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PHYSIOCHEMICAL ANALYSIS OF GROUNDWATER OF BASTAR REGION OF CHHATTISGARH

Rajesh Kumar Sahu
Department of Chemistry, Govt. Engineering College Ambikapur, Chhattisgarh, India

Abstract

Under the NAQUIM programme, groundwater from fifteen locations in the Bastar region of Chhattisgarh was analyzed to assess its physicochemical quality. The pH values range from 6.8 to 7.1, falling within the permissible limits of both WHO and BIS (IS 10500:2012), indicating neutral to slightly acidic water suitable for drinking purposes. Electrical conductivity varies from 250 to 1182 µS/cm, reflecting low to high mineralization, with elevated values at Joba and Lanjora suggesting strong water–rock interaction and localized anthropogenic influence. Bicarbonate concentrations (98–238 mg/L) indicate carbonate and silicate weathering control on groundwater chemistry. Chloride values range from 7 to 213 mg/L and remain within WHO and IS limits (250 mg/L), although higher concentrations at Joba and Lanjora point to prolonged groundwater residence time. Sulphate (ND–42 mg/L) and fluoride (ND–0.9 mg/L) concentrations are within permissible WHO and IS limits, indicating minimal health risk. Total hardness ranges from 90 to 480 mg/L, classifying groundwater from moderately hard to very hard. Hardness values exceeding IS desirable limits at some locations reduce suitability for domestic use without treatment. Calcium and magnesium are the main contributors to hardness, with occasional increase of calcium limits. Overall, groundwater quality is mostly within WHO and IS standards, but localized high mineralization and hardness highlight the need for regular monitoring and targeted groundwater management.

Keywords: Groundwater, Analysis, Environment, Bastar.

Introduction

Bastar district is a district in the state of Chhattisgarh in Central India 19.1071° N, 81.9535° E. Jagdalpur is the district headquarters (**Figure 1**). Bastar is bounded on the northwest by Narayanpur District, on the north by Kondagaon district, on the south and southwest by Dantewada and Sukma, on the east by Nabarangpur and Koraput Districts of Odisha State as shown in (**Figure 2**). The district possesses a unique blend of tribal and Odia culture. The district has an area of 4029.98 km². Bastar District is located in Chhattishgarh in the central parts of India. Bastar District, before splitting districts, was one of the largest districts in India. The district covers an area of around 6596.90 sq km. Bastar District is located in the southern part of Chhattisgarh and lies on a plateau at an average elevation of about 2000 ft above mean sea level (*District Bastar, Government of Chhattisgarh*). The spatial distribution of major settlements, road networks, protected forest areas such as Kanger Ghati National Park, and the undulating topography of the district are clearly illustrated in (**Figure 2**), which highlights the varied terrain and elevation patterns of the Bastar plateau region. According to the Census of 2011, the population of Bastar district was 834,375, comprising 413,706 males and 420,669 females (District Bastar, Government of Chhattisgarh 2011.). The 70 percent of the total population of Bastar is tribal community, and 26.76 percent of the total tribal population of Chhattisgarh. The tribal communities of Bastar are mainly Gond, Maria, Muria, Bhadra, Halba, Dhurua community, and the large population of the tribal community of Bastar still resides in dense forests. Tribal communities of Bastar are trained for their culture, art, festivals, natural life styles. Bastar district has been divided into seven Blocks / Tehsil, Jagdalpur, Bastar, Bakavand, Lohandiguda, Tokakal, Darbha, as depicted in (**Figure 1**). Bastar district is also rich in the natural resources and simple living style of tribal community. Bastar district is full of dense forests, high hills, waterfalls, caves and wild animals. The people of Bastar district are rich in rare artwork, liberal culture and innate nature(District Bastar, Government of Chhattisgarh | Cultural Capital -Satrangi Bastar |). Bastar district is a region of significant historical and cultural importance located in the southern part of Chhattisgarh State, India. The district is rich in dense forests, high hills, waterfalls, caves, and wild animals, contributing to its scenic beauty (Yash et al., 2024).

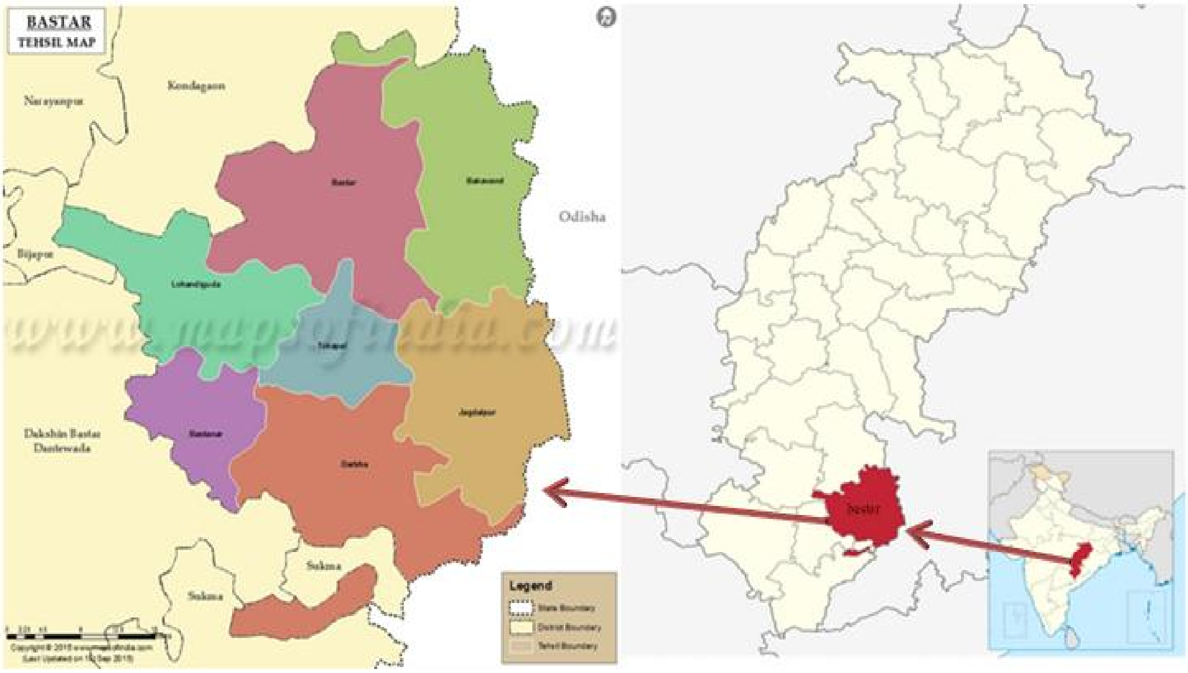
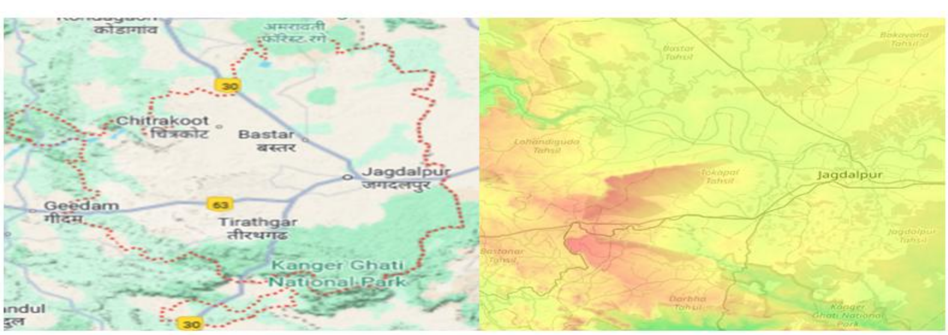


Figure 1 Tehsil-wise administrative map of Bastar district along with its location in Chhattisgarh state, Central India.

The Baster Plateau Region

It covers Bastar, Kondagaon, Narayanpur, Kanker, Bijapur, Sukma and Dantewada districts lying on the southern parts of the State. Except Indravati River plains, most of the area is covered by evergreen dense reserve forests and hilly tracts. The major landforms are high-level plateaus, structural hills and valleys and pediments and pediplains. The altitude varies from 400 to 600 m amsl. In the plains of Indravati River covering central parts, and along the Shabri River, covering southeastern parts the altitude varies from 250 to 300 m amsl. The Bastar Plateau is a significant geographical and cultural region in southern Chhattisgarh, India, forming part of the Bastar Craton with ancient Precambrian rocks such as gneisses and granitoids that reveal its long crustal history and evolution. The plateau is characterized by dense forests, rich biodiversity, and varied habitats that support a wide range of wildlife. Studies have documented a high diversity of avian species, including resident and migratory birds in the Western Bastar Plateau, revealing both ecological richness and conservation challenges due to human impacts and habitat disturbance. The spatial distribution of major settlements, road networks, protected forest areas such as Kanger Ghati National Park, and the undulating topography of the district are clearly illustrated in (Figure 2), which highlights the varied terrain and elevation patterns of the Bastar plateau region(Mitra et al., 2025) (Bharos et al., 2025).



(a) (b)

Figure 2: Location map showing major settlements and road networks (a) and elevation-based topographical relief of Bastar district, Chhattisgarh (b).

Study area

Bastar district is a district in the state of Chhattisgarh in Central India 19.1071° N, 81.9535° E. Jagdalpur is the district headquarters. The present study was conducted in the Bastar region of Chhattisgarh, India. As shown in Table 1, fifteen representative locations were selected to capture the spatial variability of the study area, namely Keshkal, Joba, Bhanpuri, Jagdalpur, Chirakot, Kumharwand, Usri Bera, Chapra Bhanpuri, Markel, Bastar, Jaipuri, Farsaguda, Lanjora, Pharasgaon, and Sonarpal. These sites are distributed between latitudes 19.07°N to 21.28°N and longitudes 80.93°E to 82.06°E. The selected locations adequately represent the diverse physiographic and soil conditions of the Bastar Plateau, providing a reliable basis for regional soil variability assessment.(*Central Ground Water Authority*).

Soil Characteristics of Bastar District, Chhattisgarh

Soil studies in Bastar district highlight considerable variability in physical, chemical, and fertility attributes. Spatial mapping using classical statistics and GIS-based ordinary kriging at four sites showed moderate variability in pH, EC, organic carbon, and heavy metals across depths and distances from highways. Morphological investigations across agro-climatic zones revealed soils ranging from shallow to deep, predominantly acidic, non-saline, and low in organic carbon, with classifications including Lithic Ustorthents, Typic Haplustepts, Typic Haplustalfs, and Typic Haplusterts. Fertility assessment in Bhatpal village indicated widespread deficiencies of nitrogen, phosphorus, sulfur, zinc, and boron, while potassium and micronutrients like iron and manganese were mostly adequate, emphasizing the need for liming and balanced nutrient management (Rao et al., 2019; Tilendri et al., 2025).

Table 1 Water Sampling Locations of Bastar District X

S. No.	Location	Latitude (N)	Longitude (E)
1	Keshkal	20.08°	81.63°
2	Joba	19.18°	81.75°
3	Bhanpuri	21.09°	80.93°
4	Jagdalpur	19.07°	82.02°
5	Chirakot	19.20°	81.72°
6	Kumharwand	19.08°	82.02°
7	Usri bera	19.16°	81.77°
8	Chapra bhanpuri	21.28°	81.67°
9	Markel	19.13°	81.98°
10	Bastar	19.07°	82.06°
11	Jaipuri	19.67°	81.67°
12	Farsaguda	19.80°	81.63°
13	Lanjora	19.72°	81.65°
14	Pharasgaon	19.86°	8163°
15	Sonarpal	19.28°	81.56°

Study Collection

To further describe the water quality in the Baster region, Water samples were also collected. Additionally, one Water sample was taken in clean, pre-rinsed polyethylene bottles from each chosen ground water location between the hours of 9:00 and 11:00. The samples set aside for the biochemistry analysis were frozen and quickly transported to the lab for processing in order to guarantee that they could retain the proper holding temperatures to prevent the sample from deteriorating. Additionally, 15 locations in Baster Town and the surrounding villages provided ground water samples. Each ground water sample was electronically sampled in a 1-L cleaned polyethylene bottle in accordance with standard operating procedures. This involved collecting the ground water sample by rinsing the bottle three times with the same ground water, then tipping the bottle and filling it to the top to avoid air contact (*Central Ground Water Authority*,).

Parameters and Analytical Methods

At the site of the testing, the parameters were joined-fin pH from a calibrated digital pH meter and electrical conductivity (EC, $\mu S \cdot cm^{-1}$) from a portable conductivity meter. Water samples collected in cleaned polyethylene bottles and kept in a cooler were analyzed for the water's chemistry. For the water chemistry analysis, the bicarbonate (HCO_3^-, mgL^{-1}) alkalinity was determined from acid titration, chlorides (Cl^-, mgL^{-1}) from argentometric titration, sulfates (SO_4^{2-}, mg•L^{-1}) and fluoride (F^-, mgL^{-1}) from standard instrumental methods, and total hardness (TH, mgL^{-1} as $CaCO_3$) from EDTA titrimetry methods. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) were titrimetrically estimated, while potassium (K^+) and sodium (Na^+) were analyzed from standard flame photometric techniques. Silica (Si) and phosphate (PO_4^{3-}) were determined from colorimetric methods. All analyses were implemented according to standard procedures for ground water quality assessment in order to safeguard analytical accuracy and reproducibility.

Result and discussion

Physico Chemical Analysis of Ground water during NAQUIM study in Baster district

From Table 2, it is evident that the Water of the study area is generally neutral in nature. The pH ranges from 6.8 to 7.1, with an average value of about 6.95, indicating neutral to slightly acidic conditions and confirming that most samples fall within acceptable limits for drinking and domestic use. Electrical conductivity (EC) varies widely from 250 to 1182 µS/cm, with a mean value of approximately 447 µS/cm, Reflecting moderate to high mineralization. Elevated EC values observed at Joba and Lanjora indicate higher dissolved ion concentrations, likely resulting from intense water–rock interaction and localized anthropogenic influences.

Bicarbonate (HCO_3^-) concentrations range between 98 and 238 mg/L, with an average of about 154.6 mg/L, suggesting that Water alkalinity is mainly controlled by carbonate and silicate weathering processes. Chloride levels are generally low to moderate across most locations (average 44.33 mg/L); however, higher concentrations at Joba and Lanjora may indicate prolonged Water residence time and localized human activities. Sulphate and fluoride concentrations remain mostly within permissible limits, with average values of 13.54 mg/L and 0.37 mg/L, respectively, indicating minimal risk from sulphate or fluoride contamination.

Total hardness (TH) values range from 90 to 480 mg/L, with an average of about 181.67 mg/L, classifying Water from moderately hard to very hard. Calcium (average 44.93 mg/L) and magnesium (average 16.65 mg/L) are the principal contributors to hardness, with higher concentrations recorded at Joba, Lanjora, and Markel. Such elevated hardness may reduce the suitability of Water for domestic use in these areas without appropriate treatment.

Sodium and potassium concentrations are generally low, averaging 17.29 mg/L and 1.41 mg/L, respectively; however, relatively higher sodium values at some sites suggest the influence of agricultural return flow, fertilizer application, and prolonged water–rock interaction. Silica concentrations show noticeable spatial variation (average 15.4 mg/L), reflecting differences in lithology and silicate mineral weathering.

Overall, Water in the study area is characterized by moderate mineralization and considerable spatial heterogeneity. Although most chemical parameters remain within acceptable limits, localized issues such as high hardness, elevated EC, and chloride enrichment degrade water quality at certain locations. These variations are primarily controlled by geological settings, hydrogeochemical processes, and localized anthropogenic activities.

Table 2 Physico-chemical characteristics of Water at different sampling locations in the Bastar region CGWB(2019-20)

S. No.	Location	pH	EC (µS/cm)	HCO_3	Cl	SO_3	F	TH	Ca	Mg	Na	K	Si
1	Keshkal	7.0	340	122.0	39.0	0.9	0.9	140	38	11.0	18.0	1.4	36.0
2	Joba	6.9	1016	226.0	142.0	42.0	0.5	345	58	48.0	57.0	1.8	23.0
3	Bhanpuri	6.9	250	98.0	14.0	10.0	0.6	90	30	3.6	13.0	0.8	24.0
4	Jagdalpur	7.0	495	195.0	28.0	ND	ND	210	48	22.0	19.0	3.6	10.0
5	Chirakot	6.9	357	171.	11.0	7.0	0.3	150	26	20.	19.	3.6	10.0

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6	Kumharwand	7.0	265	122.0	7.0	8.0	ND	100	32	4.8	10.0	0.4	6.0
7	Usri bera	7.0	301	134.0	21.0	5.0	0.2	135	40	8.4	5.4	1.0	9.0
8	Chapra bhanpuri	7.0	326	134.0	28.0	6.0	0.3	130	38	8.4	14.0	0.6	8.0
9	Markel	6.9	497	238.0	21.0	ND	0.2	230	60	19.0	11.0	0.6	5.0
10	Bastar	7.0	300	146.0	21.0	ND	0.2	140	44	7.2	7.2	0.6	4.0
11	Jaipuri	6.9	308	159.0	14.0	ND	ND	115	36	6.0	13.0	0.4	9.0
12	Farsaguda	7.0	292	110.0	28.0	ND	ND	115	36	6.0	13.0	0.4	9.0
13	Lanjora	7.1	1182	183.0	213.0	31.0	0.3	480	96	58.0	28.0	1.3	30.0
14	Pharasgaon	6.8	442	98..0	64.0	12.0	ND	180	40	19.0	28.04	3.4	32.0
15	Sonarpal	6.8	335	183.0	14.0	ND	0.2	165	52	8.4	3.7	1.2	16.0

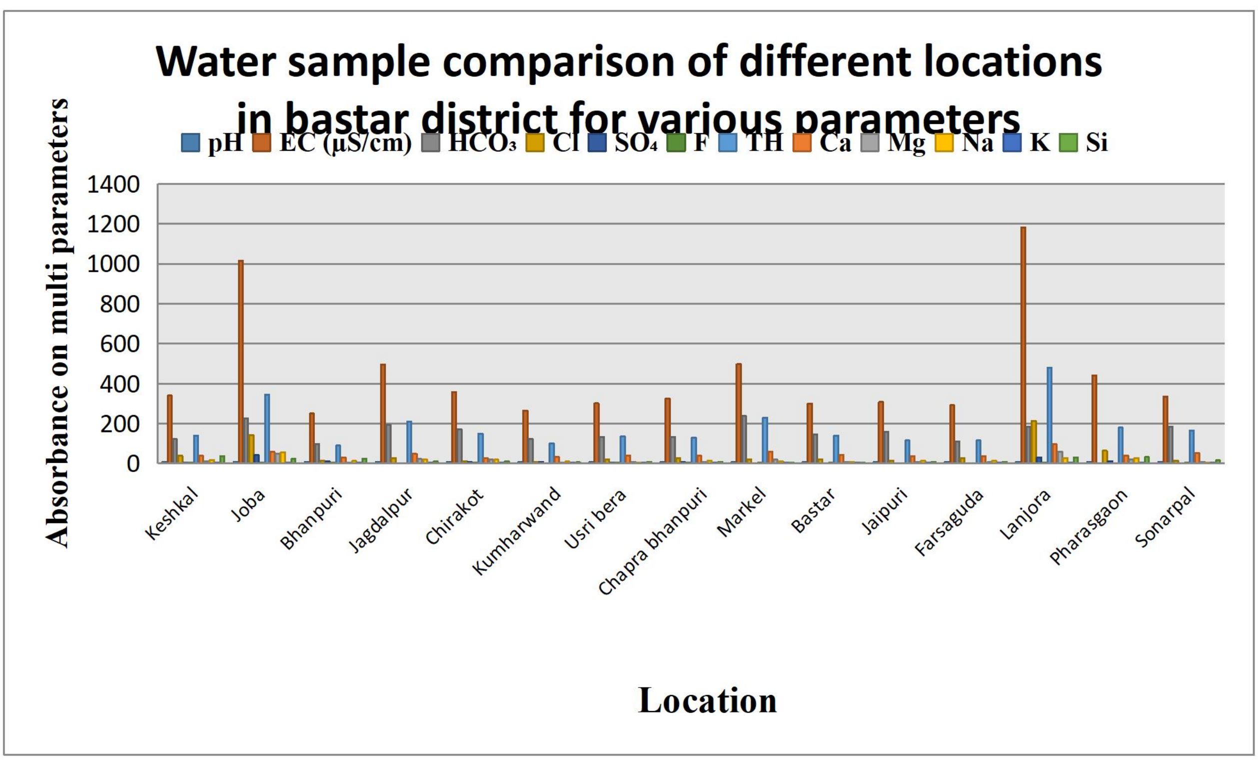

Figure 3 Comparative Analysis of Physico-Chemical Parameters of Water Samples from Different Locations in Bastar District

Conclusion

Based on the interpretation of Table 2 and the detailed analysis of the physico-chemical parameters, it can be concluded that the Water quality of the study area exhibits overall neutral to slightly acidic characteristics, with pH values ranging from 6.8 to 7.1, which fall within acceptable limits for drinking and domestic use. Electrical conductivity shows wide spatial variation (250–1182 µS/cm), indicating moderate to high mineralization, with notably higher values at Joba and Lanjora reflecting elevated dissolved ion content due to intense water–rock interaction and possible localized anthropogenic inputs. Bicarbonate concentrations (98–238 mg/L) suggest that alkalinity is largely controlled by carbonate and silicate weathering processes. Chloride levels are generally low to moderate, though higher concentrations at Joba and Lanjora point toward longer residence time and human influence. Sulphate and fluoride remain within permissible limits across most locations, indicating minimal contamination risk. Total hardness varies from moderately hard to very hard, primarily due to calcium and magnesium enrichment, which may reduce suitability for domestic use at certain sites without treatment. Overall, the Water quality shows considerable spatial heterogeneity, with most parameters within acceptable limits but localized deterioration at specific locations, emphasizing the need for regular monitoring and site-specific water management strategies.

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