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Examination of Various Chemical Parameters of Water Sample

Abstract

Water is the most precious and important resource on the earth. We all know about the importance of water in our lives and to the environment. And therefore, its quality plays a significant role in determining its usage. To maintain the quality of water, the water analysis must be done first for ensuring the type of quality degradation present in water. And for analysing the water quality, the 3 water quality parameters are used. These are physical parameters, chemical parameters, and biological parameters. This project work focuses on the evaluation of the chemical parameters of quality of water such as pH, chloride content, dissolved oxygen, and alkalinity with their definitions and measuring methods. The sample of water taken, to examine these chemical parameters of water quality, is the 'tap water.

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INTRODUCTION

Water

Water is an important natural resource on the earth. Living organisms require water for their existence and for performing different works such as plants uses water to make their food by the photosynthesis process, animals or plants requires water for completing their daily metabolic activities.

Water is a main constituent of the Earth's hydrosphere and 97% of the surface of earth is covered with it.

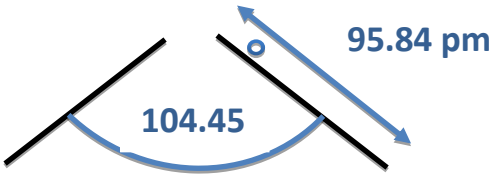
Three major sources of water are:

- Rainwater,
- Groundwater (Wells, Springs, etc.),
- Surface water (Rivers, Ponds, Lakes, etc.).

An individual uses an average of 600-700L in a day. It is hard to imagine our life without water.

Water is an inorganic compound and the chemical formula for it is H_2O. It is tasteless, odorless, and transparent in nature.

A molecule of water (H_2O) contains one oxygen and two hydrogen atoms connected covalently to the oxygen atom at an angle of 104.45°.



Structure of water molecule

Water Quality

Though 97% of the earth's surface contains water however, only 2-3% freshwater is safe and available for drinking. The rest of the water is either salty or frozen in glaciers.

That is why we need to safe water as it is limited and the most precious natural resource on the earth.

The different factors that affect the quality of water and make it unsuitable for drinking and gives rise to water pollution includes agricultural activities, industrial waste, sewage and wastewater discharge into oceans, rivers, or lakes, etc.

Thus, water quality analysis and its maintenance is necessary for all the living beings and for the environment.

For measuring the quality of water, there are three water quality parameters. These are as follows:

- Physical Parameters (includes taste, colour, odor, turbidity, TDS, TSS, TS and conductivity),
- Chemical Parameters (includes pH, hardness, chloride, dissolved oxygen [DO], chemical oxygen demand [COD], alkalinity),
- Biological Parameters (includes bacteria, algae, and virus).

Chemical Water Quality Parameters

pH

The negative of the log of the hydrogen ion conc.[H+] is called as the pH. pH is an important parameter for analyzing the quality of water as it measures how acidic or alkaline the water is.

$$pH = -\log[H^+]$$

The pH scale ranges from 0 to 14 in which 7 indicates the neutral nature, number less than 7 indicates the acidic nature and number more than 7 indicates the basic nature.

Materials Required

Beakers, pH meter, buffer solution with a known pH, tissue paper and distilled water.

Procedure

a) The pH meter is set to 'ON'.
b) To calibrate the pH meter, the pH meter's electrode is dipped in a buffer solution with known pH.
c) After calibrating the pH meter, the electrode is washed by dipping it into the beaker containing distilled water and then it is gently wiped with a tissue paper.
d) Now, the electrode is dipped into the water sample and two to three readings are noted.

Observation Table

S.No.	pH of Water sample	Average pH
1.	7.88	7.62
2.	7.36	

Result

The pH of water sample taken, i.e., the tap water is 7.62 which indicates that the water sample is slightly alkaline in nature.

Dissolved Oxygen

Dissolved Oxygen is defined as the total amount of oxygen molecules that are present in water. DO is essential for the marine life and is used as an indication of water pollution.

Dissolved Oxygen is proportional to quality of water i.e., higher the concentration of dissolved oxygen, better will be the quality of water.

Dissolved Oxygen can be measured using Winkler's Titration method.

In Winkler's Method chemicals are added to the water sample and they reacts with oxygen molecules present in water sample thereby, forming an acidic solution.

The quantity of neutralizing agent (neutralize that solution until the sample's color disappears) indicates how much oxygen is in the water sample.

The oxygen in the water sample oxidizes potassium iodide to iodine. This iodine is then titrated against the standard sodium thiosulphate solution. Starch is used as an indicator.

Since, oxygen in the water sample is in the molecular state and so, it cannot oxidize KI.

Hence, manganese hydroxide is used as an oxygen carrier to bring about the reaction between KI and oxygen.

Manganese hydroxide is obtained by the reaction of KOH with manganese sulphate (MnSO4).

Reactions Involved

$$MnSO4 + 2KOH \rightarrow Mn(OH)2 + K2SO4$$

$$2Mn(OH)2 + O2 \rightarrow 2MnO(OH)2$$

$$MnO(OH)2 + H2SO4 \rightarrow MnSO4 + 2H2O + (O)$$

$$2KI + H2SO4 + (O) \rightarrow K2SO4 + H2 + I2$$

$$2Na2S2O3 + I2 \rightarrow Na2S4O6 + 2NaI$$

Materials Required

Beakers, reagent bottle, conical flask, funnel, burette, pipette, dropper, measuring cylinder, manganese sulphate, alkaline KI solution, N/40 hypo solution, conc. HCl and starch indicator.

Procedure

a) Take 50ml of the water sample into a reagent bottle and add 1ml of manganese sulphate solution and 2ml of alkaline KI solution to it.
b) Shake the reagent bottle thoroughly.
c) A brown colour precipitate will be settle down due to the formation of MnO(OH)2.
d) Add conc. HCl and again shake the regent bottle until the precipitate completely dissolves.
e) Allow the solution to stand for five minutes.
f) Now, take 50ml of the above solution and titrate it against the N/40 hypo solution until the solution's colour becomes pale yellow.
g) Add 2-3 drops of starch indicator.
h) Again titrate it till the blue colour disappears (end point).

Observation Table

S.No.	Vol. of Sample solution taken, V1(ml)	Burette Reading		Vol. of Standard hypo solution used, V2(ml)
		Initial	Final	
1.	50	0	0.5	0.7
2.	50	0.5	1.2	
3.	50	1.2	3.2	

Calculation

Volume of water sample taken for titration, V1 = 50ml

Volume of hypo solution used, V2 = 0.7ml

Normality of water sample, N1 = N2V2/V1

= 1 x 0.7/40 x 50

= 0.7/2000

N1 = 0.00035

Since, the equivalent weight of Oxygen(O2) is 8g.
The strength of O2 = N1 x 8 g/L

= 0.00035 x 8 x 1000 mg/L

= 0.0028 x 1000

= 2.8 mg/L

Result

The amount of DO(dissolved oxygen) in the water sample is 2.8 mg/L.

Chloride

Chloride ions are usually not harmful to people but high concentrations may lead to heart and kidney diseases.

The estimate of chloride in the drinking water must be less than 250mg/L. If its value exceeds, it shows the wastewater pollution.

The presence of chlorides in water sample can be detected by using Mohr's method.

Mohr's method involves the titration of sample solution against the silver nitrate solution in presence of an indicator (K2Cr2O7).

Reactions Involved

$NaCl + AgNO3 \longrightarrow AgCl + NaNO3$

$2AgNO3 + K2CrO4 \longrightarrow Ag2CrO4 + 2K2NO3$

$Ag2CrO4 + 2Cl^- \longrightarrow 2AgCl + CrO4^{2-}$

$2AgNO3 + K2CrO4 \longrightarrow Ag2CrO4 + 2KNO3$

Materials Required

Beakers, conical flask, funnel, burette, pipette, dropper, burette stand, measuring cylinder, standard N/50 AgNO3 solution (1.8g AgNO3 in 500mL distilled water) and potassium dichromate(K2Cr2O7) as indicator.

Procedure

a) Take 10mL of the water sample in a 150mL conical flask.
b) Add few drops of K2Cr2O7 indicator to it.
c) The solution becomes yellow in colour.
d) Now, titrate it against the standard N/50 silver nitrate solution (AgNO3 solution)
e) Titration is done until the yellow colour of the solution changes to reddish brown colour (end point).
f) Note down the burette reading.
g) Repeat the experiment till concordant reading.

Observation Table

S.No.	Volume of water sample, V1 (mL)	Burette Reading		Volume of AgNO3 used, V2 (mL)
		Initial	Final	
1.	10	0.0	0.3	0.3
2.	10	0.0	0.3	
3.	10	0.0	0.3	

Calculation

Volume of water sample taken, V1 = 10mL

Volume of AgNO3 used, V2 = 0.3mL

Normality of water sample, N1 = N2V2/V1

N1 = 1 x 0.3/50 x 10

N1 = 0.0006

Since, the equivalent weight of Chlorine(Cl2) is 35.5g.

The strength of Cl2 = N1 x 35.5 g/L

= 0.0006 x 35.5 x 1000 mg/L

= 0.0213 x 1000

= 21.3 mg/L

Result: The chloride content in water sample is 21.3 mg/L.

Alkalinity

The alkalinity of the sample of water is the measure of its capacity to neutralize acids and is expressed in the form of mg of CaCO3/dm3.

Most of the samples of water are quite basic in nature. This is because of the presence of carbonates and bicarbonates of the alkali or alkaline earth metals.

The sum of the alkaline species present in the sample of water gives the total alkalinity of water sample.

Alkalinity is mainly caused due to following ions present in water:

- Hydroxides (OH^-)
- Carbonates ($CO3^{2-}$)
- Bicarbonates ($HCO3^-$)

Alkalinity can be measured by titrating the water sample against a standard acid solution using phenolphthalein and methyl orange as indicators.

Hydroxide and carbonate ions are sensitive to phenolphthalein while all the carbonates, bicarbonates and hydroxide ions are sensitive to methyl orange indicator.

The hydroxides and bicarbonates cannot exist together in water. This is due to the following reaction:

$HCO3^- + OH^- \longrightarrow H2O + CO3^{2-}$

Therefore, on the basis of concentration of ions there are five possibilities of alkalinity in water.

Table 1 : The table given below shows the different possibilities of alkalinity.

S.No.	**Result after titration**	**Volume of acid used**		
		For OH^- ions	**For $HCO3^-$ ions**	**For $CO3^{2-}$ ions**
1.	P=0	Ab	M	Ab
2.	P=M	P=M	Ab	Ab
3.	P=1/2M	Ab	Ab	2P or M
4.	P<1/2M	Ab	M-2P	2P
5.	P>1/2M	2P-M	Ab	2(M-P)

where, the terms P, M and Ab in the above table indicates:

P = Phenolphthalein indicator

M = Methyl orange indicator

Ab = Absent

Reactions Involved

On addition of acid, the following reactions happens:

$OH^- + H^+ \longrightarrow H2O$

$CO3^{2-} + H^+ \longrightarrow HCO3^- + OH^-$

$HCO3^- + H^+ \longrightarrow H2O + CO2$

Materials Required

Beakers, conical flask, funnel, burette, stirrer, burette stand, pipette, dropper, measuring cylinder, standard N/50 H2SO4 solution, methyl orange and phenolphthalein indicator.

Procedure

a) Take 25mL of the water sample in a conical flask.
b) Add 3-4 drops of phenolphthalein indicator.
c) Now, titrate the sample solution against the standard H2SO4 solution until the pink colour disappears.
d) Note down the burette reading and repeat the experiment 2-3 times to get concordant reading.
e) The same procedure is done by adding methyl orange as indicator in place of phenolphthalein and the change of the solution's colour from yellow to orange indicates the end point of titration.

Observation Table

Table 2 : Titration of water sample using Phenolphthalein indicator(P).

S.No.	Volume of water sample, V1 (mL)	Burette Reading		Volume of H2SO4 used (P end point)
		Initial	Final	
1.	25	0	4.4	4.2
2.	25	0	4.2	
3.	25	0	4.2	

Table 3 : Titration of water sample using Methyl Orange indicator(M).

S.No.	Volume of water sample, V1 (mL)	Burette Reading		Volume of H2SO4 used (M end point)
		Initial	Final	
1.	25	0	7.8	7.3
2.	25	0	7.3	
3.	25	0	7.3	

Calculation

From Table 1, the 5th row indicates the type of alkalinity present in the water sample, i.e.,

S.No.	Result after titration	Volume of acid used (mL)		
		For OH^- ions	For $HCO3^-$ ions	For $CO3^{2-}$ ions
5.	P>1/2M = 4.2>3.65	2P-M = (2x4.2)-7.3 = 1.1	Ab	2(M-P) = 2(7.3-4.2) = 6.2

Volume of water sample taken, V1 = 25mL

Normality of H2SO4 solution, N2 = 1/50

Alkalinity due to OH^- ions,

Volume of H2SO4 used, V2 = 1.1mL

Normality of water sample, N1 = N2V2/V1

N1 = 1 x 1.1/50 x 25

N1 = 1.1/1250

N1 = 0.00088

Strength in terms of CaCO3 equivalents = Normality x Equivalent weight of CaCO3 (g/L).

Alkalinity **(**OH^- ions) = N1 x 50 x 1000 (mg/L or ppm)

= 0.00088 x 50 x 1000

= 0.044 x 1000

= 44 mg/L(or ppm)

Alkalinity due to $CO3^{2-}$ ions,
Volume of H2SO4 used, V2 = 6.2mL

Normality of water sample, N1 = N2V2/V1

N1 = 1 x 6.2/50 x 25

N1 = 6.2/1250

N1 = 0.00496

Alkalinity ($CO3^{2-}$ ions) = N1 x 50 x 1000 (mg/L or ppm)

= 0.00496 x 50 x 1000

= 0.248 x 1000

= 248 mg/L(or ppm)

Total Alkalinity = Alkalinity **(**OH^- ions) + Alkalinity ($CO3^{2-}$ ions)
= 44 + 248

= 292 mg/L (or ppm)

Result

The total alkalinity of the water sample is 292 mg/L.

The alkalinity of water sample due to Hydroxide ions (OH^-) is 44 mg/L and Carbonate ions ($CO3^{2-}$) is 248 mg/L respectively. However, the Bicarbonate ions ($HCO3^-$) are absent.

RESULTS AND DISCUSSION

The results of the examination of various chemical parameters (pH, Dissolved Oxygen, Chloride and Alkalinity) of the water sample taken are tabulated as:

S.No.	Name of chemical parameter	Result
1.	pH	7.62
2.	Dissolved Oxygen (DO)	2.8 mg/L
3.	Chloride	21.3 mg/L
4.	Alkalinity	292 mg/L

CONCLUSION

The various chemical parameters of water quality including pH, dissolved oxygen, chloride, and alkalinity of the water sample taken are measured with understanding their definitions as well as measuring methods.

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