

Assessment of ground-water quality for physico-chemical, heavy metals & bacteriological (Coliform) contamination in and around Raigarh city

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ABSTRACT

Ground-water quality of Raigarh city in Chattisgarh state was assessed for drinking water purpose based on physico-chemicals, heavy metals & bacteriological (Coliform) parameters. The samples were analysed as per methods specified by Bureau of Indian Standards/standard methods. Physico-chemical analysis reveals that fluoride, nitrate and iron are higher than BIS specified limit at some sampling sites. The samples with high Iron content & other heavy metals pollution was found in groundwater located near sponge iron plant indicating possible metal leaching into groundwater. Bacteriological analysis reveals that coliform organisms were found absent at 5 locations while at 13 sampling locations, they were found in less than BIS specified limit. Four sampling stations were found heavily contaminated by coliform organisms with maximum coliform organisms were found 86/100ml of water sample.

Key words: Digestion, aspiration, heavy metals and Coliform.

INTRODUCTION

Groundwater serves as a major resource for drinking, irrigation and industrial use. It is generally considered to be cleaner than surface water. However, several factors like discharge of industrial, agricultural and domestic wastes, land use practices, geological formations, rainfall patterns and infiltration rate affect the quality of ground water in an area and once contamination of groundwater aquifers occurs, it persists for hundreds of years because of very slow movement of water in them.¹ The quantity of uncontaminated ground water is deteriorating at an alarming rate in India². As per WHO report, in developing countries, pollution of water has been reported to cause 80 % of human diseases and 30 % of infant mortality. Only after ascertaining the physical, chemical and bacteriological qualities of the samples, the suitability of any water can be determined for

different purposes³. In the recent years, there have been many studies on groundwater pollution of various states in India^{4,5,6,7}. However, there is paucity of information regarding the status of underground water quality for the state of Chattisgarh where there has been rapid industrial growth in past decades.

Study area

Raigarh district is located in the eastern part of Chattisgarh. It stretches between 21°20' to 22°49' N longitude and 82°55' to 83°45' E longitude. The district covers an area of 6392 sq km. The district occupies 6836 sq km area and as per census 2001, has 12,65,084 population with literacy rate 70.5 %. Raigarh is situated on the plateau of Archean rock consisting of Granites. The plains of the district represent "Lower Cuddapah" formations consisting of shales interbedded with limestone.

MATERIAL AND METHODS

Physico-Chemical analysis

Samples were collected from 23 sampling stations (Map 1) in year April 2005 to March 2006. The samples were analyzed as per BIS /Standard method guidelines within stipulated time. pH and TDS were determined using pH and TDS meter (Toshniwal make). Turbidity was measured by Nephelometer (Elico make). Alkalinity, chloride, calcium and magnesium were determined titrimetrically. Iron, manganese, nitrate, nitrite, sulphate and aluminium were determined using digital spectrophotometer (model 304-EI make). Fluoride was analysed as per SPANDS method.

Metal testing

Metal Ion concentration was determined by flame atomic absorption spectrometer using Perkin-Elmer Atomic Absorption Spectrophotometer (Model 3110) using Air-Acetylin flame. Quantification of metals was based upon calibration curves of standard solutions of respective metal.⁸⁻⁹

Bacteriological (Coliform) testing

Presumptive Test:

For presumptive test, MacConkey broth from Himedia was used. Both, single strength as well as double strength media was prepared dissolving appropriate quantity of media in distilled water and pH of the media was checked with digital pH meter. Bromothymol blue indicator was also added in media. The media was then distributed in 4 sets of 5 test tubes containing Durham tubes (Size: 10 cm x 2 cm) as per WHO guidelines. 5th set of test tube was used as blank. Test tubes were incubated in incubator at 37°C for 48 hours. The presence of coliform was indicated by acid formation / colour change of media. The standard MPN table was used for enumeration of coliform organisms.

Confirmatory test

MacConkey Agar from Himedia was used as a confirmatory media for enumeration of coliform counting. Appropriate quantity of the media was dissolved in distilled water and pH of the media was checked with digital pH meter. The media was sterilized in autoclave at 121°C at 15min and transferred on Petri-plates. All experiments were carried out in Laminar flow chamber. Using

nichrome loop, one loopful of the sample (which indicated lactose fermentation/acid formation) was streaked on these petri dishes. The stabbing of the culture was done as per standard procedure. After incubating petri dishes in incubator for 48 hours at 37°C, petri dishes were observed for coliform colonies. Dark red colonies with diameter 0.5 mm or more were counted and recorded.

RESULTS AND DISCUSSION

The Physico-chemical, Heavy-metal and Microbiological (Coliform) results of groundwater samples are given in Table 2, 3, 4, 5 and 6. These results have been compared with the guideline prescribed by Bureau of Indian Standards.¹⁰ Physico-chemical and Heavy metal Parameters: BIS has prescribed two types of standards for drinking water: Maximum desirable limits and maximum permissible limits. After comparing the result with these specifications, it is evident that fluoride, nitrate and iron are major worrying factors in this region. Other physico-chemical parameters meet the BIS specified limit for either maximum desirable limit or for maximum permissible limit at most of the locations or show exceeding values only as isolated pockets in some locations. Hence other analyzed parameters are not significant in discussion. Groundwater quality of Urdana (SP 20) was found most suitable as all parameters meet BIS specification while the quality of Darogapara (SP 14) and Railwaybangla para (SP13) was found worst affected.

Fluoride

Fluoride was found above BIS specified maximum permissible limit of 1.5 mg/L at 5 locations in pre monsoon season and 6 locations in post monsoon season. It was found as 1.8 mg/L in Beladula, 2.2 mg/L in Vinoba Nagar, 2.4 mg/L in SECL colony, 3.2 mg/L in Atarmuda, 1.8 mg/L in Mithumura and 2.5 mg/L in Rambhata in pre monsoon season. In post monsoon season, its concentration was 1.6 mg/L in Beladula, 1.8 mg/L in Vinoba nagar, 1.8 mg/L SECL colony, 3.6 mg/L in Atarmuda, 1.6 mg/L in Baikunthpur, 2.8 mg/L in Rambhata. Fluoride occurrence in ground water is a natural phenomenon, influenced by the local and regional geological setting and hydro-geological conditions of the region. In low

concentration (<0.6 mg/Litre) it is recommended for preventive treatment of the dental carries, however higher concentration (>1.5 mg/Litre) lead to dental fluorosis or mottled enamel. Excessively high concentration (> 3.0 mg/Litre) may lead to skeletal fluorosis¹¹. The severity of fluorosis depends on the concentration of fluoride in drinking water, daily intake, continuity and duration of exposure and climatic conditions. The fluoride concentration in the groundwater of study area is not uniform possibly due to variations in the presence and accessibility of fluoride bearing minerals to water and the weathering and leaching processes.

Nitrate

The excessive content of nitrate (NO_3^-) in ground and surface water represents an important problem in most region with intensive agricultural activity¹². High nitrate levels at some locations seem to have resulted from point source pollution, being located near drains/canals. Infiltration of irrigation water /surface run-off water from the surrounding farm lands alongwith nitrate fertilizer led to higher value of nitrate at some locations. Nitrate concentration was found exceeding maximum permissible limit at few locations. The maximum value of Nitrate was recorded at Rajiv Gandhi Nagar (48.0 mg/L) in post monsoon and minimum nitrate value was recorded at Urdana (8.2 mg/L) in pre monsoon. There was not much variations in the value of nitrate content in groundwater in Raigarh in pre monsoon and post monsoon season. It was found exceeding maximum BIS limit at 5 locations. High Levels of nitrate in groundwater vary spatially due to different degrees of evaporation/recharge, amount of fertilizer applied, anthropogenic activity and adsorption/dispersions/denitrification processes in the soil zone.

Coliform contamination

Total coliform indicates degree of pollution and higher densities of this portrays the difference between clean and polluted waters¹³. It was found that out of 23 sampling stations, only 5 stations have coliform count more than permissible limit. (>10 coliform colony /100 ml) in both season. However, coliform organism were detected in 18 sites out of 23 sampling sites but the number of coliforms are below BIS permissible limit. As per Bureau of Indian

Table -1: Sampling point location in and around raigarh city

S. No.	Location	Sampling point
1	Housing Board Colony	SP1
2	Beladula	SP2
3	Kaserpara	SP3
4	Sindhi Colony	SP4
5	Subhas- Nagar	SP5
6	Vinoba Nagar	SP6
7	Chakradhar Nagar	SP7
8	Kelo Vihar	SP8
9	SECL colony	SP9
10	Atarmuda	SP10
11	Rajiv Gandhi Nagar	SP11
12	Mithumuda	SP12
13	Railwaybangla Para	SP13
14	Darogapara	SP14
15	VikasNagar	SP15
16	Kirodimal Colony	SP16
17	Baikunthpur	SP17
18	Rambhata	SP18
19	Dhangardeepa	SP19
20	Urdana	SP20
21	Madhubanpara	SP21
22	Kewtapara	SP22
23	Bohidarpara	SP23

Standards specification for drinking water, coliform count was found highest in sampling station No. 12 (Mithumuda) following sampling station 11 and 19. (Rajiv Gandhi Nagar and Dhangardeepa respectively). The minimum and maximum coliform count found in these heavily contaminated areas was 18 -86 /100ml.

Heavy metals

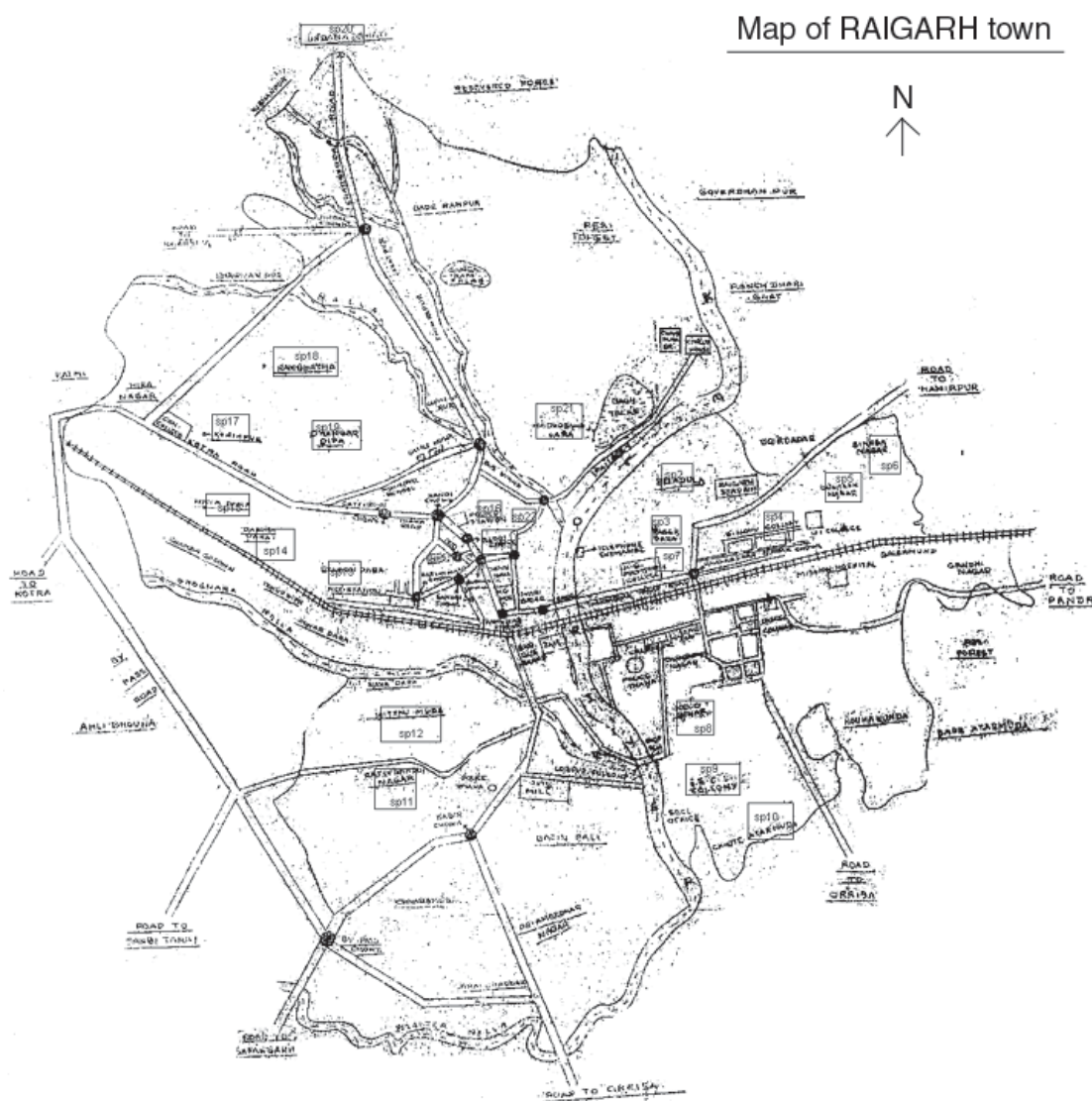
Among heavy metals, iron was found exceeding maximum permissible limits at 2 locations –Darogapara and Railway Bangla Para. BIS has recommended 0.3mg/ litre as the desirable limit and 1.0 mg/ l as the maximum permissible limit in the absence of alternate sources. The value of iron content was found more than 1.0 ppm in

Table - 2: Physico-chemical analysis (pre monsoon)

S. No.	Location	pH	TDS (mg/l)	Turbidity (NTU)	Colour	Ca ²⁺ (mg/l)	Mg ²⁺ (mg/l)	Cl ⁻ (mg/l)	Al ³⁺ (mg/l)	Alk. (mg/l)	NO ₃ ⁻ (mg/l)	NO ₂ ⁻ (mg/l)	SO ₄ ²⁻ (mg/l)	F ⁻ (mg/l)	Zn ²⁺ (mg/l)
1	Housing Board Colony	7.60	1230	0.2	<2	60	42	358	BDL	224	18.0	BDL	48.0	0.8	0.22
2	Beladula	7.46	910	0.2	<2	48	38	302	BDL	210	40.0	0.002	34.6	1.8	BDL
3	Kaserpara	7.20	1080	0.4	<2	48	44	320	BDL	240	25.2	BDL	38.0	1.4	0.14
4	Sindhi Colony	7.08	1020	0.4	<2	42	44	316	BDL	214	8.0	BDL	18.4	0.6	0.20
5	Subhas Nagar	7.12	1240	0.4	<2	69	50	356	BDL	230	15.0	BDL	12.6	0.8	0.14
6	Vinoba Nagar	6.98	1020	0.4	<2	52	38	310	BDL	208	20.0	BDL	44.2	2.2	0.18
7	Chakradhar Nagar	7.44	1236	0.6	3.0	60	44	288	BDL	230	10.4	BDL	30.8	1.2	0.14
8	Kelo Vihar	7.50	860	0.3	<2	48	34	284	BDL	194	25.0	BDL	26.0	0.8	BDL
9	SECL Colony	7.16	1080	0.3	<2	45	47	320	BDL	220	42.0	0.001	32.0	2.4	BDL
10	Atarmuda	7.12	960	0.3	<2	42	40	298	BDL	212	40.0	0.001	28.0	3.2	BDL
11	Rajiv Gandhi Nagar	7.58	1204	0.6	<2	62	42	312	BDL	245	36.0	0.002	36.0	1.0	0.40
12	Mithumura	7.45	1270	1.0	<2	65	42	329	0.002	288	45.0	0.001	44.0	1.8	0.32
13	Railway Bangla Para	7.32	1294	4.2	12.0	102	66	304	0.01	304	12.5	BDL	45.0	0.4	4.00
14	Daroga Para	7.50	1310	4.0	10.0	104	70	440	0.04	308	18.0	BDL	70.0	0.4	2.80
15	Vikas Nagar	7.32	1240	0.8	<2	80	60	388	BDL	275	16.2	BDL	40.0	0.2	0.50
16	Kirodimal Colony	7.40	1290	0.5	<2	88	63	324	BDL	266	9.4	BDL	28.5	0.5	0.42
17	Baikunth Pur	7.60	1235	0.4	<2	85	58	260	0.002	228	14.8	BDL	52.0	1.2	0.28
18	Rambhata	7.20	1040	0.8	4.0	80	54	306	0.001	290	12.0	BDL	46.0	2.5	0.35
19	Dhangardeepa	7.28	994	0.6	<2	74	45	296	BDL	240	25.6	BDL	30.5	0.9	0.50
20	Urdana	6.88	360	0.2	<2	24	26	136	BDL	129	8.0	BDL	18.0	0.2	BDL
21	Madhuban Para	7.40	1379	0.4	<2	112	80	486	BDL	264	22.6	0.001	84.0	0.4	0.20
22	Kewta Para	7.54	1320	0.4	<2	108	72	428	BDL	255	18.5	BDL	56.2	0.8	0.12
23	Bohidar Para	7.42	1360	0.4	<2	100	72	460	BDL	240	14.0	BDL	74.0	1.4	0.22

Table - 3: Physico-chemical analysis (post monsoon)

S. No.	Location	pH	TDS (mg/l)	Turbidity (NTU)	Colour	Ca ²⁺ (mg/l)	Mg ²⁺ (mg/l)	Cl ⁻ (mg/l)	Al ³⁺ (mg/l)	Alk. (mg/l)	NO ₃ ⁻ (mg/l)	NO ₂ ⁻ (mg/l)	SO ₄ ²⁻ (mg/l)	F ⁻ (mg/l)	Zn ²⁺ (mg/l)
1	Housing Board Colony	7.72	1260	0.3	<2	68	40	364	BDL	234	22.0	BDL	40.0	0.6	0.16
2	Beladula	7.50	980	0.3	<2	58	39	340	BDL	216	46.0	0.006	38.0	1.6	0.10
3	Kaserpara	7.22	1100	0.4	<2	60	36	322	BDL	242	28.2	BDL	35.0	1.2	0.18
4	Sindhi Colony	7.18	1080	0.4	<2	55	35	330	BDL	220	8.6	BDL	20.5	0.8	0.28
5	Subhas Nagar	7.10	982	0.4	<2	58	42	330	BDL	202	18.5	BDL	20.0	0.5	0.20
6	Vinoba Nagar	6.88	1060	0.5	<2	60	38	332	BDL	199	24.0	BDL	48.0	1.8	0.26
7	Chakradhar Nagar	7.52	1280	0.6	4.0	62	41	332	BDL	234	16.4	BDL	42.0	1.0	0.20
8	Kelo Vihar	7.68	890	0.3	<2	46	38	298	BDL	188	25.0	BDL	32.2	1.0	BDL
9	SECL Colony	7.22	1110	0.3	<2	45	38	340	BDL	223	45.8	0.004	28.8	1.8	0.20
10	Atarmuda	7.20	1020	0.2	<2	46	38	318	BDL	218	47.0	0.002	35.0	3.6	0.18
11	Rajiv Gandhi Nagar	7.58	1220	0.6	3.0	62	38	329	BDL	244	48.0	0.001	34.0	1.4	0.40
12	Mithumura	7.48	1240	1.6	<2	62	39	320	BDL	265	45.2	0.001	55.0	1.5	0.50
13	Railway Bangla Para	7.50	1280	5.0	14.0	98	60	410	0.02	285	12.6	BDL	50.0	0.5	5.20
14	Daroga Para	7.48	1350	5.0	16.0	106	72	460	0.04	300	18.0	BDL	80.0	0.4	3.00
15	Vikas Nagar	7.48	1250	0.6	<2	78	52	380	BDL	276	16.0	0.001	40.0	0.2	0.50
16	Kirodimal Colony	7.50	1260	0.5	<2	86	55	324	BDL	258	12.0	BDL	28.0	0.4	0.40
17	Baikunth Pur	7.52	1260	0.5	4.0	82	50	310	0.001	232	14.8	BDL	60.0	1.6	0.30
18	Rambhata	7.40	1220	1.0	5.0	84	54	340	0.001	304	12.2	BDL	50.0	2.8	0.30
19	Dhangardeepa	7.38	1040	1.0	<2	76	40	324	BDL	252	28.6	BDL	40.0	0.6	0.65
20	Urdana	6.90	390	0.2	<2	30	22	145	BDL	135	8.2	BDL	20.0	0.2	BDL
21	Madhuban Para	7.62	1360	0.6	3.0	108	76	478	BDL	258	20.2	0.001	85.0	0.4	0.30
22	Kewta Para	7.50	1300	0.6	<2	105	71	410	BDL	248	18.8	BDL	50.0	0.5	0.18
23	Bohidar Para	7.48	1340	0.5	3.0	94	70	438	BDL	239	14.6	BDL	65.0	1.4	0.30



Map of Raigarh town

these locations in both season. The highest value of iron (1.6 ppm) was found in Darogapara in post monsoon season. Although iron has got little concern as a health hazard, it is still considered as a nuisance in excessive quantities. Consumption of drinking water with a high concentration of iron can lead to liver disease over a long period of time. Iron in excess of 0.3 mg/L causes staining of laundry and ceramic ware. Dissolved iron in drinking water is difficult to remove when present in

concentration more than 1.0 mg/L. Two reasons can be attributed for high iron content in groundwater in Raigarh district—first, the bedrock of Raigarh district is limestone which also contains iron and the second - possible leaching from sponge iron plants - as the result indicates that areas nearby sponge iron plant has high iron content. Maximum iron content was found in Darogapara (1.6 mg/L) followed by Railway Bangla para (1.5 mg/L), VikasNagar (1.2mg/L) & Dhanganardeepa (1.0mg/L).

Table - 6: Coliform count in groundwater in pre and post monsoon season

S. No.	S.P.	CFU/100ML (pre monsson)	CFU/100ML (post monsoon)
1	SP1	0	0
2	SP2	2	7
3	SP3	4	6
4	SP4	2	8
5	SP5	4	9
6	SP6	5	8
7	SP7	2	6
8	SP8	0	0
9	SP9	0	0
10	SP10	2	8
11	SP11	26	45
12	SP12	38	86
13	SP13	10	6
14	SP14	0	0
15	SP15	8	7
16	SP16	6	10
17	SP17	2	2
18	SP18	16	22
19	SP19	18	44
20	SP20	0	0
21	SP21	14	22
22	SP22	4	10
23	SP23	2	8

Conclusions

The groundwater in Raigarh city has varied nature of quality which was found influenced to a great extent by regional geomorphological, hydrogeological, industrial and social pattern. The groundwater quality at Urdana (SP 20) was found most suitable for drinking purpose. All analysed parameters are within maximum desirable limits as per Bureau of Indian Standards Specifications- IS 10500-1991. Other sampling locations show different behaviour with reference to various physico-chemical parameters and Coliform organisms. Iron content was found above BIS maximum permissible limit in Darogapara (SP 14) and Railway Bangla Para (SP 13) in both season. Fluoride content was found exceeding BIS limit in Beladula (SP 2), Vinoba Nagar (SP 6), SECL Colony (SP 9) and Atarmuda (SP 10) in both season while nitrate content was found exceeding of 45 mg/L as per IS 10500:1991 at many locations in post monsoon season. Coliform organisms were found exceeding maximum permissible limit (>10 coliform colony /100 ml) in 5 sampling sites out of 23 sampling locations.

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