Ground Water Chemical Quality Bulletin for the pre-monsoon season (2024-25)

CHHATTISGARH.

Abstract

Periodic ground water quality assessment (2019-2024) highlighting the findings, trends of important parameters and ground water contamination status.

December 2024

Central Ground Water Board
North Central Chhattisgarh Region
Raipur (Chhattisgarh)

Introduction

Ground water is one of the most essential and valuable natural resource, which not only supports the life on the earth but governs the agricultural, industrial, economic and social growth of the human beings. Chhattisgarh, the newly created developing state, has plenty of ground water resources. The wide variety and complexity in nature and composition of geological formations, geological structures and variety in geomorphological features and hydrogeological conditions have given rise to the widely varying occurrence of ground water in different parts of the state.

According to UNESCO more than 80% of health issues are caused due to consumption of poor-quality water. Inorganic contaminants including Salinity, Fluoride, Nitrate, Arsenic, Iron and Uranium are important in determining the suitability of ground water for drinking purposes.

Therefore, periodic ground water quality assessment is important to alert people who utilize it for domestic and irrigation purpose.

Numerous studies have been carried out on the poor quality of groundwater. However, an extensive temporal and spatial study of Chhattisgarh will provide a better picture of the ground water quality of the state. Our efforts in the present study are to fulfill the following objectives:

i. **To present current GW quality scenario, parameter wise for each district of the Chhattisgarh State.**

ii. **To identify present day hot spots of poor-quality ground water through spatial variation analysis of latest 2024 quality data.**

iii. **To assess temporal variation of ground water quality showing improvement / deterioration during the period from 2019 to 2024, providing insights for effective water quality management measures.**

Study Area

Chhattisgarh state extends from 80° 15‟ to 84° 24‟ longitudes and from 17° 47‟ to 24° 6‟ latitudes in the central part of India. It has an area of about 135097.23 Sq. Km thus forming the 10th largest state of India with 4.12% of the country's area. Chhattisgarh is bounded by the states of Odisha in the east, Uttar Pradesh in the north; Jharkhand in the north east, Andhra Pradesh in the south, Maharashtra in the south west and Madhya Pradesh in the north western part. The state is well connected by air, railway and road network to all metros in the country. As per the administrative set up as on March 2023, there are three revenue divisions in the state. There are 28 districts comprising 178 Tehsils and 146 development blocks. Total number of villages in Chhattisgarh is 20,126 out of which 19,567 villages are inhabited. There are 14 Municipal corporations, 43 Municipalities, 112 Nagar Panchayat in the state.

Population of Chhattisgarh is 2,55,40,196 (Census, 2011). The male and female population is 1,28,27,915 and 1,27,12,281 respectively. The rural population constitutes 79.9% of the total population and 20.1% reside in urban areas. The density of population is 189 persons per sq. km. The weaker sections constitute about 43.4% of the total population out of which 31.76% are Scheduled Tribes (ST) and 11.6% are Scheduled Castes (SC). The decadal growth rate of population for the state has increase to 22.59 % (2001-2011) from the previous decade rate of 18.27%. The sex ratio for Chhattisgarh has improved to 991 from the previous decade ratio of 989. The literacy rate stands at 82.14 % for males and 65.46 % for the female population whereas the state average is 74.04%. Major aquifers and geomorphic divisions of the state is presented in **Figure-1**.

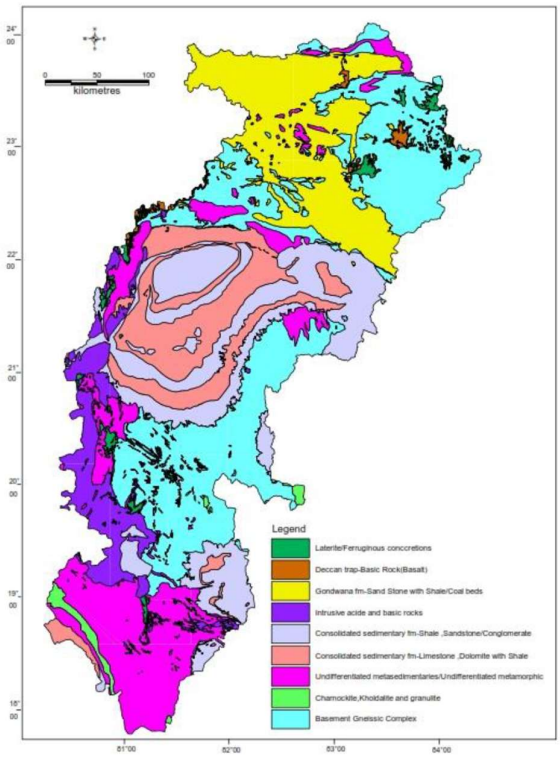

Figure 1- Map showing the major aquifers and geomorphic divisions of Chhattisgarh State.

Ground Water Quality Monitoring

Monitoring of ground water quality is an effort to obtain information on chemical quality through representative sampling in different hydrogeological units. Ground Water is commonly tapped from phreatic aquifers. The main objective of ground water quality monitoring programme is to get information on the distribution of water quality on a regional scale as well as create a background data bank of different chemical constituents in ground water. The probable causes of deterioration in ground water quality ae depicted in **Figure 2**.

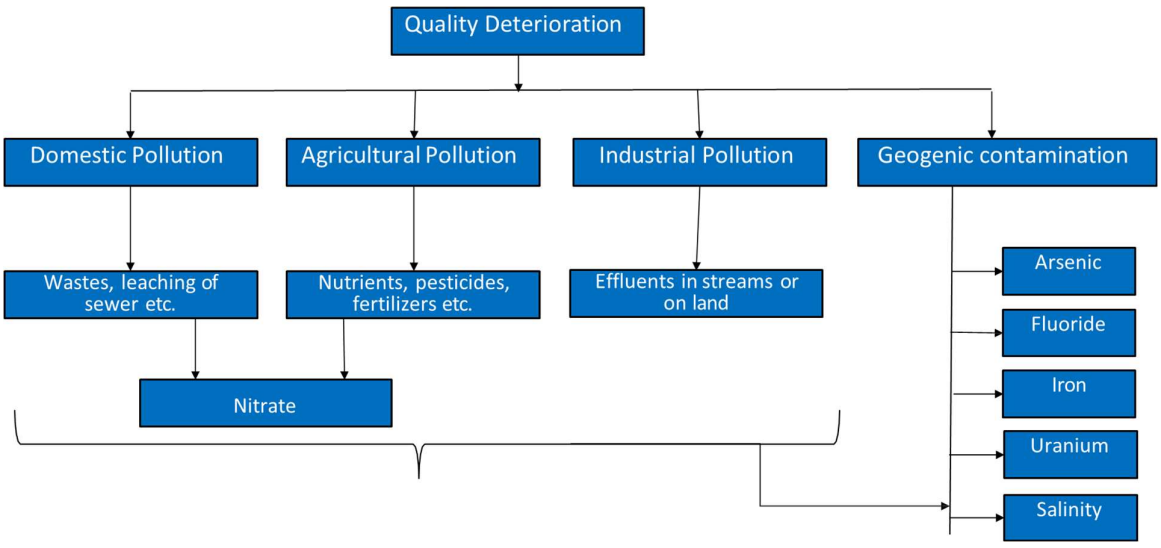

Figure 2- Schematic diagram illustrating the potential factors contributing to the degradation of ground water quality.

The chemical quality of shallow ground water is being monitored by Central Ground Water Board, Raipur twice in a year (Pre-monsoon and post-monsoon) since 2023 through 970 locations located all over the state (Figure 4). As per the Standard Operating Procedure on Ground Water Quality Monitoring issued by Central Head Quarter, Faridabad, the year 2023 was treated as Background Monitoring Year (970 water samples collected) and later the year 2024 was treated as Trend Water Quality Monitoring Year. Accordingly, during pre-monsoon period of the year 2024, total 25% of the background monitoring well were chosen for collection of ground water samples (collected 257 water samples) for the chemical quality monitoring. These water quality monitoring stations are presented here in the Figure-4.

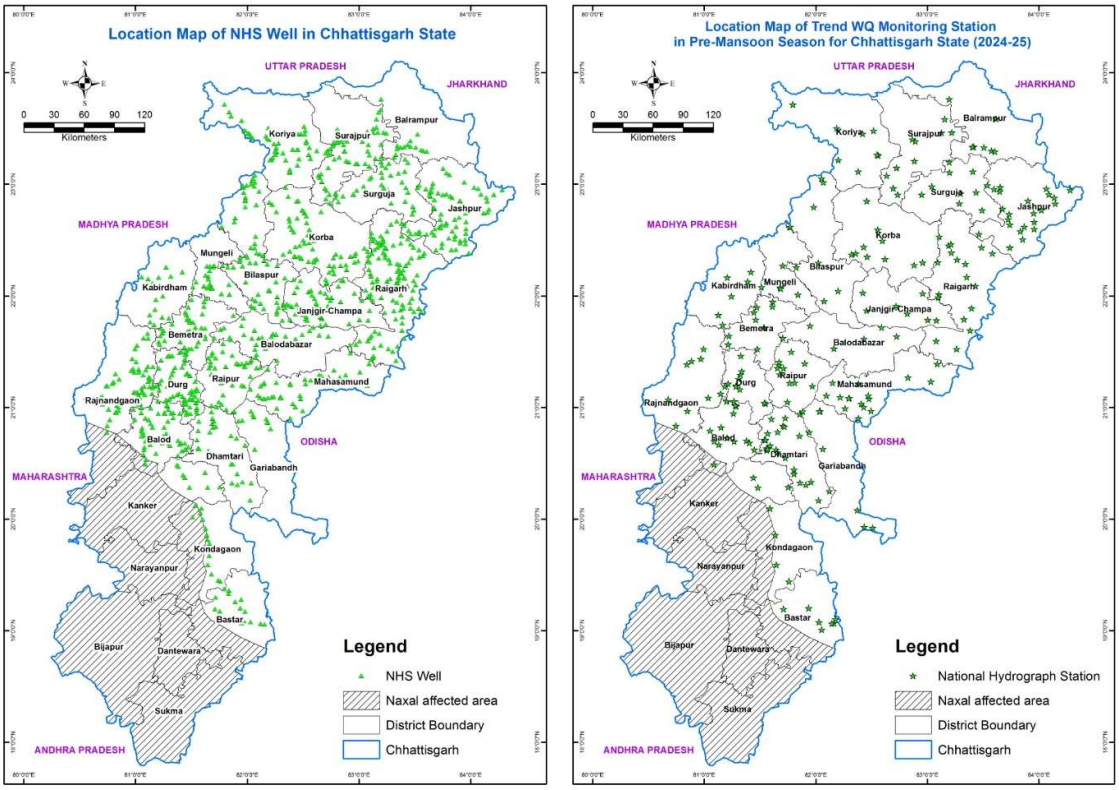

Figure 3- Map showing spatial distribution of 970 GW Quality Monitoring Stations (Baseline Stations) and Trend WQ monitoring Station (257) in Chhattisgarh State.

The district-wise number of Ground Water Quality Monitoring Stations of the Central Ground Water Board, distributed across the state of Chhattisgarh is presented in Table 1.

The present water quality bulletin is based on the changing scenario in ground water quality in network observation wells of CGWB during the pre-monsoon period of years 2024-25. As per the Standard Operating Procedure all the 15 basic parameters were alanysed along with five heavy metals viz. Iron, Arsenic, Coper, Zinc and Uranium. The findings of the analytical results are discussed in this report.

Table 1 - District wise distribution of Ground Water Quality Monitoring Stations in Chhattisgarh.

Sr.	Districts	Number of Ground Water Quality Monitoring Stations					
		2020-21	2021-22	2022-23	2023-24	2024-25 (Pre-Monsoon)	2024-25 (Post-Monsoon)
1	Balod	5	9	15	21	4	
2	Balodabazar	22	25	25	31	5	
3	Balrampur		14	14	17	8	
4	Bastar	22	22	23	27	10	

Sr.	Districts	Number of Ground Water Quality Monitoring Stations					
		2020-21	2021-22	2022-23	2023-24	2024-25 (Pre-Monsoon)	2024-25 (Post-Monsoon)
5	Bemetara	7	22	25	31	5	
6	Bilaspur	55	80	68	63	10	
7	Dhamtari	14	35	35	28	24	
8	Durg	53	63	90	94	26	
9	Gariyabandh	15	20	20	14	8	
10	Jagdalpur					4	
11	Janjgir-Champa	44	50	45	49	8	
12	Jashpur	71	69	67	79	28	
13	Kanker	11	10	10	8	4	
14	Kawardha		12	22	18	5	
15	Kondagaon	4	4	4	3	1	
16	Korba	54	68	15	65	12	
17	Koriya		46	46	49	8	
18	Mahasamund	21	32	32	39	15	
19	Mungeli	22			22	4	
20	Raigarh	125	124	126	115	24	
21	Raipur	38	26	26	40	14	
22	Rajnandgaon	7	43	67	69	10	
23	Sarangarh Bilaigarh					1	
24	Surajpur		48	48	53	11	
25	Surguja		34	34	34	8	
	Grand Total	**590**	**856**	**857**	**970**	**257**	

Ground Water Quality Scenario

Among the other significant objectives of ground water quality monitoring, assessment of suitability for drinking, irrigation and industrial use are key objectives of the board. Drinking water is a powerful environmental determinant of the health of any community. Bureau of Indian Standards (BIS) vide its document IS: 10500:2012, Edition 3.2 (2012-15) has recommended the quality standards for drinking water. The ground water samples collected from phreatic aquifers are analysed for all the major inorganic parameters. Based on the results, it is found that ground water of the Chhattisgarh State is mostly of calcium bicarbonate (Ca-HCO3) type when the total salinity of water is below 500 mg/l (corresponding to electrical conductance of 750 µs/cm at 25°C). They are of mixed cations and mixed anions type when the electrical conductance is between 750 and 3000 µs/cm and waters with electrical conductance above 3000 µs/cm are of sodium chloride (Na-Cl) type. However, other types of water are also found among these general classifications, which may be due to the local variations in hydro-chemical environments due to anthropogenic activities. Nevertheless, occurrence of higher concentrations of some chemical constituents such as EC, Fluoride, Nitrate, Iron, Arsenic and Uranium and the changes in water quality, have been observed in few parts of the state.

Quality Assessment of Ground Water in Unconfined Aquifers

Unconfined aquifers are extensively tapped for water supply and irrigation across the state therefore; its quality is of paramount importance. The chemical parameters like TDS, Fluoride, Nitrate, Iron, Arsenic and Uranium etc are main constituents defining the quality of ground water in unconfined aquifers.

Therefore, presence of these constituents and the changes in chemical quality of the collected water samples during NHS monitoring periods from the year 2019 to 2024 are discussed below.

- **Electrical Conductivity (> 3000 µS/cm)**
- **Fluoride (>1.5 mg/l)**
- **Nitrate (>45 mg/l)**
- **Iron (>1.0 mg/l)**
- **Arsenic (>0.01 mg/l)**
- **Uranium (>0.03 mg/l)**
- **Zinc (>5.0 mg/l)**
- **Copper (>0.05 mg/l)**

The Electrical Conductivity

Electrical conductivity or Total dissolved solids or Salinity is the dissolved salt content in a water body. Different substances dissolved in water gives it different taste and odor. Electrical conductivity represents total number of cations and anions present in groundwater, indicating ionic mobility of different ions, total dissolved solids and saline nature of water.

In general water having EC < 1500 µS/cm, is considered as fresh water, EC 1500 –15000µS/cm, is considered as brackish water & >15000 µS/cm is considered as saline water. Salinity always exists in ground water but in variable amounts. It is mostly influenced by aquifer material, solubility of minerals, duration of contact and factors such as the permeability of soil, drainage facilities, quantity of rainfall and above all, the climate of the area. BIS has recommended a drinking water standard for total dissolved solids a limit of 500 mg/I corresponding to EC of about 3000 µS/cm at 25°C) that can be extended to a TDS of 2000 mg/I (corresponding to EC of about 3000 µS/cm at 25°C) in case of no alternate source. Water having TDS more than 2000 mg/litre are not suitable for drinking purposes.

Present Day Scenario in Chhattisgarh w r t Electrical Conductivity

Distribution of Electrical Conductivity (EC)

The EC value of the ground waters in the State varies from 50 µS/cm in Surajpur district to 4,280 µS/cm at 25°C in Janjgir-Champa. Grouping water samples based on EC values, it is found that > 67% samples have EC less than 750 µS/cm, 32% samples have EC between 750 and 3000 µS/cm and only 0.39% of the samples have EC above 3000 µS/cm. The map showing aerial distribution of EC (Figure 4) with intervals corresponding to limits as above indicates that the ground water the entire state is within the BIS limits for EC except only at one location in the state.

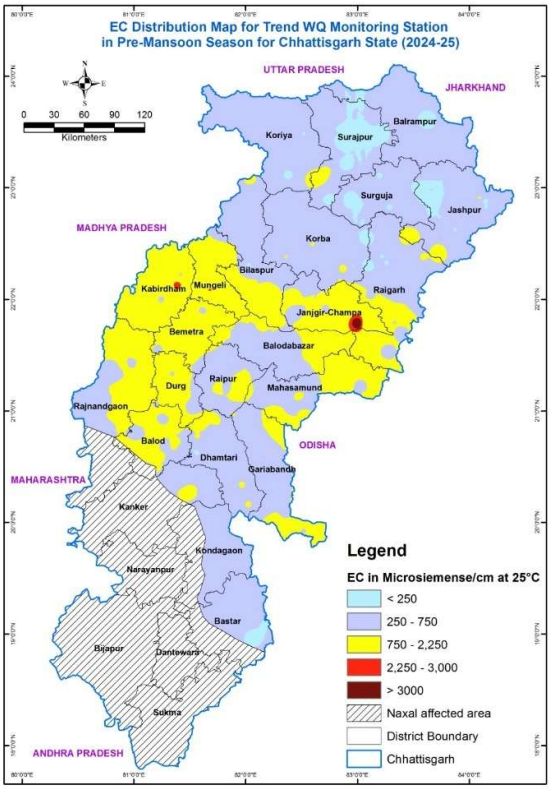

Figure 4 - Map showing the distribution of Electrical Conductivity in Chhattisgarh State based upon 2023 NHS data.

The Table 2 given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean EC values based on pre-monsoon NHS 2024 data.

Table 2- District wise range and distribution of EC in GW of Chhattisgarh (EC in µS/cm) in the year.

Sr.	District	Samples	Min	Max	Mean	< 750	750-3000	>3000
						(Percentage of Samples)		
1	Balod	4	465	1918	989	50	50	0
2	Balodabazar	5	603	1236	881	40	60	0
3	Balrampur	8	121	711	389	100	0	0
4	Bastar	10	268	773	484	90	10	0
5	Bemetara	5	680	1896	1084	20	80	0
6	Bilaspur	10	203	2163	861	40	60	0
7	Dhamtari	24	126	1440	511	79	21	0
8	Durg	26	365	2050	864	46	54	0
9	Gariyabandh	8	355	2280	757	75	25	0
10	Jagdalpur	4	65	248	197	100	0	0
11	Janjgir Champa	8	667	4280	1258	25	63	13
12	Jashpur	28	84	2160	471	82	18	0
13	Kanker	4	267	1251	688	75	25	0
14	Kawardha	5	655	1567	1048	40	60	0
15	Kondagaon	1	586	586	586	100	0	0
16	Korba	12	145	875	459	75	25	0
17	Koriya	8	96	678	355	100	0	0

Sr.	District	Samples	Min	Max	Mean	< 750	750-3000	>3000
						(Percentage of Samples)		
18	Mahasamund	15	214	2160	723	67	33	0
19	Mungeli	4	761	2563	1679	0	100	0
20	Raigarh	24	83	1896	589	75	25	0
21	Raipur	14	489	1456	745	64	36	0
22	Rajnandgaon	10	485	2670	971	40	60	0
23	Sarangarh Bilaigarh	1	393	393	393	100	0	0
24	Surajpur	11	50	1499	459	73	27	0
25	Surguja	8	125	423	317	100	0	0

Temporal Variation of EC in Ground Water During the Period From 2020- 2023

Table – 3 presents the number of locations reported EC more than 3000 µS/cm during the years 2020, 2021, 2022, 2023 and 2024. It is observed that no locations had EC more than 3000 µS/cm upto 2022, later 1-2 locations were reported EC more than 3000 µS/cm. the districts are also not same in both the two years 2023 and 2024, so it can be stated that no trend is also observed.

Table 3- Comparative change in number of locations having EC >3000 µS/cm in different districts of State.

Sr.	District	2020	2021	2022	2023	2024
1	Balod	-	-	-	-	-
2	Balodabazar	-	-	-	-	-
3	Balrampur	-	-	-	-	-
4	Bastar	-	-	-	-	-
5	Bemetara	-	-	-	1	-
6	Bilaspur	-	-	-	-	-
7	Dhamtari	-	-	-	-	-
8	Durg	-	-	-	-	-
9	Gariyabandh	-	-	-	-	-
10	Jagdalpur	-	-	-	-	-
11	Janjgir Champa	-	-	-	-	1
12	Jashpur	-	-	-	-	-
13	Kanker	-	-	-	-	-
14	Kawardha	-	-	-	-	-
15	Kondagaon	-	-	-	-	-
16	Korba	-	-	-	-	-
17	Koriya	-	-	-	-	-
18	Mahasamund	-	-	-	-	-
19	Manendragarh	-	-	-	-	-
20	Mungeli	-	-	-	**1**	-
21	Raigarh	-	-	-	-	-
22	Raipur	-	-	-	-	-
23	Rajnandgaon	-	-	-	-	-
24	Surajpur	-	-	-	-	-
25	Surguja	-	-	-	-	-

Table-4 presents the classification of percentage of samples into three different categories viz. EC below 750 µS/cm, between 750 and 3000 µS/cm and more than 3000 µS/cm.

Table 4- Periodic variation in suitability classes of ground water – Salinity as Electrical Conductivity in the State.

Parameter	Class	Percentage of Samples					Periodic Variation (2020-2024)
		2020 (N=590)	2021 (N=856)	2022 (N=857)	2023 (N=970)	2024 (N=257)	
Salinity as EC	< 750 µS/cm	73.56	75.82	80.16	69.69	67.34	
	750-3000 µS/cm	26.44	24.18	19.84	30.10	32.29	
	> 3000 µS/cm	-	-	-	0.21	0.39	

Trend of occurrence of Electrical Conductance in the ground water of Chhattisgarh State during the period from 2019 to 2024 is presented in figure-5.

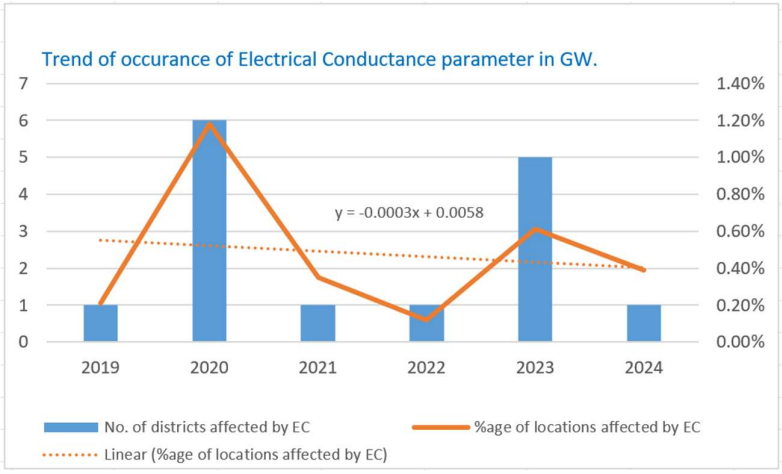

Figure 5 - Trend of occurrence of Electrical Conductance during 2019-2024.

Nitrate

Naturally occurring nitrate forms when nitrogen and oxygen combine in soil, primarily sourced from atmospheric nitrogen. Groundwater nitrate mainly comes from chemical fertilizers, animal manure leaching, and sewage discharge. Identifying natural vs. man- made sources is challenging. Chemical and microbiological processes like nitrification and denitrification also affect groundwater nitrate levels.

As per the BIS standard for drinking water the maximum desirable limit of nitrate concentration in groundwater is 45 mg/l. Though nitrate is considered relatively non-toxic, a high nitrate concentration in drinking water is an environmental health concern arising from increased risks of methaemoglobonaemia particularly to infants. Adults can tolerate little higher concentration.

Present Day Scenario in Chhattisgarh wrt to Nitrate (NO_3)

Distribution of Nitrate (NO3)

The probable sources of nitrate contamination of ground water are through excessive application of fertilizers, bacterial nitrification of organic nitrogen, and seepage from animal and human wastes and atmospheric inputs. In the State, nitrate in ground water samples varies from 0.01 to 61.1 mg/L with an

average of 17.75 mg/l NO3. BIS permits a maximum concentration of 45 mg/L nitrate in drinking water. Considering this limit, it is found that 87% of the samples, spread over the entire State, have nitrate below 45 and only 13% have more than 45 mg/L. Spatial distribution of nitrate (Figure 6) indicates a considerable area of central part of state have nitrate concentration exceeding 45 mg/L. distribution map of NO3 parameter in each district of Chhattisgarh State is presented in Figure-6.

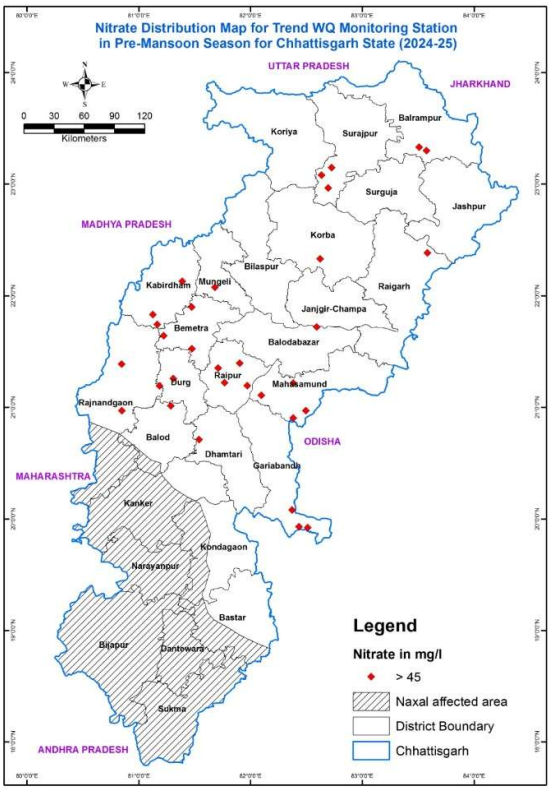

Figure 6- Map showing the distribution of Nitrate in Chhattisgarh State based upon 2023 NHS data.

The Table 5 given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean Nitrate values based on pre-monsoon NHS 2024 Data. All the results are expressed in mg/l for Nitrate.

Table 5-District wise range and distribution of Nitrate (mg/l) in the ground water of Chhattisgarh.

Sr.	District	Samples	Min	Max	Mean	< 45	> 45
						(% of Samples)	
1	Balod	4	4.56	61.03	29	75	25
2	Balodabazar	5	4.1	44.3	25	100	0
3	Balrampur	8	1.64	48.65	21	75	25
4	Bastar	10	0.02	35.67	13	100	0
5	Bemetara	5	3.64	48.96	26	60	40
6	Bilaspur	10	1.02	35.6	14	100	0
7	Dhamtari	24	0.01	45.42	10	96	4
8	Durg	26	0.31	47.23	17	92	8
9	Gariyabandh	8	0.01	48.54	31	63	38
10	Jagdalpur	4	0.17	8.31	5	100	0
11	Janjgir Champa	8	3.05	45.61	20	88	13
12	Jashpur	28	0.03	29.95	11	100	0

Sr.	District	Samples	Min	Max	Mean	< 45	> 45
						(% of Samples)	
13	Kanker	4	6.3	35.61	24	100	0
14	Kawardha	5	7.51	54.33	31	60	40
15	Kondagaon	1	1.46	1.46	1	100	0
16	Korba	12	0.07	46.9	19	92	8
17	Koriya	8	0.16	26.7	10	100	0
18	Mahasamund	15	0.34	58.39	25	73	27
19	Mungeli	4	5.61	45.19	35	75	25
20	Raigarh	24	0.11	52.5	10	96	4
21	Raipur	14	0.18	56.12	24	71	29
22	Rajnandgaon	10	3.53	50.55	24	60	40
23	Sarangarh Bilaigarh	1	45.41	45.41	45	0	100
24	Surajpur	11	0.42	58.45	21	82	18
25	Surguja	8	0.6	36.33	19	100	0

Temporal Variation of NO_3 In Ground Water During the Period From 2020 to 2023

The comparative numbers of locations having Nitrate contamination more than 45 mg/l in the ground water samples during the years from 2020 to 2024 are presented in Table-6.

Table 6- Comparative changes in number of locations having NO3 > 45 mg/l.

Sr.	District	2020	2021	2022	2023	2024
1	Balod	2	1	2	3	**1**
2	Balodabazar	5	2	2	4	**0**
3	Balrampur		3	3	0	**2**
4	Bastar			2	0	**0**
5	Bemetara	4	5	1	6	**2**
6	Bilaspur	14	11	6	5	**0**
7	Dhamtari	4	1	1	2	**1**
8	Durg	18	**15**	19	21	**2**
9	Gariyabandh	5	5	5	3	**3**
10	Jagdalpur					**0**
11	Janjgir-Champa	7	7	2	3	**1**
12	Jashpur	9	1	14	10	**0**
13	Kanker		1			**0**
14	Kawardha		2	2	2	**2**
15	Kondagaon				0	**0**
16	Korba	13	5		3	**1**
17	Koriya		6	6	2	**0**
18	Mahasamund	6	3	3	6	**4**
19	Mungeli	7			3	**1**
20	Raigarh	15	37	14	8	**1**
21	Raipur	16	15	15	6	**4**
22	Rajnandgaon	3	15	17	14	**4**
23	Sarangarh Bilaigarh					**1**

Sr.	District	2020	2021	2022	2023	2024
24	Surajpur		2	2	6	**2**
25	Surguja		4	4	4	**0**
	Total	**128**	**141**	**120**	**111**	**32**

It has been observed (Table 6) that total number of locations in various Districts having high Nitrate (> 45 mg/l) content in ground water has decreased from 128 in year 2020 to 111 in the year 2023, although no significant trend is established. For the trend water location the number of samples are reduced from around 1000 to 257 resulting in the decrease in number of locations affected by Nitrate contamination. Periodic variation in the suitability class of Nitrate parameter from the year 2020 to 2024 are presented in Table-7.

Table 7-Periodic variation in suitability classes of ground water – Nitrate as NO_3 in Chhattisgarh State.

Parameters	Class	Percentage of Samples					Periodic Variation (2020-2024)
		2020 (N=590)	2021 (N=856)	2022 (N=857)	2023 (N=970)	2024 (N=257)	
Nitrate as NO3	< 45 mg/l	78.31	83.53	86	88.56	87.55	
	> 45 mg/l	21.69	16.47	14	11.44	12.45	

Trend in the Nitrate contamination is presented in Figure – 7 covering the data from the year 2019 to 2024.

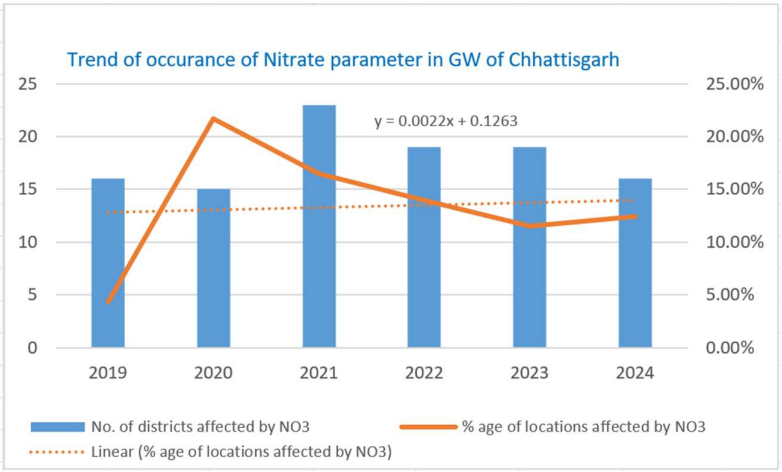

Figure 7 - Trend of Nitrate contamination in GW of Chhattisgarh during 2019-2024.

Fluoride

Fluorine does not occur in the elemental state in nature because of its high reactivity. It exists in the form of fluorides in a number of minerals of which Fluorspar, Cryolite, Fluorite & Fluorapatite are the most common.

Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. Most of the fluorides are sparingly soluble and are present in groundwater in small amount. The type of rocks, climatic conditions, nature of hydro geological strata and time of contact between rock and the circulating groundwater affect the occurrence of fluoride in natural water.

BIS has recommended a desirable limit of 1.0 mg/l of fluoride concentration in drinking water and maximum permissible limit of 1.5 mg/l in case no alternative source of drinking water is available. It is well known that small amount of fluoride (upto 1.0 mg/l) have proven to be beneficial in reducing tooth decay. However, high concentrations (>1.5 mg/l) have resulted in staining of tooth enamel while at still higher levels of fluoride (> 5.0 mg/l) further critical problems such as stiffness of bones occur. Water having fluoride concentration more than 1.5 mg/l is not suitable for drinking purposes. High Fluoride >1.5 mg/l is mainly attributed due to geogenic conditions.

Present Day Scenario in Chhattisgarh wrt Fluoride (F)

Distribution of Fluoride (F)

Fluoride in small amounts in drinking water is beneficial for the dental health while in large amounts it is injurious. During the present NHNS monitoring the minimum fluoride concentration so found was 0.02 mg/l and the maximum concentration was reported to be 3.56 mg/l with an average concentration of 0.66 mg/l. More than 83% samples found the Fluoride concentration below the BIS prescribed limit making it suitable for drinking. The distribution map showing spatial distribution (Figure-8) of fluoride contents in ground water indicates that ground waters with fluoride above 1.50 mg/L are found mainly in Mahasamund, Korba and Rajnandgaon districts of the State. It is worth mentioning that high fluoride waters are encountered in areas where high salinity is encountered.

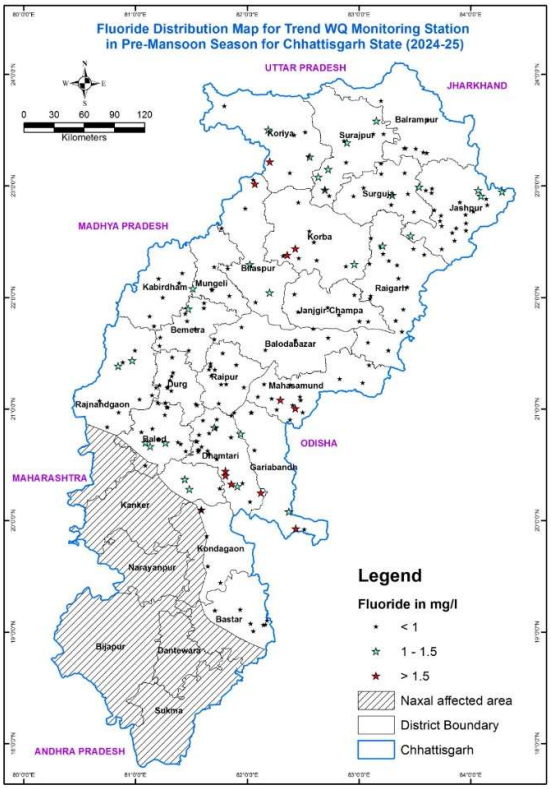

Figure 8- Map showing the distribution of Fluoride in Chhattisgarh State based upon 2024 NHS data.

The Table 8 given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean Fluoride values based on pre-monsoon NHS 2024 Data.

Table 8-District wise range and distribution of fluoride in shallow GW water of Chhattisgarh State.

Sr.	District	Samples	Min	Max	Mean	< 1.5	> 1.5
						(% of samples)	
1	Balod	4	0.06	1.01	0	100	0
2	Balodabazar	5	0.2	0.6	0	100	0
3	Balrampur	8	0.32	0.99	1	100	0
4	Bastar	10	0.05	1.9	1	90	10
5	Bemetara	5	0.02	1.2	0	100	0
6	Bilaspur	10	0.16	3.21	1	90	10
7	Dhamtari	24	0.34	2.32	1	83	17
8	Durg	26	0.06	1.43	1	100	0
9	Gariyabandh	8	0.1	1.79	1	87	13
10	Jagdalpur	4	0.31	0.38	0	100	0
11	Janjgir Champa	8	0.07	0.97	1	100	0
12	Jashpur	28	0.16	1.42	1	100	0
13	Kanker	4	0.31	1.45	1	100	0
14	Kawardha	5	0.34	0.67	1	100	0
15	Kondagaon	1	0.12	0.12	0	100	0
16	Korba	12	0.23	1.82	1	83	17
17	Koriya	8	0.45	3.5	1	87	13
18	Mahasamund	15	0.2	2.4	1	87	13
19	Mungeli	4	0.29	0.35	0	100	0
20	Raigarh	24	0.19	1.45	1	100	0
21	Raipur	14	0.22	0.96	0	100	0
22	Rajnandgaon	10	0.32	1.48	1	100	0
23	Sarangarh Bilaigarh	1	1.17	1.17	1	100	0
24	Surajpur	11	0.34	1.34	1	100	0
25	Surguja	8	0.09	1.03	0	100	0

Temporal Variation of Fluoride in Ground Water During the Period From 2020 to 2023

The comparative changes in number of locations where Fluoride concentration was found above 1.5 mg/l during the period from 2020 to 2024 are presented below in Table-9.

Table 9-Comparative changes in number of locations with Fluoride >1.5 mg/l.

Sr.	Districts	2020	2021	2022	2023	2024
1	Balod	0	0	0	0	0
2	Balodabazar	0	1	0	1	0
3	Balrampur	0	1	1	2	0
4	Bastar	0	1	0	0	1
5	Bemetara	0	0	0	0	0
6	Bilaspur	0	0	0	0	1
7	Dhamtari	0	0	0	0	4
8	Durg	0	0	0	0	0
9	Gariyabandh	4	0	0	0	1
10	Jangir-champa	0	0	0	1	0
11	Jashpur	0	3	5	0	0

Sr.	Districts	2020	2021	2022	2023	2024
12	Kanker	2	1	0	1	0
13	Kawardha	0	0	0	0	0
14	Kondagaon	0	0	0	0	0
15	Korba	1	0	0	2	2
16	Koriya	0	3	3	7	1
17	Mahasamund	0	0	0	3	2
18	Mungeli	0	0	0	0	0
19	Raigarh	5	0	2	0	0
20	Raipur	0	0	0	0	0
21	Rajnandgaon	0	0	0	4	0
22	Surajpur	0	2	2	1	0
23	Surguja	0	0	0	1	0
	Total	**12**	**12**	**13**	**23**	**12**

It has been observed (Table 9) that total number of districts affected by high fluoride has decreased as compared to the year 2023, but more or less it can be stated that number of locations with higher fluoride concentrations is almost stable. Periodic variation in suitability classes of Fluoride in Ground Water of Chhattisgarh State during 2020 to 2024 is presented in Table-10.

Table 10-Periodic variation in suitability classes of Fluoride in Ground Water of Chhattisgarh State.

Parameter	Class	Percentage of Samples					Periodic Variation (2020-2024)
		2020 (N=590)	**2021** (N=856)	**2022** (N=857)	**2023** (N=970)	**2024** (N=257)	
Fluoride as F	< 1.0 mg/l	94.41	94.97	92.93	90.52	83.27	
	1-1.5 mg/l	3.56	3.74	5.48	7.11	12.06	
	> 1.5 mg/l	2.03	1.28	1.52	2.37	4.67	

Trend for the Fluoride concentration in the ground water of the study area is presented in the figure-9 for the period from 2019 to 2024.

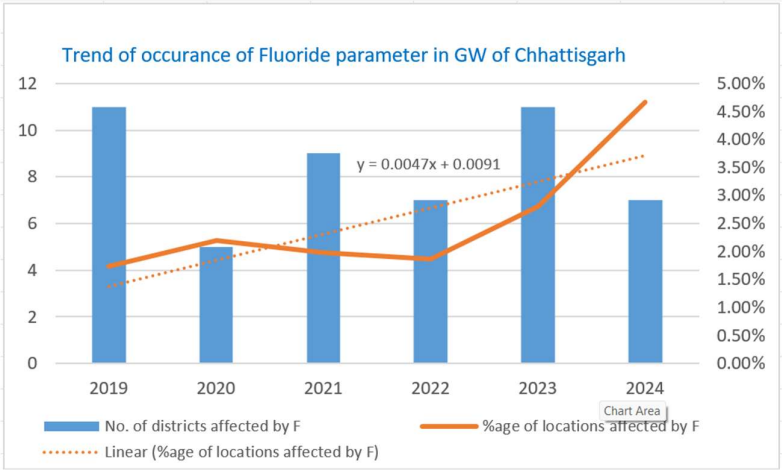

Figure 9 - Trend of Fluoride contamination in GW of Chhattisgarh during 2019-2023.

Heavy Metals

Arsenic

Arsenic, a naturally occurring element, is widely distributed throughout the Earth's crust and can be found in various environmental mediums such as water, air, food, and soil. It exists in two primary forms: organic and inorganic. While natural processes like biological activities, weathering reactions, and volcanic emissions contribute to arsenic release, human activities also play a significant role. Anthropogenic sources include mining activities, fossil fuel combustion, the use of arsenical pesticides, herbicides, and crop desiccants, as well as arsenic additives in livestock feed, especially poultry feed. Although the use of arsenical products like pesticides and herbicides has declined over recent decades, their use in wood preservation remains common. The maximum permissible limit for arsenic according to the Bureau of Indian Standards (BIS) is 10 parts per billion (ppb).

Present Day Scenario in Chhattisgarh w.r.t. Arsenic

Distribution of Arsenic (As)

The arsenic content in ground water of the state of Chhattisgarh in all the wells have been reported below detection limits for all the 257 NHS well during pre-monsoon season of the year 2024-25. The table 11 given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean Arsenic values for the reporting period. 100% of the collected samples were found Arsenic concentration below the maximum permissible limit of 0.01 mg/l as per BIS.

Table 11-District wise range and distribution of Arsenic in shallow ground water of Chhattisgarh State.

Sr.	District	Count	Min	Max	Mean	< 0.01 mg/l	> 0.01 mg/l
						(% of Samples)	
1	Balod	4	0	0	0	100	0
2	Balodabazar	5	0	0	0	100	0
3	Balrampur	8	0	0	0	100	0
4	Bastar	10	0	0	0	100	0
5	Bemetara	5	0	0	0	100	0
6	Bilaspur	10	0	0	0	100	0
7	Dhamtari	24	0	0	0	100	0
8	Durg	26	0	0	0	100	0
9	Gariyabandh	8	0	0	0	100	0
10	Jagdalpur	4	0	0	0	100	0
11	Janjgir Champa	8	0	0	0	100	0
12	Jashpur	28	0	0	0	100	0
13	Kanker	4	0	0	0	100	0
14	Kawardha	5	0	0	0	100	0
15	Kondagaon	1	0	0	0	100	0
16	Korba	12	0	0	0	100	0
17	Koriya	8	0	0	0	100	0
18	Mahasamund	15	0	0	0	100	0
19	Mungeli	4	0	0	0	100	0
20	Raigarh	24	0	0	0	100	0
21	Raipur	14	0	0	0	100	0
22	Rajnandgaon	10	0	0	0	100	0

Sr.	District	Count	Min	Max	Mean	< 0.01 mg/l	> 0.01 mg/l
						(% of Samples)	
23	Sarangarh Bilaigarh	1	0	0	0	100	0
24	Surajpur	11	0	0	0	100	0
25	Surguja	8	0	0	0	100	0

Temporal variation of Arsenic in ground water during the period from 2020 to 2024

As compared to the data available in year 2020, the number of locations having Arsenic more than 0.01 mg/l in ground water samples has marginally decreased (Table 12) during the year 2023 and 2024.

Table 12- Comparative change in number of locations having As > 0.01 mg/l

Sr.	District	2019	2020	2023	2024
1	Balod	0	0	0	0
2	Balodabazar	0	0	-	0
3	Balrampur	0	-	-	0
4	Bastar	0	0	-	0
5	Bemetara	0	0	-	0
6	Bilaspur	0	0	-	0
7	Dhamtari	0	0	0	0
8	Durg	0	0	1	0
9	Gariyabandh	0	0	-	0
10	Jagdalpur	-	-	-	0
11	Jangir-champa	0	0	-	0
12	Jashpur	0	0	0	0
13	Kanker	0	0	0	0
14	Kawardha	0	-	-	0
15	Kondagaon	0	0	0	0
16	Korba	0	0	0	0
17	Koriya	1	-	-	0
18	Mahasamund	0	0	-	0
19	Mungeli	0	0	-	0
20	Raigarh	2	0	1	0
21	Raipur	0	0	0	0
22	Rajnandgaon	0	0	-	0
23	Sarangarh Bilaigarh	-	-	-	0
24	Surajpur	0	-	-	0
25	Surguja	0	-	-	0

Table 13-Periodic variation in suitability classes of Arsenic in Ground Water of Chhattisgarh State.

Parameters	Class	Percentage of Samples					Periodic Variation (2020-2024)
		2019	2020	2021/2022	2023	2024	
		(N=917)	(N=590	-	(N=374)	(N=257)	
Arsenic	< 10 ppb	99.7	100	-	99.48	100	
	> 10 ppb	0.3	0.00	-	0.52	0.00	

Iron

Iron is a common constituent in soil and ground water. It is present in water either as soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colorless because the iron is completely dissolved. When exposed to air, the water turns cloudy due to oxidation of ferrous iron into reddish brown ferric oxide.

The concentration of iron in natural water is controlled by both physico-chemical and microbiological factors. It is contributed to ground water mainly from weathering of ferruginous minerals of igneous rocks such as hematite, magnetite and sulphide ores of sedimentary and metamorphic rocks. The permissible Iron concentration in ground water is less than 1.0 mg/litre as per the BIS Standard for drinking water.

Distribution of Iron (Fe)

The iron content in ground water of the state ranges from BDL to 1.68 mg/l. BIS recommends that iron concentration up to 1.0 mg/l in drinking water is acceptable. Classification of samples based on this recommendation, it is found that only two locations in Rajnandgaon district (0.78% samples of the state) have iron content above 1.0 mg/l. Table 14 given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean Iron values based on NAQUIM and Hot Spot Data for the year 2023.

Table 14-District wise range and distribution of Iron in shallow GW of Chhattisgarh State (2024-25).

Sr.	District	Samples	Min	Max	Mean	< 1.00	> 1.0
						(% of Samples)	
1	Balod	4	0.003	0.0299	0	100	0
2	Balodabazar	5	0.002	0.015	0	100	0
3	Balrampur	8	0.01	0.28	0	100	0
4	Bastar	10	0.008	0.038	0	100	0
5	Bemetara	5	0.007	0.063	0	100	0
6	Bilaspur	10	0.005	0.042	0	100	0
7	Dhamtari	24	0.007	0.28	0	100	0
8	Durg	26	0.005	0.253	0	100	0
9	Gariyabandh	8	0.005	0.268	0	100	0
10	Jagdalpur	4	0.126	0.276	0	100	0
11	Janjgir Champa	8	0.006	0.042	0	100	0
12	Jashpur	28	0.002	0.211	0	100	0
13	Kanker	4	0.006	0.063	0	100	0
14	Kawardha	5	0.007	0.042	0	100	0
15	Kondagaon	1	0.026	0.026	0	100	0
16	Korba	12	0.009	0.288	0	100	0
17	Koriya	8	0.008	0.033	0	100	0
18	Mahasamund	15	0.005	0.042	0	100	0

Sr.	District	Samples	Min	Max	Mean	< 1.00	> 1.0
						(% of Samples)	
19	Mungeli	4	0	0.211	0	100	0
20	Raigarh	24	0.003	0.264	1	100	0
21	Raipur	14	0.01	0.673	0	100	0
22	Rajnandgaon	10	0.009	1.48	0	80	20
23	Sarangarh Bilaigarh	1	0.012	0.012	0	100	0
24	Surajpur	11	0.009	0.447	0	100	0
25	Surguja	8	0.009	0.364	0	100	0

Temporal Variation of Iron in Ground Water During the Period From 2020 To 2024

The data for Iron content as available for the years 2015, 2019, 2020 and 2023 are also taken for this report. During the current study period, only two locations in Rajnandgaon district have been found Iron content above 1 mg/l against the limit. The number of locations having Iron more than 1.0 mg/l in ground water samples is presented (Table-14). Periodic variation in suitability classes of Iron in Ground Water of Chhattisgarh State is presented in Table 15.

Table 15-Comparative changes in the number of locations having Iron > 1.0 mg/l.

Sr.	Districts	2015	2019	2020	2023	2024
1	Balod	0	0	0	26	0
2	Balodabazar	7	5	5	-	0
3	Balrampur	6	1	-	-	0
4	Bastar	1	3	0	-	0
5	Bemetara	1	0	0	-	0
6	Bilaspur	22	17	15	-	0
7	Dhamtari	7	10	2	0	0
8	Durg	1	1	0	23	0
9	Gariyabandh	6	5	2	-	0
10	Jagdalpur	-	-	-	-	0
11	Jangir-champa	17	2	6	-	0
12	Jashpur	24	0	7	2	0
13	Kanker	2	0	-	0	0
14	Kawardha	0	1			0
15	Kondagaon	4	1	0	0	0
16	Korba	34	18	16	6	0
17	Koriya	4	5	-	-	0
18	Mahasamund	7	4	2	-	0
19	Mungeli	11	3	5	-	0
20	Raigarh	20	0	4	3	0
21	Raipur	8	1	3	0	0
22	Rajnandgaon	2	6	0	-	2
23	Sarangarh Bilaigarh	-	-	-		0
24	Surajpur	20	6	-	-	0
25	Surguja	7	3	-	-	0

Table 16-Periodic variation in suitability classes of Iron in Ground Water of Chhattisgarh State.

Parameters	Class	Percentage of Samples					Periodic Variation (2015-2023)
		2015	**2019**	**2020**	**2023**	2024	
		(N=616)	(N=917	(N=590)	(N=374)	(N=257)	
Iron	< 1.0 mg/l	65.75	89.97	88.64	83.96	80.00	
	> 1.0 mg/l	34.25	10.03	11.63	16.04	20.00	

No trend graph could be plotted for Iron parameter as this year only two locations across the state has been observed to have Iron contamination above 0.1 mg/l.

Uranium

Uranium occurs naturally in groundwater and surface water. Being Naturally occurring uranium in groundwater and surface water poses health risks due to its radioactive properties. Sources include natural deposits, nuclear industry emissions, coal combustion, and phosphate fertilizers. Human exposure occurs mainly through drinking water, food, air, and occupational hazards. Concentrations exceeding 30 ppb, according to BIS standards, can cause damage to internal organs with prolonged intake, necessitating caution in consumption.

Present Day Scenario in Chhattisgarh wrt Uranium

Distribution of Uranium (U)

The Uranium content in ground water of Chhattisgarh State ranges from 0.0002 to 0.041 mg/L during the pre-monsoon period of the year 2024-25. BIS recommends that uranium concentration up to 0.03 mg/L in drinking water is acceptable. Classification of samples based on this recommendation, it is found that 98.44% of the collected samples have Uranium below the BIS prescribed maximum permissible limit only 0.65% samples are found to have Uranium content above the limit. Figure -14 showing the spatial distribution of Uranium content in ground water (2024) indicates that ground waters with Uranium above 0.03 mg/L are found mainly in three districts of the State viz Koriya, Korba and Surajpur.

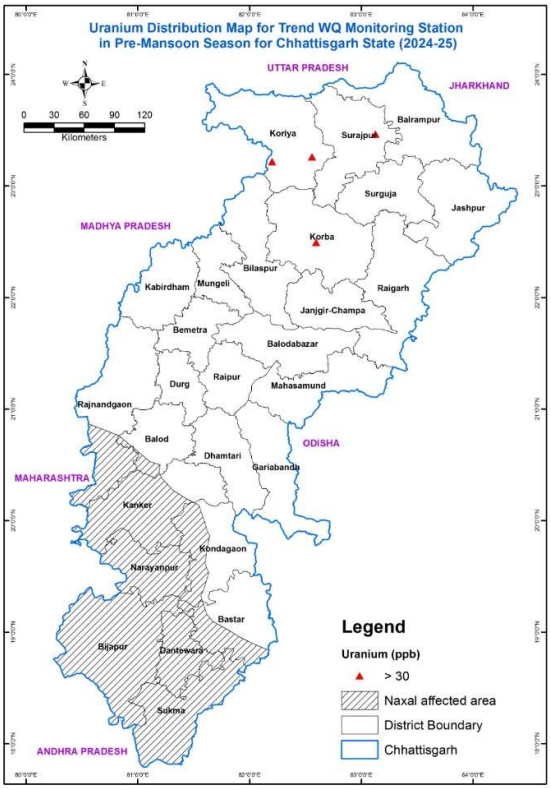

Figure 10 - Map showing the distribution of Uranium in Chhattisgarh State based upon 2023 NHS data.

The Table 17 given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean Uranium values based on NHS 2024 Data.

Table 17-District wise range and distribution of Uranium in GW of Chhattisgarh State (2024-25).

Sr.	District	Samples	Min	Max	Mean	< 0.030 mg/l	> 0.030 mg/l
1	Balod	4	0.00001	0.00088	0	100	0
2	Balodabazar	5	0.00001	0.00067	0	100	0
3	Balrampur	8	0	0.0025	0	100	0
4	Bastar	10	0	0.00572	0	100	0
5	Bemetara	5	0	0.00002	0	100	0
6	Bilaspur	10	0	0.01423	0	100	0
7	Dhamtari	24	0	0.00223	0	100	0
8	Durg	26	0	0.00314	0	100	0
9	Gariyabandh	8	0	0.00472	0	100	0
10	Jagdalpur	4	0.00029	0.00088	0	100	0
11	Janjgir Champa	8	0	0.01183	0	100	0
12	Jashpur	28	0	0.00883	0	100	0
13	Kanker	4	0	0.00356	0	100	0
14	Kawardha	5	0	0.0001	0	100	0
15	Kondagaon	1	0	0	0	100	0
16	Korba	12	0	0.03642	0	92	8
17	Koriya	8	0	0.04123	0	75	25
18	Mahasamund	15	0	0.00054	0	100	0
19	Mungeli	4	0.004015	0.012935	0	100	0

Sr.	District	Samples	Min	Max	Mean	< 0.030 mg/l	> 0.030 mg/l
20	Raigarh	24	0	0.0216	0	100	0
21	Raipur	14	0	0.00026	0	100	0
22	Rajnandgaon	10	0	0.00667	0	100	0
23	Sarangarh Bilaigarh	1	0	0	0	100	0
24	Surajpur	11	0	0.0365	0	91	9
25	Surguja	8	0	0.001506	0	100	0

Temporal variation of uranium in ground water during the period from 2020 to 2023

It has been observed (Table 18) that total number of districts affected by high Uranium has decreased from **5** in 2023 to **4** in 2024.

Table 18-Comparative changes in number of locations with Uranium > 0.03 mg/l.

Sr.	District	2020	2021	2022	2023	2024
1	Balod	-	0	-	0	0
2	Baloda Bazar	-	0	-	0	0
3	Balrampur	-	0	-	0	0
4	Bastar	-	0	-	0	0
5	Bemetara	-	0	-	0	0
6	Bilaspur	-	0	-	0	0
7	Dhamtari	-	0	-	0	0
8	Durg	-	0	-	0	0
9	Gariyaband	-	0	-	0	0
10	Jagdalpur					0
11	Janjgir Champa	-	0	-	0	0
12	Jashpur	-	0	-	0	0
13	Kanker	-	0	-	0	0
14	Kawardha	-	0	-	0	0
15	Kondagaon	-	0	-	0	0
16	Korba	-	1	-	2	1
17	Koriya	-	0	-	2	2
18	Mahasamund	-	0	-	0	0
19	Mungeli	-		-	0	0
20	Raigarh	-	0	-	1	0
21	Raipur	-	0	-	0	0
22	Rajnandgaon	-	0	-	0	0
23	Sarangarh Bilaigarh					0
24	Surajpur	-	0	-	0	1
25	Surguja	-	0	-	0	0

The trend for Uranium contamination in the ground water during the years from 2019 to 2024 is plotted in the graph shown below in Figure-15.

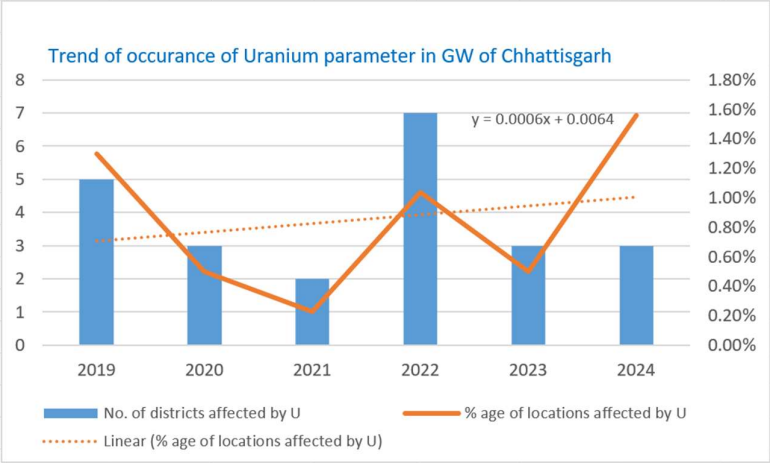

Figure 11 - Trend of Uranium Contamination in the GW of Chhattisgarh State during 2019-2024.

Alogwith these heavy metals Copper and Zinc were also analysed in all the 257 ground water samples collected from the 257 trend water quality monitoring stations, but no location have been found significantly contaminated with Copper and Zinc. Hence, trend graphs and plots were not prepared.

Summary

The analytical results of NHS monitoring wells shows that number of locations contaminated with EC, NO3 and U parameters has decreased as compared to previous years, while Fluoride contaminated locations have a slight increase in numbers. But, still no concrete conclusion can be drawn based upon the findings of the study as the numbers and district affected with these parameters are not constant. This decline in water quality may stem from geogenic or anthropogenic sources. While most samples from Central Ground Water Board observation wells meet drinking water standards for basic parameters and heavy metals, some exceed permissible limits, posing health risks with prolonged use.

District Wise Contaminant Wise Status Summary Based on NHS 2024 Pre- Monsoon Data

The Table 19 provides a detailed summary of groundwater quality across various districts in the state focusing on basic parameters (electrical conductivity, nitrate, fluoride) and heavy metals (iron, arsenic, uranium, Zinc and Copper).

Table 19- Summary of Ground WQ in Chhattisgarh State for the year 2024-25. (Number of Locations (% of Locations affected).

Sr.	District	EC	NO3	F	Fe	U	As	Cu	Zn
1	Balod	0 (0%)	1 (25%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
2	Balodabazar	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
3	Balrampur	0 (0%)	2 (25%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (13%)
4	Bastar	0 (0%)	0 (0%)	1 (10%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
5	Bemetara	0 (0%)	2 (40%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
6	Bilaspur	0 (0%)	0 (0%)	1 (10%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
7	Dhamtari	0 (0%)	1 (4%)	4 (17%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
8	Durg	0 (0%)	2 (8%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
9	Gariyabandh	0 (0%)	3 (38%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
10	Jagdalpur	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
11	Janjgir Champa	1 (13%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
12	Jashpur	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Sr.	District	EC	NO3	F	Fe	U	As	Cu	Zn
13	Kanker	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
14	Kawardha	0 (0%)	2 (40%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
15	Kondagaon	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
16	Korba	0 (0%)	1 (8%)	2 (17%)	0 (0%)	1 (8%)	0 (0%)	0 (0%)	0 (0%)
17	Koriya	0 (0%)	0 (0%)	1 (13%)	0 (0%)	2 (25%)	0 (0%)	0 (0%)	0 (0%)
18	Mahasamund	0 (0%)	4 (27%)	2 (13%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
19	Mungeli	0 (0%)	1 (25%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
20	Raigarh	0 (0%)	1 (4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
21	Raipur	0 (0%)	4 (29%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
22	Rajnandgaon	0 (0%)	4 (40%)	0 (0%)	2 (20%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
23	Sarangarh Bilaigarh	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
24	Surajpur	0 (0%)	2 (18%)	0 (0%)	0 (0%)	1 (9%)	0 (0%)	0 (0%)	0 (0%)
25	Surguja	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

State Summary

The Table 20 provides a summary of ground WQ in the state of Chhattisgarh, broken down by the number of samples collected & the percentage of those samples that are contaminated with various parameters.

Table 20- Summary of Ground Water Quality in Chhattisgarh 2024-25.

Chhattisgarh State summary for the selected parameters (Basic and Heavy Metals)	Total Number of Basic Samples	Number of samples contained more than the permissible limits of the respective parameters (% of samples contained) for the year 2024-25 (Pre-Monsoon)				
		EC	NO3	F		
	257	1 (0.39%)	32 (12.45%)	12 (4.67%)		
		U	Fe	As	Zn	Cu
		4 (1.56%)	2 (0.78%)	0 (0 %)	1 (0.39%)	0 (0 %)

Graphical representation of the same is depicted hereunder in Figure-16.

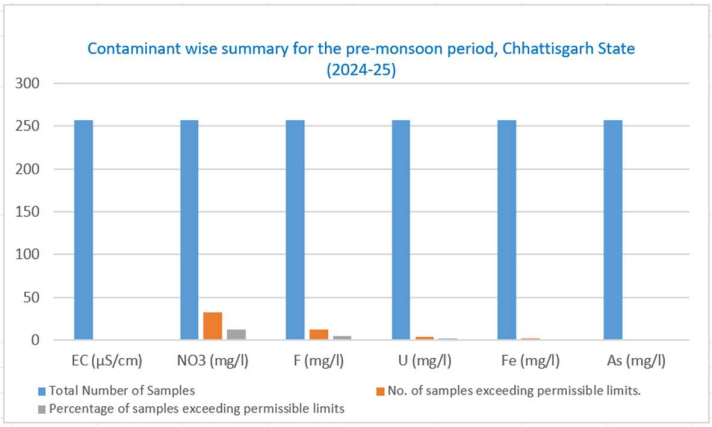

Figure 12 – Graph showing contaminant wise state summary.

** The End of the GW Quality Bulletin ***