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Assessment of Ground Water Quality of Bhagwanpur Industrial Area of Haridwar in Uttarakhand, India

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Abstract The ground water quality of Bhagwanpur Industrial Area of Haridwar district of Hilly state Uttarakhand in India has been studied. Under the study, the ground water samples were collected as per Bureau of Indian Standard from the selected locations of the area with the identification of their longitude and latitude. The GIS locations of the sampling sites have been shown in GIS map. Further, the samples were analyzed as per guidelines of BIS for 12 drinking water quality parameters like Colour, Temperature, pH, Total Hardness, Alkalinity, Chloride, TDS, Sulfate, Nitrate, Fluoride, Arsenic and Iron in analytical laboratory within the standard time limit of analysis. The results of the study have been explained in the paper. The Arsenic and Iron values in the ground water samples in some places have been found more than BIS standard limits. The probable reasons of the problem with the hydrogeology of Bhagwanpur area have also been described in the paper.

Keywords: *drinking water, ground water, water quality, chemical analysis, Bhagwanpur industrial area, Haridwar, Uttarakhand, India*

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1. Introduction

Water is a precious prime natural resource on the planet earth which plays a vital role in various sectors like domestic applications, agriculture, industrial activities, hydropower generation, fisheries, livestock production, forestry and other creative activities [1]. Currently, the surface water quality as well as ground water quality has become serious due to several factors like rapid increase in the population, urbanization, deforestation, industrialization etc. in the plain areas of the state. Due to these reasons, the water levels of water sources are getting depleted and unfavorably affected in both way quantitatively and qualitatively [2-24]. During the past decades, careless and unscientific patterns of disposal of industrial, agricultural, and domestic wastes have enlarged the problem of pollutants which are contaminating not only the surface waters but groundwater sources also [25]. Water quality of any area or water source can be monitored by its physical, chemical and biological characteristic. Moreover the landfill sites and mining waste dumps are some factors of metal pollution in drinking water. The higher amounts of the metal ions create human health problems [10,11,12,26,27,28,29,30]. Metals such as copper, iron, aluminium, calcium, chromium, lead, magnesium, manganese etc. may occur in drinking water due to geogenic activities or may be due to anthropogenic activities [31]. The researchers are working on improving existing analytical tools for the determination of elements upto nano, pico, and femto levels. The regular monitoring has become necessary to know the existing water quality status and the level of potential pollutants in the water for researchers and decision makers [26,27,28,29].

Hilly state Uttarakhand is comprised of two regions as Kumaun and Garhwal regions where geographical conditions are entirely different from the other plain areas of the country. In the state, the local community uses numerous traditional water management techniques to store water for their drinking and irrigation uses [3]. Tube wells are the main sources of irrigation in Haridwar district. According to Central Ground Water Board (CGWB), rainfall is the only source of water for ground water recharge in the area. There are 225 State Government tube-wells and 32930 private tube wells. The average rainfall of Hardwar district is about 1174.3 mm per annum. Haridwar district is divided in Roorkee, Bhagwanpur and Laksar Tehsils and have 06 developmental blocks like Bhagwanpur, Laksar, Khanpur, Roorkee, Bahdarabad and Narsan [32]. A large portion of population lives in the hilly parts of the state and approximately 90 % of the rural population depends upon the natural water sources for their survival. The production

of drinking water occurs by alluvial aquifers that are hydraulically associated with a water system.

Hardwar district of Uttarakhand comes under Gangatic riverine system and has the Solani, Ratmau Rao and Banganga as main tributaries of the area. Geologists have divided Haridwar area into three zones such as Siwalik, Bhabar and Gangetic Alluvial Plains from North to South. The selected Bhagwanpur area of Haridwar falls under only Upper and Middle Siwalik zones. In which the Upper Siwalik zone holds the boulders, pebbles, sand and clay where as the Middle Siwalik zone comprises mostly grey micaceous sandstone and siltstone. The major part of Bhagwanpur block has been occupied by Gangetic Alluvial Plains and lithologically, the alluvium is composed of unconsolidated to semi-consolidated deposits of sand, silt, clay and kankar.

The water levels are declining at faster rate in Bhagwanpur Block due to heavy pressure on ground water. However, the ground water abstraction for drinking, domestic and agriculture purposes is higher in Bhagwanpur block as compared to other blocks. The quality of water of any specific area can be assessed by physico-chemical and biological parameters of water. The values of these parameters are harmful for human health if they found more than limits. Characterization of water quality is necessary to study about the existing water quality. The assessment of water quality includes sampling, analyzing and characterization of drinking water samples obtained from sources on continuous basis, which explains the quality of water after comparing with water quality standards [32-39]. In Haridwar district, an industrial estate is developed at Bhagwanpur other than SIDCUL of Haridwar. The impact of Industrial development on natural resources specially on ground water resource has become necessary to study. Therefore, it has been decided to study the ground water quality. We have selected 04 sites in Bhagwanpur industrial area for ground water monitoring which is about 11 km away from Roorkee. The results of this monitoring are interpreted in the present paper.

2. Materials and Method

2.1. Study Area

The selected study area Bhagwanpur is a town of Haridwar district in Uttarakhand state of India. The GPS co-ordinates of the selected locations for water sampling were collected by using a GPS system (Make: Garmin, Taiwan; Model: GPSmap 76CSx). The sampling locations are depicted in the Map (Figure 1) using the coordinates. The following four sampling locations were identified for water sample collection near industrial area of Bhagwanpur.

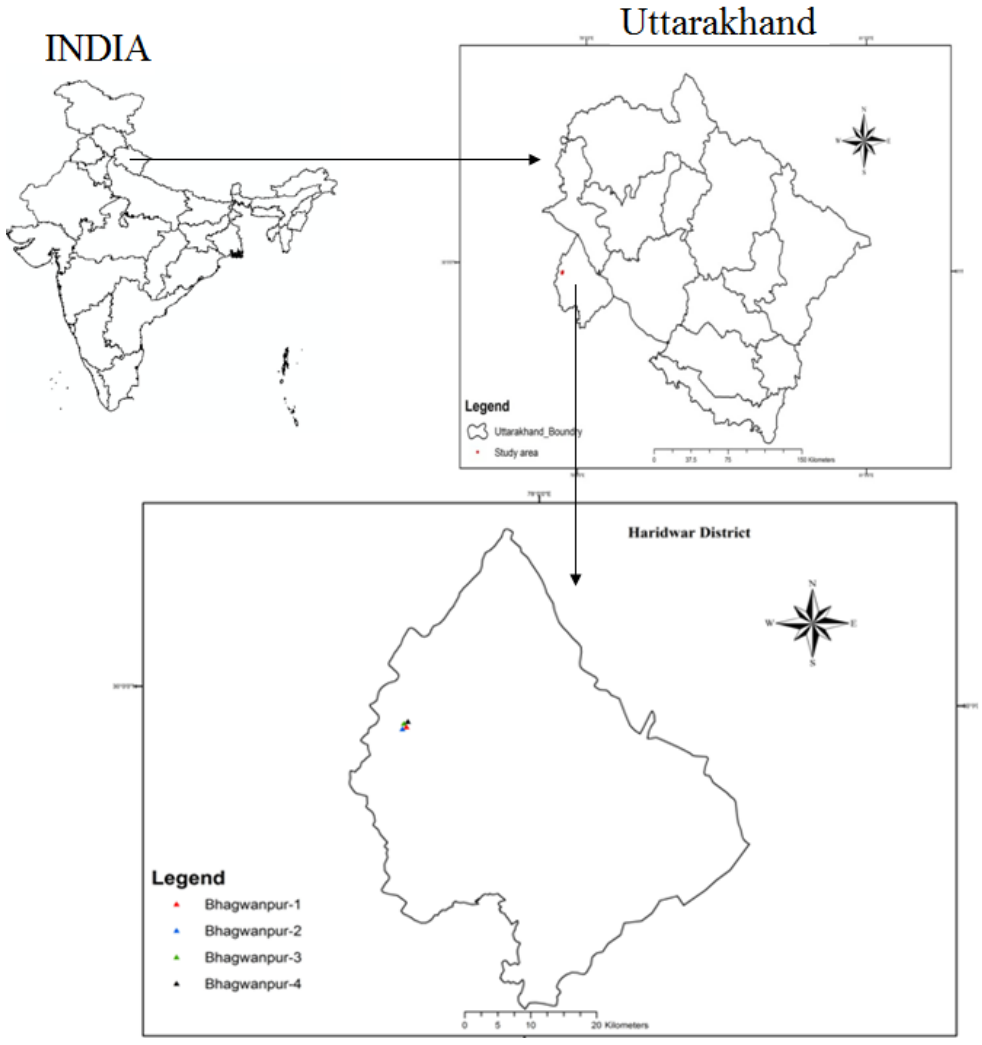

Figure 1. Water sample collection sites of Bhagwanpur area in Map

Sr. No.	Sample No.	Sample collection site
1	Bhagwanpur-1	Tube well near C.H.C. Bhagwanpur
2	Bhagwanpur-2	Hand Pump near B.K. Canework Industry Bhagwanpur
3	Bhagwanpur-3	Hand Pump near Industrial Unicure India Industry Bhagwanpur
4	Bhagwanpur-4	Hand Pump Near Sherya Medicine Industry Bhagwanpur

2.2. Water Sample Collection

Water samples from 04 locations were collected 02 times from each siteduring March and April month of 2015 considering the guideline of BIS [27] (BIS: 10500, 2012; APHA 2015). High-density polyethylene Tarson brand bottles were used after 2-3 times rinsing with the sample of each site. Ground water samples from tube well and hand pumps were obtained. For the analysis of trace metals, ground water samples were collected in acid-leached polyethylene bottles. The samples were preserved by the addition of 5 ml ultra pure nitric acid in one liter sample to minimize the adsorption and precipitation by lowering the pH less than two 2. Some important water quality parameters such as turbidity and pH of the collected samples were measured at the time of sample collection on the site. The collected water samples were carried to State Level Water Quality Analysis Laboratory in Uttarakhand Jal Sansthan campus, Dehradun in sample box at 4°C temperature for further analysis.

2.3. Water Sample Analysis in Laboratory

The water samples were analyzed in the laboratory with the available facilities in the laboratory [27,29,32-39]. Total 15 water quality parameters were analyzed in the laboratory as given in Table 1.

3. Results

The collected water samples were analyzed in laboratory for 12 drinking water quality parameters such as Colour, Temperature, pH, Total Hardness, Alkalinity, Chloride, TDS, Sulfate, Nitrate, Fluoride, Arsenic and Iron using various specific analytical instruments (Table 1). According to BIS 10500 (2012), the desirable limit for drinking water has been explained as acceptable limit and permissible limit as a limit in the absence of alternate source [26]. The mean values and standard deviations were studied and shown in Table 2 for March and April samples of 2015.

The values of colours of the ground water samples of Bhagwanpur (no. 1 and 2) sites are below the desirable limit of BIS where as the colour of Bhagwanpur no. 4 site were within the desirable limit (DL) and permissible limit (PL). The pH values of all the samples during both the months were also found within the DL and PL of BIS specification.

Total hardness and alkalinity values of all the samples in March and April Months were well within DL and PL standard values of BIS. In March month, only site no 2 and 3 show the highest value of total hardness as 343 mg/l whereas site no 2 has highest value of 363 mg/l hardness in April month. On the other hand in case of Alkalinity, site no. 4 shows the highest value as 372 and 371 mg/l in March and April months respectively.

The chloride values of all the four selected site samples of Bhagwanpur area were found less than the desirable standard limit of BIS during both the months of monitoring. Similarly, the total dissolved solids (TDS) values of all the samples were fall below the DL values. Among all the 04 sites, only Bhagwanpur-4 (no. 4) site shows the highest TDS values.

Sulphate, Nitrate and Fluoride values of the samples were also less than their desirable limits during both times of monitoring. Only arsenic values of all the four samples in both the months were analyzed as slightly greater than DL values.

The amount of Iron in the sample of third sampling site (Bhagwanpur-3) was found more than the DL of BIS as 0.61 mg/l and 0.68 mg/l in March and April months respectively. The remaining samples showed iron values less than 0.30 mg/l in both the months.

Table 1. Instruments used in water quality analysis

S.N.	Parameters	Adopted Method	Instrument Used
1	pH	Electrometric Method	pH Meter (Make: Model: CL46)
2	Colour	Spectrophotometric method	Spectrophotometre (Model:DR 5000; Make: Hach;USA)
3	Temperature	Electrometric method	Temperature meter
4	TDS, mg/L	Electrometric Method	TDS/Conductivity Meter (HACH- sension5)
5	Chloride, mg/L	Mercuric Nitrate (Titration) Method	Digital Titrator (Make: Hach, USA; Model: 16900-01)
6	Sulphate, mg/L	SulfaVer4 Method	Spectrophotometer (Make: Hach, USA; Model: DR 5000)
7	Total Hardness, mg/l	EDTA Titration method	Digital Titrator (Make: Hach, USA; Model: 16900-01)
8	Alkalinity, mg/l	Sulphuric Acid Titration method.	Digital Titrator (Make: Hach, USA; Model: 16900-01)
9	Nitrate, mg/l	Cadmium Reduction method.	Spectrophotometer (Make: Hach, USA; Model: DR 5000)
10	Fluoride mg/l	SPADNS method	Spectrophotometer (Make: Hach, USA; Model: DR 5000)
11	Arsenic, mg/l	Hydride Generation Atomic Absorption Spectrometric (HGAAS) method	Atomic Absorption spectrometer (AAS) (Model: AA 240; Make: Varian, Australia)
12	Iron, mg/l	Spectrophotometric methods	Spectrophotometre (Model:DR 5000 ; Make: Hach;USA)

Table 2. Water quality analysis results of all the four selected sites.

Water Quality Parameters	BIS 10500 Limits (2012)		March 2015		April 2015	
	Desirable Limit (DL)	Permissible Limit (PL)	Mean	Std. Deviation	Mean	Std. Deviation
Colour (Hazan)	5	15	4.250	2.217	4.250	2.217
Temperature (°C)	-	-	18.43	0.1708	25.58	0.3594
pH	6.5	8.5	7.485	0.1063	7.483	0.1021
Total Hardness (mg/l)	200	600	283.3	70.63	292.0	75.39
Alkalinity mg/l)	200	600	292.3	60.28	292.5	57.20
Chloride (mg/l)	250	1000	12.68	5.665	12.73	5.469
TDS (mg/l)	500	2000	357.0	51.76	355.0	51.76
Sulfate (mg/l)	200	400	7.500	2.082	6.025	4.033
Nitrate (mg/l)	45	No Relaxation	0.6750	0.4272	0.6500	0.3697
Fluoride (mg/l)	1.0	1.5	0.1225	0.05188	0.3275	0.3843
Arsenic (mg/l)	0.01	0.05	0.0125	0.001291	0.0125	0.002082
Iron (mg/l)	0.3	No Relaxation	0.1925	0.2798	0.2125	0.3132

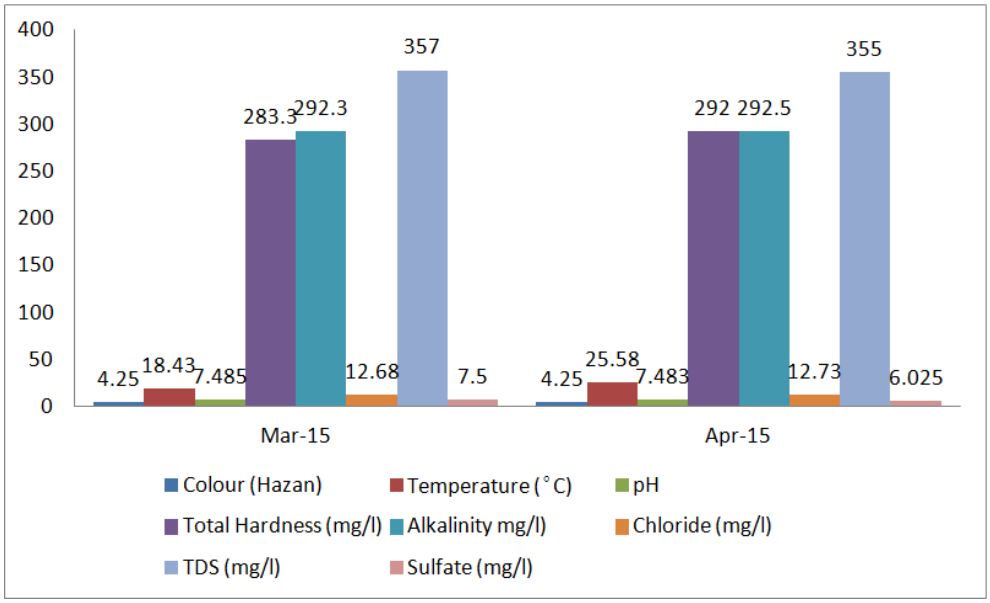

Figure 2A. Results of total eight water quality parameters during the Months of March and April 2015

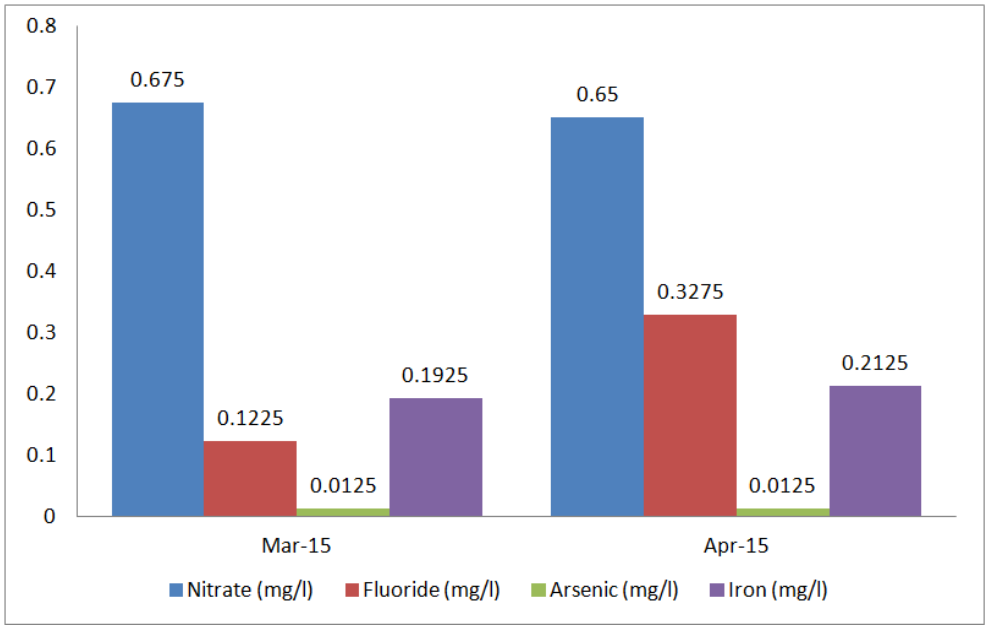

Figure 2B. Nitrate, Fluoride, Arsenic and Iron values during the months of March and April 2015

4. Discussion

Almost all the drinking water quality parameters of all the ground water samples under the study were within the standard limits of BIS except Arsenic values of all the four sites in both the months and Iron values of Bhagwanpur site no. 3 in March and April months were also found more than BIS values (Figure 2A and Figure 2B). The reason of the higher values of Arsenic and Iron may be the effect of Industrial developmental activities in the area which affect the ground water quality. Although, the development of Ground water in Hardwar district has been performed through tube wells but suitable management is necessary to reduce the excess withdrawal of ground water in Bhagwanpur block. Excess withdrawal of ground water in this area may also be a reason for this metallic contamination. Besides this, Rainwater harvesting and artificial recharge practices should be adopted on a larger scale by the local people of the area. According to Hydrogeologically point of view, Alluvium as the main water bearing formation of Bhagwanpur area, having coarse sand, fine sand and silt. CGWB reported that the water level data of the area have showed the presence of multilayer aquifer system. As per CGWB, the stage of ground water development is about 96.40%. Hydrogeological investigations of CGWB reports that the water levels in Hardwar district are sustained apart from Bhagwanpur block. The water levels in Bhagwanpur block are declining (CGWB) [31]. Specific Suitable measures may be beneficial to maintain the ground water quality of the area [6,7,17,40].

5. Conclusion

The ground water quality of Bhagwanpur industrial area of Haridwar has been studied for the 12 selected drinking water quality parameters as per BIS. After the analysis of samples, it has been found that the overall water quality of the area is good except the higher values of arsenic and iron at some places. Geogenic or industrialization may be the reasons for this type of issues. However, the ground water may be used for the purposes as well as the treatment of such water can also be adopted before use. Regular monitoring of the ground water samples of Bhagwanpur area is required by concerned departments and the reports of the monitoring should be shared among the concerning departments.

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