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A Study to Explore the Groundwater Quality of Dalli Rajhara Area Balod District, Chhattisgarh: with Special Reference to Pollution Due to Mining Activities

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Abstract—*Chhattisgarh is one of the richest Indian states in natural resources. The iron ore deposits in Dalli Rajhara (Balod District) are widespread and have been a backbone to industrial development in the state. A highly mechanized opencast mine is in Dalli Rajhara which is one of the two principal sources of iron supply to the Bhilai Steel Plant. The environmental impact of large scale mining activities in Dalli Rajhara includes contamination of soil, groundwater and surface water by chemicals from mining processes. The present study aimed to characterize the various physico-chemical parameters of water and to know the current level of iron present in the ground water (tube wells) in and around the mining areas of Dalli Rajhara. Twelve sampling stations were selected for the study and compared during the Pre-monsoon period. The physico-chemical parameters such as pH, Electric Conductivity (EC), Total Dissolved Solids (TDS), Turbidity, Total Hardness (TH), Total alkalinity and Total acidity were examined by standard method while Atomic Absorption Spectrometry (AAS) was applied for the determination of Iron in the water samples. The total dissolved solid, total hardness and Iron concentration in ground water was ranged from 200 - 670, 175 - 490 and 1.2 - 3.2 mg l^{-1}, respectively. The results were compared with standard values of drinking water prescribed by BIS (Bureau of Indian Standards) and WHO (World Health Organization), which shows the excess presence of iron in ground water, and pH value shows the water to be slightly acidic to basic in nature. The ground water is thus found to be contaminated and prolonged exposure may lead to health related problems among the local people. Hence, implementation of groundwater protection measures in this area is necessary.*

Keywords: *physico-chemical, contamination, ground water*

1. INTRODUCTION

Iron ore deposits in Chhattisgarh are widespread and have been a backbone to industrial development in the state[1]. The Coal, Bauxite and Iron ore abundantly occur in northern and southern part of the state including Bailadila (Dantewada), Dallirajhra (Balod) and Kawardha. According to present statistical analysis about 75 – 80% human requirements are fulfilled by groundwater. Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of lithologic formations. Groundwater makes up ≈ 20% of the world's fresh water supply, which is ≈ 0.61% of the entire world's water, including oceans and permanent ice. From many years ground water was thought purest form of water due to the protected layer of rocks and soil that act as filter. In India, groundwater is used intensively for drinking, irrigation and industrial purposes. Several land and water-based human activities are causing pollution of this precious resource [2][3]. Owing to in-discriminated industrialization and anthropogenic sources, the water quality of available groundwater resources is being increasingly degraded [4]. Heavy metals are non-biodegradable and toxic to the living organisms. It enters into environment through combustion of fossil fuel, metallurgical process, agricultural runoff etc.[5][6]. The quality of ground water is of great importance in determining the suitability of particular ground water for a certain use (public water supply, irrigation, industrial applications, power generation etc.). It is also important to know the geochemistry of the chemical-soil-groundwater interactions in order to assess the fate and impact of pollutant discharged on to the ground. Pollutants move through several different hydrologic zones as they migrate through the soil to the water table[7]. The major sources of heavy metals in ground water include rock minerals, discharge of sewage and other waste effluents on land and runoff water. The water used for drinking purpose should be free from any toxic elements, living and nonliving organism and excessive amount of minerals that may be hazardous to health. Some of the heavy metals are extremely essential to humans, for example, cobalt; copper, etc., but large quantities of them may cause physiological disorders. The cadmium, chromium and lead are highly toxic to humans even in low concentrations [7]. The environmental impact of large scale mining activities in Dalli-

Rajhara includes, contamination of soil, groundwater and surface water by chemicals from mining processes[1]. So this study aimed to characterize the physico-chemical parameters of water, and to know the level of different metals present in the ground water (tube wells) in and around the mining areas of Dalli Rajhara.

2. EXPERIMENTAL

2.1. Study area

Dalli Rajhara is located in southern Balod district withLatitude 20° 33'00" to 20°35'00" N, Longitude 81°00'45" to 81°07'00 E. The preparations for mechanizing the Dalli mine began in 1977.The mine area covered 14 ha. This mine is controlled by Steel Authority Of India Ltd. The Dalli Rajhara iron ore mines feed into the Bhilai Steel Plant (C.G.). Iron ore in Dalli covered area about 85 square km. Iron ore in Dalli are bands of hematite and quartzite. Iron ore are lentiform and it seen in various sizes. Chemical composition of Dalli iron ore is as follows-

Fe	66.3%
Mn	15%
SiO_2	1.44%
S	0.1%

The Rajhara mine ore body is a Precambrian banded iron formation and is worked on a very large scale in a highly mechanized opencast mine. It is one of the 2 principal sources of iron supply to the Bhilai Steel Plant. The mines are open cast mines and the poignant view as one enters the township at dusk is that of thousands of glittering lights on the hills.

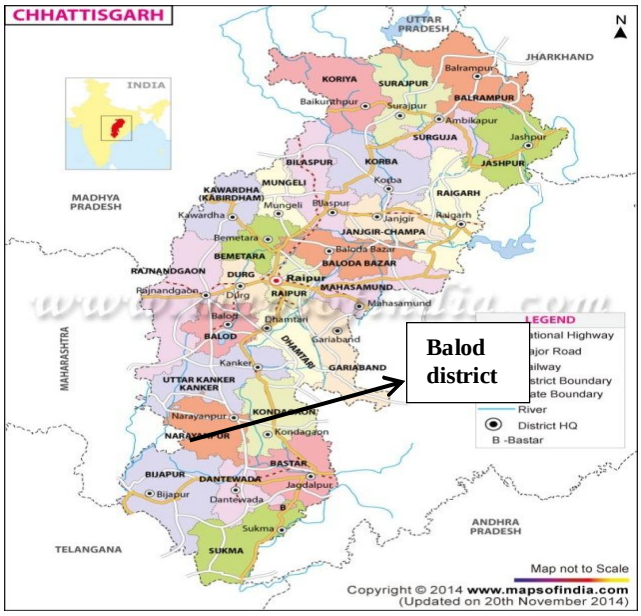

Fig. 1: Location of Balod District at Chhattisgarh

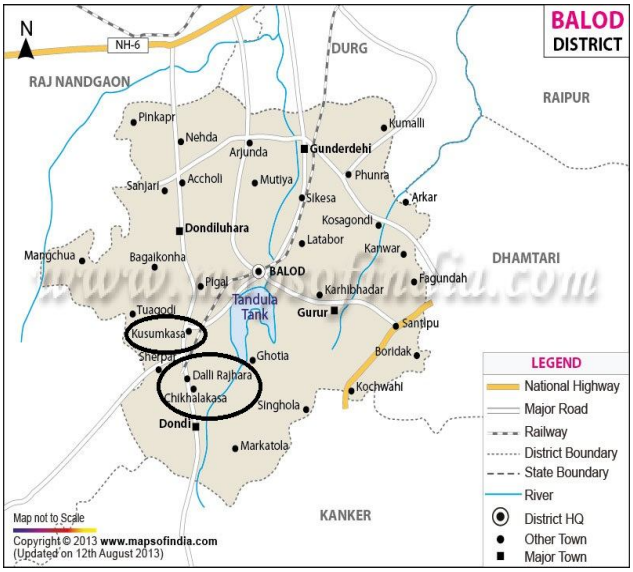

Fig. 2: Location of Dalli Rajhara in Balod District

2.2. Topography

It is a hilly terrain. The general ground level is located at 425 mRL and the peak old benches are at 543 mRL.

2.3. Geology

The iron deposit of the Dalli Rajhara range are associated with the BIF (Banded Iron Formations) belonging to the Chilpi formation of Pre-Cambrian age, generally known as iron-ore series of Dharwarian system. The lithology of this area is dominantly of the sedimentary-metamorphic type.Hard massive and abrasive BHQs (banded hematite quartz) and soft phyllites/shales respectively constitute the footwall and the hang wall. Hard massive and abrasive BHQs (banded hematite quartz) and soft phyllites/shales respectively constitute the footwall and the hang wall. The current reserves are as follows (as on 1.04.2006) –

Reserves	Fe%	SiO_2%	Al_2O_3	P%
33.68%	67.31	1.76	0.84	0.045

A unique feature of this mine is the high stripping Ratio, which is normally very marginal in other iron-ore mines in the country. The overall stripping ratio for the deposit is 1.5(waste: ore), whereas, it is as high as about 4.6 for the upper horizons, i.e. for + 423mRL.

3. METHODOLOGY

3.1. Sampling and Materials

A random sampling method was used for collecting ground water samples from hand pumped tube wells from twelve different locations of Dalli Rajhara area during the Pre-monsoon season (March -April 2015) which are illustrated in Table No. 1.

Samples were collected in sterilized screw-capped polyethylene bottles of one litre capacity. The water sample was divided in two portions.The 1st portion was used for measurement of the physico-chemical parameters. The 2nd portion was acidified with few drops of ultra-pure nitric acid (E.Merck) for analysis of the metals.Samples collected from study sites were properly labelled and a record was prepared. Borosilicate glassware, distilled water and good quality reagents were used throughout the testing.

Table I: Sampling Points

Sampling Station	Number of Samples collected	Sampling point number
Rajhara colony	02	1, 2
Gurunanak Market	02	3,4
Chandanibhata	01	5
Dalli old Market	01	6
Konde Road	01	7
ShahidHospital Area	01	8
Dalli Camp	02	9, 10
Chiklakasa	02	11, 12

3.2. Analysis

The physico-chemical parameters such as pH, Electric Conductivity (EC), Total Dissolved Solids (TDS), Turbidity, Total Hardness (TH), Total alkalinity and Total acidity were examined by standard method while Atomic Absorption Spectrometry (AAS) was applied for the determination of Iron in the water samples. The results were compared with standard values of drinking water prescribed by BIS (Bureau of Indian Standards)[8]and WHO (World Health Organization)[9]. The methods used for various physicochemical parameters are illustrated in table 2.

Table 2: Methods Used for Estimation of Various Physicochemical Parameters

Parameters	Method
pH	Water Analyser kit
Electrical onductivity	Water Analyser kit
TDS	Water Analyser kit
Total Hardness	EDTA Titration Method
Total Alkalinity	Titration Method
Total Acidity	Titration Method
Turbidity	Turbidity Meter
Iron	Atomic Absorption Spectrophotometer

3.3. Determination of Iron

Fully automatic double beam atomic absorption spectrophotometer model no. AA 8000 and hollow cathode lamp were used for the determination of heavy metal. The wavelength used for absorption was 248.33 nm for Fe.

4. RESULTS AND DISCUSSION

The physico-chemical parameters which were analysed in pre monsoon season (March-April 2015) have been shown in Table 3.

Table 3: Physico-chemical parameters of sampled water

Parameters	Sampling Points											
	1	2	3	4	5	6	7	8	9	10	11	12
pH	6.0	6.31	6.29	6.29	6.57	6.73	6.68	7.16	6.18	6.51	6.46	6.42
Electrical Conductivity (µmhos/cm)	400	410	410	580	670	1340	850	420	990	480	860	740
Total Dissolved Solids(mg/l)	200	200	210	270	330	670	430	210	490	240	400	380
Total Hardness (mg/l)	191.41	175.78	187.5	199.22	292.97	484.37	375	207.03	355.47	195.31	304.69	308.59
Turbidity, NTU	12	12.5	12.6	13.6	20	31	25	14	30	13.2	23	21
Total Alkalinity (mg/l)	333.33	291.66	250	166.66	291.66	166.66	208.33	250	166.66	250	250	166.66
Total Acidity(mg/l)	184.61	123.07	138.46	161.53	115.38	153.84	138.46	69.3	123.07	107.69	123.07	123.07
Iron(mg/l)	3	2.99	3.1	3.2	2.7	1.5	1.7	2	BDL*	BDL	1.7	1.2

*Below Detection Limit

4.1. PH

The presence of hydrogen ion concentration is measured in terms of pH range. In our study the pH value ranges from 6.0 to 7.16. The desirable pH range necessary for drinking water is from 6.5 to 8.5. On an average, pH of all samples was in desirable limit as prescribed for drinking water standard.

4.2. Electrical Conductivity

The electrical conductivity of water is due to the presence of dissolved inorganic salts. In our samples the value ranges from 400 to 1340 µmhos/cm.The minimum and maximum values were reported at the sampling location 1 and 6 respectively.

4.3. Turbidity

Turbidity of water is due to the presence of suspended particles of the chemical substance. Turbidity observed from water samples ranged between 12 to 31 NTU, which shows that turbidity of water samples at station point 6 and 9 found above the permissible limit.

4.4. Total Dissolved Solid (TDS)

Total dissolved solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro granular suspended form. The permissible limit of TDS of drinking water is 500-1500 mg/l (WHO). Total dissolved solid content of the water samples was found between 200 – 670 mg/l which is withinthe permissible limit.

4.5. Total Hardness

Total hardness was found in the sample water ranges from 175.78 - 484.37mg/l, which shows thatwater is safe for drinking purpose. Hardness has no known adverse effects on health. However, maximum permissible level prescribed by W.H.O for drinking water is 600 mg/l.

4.6. Total Alkalinity

Total alkalinity of water in terms of $CaCO_3$ ranges from 166.66-333.33 mg/l. The permissiblelimit of total alkalinityfor drinking water is 200-600 mg/l (WHO).Minimum alkalinity was found from thesample station number 4 and maximum alkalinitywas found from sample station number 1.

4.7. Total Acidity

Acidity of water is its capacity to neutralize a strong base and is mostly due to the presence of strong mineral acids, weak acids and the salt of strong acid and weak base. The value ranges from 69.3 to 184.61 mg/l.

4.8. Iron

Iron is the main ingredient of haemoglobin, cytochrome and myoglobin. Long term consumption of drinking water with high concentration of iron may lead to liver diseases [10]. The iron concentration reported ranges from 1.2– 3.2 mg /l. Thehighest value of iron was reported at station point 4. The permissible limit of iron for drinking water is 0.3- 1.0 mg/l (WHO and BIS).

5. CONCLUSION

It is clear from the table 3 and Fig. 3 that the concentration of iron in different samples is much more than the maximum permissible limit as given by BIS andW.H.O. The increasing concentration of heavy metal has been correlated with the mining practices and growing population. Due to large scale mining activities in Dalli-Rajhara the groundwater is contaminated by chemicals from mining processes.

Hence, it is concluded that the ground water is found to be contaminated and prolonged exposure may lead to health related problems among the local people residing in and around Dalli Rajhara area. Hence, implementation of groundwater protection measures in this area is necessary.

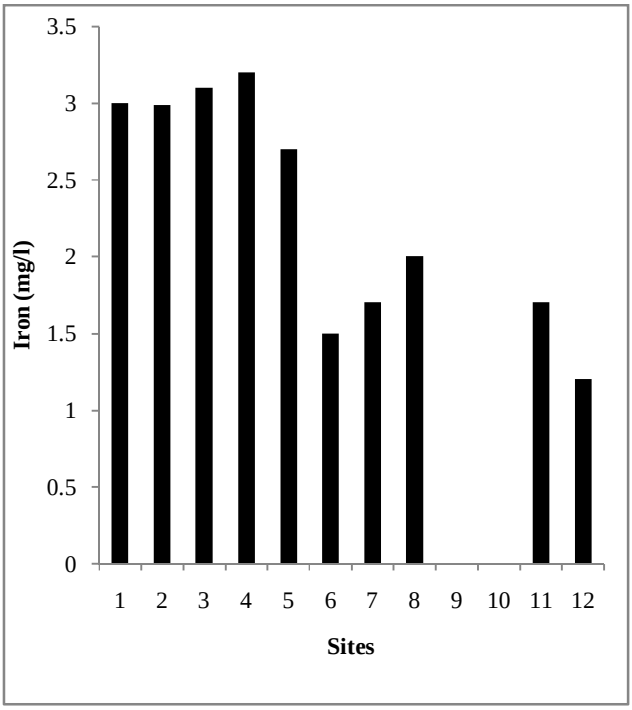

Fig. 3: Iron Level of Different Groundwater Sties

6. ACKNOWLEDGEMENT

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