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Effect of industrialization on groundwater quality in Bhanpuri industrial area of Raipur (CG)

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Abstract
Six different samples of groundwater were randomly collected following the standard sampling methods from Bhanpuri industrial area in Raipur (Chhattisgarh) and tested for various physiochemical parameters and heavy metals. The concentration of TDS, EC, nitrate, iron and lead were exceeding the standard limits prescribed by BIS. According to the NPI values, the major sources of pollution at the six different sampling points are EC, TDS, chloride, fluoride, nitrate, iron and lead. The concentration of lead is very high at all the sampling points. Evaluation of NPI for physicochemical parameters indicates that the studied water is not good for drinking but suitable for commercial and irrigation purpose. The present study shows that the industries have negative impact on the groundwater quality of Bhanpuri area.

Keywords: Industrial, ground water, heavy metals, pollution, drinking water, irrigation.

Introduction
Rapid growth of the population and the large-scale urbanization to meet the demands of the people are the simultaneous, inevitable happenings that form the present scenario of the nation. Groundwater pollution may be defined as an artificially induced degradation of natural groundwater quality (Goel and Sharma, 1996). Groundwater pollution is much high in areas which are densely populated with industries. If the groundwater of an area gets contaminated, it is not an easy task to restore back its original quality and sometimes it may be an impossible task too. Therefore, determining the quality of underground water is important to observe the suitability of water for a particular use.

Study Area
The city of Raipur is the capital of Chhattisgarh and is located near the centre of a large plain. °The city is situated in the fertile plains of Chhattisgarh Region. It is situated between 22 ′33 °N to 21 ° ′14 N Latitude and 82′ ° 6′to 81° 38' E Longitude. In terms of culture, education and economy, Raipur is an advance town in Chhattisgarh state. It is the Divisional and District Headquarter. The selected site of study Bhanpuri is an industrial area. It falls in Raipur district situated in Chhattisgarh state, with a population 20421. The male and female populations are 10491 and9930 respectively. The size of the area is about 4.65 square kilometer. There are more than 600 small, medium and large industries present at the site. The map showing the locations of the study area has been given in figure 1 and 2. The ground water samples were collected from six different sites at Bhanpuri industrial area. The coordinates of the sampling sites are presented below in table 1:

Table 1: Geographical coordinates of sampling points.

S. No.	Sample Code	Latitude	Longitude	Area
1.	GWS1	21.296744	81.638752	J.B. Industries, Bhanpuri
2.	GWS2	21.30407	81.64042	V.K. Machinery, Bhanpuri
3.	GWS3	21.31280	81.64074	Suraj Pulses, Bhanpuri
4.	GWS4	21.30429	81.63782	Anil Industries, Bhanpuri
5.	GWS5	21.29945	81.638225	Aero Agro Chemical Industries ltd, Bhanpuri
6.	GWS6	21.31223	81.64459	B.D. Industries, Bhanpuri

The main aim of the present study was to assess the effect of industrialization on groundwater quality in Bhanpuri industrial area of Raipur, Chhattisgarh and to assess the suitability of ground water for drinking/irrigation purpose.

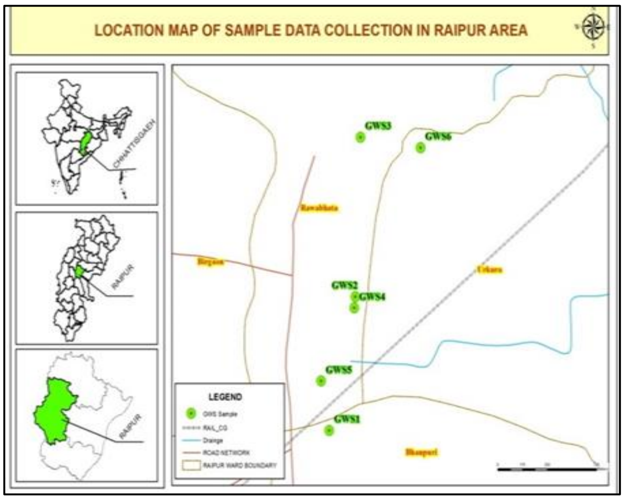

Fig. 1: Google image of sampling locations,

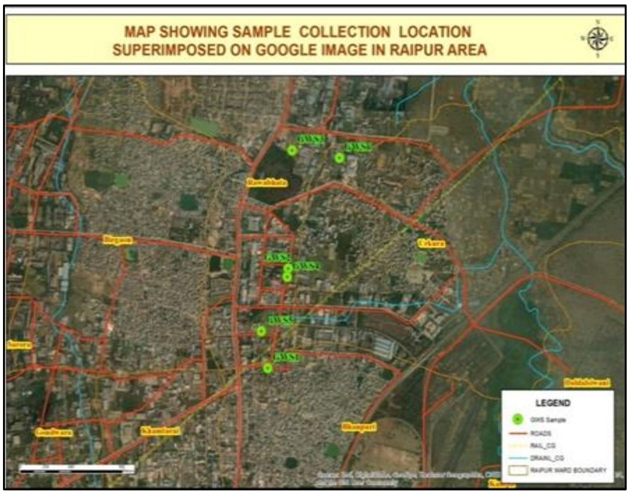

Fig. 2: Sampling points superimposed on Satellite Imagery.

Material and Methods

The standard solutions that were used in the experiments were prepared from analytical grade compounds of Merck Company and the glassware of Borosil was used. The reagent bottles, beakers and volumetric flasks used were cleaned by soaking them overnight in 2 N HCl, rinsing with water and oven drying at 60ºC before performing the chemical analyses. EUTECH pc 510 pH and Conductivity meter was employed for all pH measurements. For the analysis of lead and iron Atomic Absorption Spectrophotometer (Varian AA 240) was used. Fluoride was analyzed using UV VIS Spectrophotometer (Varian Carry 100).

Six groundwater samples were collected from the industrial area of Bhanpuri in Raipur. The samples were taken from bore wells which were in constant use. The samples for heavy metal analysis were collected in acid rinsed (2 N HCl) bottles then very thoroughly washed and rinsed with de-ionized water and were acidified with 1N nitric acid up to the pH > 2. Alkalinity, chloride, nitrate and residual chlorine were analyzed using TWAD Board Field Water Testing Kit, and other parameters were conducted following APHA (1995).

Result and Discussion

Variations are seen in the physical and chemical characteristics of each sample. This variation reveals that the quality of groundwater also differs from one location to another. The values obtained for various physical and chemical parameters after the analysis are compared with the recommended standards by BIS (1993) and WHO (2004) listed in the table below

Table 2: Physico-chemical parameters of the analyzed samples of ground water (GWS1 – GWS 6).

S. No.	Parameters	Sample Codes						Drinking water standards	
		GWS1	GWS2	GWS3	GWS4	GWS5	GWS6	BIS	WHO
1.	Color	Clear	Clear	Clear	Clear	Clear	Clear	5Hazen	Not mentioned
2.	Odor	None	None	None	None	None	None	Un-objectionable	None
3.	Ph	6.75	7.46	7.23	7.60	7.62	7.66	6.5-8.5	6.5-8.5
4.	Conductivity µS/cm	2030	3130	3420	1850	1350	2980	300	NG*
5.	TDS	1218	1878	2058	1110	810	1788	500	NG
6.	Alkalinity	200	200	180	160	150	140	200	NG
7.	Res. Chlorine	BDL*	0.20	BDL	0.20	BDL	BDL	0.20	NG
8.	Chloride	120	300	360	140	100	380	250	250
9.	Fluoride	1.5	1.5	1.0	1.5	1.0	1.0	1.0	1.5
10	Nitrate	75	100	100	45	100	75	45	50
11	Iron	0.1284	0.0508	0.3601	0.0822	0.3340	0.7470	0.3	NL*
12	Lead	0.82	0.84	0.66	0.85	0.61	0.67	0.05	0.01

The analysis of samples showed the pH value ranges from 6.75 to 6.75, it indicates the pH of water is perfectly according to the recommended BIS value. The limit prescribed by BIS for electrical conductivity in water is 300µS/cm and the conductivity values of the groundwater samples varied widely from 1350 to 3420 µS/cm. High conductivity of water sample shows an alarming condition towards mixing of electrolytes from industrial waste. The values of total alkalinity in the 6 groundwater samples varied from a minimum of 140 mg/l to a maximum of 200 mg/l and this is according the BIS desirable limit of 200 mg/l. The values for TDS are exceeding the permissible limit (500 mg/l) in all the groundwater samples, ranged from 810 mg/l to 2058 mg/l. The chloride values are within the limit but samples GWS2 (300mg/l), GWS3 (360mg/l) and GWS5 (380mg/l) have value above the BIS permissible limit (250 mg/l). The concentration of fluoride in GWS1, GWS2 and GWS4 was reported 1.5 mg/l which is above the desirable limit (1.00 mg/l) of drinking water standards of BIS while the sample GWS3, GWS5 and GWS6 showed 1.0 mg/l. The measured levels of dissolved nitrates except groundwater sample GWS4 (45 mg/l); all the other samples showed higher levels of nitrate (ranging from 75 to 100 mg/l) in comparison to the recommended BIS guidelines (45 mg/l).

Concentration of iron in GWS3 (0.360 mg/l), GWS5 (0.334 mg/l) and GWS6 (1.747 mg/l) were found to exceed standard limit while samples GWS1 (0.128mg/l), GWS2 (0.050 mg/l) and GWS4 (0.082 mg/l) were found as per the recommended BIS (0.3 mg/l) standards. Iron concentrations however do not pose potential health risk as they fall well within the recommended daily dietary allowance (Adams, 2001). The values of lead in all water samples tested ranged from 0.61 – 0.85 mg/l hence need a special attention. The values of lead obtained for all samples of ground water i.e. GWS1 (0.82 mg/l), GWS2 (0.84 mg/l) GWS3 (0.66 mg/l) GWS4 (0.85 mg/l) GWS5 (0.61mg/l) and GWS6 (0.67 mg/l) were above the values of BIS (0.05 mg/l) and WHO (0.01 mg/l) standard. Excessive exposure to lead is associated with various neuro-developmental problems and a 4.1-fold increased risk of attention deficit hyperactivity disorder in children (Brodkin et al., 2007; Sanborn et al., 2002).

Zacchaeus et al., (2020) have assessed the same impacts of industrialization on the quality of groundwater in Shagamu and Ota industrial areas of Ogun State, Nigeria. The levels of pH, Calcium, Lead, Nickel, Magnesium, Iron, Cadmium and Chromium were found to be higher than the prescribed limit. Similar findings of industrial area ground water were reported by Sadeque and Majeed, (2015) at Waluj Industrial Area in Aurangabad; Dewangan et al., (2013) at Korba city (CG); Kulshreshtha et al., (2013) at industrial areas of Ratlam (M.P); Rameeza et al., (2012) at industrial areas of Vishakhapatnam; Shakeri et al., (2009) in industrial areas Aurangabad.

Nemerow's Pollution Index –NPI

"The Nemerow index evaluation method used to analysis the quality of water. The pollution causing parameters are determined through Nemerow's pollution index using the average values of physico-chemical parameters indicated in Table 5, NPI is evaluated for all the parameters for each sample analyzed, thus identifying the pollution causing parameters. The equation used in evaluating the NPI is reproduced below:

NPI = Ci / Li,

Where; Ci = observed concentration of i parameter Li = permissible limit of i parameter.

In above expressions unit of Ci and Li should be identical. Each value of NPI shows the relative pollution contributed by single parameter. It has no units. Li values for different water quality parameters are indicated in Table 3, NPI value exceeding 1.0 indicate the presence of impurity in water. It indicates its presence in surplus amount in the water samples and particular parameter has the potential of contributing pollution to the water body or the underground water studied" (Chen Jie et al., 2012).

As per Nemerow's Pollution Index (NPI), the pollution parameters at each station is calculated and presented in Table 3

Table 3: NPI values of different sampling stations.

Parameters	GWS1	GWS2	GWS3	GWS4	GWS5	GWS6
pH	0.794	0.878	0.851	0.894	0.896	0.901
Conductivity	6.767	10.433	11.400	6.167	4.500	9.933
TDS	2.436	3.756	4.116	2.220	1.620	3.576
Alkalinity	1.000	1.000	0.900	0.800	0.750	0.700
Res. Chlorine	-	1.000	-	1.000	-	-
Chloride	0.480	1.200	1.440	0.560	0.400	1.520
Fluoride	1.500	1.500	1.000	1.500	1.000	1.000
Nitrate	1.667	2.222	2.222	1.000	2.222	1.667
Iron	0.428	0.169	1.200	0.274	1.113	2.490
Lead	16.400	16.800	13.200	17.000	12.200	13.400

The result of the present study according to Nemerow index revealed that the quality of ground water at station 1 is polluted due to EC, TDS, fluoride, nitrate and lead, as the NPI value of these parameters is more than 1(NPI>1). Similarly at station 2 the pollution is due to EC, TDS, chloride, fluoride, nitrate and lead. At station 3 the pollution is due to EC, TDS, chloride, nitrate, iron and lead, at station 4 the pollution is due to EC, TDS, fluoride, nitrate and lead. At station 5, the pollution is due to EC, TDS, nitrate, iron and lead and at station 6 the pollution is due to EC, TDS, chloride, nitrate, iron and lead. Evaluation of NPI for physicochemical parameters indicates that the studied water is not good for drinking but suitable for commercial and irrigation purpose.

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