



University of Technology

Building & construction department

Sanitary and Environmental Engineering

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**Sanitary Engineering Lab
Treatment 3rd Class**

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Experimental Tests for Sanitary Engineering Lab :**1-Physical Characteristics (Color, Odor and Temperature).****2- pH.****3- Turbidity****4- Conductivity****5- Total Solids in Water****6- Total Dissolved Solids****7- Total Suspended Solids****8- Settling Column****9- Jar Test (To determine the optimum concentration of coagulant to be added to the water).****10- Dissolved oxygen.****11-Sludge Volume Index**

(EXP-1)
Physical characteristics

The principal physical characteristics of wastewater include color, odor and temperature.

Color

Color is a qualitative characteristic that can be used to assess the general Condition of wastewater. Wastewater that is light brown in color, while a light-to-medium grey color is characteristic of wastewaters that have undergone some degree of decomposition or that have been in the collection system for some time. Lastly, if the color is dark grey or black, the wastewater is typically septic, having undergone extensive bacterial decomposition under anaerobic conditions. The blackening of wastewater is often due to the formation of various sulphides, particularly, ferrous sulphide. This results when hydrogen sulphide produced under anaerobic conditions combines with divalent metal, such as iron, which may be present.

Odor

The determination of odor has become increasingly important, as the general public has become more concerned with the proper operation of wastewater treatment facilities. The odor of fresh wastewater is usually not offensive, but a variety of odorous compounds are released when wastewater is decomposed biologically under anaerobic conditions.

Temperature

The temperature of wastewater is commonly higher than that of the water supply because warm municipal water has been added. The measurement of temperature is important because most wastewater treatment schemes include biological processes that are temperature dependent. The temperature of wastewater will vary from season to season and also with geographic location.

(EXP-2)**pH****Introduction:**

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment is pH-dependent. At a given temperature the intensity of the acidic or basic character of a solution is indicated by hydrogen ion activity.

Basic Theory:

In general, pH is a measure of the degree of acidity or alkalinity of a substance or refers to the measure of hydrogen ion concentration in a solution and defined as the negative log of H⁺ ions concentration in water and wastewater. The values of pH 0 to a little less than 7 are termed as acidic and the values of pH a little above 7 to 14 are termed as basic. When the concentration of H⁺ and OH⁻ ions are equal then it is termed as neutral pH. It's related to the active acid concentration of a solution by this equation:

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

Measurement:

A pH meter is an electronic device used for measuring the pH (acidity or alkalinity) of a liquid. A typical pH meter consists of a special measuring probe (a glass electrode) connected to an electronic meter that measures and displays the pH reading.

Apparatus:

1. pH meter
2. Standard flasks
3. Beaker
4. Wash Bottle

Chemicals:

1. Buffers Solutions of pH 4.01, 7.0 and 9.2
2. Distilled Water

Procedure:

The major steps are involved in the experiment its calibrating the Instrument and Testing of Sample.

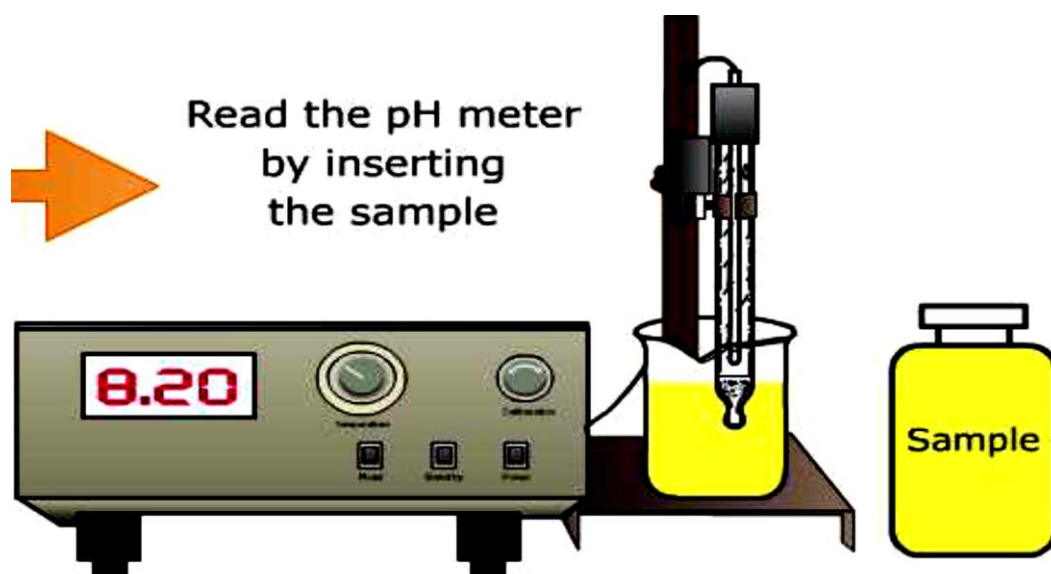
Calibrating the Instrument:

Using the buffer solutions calibrates the instrument:

In a 50 mL beaker take pH 4.0 buffer solution place the electrode in the beaker containing the stirred buffer and check for the reading in the pH meter until its reach pH 4.0 Take the electrode from the buffer, wash it with distilled water and then wipe gently with soft tissue and Repeat the same steps as the previous for pH (7.0, 10.0) buffer solution.

Testing of sample:

In a clean dry 50 mL beaker take the water sample and place the electrode in the beaker and check for the reading in the pH meter. Wait until you get a stable reading .Take the electrode from the water sample, wash it with distilled water and then wipe gently with soft tissue.



(EXP-3)**Conductivity**

The conductivity of water is a measure of the ability of water to carry an electric current. Conductivity is defined as 'the ability to conduct or transmit electricity. The conductivity of water is directly linked to the concentration of the ions and their mobility. The ion in water acts as electrolytes and conducts the electricity. The electrical conductivity can be expressed as mhos (Reciprocal of ohms) or as Siemens. Water shows significant conductivity when dissolved salts are present. Over most ranges, the amount of conductivity is directly proportional to the amount of salts dissolved in the water.

Principle:

Conductivity is measured with a probe and a meter. A voltage is applied between the two electrodes in the probe immersed in the sample water. The drop in voltage caused by the resistance of the water is used to calculate the conductivity per centimeter. Conductivity (G), the inverse of resistivity (R) is determined from the voltage and current values according to Ohm's law. $R=V/I$ then, $G=1/R=I/V$. The meter converts the probe measurement to micro mhos per centimeter and displays the result for the user.

Materials Required:**Apparatus Required**

1. Conductivity Meter with Electrode probe
2. Magnetic Stirrer with stirring bead
3. Standard flask
4. Measuring jar
5. Beaker 250 mL
6. Funnel
7. Tissue Paper

Chemicals Required

1. Potassium Chloride Regents
2. Distilled Water

Procedure:

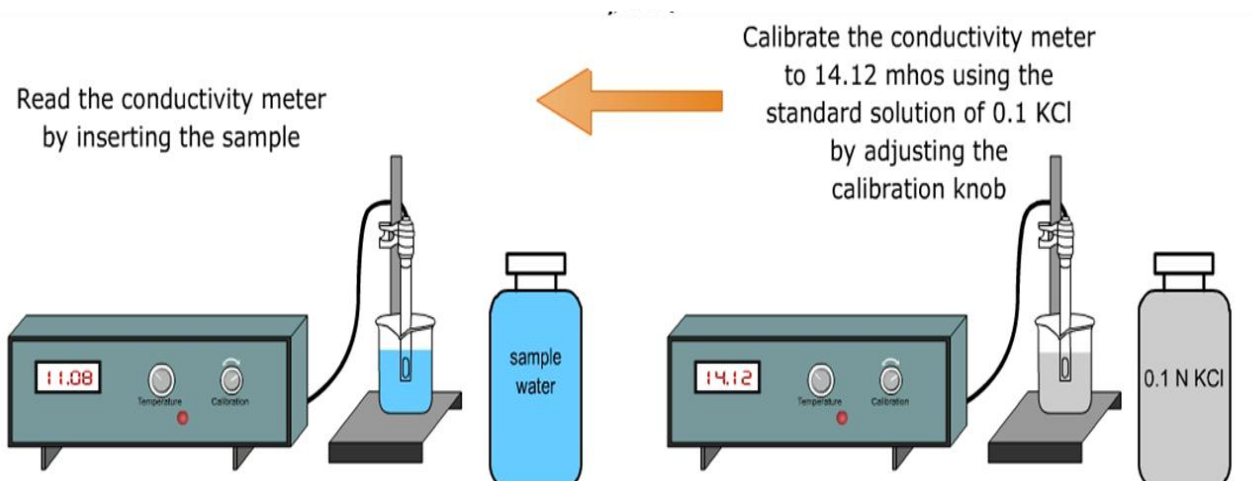
Calibration of Conductivity Meter

Take 0.1N Potassium Chloride in a beaker. Switch on the magnetic stirrer and place the beaker on the stirrer. Insert the magnetic bead in the beaker. Place the electrode inside the solution. Select the calibration button and using up and down key adjusts the conductivity of the 0.1N potassium chloride solution to 14.12 millisiemens / cm at 30oc. Now the meter is ready for the measurement of samples.

Testing of Water Sample:

- Rinse the electrode thoroughly with deionized water and carefully wipe with a tissue paper.
- Measure 200 mL of water sample and transfer it to a beaker and place it on the magnetic stirrer.

Dip the electrode into the sample solution taken in a beaker and wait for a steady reading. Make sure that the instrument is giving stable reading. Note down the reading in the display directly, which is expressed in millisiemen.



(EXP-4) Turbidity

Introduction:

Turbidity is the term referring to the cloudiness of a solution and it is a qualitative characteristic which is imparted by solid particles obstructing the transmittance of light through a water sample. Turbidity often indicates the presence of dispersed and suspended solids like clay, organic matter, silt, algae and other microorganisms.

Several methods are available to test turbidity in water.

1-Jackson Candle Turbidimeter: The Jackson Candle Turbidimeter consists of flat-bottomed glass tube that sits over a candle. A water sample is poured into the tube until the visual image of the candle flame diffuses into a uniform glow. The depth of the sample corresponds to a certain number of Jackson turbidity units, or JTUs.



2- Secchi Disk: is a black and white disk that is lowered by hand into the water to the depth at which it vanishes from sight, the distance to vanishing is then recorded.

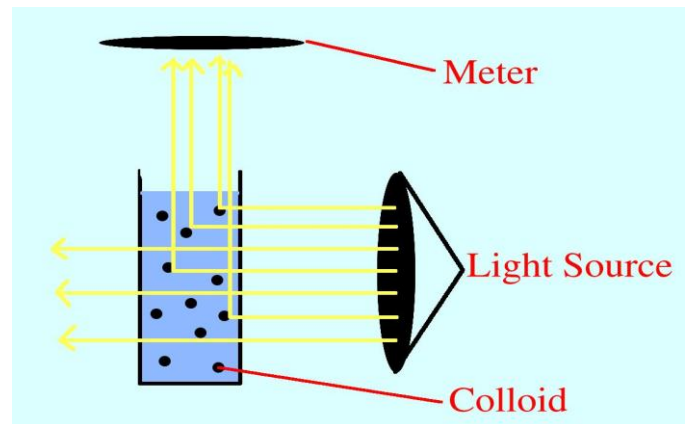


3- Nephelometric turbidity meter:

Principle:

Turbidity is based on the comparison of the intensity of light scattered by the sample under defined conditions with the intensity of the light scattered by a standard reference suspension under the same conditions. The turbidity of the sample is thus measured from the amount of light scattered by the sample taking a reference with

standard turbidity suspension. The higher the intensity of scattered light the higher is the turbidity. The turbidimeter shall consist of a nephelometer with light source for illuminating the sample and one or more photo-electric detectors with a readout device to indicate the intensity of light scattered at right angles to the path of the incident light. Formazin polymer is used as the primary standard reference suspension.



Materials Required:

Apparatus Required

1. Turbidity Meter
2. Sample Cells
3. Standard flasks

Chemicals Required

1. Hexamethylenetetramine reagent
2. Hydrazine sulphate reagent
3. Distilled water

Standard 4000 NTU Solution

- Mix 5 mL of hydrazine sulphate solution and 5 mL of Hexamethylenetetramine solution in a 100 mL standard measuring flask.
- Allow the mixture to stand for 24 hours.
- After 24 hours, make up the volume to 100 mL using turbidity free distilled water.
- The standard 4000 NTU solution is ready.

Calibration of turbidimeter:

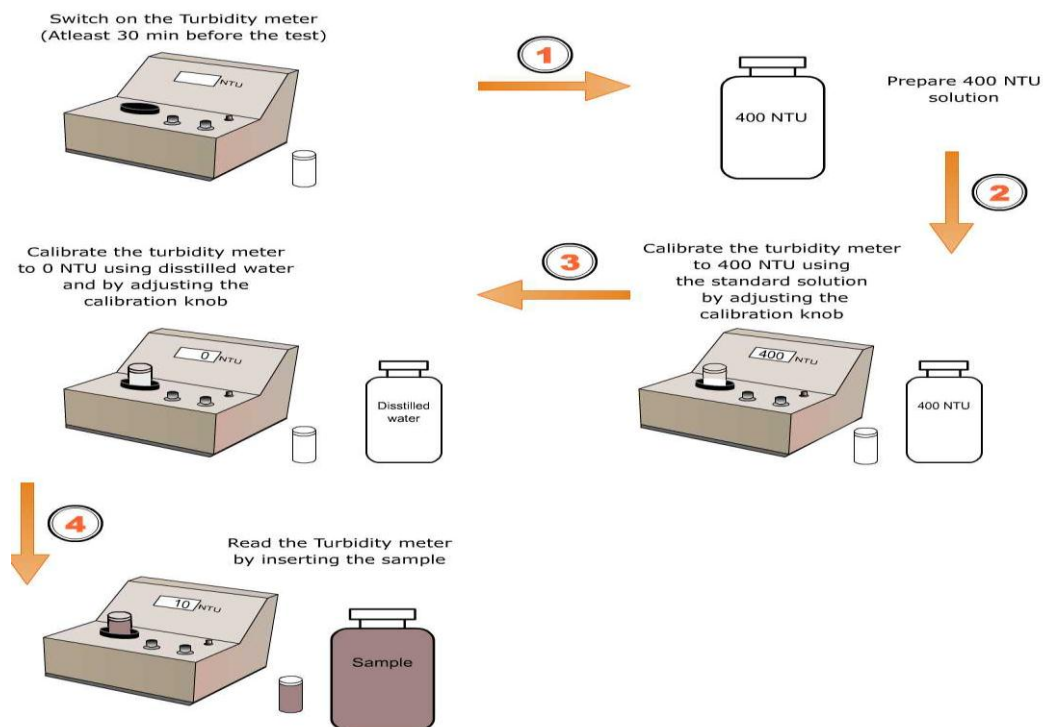
Step 1 To the sample cells, add turbidity free distilled water up to the horizontal mark. Place it in the turbidity meter such that the vertical mark in the sample cell should

coincide with the mark in the turbidity meter and cover the sample cell. Now using the set zero knob, adjust the reading to zero.

Step 2 prepares a standard solution. In this case, a 200 NTU solution is prepared by diluting the standard 4000 NTU solution and added to the sample cells, up to the horizontal mark. Place it in the turbidity meter such that the vertical mark in the sample cell should coincide with the mark in the turbidity meter and cover the sample cell. If the instrument is not showing 200 NTU, using the calibration knob adjust the reading to 200 NTU. Repeat the procedure for two / three times. Now the instrument is calibrated.

Testing of Water Sample:

To the sample cells, add sample water up to the horizontal mark, wipe gently with soft tissue and place it in the turbidity meter such that the vertical mark in the sample cell should coincide with the mark in the turbidity meter and cover the sample cell. Check for the reading in the turbidity meter. Wait until you get a stable reading.



(EXP-5)**Total Solids****Introduction:**

The term “solids” is generally used when referring to any material suspended or dissolved in water or wastewater that can be physically isolated either through filtration or through evaporation. Solids can be classified as either filterable or non-filterable. Filterable solids may either be settleable or non settleable. Solids can also be classified as organic or inorganic. Total Solids is the term applied to the material residue left in the vessel after evaporation of a sample and its subsequent drying in an oven at a defined temperature. Solids analyses are important in the control of biological and physical wastewater treatment processes. Measurement of Solids can be made in different water samples (industrial, domestic and drinking water) and it is defined as residue upon evaporation of free water. Total solids are nothing but summation of total dissolved solids and total suspended solids.

Principle:

The sample is evaporated in a weighed dish on a steam bath and is dried to a constant mass in an oven either at 103-105°C. Total solids/residue is calculated from increase in mass.

Measurement:**Apparatus:**

1. Oven
2. Desiccators
3. Balance
4. Dish
5. Vacuum Pumps
- 6-Forcep

Procedure:

- Take a clean porcelain dish which has been washed and dried in a hot air oven at 105°C for one hour.

- Cool the dish, weigh and keep it in a desiccator. We denote the weight measured as (W1).
- Transfer carefully 50 ml of sample into the dish and evaporate to dryness on a steam bath
- Place the evaporated sample in an oven adjusted at 103⁰C and dry it for 1 hr.
- Cool the dish in a desiccator, weigh the dish as soon as it has cooled and Note the weight with residue as (W2).

Calculation:

Determine the total solids with the following formula:

Initial weight of the Crucible (**W1**) = g

Final weight of the Crucible + sample (**W2**) = g

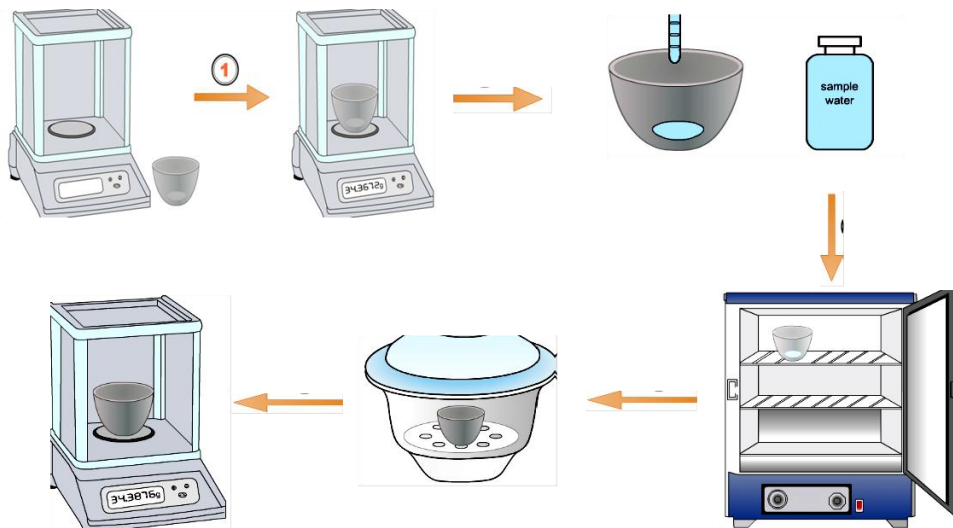
Weight of residue (**W**) = **W2 - W1**..... g

T.S= (1000*1000 **W**) / **v** =.....**mg/L**

W = weight of total residue in (**mg**). (Therefore multiply W with 1000)

V = Volume of the sample (**mL**)(To convert mL to L)

Procedure chart



(EXP-6)**Total Dissolved Solids****Introduction:**

The term total dissolved solids refer to materials that are completely dissolved in water. These solids are filterable in nature. It is defined as residue upon evaporation of filterable sample.

Principle:

A well-mixed sample is filtered through a standard glass fiber filter, and the filtrate is evaporated to dryness in a weighed dish and dried to constant weight at 179-181°C.

The increase in dish weight represents the total dissolved solids.

Measurement:**Apparatus:**

1. Oven
2. Desiccators
3. Balance
4. Dish
5. Vacuum Pumps
- 6-Forceps
- 7- Filter paper

Procedure:

- To measure total dissolved solids, take a clean porcelain dish which has been washed and dried in a hot air oven at 180(C) for one hour.
- Now weigh the empty evaporating dish in analytical balance. Let's denote the weight measured as (W1).
- Mix sample well and pour into a funnel with filter paper. Filter approximately (80 -100) mL of sample
- Using pipette transfer 75mL of filtered sample in the porcelain dish.

- Place sample in the hot oven (105c⁰) Dry the sample to get constant mass.
Drying for long duration usually 1 to 2 hours
- Cool the dish in a desiccator, weigh the dish as soon as it has cooled and Note the weight with residue as (W2).

Calculation:

Determine the total dissolved solids with the following formula:

Initial weight of the Crucible (W1) = g

Final weight of the Crucible + sample (W2) = g

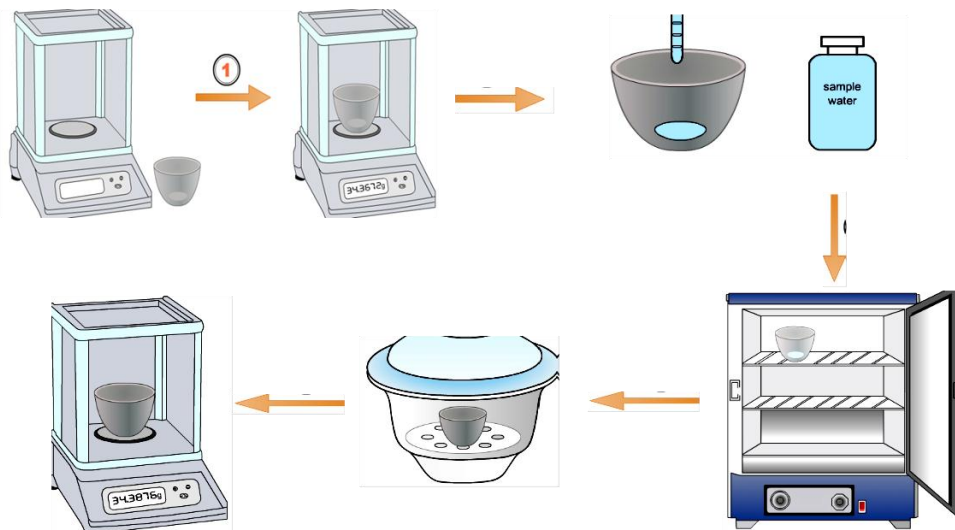
Weight of residue (W) = W2 - W1..... g

T.D.S= (1000*1000 W) / v =.....mg/L

W = weight of total residue in (mg). (Therefore multiply W with 1000)

V = Volume of the sample (mL)(To convert mL to L)

Procedure chart



(EXP-7)**Total suspended solids:****Introduction:**

The term total suspended solids can be referred to materials which are not dissolved in water and are non-filterable in nature. It is defined as residue upon evaporation of non-filterable sample on a filter paper.

Principle:

A well-mixed sample is filtered through a weighed standard glass fiber filter and the residue retained on the filter is dried to a constant weight at 103-105°C. The increase in a weight of the filter represents the total suspended solids. If the suspended material clogs the filter and prolongs filtration, the difference between the total solids and total dissolved solids may provide an estimate of the total suspended solids.

Measurement:**Apparatus:**

1. Oven
2. Desiccators
3. Balance
4. Dish
5. Vacuum Pumps
- 6-Forceps
- 7- Filter paper

Procedure:

- Take a clean Filter paper which has been dried in a hot air oven at 105(C) for one hour, weigh the Filter paper in analytical balance. Let's denote the weight measured as (W1).
- Mix sample well and pour into a funnel with filter paper. Filter approximately (80 -100) mL of sample.

- Place Filter paper with unfiltered sample in the hot oven (105c0) Dry the sample to get constant mass. Drying for long duration usually 1 to 2 hours
- Cool the Filter paper in a desiccator, weigh the Filter paper as soon as it has cooled and Note the weight with residue as (W2).

Calculation:

Determine the total suspended solids with the following formula:

Initial weight of the Filter paper (W1) = g

Final weight of the Filter paper + sample (W2) = g

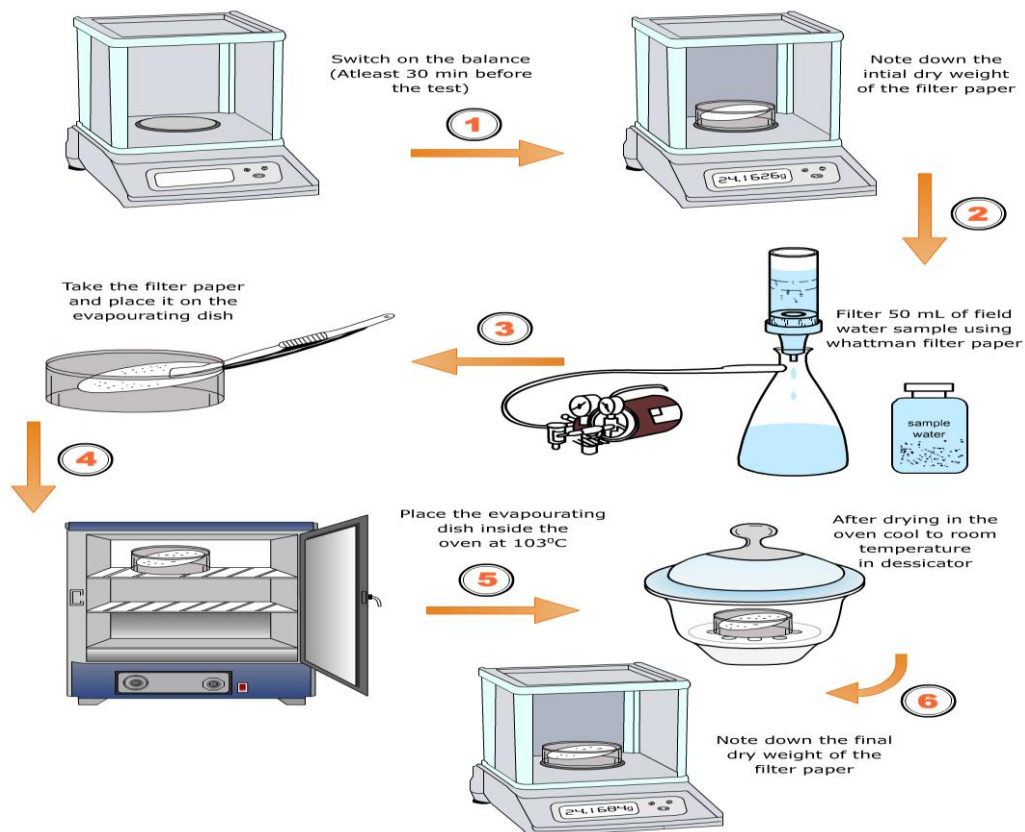
Weight of residue (W) = W2 - W1..... g

T.S.S= (1000*1000 W) / v =.....mg/L

W = weight of total residue in (mg). (Therefore multiply W with 1000)

V = Volume of the sample (mL)(To convert mL to L)

PROCEDURE CHART



(EXP-8)**Settling Column**

Sedimentation is the process of separating of a dilute slurry or suspension by gravity settling into a clear fluid. Sedimentation is classified upon the characteristics and concentration of suspended materials:

- Discrete particles
- Flocculent

Discrete particles

Discrete particles are particle whose size, shape and specific gravity do not change with time i.e. non-interactive settling of particles from a dilute suspension. Examples are grit and sand, and their mass is constant.

Flocculants particles

Particles which agglomerate (coalesce/flocculate) during settling i.e. no constant characteristics. Their mass varies during the process of settling and an increase in mass causes a faster rate of settlement

There in the water suspended particles of different sizes which are difficult to calculate the speed of sedimentation of particles separated in theory. So can estimate the total removal of particles suspended any rate for this work by use a special column for Sedimentation length (m 1) and diameter (mm150) with sites to take the models at different heights.

Apparatus Required:

1-column for Sedimentation length (m 1) and diameter (mm150) .

2-Turbidity Meter.

Procedure:**Testing of Sample:**

- 1- Fill the column by sample which has a concentration of homogeneous through various depths and measured turbidity value of the sample
- 2- leave the sample to settle for (3-5) minutes
- 3- take samples from different depths during different time periods
- 4- Carefully take (20) ml of sample from each depth of sample and measured turbidity.

Calculation:

1-regulates the table as follows and placed the results of the required Relations

Time	Turbidity1 (NTU)	% Percentage removal					
		10	20	30	40	50	60
10							
20							
30							
40							

Percentage removal = $(\text{turbidity1} - \text{turbidity2}) / \text{turbidity1} * 100$

3- Plotted the following relationships: depth, time and Percentage removal

(EXP-9)**Jar Test****Introduction**

Coagulation/flocculation is the process of binding small particles in the water together into larger, heavier clumps which settle out relatively quickly. The larger particles are known as floc. Properly formed floc will settle out of water quickly in the sedimentation basin, removing the majority of the water's turbidity. In many plants, changing water characteristics require the operator to adjust coagulant dosages at intervals to achieve optimal coagulation. Different dosages of coagulants are tested using a jar test, which mimics the conditions found in the treatment plant. Jar testing is a pilot-scale test of the treatment chemicals used in a particular water plant. Jar testing entails adjusting the amount of treatment chemicals and the sequence in which they are added to samples of raw water held in jars or beakers

Principle:

The first step of the jar test involves adding coagulant to the source water and mixing the water rapidly (as it would be mixed in the flash mix chamber) to completely dissolve the coagulant in the water. Then the water is mixed more slowly for a longer time period, mimicking the flocculation basin conditions and allowing the forming floc particles to cluster together. Finally, the mixer is stopped and the floc is allowed to settle out, as it would in the sedimentation basin.

Purpose

To determine the optimum concentration of coagulant to be added to the source water and thus calculate the best ratio for the removal using alum or any other coagulant.

Chemical compounds coagulase:

There are many chemicals used in the Coagulation/flocculation and the following compounds most widely used are: aluminum sulfate (alum), sodium aluminate, ferric chloride, ferric sulfate, hydrated lime and Sodium Carbonate.

Materials Required:**Apparatus Required:**

1-jar testing device (Sedimentation Jar Test): consist o

- Four or six-place gang stirrer
- Four to six beakers 1000 ml

2-Turbidity Meter

3-pH Meter

4- Pipettes 10 ml

Chemicals Required:

A solution of alum (dissolving (1 g) of alum used in the treatment in one liter of distilled water)

Procedure:

Can work experience to find a relationship with many variables and so:

- 1-When you change the period of mixing.
- 2- When you change the period of sedimentation.
- 3- When comparing different materials coagulation.

Testing of Sample:

1-measured turbidity and pH value of the raw water sample

2- Placed one liter sample of raw water in each Baker with the addition of coagulase material doses by Pipette in different concentrations.

3- Start mixing solutions for (1-2) minutes on the maximum speed (flash mix), then reduce the speed to slow speed (slow mix) and continue to mixing on solutions for the slow speed (15-20 minutes)

4- At the end of the mixing period, turn off the stirrer, let the flocs settle (at least 20 minutes) ,Carefully take (50) ml of sample from each beaker of sample by Pipette and measured turbidity and pH in each of the samples.



Calculation:

1-regulates the table as follows and placed the results of the required Relations

No Beaker	1	2	3	4	5	6
Dosage						
Turbidity						
pH						

2- Percentage removal = (turbidity1- turbidity2)/ turbidity1 *100

3- Plotted the following relationships:

- The relationship between the dose of alum and final turbidity.
- The relationship between the dose of alum and Percentage removal.

(EXP-10)**Dissolved oxygen**

The term Dissolved Oxygen is used to describe the amount of oxygen dissolved in a unit volume of water. Dissolved oxygen (DO) is essential for the maintenance of healthy lakes and rivers. The presence of oxygen in water is a good sign. Depletion of dissolved oxygen in water supplies can encourage the microbial reduction of nitrate to nitrite and sulfate to sulfide. Analysis of dissolved oxygen is an important step in water pollution control and wastewater treatment process control.

The Factors Effect on Dissolved Oxygen Concentration is:

- Water Temperature
- Atmospheric Pressure
- Water movement
- Aquatic Organisms
- Salinity
- Organic Matter

Principle:

Dissolved Oxygen can be measured either by titrimetric or electrometric method.

1-Titrimetric Method (Winkler Method)

Titrimetric method is based on the oxidizing property of DO. Divalent Manganese salt in solution is precipitated by strong alkali to divalent manganese hydroxide. Addition of Potassium iodide or Potassium hydroxide is added to create a pinkish brown precipitate. In the alkaline solution, dissolved oxygen present in the sample rapidly oxidized to form trivalent or higher valiancy hydroxide



Iodide ions are added and acidified (acid facilitates the conversion by the brown), which reduces tetravalent hydroxides back to their stable divalent state thereby liberating equivalent amount of iodine.



Thiosulphate solution is used, with a starch indicator, to titrate the iodine.

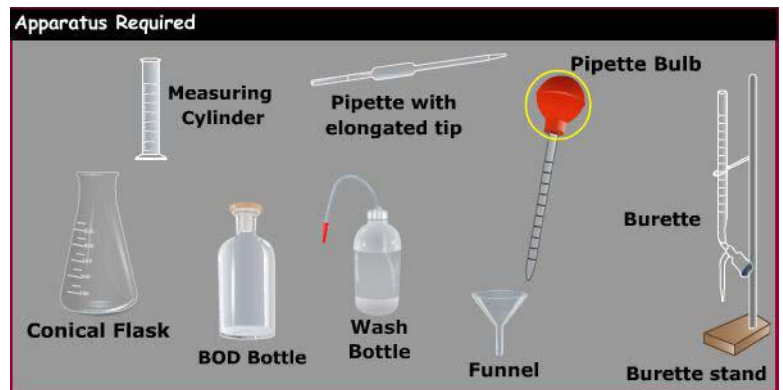


This iodine is equivalent to dissolved oxygen present in the sample.

Materials Required

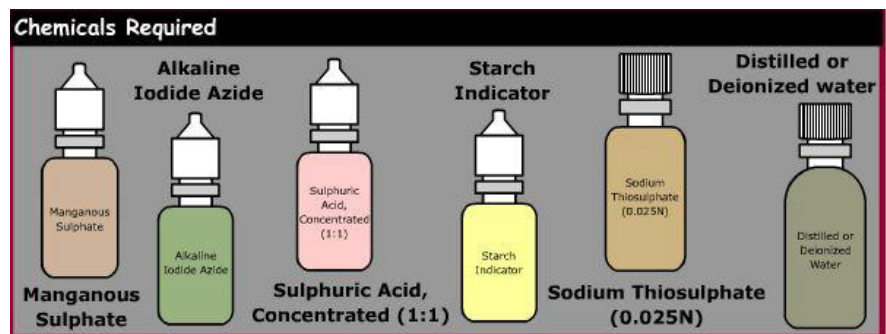
Apparatus Required

1. Burette
2. Burette stand
3. 300 mL glass stoppered BOD bottles
4. 500 mL conical flask
5. Pipettes with elongated tips
6. Pipette bulb
7. 250 mL graduated cylinders
8. Wash bottle



Chemicals Required

1. Manganese sulphate solution
2. Alkaline iodide-azide solution
3. Sulphuric acid, Concentrated
4. Starch indicator solution
5. Sodium thiosulphate
6. Distilled or deionized water
7. Potassium Hydroxide
8. Potassium Iodide
9. Sodium Azide



Procedure:

For testing the given sample, first the reagents are required to be prepared.

Preparation of Reagents

a) Manganese sulphate solution: Dissolve Manganese Sulphate: 480g of in freshly boiled and cooled distilled water filter the solution and make up to 1000 mL (One litre). Take

Manganese sulphate and transfer it to the beaker. To dissolve the content, place it in the magnetic stirrer.

b) Alkaline Iodide Sodium Azide Solution: To prepare this reagent, take 700 g of Potassium hydroxide and add 150 g of potassium iodide and dissolve it in freshly boiled and cooled water, and make up to 1000 mL (One litre). Dissolve 10 g of Sodium Azide in 40 mL of distilled water and add this with constant stirring to the cool alkaline iodide solution prepared.

c) Sodium Thiosulphate Stock Solution: Weigh approximately 25 g of sodium thiosulphate and dissolve it in boiled distilled water and make up to 1000 mL. Add 1 g of Sodium Hydroxide to preserve it.

d) Starch Indicator: Weigh 2 g of starch and dissolve in 100 mL of hot distilled water. In case if you are going to preserve the starch indicator add 0.2 g of salicylic acid as preservative.

Testing Of Sample

1. Take BOD bottle and fill it with sample to be tested. Avoid any kind of bubbling and trapping of air bubbles. Remember – no bubbles!
2. Add 2mL of manganese sulfate to the BOD bottle by inserting the calibrated pipette just below the surface of the liquid.
3. Add 2 mL of alkali-iodide-azide reagent in the same manner. Carefully stopper and invert several times, brownish-orange cloud of precipitate or floc will appear.
4. Add 2 mL of concentrated sulfuric acid via a pipette held just above the surface of the sample Carefully stopper and invert several times to dissolve the floc.

5. Measure out 203 mL of the solution from the bottle and transfer to an conical flask. Titration needs to be started immediately after the transfer of the contents to conical flask.
6. Titrate it against sodium thiosulphate using starch as indicator. (Add 3 - 4 drops of starch indicator solution)
7. End point of the titration is first disappearance of the blue color to colorless.

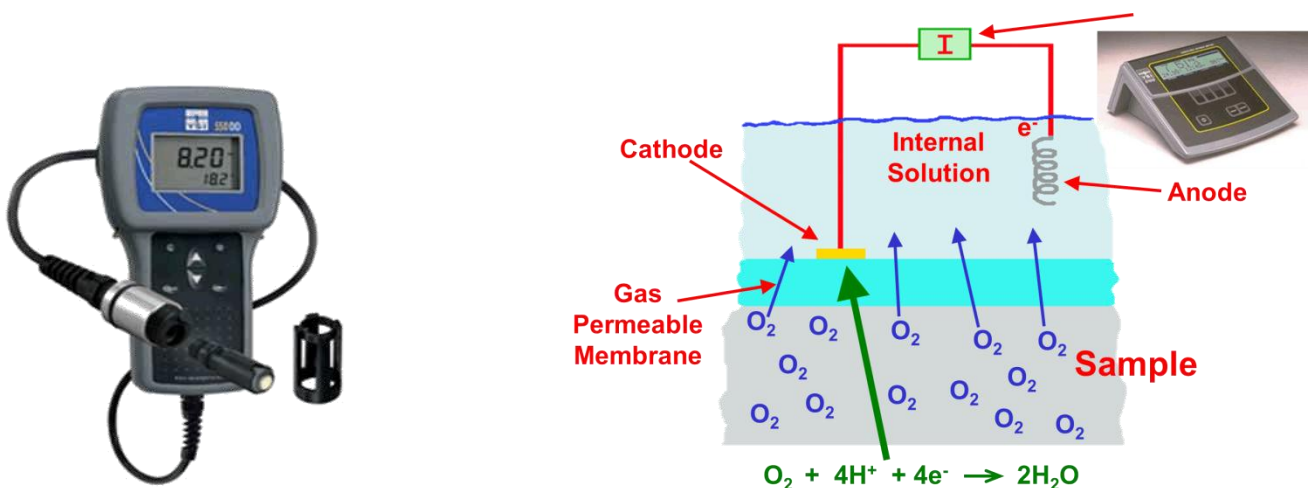
Calculation:

Dissolved Oxygen =
(mg/L)

$$\frac{V \text{ of Sodium Thiosulphate} * \text{Normality of Sodium Thiosulphate} * 1000}{\text{Volume of Sample Taken}}$$

2- Electrometric Method

The electrode method offers several advantages over the titrimetric method including speed, elimination or minimization of interferences, field compatibility, continuous monitoring and in situ measurement. The membrane electrode is composed of two solid metal electrodes in contact with supporting electrolyte separated from the test solution by a gas permeable membrane. Oxygen dissolved in the sample diffuses through the membrane on the DO probe and is chemically reduced (accepts electrons), producing an electrical current between the anode and cathode in the probe. The amount of current is proportional to the concentration of DO



(EXP-11)**Sludge Volume Index**

The sludge volume index (SVI) is the volume in milliliters occupied by 1 g of a suspension after 30 min settling. SVI typically is used to monitor settling characteristics of activated sludge and other biological suspensions. Although SVI is not supported theoretically, experience has shown it to be useful in routine process control.

Apparatus Required:

1-column for Sedimentation length (m 1) and diameter (mm150).

Procedure

Determine the suspended solids concentration of a well-mixed sample of the suspension. Determine the 30 min settled sludge volume.

Calculations

$$SVI = \frac{\text{Settled Sludge Vol}_{30}, \text{ mL/L} \times 1,000}{\text{Mixed Liquor Suspended Solids, mg/L}}$$

