BOD. Polluted waters will continue to absorb oxygen for many months, and it is not practically feasible to determine this ultimate oxygen demand.

Chemicals Required:

1.Sodium Hydroxide
2.Manganous Sulphate
3.Potassium iodide
4.Sodium thiosulphate
5.Conc.H_2SO_4
6.Starch

Reagent Preparation:

1.ManganousSulphate: 12 g of ManganousSulphate is dissolved in 25ml of distilled water.

2.Alkali-Iodide Azide Solution 9 g of Sodium Hydroxide and 2.5 g of Potassium iodide are dissolved in 25ml of distilled water.

3.Sodium thiosulphate Solution (0.025 N) 6.2 g of Sodium thiosulphate is dissolved in 1 litre of water.

4.Starch Solution: Take 1 gm of starch. Prepare paste with distilled water. Make 100 ml with water and boil by stirring and cool it.

Procedure:

1.Distilled water is aerated for 4 hours to attain saturated Dissolved Oxygen (DO) level. In distilled water 1 ml of each nutrients (Phosphate buffer, Magnesium Sulphate, Calcium Chloride and Ferric Chloride) and 1 ml of pre-acclimatized seed per 1 litre of distilled water is added.

2.Two BOD bottles are taken. The wastewater sample 1 ml is taken in the BOD bottles and the aerated water is filled. DO test is conducted for the one BOD bottle sample by
the following steps and initial DO is noted.

3.Distilled water is aerated for 4 hours to attain saturated Dissolved Oxygen (DO) level. In distilled water 1 ml of each nutrients (Phosphate buffer, Magnesium Sulphate, Calcium Chloride and Ferric Chloride) and 1 ml of pre-acclimatized seed per 1 litre of distilled water is added.

4.Two BOD bottles are taken. The wastewater sample 1 ml is taken in the BOD bottles and the aerated water is filled. DO test is conducted for the one BOD bottle sample by the following steps and initial DO is noted

5.1 ml of Manganese Sulphate solution is added, followed by 1 ml of Alkali Iodide Azide reagent. Then the bottle is mixed twice and allowed to precipitate settle.

6.1 ml of Sulphuric Acid is added and mixed twice. 200 ml of sample is taken and titrated against Sodium thiosulphate solution with starch indicator.

7.Disappearance of blue colour is taken as end point. Volume of Sodium thiosulphate consumed is noted.

8.Another bottle is placed in incubator at 20º C. After 5 days DO test is conducted and final DO is noted.

CALCULATION

DO Calculation

Sodium thiosulphate Vs given sample

S.No	Volume of given sample (ml)	Burette reading (ml)		Indicator	End point
		Initial	Final		

Calculation:

DO in (mg/l) = (V_2 x N x 8 x 1000)/V1

V1 = Volume of water sample in ml.

V2 = Volume of Sodium thiosulphate consumed in ml.

N = Normality of Sodium thiosulphate

Initial DO

Final DO

BOD Calculation

BOD_5 (mg/L) = [(Initial DO – Final DO) x dilution factor]

Where

$$\text{Dilution factor} = \frac{Volume of diluted sample}{Volume of wastewater sample added}$$

Result:

BOD_5 of given sample at 20°C = mg/l

Inference:

BIS Standard of wastewater effluent BOD to be discharged on land for irrigation purpose is 500 mg/l. The amount of BOD obtained at 20°C is .So, this wastewater can/cannot be used for irrigation purpose.

Ex.No: 13 Determination of COD for given sample

Date:

Aim:
To determine the chemical oxygen demand (COD) exerted by the given waste water sample.

Apparatus Required:
Reflux Apparatus, Burette, Hot plate/Heating mantle

Principle:
The organic matter present in sample gets oxidized completely by $K_2Cr_2O_7$ in the presence of H_2SO_4 to produce CO_2 and H_2O. The excess of $K_2Cr_2O_7$ remaining after the reaction is titrated with Fe $(NH_4)_2$ $(SO_4)_2$. The dichromate consumed gives the oxygen required for the oxidation of organic matter.

Reagents:

1.Standard Potassium Dichromate 0.2N

2.Sulphuric Acid with reagent (Conc.$AgSo_4$ + H_2SO_4)

3.Std.Ferrous Ammonium Sulphate (0.1N)

4.Ferroin Indicator

5.Mercuric Sulphate

6.Silver Sulphate

Procedure:

1. 1.Take 10 ml of sample.
2. 5ml of more Conc Dichromate solution are placed in a flask together with glass beads.
3. Add slowly 15 ml of H_2SO_4 containing $AgSo_4$ and mix thoroughly.
4. Add pinch of mercurous sulphate ($Hgso_4$) and silver sulphate (Ag_2So_4).
5. Connect the flask to condenser. Mix the contents thoroughly before heating. Improper mixing may result in bumping and the sample may be blown out.
6. Reflux for a minimum period of 2 hours. Cool and wash down the condenser with distilled water.
7. Dilute the sample to make up to 40 ml with distilled and cool.
8. Add 2-3 drops of Ferroin indicator. Mix thoroughly and titrate it against 0.1N
9. Fe $(NH_4)_2$ $(SO_4)_2$. Sharp colour changes from blue-green to wine red indicate the end point.
10. Reflux the blank solution in the same manner using distilled water instead of sample.

Tabulation:

Sl.No	Volume of water sample (ml)	Burette Reading (ml)		Concurrent Burette Reading (ml)	Volume of FAS (ml)
		Initial Reading	Final Reading		

Calculation:

Quantity of Fe $(NH_4)_2$ $(SO_4)_2$ added for blank (A) =

Quantity of Fe $(NH_4)_2$ $(SO_4)_2$ added for sample (B) =

$$\text{Chemical Oxygen Demand (COD)} = \frac{(A-B) \times N \times 8 \times 1000 \times \text{Dilution factor}}{\text{Volume of Sample}}$$

Result:

The COD for the given water sample is -----------

Inference:

The BIS standard for COD of wastewater effluent to be discharged into marine coast is 250 mg/l. The amount of COD obtained in the given sample is .So; this water can/cannot be disposed in the marine coast.

Ex.No: 14 Determination of Ammonia Nitrogen In Wastewater

Date:

Aim

To determine the amount of Ammonia Nitrogen present in the given sample.

Principle

Ammonium ion reacts with Nessler's reagent (K_2HgI_4) to form a brown colour substance, and can be determined colorimentically. Most of the natural water sand wastewater shave interfering substances, therefore, the steam distillation of ammonia becomes essential.

Apparatus required

1. Measuring jar
2. Conical flask
3. Burette
4. Pipette

Reagents

1. Phosphate buffer solution
2. Boric acid
3. Methyl orange indicator
4. Sulphuric acid 0.02N (1 ml contains 0.28 mg of nitrogen)

Procedure

1. Take 50ml of the sample in a conical flask.
2. Add 5ml of phosphate buffer solution and 10 ml of boric acid solution.
3. Add 3 -5 drops of methyl orange indicator.
4. Titrate against 0.02N of sulphuric acid till the end point is changes from orange to yellow.

Environmental Significance

1. Excess of ammonia in the form of nitrogen leads to Eutrophication in lakes.
2. Consumption of Nitrogen greater than 2mg/l in drinking water may lead to mathemoglobonemia in children.

Application

1. Determination of ammoniacal nitrogen used for standardizing the drinking water supply.
2. The data is used in the treatment of waste water before it is subjected to water courses.
3. It is also used to determine the extend of eutrophication and possible methods of removal of Nitrogen.

Tabulation

S.No	Volume of water Sample (ml) (ml)	Initial burette Reading (ml)	Final burette Reading (ml)	Concurrent Burette reading (ml)	Volume of Sulphuric acid (ml)

Calculation

$$NH3\text{-}N2\,mg/l = \frac{\text{Volume of } H_2SO_4 \text{ consumed} \times 0.28 \times 1000}{\text{Volume of sample taken}}$$

Result

The amount of Ammonia Nitrogen present in the given sample is------------mg/l.

Ex.No: 15 Determination of total and faecal coliform (Demonstration only)

Date:

Aim:

The determination of total and faecal coliforms in a water sample is commonly performed using the
Membrane Filtration (MF) technique or the **Most Probable Number (MPN) technique**.

Materials Required

- Sterile sample collection bottles
- Membrane filtration apparatus (funnel, base, vacuum flask, vacuum pump)
- Sterile membrane filters (0.45 µm pore size, gridded)
- Sterile petri dishes with absorbent pads
- Sterile buffered dilution water
- Sterile forceps and an alcohol lamp/Bunsen burner
- Culture media:
    - **m-Endo agar/broth** (for Total Coliforms)
    - **m-FC agar/broth** (for Faecal Coliforms)
- Incubator(s) capable of maintaining 35°C and 44.5°C
- Low-power microscope (10-15x magnification)

Procedure

I. Sample Collection and Preparation

1. Collect a minimum of 100 mL of water sample using aseptic techniques.
2. If immediate analysis is not possible, store the sample at or below 10°C for a maximum of 8 hours.
3. If the sample is likely to have a high bacterial count (e.g., non-potable water), prepare serial dilutions using sterile buffered water to ensure a countable range of colonies (20-80 for total coliforms, 20-60 for faecal coliforms).

II. Membrane Filtration

1. Disinfect the workbench and sterilize the filtration apparatus (if not using pre-sterilized disposable units).
2. Using sterile forceps (flamed in the Bunsen burner and cooled), place a sterile absorbent pad into a sterile petri dish.
3. Apply approximately 2 mL of the appropriate culture broth (m-Endo or m-FC) to the pad to saturate it, or use a pre-poured agar plate.
4. Aseptically place a sterile membrane filter, grid-side up, onto the filter base of the apparatus.
5. Shake the sample vigorously about 25 times to ensure an even distribution of bacteria.

6. Pour the appropriate volume of the water sample (e.g., 100 mL for potable water) into the funnel.
7. Turn on the vacuum pump and filter the sample completely through the membrane.
8. Rinse the funnel twice with 20-30 mL of sterile buffered dilution water to wash down any remaining bacteria.
9. Turn off the vacuum. Aseptically remove the membrane filter with sterile forceps and place it onto the saturated absorbent pad (or agar plate) in the petri dish using a rolling motion to avoid trapping air bubbles.

III. Incubation

1. Invert the petri dish (to prevent condensation from dripping onto the filter) and place it in the incubator.
2. **For Total Coliforms:** Incubate at **35°C ± 0.5°C** for 24 hours.
3. **For Faecal Coliforms:** Place the petri dish in a sealed waterproof plastic bag (or use a water-tight container) and submerge it in a water bath incubator set at **44.5°C ± 0.2°C** for 24 hours.

IV. Analysis and Interpretation

1. After incubation, remove the petri dishes and examine the filters under low-power magnification (10-15x).
2. **Total Coliforms:** Count colonies that are **dark red with a distinctive metallic green sheen** (on m-Endo agar).
3. **Faecal Coliforms:** Count colonies that are **dark blue** (on m-FC agar).
4. Calculate the coliform density using the following formula:

$$\text{Coliforms/100 ml} = (\text{Coliform colonies counted (CFU)} / \text{Volume of sample filtered (ml)}) \times 100$$

5. Dispose of all cultured materials using appropriate sterilization methods, such as autoclaving.

TOPIC BEYOND SYLLABUS

Determination of Hardness in water sample

Date:

Aim:

To determine the total hardness present in the given water sample.

Apparatus Required:

Burette, Conical flask, Pipette, Measuring jar.

Principle:

Hardness is generally caused by the Calcium and Magnesium ions present in water. Polyvalent ions of some other metals like Strontium. Iron, Aluminium, Zinc and Manganese are also capable of precipitating soap and thus contributing to hardness. However, the concentration of these ions is very low in natural waters, therefore hardness is generally measured as concentration of only Calcium and Magnesium (as Calcium Carbonate), which are far higher in quantity over other hardness producing ions. Calcium and Magnesium form a complex of wine red colour with Eriochrome Black-T at pH of 10.0 ± 0.1. The EDTA has got a stronger affinity to Ca^{2+} and Mg^{2+} and therefore by EDTA, the former complex is broken down and a new complex of blue colour is formed.

Reagents:

1. EDTA solution 0.01N (Ethylene Diamine tetra Acetic Acid)
2. Buffer solution
3. Eriochrome Black-T Indicator.

Procedure:

1. Take 50ml water sample in a conical flask. If the sample is having higher Calcium, take a small volume and dilute to 50ml.
2. Add 1 ml of buffer solution.
3. If the sample is having higher amount of heavy metals add 1 ml of Na_2S solution.
4. Add 100-200 mg of Eriochrome Black-T indicator, the solution turns wine red.
5. Titrate the contents against EDTA solution. The end point colour changes from wine red to blue. Repeat the titrations to get concurrent values.

Tabulation:

Sl.No	Volume of water sample (ml)	Burette Reading (ml)		Concurrent Burette Reading (ml)	Volume of EDTA (ml)
		Initial Reading	Final Reading		

Calculation:

$$\textbf{Hardness in mg/l of Caco}_3 = \frac{\textbf{Volume of EDTA used} \times 1000}{\textbf{Volume of Sample}}$$

Result:

The total hardness present in the given water sample is -------------------

Inference:

The water containing 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard.

Date:

Determination of Chlorides

Aim

To find the amount of chlorides present in the given water sample.

Apparatus Required:

Burette, Conical flask, Pipette, Measuring jar.

Principle:

Silver Nitrate react with chloride to form very slightly soluble white precipitate of AgCl. At the end point when all the chlorides get precipitated free silver ions react with chromate to form reddish brown colour.

Reagents:

1. Silver Nitrate,0.02N
2. Potassium Chromate

Procedure:

1. Take 25 ml water sample in a conical flask and add 1-2 ml Potassium chromate solution.
2. Titrate the contents against 0.02N silver nitrate until a persistent red tinge appears.

Tabulation:

Sl.No	**Volume of water sample (ml)**	**Burette Reading (ml)**		**Concurrent Burette Reading (ml)**	**Volume of Silver Nitrate (ml)**
		Initial Reading	**Final Reading**		

Calculation:

$$\text{Chloride, mg/l} = \frac{\text{ml of } AgNo_3 \text{ X Normality of } AgNo_3 \text{ X1000 X Eq.wt of chlorine}}{\text{Volume of Sample}}$$

Result:

The amount of chloride present in the given water sample is ----------------

Inference:

The high concentrations of chloride ions mostly results in an unpleasant salty taste of water and it also inhibits the corrosion of plumbing system. Very high chloride content of water may also produce laxative effect. An upper limit of 250 mg/L has been set for the chlorideions.

VIVA QUESTIONS

1.State whether the following statement is True or False. Carbonate hardness can be removed by adding lime to water. a)True b) False

Answer:a

Explanation: Carbonate hardness is due to the presence of carbonates and bicarbonates of calcium and magnesium in water and can be removed by boiling or by adding lime to it.

2.Which of the following statement is wrong regarding permanent hardness? a)It is also called carbonate hardness
b) It is due to the presence of sulfates, chlorides and nitrates of calcium and magnesium
c)It cannot be removed by boiling
d)It requires special methods of water softening to get removed

Answer:a

Explanation: Permanent hardness is called non-carbonate hardness whereas temporary hardness is called carbonate hardness.

3.One degree of hardness is equivalent to______ppm
a) 2
b) 1
c) 10
d) 100

Answer: b

Explanation: Water is said to have one degree of hardness when its soap destroying power is equivalent to the effect of 14.25mg of calcium carbonate in one litre of water.

4.

Degree of hardness	Nature of water
1	Extremely soft water
2	Very soft water
3	Soft water
9	?

What can be filled in place of the question mark in the above table?
a) Excessive hard water
b) Reasonably soft water
c) Very hard water
d) Hard water

Answer: d

Explanation: When the degree of hardness is 9, then it indicates the hard water. For excessive hard water, it is 15 and for very hard water, it is 11.

5. In which method of determining total hardness of water is based on the premise that hardness producing substance react with soap and form insoluble compounds before lather is produced?

a) Clark's method
b) Hehner's method
c) Versenate method
d) EDTA method
Answer: a
Explanation: In Clark's method, total hardness is found by determining the standard soap solution required to obtain permanent lather with the water sample of known volume.

6.What is the indicator used in EDTA method?
a) Potassium chromate
b) Potassium dichromate
c) Potassium chloride
d) Erio chrome, black T
Answer:d
Explanation: Hardness is determined by using Ethylene diamine tetra-acetic acid using Erio chrome, black T as indicator at a pH between 8.5 and 11.

7.The permissible limit of pH preferred for potable water is____ppm. a) 6.5-9
b) 7-8.5
c) 10-14
d) 0-7
Answer: a
Explanation: The permissible limit of pH for potable water should not exceed 9 and should not be less than 6.5 and the preferred limit is 7-8.5.

8. Given list 1 and list 2, find which of the following pair is correctly matched?

List 1 (Chemical substance)	**List 2 (Permissible limit in ppm)**
A. Lead	1. 0.05
B. Phenol	2. 0.001
C. Zinc	3. 0.01
D. Chromium	4. 5
	5. 0.2

A-5
b) B-3
c) C-4
d) D-2

Answer: c

Explanation: Lead has a permissible limit of 0.05ppm, phenol has 0.001ppm, zinc has 5ppm and chromium has a permissible limit of 0.05ppm in water.

9. What is the concentration of H+ ions in moles/L in water if the pOH value is 6?
a) 10^{-6}
b) 10^{-7}
c) 10^{-8}
d) 10^{-9}

Answer: c
Explanation: pH + pOH
= 14 pOH = 6, so pH =
14-6= 8
$H^+ = 10^{-pH} = 10^{-8}$moles/L.

10. The carbonaceous demand occurs due to oxidation of
a) Ammonia
b) Sulfur
c) Organic matter
d) Nitrogen
Answer: c
Explanation: The carbonaceous demand occurs due to oxidation of organic matter. The carbonaceous demand is also called as the initial demand.

11. The biochemical oxygen demand is computed by
a) Dissolved oxygen / Dilution factor
b) Dissolved oxygen + Dilution factor
c) Dissolved oxygen – Dilution factor
d) Dissolved oxygen * Dilution factor
Answer: d
Explanation: BOD = Dissolved oxygen * Dilution factor.
Where, Dilution factor = Volume of diluted sewage sample / Volume of undiluted sewage sample.

12. The full form of BOD is
a) Biodegradable oxygen demand
b) Biological oxygen demand
c) Biochemical oxygen demand
d) Bandwidth on demand
Answer:c
Explanation: The full form of BOD is biochemical oxygen demand. It is measured in ppm or mg/L.

13. ______is the amount of oxygen required to oxidize only organic matter in sewage.
a) Turbidity
b) BOD
c) COD
d) DO
Answer: b
Explanation: BOD is the amount of oxygen required to oxidize only organic matter in sewage. It is always less than COD as COD oxidizes both organic and inorganic matter.

14. The design value of the velocity of flow in a flocculator is ________ a) 0.2-0.8m/s
b) 0.3-0.5m/s
c) 0.6-0.8m/s
d) 0.1-0.5m/s
Answer: a
Explanation: The normal value of the velocity of flow in a flocculator is 0.4m/s and its range is 0.2-0.8m/s.

15. ___________is an operation designed to force agitation in the fluid and induce coagulation.

a) Sedimentation
b) Flocculation
c) Disinfection
d) Aeration
Answer: b
Explanation: Flocculation is an agitating process in which destabilized particles are brought into contact to promote agglomeration.

16. What is the normal value of the detention period adopted in a flocculator for design purpose?
a) 30min
b) 60min
c) 90min
d) 100min
Answer: a
Explanation: The detention period in a flocculator for design purpose should be in the range of 10-40min and its normal value should be 30min.

17. Which of the following is termed as free available chlorine?
a) Hypochlorous acid
b) Hypochlorite ions
c) Molecular chlorine
d) Hypochlorous acid, Hypochlorite ions, Molecular chlorine
Answer: d
Explanation: The chlorine existing in water as hypochlorous acid, hypochlorite ions, molecular chlorine is termed as free available chlorine.

18. The permissible limit of free residual chlorine is
a) 0.02ppm
b) 0.2ppm
c) 1ppm
d) 2ppm
Answer: b
Explanation: The water is satisfactorily disinfected if the free residual chlorine is 0.2 ppm at the contact period of 10 minutes.

19. What is the chemical formula of bleaching powder?
a) $Ca (OCl)_2$
b) $Ca (OCl)$
c) $Ca (OCl)_3$
d) $CaCl_2$
Answer: a
Explanation: The chemical formula of bleaching powder is $Ca (OCl)_2$. It is called as chlorinated lime.

20.The permissible limit of turbidity of domestic water is_____ppm. a) 5-10
b) 1-5
c) 10-50
d) 10-30
Answer: a
Explanation: According to WHO, the permissible limit for drinking water is 5NTU.

21. What is the full form of NTU in context with turbidity?
a) Number of transfer unit
b) Neurological turbidity unit
c) Nephelometric turbidity unit
d) Network terminal unit
Answer: c
Explanation: The value of turbidity measured by nephelometer is expressed in terms of NTU. Sometimes, it is referred as FTU or Formazin turbidity unit.

22.The size of suspended solids lies in the range of ________ a) $10^{-3} – 10^{-6}$ mm
b) $10^{3} – 10^{6}$ mm
c) $10^{-1} – 10^{-3}$ mm
d) $10^{1} – 10^{3}$ mm
Answer: c
Explanation: Size of suspended solids – $10^{-1} – 10^{-3}$ mm, size of colloidal solids – $10^{-3} – 10^{-6}$mm, size of dissolved solids – < 10^{-6} mm.

23. Suspended solids are measured by which of the following?
a) Turbidity rod
b) Gravimetric test
c) Chromatography
d) Jackson's turbidity meter
Answer: b
Explanation: Turbidity rod and Jackson's turbidity meter is used to find turbidity whereas chromatography is used to detect odour . Hence b is the correct answer.

24. The maximum permissible limit for suspended solids is ____
a) 10 mg/l
b) 20 mg/l
c) 30 mg/l
d) 40 mg/l
Answer: c
Explanation: The maximum permissible limit for suspended solids is 30mg/l for testing waste water which is set by the Environmental Protection Agency (EPA).

25. Identify the correct relation between the following?
a) Dissolved solid = Total solid + Suspended solid
b) Dissolved solid = Total solid – Suspended solid
c) Total solid = Dissolved solid / Suspended solid
d) Dissolved solid = Suspended solid – Total solid
Answer: b
Explanation: Dissolved solid is the difference between total solid and suspended solid. Suspended solid is non-filterable solid whereas dissolved solid is filterable solid.

26. Which method is used to measure the color of water?
a) Gravimetric analysis
b) Chromatography
c) Tintometer method
d) Hydrometer analysis
Answer: c
Explanation: The colors in water are measured by Tintometer method.It is measured on Burgess scale or cobalt scale by Nessler's tube.

27 TCU (True Color Unit) is equivalent to ______
a) The color produced by 1 g of platinum cobalt
b) The color produced by 1 mg of platinum cobalt
c) The color produced by 1 mg of platinum cobalt in 1L of distilled water
d) The color produced by 1 mg of platinum cobalt in 1mL of distilled water

Answer: c

Explanation: 1 TCU (True Color Unit) is equivalent to color produced by 1 mg of platinum cobalt in 1L of distilled water. The true color unit is also called as Hazen unit.

28. The range for threshold odour
number is a) 0-3
b) 1-5
c) 1-3
d) 0-5

Answer: c

Explanation: The maximum value of Threshold odour number is 3 and its range is 1-3. The threshold odour number is used to measure the intensity of taste and odour.

29. ---represents the bacterial density that is most likely to be present in water.
a) BOD
b) COD
c) MPN
d) Coliform index

Answer: c

Explanation: Most Probable Number is a number that indicates the bacterial density present in water.BOD and COD are the terms related to the oxygen required by microorganism to oxidize organic and inorganic matter.