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SUITABILITY ASSESSMENT OF GROUND WATER QUALITY IN RURAL AREAS OF HARIDWAR DISTRICT, UTTARAKHAND

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ABSTRACT

Ground water quality has become an important water resources issue due to rapid increase of population, industrialization, unplanned urbanization, flow of pollution from upland to lowland, and too much use of fertilizers, pesticides in agriculture. In this work, the groundwater quality of rural area of Haridwar district was studied. The samples were collected from five different rural areas and analysed with respect of physico-chemical parameters. The quality parameters were compared with standard permissible limits for drinking water proposed by national and international government bodies. The results showed that all the water quality parameters were below the permissible limits at most of the sampling stations. Only the Ca and Mg hardness were reported higher in concentration at three different sampling location. Risk assessment in respect of Ca and Mg contents at some groundwater sources indicated that these hand pump water can be consumed safely by human.

KEY WORDS : Ground water quality, Haridwar, Water quality.

INTRODUCTION

Groundwater is a significant source of water in many parts of India. About 50% of the total irrigated area is dependent on groundwater and about 60% of the irrigated food production depends on irrigation from groundwater wells (CWC, 2015). Open wells are traditional and tube wells are replacing open wells now-a days for irrigation. Water quality from shallow wells is inferior compared to deep wells (Kumar and Babu, 2013). Groundwater is indispensable for continuity of life and sustainability of environment. It is needed in almost every sphere of human activity (Matta, 2010). In recent years, the increasing threat to groundwater quality due to human activities has become a matter of great concern. A vast majority of groundwater quality problems present today are caused by industrial effluents, natural processes, agro-based practices and mining activities (Nagaraju *et al.,* 2014; Matta *et al.,* 2014; Matta *et al*., 2015). Rapid urbanization and industrialization in India has resulted in steep increase of generation of wastes. Due to lack of adequate infrastructure and resources the waste is not properly collected, treated and disposed; leading to accumulation and infiltration causing groundwater contamination (CPCB, 2007; Matta *et al*., 2016; Matta *et al.,* 2018). Till date, there have been various studies on suitability assessment of groundwater quality with reference to physico-chemical properties and pollution (Kaushik *et al.,* 2000; Haritash *et al.,* 2008; Srinivas *et al.,* 2013; Sivasubramanian *et al.,* 2013; Matta *et al.,* 2016a).

Haridwar district comes under Ganga river system which sustain the people of northeast region, India, by providing freshwater resource (Matta *et al.,* 2018a, b). The main tributaries of Ganges like Solani, Ratmau Rao and Banganga and their feeding nallahs drain the area. These tributaries are ephemeral in nature. As far as canal irrigation is concerned, western part of the district is well covered with 300 km length canal network (CGWB 2009).

The present work carried out with the objective to investigate the main physico-chemical

characteristics and to assess the suitability of groundwater for drinking purpose, as per the guidelines proposed by WHO (2011) and BIS (Bureau of Indian Standards) (2012) in Haridwar districts, Uttarakhnad, India

METHODS AND METHODOLOGY

Study area

Hardwar district is located in south – western part of Uttarakhand State. It lies from 29^0 35' to 30^0 40' North latitude and 77^0 43 ' to 78^0 22' East longitude. Dehradun and Pauri bounds the district in northeast, Bijnor district of Uttar Pradesh in the south-east, southern boundary with Muzaffarnagar district of Uttar Pradesh while the western part is bounded by the district Saharanpur. The geographical area of the district is 2360 km^2 (CGWB 2009). The population of Haridwar district is around 1,927,029 (District Census, 2011). The regional climatic condition lies within the range of about -2 ^{0}C to 44 ^{o}C temperature. In 2011, the vegetation, water, urban and barren area is about 277.70, 9.56, 693.47 and 11.74sq.km. respectively.

For the assessment of groundwater quality five different locations were selected i.e. Sarai, Dinarpur, Ibrahimpur Alipur, and Bahadrabad.of rural area of Haridwar district, Uttarakhand, India (Fig. 1). The GPS co-ordinates of the selected location for water sampling were collected by GARMIN GPSMAP (Model: 60CSX, Made in: Taiwan).

Village Sarai is situated 29.6820°N latitude and 78.2187°E longitude. It is located 7 km towards west from district head quarter, Haridwar. Sarai population is 8037 (CENSES 2011). Village Dinarpur is situated 29°51.149' N latitude and 78°02.520' E longitude. It is located 18 km towards west from district Haridwar. Dinarpur population is 1,094 (CENSUS 2011). Ibrahimpur is situated between 29.8942°N latitude and 78.0530°E longitude.

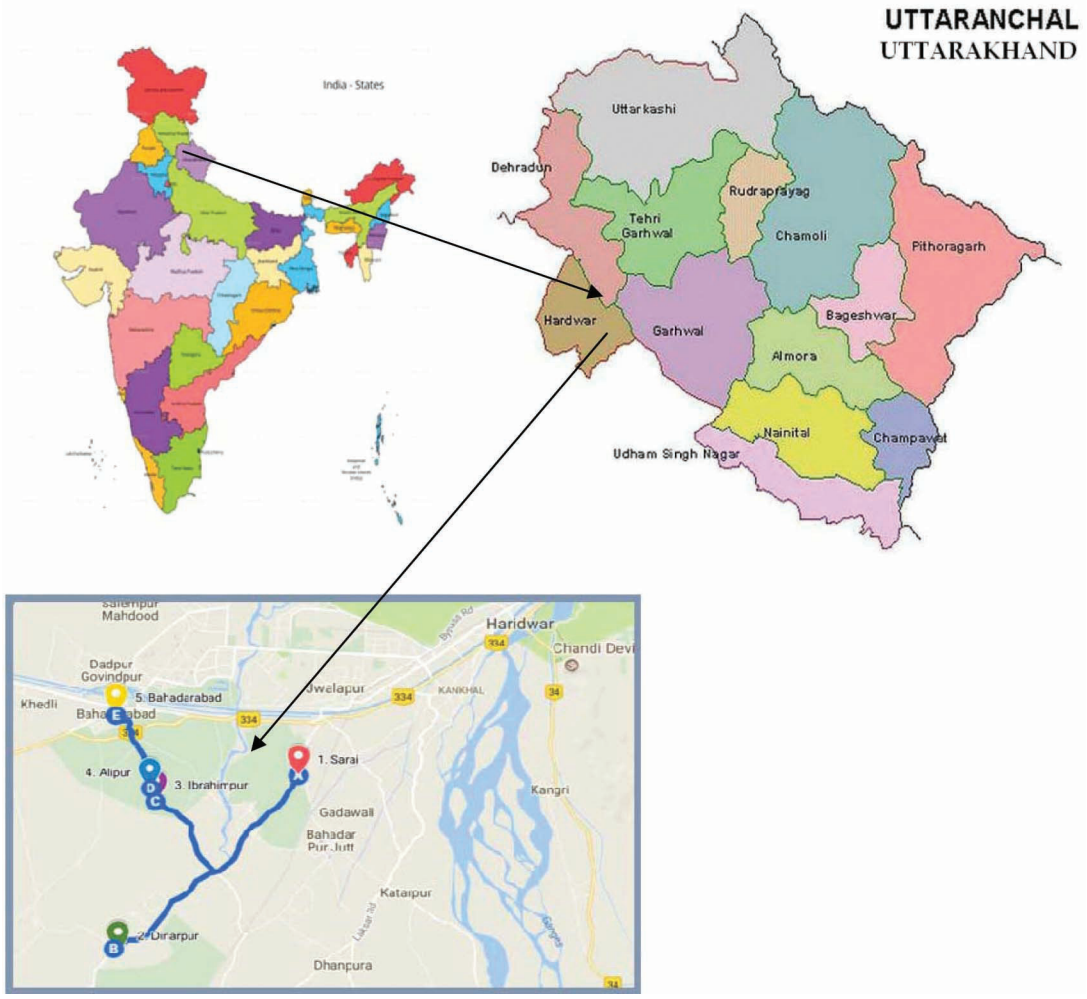

Fig. 1. A. Map of India, **B.** Map of Uttarakhand, **C.** Terrain View of Location Map of Study Area

Ibrahimpur located 13 km towards west from district Haridwar. Ibrahimpur population is 3,678 (CENSUS 2011). Alipur located 29°55.713' N latitude and 078°03.184 E longitudes. Alipur located 14 km towards west from district Haridwar. Alipur population is 3,678 (CENSUS, 2011). Bahadrabad is a town of Haridwar and situated between 29.9195°N latitude and 78.0409°E longitude. It is located 12 km towerds west from district Haridwar. Bahadrabad population is 10,096 (CENSUS 2011). All sampling site elevation/altitude is 271 meter of above sea level.

Collection of samples and analysis

Total of 24 ground water samples were fortnightly collected from different hand pumps of the rural areas during the period April 2017 to May 2018. Each sample was collected inacid-washed Nalgene Wide-Mouth Natutal HDPE polypropylene, 1000 mL bottles. Before collection of water in a particular bottle, the bottle was rinsed thoroughly with the respective samples of the groundwater. Sample location was marked on the bottle and suitable preservatives were added for storage till completion of quantitative chemical analysis. The bottle was filled to the brim with water taking care that no air bubble was trapped within the water sample. In order to prevent evaporation, the bottles were sealed with double plastic caps and precaution was also taken to avoid sample agitation during transfer to the laboratory. Immediately after collection, samples were transferred to the laboratory. A total of 14 physico-chemical parameters like Temperature, pH, Electrical conductivity (EC), Total Dissolve Solids (TDS), Dissolve Oxygen (DO), Chloride, Alkalinity, Calcium, magnesium and Total hardness were analysed out of them Temperature, pH, EC, TDS and DO were observed on the spot with the use of Portable Multi-Parameter Instrument, Model – TMULTI 27 (TOSHCON) (Kamboj *et al.,* 2017) and remaining were analysed as per standard methods of APHA, (2012). These parameters help toevaluate the drinking, irrigational as well as domestic suitability of ground water in the study area.

RESULTS AND DISCUSSION

The average value all the sites with their SD are presented in Table 1. The obtained data were compared with standard permissible limits proposed by WHO (2011) and BIS (2012).

In the study of groundwater quality, the minimum value of pH was 6.36±0.95 at site 1 and maximum value at site 3 was pH 7.0±0.21. In this study data was compared and found the average pH value were under the permissible limit of WHO/BIS. pH controls the chemical state of many nutrients including dissolved oxygen, phosphate, nitrate etc. due to this effect, aquatic organisms are affected by pH changes as their metabolic activities are pH dependent (Subba *et al.* 2014; Matta *et al.,* 2018c).

The minimum temperature value at site 1 is 22.3°C and maximum value at site 3 is 23.6°C. Water temperature is an important parameter which influences the chemical process such as dissolution-precipitation, adsorption – desorption, oxidation – reduction and physiology of biotic community in an aquatic habitat (Jayalakshmi *et al.,* 2011; Aken, 2008; Matta *et al.,* 2017).

The minimum Electric conductivity value at site 4 is 482.83 µS/cm and maximum value at site 1 is 599 µS/cm. In this study site 1 data were compared and found the average EC values were above the permissible limit of WHO/BIS. Electrical conductivity (EC) is a measure of the ability of water to conduct electrical current. This is measured in terms of the amount of ions in a solution. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulphate and phosphate anions or sodium, magnesium, calcium, iron and aluminium cations. Various phenomena are reported in the literature which cause enhancement in the value of EC such as natural enrichment in electrolytes, phenomena of mineralization or weathering of sediments (Abegaz, 2005).

Minimum value of TDS at site 3 is 287 mg/L and maximum value at site 1 is 384.5 mg/L. In this study data were compared and found the average TDS value were under the permissible limit of WHO/BIS. The excess of dissolved solids creates an imbalance due to increased turbidity and cause suffocation to aquatic life even in the presence of high dissolved Oxygen. Water containing high solid concentration may cause constipation effects. Thus, high level of TDS may aesthetically be unsatisfactory for bathing and washing (Jain *et al.* 2004; Matta *et al.,* 2016b).

The minimum value at BOD at site 1 is 3 mg/L and maximum value at site 4 is 3.5 mg/L. In this study data was compared and found the average BOD value were under the permissible limit of WHO/BIS. BOD is a chemical procedure for

determining the amount of dissolved oxygen needed by aerobic biological organisms in a BOD of water to break down organic material present in a given water sample at certain temperature over a specific time period (Suthar *et al.,* 2012).

The minimum value of COD at site 1 is 5.4 mg/L and maximum value at site 4 is 6.4 mg/L. In this study site 4 data were compared and found the average BOD values were above the permissible limit of WHO/BIS. COD is a measure of the oxygen required for the chemical oxidation of organic matter with the help of strong chemical oxidant. High COD may cause oxygen depletion on account of decomposition of microbes to a level detrimental to aquatic life (APHA, 2012).

Total hardness minimum value at site 2 is 253 mg/L and maximum at site 5 is 358 mg/L. Although hard water has no known effect on health, but is unsuitable for domestic uses. During the study of water quality of a tributary of River Ganga Matta *et al.,* (2017a) reportedthe minimum Hardness 139.8 mg/L whereas maximum was 140.5 mg/L. While the average Hardness was noticed as 140.2±0.36 mg/L.

265 mg/L is minimum value of alkalinity at site 1 and 430 mg/L is maximum value at site 5. In this study site 5 data were compared and found the average Alkalinity values were above the permissible limit of WHO/BIS. Higher amount of alkalinity may be due to the presence of large amount of carbonates and bicarbonates ions from rocks and other resources.

The minimum value of chloride at site 3 (220 mg/L) and maximum value at site 5 is 378 mg/L. In this study data was compared and found the average Cl^- value was under the permissible limit of WHO/BIS. All type of natural and raw water contains chlorides. It comes from activities carried out in agricultural area, Industrial activities and from chloride stones. Its concentration is high

Table 1. Comparison of Data for sampling sites with WHO and BIS Standard.

Sites/Parameter	Sarai	Dinarpur	Ibrahumpur	WHO(2011)(mg/L)	BIS(2012)(mg/L)
pH	6.36±0.95	6.8±0.14	7.0±0.21	6.5-8.5	6.5-8.5
Temp. (°C)	22.33± 2.25	22.66±1.75	23.66±2.87	18-35	19 – 40
Conductivity	590±197.56	534±194.40	518.66±70.54	400-2000	-
DO (mg/L)	4.56±0.77	4.5±0.97	4.33±0.96	-	0- 5
TDS (mg/L)	384.5±91.37	301.7±154.75	287.66±25.90	500-1000	500 – 2000
BOD (mg/L)	3.0±0.63	3.96±0.54	3.11±0.80	-	0 – 6
COD (mg/L)	5.4±1.33	5.78±0.47	5.9±0.66	-	0– 10
T. Hardness	341.66±27.86	253.66±28.71	327.33±28.04	250-500	300 – 600
Alkalinity	265.83±36.66	328.33±36.69	364.16±39.04	-	200 – 600
Cl^- (mg/L)	339.33±56.22	261.5±82.39	220±32.31	250– 1000	250 – 1000
Ca (mg/L)	188.33±20.16	185±21.90	215±36.05	-	75 – 200
Mg (mg/L)	135±17.88	85.66±46.20	112.33±24.54	30 – 50	30 – 100
Na (mg/L)	21.88±1.10	21.13±1.07	6.30±3.68	-	20 – 200
K (mg/L)	1.33±0.40	169.64±412.67	2.05±0.84	-	10 – 12

Sites/Parameter	Alipur	Bahadrabad	WHO(2011) (mg/L)	BIS(2012)(mg/L)
pH	6.65±0.43	6.85±0.28	6.5-8.5	6.5-8.5
Temp. (°C)	22.33±1.63	22.33±2.06	18-35	19 – 40
Conductivity	482.83±140.90	449.5±240.89	400-2000	-
DO (mg/L)	4.28±1.05	4.41±1.03	-	0- 5
TDS (mg/L)	296.83±97.06	372 ±107.74	500-1000	500 – 2000
BOD (mg/L)	3.51±0.62	3.38 ±0.35	-	0 – 6
COD (mg/L)	6.78±0.74	6.08±0.72	-	0– 10
T. Hardness	286.66±37.23	358±26.07	250-500	300 – 600
Alkalinity	320±104.45	430.83±25.96	-	200 – 600
Cl^- (mg/L)	287.83±132.10	378.5±128.83	250– 1000	250 – 1000
Ca (mg/L)	202.66±39.40	231.66±31.09	-	75 – 200
Mg (mg/L)	84±47.89	126.33±29.57	30 – 50	30 – 100
Na (mg/L)	6.45±3.27	8.50±5.37	-	20 – 200
K (mg/L)	2.78±1.11	1.89±0.96	-	10 – 12

because of human activities.

The minimum value of calcium at site 2 is 185 mg/L and maximum value at site 5 is 231 mg/L. In this study data were compared and found the average Ca values were above the permissible limit of WHO/BIS. Calcium (Ca) is fifth most abundant element in the earth crust and is very important for human cell physiology and bones (BIS, 2012).

The minimum value of magnesium at site 1 is 135 mg/L and maximum value is found at site 4 is 84 mg/L. In this study data were compared and found the average Mg values were above the permissible limit of WHO/BIS. Increase in contamination in the ground water that could be accounted by urbanization, industrialization, anthropogenic activity and various other factors (Fakayode, 2005).

Observed the minimum value of sodium at site 3 is 6.30 mg/L and maximum value at site 2 is 21.88. In this study data were compared and found the average Na values were under the permissible limit of WHO/BIS. Sodium plays an important role in preventing many fatal diseases like kidney damages, hypertension, headache, etc. in human body (WHO, 2011).

After observation, minimum value of potassium at site 1 is 1.33 mg/L and maximum value at site 4 is 2.78 mg/L. In this study data were compared and found the average K value were under the permissible limit of WHO/BIS. Potassium is extensively found in some of igneous and sedimentary rocks, its concentration in natural waters is usually quite low. This is due to the fact that potassium minerals offer resistance to weathering and dissolution (jain *et al*, 2010).

The groundwater quality of Haridwar district has also been analysed by Central Ground Water Board in 2009. Under the analysis, all the parameters have been found within the limit and revealed fresh water quality that is being used for drinking purpose (CGWB, 2009a).

CONCLUSION

Monitoring of the ground water quality is done by collecting representative water samples and analysis of physicochemical characteristics of water samples at different locations of district Haridwar. The average values of all physiochemical parameters were found within the permissible limits of the WHO and BIS guideline for drinking water, but some sites of ground water were found to have even higher as compared to standard limit. During the survey of sampling sites there was accumulation of domestic solid waste and sewage waste water was observed around the hand pumps. The uses of fertilizers on agricultural lands were also observed which could also affect the groundwater quality. So, there is a need of solid waste management in major human settlements so that harmful chemicals couldn't contaminate the water bodies.

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