RESEARCH PAPER

Beneath the Surface: Groundwater Challenges in Chhindwara's Coal Mining Landscape

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ABSTRACT
The primary issue for the existence of all living things on Earth is the quality of the water. The most important concern for the locals is the quality of the groundwater in the mining areas. In the current study, groundwater samples from the Chhindwara district's coal mining areas were gathered in various sessions and examined for various aspects of water quality, including pH, TDS (Total Dissolved Solid), Electrical Conductivity (EC), Chlorides, Sulfate, Nitrate, Iron, Hardness, Magnesium, and Sodium. Following examination, the results were compared to other water quality standards, including IS and WHO. The results show that the mining operations had some impact on the groundwater's quality.
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1.0 INTRODUCTION

Worldwide, groundwater is used for agriculture as well as home and industrial water supplies. Due to the rapid population growth and the accelerated rate of industrialization, the demand for fresh water has significantly increased during the previous few decades. Water-related illnesses account for more than 80% of all human diseases, according to the WHO (Kavitha and Elangovan, 2010).

Groundwater is a priceless natural resource that meets the essential requirements of all living things. It cannot be produced or added to by hydrological processes, electronic means, or any other method (Brindha and Elango, 2011; Sathiyamurthy, 2012). Despite the fact that 75% of the globe is covered in water, people on globe struggle without access to clean water. For home, agricultural, and industrial purposes, ground water is a crucial resource (Jameel and Sirajudeen, 2006; Rengaraj et al., 1996).

Understanding groundwater quality is crucial since it is a significant indicator of whether or not it is suitable for human use, agriculture, and/or industry. Concern over water quality has grown in recent years on a global scale. To evaluate the quality of groundwater, several investigations (Khan et al. 2020; Babiker et al. 2007) were carried out. Indeed, the main source of water supply is groundwater, which is also currently the most important natural resource for a variety of human endeavors (Prasad & Narayana, 2004). According to Morris et al. (2003), more than one-third of the world's population relies on groundwater for both direct consumption and food production. In addition, groundwater has been sought after as a source in many developing and underdeveloped countries to supply clean drinking water, particularly to rural populations (Gordana et al. 2014).

When groundwater is polluted, it is impossible to restore its quality by removing the pollutants at the source (Ramakrishnaiah et al. 2009). It is crucial that human activities on the surface do not adversely harm the priceless resource because groundwater has a significant potential to meet future water demand (Sarukkalige, 2009). Poor environmental management has a disastrous effect on the availability of clean water, cleanliness, and public health (Okoro et al. 2009). The importance of groundwater as a source of drinking water for people around the world is emphasized by Tay and Kortatsi (2008). Quality variations and subsequent contamination can unquestionably have an impact on people's health. The extent and nature of human influence, as well as geochemical, physical, and biological processes taking place underground, are the key factors influencing groundwater quality (Zaporozec, 1981). Therefore, it becomes crucial to routinely check the water's quality and devise improvements (Yisa and Jimoh, 2010).

The estimated 230 km of groundwater are used annually, with India using the most groundwater globally. In addition, 85% of the groundwater in India is used for drinking water and over 60% is used for cultivation. In many areas of the nation, groundwater levels have decreased by more than 4 m as a result (CGWB 2014). Around the planet, groundwater is currently vanishing at a pace of 800 km3 per year. Irrigated agricultural lands are

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an important factor in groundwater depletion (Burek et al. 2016, Dimple et al. 2022).

2.0 Study Area: Pench Kanhan Valley Coal Mining Area

The present study was conducted on the Chhindwara district which is located in the southern part of Madhya Pradesh state. The study was conducted on the Western Coalfield regions of the Chhindwara district which was approximately located between latitude 21˚52' N to 22˚17' N and longitude 78˚45' E to 79˚20'E. The Pench Kanhan Valley Coalfield is located 30 kilometres (19 miles) northwest of Chhindwara. While the Pench Valley has five seams in a column of 50-80 m thickness, the Kanhan Valley coal belt runs for around 25 km (16 mi). The total coal reserves (proven, indicated, and inferred) in the Pench Kanhan Coalfield are 2,411.28 million tonnes, according to the Geological Survey of India. Newton, Chikli, Borkuhi, Ramanwara, Eklahera, Bamori, North Chandameta, East Dongar Chikli, Ambara Sukri, Datla, and Shivpuri are important collieries in the Pench valley (Figure -1).

3.0 Materials and methods

The study included 11 sample sites. Ground water samples were gathered from both hand pumps and tube wells. Water samples were collected from several sampling sites throughout the pre- and post-monsoon seasons in 2022 (Table 1, Figure 1). The 13 parameters of the samples were analyzed on-site, such as pH, dissolved oxygen, and conductivity, while the remaining parameters were analyzed in the laboratory.

The samples were collected in the sterilized plastic sampling bottle by following standard procedures. After sample collection, bottles were sealed on site with proper labelling. The samples were kept cool while being transported to the laboratory of the Indira Priyadarshini College, Chhindwara, where the samples were analyzed with the standard procedures of the APHA (1986). After the analysis the results were compared with standards of the IS, BIS and WHO.

Table – 1: Showing the geographical positions of sampling locations

Station Name	Station Code	Type of Water	Latitude	Longitude
Urdhan	Site-1 (S1)	Hand Pump	22.280704	78.948102
	Site-2 (S2)	Hand Pump	22.281551	78.955840
Nehariya	Site-3 (S3)	Hand Pump	22.278661	78.964388
	Site-4 (S4)	Hand Pump	22.280520	78.977331
Zurra Mathni	Site-5 (S5)	Hand Pump	22.239437	78.932032
	Site-6 (S6)	Hand Pump	22.244252	78.943292
Vishnupuri	Site-7 (S7)	Hand Pump	22.201533	78.858497
	Site-8 (S8)	Hand Pump	22.195165	78.858158
New Sethia	Site-9 (S9)	Hand Pump	22.215822	78.843600
	Site-10 (S10)	Hand Pump	22.216018	78.844242
Mahendrapuri	Site-11 (S11)	Hand Pump	22.180273	78.77250

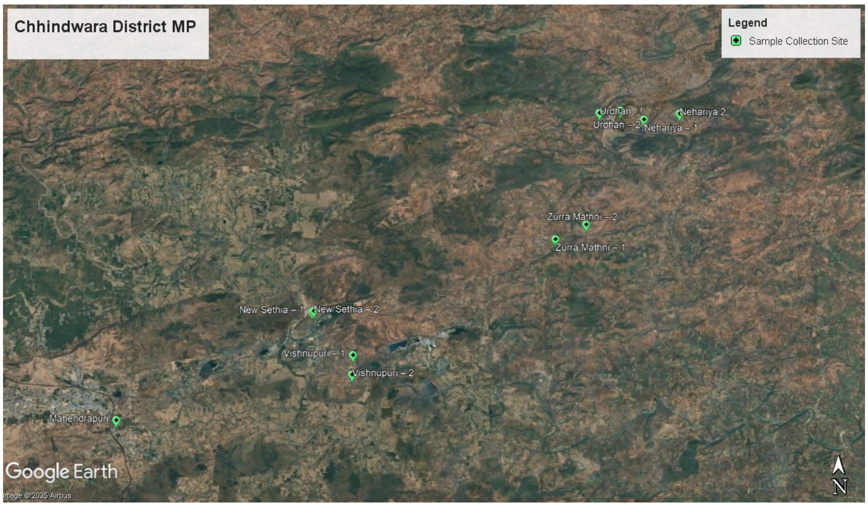

Figure – 1: Google earth map showing sample collection sites in study area

3.1 Data Analysis

The samples were collected in the sterilized plastic sampling bottle by following standard procedures. After sample collection, bottles were sealed on site with proper labelling. The samples were kept cool while being transported to the laboratory of the Indira Priyadarshini College, Chhindwara, where the samples were analysed with the standard procedures of the APHA (1986). After the analysis the results were compared with standards of the IS, BIS and WHO. Using a random sampling technique, all water samples were collected in plastic bottles (two litter). Groundwater sampling sites were chosen using Google Earth Pro software, and following the selection of these sites, site visits were undertaken to obtain consent from local residents. The Global Positioning System (GPS) was used to record the study areas locations during the sampling process.

3.2 Physico-chemical analysis

The physical examination of water samples was conducted at the sampling site utilizing portable instruments, and this analysis was then performed in the laboratory of the Indira Priyadarshini College, Chhindwara; the results were used in the final results of that study.

3.3 WHO and IS 10500:2012 Drinking Standards

The present study was carried out Pench coal mine area in Chhindwara district. All the water quality parameters compared with WHO and IS 10500:2012 standard. Water quality regulations are critical to making sure the safety of drinking water. The World Health Organization (WHO) and the Bureau of Indian Standards (10500:2012) have established recommendations for acceptable water quality. This study compares the drinking water quality parameters set by the World Health Organization and the Indian Standard 10500:2012 (Table – 2).

Table – 2: WHO and IS Standards for drinking water.

S. No.	Parameter	WHO	IS 10500:2012	
			Acceptable Limit	Permissible Limit
1	pH	7 – 8.5	6.5 – 8.5	No relaxation
2	EC	500 – 1000	–	–
3	TDS	600	500	2000
4	Total Alkalinity	200	200	600
5	Chloride	250	250	1000
6	Total Hardness	200	200	600
7	Fluoride	1.5	1.0	1.5
8	Nitrate	50	45	No relaxation
9	Sulphate	No health-based guideline value is proposed	200	400
10	Iron	0.3	0.3	No relaxation
11	Cupper	2.0	0.05	1.5
12	Nickle	0.07	0.02	No relaxation
13	Zink	No health-based guideline value is proposed	5	15

4. RESULT AND DISCUSSION

4.1 pH

The pH values are in the water are plays important role in determining the nature of water either it is acidic or alkaline. The nature of water plays important role its suitability for different uses. The values of pH were observed from 7.20 to 8.20, the higher value were observed in post-monsoon season were as the lower value were observed in the pre-monsoon season. Similar observations were represented by Narayana and Suresh (1989), Gill, et al., 1993), Mehta and Trivedi (1993), Mittal, et al., (1994). Similarly, the pH values of the samples varied between 6.30 to 7.90 at upstream, 7.42 to 8.14 near the village and 7.20 to 8.05 at downstream (Mohamad et al., 2015).

4.2 Electrical Conductivity (EC)

The values of the Electrical Conductivity in the present study various from 256.72 to 452.24 µS/cm. the higher value of the EC were observed in pre-monsoon whereas lower value in the post-monsoon. The value of the EC was directly depending on the temperature and indirectly measures the salinity of the water. A similar observation was also observed by Paliwal (1975), according to him in semi-arid and arid zones of Rajasthan groundwater available mostly at depths of 200 to 300 feet showed electrical conductivity of well-water between 5,000µmhos/cm to 6,000 µmhos/cm

4.3 Total Dissolved Solids (TDS)

The values in the present study was observed from 158 to 328 mg/l. The higher value of the TDS was found in pre-monsoon and lower in post-monsoon. The values of the TDS in the water quality shows the concentration of the solid contents present in the water samples. A high content of dissolved solids increases the density of water and influences the osmoregulation of freshwater organisms. TDS values are estimated by pursuing the empirical relationship (Kotaiah and Kumaraswamy, 1994; Ramababu and Bandyopadhyay, 1996 and Chandanakeri, 1996).

4.4 Total Alkalinity

The values of total Alkalinity were found between 172 to 303 mg/l. the higher value of Alkalinity was found in pre-monsoon and lower during the post-monsoon. Comparable observations were made by Bhatnagar, et al. (1981) in the groundwater of Ludhiana city, Punjab. Gopal and Bhargava (1982) have reported the quality of groundwater in the arid district of Rajasthan.

4.5 Chloride (Cl)

The concentration of the chloride was lies between 36 to 118 mg/l. the maximum value of the chloride was observed in pre-monsoon and lower value was in post-monsoon season. The values of the chloride were found in the acceptable limit as per standards. A similar observation has been made by Sohani, et al. (2001).

4.6 Total Hardness (TH)

The total hardness of the water samples was depending on the presence of Calcium and magnesium ion on the water samples, similar observation represented by, the level of hardness (mg/m) and with reference to the equivalents of calcium carbonate concentration has been classified as (APHA, 1995; Kotaiah and Kumar Swamy, 1994). During the study the value TH were lies between 104 to 162 mg/l the higher concentration of the TH was found in pre-monsoon season and lower during post-monsoon.

4.7 Fluoride

The fluoride content of groundwater showed higher values up to 5mg/L have been reported in parts of Bhandara, Chandrapur, and Aurangabad districts of Maharashtra (Borah et al., 2010). The amount of the fluoride in the water samples were varies between 0.04 to 1.20 mg/l. the maximum value of the fluoride was found in pre-monsoon season while lower on post-monsoon.

4.8 Nitrate

The major sources of the nitrate in the water concentration was anthropogenic disturbances. The higher level of the nitrate can cause numerous harmful diseases. During the study the concentration of the nitrate were lies between 3.80 to 13.00 mg/l. It is found that Nitrate of the groundwater (bore well water) nearby the industrial belt are within the permissible limit as per IS: 10500-2012 (Channabasava et al., 2017).

4.9 Sulphate

The concentration of the sulphate in the water samples were lies between 50 to 102 mg/l. higher value of the was recorded during the pre-monsoon season whereas lowest value was recorded during the post-monsoon season. The values of the sulphate in the mining area were depends on the sediments present on this region. A similar observation was made by Abool et al. (1986) according to them the sulphate content varies between 0.2 mg/L and 65.6 mg/L in well water of Bhopal city.

4.10 Heavy Metals

The heavy metals incudes Iron (Fe), Nickel (Ni), Cupper (Cu) and Zink (Zn). These heavy metals are seriously threaten to the human health and also to environment. During the study the values of Fe lies between 0.01 to 0.6 mg/l. Rao, et al., (1986) reported iron ranged between traces to 0.32 mg/l in the groundwater Nuzuid town in Andra Pradesh. Drinking water containing 0.3 mg/l affect the taste. Similarly, the values of cupper varied from 0.00 to 0.07 mg/l, the value of Nickle found from 0.0011 to 0.01and Golekar et al. (2013) have recorded the concentration of Nickel was above the desirable limit of 0.05 mg/l. The value of Zink lies between from 0.40 to 3.80 and a similar observation has been reported by Suresh et al. (2015) who estimated on Zink of 0.003 to 0.186 mg/l in the Gomathi river basin. The maximum value of Fe, Cu and Ni were found in the pre-monsoon season while the maximum concentration of Zn were found in the post-monsoon season and minimum value of the Fe, Cu, Ni and Zn were observed in the pre-monsoon season. Similar observation in the concentration of the heavy maters were also recorded by Yadav and Jamal (2011) in coal mining areas of the Sonbhadra district, Uttar Pradesh and Singrauli district, Madhya Pradesh.

Table – 3: Physico-Chemical Parameter of Ground water samples of Pench coal mine area during Pre-Monsoon 2022

Site → / Parameter ↓	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
pH	7.65	7.55	7.65	8.15	7.60	7.25	7.20	7.60	7.45	8.00	7.75
EC	268.66	373.13	292.54	256.72	268.66	361.19	420.90	268.66	280.60	310.45	334.33
TDS	180	250	196	172	180	242	282	180	188	208	224
T. Alk.	8	8	12	10	6	10	8	6	10	8	10
Cl	142	178	182	170	168	162	192	138	158	170	182
TH	8.4	7.8	9.0	8.8	8.8	8.2	8.0	9.2	8.8	8.4	9.0
F	1.2	1.8	1.4	1.8	2.0	1.8	1.4	1.4	2.0	2.0	1.2
NO_3	6.2	3.2	4.0	4.0	3.0	3.0	4.0	5.4	5.4	4.0	3.2
SO_4	38	58	48	40	36	42	60	68	54	60	72
Fe	10.0	12.0	10.0	8.0	6.0	10.0	12.0	8.0	8.0	6.0	10.0
Cu	84	72	80	70	64	80	76	58	74	72	70
Ni	2	0	8	2	8	6	2	0	0	8	10
Zn	112	108	112	120	114	118	112	106	104	106	106

Table – 4: Physico-Chemical Parameter of Ground water samples of Pench coal mine area during Post-Monsoon 2022

Site → / Parameter ↓	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
pH	7.85	7.85	8.10	7.95	8.20	7.75	7.90	7.65	8.20	7.80	8.05

EC	358.21	334.33	310.45	417.91	423.88	429.85	361.19	450.75	331.34	298.51	310.45
TDS	240	224	208	280	284	288	242	302	222	200	208
T. Alk.	10	10	14	12	18	12	14	12	20	16	14
Cl	170	174	180	174	158	162	182	170	164	168	162
TH	8.4	8.0	8.6	8.2	8.8	8.0	8.8	8.6	8.2	8.2	8.8
F	3.0	3.2	4.2	3.0	2.2	2.0	2.0	2.2	1.8	2.0	2.2
NO_3	7.5	8.0	10.5	7.5	5.5	5.0	5.0	5.5	4.5	5.0	5.5
SO_4	82	78	82	102	88	114	98	102	82	84	80
Fe	8.0	5.0	6.0	8.0	10.0	8.0	8.0	6.0	6.0	8.0	4.0
Cu	100	98	104	90	94	84	102	74	88	96	92
Ni	6	4	16	8	0	8	0	6	4	0	6
Zn	124	112	130	152	162	154	134	136	150	150	134

Table – 5: Summary of statistics of groundwater parameter of Pench coal mine area during 2022

Statistics → / **Parameter ↓**	**Min.**	**Max.**	**Mean**	**Median**	**S.D.**
pH	7.20	8.20	7.73	7.73	0.2607
EC	256.72	452.24	345.50	334.33	56.4508
TDS	172.00	303.00	231.48	224.00	37.8221
T. Alk.	6.00	20.00	10.97	10.00	3.0871
Cl	132.00	192.00	162.61	162.00	14.8449
TH	7.40	9.20	8.38	8.20	0.4085
F	1.20	4.20	1.93	1.80	0.6436
NO_3	3.00	10.50	5.70	5.40	1.7782
SO_4	36.00	118.00	78.67	82.00	22.8017
Fe	4.00	12.00	7.67	8.00	1.9948
Cu	58.00	104.00	80.91	80.00	11.7802
Ni	0.00	16.00	4.18	4.00	3.9801
Zn	104.00	162.00	126.00	124.00	17.1318

5. CONCLUSION

The present research evaluated the groundwater quality in the Chhindwara district's Pench–Kanhan Valley coal mining area before and after the 2022 monsoon. The physico-chemical research showed that mining operations had a discernible impact on groundwater quality, even if the majority of values are still within the WHO and IS 10500:2012 permissible limits. There were clear seasonal differences, with the pre-monsoon season showing somewhat greater quantities of EC, TDS, Alkalinity, Chloride, Hardness, Fluoride, Nitrate, Sulphate, and Heavy metals like Fe, Cu, and Ni. Reduced dilution, higher evaporation, and improved leaching of pollutants originating from mining are probably the causes of this development.

Although most water samples are safe for home use, some parameters—especially Fluoride, Iron, Nickel, and Sulphate—approached or above acceptable levels at many sites, suggesting localized contamination issues. If preventive measures are not taken, ongoing coal resource exploitation and inappropriate waste disposal could worsen groundwater degradation. In order to safeguard groundwater supplies in the mining region, the study emphasizes the necessity of consistent monitoring, better mine water management, and the implementation of sustainable practices. Groundwater may be used safely and sustainably for future generations by strengthening environmental rules, raising community awareness, and incorporating scientific data into local planning.

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