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Evaluation of Hardness of Ground Drinking Water in Vehari, Pakistan

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Abstract: Ground water contamination has become a major concern in recent years. Hard water is considered a primary cause of many health-relating issues due to its unsuitability for drinking, domestic, industrial and agricultural purposes. Current studies were performed to explore the degree of hardness in drinking water of the selected areas of Vehari city, Pakistan. For this purpose, ten water samples were collected and analyzed. This research involves present practices and easy approaches to evaluate the quality of drinking water. The tested samples have shown pH 7.3-7.7, temperature 27-32^{0}C and TDS value of 545-1155 mg/L. The hardness of tested water samples was found in the range of 110-530 mg/L by titration method. The soap solution method demonstrated the degree of hardness (d^{o}TH) in the range of 19.8-35.41. The obtained results were compared with the national and international standards worldwide. The drinking water of investigated areas was found hard, contaminated and unsuitable.

Keywords: Water quality; hardness; soap solution, complexometric.

Introduction

Water is a precious commodity (Abhilash et al., 2017) and the most vital resource of life on the earth (Joshi et al., 2017). In the last few decades, there has been a gigantic increase in the fresh water due demand to quick increase in population and industries (Perveen and Zaidi, 2018; Abhilash et al., 2017). For harmless life, drinking water must be safe and prevented from germs, inorganic and organic contaminants, pesticides, fertilizers, weed killers and wild garbage (Ilyas et al., 2017). However, polluted water is not suitable for human fitness and causes a lot of diseases and waterborne infections (Ilyas et al., 2017; Joshi et al., 2017; Perveen et al., 2018) especially due to the poor sanitary conditions (Khalid et al., 2018).In 1970s, only 38% people had access to safe drinking water in developing countries (Kumar et al., 2012); one billon human beings still lack approach to clean drinking water (Chauhan et al., 2015). In Pakistan, clean drinking water is accessible to just 40% to 60% of its population (Khalid et al., 2018). Around six thousands of children die every day due to various health issues associated with unhygienic drinking water and poor sanitary system (Khalid et al., 2018).Dumping of solid waste materials and litters into water bodies has negative effect on aquatic life (Kumar et al., 2016; Lavecchia et al., 2016; Perveen and Zaidi, 2018). Commercial waste carries pollutants and heavy metals like asbestos, lead, mercury and petrochemicals which are exceedingly dangerous to people and environment (Vosoogh et al., 2017).

Hard water contains the higher concentration of magnesium (Mg^{+2}) and calcium (Ca^{+2}) ions (Vosoogh et al., 2017), strontium, manganese, iron and some other metals (Malakootian et al., 2009). Hard water can be classified into two groups: (a) Carbonates based hardness which is caused by calcium bicarbonate, magnesium bicarbonate, magnesium bicarbonate, calcium bicarbonate.(b) Non-Carbonates based hardness which is caused by calcium sulphate, magnesium sulphate, calcium chloride, magnesium chloride (Sengupta, 2013). Non-carbonate hardness can't be removed by just warming the water so it called changeless hardness (Sengupta, 2013). In drinking water, degree of hardness is generally evaluated in terms of its calcium carbonate content; water in range of 0-75 mg/L is regarded as soft, 75-150 mg/L as medium hard, 150-300 mg/L as hard, 300-500 mg/L as very hard and greater than 500 mg/L requires treatment (Qasim et al., 2014). Hard water creates serious problems for domestic life, agriculture and industry (Ahn et al., 2018). The regular intake of hard water may increase the risk of cancer, (Jiang et al., 2016)reproductive system failure, cardiovascular diseases, high blood pressure and many heart diseases. The rate of growth retardation in children and drinking of hard water are directly related with each other (Sengupta, 2013). A few investigations have shown a connection between water hardness (especially calcium and magnesium) and cardiovascular ailments, Alzheimer's infection and atopic skin inflammation (Ahn et al., 2018). One of the most perceptible impacts of hard water is skin bothering. Dermatitis in youngsters is also suggested to be caused by drinking of hard water (Chaumont et al., 2012; McNally et al., 1998). Hard water minerals (magnesium, calcium, manganese & iron and so on) bring about scaling issues in pipelines of boilers (Saeed and Hamzah, 2013). Hardness has been examined as a significant factor among all the water quality parameters.

Currently, there are large number of investigations are focused on the water quality and its treatment (Iqbal et al., 2019; Rehman et al., 2019; Ullah et al., 2019). The present investigations were carried out to evaluate the quality of ground drinking water of Vehari city of Pakistan.

Materials and Methods

Ten different areas of Vehari city within 11 km^2 area were selected for the collection of ground drinking water samples namely S1 (Muslim Town), S2 (Danewal Town), S3 (D-Block), S4 (Peoples Colony), S5 (Vehari Zoo), S6 (9/11), S7 (College Town), S8 (Seed Farm Road), S9 (Tariq-bin-Ziyad Colony) and S10 (Sharqi Colony).

Analytical grade chemicals were used for the experiments. Ethylenediamine tetra acetic acid (EDTA) (Sigma-Aldrich) was used as a complexing reagent. Eriochrome Black T (EBT) (BDH Laboratory) was used as indicator. Ammonium hydroxide (Merck), magnesium sulphate (BDH) and ammonium chloride (Scharlau) were used for buffering the solution.

Different physico-chemical parameters i.e., and hardness, total dissolved solids (TDS), pH and temperature of the water samples were investigated. Color of water samples were monitored visually. Water hardness was determined by titration and soap solution method.

(i) 20 ml of the water sample was taken into a 250 ml clean flask and then buffer solution (2ml) of pH 9-10 was added into it to maintain the pH value in the range of 9-10. The hardness of water sample was finally evaluated by using standard solution of EDTA. The end point of this titration was indicated by a color change from wine red to blue. The value of calcium carbonate in water sample was found by the following formula:

Hardness = Volume of EDTA x N x 50

Volume of sample taken

Molarity of EDTA = 0.02 M
Volume of sample = 20 mL

(ii) 0.5g, 1g and 2 grams of commercial liquid soap of type A was mixed well with warm distilled water (200 mL) in three different test tubes which were labeled as A_1, A_2 and A_3, respectively. Using the soap of type B or C in place of A will produce solutions B_1, B_2 and B_3, respectively (in case of B type soap) or C_1, C_2 and C_3, respectively (in case of C type soap). 5 ml of water sample (S1/S2/S3/S4/S5/S6/ S7/S8/S9/S10) was poured into a test tube. Then soap

solution (of A/B/C) type was added drop wise using a dropper in water sample. The lid was put on the test tube after addition of every drop and the solution was shaken well for 15 seconds. Soap solution was continuously added until 2cm suds layer was formed in the solution mixture. The volume of the added soap solution was recorded. This assay was repeated three times with every sample solution along with a particular soap solution (Qasim et al., 2014).

Results and Discussion

Ground water was analyzed to find its suitability for agricultural and domestic purposes. Attempts were made to evaluate the water quality parameters including hardness, TDS, pH and temperature in ground drinking water of Vehari city and results were compared with the WHO standards. Total hardness was determined by two different methods; titration method and soap solution method. The physical data of the tested water samples are summarized in Table 1.

Table 1 Physical characteristics of the samples.

Sr#	Sample#	Depth (ft)	Color	TDS (mg/L)	pH	Temp ^0C
1	S1	100	Transparent	845	7.5	32
2	S2	150	Transparent	545	7.7	29
3	S3	90	Slightly yellow	1001	7.3	29
4	S4	90	Transparent	785	7.5	28
5	S5	100	Transparent	896	7.3	27
6	S6	90	Transparent	1155	7.4	30
7	S7	100	Slightly yellow	1000	7.3	28
8	S8	120	Transparent	557	7.3	32
9	S9	150	Transparent	1040	7.5	29
10	S10	180	Transparent	556	7.4	30

All the investigated water samples were clear and colorless except the samples S3 and S7.

pH is one of the most important water quality parameters (Khalid et al., 2018). The pH of investigated water samples was found to be 7.3-7.7 indicating their basic nature (Table 1). According to WHO International Standards of Drinking-water in 1958, the pH in the range of 6.5-9.2 is permissible; the same range was also recommended in 1963 and 1971. According to 1984 guidelines for drinking-water quality, the allowable pH range was changed to 6.5–8.5. In the 1993 guidelines, the health-based effects of pH were not discussed. However, it is confirmed that the pH value shows direct impact on human health so pH is considered as one of the most important parameters to evaluate the quality of water (WHO, 2003).

The variations in temperature of different areas may be due to influence of environmental temperature. There is a close relation between atmospheric temperature and water temperature. However, the temperature of the tested water samples was found in the range of 27-32^{0}C (Table 1). Higher temperature (32^{0}C) was observed for samples S1 and S8 and the lowest temperature (27^{0}C) for S5 (Table 1).

The TDS represents total amount of anions and cations present in drinking water. The total concentration of dissolved minerals in drinking water represents a usual warning of the over-all suitability of water for various purposes. The observed TDS values 545-1155 mg/L (Table 1) of the investigated water samples were higher as compared to those recommended by WHO (500 ppm). Higher TDS contents might be due to dissolution of inorganic and organic contaminants in the groundwater. It may change the taste of drinking water and also makes it unsuitable for bathing and washing.

The hardness of tested water samples was found in the range of 110-530 mg/L by titration method; the highest value (530 mg/L) was observed for S5 while the lowest hardness value (110 mg/L) was observed for S2 (Table 2, Fig. 1). The acceptable and permissible limit for water hardness is upto 450 mg/L (Pal et al., 2018).

Fig 1: Variations in hardness of ground water samples.

The hardness of water was also calculated from the volume of cleanser which was needed to produce foam (froth) with water (5mL). The volume of cleanser required to produce froth was noted in terms of drops of soap solution which was converted into a number of millimeters (volume). Two drops of soap solution were considered equal 0.1 mL (Table 3). It was noted that a foam layer of a certain height (2cm) was formed when specific number of drops of a prepared soap solution were added to the sample solution. For example, 150 drops (equivalent to 7.5 mL) of prepared soap (type A) solution were added to the 5 ml solution (S1) to produce a foam layer of 2cm height.

Degree of total hardness of various water samples was calculated by applying the following formula; (Table 4, Fig. 2).

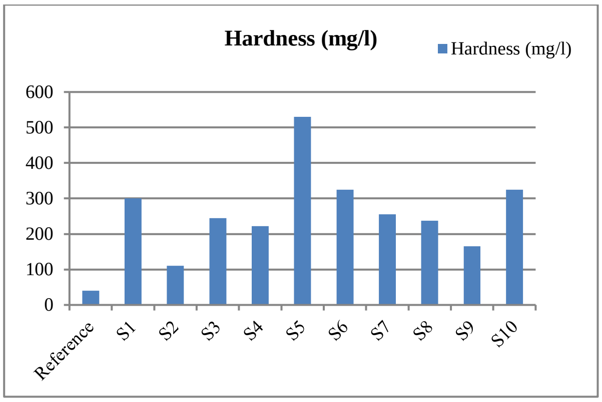
Calculations of sample 1 (S1) with type A soap

Table 2 Hardness of different ground drinking water in different areas of Vehari city; S1 (Muslim Town), S2 (Danewal Town), S3 (D-Block), S4 (Peoples Colony), S5 (Vehari Zoo), S6 (9/11), S7 (College Town), S8 (Seed Farm Road), S9 (Tariq-bin-Ziyad Colony) and S10 (Sharqi Colony).

Sample	Reference	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Hardness (mg/l)	40	300	110	245	222	530	325	255	237	165	325

Table 3: Analysis results of ground drinking water samples by using prepared soap solutions

Type of soap A/B/C used		Volume of soap A/B/C used for samples solutions S1-S10									
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Soap solution of Type A (SA)	Vol of A1	7.5	7.0	8.0	8.5	9.5	6.5	4.5	5.0	4.5	6.5
	Vol of A2	8.0	7.0	6.5	6.5	9.0	4.5	5.5	4.0	4.5	3.0
	Vol of A3	7.5	6.5	7.0	6.0	7.5	7.0	7.0	4.5	7.5	5.0
Soap solution of Type B (SB)	Vol of A1	3.0	4.0	2.5	5.0	5.5	4.5	3.5	4.5	4.0	4.0
	Vol of A2	5.0	4.5	5.5	5.5	8.0	4.5	4.0	4.4	3.0	2.5
	Vol of A3	5.0	5.0	6.0	7.5	8.0	6.5	5.0	5.5	3.0	4.5
Soap solution of Type C (SC)	Vol of A1	2.0	2.5	3.5	4.5	5.0	3.5	3.0	3.0	2.5	2.5
	Vol of A2	3.0	3.5	2.5	4.5	5.0	3.5	3.0	2.5	3.5	4.5
	Vol of A3	3.5	3.0	2.5	4.0	4.5	2.5	4.0	3.0	3.5	3.0



solution A:

d^0 TH of A_1= V (mL) of A1 × V of sample = 7.5 × 5 = 37.5

d^0 TH of A_2= V (mL) of A2 × V of sample = 8 × 5 = 40

d^0 TH of A_3= V (mL) of A3 × V of sample = 7.5 × 5 = 37.5

This method of calculation was repeated with all other water samples (S2-10) using the same (A) or other type of soap solutions (B or C).

Fig. 2 Graphical representation of degree of hardness by using soap solution method.

The data show that S5 has shown the maximum degree of hardness in comparison with other samples. This interpretation was in accordance with the results obtained by complexometric titrations. The S5 was not found fit for drinking purposes as its hardness limit exceeded the recommended value.

Table 4 Degree of total hardness (d°TH) of groundwater samples.

Sample	d°TH with soap solutions A/B/C			d°TH (average)
	A	B	C	
S1	38.33	20	14.16	24.163
S2	24.16	21.66	16.1	20.64
S3	23.58	23.33	12.5	19.8
S4	36.66	29.66	28.5	28.27
S5	38.91	23.08	44.25	35.41
S6	27.66	27.66	20.1	25.14
S7	29	23	21	24.33
S8	22.8	26.5	14.66	24.65
S9	29.66	15.66	15.66	20.32
S10	24.83	23	20.33	22.72
Average	29.559	23.355	20.726	24.54433
Median	28.33	23.04	18.1	24.24667
Average Deviation	5.0648	2.751	6.3144	3.05853333
Standard Deviation 5.93017614	3.76626406	8.99487321		4.37522674

Conclusion

The groundwater samples of the selected areas were subjected to physicochemical analysis. The tested samples show pH 7.3-7.7, temperature 27-32^{0}C and TDS value of 545-1155 mg/L. The hardness was found in the range of 110-530 mg/L. The soap solution method demonstrated the degree of hardness (d°TH) in the range of 19.8-35.41. Some of the physicochemical parameters were beyond the permissible limits so the Government should pay attention to improve the water quality of Vehari city. Water should be boiled at right temperature before domestic use. For highly contaminated water, suitable and proper treatment should be done to prevent severe effects on human health. Therefore, an effective and thorough hygienic condition should be given to these water bodies in Vehari city in order to maintain a good water quality. In order to ensure improvement in the quality and quantity of water resources in Vehari, there is a need for sustainable measures to put in place proper sanitation facilitiesshould in order to reduce contamination from leakages of water supply pipes. Industrial wastes should be dumped off properly. Insecticides and pesticides need special care which may contaminate the water sources. Water filtration plant should be installed in those areas where the water is not fit for domestic purposes.

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