Research Article

Determination of the hardness of drinking packaged water of Kalyani area, West Bengal

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Abstract

Background: Water with high concentration of minerals is hard water. Water is essential for life. But water with very high degrees of hardness is harmful to health. **Material and Methods**: Four samples of packaged water samples were collected from kalyani area, West Bengal and tested by using EDTA titrimetric method with indicator and electrochemistry (non-indicator) principle. **Results and discussion:** Out of all the samples tested majority of them shows moderately hard character and single sample water as soft water character. Also from the experiment calcium and magnesium content has been determined. **Conclusion:** These studies Concludes that there is a differences in between all the parameter in respect to all the brands and also in the case of inter study except in magnesium content for two brands all the other brands having different value.

Keywords: Hardness, complexometric titration, water, electrochemistry, indicator

Introduction

Water that has a high mineral content is known as hard water. Hard water contains bi carbonate, chlorides and sulphates of calcium and magnesium. Hard drinking water may have moderate health benefits, but can pose serious problems in industrial settings, where water hardness is monitored to avoid costly breakdowns in boilers, cooling towers, and other equipment that handles water. In domestic settings, hard water is often indicated by a lack of foam formation when soap is agitated in water, and by the formation of lime scale in kettles and water heaters. Wherever water hardness is a concern; water softening is commonly used to reduce hard water's adverse effects (Harris, 2010).

Hardness of water

Water quality is evaluated using a number of parameters, including total ionic content, pH, total dissolved solids, organic compounds, and water hardness. Water hardness is a measure of the concentration of all the polyvalent cations dissolved in the water. The most common such cations are calcium and magnesium, although iron, strontium, and manganese may contribute to water hardness. Water hardness is often defined as the sum of the concentrations of Ca^{2+} and Mg^{2+} in water. “Hard” water typically contains high concentrations of Ca^{2+} and Mg^{2+}, which react with the fatty acids in soap, causing them to precipitate. “Soft” water, such as rainwater or water that has passed through a water softener, has very little Ca^{2+} and Mg^{2+}.

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Most waters contain more calcium than magnesium. The calcium usually comes from the dissolution of calcium carbonate. Thus, water hardness is usually reported as milligrams of calcium carbonate per liter of solution.

Table 1. Water Hardness

Calcium Carbonate (PPM)	Designation
0-43	Soft
43-150	Slightly Hard
150-300	Moderately Hard
300-450	Hard
450	Very Hard

Classification of hardness of water

There are two types of hardness: Temporary hardness and Permanent hardness.

Temporary hardness is a type of water hardness caused by the presence of dissolved bicarbonate minerals (calcium bicarbonate and magnesium bicarbonate). When dissolved, these minerals yield calcium and magnesium cations (Ca^{2+}, Mg^{2+}) and carbonate and bicarbonate anions (CO_3^{2-}, HCO_3^-). The presence of the metal cations makes the water hard.

However, unlike the permanent hardness caused by sulphate and chloride compounds, this "temporary" hardness can be reduced either by boiling the water, or by the addition of lime (calcium hydroxide) through the process of lime softening. Boiling promotes the formation of carbonate from the bicarbonate and precipitates calcium carbonate out of solution, leaving water that is softer upon cooling.

Permanent hardness is hardness (mineral content) that cannot be removed by boiling. When this is the case, it is usually caused by the presence of calcium sulphate/calcium chloride and/or magnesium sulphate/magnesium chloride in the water, which do not precipitate out as the temperature increases. Ions causing permanent hardness of water can be removed using a water softener, or ion exchange column.

Total Permanent Hardness = Calcium Hardness + Magnesium Hardness

The calcium and magnesium hardness is the concentration of calcium and magnesium ions expressed as equivalent of calcium carbonate.

Total permanent water hardness expressed as equivalent of $CaCO_3$ can be calculated with the following formula:

Total Permanent Hardness ($CaCO_3$) = 2.5(Ca^{2+}) + 4.1(Mg^{2+}) (IS:3025 (Part 21)– Reaffirmed, 2002).

The electrical current through a chemical cell is carried out by the ionic species in the solution conductometrically. The ease with which current is conducted through a solution (under the influence of potential difference applied across two electrodes) is mainly depends upon the concentrations and kind of ions in the solution. If two suitable electrodes are present in a solution and potential difference is applied across those electrodes then current will flow through the solution. During progress of a conductometric titration changes in the conductivity of the solution usually occur and at the end point involving neutralization or precipitation reaction the conductivity of the solution will be minimum. The equivalence point may be located graphically by plotting the change in conductance as a function of the volume of titrant added (Ghara et. al., 2017).

Material and methods

Materials

Disodium edetate Ammonia solution, Eriochrome black T, Sodium chloride, Calcium carbonate was required and it was purchased from Merck India Pvt. Ltd. Also Sodium hydroxide and Ammonium chloride were required as it was purchased from Loba Chem Pvt. Ltd.

In this test 4 different brands of water were used which is purchased from different stalls of kalyani station. The four water samples were taken.

Instrument and Apparatus required

A SYSTROICS model 306 Conductivitymeter with Conductivity cell type CD-10 and a simple weight machine from EAGLE was used. From the instrument conductance reading was noted which having the units called Millisiemens (mS) and Microsiemens (uS). All the glass apparatus that were used are made of BOROSILICATE GLASS and were properly calibrated.

Titration method

The determination of the total hardness of water is based on a complexometric titration of calcium and magnesium with an aqueous solution of the disodium salt of EDTA at pH value of 10.The determination of calcium in the presence of magnesium is based on the same principle, but at a pH value of 12. In this condition, magnesium ions are precipitated as hydroxide and do not interfere with the determination of calcium. The magnesium present in the sample may be calculated by subtracting the volume of EDTA solution required for the calcium determination from the volume required for the total hardness determination for equal volumes of the sample (WHO/M/26.R1, 1999).

Standardization of EDTA solution

Pipette 20.0 ml of the calcium standard solution into a 250 ml conical flask and dilute to 100 ml, preferably with deionized water. Add 4 ml of the buffer solution and 6 drops of the Mordant black 11 solution. The colour of the solution should now turn to claret or violet and its pH value should be 10.0 + 0.1. Titrate with the EDTA solution, rather rapidly at the beginning and slowly towards the end of the titration. Add the EDTA solution until the colour of the solution starts to change from claret or violet to blue and then to a distinct blue endpoint (t ml).

1 ml of the EDTA solution equivalent to calcium carbonate (in mg)

$$E(CaCO_3) = \frac{20 \text{ X } 1 \text{ mg}(CaCO_3)}{t}$$

Determination of total hardness (calcium + magnesium) of water

Pipette 50.0 ml of the sample into a 250 ml conical flask and dilute to 100 ml, preferably with deionized water. Add 4 ml of the buffer solution and 6 drops of the Mordant black 11 solution. Titrate with the EDTA solution was standardized before to a distinct blue endpoint (v ml).

$$CaCO_3\text{content (mg/l)} = \frac{\text{v X E}(CaCO_3)\text{ X } 1000}{50}$$

Determination of calcium in presence of magnesium

Pipette 50.0 ml of the sample into a 250 ml conical flask and dilute to 100 ml, preferably with deionized water. Add 2 ml of 2 mol/l of NaOH solution and approximately or 6 drops of the mordant black II indicator. The colour of the solution should now turn to claret or violet and its pH value should be at least 12.0.

Titrate with the EDTA solution to a distinct blue endpoint (v1 ml).

$$CaCO_3 \text{content (mg/l)} = \frac{\text{v IX E}(\ CaCO_3)\ X\ 1000}{50}$$

Determination of magnesium

The magnesium present in the sample may be calculated by subtracting the volume of EDTA solution required for the calcium determination from the volume required for the total hardness determination, for equal volumes of the sample.

1 ml 0.01M EDTA = 0.2432 mg magnesium.

Titration No 2: Here the hardness of the water was determined by electrochemistry (Conductometric) method but the procedure will be same as indicator method. All the results were calculated statistically.

Results and discussion

Intramethod analysis

Table 2. Analysis of samples by Indicator method

Brands	Hardness (mg/L)	Ca in Mg (unit)	Mg (unit)
Sample 1	279.45	272.64	0.146
Sample 2	286.27	211.29	1.604
Sample 3	188.57	143.15	0.972
Sample 4	286.27	249.92	0.730
Mean	260.14	219.25	0.863
SD	47.82153	56.703065	0.60359
%RSD	18.383	25.862287	69.95058

Table 3. Analysis of sample by conductometric method

Brands	Hardness (mg/L)	Ca in mg	Mg (unit)
Sample 1	49.0752	42.4864	0.1556
Sample 2	47.48	42.48	0.107
Sample 3	98.377	42.48	1.196
Sample 4	29.99	22.27	0.166
Mean	56.23055	37.4291	0.40615
SD	29.39762	10.10607	0.527194
%RSD	52.28052	27.00056	129.8028

Table 4. Comparison of hardness in between two methods

Methods	Hardness (unit)			
	Sample 1	Sample 2	Sample 3	Sample 4
Indicator	279.45	286.27	188.57	286.27
electrode	49.0752	47.48	98.377	29.99
Mean	164.26	166.88	143.47	158.13
SD	162.8996	168.850028	63.77608	181.2173
% RSD	99.17022	101.183538	44.45147	114.6002

Hardness, Ca and Mg difference between brands are not meeting the acceptance criteria in both the methods, which mean the brands are having huge differences in all criteria between them.

Table 5. Comparison of calcium content in between two methods

Methods	Ca content in presence of Mg (unit)			
	Sample 1	Sample 2	Sample 3	Sample 4
Indicator	272.64	211.29	143.15	249.92
electrode	42.4864	42.48	42.48	22.27
Mean	157.56	126.89	92.82	136.10
SD	162.743171	119.3667	71.18444	160.9729
% RSD	103.287551	94.07471	76.69497	118.2798

Table 6. Comparison of magnesium in between two methods

Methods	Mg Content (unit)			
	Sample 1	Sample 2	Sample 3	Sample 4
Indicator	0.146	1.604	0.972	0.730
electrode	0.1556	0.107	1.196	0.166
Mean	0.15	0.86	1.08	0.45
SD	4.540192	1.058538851	0.158392	0.398525
% RSD	4.540192	123.7333549	14.6118	88.99629

All the parameters measured in case of all the brands are having huge differences in % RSD, but the Mg content in the brand number 1 & 3 having closely same value in the case of both indicator & electrode method**.**

Table 7. Hardness character of the sample water according to methods

Samples	Hardness	Methods
Sample 1	Moderately hard/slightly hard	Indicator/conductometric
Sample 2	Moderately hard/slightly hard	Indicator/conductometric
Sample 3	Moderately hard/slightly hard	Indicator/conductometric
Sample 4	Moderately hard/soft	Indicator/conductometric

From the above result it is evident that only one brand (Sample-4) is soft in nature and may be considered to intake as drinking water.

Conclusion

So from the above experiment in case of intra study it can be concluded that there is a differences in between all the parameter in respect to all the brands and also in the case of inter study except in magnesium content for two brands all the other brands having different value. Out of all the samples tested majority of them shows moderately hard character and single sample water as soft water character. Also from the experiment calcium and magnesium content has been determined.

Conflicts of interest: Nil

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