Assessment of suitability of ground water quality in and around Laksar, Haridwar, Uttarakhand on the basis Water Quality Index (WQI)

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Abstract

The aim of present study is to assess the quality of the groundwater at selected villages of Laksar Block on the basis of Water Quality Index (WQI). During the present study maximum value of TS (790.6±28.26 mg/l) was found at site S1, while the minimum value (705.3±5.59 mg/l) was found at site S4. The maximum average value of TDS (548.7±30.37 mg/l) was found at site S5, while the minimum value (352.8±5.59 mg/l) was found at site S4. The maximum average value of pH (7.8±0.58) was found at site S1, while the minimum value (6.9±0.70) was found at site S6. The maximum average value of DO (6.5±0.57) was mg/l found at site S4, while the minimum value (6.1±0.57) was mg/l found at site S6. The maximum average value of TH (396.9±65.94) was mg/l found at site S3, while the minimum value of TH (223.3±5.59mg/l) was found at site S4. The maximum average value of CaH (331.3±32.57mg/l) was found at site S1, while the minimum value of CaH (142.4±2.88mg/l) was found at site S4. The maximum average value of Chloride (137.3±8.72mg/l) was found at site S1, while the minimum Chloride average value (53.4±2.83mg/l) was found at site S4. The maximum value of Sulphate (45.11±0.78mg/l) was found at site S5, while the minimum value (28±2.24mg/l) was found at site S4.

Key words: *Drinking water quality, Industrialization, Physico chemical, WQI.*

Introduction

Water is an essential component of the planet earth, required for every physical and physiological activity of plants and animals. Without water life is not possible on the earth. Water is one of the five elements of the universe. Origin and evolution of life on planet earth is most intimately linked with water. It is the most abundant and essential compound in all the living systems. The amount of water in living organisms constitutes approximately 60-99% by weight and is an internal medium for all biochemical reactions. It is a principal ingredient for photosynthesis and plays a vital role in food production in plants as well as in animals. About 97% of the total water present on the earth (1400 million billion), is not usable for drinking purpose due to saline nature. Only 3% of the total water is available as fresh water, out of which 2% of water is lodged in the polar ice caps and glaciers, only 1% water is available for portable use (WHO, 2004). Out of the total fresh water present on the earth maximum quantity is used in irrigation sector (Bhutiani *et al.,* 2018). The precipitation is the principal source of all water supplies on the earth. After precipitation some amount of water infiltrates into the soil and some amount of water moves over the surface as runoff. Groundwater plays a vital role in the life of both animals and plants in both drinking and irrigation purpose. It occurs under the surface of the earth in thousands of local aquifer systems and compartments that have similar characters and not in a single widespread aquifer.

Both the quality and quantity of groundwater are equally important because both are the major factors in determining the suitability of groundwater for drinking, domestic, irrigation industrial purposes. Groundwater contamination may occur by both natural factors and anthropogenic activities such as weathering of rocks, ore formation and leaching or due to increased population, industrial activities, urbanization, exploration, agricultural practices and exploitation of natural resources (Akinmosin *et al.*, 2009). Around 80% of the diseases and deaths in the developing countries are related to water contamination (UNESCO, 2007). Water pollution

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not only affects water quality but also threats the human health, economic development, and social prosperity (Milovanovic, 2007).

The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. It is necessary to know about different Physico-chemical, heavy metal and microbiological characteristics of water before it is used for different purposes (Kolhe and Shinde, 2014). The easy availability of water depends on the depth of water table which normally decreases in summer when demand for water is at its maximum (Bhutiani *et al.,* 2018).

Materials and Methods

Study area: Laksar block is an administrate part of district Haridwar. The average height of Laksar block from sea level is 745 feet and it is located between the towns of Khanpur and Sultanpur and close to the towns of Pathri, Jhabrera and Roorkee in Haridwar district (Fig 1. and Table 1). Peoples of the study area mostly depend on farming profession and the crops grown in the study area are sugar cane, wheat, paddy, barley and maize.

The groundwater samples were collected from all sites in the jerry cans of 2 liters capacity using Grab sampling from May, 2017 to January, 2018. The collected samples were analyzed for various physico-chemical parameters as per the standard methods described in APHA, 2012; Trivedy and Goel, 1986 and Khanna and Bhutiani, 2008. All the sampling sites were shown in figure 1.

Table 1. Sampling locations different sites

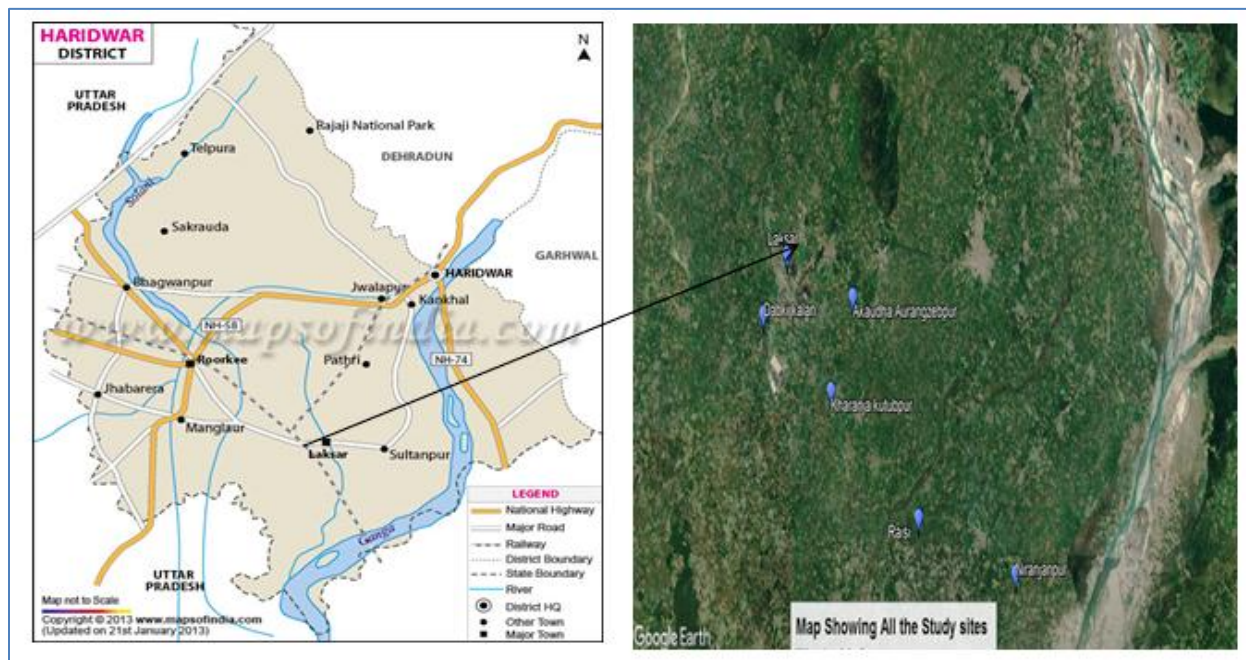| SN	Name of the site	Latitude	Longitude
S1	Laksar	29° 45' 13.8348" N	78° 1' 17.3352" E
S2	AkaudhaAurangzebpur	29° 44' 42.3924" N	78° 3' 3.3408" E
S3	Raisi	29° 41' 58.0128" N	78° 4' 49.17" E
S4	Niranjanpur	30° 17' 50.6436" N	78° 0' 36.4068" E
S5	KharanjaKutubpur	29° 43' 51.6936" N	78° 2' 33.846" E
S6	DabkiKalan	29° 44' 29.256" N	78° 0' 39.5136" E

Fig 1. Showing Sampling Location in and around Laksar.

Water Quality Index (WQI)

Water Quality Index (WQI) is a very useful and efficient method, which can provide a simple indicator of water quality and it is based on some important parameters. In current study WQI was calculated by using the Weighted Arithmetic Index method of Cude, 2001 and Brown *et al.*, 1970. In this model, different water quality components are multiplied by a weighting factor and are then aggregated using simple arithmetic mean. For assessing the quality of water firstly, the quality rating scale (Qi) for each parameter was calculated by using the following equation-

$$Qi = \frac{Vo - Vi}{Vs - Vi} \times 100$$

Where,

Qi = Quality rating of ith parameter for a total of n water quality parameters

Vo = Observed value of the water quality parameter obtained from laboratory analysis

Vi = Ideal value of that water quality parameter can be obtained from the standard Tables.

Vi for pH = 7 and for other parameters it is equal to zero, but for DO Vi = 14.6 mg/L

Sn = Recommended WHO standard of the parameter.

Then, after calculating the quality rating scale (Qi), the Relative (unit) weight (Wi) was calculated by a value inversely proportional to the recommended standard (Sn) for the corresponding parameter using the following expression-

$$Wi = \frac{K}{Xi}$$

Where,

Wi = Relative (unit) weight for nth parameter

Xi= Standard permissible value for nth parameter

K= Proportionality constant.

That means, the Relative (unit) weight (WI) to various water Quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

Finally, the overall WQI was calculated by aggregating the quality rating with the unit weight linearly by using the following equation-

$$WQI = \frac{\sum QiWi}{\sum Wi}$$

Where,

Qi = Quality rating

Wi = Relative (unit) weight

In general, WQI is defined for a specific and intended use of water. In this study the WQI was considered for human consumption or uses and the maximum permissible WQI for the drinking water was taken as 100 score table 2.

Table 2. Water Quality Index (WQI) and its status according to Chaterjee and Raziuddin (2002).

Water quality Index Level	Water Quality Status
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking

Results and Discussion

The average results of various physico-chemical parameters analyzed during the study period such as Total Solid (TS), Total dissolved solids (TDS), pH, Dissolved Oxygen (DO), Total Hardness (TH), Calcium Hardness (CaH), Chloride (Cl), and Sulphate (SO$_4$) and their WQI values was tabulated in table 3.

Total Solids: During the present study maximum TS value was found (790.6±28.26 mg/l) at S1 site while the minimum TS value was found (705.3±5.59 mg/l) at site S4 and the average value was found (764.05±30.54mg/l) (Table 4). Similar results were reported by Bhadja and Vaghela, 2013.

Total Dissolved Solids (TDS): Total dissolved solids comprise inorganic salts principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulphates and some small amounts of organic matter that are dissolved in water. Palatability decreases and may cause gastrointestinal irritation in humans. During the present study maximum value of TDS was found (548.7±30.37mg/l) at site S5, while the minimum value was found (352.8±5.59 mg/l) at site S4 and the average value was found (511.18±30.77mg/l). Similar results were reported by Kumar *et al.,* 2017 and Bhutiani *et al.,* 2018.

pH: During the study maximum value of pH was found (7.8±0.58) at S1 site, while the minimum value was found (6.9±0.70) at site S6 and the pH average value was found (7.1±0.35). Similar trend was found by Saxena and Saxena, 2015.

Parameters/ Sites	S-1		S-2		S-3		S-4		S-5		S-6	
	OV	WQI	OV	WQI	OV	WQI	OV	WQI	OV	WQI	OV	WQI
Total Solids (TS)	790.6	0.0526	777	0.0518	760.1	0.0506	705.3	0.0470	780.9	0.0520	770.4	0.0513
Total Dissolved Solids (TDS)	539.9	0.6591	541.7	0.6613	548.1	0.6692	352.8	0.4307	548.7	0.6700	535.9	0.6542
pH	7.8	65.0185	7.1	8.1273	7.4	32.5092	6.9	-8.1273	7.07	5.6891	6.9	-8.1273
Dissolved Oxygen (DO)	6.2	49.6046	6.2	49.6046	6.2	49.6046	6.5	47.8393	6.2	49.6046	6.1	50.1951
Total Hardness (TH)	381.8	1.29916	377.7	1.2851	396.9	1.3506	223.3	0.7598	380.78	1.2956	377.7	1.2811
Calcium Hardness (CaH)	331.3	17.9461	327	17.7159	326.4	17.6850	142.4	7.7154	330	17.8800	329.1	17.8260
Chloride (Cl)	137.3	0.6650	119.1	0.5769	61.6	0.2983	53.4	0.2586	114	0.5521	125	0.6055
Sulphate (SO4)	40.2	0.3057	42.4	0.3224	42.1	0.3201	28	0.2129	45.11	0.6937	40.22	0.3058
	WQI- 135.55		WQI- 78.35		WQI- 102.49		WQI- 49.14		WQI- 76.44		WQI- 62.79	

Table 3. Sample showing observed values and WQI

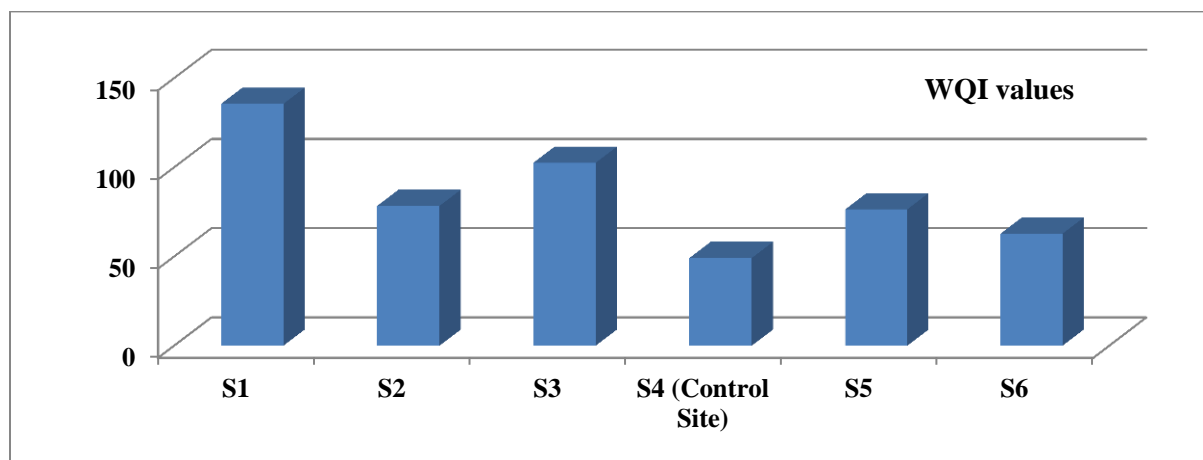**WQI- Water Quality Inde,   OV- Observed Values of the parameters**

Fig 2. Showing graphical representation of of WQI values.

Dissolved Oxygen (DO): During the present study maximum DO value was found (6.5±0.57 mg/l) at site S4, while the minimum value was found (6.1±0.57 mg/l) at site S6 and DO average value was found (6.2±0.14 mg/l). Similar trend was found by Jai *et al.,* 2014.

Total Hardness: Hardness is the ability of water to cause precipitation of insoluble Ca and Mg salts of higher fatty acids from excessive soap consumption Affect water supply system during the present study maximum TH value was (396.9±65.94 mg/l) found at site S3, while the minimum value of TH (223.3±5.59 mg/l) was found at site S4 and the TH average value was found (365.36±65.58mg/l)Table 4. Similar results were reported by Ramakrishnaiah *et al.,* 2009.

Calcium Hardness (CaH): During this study maximum value of CaH (331.3±32.57 mg/l) was found at site S1, while the minimum value of Calcium Hardness (142.4±2.88 mg/l) was found at site S4 and total CaH value was found (297.7±76.10 mg/l) Table 4. Similar results were reported by Shankar, 2007.

Chloride (Cl): Chloride occurs naturally in all types of water. The high concentration of chloride is considered injurious to some people suffering from diseases of kidneys Taste, indigestion, corrosion and palatability are affected (Khan *et al.,* 2012). during the present study maximum Chloride value (137.3±8.72 mg/l) was found at site S1, while the minimum Chloride value (53.4±2.83 mg/l) was found at site S4 and the Chloride average value was found (101.73±35.23 mg/l) Table 4. Similar trend was found by Saxena and Saxena, 2015.

Sulphate (SO$_4$): During the present study maximum value of SO4 (45.11±0.78 mg/l) was found at site S5 , while the minimum value (28±2.24 mg/l) was found at site S4 and total SO4 value was found (39.67±6 mg/l). Table 4 Similar trend was found by Mandloi, 2014.

Water quality index value of of all the study sites were also calculated using weighted arithmetic index method. Village Niranjanpur (S4) was taken as control for the whole study because the anthropogenic activity was found very less as compared to other study villages. The water quality index rating of the study site S1, S2, S3, S4, S5 and S6 was 135.55, 78.35, 102.49, 49.14, 76.44, and 62.79 respectively. The values when compared with criteria described by Chaterjee and Raziuddin

(2002), depicted in the table 2 shows that none of the site fall in the category of excellent water quality (0-25) even the control site water quality falls in the category of good water quality (26-50). Site S6 falls in the category of poor water quality (50-75) while S5 and S2 falls in the category of very poor water qulity (75-100). Site S1 and S3 falls in the category of unsuitable for drinking (more than 100). The WQI value of the study area suggests that the ground water quality of the study area is vey poor and in some areas unsuitable for drinking purpose (Table 3 and Fig 2). The depleted water quality in the study area may be due to industrial acitivity as a number of industries whether seasonal and full time are running in the study area and releasing their solid and liquid waste whether treated or partially treated on the ground. The burying of the solid waste in the ground cause ground water depletion because of leachate.

Conclusion

During the present study we found that the condition of the water is not suitable for drinking purpose. Industries and seasonal activities are responsible for the degraded quality of water in the study area**.** From WQI result is show that sample site S-4 suitable for drinking water while sample from S-1,S-2,S-3,S-5 and S-6 are very poor in WQI rating and unfit for drinking

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