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Assessment of drinking water quality and its health impact on local community in coastal belt Karachi

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Abstract. For survival of human beings clean water is an essential commodity whereas contamination in drinking water threatens to mankind. The main cause of water contamination is social and development activities of human being along with increasing population. The community in the study area has acute shortage of drinking water along with about 40 to 60% has no access to safe drinking water. This study indicates drinking water quality of two major sources of coastal belt of Karachi one is supplied by Karachi Water & Sewerage Board (KWSB) as tap water and the other through groundwater. The physicochemical analysis was carried out by following the standard methods for checking the quality of drinking water. The analyzed results showed that the quality of groundwater was unfit as potable water. The most critical situation was observed as high level of contamination followed by high turbidity and increased salinity levels. TDS in surface water were found 12% above and TDS in groundwater was 20% below the National Drinking Water Quality Standards (NDWQS) of Pakistan as well as the permissible WHO drinking water quality guidelines.

Keywords: coastal belt; tap water; groundwater; contamination; physicochemical; health; community

1. Introduction

Water is an essential natural resource that is vital for ecosystem functioning and human being water is an essential component of life (Okoro *et al.* 2016). Water occupies more than 70% of the Earth's surface but out of this total stock less than 3% is sweet freshwater. Again out of this total 3% the quantity of freshwater accessible for human intake is hardly 0.01%; the remaining water is confined in snow caps and glaciers (Ahmed *et al.* 2014). Accessible lesser portion of the Earth's total fresh water is becoming highly contaminated due to numerous human influenced activities like dumping of residential, industrial and chemical waste along with application of fertilizers and pesticides in agricultural practices. The human influenced practices induce numerous injurious constituents in the water and they consequently cause water based and water related diseases in the society (Soomro *et al.* 2011).

The situation is not good in developing countries as majority of the people use that water which

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is contaminated with objectionable level of toxic substances, pathogenic organisms as well suspended solids (Amin *et al.* 2012). The United Nations (UN) in an study has projected that around 2.5 billion people have no proper sanitary system in developing countries and more than 780 million have no access to potable water (UNICEF and WHO 2012). Resultantly approximately 2.3 billion people are suffering from water related diseases all around the world (UNESCO 2003).

In Pakistan, state of inferior water quality is one of the core health associated apprehensions. The raw water sources both surface as well as groundwater are suspected to be contaminated with numerous toxic compounds and microorganisms (Azizullah *et al.* 2011). World Health Organization estimated that 1.6 million deaths of children per year are attributed to unsafe drinking water, poor sanitation and lack of hygiene (WHO 2013). In Pakistan, it is estimated that 100-150 children die every day due to diarrhea infection caused by unsafe drinking water and unhygienic conditions, about 65 to 75 million people of 2010 census are lacking safe drinking water and sanitation. The demand of water will increase as the country's current population about 194 million is projected to increase to 384 million in 2050, (Population Reference Bureau 2014).

The findings of various researchers show that about 68% rural population of Pakistan is drinking water of poor quality (Tahir *et al.* 1998). One hundred million cases of diarrheal diseases are being registered in hospitals of Pakistan within one year (Tahir *et al.* 1997). Poor water quality is major health risk in Pakistan (Anwar *et al.* 2013).

Pakistan's coastline is about 970 km; out of which Sindh's coastline is 270 km long (Siddiqui *et al.* 2004) and Karachi's coastal belt is only 30 km. Currently Karachi the biggest, highly industrialized and thickly populated city of Pakistan is experiencing severe air as well as water pollution related issues (Waseem *et al.* 1995).

2. Purpose of study

This scientific study was conducted to determine:

• To determine the biological and the physicochemical characteristics of surface as well as groundwater in the research area i.e., Karachi coastal belt.

• To compare the physicochemical as well as biological parameters with the Pakistan's National Water Quality Standards as well as WHO drinking water guidelines.

3. Area of researck work

The area of this research work focuses on coastline of Karachi city which lies in Malir district. The Malir district is geographically located at 24° 45° to 25° 37° N and 67° 06° to 67° 34°E as shown in Fig. 1. The area of Malir district is approximately 2268 square kilometers. The location area of this research work is also shown in Fig. 1. Karachi city census reports 1998 of Malir along with selected locations are given in Table 1. The name of villages in District Malir are: 1-Latt Basti Goth, 2-Bakhtawar Goth, 3-Sach Dino Goth, 4-Rehri Miann Goth, 5-Rehri Miann Goth-2, 6- Salih Mohammad Goth, 7-Dawood Usman Goth, 8-Hassan Jatt Goth, 9-Jumma Kalmati Goth, 10- Ali Akber Shah Goath, 11-Ali Akber Shah Goath-2, 12-Chashma Goth.

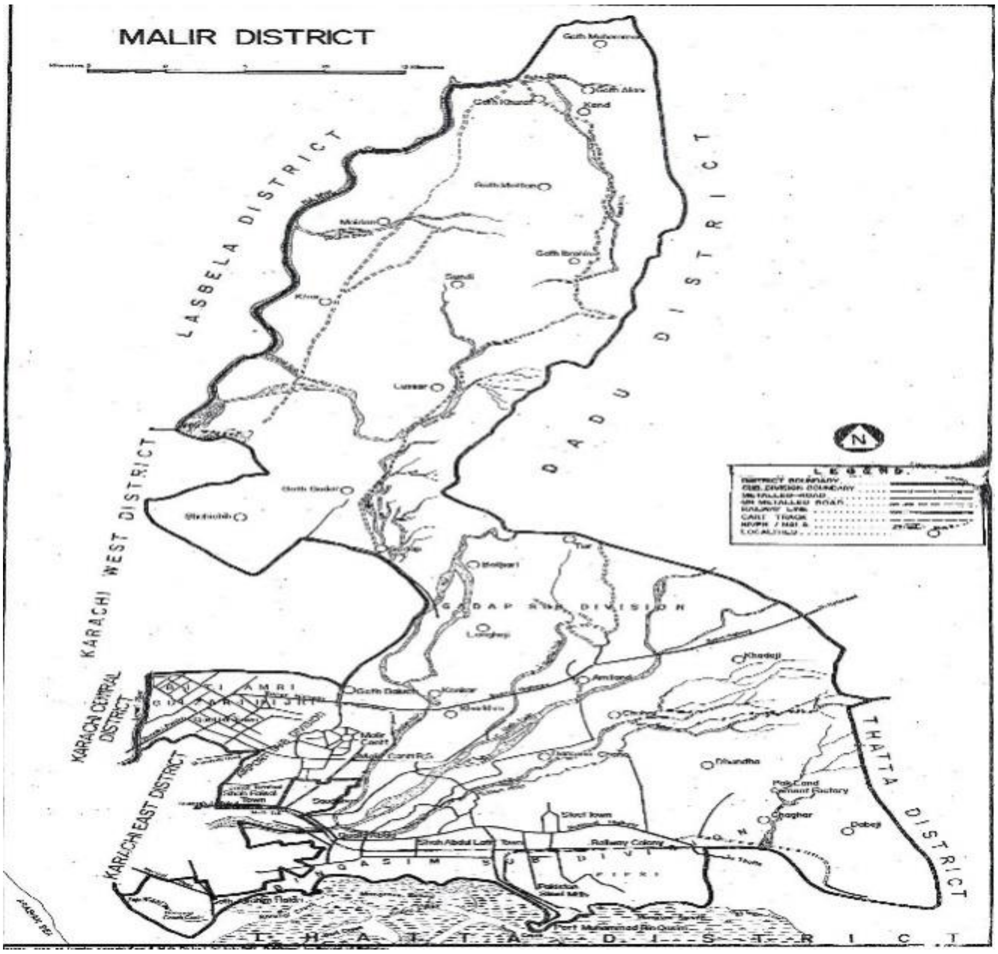

Fig. 1 Map of district Malir and study area

Table 1 Local name of location and their code

Sr. No.	Name of Location	Code No.
1	Latt Basti Goth	LB
2	Bakhtawar Goth	Bakht
3	Sach Dino Goth	SD
4	Rehri Miann Goth	RM
5	Rehri Miann Goth–2	RM2
6	Salih Mohammad Goth	SM
7	Dawood Usman Goth	DU
8	Hassan Jatt Goth	HJ
9	Jumma Kalmati Goth	JK
10	Ali Akber Shah Goath	AASh
11	Ali Akber Shah Goath - 2	AASh2
12	Chashma Goth	Chash

The most common problem in this area is shortage and supply of polluted drinking water. The source of drinking water is tribulation network and at the point of end user it is heavily contaminated with fecal coliforms throughout the study area. The drinking water contamination estimated accounts for 60 to 80 % of all waterborne diseases. This water pollution in the study area is due to discharge of untreated industrial effluent of Karachi Export Processing Zone (KEPZ), industries, factories, wastage of slaughterhouse and municipal wastewater directly in to the neighborhood area and Arabian Sea. The stagnant untreated industrial effluent and municipal wastewater is shown in Fig. 2.

4. Materials and methods

Twelve (12) different locations were selected for investigation of tap and groundwater quality. The samples were taken during the months of May 2015 to January 2016, according to population density in different area by method of cluster analyses (CA). The global position system (GPS) coordinates are shown in Table 2 and also noted at each sample collection station to mark sample location on the map of study area as shown in Fig. 3.

Fig. 2 Stagnant untreated industrial effluent and municipal wastewater

Table 2 Name of sample location and their coordinates

Sr. No.	Name of location	Latitude	Longitude
1	Latt Basti Goth	24.816186	67.249868
2	Bakhtawar Goth	24.819293	67.233264
3	Sach Dino Goth	24.815173	67.241449
4	Rehri Mian Goth	24.815194	67.228924
5	Rehri Mian Goth-2	24.822294	67.240661
6	Salih Mohammad Goth	24.869619	67.244139
7	Dawood Usman Goth	24.820165	67.199032
8	Hassan Jatt Goth	24.815219	67.241519
9	Jumma Kalmati Goth	25.273525	66.754112
10	Ali Akber Shah Goath	24.803682	67.159719
11	Ali Akber Shah Goath - 2	24.803847	67.157809
12	Chashma Goth	24.803682	67.193981

Fig. 3 Location map of research area and location of sampling station

Two types of water samples i.e., tap water supplied by Karachi Water and Sewerage Board (KWSB) and groundwater, were collected from the study area. During water samples analyses the shallow groundwater is less saline, but the deep groundwater was found more saline. The usage of groundwater increased in condition of shortage of water by Karachi Water and Sewage Board.

The samples from tap and ground water were collected in fresh polythene plastic bottles having capacity of 0.5 and 1.0 liter each. The collected samples were placed in thermostat container at 25°C and then they were analyzed (Samo *et al.* 2015). Prior to sample collection the sample bottles were washed away properly and thoroughly rinsed with distilled water. Then the samples immediately transported to the laboratory. The relevant equipment were calibrated as per standard methods of water testing (APHA, AWWA and WEF 1998). After words all sample bottles were brought to Pakistan Council for Research in Water Resources (PCRWR) laboratory, Karachi for testing respective water quality parameters.

Under the study 36 numbers of samples were collected randomly from 12 sampling stations. Samples were taken from the tap water of government sector Karachi Water and Sewerage Board (KWSB) supply system as well as private sector borings. During sampling of tap water and groundwater, noted proper location and depth of bore, health status, waterborne diseases, water based and water related diseases through NGO’s, CBO’s, Social activates and local community people of the study area.

5. Results and discussion

The collected water samples of tap water samples showed minimum result of Electrical Conductivity (EC) as 603 μS/cm and maximum result of 933 μS/cm whereas the ground water samples showed the minimum result of 3900 µS/cm and maximum result of 9960 µS/cm. On the contrary the National Drinking Water Quality Standard (NDWQS) has not set guideline value. The analyzed results of tap water and groundwater are shown in Figs. 4 and 5 respectively.

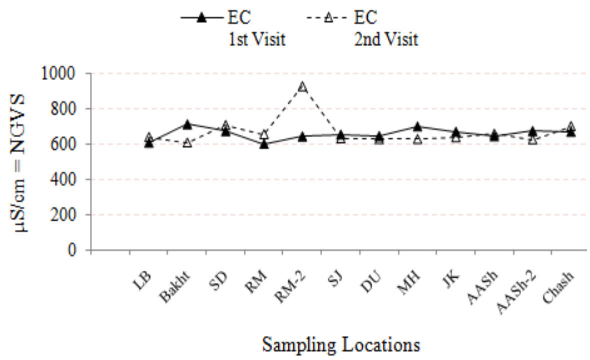

Fig. 4 Electrical Conductivity (E.C) of tap water at respective sampling locations

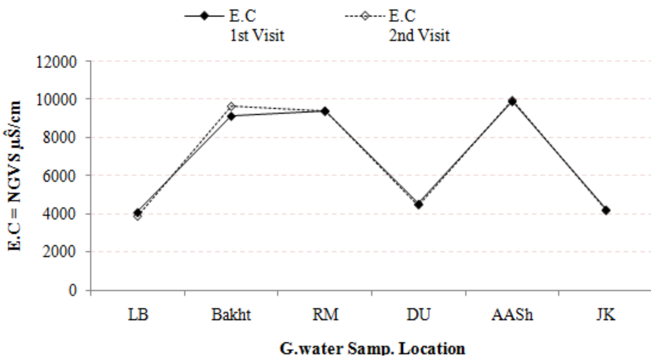

Fig. 5 Electrical Conductivity (E.C) of groundwater at respective sampling locations

The level of Total Dissolve Salts (TDS) of 95% of tap water samples were found under acceptable levels and only 5% of water samples showed higher level. However in groundwater samples the minimum TDS level was 2496 mg/L and maximum level was 6374 mg/L. Whereas the National as well as WHO acceptable level is 1000 mg/L. The results of TDS of tap water and groundwater are shown in Figs. 6 and 7 respectively.

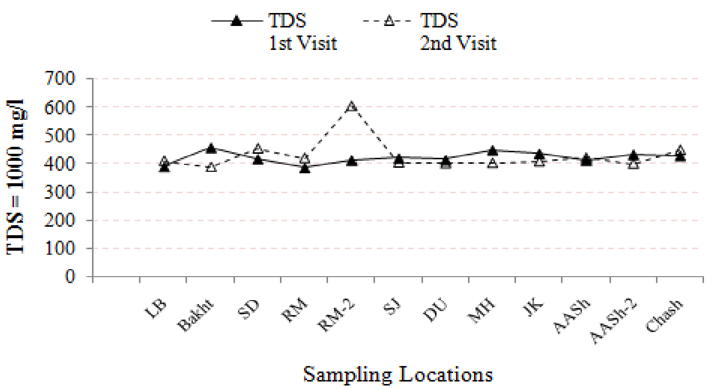

Fig. 6 TDS results of tap water samples of respective sampling locations

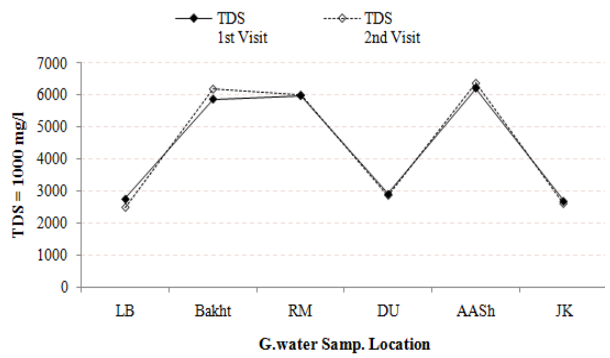

Fig. 7 TDS results of groundwater samples of respective sampling locations

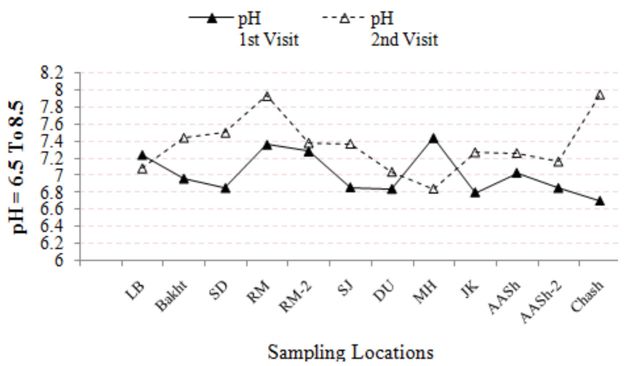

Fig. 8 pH results of tap water samples of respective sampling locations

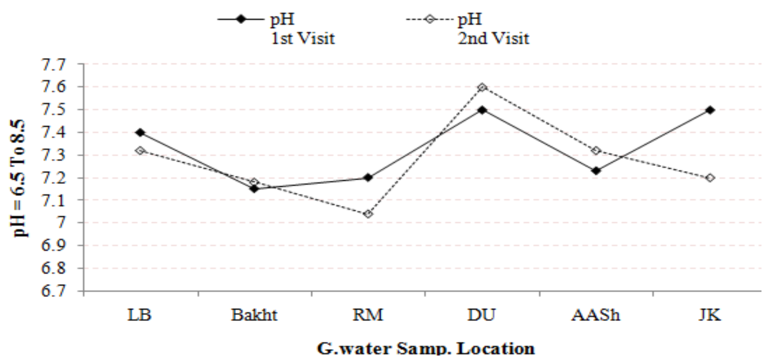

Fig. 9 pH value of groundwater samples of respective sampling locations

The pH concentration of tap water supplied by Karachi Water & Sewerage Board (K.W.S.B) as well as that of groundwater fetched through hand-pumps or dug wells vary from 6.7 to 8.5. As per National and WHO standards the permissible value is in between 6.5 to 8.5. The results of pH of tap water and groundwater are shown in Figs. 8 and 9 respectively.

The collected tap water sample showed concentration of 36 mg/l of Calcium (Ca) and maximum concentration was 60 mg/l. In case of groundwater samples the minimum concentration was 124 mg/l and maximum concentration was found 320 mg/l. The permissible NDWQS concentration is 75 mg/l. The results of Ca of tap water and groundwater are shown in Figs. 10 and 11 respectively.

The Magnesium (Mg) concentration was found less than permissible levels in all water samples of tap water. Whereas in the ground water samples, 50% samples showed lower level as against the permissible level and 50% samples showed above the permissible levels. The results of Mg of tap water and groundwater samples are shown in Figs. 12 and 13 respectively.

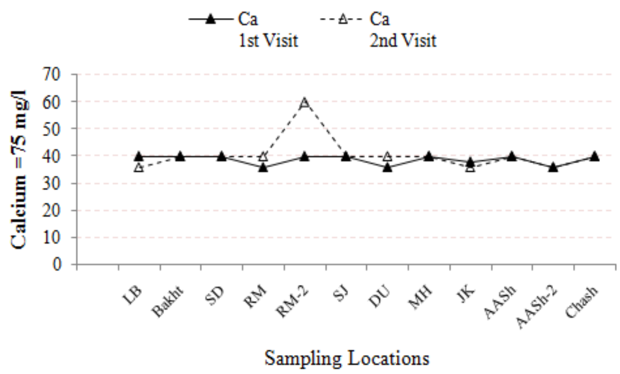

Fig. 10 Results of Ca tap water samples of respective sampling locations

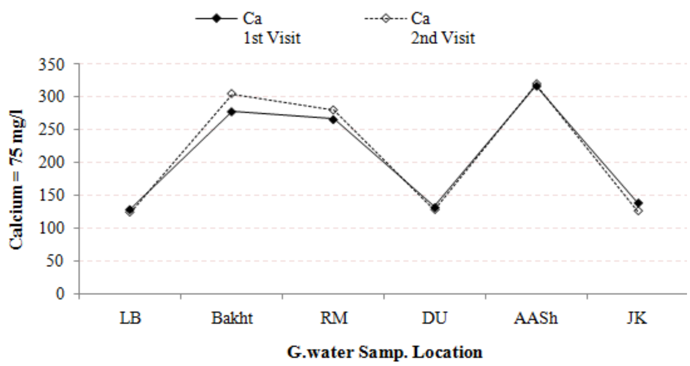

Fig. 11 Results of Ca groundwater samples of respective sampling locations

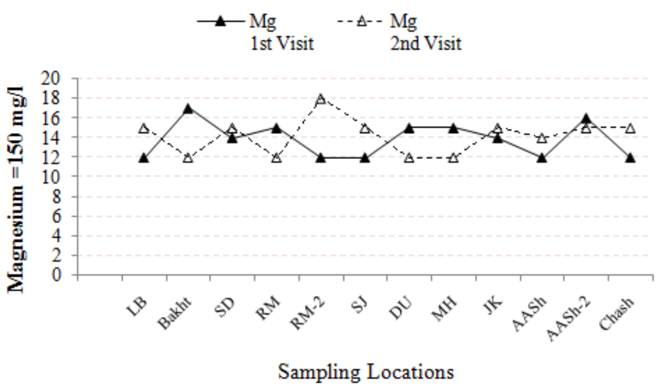

Fig. 12 Level of Mg of tap water samples of respective sampling locations

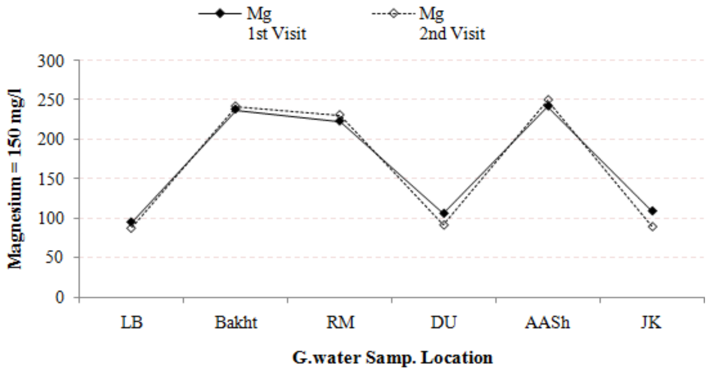

Fig. 13 Level of Mg of ground water samples of respective sampling locations

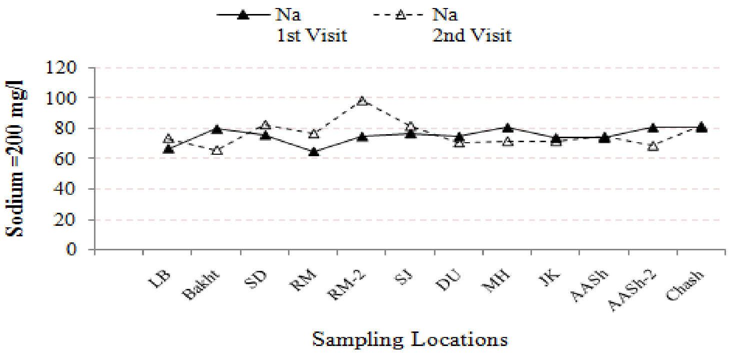

Fig. 14 Result of Na of tap water samples of respective sampling locations

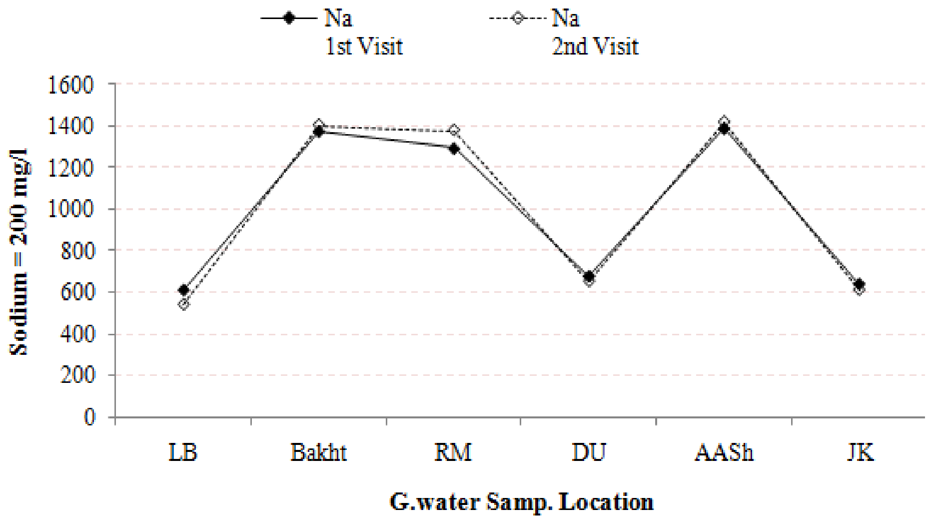

Fig. 15 Result of Na of groundwater samples of respective sampling locations

In 95 % tap water samples the Sodium (Na) level was found under permissible limits and in only 5 % of the samples Na was found above the limits. But in groundwater the minimum level of

Na was found 542 mg/l and maximum concentration was found 1420 mg/l. The permissible National Standard as well as WHO guideline is 200 mg/L. The results of Na of tap water and groundwater samples are shown in Figs. 14 and 15 respectively.

In 85% of tap water samples the Potassium (K) level was under permissible limits and in 15% samples was above the limits. Where as in groundwater samples the K levels varies from 14.7 to 78.4 mg/l. The National Standard and WHO guideline for K is 12 mg/l. The results of K of tap water and groundwater samples are shown in Figs. 16 and 17 respectively.

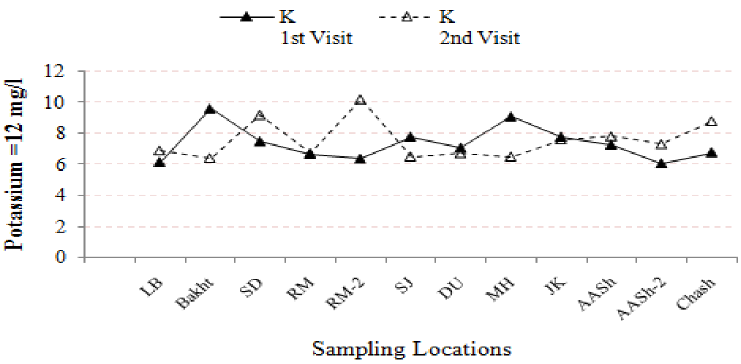

Fig. 16 The Result of K tap water samples of respective sampling locations

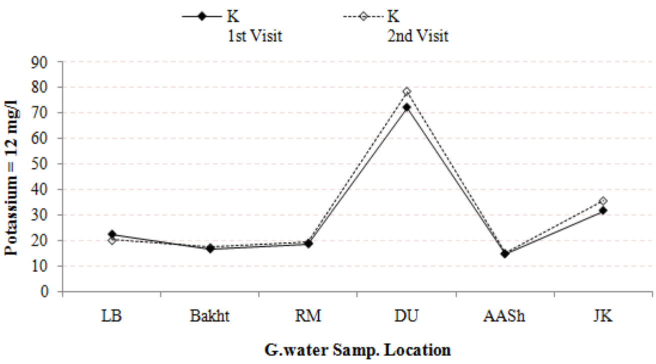

Fig. 17 The result of K of groundwater samples of respective sampling locations

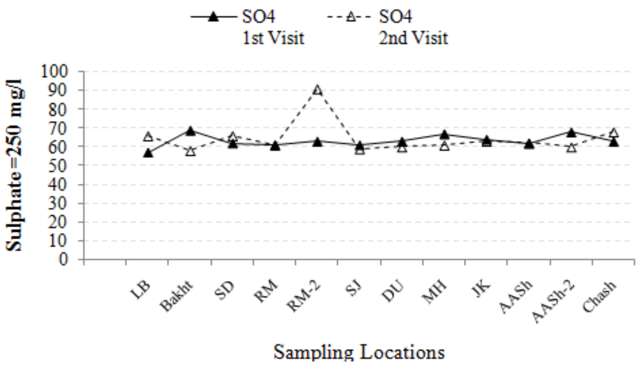

Fig. 18 Result of Sulphate (SO_4) of tap water samples of respective sampling locations

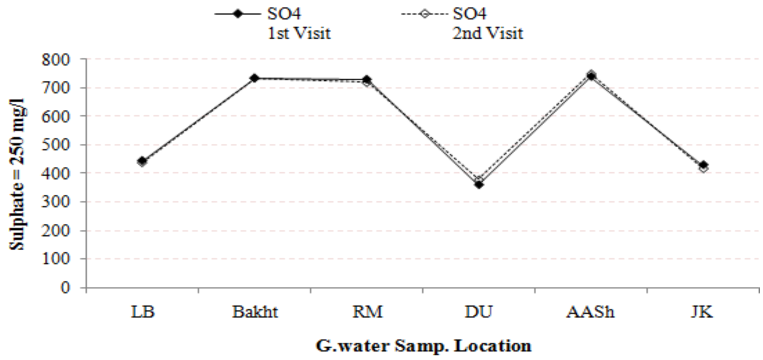

Fig. 19 Result of sulphate (SO_4) of groundwater samples of respective sampling locations

The concentration of Sulphates (SO_4) of all tap water samples were found below the acceptable levels. However, in case of groundwater samples all the results of the samples showed higher results in comparison to National Standards or WHO guidelines which is 250 mg/l. The results of SO_4 of tap water and groundwater samples are shown in Figs. 18 and 19 respectively.

The analyzed results of Chloride (Cl) in all the collected tap water samples were within the acceptable levels. On the other hand, all the ground water samples indicated higher concentrations as against the permissible National Standards as well as WHO guidelines which is 250 mg/l. The results of Cl of tap water and groundwater samples are shown in Figs. 20 and 21 respectively.

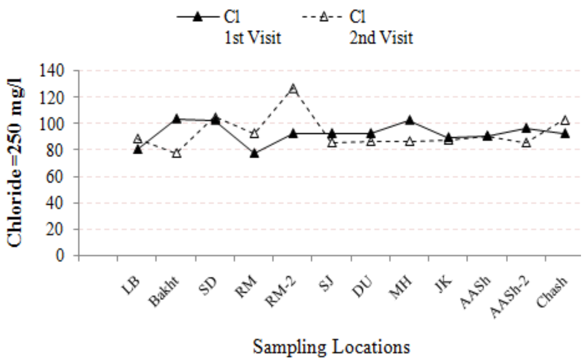

Fig. 20 Result of Cl of tap water samples of respective sampling locations

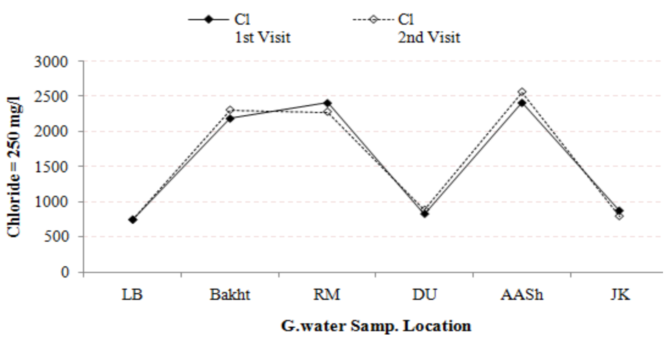

Fig. 21 Result of Cl of groundwater samples of respective sampling locations

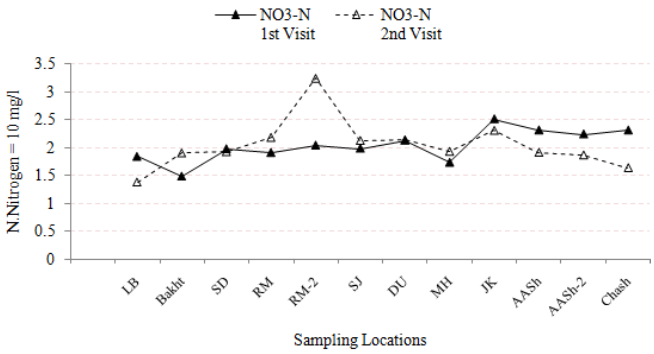

Fig. 22 Results of NO_3-N of tap water samples of respective sampling locations

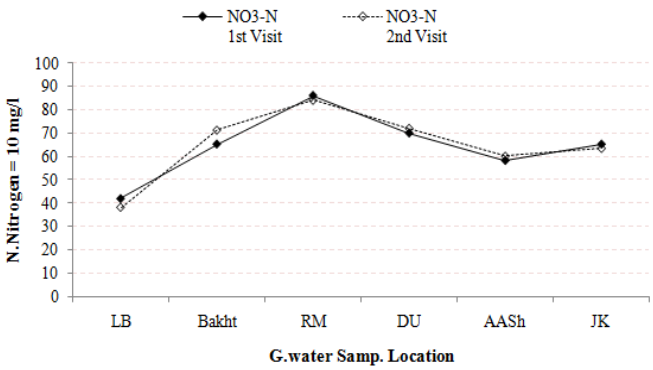

Fig. 23 Results of NO_3-N of groundwater samples of respective sampling locations

The concentration of Nitrate-Nitrogen (NO_3-N) in all the tap water samples was found within the acceptable levels and in case of groundwater samples all of the water samples indicated higher levels in comparison to the permissible National Standards as well as WHO guidelines which is 10 mg/l. The results of NO_3-N of tap water and groundwater samples are shown in Figs. 22 and 23 respectively.

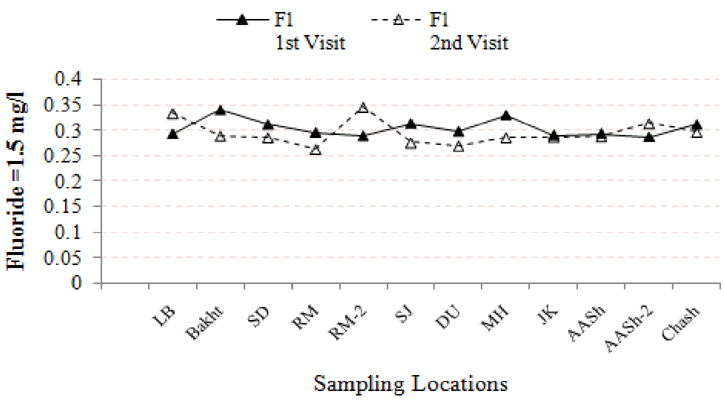

Fig. 24 Results of Fl of tap water samples of respective sampling locations

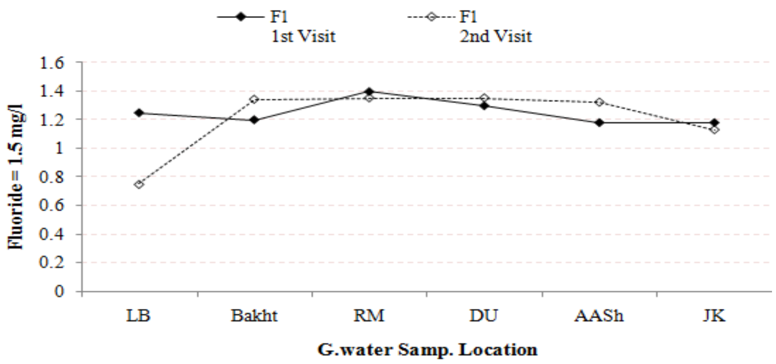

Fig. 25 Results of Fl of groundwater samples of respective sampling locations

The analyzed concentrations of Fluoride (Fl) in 100% tap water samples were found within acceptable levels. Whereas in groundwater 100% water samples were found above the limits which is 1.5 mg/l. The results of Fl of tap water and groundwater samples are shown in Figs. 24 and 25 respectively.

6. Conclusions

From the findings it is evident that the drinking water quality of water supplied by KWSB as well as the groundwater fetched from hand pumps or wells is not compatible with safe drinking water quality. Physicochemical analysis shows that almost all water samples were not fit for drinking purposes as the concentration is higher as against the NDWQS)/WHO guidelines. Even if anyone water quality parameter is higher than the acceptable level then the water is not considered fit for human consumption.

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