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ECCENTRIC OBSERVATION OF TOTAL HARDNESS IN LOHARA VILLAGE, CHANDRAPUR DISTRICT, CENTRAL INDIA

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Abstract

The potability of water is judged by its physical, chemical and biological analysis. While analysing the water quality of Chandrapur district for winter 2012, summer 2013 and post-monsoon 2013 an eccentric observation was observed for total hardness estimation from the groundwater sample of Lohara village. While performing total hardness of groundwater sample by EDTA complexomertirc titration, after addition of buffer and inhibitor solution followed by Eriochrome Black T indicator a blue colour was formed instead of wine red colour. This observation was reported from all three sampling seasons. Perhaps, this may be the first time that such an observation was reported in the scientific literature. However, calcium hardness was found to be 84 ppm as $CaCO_3$ in all three sampling season.

Keywords: Hardness, Water quality, Complexometric titration, Lohara, Chandrapur, Central India

Introduction

Water is the elixir of life. Only a tiny fraction of the water which covers the earth is of use to humanity: 97% is salt water, filling the oceans and seas. Of the reminder, 99% is out of reach-frozen up in icecaps and glaciers, or buried deep underground. We depend on what is left- in rivers, lakes and accessible aquifers- to quench our thirst, wash away our wastes, water our crops, and, increasingly, to power our industries. In most parts of the world, this limited supply is overstrained. Industrial wastes, sewage and agricultural run-off overload rivers and lakes with chemicals, wastes and nutrients, and poison water supplies. Sediments from eroded land silt up dams, rivers and hydroelectric schemes (UNEP Profile, 1990). Water quality at a particular area is decided by its physical, chemical and biological analysis. These parameters decide whether water is potable or not.

Water hardness is the traditional measure of the capacity of water to react with soap hard water requiring considerably more soap to produce lather. Hard water often produces a noticeable deposit of precipitate (e.g. insoluble metals, soaps or salts) in containers, including "bathtub ring". It is not caused by a single substance but by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations, although other cations (e.g. aluminium, barium, iron, manganese, strontium and zinc) also contribute. Water containing calcium carbonate at concentrations below 60 mg/l is generally considered as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard (McGowan, 2000). Although hardness is caused by cations, it may also be discussed in terms of carbonate (temporary) and non-carbonate (permanent) hardness (WHO, 2011).

Divalent cations cause hardness of water (Sawyer, McCarty and Parkin, 1994). Water hardness due to Ca^{2+} and Mg^{2+} is expressed as the amount of Ca^{2+} and Mg^{2+} ions in ppm. The hardness is due to both Ca^{2+} and Mg^{2+} salts but, the two are determined together in the titration. Hardness of water is estimated by EDTA complexometric titration. The total Ca^{2+} and Mg^{2+} is titrated with standard EDTA solution (0.01 M) using a metallochrome indicator Eriochrome Black T. The technique involves titrating metal ions with a complexing agent or chelating agent (Ligand). In this method, a simple ion is transformed into a complex ion and the equivalence point is determined by using metal indicators or electrometrically.

While performing groundwater quality analysis from Chandrapur district an eccentric observation was observed for total hardness of groundwater sample from Lohara village which was unusual and similar results were consistently observed for winter, summer and post-monsoon season. This type of observation was not reported in the scientific literature previously and this may be the first time this is being reported.

Study Area

Chandrapur district is located in the eastern part of Maharashtra in 'Vidarbha' region lying between $19^0 25'$ N to $20^0 45'$ N and $78^0 50'$ E to $80^0 10'$ E and covers an area of 11,364 km^2. This district is considered to be one of the most important mining deposits of India. Intense coal mining activities along with natural processes like rock alteration attributes to high major and trace metal concentration in the groundwater and stream water.

Lohara village is located in the Chandrapur taluka of the Chandrapur district. The village is situated on Chandrapur-Mul road and was at an altitude of 202 m above mean sea level (amsl). The population of the village was about 1500 individuals. The main source of the drinking water was groundwater.

Methodology

To ascertain the groundwater quality of Lohara village a representative groundwater samples from a hand pump was collected in a pre-cleaned, dry, one liter capacity polythene bottle. Groundwater sampling was carried out by grab sampling method for winter (November 20012), summer (April 2013) and post monsoon (October 2013). The temperature and pH of groundwater was determined in the field itself. The sample was brought to the laboratory and preserved for further physicochemical analysis. The water sample was analyzed for electrical conductivity, total dissolved solids, total alkalinity, total hardness, calcium hardness and chlorides by employing standard method as described in APHA. Total and calcium hardness was determined by EDTA complexometric titration (APHA, 1998; Ramteke, Moghe and Sarin, 1986). All reagents used for the analysis were of AR grade.

The groundwater sample which was collected from the hand pump (Latitude $19^0$59'08.62" N, Longitude $79^0$21'32.90" E; altitude 202 m amsl) was located in centre of the village. The hand pump was about 12 years old with a depth of about 60 feet. Villagers use this water for drinking and domestic purpose as there is no other source for drinking water. Tap water facilities were not available in the village. The availability of water from this hand pump was throughout the year and it was catering to the needs of villagers for drinking and domestic water. Some villagers also use dug well water for domestic and drinking purpose.

Result and discussion

Analytical results for winter, summer and post monsoon are depicted in table 1. From the table it was observed that pH of groundwater was in the range of 5.72-5.97. This indicated that water was in acidic condition. However, such an acidic condition was unusual in groundwater. Higher acidic pH condition was observed in summer season (5.72) followed

Table 1. Water quality in Lohara village

Parameter ➡ Season ⬇	Temperature	pH	Electrical conductivity	TDS	Total alkalinity	Total hardness	Calcium hardness	Chlorides
Winter 2012	29.5	5.97	290	180	104	ND	84	16
Summer 2013	30	5.72	330	190	84	ND	84	15
Post monsoon 2013	29	5.74	330	200	108	ND	84	15

All parameters are expressed in ppm except temperature ^{o}C, conductivity µS/cm. ND – not detected

by post-monsoon (5.74) and winter (5.97). Electrical conductivity (EC) was in the range of 290-330 µS/cm. Minimum EC was observed in winter (290 µS/cm) whereas, in summer and post monsoon it was similar i.e. 330 µS/cm. Total dissolved solids (TDS) from the study area was in the range of 180-200 ppm. Minimum TDS concentration was observed in winter (180 ppm) followed by summer (190 ppm) and post monsoon (200 ppm). Phenolphthalein alkalinity was absent for all three seasons, whereas total alkalinity (methyl orange alkalinity) was in the range of 84-108 ppm as $CaCO_3$. Minimum total alkalinity was found in summer (84 ppm as $CaCO_3$) followed by winter (104 ppm as $CaCO_3$) and post monsoon (108 ppm as $CaCO_3$). Chloride (Cl^-) concentration was in the range of 15-16 ppm. Minimum Cl^- concentration was in summer and post monsoon (15 ppm) whereas in winter it was 16 ppm. The calcium hardness was found to be 84 ppm as $CaCO_3$ for all three sampling seasons. This calcium hardness was slightly above the Indian standards specification for drinking water (75 ppm as $CaCO_3$)

While considering EC of groundwater sample from the study area, it was in the range of 290-330 µS/cm. As EC denotes number and types of ions the solution contain, from the results, the can be concluded that in the water sample less number and types of ions were present. The chloride (Cl^-) ions concentration indicated the presence of anions; however, its concentration was less (15-16 ppm). The alkalinity of water sample was in the range of 84-108 ppm as $CaCO_3$. The phenolphthalein alkalinity was absent for all the three seasons which denotes absence of OH^- ions. From the analysis it can be concluded that anions (Cl^-, OH^- and ions responsible for EC) where present in less number. The presence of anions and cations in a water sample is always in balanced condition. The presence of less number of anions in the water sample may be responsible for presence of less number of cations.

While performing the total hardness analysis of water sample from Lohara village during different sampling seasons (winter, summer and post-monsoon) it was observed that in water sample after addition of buffer solution (2 mL) and inhibitor solution (1 mL) followed by Eriochrome Black T indicator (powder form) a blue colour was formed instead of wine red colour. The procedure was performed repeatedly and in each time same observations were recorded in all three seasons. Thus, total hardens of the water sample could not be estimated. Whereas, in case of calcium hardness estimation from the same water sample; after addition of 2 N NaOH (1 mL) followed by ammonium perporate indicator (powder form) a pink colour was formed. After titrating it with 0.01 M EDTA solution it gave end point colour change from pink to purple. This observation for calcium hardness was in accordance with the standard method as described in APHA. The results were compared for different seasons and for each season it was observed that calcium hardness was 84 ppm as $CaCO_3$.

When a small quantity of Eriochrome Black T indicator, having a blue colour, was added to the water with pH of about 10.0, it combines with a few of the Ca^{2+} and Mg^{2+} ions to form a weak complex ion which was wine red colour, as shown in the equation 1.

$$M^{2+} + EBT \rightarrow (M.EBT)_{complex} \text{ (wine red colour) ...... (1)}$$

While performing the total hardness analysis of water sample from the study area it was observed that instead of formation of wine red colour after addition of reagents and indicator a blue colour was formed. Thus, it may be concluded that EBT does not react with Ca^{2+} and Mg^{2+} ions and it imparts its own blue colour in the water sample.

While estimating the total and calcium hardness of water sample from Lohara village, simultaneous estimation of hardness for other 35 village from Chandrapur district was also carried out and for which satisfactory results were obtained for all three seasons. Thus, the possibility of any mistake in preparation of regents and procedure adopted (EDTA complexometric titration) to estimate total and calcium hardness can be ruled out.

Calcium hardness from water sample in Lohara village for all three sampling seasons was found to be 84 ppm as $CaCO_3$. Thus, it can be concluded that calcium hardness was present in the water sample. The presence of calcium hardness in water sample ensures that total hardness must be present and should be more than 84 ppm. However, while performing total hardness of water sample from the study area, after addition of EBT indicator, a blue colour was formed (this colour was of EBT indicator) this shows that EBT does not react with divalent cations present in the water sample which were responsible for hardness in water sample and was set free in the water sample and imparted its own blue colour.

While performing total hardness of water sample from the study area, excess quantities of reagents—buffer solution and inhibitor solution—were also added followed by EBT indicator; still blue colour formed insisted of wine red. Thus, at pH 10.0, after addition of buffer solution, some interfering substances/chemicals were prevailed in the water sample which prohibited the divalent metal ions (Ca^{2+} and Mg^{2+}) to react with EBT indicator to form metal-EBT complex which should give wine red colour. The inhibitor reagent, hydroxylamine hydrochloride, which was added to the water sample, may not be having the potential to remove interfering substances/chemicals which were responsible for forming a blue colour rather a wine red colour.

Conclusion

While estimating the total hardness of groundwater sample from Lohara village by EDTA complexometric titration the water sample gave eccentric observations. This method of estimation of total hardness is the standard method approved by APHA and accepted world over. The metal-EBT complex which imparts wine red colour could not be formed and instead of it blue colour was formed. This observation was observed at repeated titration and for all three sampling seasons (winter, summer and post-monsoon). The addition of reagents for total hardness was not developing the conditions which needed for formation of metal-EBT complex which imparts wine red colour. However, calcium hardness was obtained for all three seasons and it was 84 ppm as $CaCO_3$ for each season. Thus, it can be concluded that there may be presence of some unusually chemicals/substances in the water from Lohara village which interferes with the divalent metal ions and does not allow it to react with EBT to form a wine red colour. The relevance of study is it added a new knowledge about hardness of water. There are some chemicals/situations which hinders the formation of wine red colour. However, exactly which chemicals/situations is interfering in doing so is unknown.

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