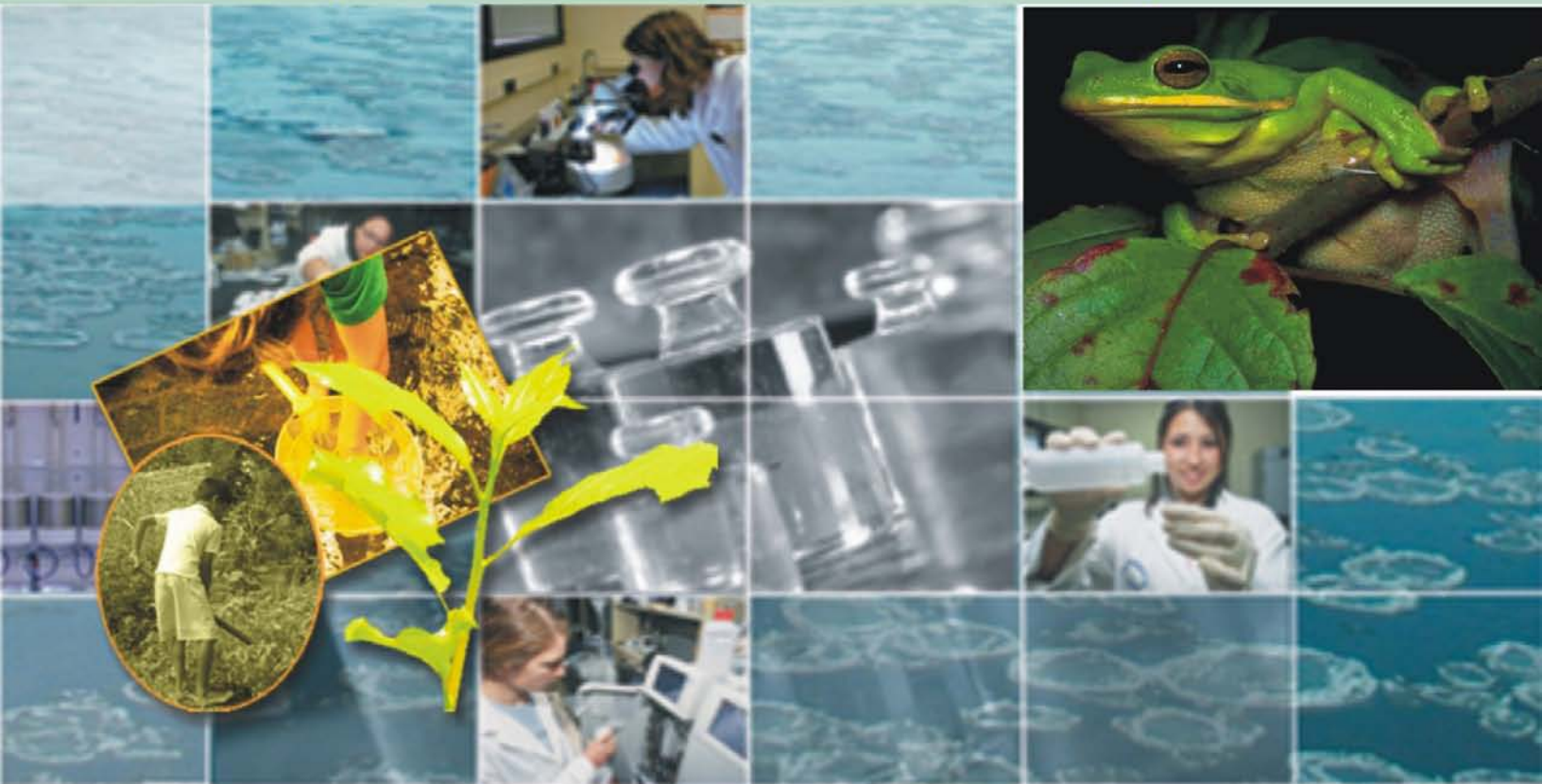


NEW AGE

ENVIRONMENTAL ENGINEERING LABORATORY MANUAL

For First Year Engineering Students (Common to All Branches)



R.C. Gaur



NEW AGE INTERNATIONAL PUBLISHERS

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(Common to All Branches)**

R.C. Gaur

Professor of Civil Engineering
University College of Engineering
Rajasthan Technical University, Kota
Rajasthan



PUBLISHING FOR ONE WORLD

NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS

New Delhi • Bangalore • Chennai • Cochin • Guwahati • Hyderabad
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ISBN (13) : 978-81-224-2652-6

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NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS

4835/24, Ansari Road, Daryaganj, New Delhi - 110002

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PREFACE

The environment can be defined as the surroundings in which we live. These surroundings may be living (biotic) or non living (abiotic). There is a dynamic equilibrium between biotic and abiotic environment. We are influenced in our day to day activities by the environment. We in turn affect the environment by our activities, by consuming its natural resources and producing pollution. Pollution is the mixing of undesirable elements in any of the natural resources. For example when we mix the human excreta with water and produce sewage and dispose it in the river we pollute the river. There are many indices of designating and measuring this pollution like Biochemical Oxygen Demand, etc. Now this pollution degrades the quality of water. Water, fit for drinking is the second most important requirement (first is the air) for human beings. It must have some useful ingredients and must not have the pollutants.

Actually Environmental Engineering is a very broad subject, but its basic knowledge is compulsory for every engineer. Some of the knowledge can be obtained by doing some simple experiments to judge the quality of water and wastewater and that is why the laboratory analysis of Environmental Engineering has been recommended for the first year students of all branches in Engineering in the esteemed Technical University of Rajasthan. This manual covers the syllabus of Rajasthan Technical University.

This laboratory Manual has been designed to cater the fundamental knowledge of a part of environmental engineering i.e. water and waste water. To understand the significance of the experiment some theory has been included before the experiment. Then the comments give the overall aspect and in the end the student has to critically comment on the results of the experiment that why this result is there and what is the meaning of it. This is the most important part of the experiment and the evaluator must evaluate the work in light of this.

The requirement of the apparatus and the reagents etc. and how to make them in the laboratory, simplifies the work of the institution.

The students are advised to prepare the solutions by themselves afresh to have the complete knowledge and good results.

Though there are so many tests for examination of water and wastewater actually Total dissolved solids, Chlorides, Fluorides and Nitrates are the main chemical examinations for acceptance or rejection of a water source as source of supply for a community. As disinfection is a must, so microbiological examination is done after the treatment of water to be supplied. The microbiological examination is difficult, time taking and beyond the scope of this primary level of First year B.Tech. students. However the test of residual chlorine makes it possible indirectly. If there is required amount of residual chlorine then it is assumed that there are no bacteria. Determination of sulfate is necessary to find whether the water is fit for construction (concrete) purpose or not.

The dissolved oxygen in sewage directly leads to the determination of BOD of sewage. The determination of dissolved and settleable solids gives idea about the design of grit chamber and the offensiveness of the sewage.

So the manual on Environmental Engineering Laboratory provides a sufficient basic tool for the examination of water and wastewater for first year students of every branch of B.Tech /B.E degree and any body engaged in this profession

It has been taken into consideration that the method of measurements is simple as they are meant for preliminary examination of water and waste water at a primary level.

Rakesh Chandra Gaur

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EXPERIMENT 1

Object: Measurement of pH of Water

THEORY

pH as defined by Sorenson is negative logarithm of hydrogen ion concentration. At a given temperature the acidic or basic character of a solution is indicated by pH or hydrogen ion activity. Actually the alkalinity and acidity of the water is something different. The alkalinity and acidity are the acid and base neutralizing capacities of water and are usually expressed as milligrams of CaCO_3 per litre. The pH is important in every phase of environmental engineering practice. In water treatment process it is a factor that is to be considered in chemical coagulation, disinfection, water softening and corrosion control. Coagulation means the mixing of alum like chemicals to make flocks and to increase the settlement of colloidal particles in water purification. The efficiency of the chemical coagulant like alum depends upon the pH of water and it is most efficient in the pH range of 6.5 to 8.5. Similarly chlorine is added to water to kill the bacteria and other microorganism and this process is known as disinfection. The efficiency of chlorine is also dependent on the pH of water. So the determination and then the required adjustment of pH is a must for the efficient use of coagulant and disinfectants.

The pure water dissociates to yield a concentration of hydrogen ions equal to about 10^{-7} mol/l.



The amount of hydroxyl ions is equal to the hydrogen ions, so 10^{-7} mol of hydroxyl ion is produced simultaneously. The equilibrium equation gives

$$\{\text{H}^+\} \{\text{OH}^-\} / \text{H}_2\text{O} = K$$

As the concentration of water is so extremely large and is diminished so much little by the slight degree of ionization it may be considered as constant and the above equation can be written as

$$\{H^+\} \{OH^-\} = K_w$$

For pure water at 25°C

$$\{H^+\} \{OH^-\} = 10^{-7} \times 10^{-7} = 10^{-14}$$

This is known as the ion product or ionization constant for water

When an acid is mixed in water it ionizes in the water and the H ion activity increases. Consequently the OH ion activity must decrease according to the ionization constant. For example if acid is added to increase the $\{H^+\}$ to 10^{-2} , the $\{OH^-\}$ must decrease to 10^{-12}

$$10^{-2} \times 10^{-12} = 10^{-14}$$

Similarly if a base is added to increase the $\{OH^-\}$ to 10^{-3} , the $\{H^+\}$ decreases to 10^{-11} . However the $\{H^+\}$ or the $\{OH^-\}$ can never be reduced to zero no matter how basic or acidic the solution may be.

Designating the hydrogen ion concentration in terms of molar concentration is cumbersome and to overcome this difficulty, Sorenson gave such value in terms of their negative logarithms as pH.

$$\text{So } \text{pH} = -\log \{H^+\}$$

$$\text{Or } \text{pH} = \log 1 / \{H^+\}$$

The pH scale is represented as ranging from 0 to 14 with pH 7 at 25°C designating absolute neutrality. pH lesser than 7 is acidic and more than 7 is a basic solution.

MEASUREMENT OF pH

Although the hydrogen electrode is the absolute standard for the measurement of pH, due to the difficulties in its operation, the glass electrodes are more useful. They are available in a wide range, i.e. portable battery operated units suitable for field measurements to highly precise laboratory instruments. Depending upon the type of electrode pH measurements can be done for extreme test conditions. The pH measurement of semisolid substances can be done with a spear type electrode. The instruments are standardized with buffer solutions of known pH values. The pH of the buffer solution should be within 1 to 2 units of the sample whose pH is to be measured.

The pH value can be determined either electrometrically or colorimetrically. The electrometric is more accurate but as it requires special apparatus colorimetric methods are generally used for normal determinations of pH useful for environment engineers.

(A) Electrometric Determination of pH

The basic principle of electrometric pH measurement is determination of activity of hydrogen ions by potentiometric measurements using a glass electrode. Contact between the test solution and electrode is achieved by means of a liquid junction. The electromotive force is measured with a pH meter, that is high impedance voltmeter calibrated in terms of pH.

Apparatus

The apparatus consists of a pH meter with glass and reference electrode with temperature compensation. The pH meter contains a glass electrode which generates a potential varying linearly with the pH of the solution in which it is immersed. A calomel or Ag/AgCl/KCl reference electrode is generally located around the glass electrode stem.

Procedure

- (i) Calibrate the electrodes with two standard buffer solutions of pH 4.0 and 9.2 (The buffer solution is a solution offering resistance to change in pH and whose pH value is known)
- (ii) The temperature of sample is determined simultaneously and is entered into the meter to allow for a correction of temperature.
- (iii) Wash the electrodes carefully with distilled water and wipe with tissue paper.
- (iv) Immerse the electrodes into the sample of water (whose pH is to be determined) and wait upto one minute for steady reading.
- (v) The reading is observed after the indicated value becomes constant.

(B) Colorimetric Method**Apparatus and reagents**

Aquascope complete with cell and slides of standard colours

Universal indicator for pH 4 to pH 11

Bromothymol blue indicator for pH 6 to pH 7.6

Procedure

- (i) Take four test tubes and fill them half with sample water.
- (ii) Add 10 drops of the universal indicator to each of the test tubes.
- (iii) Mix the solution in the test tubes by turning them up and down
- (iv) Observe the tinge of the colours developed in the test tubes and match them with the colour scale given on the indicator bottle.
- (v) The colour scale given on the bottle will directly give the pH value.

If the pH value is between 6 and 7.6 a more accurate method is used.

- (i) Fill the sample of water in the aquascope upto black line mark. Put 15 drops of Bromothymol Blue indicator in the middle compartment of the cell and stir it with the stirrer.
- (ii) After 5 minutes observe the developed colour and match it with the colour slides available on the Aquascope.
- (iii) The indicated pH of the matching slide will give the pH of the sample.

Observations

S. No.	Sample	pH with pH meter	pH with Universal indicator	pH with Bromothymol blue indicator
1	A			
2	B			
3	C			
4	D			

Results

The pH values of the given samples are as follows.

A :
 B :
 C :
 D :

Comments

- (i) The acceptable value of pH for potable water is 7.0 to 8.5. Water having pH below 6.5 and above 9.2 is rejectionable.
- (ii) Higher value of pH accelerates the scale formation in water heating apparatus and the boilers.
- (iii) Higher values of pH reduce the germicidal potential of Chlorine.
- (iv) pH value below 6.5 starts corrosion in pipes thereby releasing toxic metals like Zn.
- (v) In biological treatment of waste waters if the pH goes below 5 the decomposition is severely affected. There is a suitable range of 5 to 10 pH for aerobic decomposition of organic matter present in the waste waters. If the pH is beyond this range then it has to be adjusted by addition of acid or alkali.
- (vi) pH value is very much important for any chemical reaction as a chemical is highly effective at a particular pH. Chemical coagulation (use of Alum), disinfection (use of Chlorine), water softening and corrosion control are governed by pH adjustment.

So the observed pH value of the sample indicates that

.....

Quiz Questions

1. **pH is defined as**
 - (i) Logarithm of Hydrogen ions
 - (ii) Negative logarithm of Hydrogen ions
 - (iii) Hydrogen ion concentration
 - (iv) OH ion concentration
2. **pH of neutral water is**
 - (i) less than 7
 - (ii) more than 7
 - (iii) 7.0
 - (iv) 0.0
3. **For pure water at 25°C, the product of H⁺ and OH⁻ ions is**
 - (i) 10^{-7}
 - (ii) 10^{-14}
 - (iii) 10
 - (iv) 107
4. **The acceptable value of pH of potable water is**
 - (i) 7.0 to 8.5
 - (ii) 6.5 to 9.5
 - (iii) 6 to 8.5
 - (iv) 6.5 to 10
5. **Acidity of water means**
 - (i) pH of water in acidic range
 - (ii) pH of water in alkaline range
 - (iii) base neutralizing capacity of water
 - (iv) acid neutralizing capacity of water
6. **The alum is most effective as a coagulant in the pH range of**
 - (i) 6.5 to 8.5
 - (ii) 6 to 9.0
 - (iii) 6.5 to 9.5
 - (iv) 7.0 to 7.5

7. For the aerobic decomposition of organic matter the pH should not go below
- (i) 5.0
 - (ii) 6.0
 - (iii) 7.0
 - (iv) 9.0
8. Following indicator is used for pH determination of water between 4 to 11 pH
- (i) Phenolphthalein
 - (ii) Methyl orange
 - (iii) Universal Indicator
 - (iv) Bromthymol Indicator

Correct Answers

1. (ii) 2. (iii) 3. (ii) 4. (i) 5. (iii) 6. (i) 7. (i) 8. (iii)

EXPERIMENT 2

Object: Measurement of Hardness of Water

Apparatus

- (i) Burette,
- (ii) Two Conical flasks
- (iii) Measuring Cylinder

Reagents

- (i) Erichrome Black-T indicator. Dissolve 0.2 gm of the dyestuff in 15 ml of Triethanolamine and 5 ml ethanol or dissolve 0.5 gm dyestuff in 100 ml of rectified spirit.
- (ii) Ammonia buffer. Dissolve 16.9 gm of Ammonium Chloride (NH_4Cl) in 143 ml of concentrated ammonium hydroxide (NH_4OH). Add 1.25 gm of magnesium salt of EDTA to obtain sharp change in colour of indicator and dilute to 250 ml with distilled water. One or two ml of this solution is required for raising the pH value of sample to 10.
- (iii) Standard Ethylene diamine tetra acetic acid (E.D.T.A.) solution 0.01M. Dissolve 3.723 gm EDTA sodium salt and dilute to 1000 ml.
- (iv) Inhibitor. Dissolve 4.5 gm of hydroxylamine hydrochloride in 100 ml of 95% ethyl alcohol or isopropyl alcohol.

THEORY

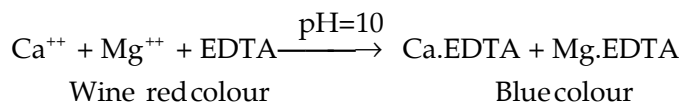
The hardness of water is mainly due to the presence of carbonates, bi-carbonates, chlorides and sulphates of calcium and magnesium in dissolved form. These salts cause excessive consumption of soap used for cleaning purpose. Sodium soaps react with multivalent metallic cations to form a precipitate, thereby lose their surfactant properties. Total Hardness is composed of two components, temporary and permanent hardness. The temporary hardness is due to the presence of carbonates and bi-carbonates of calcium and magnesium.

It can be easily removed by boiling the water or by adding lime to water. The permanent hardness i.e non-carbonate hardness is due to presence of sulphates, chlorides and nitrates of calcium and magnesium. It requires special methods of water softening. Hardness is expressed in part per million or commonly known as ppm.

Water with hardness upto 50ppm is known as soft water. 50 to 150 ppm it is termed as Medium and 150 to 300 ppm it is termed as moderately hard water. If the hardness is more than 300 ppm it is known as hard water.

Total hardness is commonly found by determining the amount of calcium and magnesium by a gravimetric analysis and by calculating their equivalent values in terms of CaCO_3 .

The most common testing method for hardness is the EDTA titrimetric method. Disodium ethylenediamine tetra acetate (Na_2EDTA) forms stable complex ions with Ca^{++} , Mg^{++} , and other divalent cations causing hardness, and remove them from solution. When a small amount of Erichrome black T dye is added to the water containing hardness ions at pH 10, the solution becomes wine red and if there is no hardness the colour is blue. With the addition of EDTA the water sample having indicator dye starts forming stable complexes until all ions have been removed from solution and the water colour changes from wine red to blue indicating the end point.



Calcium hardness can be determined by increasing the pH value of water to 12, at which magnesium ions get precipitated and EDTA forms stable complex while reacting with calcium ions, resulting in change of colour from pink to purple when murexide is used as an indicator.

Procedure

(A) Total Hardness

1. Take 100 ml of sample of water in a conical flask
2. Add one ml of Ammonia buffer and 1 ml of inhibitor solution to it
3. Add 3 drops of Erio chrome black T indicator, Wine red colour will develop.
4. Titrate with standard E.D.T.A (0.01 M) solution until the colour changes from wine red to blue.
5. Note down the volume of EDTA consumed, say C_1 ml.
6. Take same amount of deionized distilled water and repeat the same exercise. Let the volume of EDTA consumed is C_2 ml.
7. Net volume of EDTA solution required by water sample is $C = C_1 - C_2$

(B) Calcium Hardness

- 1 Take 30 ml of sample water in a conical flask
- 2 Add 1 ml NaOH to raise pH to 12.0 and a pinch of murexide indicator.
- 3 Titrate with EDTA till pink colour changes to purple. Note the volume of EDTA used say D1 ml.
- 4 Take same amount of deionized distilled water and repeat the exercise. Let the volume of EDTA consumed is D2 ml.
- 5 Net volume of EDTA solution required by water sample $D = D1 - D2$.

Observations

Test	Volume of sample water	Volume of distilled water	Initial reading of burette	Final reading	MI of EDTA
Total hardness					C1 C2
Calcium hardness					D1 D2

(A) Calculations for Total Hardness

$$\text{Total Hardness (mg/l) as CaCO}_3 = \frac{\text{ml of EDTA used ('C')}}{\text{ml of sample}} \times 1000$$

(B) Calculation for Calcium Hardness

$$\text{Calcium Hardness (mg/l) as CaCO}_3 = \frac{'D' \times 1000}{\text{ml of sample}}$$

Results

The Total hardness of the given sample of water is.....mg/l

The Calcium hardness of the given sample of water is.....mg/l

The magnesium Hardness = Total Hardness – Calcium Hardness = mg/l

Comments

- Hardness of water is an important consideration in determining the suitability of water for domestic and industrial uses.
- The environmental engineer uses this value as a basis for recommending the need for softening processes.
- Determination of hardness serves as a basis for routine checkup of softening process.
- Hardness imparts taste to water upto certain limit. The calcium salts are useful for the growth of children

- Absolutely soft waters are corrosive but the hard water forms scales on the pipeline inner surface and the boilers etc.
- Hard water causes excessive consumption of soap
- Magnesium hardness, associated with sulfate ion has a laxative effect (loose motion).
- The hardness of water affects the working of dyeing process.

The observed value of hardness of water indicates that water is

Quiz Questions

1. **The hardness of water is mainly due to the presence of**
 - (i) Carbonate, bicarbonate, chlorides and sulfates of calcium and magnesium
 - (ii) Carbonate, bicarbonates of calcium and magnesium
 - (iii) Chlorides and sulfates of calcium and magnesium
 - (iv) Nitrate and sulfates of calcium and magnesium
2. **The hard water**
 - (i) is not tasty
 - (ii) is saline water
 - (iii) consumes more soap for cleaning purposes
 - (iv) consumes more chlorine as disinfectant
3. **The temporary hardness is due to**
 - (i) Carbonate and bicarbonate of calcium and magnesium
 - (ii) Sulfate of calcium and magnesium
 - (iii) Chlorides of calcium and magnesium
 - (iv) Nitrates of calcium and magnesium
4. **Water with hardness upto 50 ppm is known as**
 - (i) Hard water
 - (ii) Soft water
 - (iii) Moderately hard water
 - (iv) Moderately soft water
5. **The permanent hardness is due to**
 - (i) Sulfates, chlorides and nitrates of calcium and magnesium.
 - (ii) Carbonate and bicarbonate of calcium and magnesium

- (iii) Sulfate and bicarbonates of calcium
- (iv) Chlorides and carbonates of magnesium

6. E.D.T.A means

- (i) Ethylene diamine tetra acetic acid
- (ii) Erichrome diamine tetra acetic acid
- (iii) Ethyle dye toluene acid
- (iv) Erichrome dye toluene acid

7. The hard water

- (i) is corrosive
- (ii) forms scales
- (iii) is tasteless
- (iv) is costly

8. Magnesium hardness with sulfate ions produces

- (i) Cancer
- (ii) Laxative effect
- (iii) Breathing problem
- (iv) Tiredness

Correct Answers

1. (i) 2. (iii) 3. (i) 4. (ii) 5. (i) 6. (i) 7. (ii) 8. (ii)

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EXPERIMENT 3

Object: Measurement of Residual Chlorine in Water

THEORY

The drinking water (potable water) should be bacteria free. Killing of bacteria and other micro-organisms in water which may produce disease, is known as disinfection. Chlorine is generally used for this purpose either in liquid form or in solid form (bleaching powder) for small installations. A certain amount of chlorine is required for effective disinfection depending upon the quality of water. Chlorine in excess of that remains unused and is known as 'Residual Chlorine'. The water flows in the pipelines from the treatment plants and then reaches to the consumers, after traveling for sometime. The residual chlorine in the water entering into distribution system is used to kill the micro-organisms present in the pipeline and other components of the distribution system and thus safe potable water reaches to the consumer. To assure this availability it is proposed that the amount of residual chlorine in the drinking water at the consumer end should be 0.1 to 0.2 mg/l. preferably 0.2 mg/l. If we add more chlorine and the residual chlorine is also more than 0.2 mg/l it is harmful and undesirable from taste point of view also.

This test is performed by adding some drops of orthotolidine to water and observe the colour produced.

Orthotolidine is an aromatic organic compound that is oxidized in acid solution by chlorine, chloramines and other oxidizing agents to produce a yellow coloured compound called Holoquinone. This produces a yellow colour and the intensity of colour produced is proportional to the chlorine present.

Apparatus	Chloroscope
Reagent	Orthotolidine

Acidified solution of orthotolidine is prepared by mixing 1.35 gram of orthotolidine dihydro-chloride with 500 ml of distilled water and then adding 500 ml of dilute hydro-chloric acid. (150 ml of concentrated HCl is diluted to 500 ml by mixing distilled water). The orthotolidine solution is also available in solution form in the market and the bottle itself contains the colour slides to compare.

Procedure

- (i) Take water sample in one tube of the chloroscope and distilled water in the other tube
- (ii) Add 4 drops of orthotolidine in both the tubes.
- (iii) Colour shall develop only in the water having chlorine
- (vi) Match the colour with the colour slides present in the Chloroscope
- (v) Higher is the amount of chlorine present darker shall be the intensity of yellow colour.
- (vi) If there is very less amount of chlorine (<0.1 Mg/l) the yellow colour produced shall be very faint and at that time compare it with the distilled water tube with no colour.

OBSERVATIONS, CALCULATION AND RESULT

The amount of residual chlorine in the given sample of water =mg/l

Comments

Some amount of active chlorine should be present at each stage of water treatment and distribution. The residual chlorine at the consumers end should be 0.2 mg/l. Excessive chlorine gives bad odour and taste and is harmful also (may lead to cancer).

Quiz Questions**1. Disinfection means**

- (i) Killing of disease producing bacteria and other microorganisms.
- (ii) Killing of all bacteria and other microorganisms.
- (iii) Removing infection from water.

2. Bleaching powder is mixed in water for

- (i) Making it clean
- (ii) Disinfection of water
- (iii) Adjusting its pH
- (iv) Making it soft water

3. Residual chlorine means

- (i) Chlorine required for the disinfection of water normally
- (ii) Chlorine required for the disinfection of water in the rainy season
- (iii) Chlorine available at the consumer's end.
- (iv) Chlorine required as the superchlorination.

4. Potable water is

- (i) tasty water
- (ii) wholesome water
- (iii) Mineral water
- (iv) Water free from disease producing elements and bacteria.

5. The amount of residual chlorine in water should be

- (i) 0.2 mg per litre
- (ii) 2.0 mg/litre
- (iii) 2.5 mg/litre
- (iv) 4.0 mg/l

6. Residual chlorine is detected in water by

- (i) Erchrome black T
- (ii) Bleaching powder
- (iii) Methyl orange
- (iv) Orthotolidine

7. Excessive chlorine in water gives

- (i) Bad odour
- (ii) Bad taste
- (iii) Harmful effect
- (iv) All of the above

8. If more chlorine is present in water, the colour produced by orthotolidine is

- (i) lighter
- (ii) darker
- (iii) no difference

Correct Answers

1. (i) 2. (ii) 3. (iii) 4. (iv) 5. (i) 6. (iv) 7. (iv) 8. (ii)

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EXPERIMENT 4

Object: Measurement of Conductivity of Water

THEORY

Conductivity is a numerical expression of the ability of an aqueous solution to carry the electric current. This ability depends on the presence of ions, their mobility, valence, relative concentrations and on the temperature of measurement. The inorganic acids, bases, and salt solutions are relatively good conductors. On the contrary, molecules of organic compounds that do not dissociate in aqueous solution have a poor conductivity.

The conductivity is measured in the laboratory in term of resistance measured in ohms. The electric resistance of a conductor is inversely proportional to its cross sectional area and directly proportional to its length. The magnitude of the resistance measured in an aqueous solution therefore depends on the characteristics of the conductivity cell used. Specific resistance is the resistance of a cube of 1cm. In aqueous solutions such a measurement is seldom made because of the difficulties in fabrication of electrode. Actually the electrodes measure a given fraction of the specific resistance known as the cell constant C

$$C = \frac{\text{Measured resistance, } R_m}{\text{Specific resistance, } R_s}$$

The reciprocal of resistance is conductance. It measures the ability to conduct a current and is expressed in reciprocal of ohms i.e mhos. In water analysis generally micromhos is used. Knowing the cell constant the measured conductance is converted to the specific conductance or conductivity, K_s , as the reciprocal of the specific resistance.

$$K_s = 1/R_s = C/R_m$$

The term conductivity is preferred and usually reported in micromhos per centimeter (μ mhos/cm)

Freshly made distilled water has a conductivity of 0.5 to 2.0 μ mhos/cm that increases after some days due to the absorption of CO_2 from atmosphere.

The conductivity of potable waters varies generally from 50 to 1500 μ mhos/cm. The conductivity of municipal waste waters may be near to that of the potable water. However the industrial waste waters may have conductivities above 10000 μ mhos/cm.

Measurement of conductivity with lesser accuracy than laboratory analysis is done continuously by the field recorders. These automatic recorders give idea about any sudden drastic change in the quality of raw water or the waste water, so that required precautions may be taken.

Actually the total dissolved solids in water can be estimated by measuring its conductivity and multiplying it by an empirical factor. This factor varies from 0.55 to 0.9 depending upon the soluble components of water and the temperature. This factor can be obtained for a system by observing the conductivity and the dissolved solids and then it can be used for continuous monitoring.

Apparatus

- (a) **Conductivity meter:** This is an instrument consisting of a source of alternating current, a Wheatstone bridge, a null indicator and a conductivity cell. Generally an instrument capable of measuring conductivity with an accuracy of 1 % or 1 μ mhos/cm is used. A thermometer capable of reading upto 0.1° C within a range of 15 to 30°C is used.
- (b) **Conductivity Cell :** Platinum-electrode type conductivity cells containing platinized electrodes are used depending upon the expected range of conductivity. Non platinum-electrode type conductivity cells containing electrodes constructed from durable metals like stainless steel are used for continuous monitoring systems.

Reagents

- (a) **Conductivity water:** Pass distilled water through a mixed bed deionizer and discard first liter. Conductivity should be less than 1 μ mhos/cm.
- (b) **Standard Potassium Chloride Solution (KCl, 0.01M),** Dissolve 745.6 mg of anhydrous KCl in conductivity water and dilute to 1000 ml at 25°C. This is the standard reference solution having a conductivity of 1413 μ mhos/cm at 25°C, useful for the cell constants between 1 and 2.

Procedure

(i) Determination of Cell Constant

Wash the conductivity cell with 0.01 M KCl solution. Adjust the temperature of the standard KCl at 25 $\pm$ 0.1°C. Measure resistance of the KCL and note the temperature.

The Cell Constant, $C = (0.001413) (R_{KCL}) [1+0.0191(t-25)]$

(ii) Conductivity Measurement

Rinse cell with the sample. Adjust temperature of the sample to $25 \pm 0.1^\circ\text{C}$. Measure sample resistance or conductivity and the temperature

If the temperature deviates from 25°C the corrected conductivity shall be as follows

$$K = \frac{(K_m) C}{(1+0.019(t-25))}$$

K_m is the measured conductivity at $t^\circ\text{C}$.

OBSERVATIONS AND CALCULATION

Water sample No.	Temperature	Electrical conductivity $\mu\text{ mhos / cm}$	Total dissolved solids in $\text{mg/l} = \text{EC} \times 'K'$ (selected or measured 'K')

Result

The electrical conductivity of the given water sample is..... $\mu\text{ mhos/cm}$

Comments

- (i) Knowing the conductivity the total dissolved solids can be calculated.
- (ii) Continuous monitoring of the conductivity of a flowing stream of water or waste water reflects any sudden change and the probable cause can be detected.

Quiz Questions

1. Conductivity is

- (i) Ability of an aqueous solution to carry current
- (ii) Ability of an aqueous solution to dissolve a solid
- (iii) Ability of a solution to conduct heat
- (iv) Ability of a solution to conduct sound

2. Conductivity depends upon

- (i) Presence of ions
- (ii) Valence & relative concentration
- (iii) Temperature
- (iv) All of the above

3. The electric resistance of a conductor is

- (i) Inversely proportional to its cross sectional area
- (ii) Directly proportional to its length
- (iii) Inversely proportional to its cross sectional area and directly proportional to its length
- (iv) Directly proportional to its cross sectional area and inversely proportional to its length

4. Specific resistance is the resistance of

- (i) A cube of 1 cm.
- (ii) One litre of water
- (iii) One gallon of water
- (iv) None of the above

5. Conductance is

- (i) Reciprocal of the resistance
- (ii) Square of the resistance
- (iii) Cube of the resistance
- (iv) None of the above

6. The conductivity of potable water varies from

- (i) 50 to 1500 micro mhos/cm
- (ii) 150 to 2500 micro mhos/cm
- (iii) 500 to 5000 micro mhos/cm
- (iv) more than 15000 micro mhos/cm

7. The measurement of conductivity may lead to the estimation of

- (i) Total solids
- (ii) Total dissolved solids
- (iii) Suspended solids
- (iv) Colloidal solids

8. Freshly made distilled water has a conductivity of

- (i) 2.0 to 2.5 micro mhos/cm
- (ii) 0.5 to 2.0 micro mhos/cm
- (iii) 2.5 to 3.5 micro mhos/cm
- (iv) 3.5 to 4.5 micro mhos/cm

Correct Answers

1. (i) 2. (iv) 3. (iii) 4. (i) 5. (i) 6. (i) 7. (ii) 8. (ii)

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EXPERIMENT 5

Object: Measurement of Chlorides in Water

THEORY

Chloride is the most common ion in the water. It gives the salty taste to water particularly when sodium chloride is there. Some chloride concentration is desirable as it adds taste to water but beyond the prescribed limit (200 p.p.m.) it is not desirable.

The chloride concentration in sewage is more than the water supplied as the sodium chloride consumed by us in the food is passed through the fecal material as it is.

High chloride content may harm metallic pipes and structures as well as the plants.

Apparatus

- (i) Conical flask
- (ii) Burette
- (iii) Pipette
- (iv) Measuring cylinder

Reagents

(i) *Standard Silver Nitrate (0.0141N)*

Mix 2395 mg of Silver Nitrate AgNO_3 in distilled water and dilute it to 1000 ml

(ii) *Potassium Chromate Indicator Solution*

Dissolve 50 g of potassium chromate (K_2CrO_4) in distilled water and add it to silver nitrate solution till a perfectly red precipitate is obtained. Wait for 12 hours and filter it. Dilute it to 1000ml and the indicator is ready.

Procedure

- (i) Take 100 ml of water sample and adjust its pH between 7 to 8 with H_2SO_4 or NaOH if it is not already in this range. In the case of raw turbid water add 3 ml of aluminum hydroxide suspension and filter it to get a clean water sample.
- (ii) Add accurately 1 ml of potassium chromate indicator solution.
- (iii) Titrate against the standard AgNO_3 solution till pinkish yellow precipitate of silver chromate (Ag_2CrO_4) appears in the water sample. Note down the volume of silver nitrate consumed.

Observations

S. No.	Sample description	Initial burette reading	Final burette reading	Volume of AgNO_3
1	A			
2	B			

Calculations

$$\text{Chloride in mg/L} = \frac{V \times N \times 35450}{\text{Volume of sample in ml}}$$

Here

V = Volume of titrant (Silver Nitrate) used in ml.

N = Normality of $\text{AgNO}_3 = 0.0141$

Result

The chlorides in the given sample of water =ppm

Comments

The chloride determination of water gives the idea about the salinity of water

Saline water is not fit for drinking and irrigation purposes.

The observed water having chloride concentration asppm is.....

Quiz Questions

1. Most common ion in the water is

- (i) Fluoride
- (ii) Nitrate
- (iii) Chloride
- (iv) Sulfate

2. Chloride gives salty taste to water particularly when present as:-

- (i) Sodium chloride
- (ii) Magnesium chloride
- (iii) Potassium chloride
- (iv) Zinc Chloride

3. The acceptable limit of chloride in potable water is

- (i) 200 mg/L
- (ii) 500mg/L
- (iii) 1000 mg/L
- (iv) 1500 mg/L

4. The chloride concentration in sewage is

- (i) More than the water supplied
- (ii) Less than the water supplied
- (iii) Equal to the water supplied
- (iv) None of the above

5. Chloride consumed by us

- (i) Pass through the fecal matter as it is.
- (ii) Gets changed into another form
- (iii) Gets disappeared
- (v) None of the above

6. High chloride content in water

- (i) Harms metallic pipes
- (ii) Harmful for irrigation
- (iii) Harmful to human beings
- (iv) All the above

Correct Answers

1. (iii) 2. (i) 3. (i) 4. (i) 5. (i) 6. (iv)

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EXPERIMENT 6

Object: Measurement of Nitrates in Water

THEORY

Generally the ground water has high nitrate concentration because of the percolating sewage, industrial waste, chemical fertilizers, leaches from solid waste landfills, septic tank effluents etc. Whatever may be the reason the high concentration of nitrate is harmful to human beings, particularly for infants. The low acidity in the infants' intestine permits the growth of nitrate reducing bacteria that converts the nitrate to nitrite that is then absorbed in the blood stream. The nitrite has a great affinity for hemoglobin than the oxygen and it replaces oxygen in the blood. The deficiency of oxygen causes suffocation. The colour of the skin of the infants becomes blue so it is termed as blue baby disease. The medical name is 'methemoglobinemia'. This disease is a fatal disease and it takes place when the concentration of nitrates is more than 45 ppm. So it is important to find the amount of nitrate in drinking water though it is a difficult task and requires spectrophotometer also

Apparatus

- (i) Spectrophotometer with a range of 300 – 700 nm.
- (ii) Nessler tubes capacity 100 ml

Reagents

- (i) Standard silver sulphate
- (ii) Phenol disulphonic acid
- (iii) Ammonium hydroxide
- (iv) Stock nitrate solution: Dry potassium nitrate (KNO_3) in an oven at 105°C for 24 hours. Dissolve 0.1631 g in water and dilute to 1000 ml. 1.0 ml = 100 micro gram NO_3^- N. Preserve with 2 ml CHCl_3 /l
- (v) Standard nitrate solution

Procedure

- (i) Take 50 ml of filtered sample in a flask.
- (ii) Add an equivalent amount of silver sulphate to remove chlorides. So chloride determination is done prior to the nitrates. $1 \text{ mg/ICl} = 1 \text{ ml Ag}_2\text{SO}_4$ solution.
- (iii) Slightly warm and filter the precipitated AgCl.
- (iv) Evaporate the filtrate in a porcelain dish to dryness.
- (v) Cool and dissolve the residue in 2 ml phenoldisulphonic acid and dilute to 50 ml.
- (vi) Add 10 ml of liquid ammonia to develop a yellow colour. Actually nitrate reacts with disulphonic acid and produces a nitro- derivative that in alkaline medium produces a yellow colour..
- (vii) Observe the colour developed at 410 nm with a light path of 1 cm.
- (viii) Calculate the concentration of nitrate from the standard curve.
- (ix) Prepare the standard curve using suitable aliquots of standard nitrate solution in the range of 5 to 500 mg NO_3 by following the above procedure.

OBSERVATION, CALCULATION AND RESULT

The observed value of nitrates in the given sample of water =mg/l

Comments

- The determination of nitrates is important from health point of view that is safe against the diseases produced
- It is also used to assess the self purification capacity of water bodies and the nutrient balance in surface waters and soil.
- It is useful to find out state of decomposition of organic matter in sewage.

The observed value of nitrates in the given sample of water indicates that.....

Quiz Questions

1. Which water generally has high nitrate concentration?
 - (i) Surface water
 - (ii) Ground water
 - (iii) Distilled water
 - (iv) None of above
2. The ground water has high nitrate concentration because of
 - (i) Percolating sewage
 - (ii) Industrial waste

- (iii) Chemical fertilizers, leaches etc.
- (iv) All of above
- 3. The high nitrate concentration of water fed to infants causes**
 - (i) Green baby disease
 - (ii) Blue baby disease
 - (iii) Anemia
 - (iv) Cancer
- 4. The acceptable limit of nitrates in potable water is**
 - (i) 75 mg/L
 - (ii) 45 mg/L
 - (iii) 90 mg/L
 - (iv) 200 mg/L
- 5. The determination of nitrates is important as to**
 - (i) determine nitrates important from health point of view that is safe against the diseases produced
 - (ii) assess the self purification capacity of water bodies and the nutrient balance in surface waters and soil.
 - (iii) find out state of decomposition of organic matter in sewage
 - (iv) All of above

Correct Answers

1. (ii) 2. (iv) 3. (ii) 4. (ii) 5. (iv)

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EXPERIMENT 7

Object: Measurement of Fluoride in Water

THEORY

Fluoride is essential for human beings to fight against dental caries. The desirable concentration is 1 mg/l, if it is more than this it proves to be harmful. Fluoride concentration of more than 3 ppm is not allowed in potable water in any case. As per W.H.O the fluorides should not be more than 1.5 ppm. Actually the higher concentration of fluoride leads to the discoloration of teeth known as dental fluorosis. The more dangerous is the deformation of the Skelton. In Rajasthan about 25 districts are fluoride affected and some of them are severely affected. The fluoride in the ground water of Nagaur District is so high (5-10 ppm) that above 50% of the people in one particular area (known as 'Banka Patti') are with distorted Skelton. The name Banka itself means distorted or bent bones. The skeletal fluorosis affects the bones, tendons and ligaments followed by pain and ultimately leads to the seizer of neck and other limbs movement. So it is very important to check the fluoride concentration in drinking water.

The actual laboratory determination is done by spectrophotometer but it can be done at student's primary level by visual comparison also. In this test we use the combination of zirconium and either alizarin dye or SPADNS dye. This combination gives a reddish colour and the colour produced is commonly referred as a 'lake'. The intensity of colour produced is reduced if the amount of zirconium present is decreased. Fluoride ion combines with zirconium ion to form a stable complex ion, ZrF_6^{2-} and the intensity of the color reduces accordingly. The action takes time, about 1 hr when alizarin is used. The SPADNS dye takes no time and is more resistant against the interferences but the making of this is difficult. The reduced colour is compared with the standard sodium fluoride solutions and the results are obtained by visual colour comparison.

Equipment and Reagents

(i) Nessler tubes

(ii) Standard Sodium fluoride solution

Dissolve 0.0221 gm of dry sodium fluoride in distilled water and make upto 1000 ml. One ml of this solution contains 0.01 mg of fluoride as F.

(iii) Acid zirconium alizarin reagent

Dissolve 0.3 gm of zirconium oxychloride or 0.25 gm of zirconium oxynitrate in 50 ml of distilled water. Dissolve 0.07 gm of alizarin sodium monosulphonate in another 50 ml of distilled water and add the later solution to the zirconium solution calmly with continuous stirring.

(iv) Sodium thiosulphate solution (0.1N)

Dissolve 25 gm of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ in distilled water and make upto 1 litre.

Procedure

- (i) The sample should be free from chlorine, it should be dechlorinated with sodium thiosulphate solution before use.
- (ii) Take 1, 2, 3, 5, 7, 9, 11 ml of standard sodium fluoride solution in six Nessler Tubes.
- (iii) Add 5 ml of acid zirconium reagent in each Nessler tube.
- (iv) Add 5 ml of acid zirconium reagent in each Nessler tube containing 100 ml of sample.
- (v) Mix thoroughly and compare the colour developed after one hour with the six tubes.

CALCULATION AND RESULTS

Fluoride in given sample (mg/l) =

Comments

- (i) Potable water should have fluoride between 1 to 1.5 only. In extreme cases where no other solution is there water with fluoride upto 3 mg/l may be tolerated. Beyond this limit it is dangerous to use water without treatment. i.e. reduction of fluoride.

The fluoride value of the given sample of water shows that.....

Quiz Questions**1. Fluoride is essential for human beings**

- (i) To fight against dental caries.

- (ii) To fight against fluorosis
- (iii) To fight against molten enamel
- (iv) To fight against deformed skeleton

2. The desirable concentration of fluorides in potable water is

- (i) 3.0 mg/L
- (ii) 1.0 to 1.5 mg/l
- (iii) 45 mg/l
- (iv) 200 mg/l

3. The skeletal fluorosis affects

- (i) Bones
- (ii) Tendons
- (iii) Ligaments
- (iv) All of the above

4. The dental fluorosis affects

- (i) the root of teeth
- (ii) The enamel of the teeth
- (iii) The gums
- (iv) The jaws

Correct Answers

1. (i) 2. (ii) 3. (iv) 4. (ii)

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EXPERIMENT 8

Object: Measurement of Dissolved Oxygen in Water

THEORY

The oxygen remains in water in dissolved form depending upon the temperature of water. As the temperature increases, the solubility of D.O in water decreases. For example the maximum D.O at 20°C is 9.17 mg/l where as at 25°C it is 8.38 mg/l. A minimum of 4 mg/l D.O is essential for the aquatic life. The organic matter present in the waste water poses a Biochemical Oxygen Demand. This demand is met with the Dissolved Oxygen present in the fresh body of water. If the organic load (volume x BOD) of the waste water is more than the asset (volume x D.O) the whole of the oxygen is depleted. This causes the death of fish and other aquatic animals and plants and they being organic matter further increase the demand of oxygen for the degradation. So it is necessary to find out the D.O of water to maintain sanitary conditions. It can be achieved by the treatment of waste water. Treatment means the reduction of BOD below the allowable limits. The limit is 30 mg/l for disposal of wastewater (sewage) in water.

Apparatus

- Glass stoppered bottles, 300ml capacity
- Conical flasks
- Burettes 25 ml
- Measuring cylinders 400 ml
- Pipettes

Reagents

(i) *Standard Manganous Sulphate Solution*

Dissolve 480 gm of tetrahydrate manganous sulphate in distilled water, filter and dilute one litre. The solution should not give colour with starch when added to an acidified solution of KI.

(ii) Standard Sodium Thiosulphate (0.025N):

Dissolve 1.575 gm of $\text{Na}_2\text{S}_2\text{O}_3$ in distilled water and make upto 1 litre.

(iii) Alkaline Potassium Iodide Solution

Dissolve 500 gm NaOH and 150 gm of KI in distilled water and dilute to one litre. Dissolve 10 gm of NaN_3 in 40 ml of distilled water separately and pour it in the above solution This solution should not give colour with starch solution when diluted and acidified.

(iv) Starch Indicator

Dissolve 2 gm of L.R. grade soluble starch in distilled water and pour this imulsion into 100 ml of boiling water and keep on boiling for 5 minutes. Add 0.3 gm of salicyclic acid or toluene as preservative.

*(v) Concentrated Sulphuric Acid***Procedure**

- Fill the 300 ml bottle completely with the sample water.
- Add 1 ml of mangneous sulphate solution by a pipette touching the bottom of the bottle.
- Similarly add 1 ml of alkaline potassium iodide.

Put the stopper and mix it thoroughly by turning up side down.

- A yellow precipitate will appear. Allow it to settle for 5 minutes.
- Add 1 ml of Concentrated H_2SO_4 carefully. Mix it again by turning it upside down so that the ppt gets dissolved.
- Take 203 ml of this solution (it is equivalent to 200 ml of original sample to compensate for the addition of chemicals) and titrate with N/40 Sodium thiosulphate solution drop by drop till the yellow colour disappears
- Add 1 ml of starch indicator and continue the titration till the blue colour disappears.
- As 0.025 N sodium thiosulphate is used to measure the D.O in a volume of 200ml of original sample, 1.0 ml of the titrant is equal to 1.0 mg/L of D.O.

Observations

Sample No.	Temperature of sample	Volume of sample	Initial burette reading	Final burette reading	MI of $\text{Na}_2\text{S}_2\text{O}_3$ solution used	D.O in mg/l

Result

The Dissolved Oxygen in the given sample of water at.....°C =.....Mg/l.

Comments

The D.O determination is done to find out the quality of water. It is also useful for the BOD determination of waste water. A minimum D.O of 4 ppm is necessary for the aquatic life. D.O increases the taste and freshness of drinking water.

The measured D.O. of the sample of water suggests that.....

Quiz Questions

1. The concentration of Dissolved Oxygen in water is mainly dependent on
 - (i) The temperature
 - (ii) Chloride concentration
 - (iii) Organic purity of water
 - (iv) All of the above
2. The minimum Dissolved Oxygen required for aquatic life in general is
 - (i) 9.2 ppm
 - (ii) 4 ppm
 - (iii) 8.4 ppm
 - (iv) 12 ppm
3. The treatment of wastewater is mainly done
 - (i) To satisfy its B.O.D.
 - (ii) To remove suspended solids
 - (iii) To remove odour
 - (iv) To remove colour
4. The allowable limit of BOD of wastewater to be disposed in rivers is
 - (i) 45 ppm
 - (ii) 30 ppm
 - (iii) 100 ppm
 - (iv) 300 ppm
5. The Dissolved Oxygen in potable water
 - (i) imparts freshness
 - (ii) improves taste
 - (iii) improves smell
 - (iv) none of the above

Correct Answers

1. (iv) 2. (ii) 3. (i) 4. (ii) 5. (i)

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EXPERIMENT 9

Object: Measurement of Total Solids in Sewage

THEORY

Sewage or the waste water contains solids in suspended, colloidal or dissolved form. The Suspended solids are those which can be filtered out by a filter paper. The suspended solids are of two type, settelable and non- settleable. It is difficult to remove the dissolved solids. Though the sewage normally contains 99.9 percent of water and only 0.1 percent of solids, but it is the solids that have the nuisance value. Nuisance is basically their biodegradability. The organic matter in the sewage is putrescible, i.e. highly susceptible of decay. During this decay or the decomposition the organic matter gets converted into inorganic matter. The decomposition of organic matter depends upon temperature of the reaction. Higher is the temperature faster is the reaction. It also depends upon the pH. If the pH goes below 5 the anaerobic decomposition ceases. The presence of toxic material reduces the degradation. Nutrients like N, P and K accelerate the degradation.

This process takes place mainly in two conditions. First is aerobic and the second is anaerobic. Aerobic means the decomposition of the organic matter in presence of oxygen and anaerobic is the decomposition in absence of oxygen. Actually the decomposition of organic matter is done by the bacteria under favourable conditions. The aerobic bacteria convert the organic matter (solids) in sewage into more stable form like sulfates, nitrates etc. and less harmful gases like CO_2 . The anaerobic bacteria produces obnoxious gases like H_2S , pungent gases like NH_3 , explosive gases like CH_4 , and toxic gases like CO etc. during the decomposition.

The treatment of wastewater is necessary before it is disposed into a body of water i.e river etc or on the land to protect them by the foul effects of the solid matter present in the wastewater. The foul effects are of many types. First is the Biochemical Oxygen Demand. B.O.D is the requirement of oxygen imposed by the aerobic bacteria for the decomposition of biodegradable organic matter at some certain temperature. Water has dissolved oxygen

in it that is required for the very existence of the aquatic animals and plants. When sewage is discharged in water, its Biochemical oxygen demand is satisfied by the dissolved oxygen of the water and ultimately the water becomes deficient of oxygen and the aquatic life is endangered.

So to reduce the BOD first of all the settleable solid are removed may it be organic or inorganic by sedimentation. Then the colloidal and dissolved organic solids are supplied with the oxygen to get converted into inorganic solids and come out of the solution and thus get 'Bio-flocculated'. Now they get settled and can be removed leading to a less harmful waste water.

This is the reason of determination of total solids in wastewater.

Apparatus

- (i) Evaporating Dish
- (ii) Drying Oven
- (iii) Analytical balance

Procedure

The sample is well mixed and 50 ml of it is taken in an evaporating dish of known weight. The waste water is dried to evaporate in an oven at 102°C to 105°C. The dish is again weighed with the residue left over the dish. The difference gives the weight of the total solids in mg., in 50 ml. of sewage. The balance should be capable of weighing one microgram.

CALCULATION AND RESULTS

$$\text{The total solids} = \frac{\text{Weight of dish with residue} - \text{Initial weight of dish}}{\text{Volume of waste water}} \times 1000 \text{mg/litre}$$

Comments

- (i) The determination of total solids gives an idea about the total foulness of the wastewater
- (ii) It gives an indirect estimation of the BOD of the waste that is again the foulness of the wastewater.
- (iii) Higher are the total solids more care is to be taken in its treatment and it shall require more efforts.
- (iv) The further determination of dissolved solids give more fare idea about the BOD i.e the offensiveness of the wastewater.
- (v) The estimation of total solids gives a general picture of the load on sedimentation and grit removal processes in sewage treatment

The determined total solids =mg/l show that the wastewater ispoor / moderate / strongly offensive.

Quiz Questions**1. Sewage contains**

- (i) about 99% solids
- (ii) about 99.9 % solids
- (iii) about 99.9 % water
- (iv) None of above

2. Sewage contains

- (i) organic solids
- (ii) inorganic solid
- (iii) all of above
- (iv) none of above

3. The solids in sewage are

- (i) Dissolved solids
- (ii) Suspended solids
- (iii) Colloidal solids
- (iv) All of above

4. The decomposition of sewage depends upon

- (i) Temperature
- (ii) pH
- (iii) Absence of toxic matter
- (iv) All of above

5. The aerobic decomposition leads to gases like

- (i) NH_3
- (ii) H_2S
- (iii) CO_2
- (iv) CH_4

6. The anaerobic decomposition leads to gases like

- (i) CO_2
- (ii) CH_4
- (iii) SO_2
- (iv) NO_2

7. The determination of total solids gives an idea about

- (i) The foulness of the sewage
- (ii) The B.O.D. of the sewage
- (iii) The expected load on sedimentation units
- (iv) All of above

Correct Answers

1. (iii) 2. (iii) 3. (iv) 4. (iv) 5. (iii) 6. (ii) 7. (iv)

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EXPERIMENT 10

Object: Measurement of Total Dissolved Solids in Sewage

THEORY

Sewage contains 99.9% water and only 0.1% solids but the nuisance caused by them is considerable, as they are highly putrescible (readily degradable) and therefore require proper treatment before disposal. The solids present in sewage may be classified as suspended and dissolved solids which may further be subdivided into volatile and non volatile solids. The volatile matter is organic matter. Quantification of volatile or organic fraction of solid which is putrescible is necessary as this constitutes the load on biological treatment units or oxygen resources of a stream when sewage is disposed of in a river. The dissolved solid may be inorganic also and the inorganic fraction is considered when sewage is used for land irrigation or when reuse of sewage is done for any other purpose. The measurement of total dissolved solids in water can be done in similar way, by taking the sample of water, in place of sewage.

Apparatus

- (i) Evaporating dishes
- (ii) Drying oven
- (iii) Standard filter paper
- (iv) Digital weighing balance (microgram)
- (v) Conical flask
- (vi) Measuring cylinder

Procedure

Take 50 ml of well mixed sewage sample in a measuring cylinder. Have four folds of the standard filter paper and fix it on the funnel placed over a conical flask. Pour the sewage

gently on the funnel and allow it to slowly filter down through the funnel shaped filter paper. Pour it intermittently so that the filtrate is only sewage containing dissolved solids and the suspended impurities are filtered out.

Transfer filtrate to a weighed evaporating dish (weight say A mg) and evaporate to dryness in the drying oven. Dry evaporated sample for 1 hr in an oven at 180°C and cool it. Weight it say as B mg, and calculate the dissolved solids as below.

CALCULATIONS AND RESULT

$$\text{Total Dissolved Solids in mg/litre} = \frac{(A-B) \times 1000}{50 \text{ (volume of sample in ml)}}$$

Comments

The total dissolved solids give an idea about the organic and inorganic matter present in the sewage in dissolved form. Organic matter is volatile and can be determined by igniting the residue at higher temperature at 550 °C. Even the total dissolved solids give a fair idea about the organic matter and the anticipated treatment of the wastewater. Treatment means to satisfy the BOD. BOD can be satisfied aerobically or anerobically. Aerobic treatment is better as it produces less harmful end products but it is generally costly. So depending upon the foulness (organic solid matter) and the funds available the selection of process is done.

The total dissolved solids in the given sewage sample aremg/L which shows that.....

Quiz Questions

1. Putrescible solid means
 - (i) Readily degradable organic matter
 - (ii) Most offensive matter
 - (iii) Solids with high BOD
 - (iv) All of above
2. The solids in sewage may be
 - (i) Suspended
 - (ii) Dissolved
 - (iii) Volatile or non volatile
 - (iv) All of above

3. **The dissolved solids that impose BOD are**
 - (i) Volatile solids
 - (ii) Non volatile solids
 - (iii) Inorganic solids
 - (iv) None of the above
4. **The volatile or organic fraction of the solids is observed because**
 - (i) It produces BOD
 - (ii) It is putrescible
 - (iii) It consumes the D.O
 - (iv) All of the above
5. **Aerobic treatment is better as**
 - (i) It produces more stable solids
 - (ii) It produces lesser harmful gases
 - (iii) It is more hygienic
 - (iv) All of the above
6. **Anaerobic treatment is more desirable**
 - (i) When the concentrated solid organic matter (sludge) is to be digested
 - (ii) When a cheaper method is sought
 - (iii) When the end products are to be used, e.g biogas
 - (iv) All of the above

Correct Answers

1. (iv) 2. (iv) 3. (i) 4. (iv) 5. (iv) 6. (iv)

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EXPERIMENT 11

Object: Measurement of Settleable Solids in Sewage

THEORY

As explained earlier sewage contains 99.9% water and 0.1% solids. The solids are either in dissolved form or in suspension. When sewage is passed through a filter the filtrate is not clear and looks turbid (turbidity is the obstruction in the passage of light). The turbidity is because of the filterable solids. This fraction consists of colloidal solids as well as dissolved solids. The colloidal fraction consists of the particulate matter of diameter ranging from 1 milimicron to 1 micron. The colloidal fraction consists of finely divided particles of gels, emulsions, grease, oil causing foams. The colloidal particles are also the fine clay particles with same charge repulsing each other. Because of their size and charge they can not settle by gravitational force. They have to be removed either by biological oxidation or chemical coagulation.

But a major portion of the suspended solids consists of larger, heavier particles that can settle in calm and quiescent conditions. They are known as settleable solids. In sewage treatment, after screening the first treatment unit is a sedimentation chamber known as the grit chamber. It is intended that particles of size 0.15mm to 0.2 mm with a specific gravity of 2.4 to 2.65 are settled in the grit chamber. These particles are generally inorganic particles and they are not degradable. The deposited particles, known as grit can be easily disposed of without any treatment. Even they can be used for filling purposes or low grade concrete.

The significance of this test is in finding the settelable portion of the suspended solids to design the grit chambers and to estimate the amount of deposited material daily in the grit chambers that is to be removed and disposed or used.

Apparatus

Imhoff Cone: It is a long glass cone specially designed with a mark on the top indicating its capacity as one litre; mounted on a stand.

Procedure

Pour the well mixed sample in the Imhoff cone upto 1 litre mark. Allow the sample to settle for 45 minutes. Gently stir sides of the cone with a knife so that the material sticking to the sides may also get settled. Allow it to settle for further 15 minutes. Thus the total settling time is 1 hour. The bottom of the cone is graduated in milliliters. Read from the graduated scale in terms of milliliters per litre.

CALCULATION AND RESULTS

Direct reading on the graduated bottom of the cone gives the amount of settleable solids in milliliters per litre of sewage.

The settleable solid in the given sample of sewage aremilliliters /L

Comments

The first step of treatment of sewage after screening is the removal of settleable solid from it. The settleable solids are the larger suspended solids that can easily settle in a sedimentation tank without any coagulation (mixing of chemicals like alum). The settleable solids may be small (lighter) and large (heavier). The lighter are organic and the heavier are inorganic particles. In grit chambers the intention is to separate the inorganic matter so that it can be disposed off safely without any treatment, so the detention time is kept very small i.e. say 60 seconds. However in this test as the detention time is 60 minutes, so it is expected that almost all (organic as well as inorganic) particles get settled down. It is a useful test to determine the sewage characteristics regarding the solids that can be separated easily as apart of the treatment. This removal of solids improves the efficiency of other unit operations as the biological treatment etc.

The given sample of sewage contains.....ml/L of settleable solids indicates that.....

Quiz Questions

1. Turbidity is caused due to
 - (i) The suspended particles
 - (ii) The settleable particles
 - (iii) The colloidal particles
 - (iv) All of the above

2. The colloidal fraction consists of particles with dia
 - (i) More than 1 micron
 - (ii) 1 millimicron to 1 micron
 - (iii) 0.15 mm
 - (iv) 0.2mm
3. The settleable suspended solids with diameter 0.15 to 0.2mm are generally
 - (i) Inorganic
 - (ii) Organic
 - (iii) All of above
 - (iv) None of above
4. The settleable solids are determined for the design of
 - (i) Screens
 - (ii) Grit chambers
 - (iii) Filters
 - (iv) Intakes

Correct Answers

1. (iii) 2. (ii) 3. (i) 4. (ii)