Periodic ground water assessment (2020-2024) highlighting the findings, significant trends and ground water contamination status

GROUND WATER CHEMICAL QUALITY BULLETIN

JHARKHAND

1.0 Introduction:

Ground water is an important resource for drinking, irrigation and industrial sector. For the sustainable socio-economic development ground water plays an important role. In Jharkhand in Alluvial area no scarcity of water, in hard rock area water is insufficient particularly in pre-monsoon. Withdrawal of more than sufficient water causes deterioration of water quality in some places and declining of water levels. Ground water quality is dependent of rock and minerals. Due to redox reaction with minerals and aquifer, ions dissolves and sometimes causes parameters more than permissible limit. Water quality also deteriorates due to excessive use of fertilizer, urbanization and discharge of industrial effluents. More than 80% of disease are caused by poor quality drinking water according to UNESCO. Inorganic contaminants including Salinity, Fluoride, Nitrate, Arsenic, Iron and uranium.

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

During the pre-monsoon of year 2024-25, trend sampling was done to achieve following goals:

i) presentation of ground water quality scenario, parameter wise each district.

ii) To identify present day hotspot of poor-quality ground water through spatial variation analysis of latest 2024 quality data.

iii) To assess variation of ground water quality showing improvement/deterioration during the period from 2020 to2024 providing insights for effective water quality management measures.

2.0 Study Area

Jharkhand is located between 21°55' & 25°15' N latitude and between 83°15' & 87°55’ E longitude. The state falls in four major sub basins namely Subarnarekha, Damodar, North Koel and South Koel. Many parts of the Jharkhand state lie on the Chhota Nagpur Plateau. Jharkhand state consists of five regions namely: Santhal Paragna, North Chhotanagpur, South Chhotanagpur, Kolhan and Palamu. Santhal Paragna comprises six districts: Godda, Deoghar, Dumka, Jamtara, Sahibganj and Pakur. Districts of North Chotanagpur Region include Bokaro district, Chatra district, Dhanbad district, Giridih district, Hazaribagh district, Koderma district and Ramgarh district. Districts of South Chotanagpur Region include the districts like Gumla District, Khunti District, Lohardaga District, Ranchi District, and Simedega District. There are total three districts under the administrative area of Kolhan region: West

Singhbhum, East Singhbhum and Saraikela-Kharsawan. Palamu region comprises three districts: Garhwa, Latehar and Palamu. The state of Jharkhand preserves the records of long geological history ranging from Archean metamorphic to recent alluvial sediments. Ground water occurrence and movement, the two cardinal parameters of water bearing zones vary considerably in the state, depending upon various factors. One of the major factors is the rock type, within which water bearing zones are confined. At shallow level, ground water occurs within weathered zone andalso within the secondary porosities, like joints & fractures. Ground water occurs under unconfined condition within the shallow aquifer

3.0 GROUND WATER QUALITY MONITOIRING

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 program is to get information of ground water quality distribution in regional scale and create a background data bank of different chemical constituent in ground water. A probable cause of ground water quality deterioration is depicted in Figure (1).

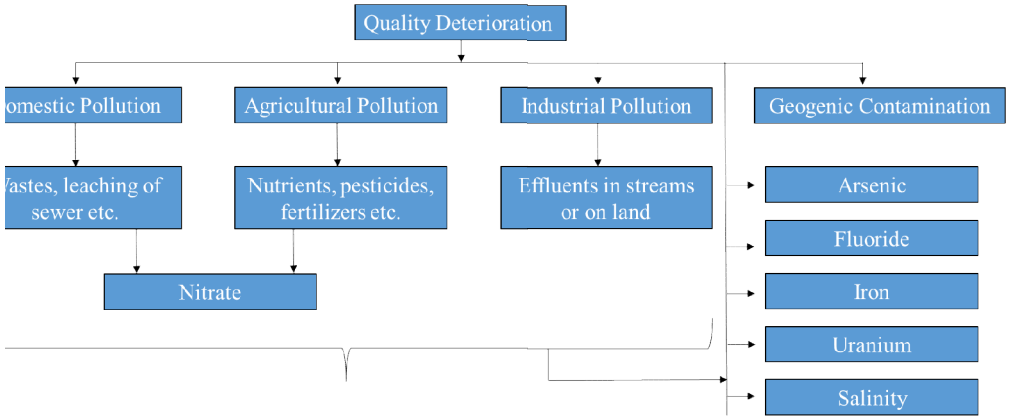

Figure 1: Schematic diagram illustrating the potential factors contributing to the degradation of groundwater quality.

As per SOP on Ground Water Quality Data Analysis, the chemical quality of shallow ground water is being monitored by CGWB twice in a year (pre-monsoon and post-monsoon). During the pre-monsoon of 2024, trend sampling was done through 138 locations as given in Figure 2. The district wise distribution of water quality monitoring stations for trend sampling is given in Table 1. In the Table, only those samples from 2020-2023 were taken into considerations which were common to the trend sampling done in 2024. In the year 2020 and 2021, due to Covid pandemic, samples were not collected from many locations. These samples were analyzed in the Regional Chemical Laboratory, of Central Ground Water Board, Mid-Eastern Region, Patna.

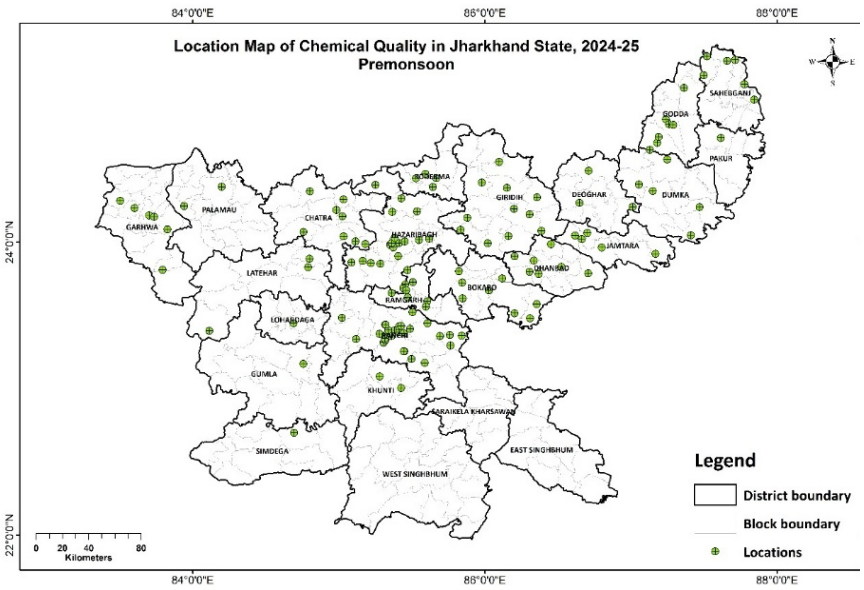

Figure-2 Map showing spatial distribution of 138 groundwater quality monitoring station in Jharkhand based on Trend sampling in 2024 (Pre-monsoon)

Table1: District wise distribution of water Quality Monitoring Stations

District	Number of Water Quality Monitoring Stations				
	May 2020	May 2021	May 2022	May 2023	May 2024
Bokaro	4	8	4	8	8
Chatra	0	0	8	8	8
Deoghar	0	0	2	3	3
Dhanbad	0	0	4	7	7
Dumka	0	0	4	5	5
Garhwa	0	0	6	6	6
Giridih	0	0	9	10	11
Godda	0	0	4	7	7
Gumla	1	1	1	1	1
Hazaribagh	10	17	13	19	19
Jamtara	0	0	3	5	5
Khunti	2	0	2	1	2
Koderma	0	0	3	4	4
Latehar	2	0	4	4	4
Lohardaga	1	1	1	1	1
Pakur	0	0	1	1	1
Palamu	0	0	1	2	2
Ramgarh	6	9	9	9	9
Ranchi	28	27	27	28	28
Sahibganj	0	0	6	6	6
Simdega	-	-	1	1	1
Total	54	63	113	136	138

4. Ground water quality Scenario:

The main objectives of ground water quality monitoring are to evaluate the suitability of ground water for drinking purposes as the quality of drinking water is powerful determinant of the health of a community.

The Bureau of Indian Standards(BIS) vide its document IS: 10500:2012, edition 3.2(2012-2015) has recommended the quality of drinking water. The ground water samples collected from shallow aquifers are analyzed for all major inorganic parameters. Occurrence of high concentrations of some parameters such as EC, Fluoride, Nitrate and the changes in water quality based on these parameters have been observed in various part of Jharkhand.

4.1 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,

are main constituents defining the quality of ground water in unconfined aquifers. Therefore, presence of these parameters and changes in chemical quality with respect to these in ground water in samples collected during NHS monitoring2020 -2024 are discussed below.

1. Electrical conductivity (>3000µs/cm at25^{0}C)
2. Fluoride(>1.5ppm)
3. Nitrate(>45ppm)

4.1.1 The Electrical conductivity

Electrical conductivity or Total dissolved solids or Salinity is the dissolved salt content in water body. Different substances dissolve in water giving it taste and odor. Electrical conductivity represents total no. of cations and anions present in ground water, indicating ionic mobility of different ions, total dissolved solids and saline nature of water.

In general EC <1500 µs/cm at25^{0}C, is considered as fresh water, EC 1500-15000µs/cm at25^{0}C is called brackish water and > 15000µs/cm at 25^{0}C is called saline water. Salinity always exists in water in variable amounts. It is mostly influenced by aquifer material, solubility of minerals, duration of contact and factors such as permeability of soil, drainage facilities, quantity of rainfall and above all climate of the area. BIS has recommended TDS of limit 500mg/L corresponding to EC of 750 µs/cm, at 25^{0}C. TDS can be extended to 2000 mg/L (corresponding to EC of about 3000 µs/cm at 25^{0}C) in case no alternate sources. Water having TDS more than 2000 are not suitable for drinking purposes.

Present day scenario of Jharkhand W.r.t Electrical conductivity(EC)

<u>Distribution of Electrical conductivity(EC)</u>

In Jharkhand, EC varies from 140–2728µs/cm at25^{0}C This Maximum value of EC is found in Hazaribagh district, Chauparan block, Chauparan location. Out of 138 samples, no sample has shown EC more than 3000µs/cm at 25^{0}C.

Grouping water samples based on EC values, it is found that 36.2 % of them have EC less than 750 µS/cm and rest 63.8 % have EC value between 750 and 3000 µS/cm. The map showing aerial distribution of EC (Figure3) with intervals corresponding to limits as above indicates that less than 750 µS/cm class of water, occur throughout the state in patches. However, locations having EC values greater than 3000 µS/cm are mostly saline and is not suitable for drinking purpose in terms of Electrical Conductance. Table 2 provides the number of samples analyzed per district, along with their minimum, maximum, and mean EC values based on NHS 2024 pre-monsoon Data.

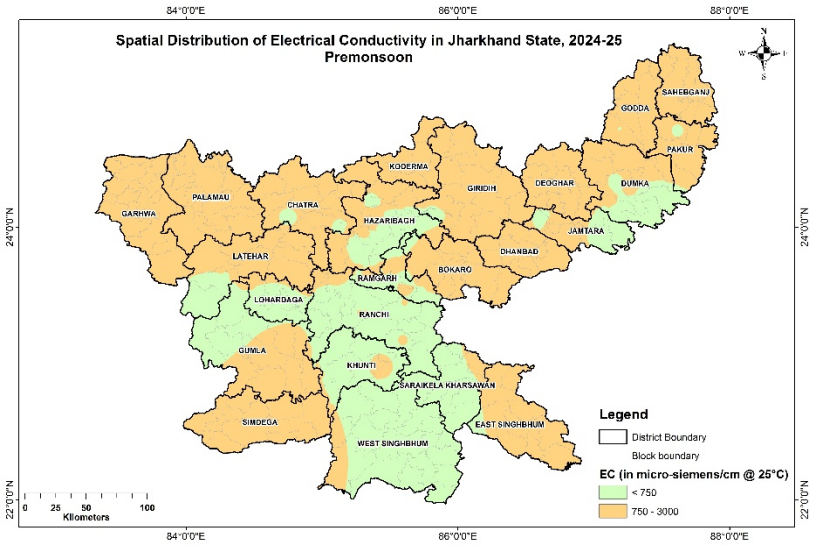

Figure 3: Map showing distribution of Electrical Conductivity Jharkhand based on NHS 2024 Data

Table2: District wise Range and distribution of EC in shallow GW of Jharkhand

District	No. Of samples analysed	Permissible limit (µS/cm)	Min	Max	Average	No. Of samples (%)		
						<750	750-3000	>3000
Bokaro	8	3000	810	1609	1182.5		100	
Chatra	8		190	1817	312.5	25	75	
Deoghar	3		795	1268	1033		100	
Dhanbad	7		830	2012	1330.4		100	
Dumka	5		625	1091	789.2	60	40	
Garhwa	6		774	1555	1108.3		100	
Giridih	11		494	1906	1146.3	9.1	90.9	
Godda	7		648	2002	1274.3	14.3	85.7	
Gumla	1			1022			100	
Hazaribagh	19		339	2728	906.5	52.6	57.4	
Jamtara	5		140	1091	624.6	40	60	
Khunti	2		220	1058	639	50	50	
Koderma	4		1088	1972	1383.5		100	
Latehar	4		171	1605	1101.5	25	75	
Lohardaga	1			333		100		
Pakur	1			661		100		
Palamu	2		1042	1061	1051.5		100	
Ramgarh	9		252	1156	756.1	44.4	55.6	
Ranchi	28		178	1213	554.6	82.1	17.9	
Sahibganj	6		964	2205	1590		100	
Simdega	1			1475		100		

TEMPORAL VARIATION OF EC IN GROUND WATER DURING THE PERIOD FROM 2020 TO 2024

In comparison to 2020-2024 chemical quality data it has been observed that no districts of Jharkhand have shown EC values more than 3000 µS/cm in 2024. In Table 3, periodic variation in Electrical conductivity from 2020-2024 is given

Table 3: Periodic variation in suitability Classes of groundwater Electrical Conductivity (EC) of Jharkhand

	Class	Percentage of samples					Periodic Variation 2020-2024
		2020	2021	2022	2023	2024	
		(n=54)	(n=63)	(n=113)	(n=136)	(n=138)	
Salinity as EC	<750 µS/cm	46.3	54	48.7	38.2	36.2	-10.1
	750-3000 µS/cm	53.7	46	51.3	61.8	63.8	10.1
	>3000 µS/cm	0	0	0	0	0	0

4.1.2. Nitrate

Naturally occurring nitrate forms when nitrogen and oxygen combine in soil, primarily sourced from atmospheric nitrogen. Ground water nitrate mainly comes from chemical fertilizers, animal manure leaching and sewage discharge. Identifying natural vs. Manmade source is challenging. Chemical and microbiological

process like nitrification and denitrification also affect ground water nitrate levels.

Though nitrate is considered relatively nontoxic, high concentration of nitrate in drinking water is an environmental health concern arising of increased risk of methaemoglobonaemia for infants. Adult can tolerate little higher concentration. As per BIS standard maximum desirable limit in drinking water is 45mg/L.

Scenario of Jharkhand w.r.t Nitrate (NO_3)

Distribution of Nitrate(NO_3)

The probable source of nitrate contamination of ground water through excessive application of fertilizers, bacterial nitrification of organic oxygen and seepage from animal and human wastes and atmospheric inputs. In the State, nitrate in ground water samples varies from 0.3 to 105 mg/L. BIS permits a maximum concentration of 45 mg/L nitrate in drinking water. Considering this limit, it is found that 60.1 % of the samples, spread over the entire State, have nitrate below 45 and 39.9 % have more than 45 mg/L. Spatial distribution of Nitrate in the region is given in Figure 4.

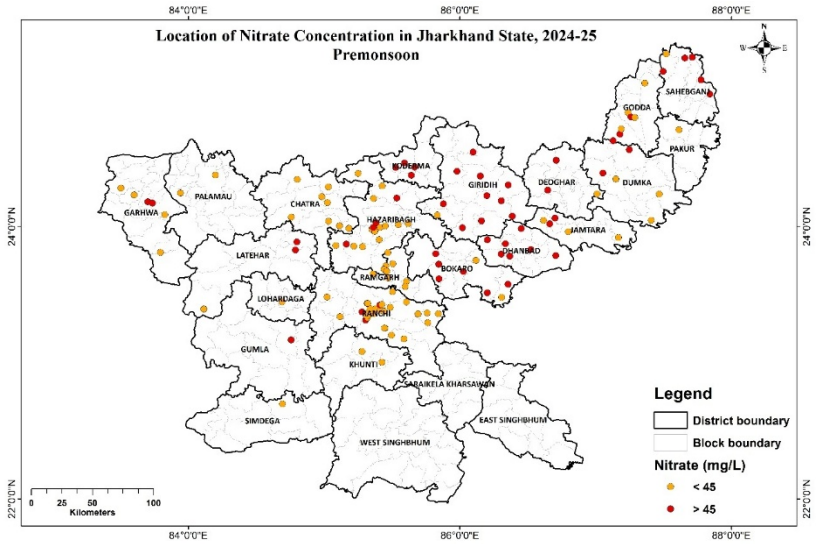

Figure- 4Map showing distribution of Nitrate in Jharkhand based on NHS 2024 Data

Table 4, given below provides the number of samples analyzed per district, along with their minimum, maximum, and mean Nitrate values based on NHS 2024 Data.

Table 4: District wise Range and distribution of Nitrate in shallow GW of Jharkhand

District	No. Of samples analysed	Permissible limit (mg/L)	Min	Max	Average	No. Of samples (%)	
						≤ 45 mg/L	> 45 mg/L
Bokaro	8	45	7.38	72	54.7	25	75
Chatra	8		2.17	44.6	31.2	100	
Deoghar	3		33	51	43.2	33.3	66.7
Dhanbad	7		56	105	77.1		100
Dumka	5		24	55.5	40.3	60	40
Garhwa	6		0.3	49.8	31.7	66.7	33.3
Giridih	11		5.08	91	63.3	9.1	91.9

District	No. Of samples analysed	Permissible limit (mg/L)	Min	Max	Average	No. Of samples (%)	
						≤ 45 mg/L	> 45 mg/L
Godda	7		12.47	52	34	57.1	42.9
Gumla	1				49.6		100
Hazaribagh	19		2.66	50.9	30.1	73.7	26.3
Jamtara	5		4.39	78	44.7	60	40
Khunti	2		17.59	22.52	20.1	100	
Koderma	4		59	80	69		100
Latehar	4		10.2	58.2	42.4	25	75
Lohardaga	1			19.14		100	
Pakur	1			4.92		100	
Palamu	2		2.1	22.4	12.2	100	
Ramgarh	9		15.4	42.2	27.5	100	
Ranchi	28		1.03	49..2	17.6	89.3	10.7
Sahibganj	6		7.99	78	50.0	16.7	83.3
Simdega	1			40.3		100	

TEMPORAL VARIATION OF NO_3 IN GROUND WATER DURING THE PERIOD FROM 2020 TO 2024

It has been observed (Table 5) that No. of locations in various Districts having high Nitrate (more than 45 mg/l) content in ground water has increased in 2024 because of trend sampling.

For removal of nitrate, suitable techniques – a) non-treatment techniques like blending and b) treatment processes such as ion-exchange, reverse osmosis, biological denitrification and chemical reduction are useful.

Table 5: Comparative change in number of locations having Nitrate>45mg/L in various Districts

District	Number of locations having Nitrate > 45 mg/L				
	2020	2021	2022	2023	2024
Bokaro	3	6			6
Chatra				1	0
Deoghar					2
Dhanbad			1		7
Dumka					2
Garhwa			3	1	2
Giridih			4		10
Godda					3
Gumla		1		1	1
Hazaribagh	7	14	12	2	5
Jamtara					2
Khunti					0
Koderma			1		4
Latehar	2			3	3
Lohardaga	1				0
Pakur					0
Palamu					0
Ramgarh	3	7			0
Ranchi	24	16	1	3	3
Sahibganj					5
Simdega				1	0
Total	40	44	22	12	55

Table 6: Periodic variation in suitability Classes of Nitrate in ground water of Jharkhand

	Class	Percentage of samples					Periodic Variation 2020-2024
		2020	2021	2022	2023	2024	
		54	63	113	136	138	
Nitrate as NO_3	≤ 45 mg/L	25.9	30.2	80.5	91.2	60.1	34.2
	>45 mg/L	74.1	69.8	19.5	8.8	39.9	-34.2

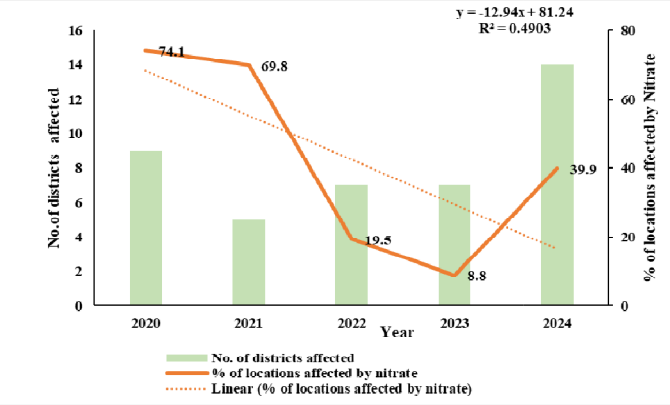

Figure 5. Graphical Representation of Periodic Variation in Nitrate from 2020 to 2024

4.1.3 Fluoride

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

Most of the fluoride found in ground water is naturally occurring from break down of rocks and soils or weathering and disposition of atmospheric particles. Most of the fluorides are sparingly soluble and are present in ground water in small amount. The types of the rocks, climatic conditions, nature of hydrogeological strata and time of contact between the rock and the circulating ground water affect the occurrence of Fluoride in natural water.

BIS has recommended a desirable limit of 1mg/l of fluoride concentration in drinking water and maximum permissible limit is 1.5mg/l in case there is no alternative source available. A small amount of fluoride (1.0mg/l) reduces the tooth decay. However, >1.5mg/l causes staining of tooth enamel while >5mg/l of Fluoride causes critical problems such as stiffness of bone occur. The high concentration of Fluoride >1.5mg/l is mainly attributed due to geogenic conditions.

Scenario of Jharkhand w. r. t fluoride

Distribution of Fluoride (F^-)

Fluoride in small amounts in drinking water is beneficial for the dental health while in large amounts it is injurious. The fluoride content in ground water ranges from 0.0 to 2.53 mg/L. BIS recommends that fluoride concentration up to 1.0 mg/L in drinking water is desirable, up to 1.50 mg/L it is permitted and above 1.50 mg/L is injurious. Classification of samples based on this recommendation, it is found that 74.7 % samples have fluoride in desirable range, 18.8% samples were between 1-1.5 mg/L and the remaining 6.5 % have fluoride concentration above 1.50 mg/L. For dental health small amount of Fluoride is beneficial while the large amount is injurious.

Map showing spatial distribution (Figure. 6) of fluoride contents in ground water indicates that ground waters with fluoride above 1.50 mg/L are found mainly in Godda, Chatra, Palamu, Bokaro and Hazaribagh districts of theState.

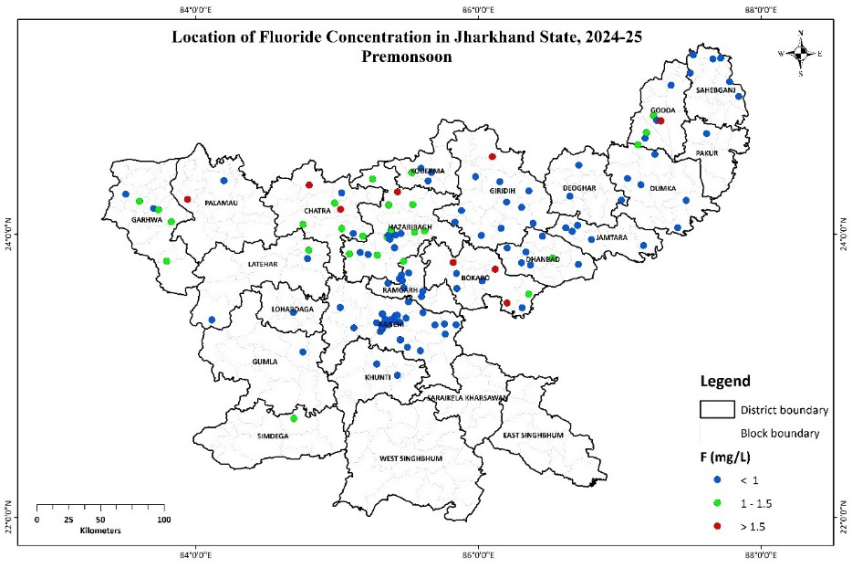

Figure. 6 Map showing distribution of Fluoride in Jharkhand based on NHS 2024 Data

Table 7, given below provides the number of samples analyzed per district, along with their minimum, maximum, and mean Fluoride values based on NHS 2024 Data.

Table 7: District wise Range and distribution of Fluoride in shallow GW of Jharkhand

District	No. Of samples analysed	Permissible limit (mg/L)	Min	Max	Average	No. Of samples (%)	
						< 1.5 mg/L	> 1.5 mg/L
Bokaro	8	1.5	0	2.53	0.97	62.5	37.5
Chatra	8		0.78	1.72	1.2	75	25
Deoghar	3		0.57	0.89	0.71	100	
Dhanbad	7		0	1.29	0.51	100	
Dumka	5		0.46	0.7	0.55	100	
Garhwa	6		0.9	1.43	1.13	100	
Giridih	11		0	2.01	0.48	90.9	9.1
Godda	7		0.66	1.51	1.1	85.7	14.3
Gumla	1			0.7		100	
Hazaribagh	19		0.46	1.56	1	94.7	5.3
Jamtara	5		0	0.96	0.53	100	
Khunti	2		0.86	0.91	0.9	100	
Koderma	4		0.02	1.01	0.3	100	
Latehar	4		0.7	1.04	0.9	100	
Lohardaga	1			0.83		100	
Pakur	1			0.3		100	
Palamu	2		0.86	1.52	1.19	50	50
Ramgarh	9		0.27	1.3	0.65	100	
Ranchi	28		0.11	0.88	0.4	100	
Sahibganj	6		0.28	0.57	0.43	100	
Simdega	1			1.1		100	

TEMPORAL VARIATION OF FLUORIDE IN GROUND WATER DURING THE PERIOD FROM 2020 TO 2024

It has been observed (Table 8) that total number of districts affected by high fluoride has increased from 5 in 2023 to 9 in 2024. This may be due to the reason that in pre-monsoon of 2024, only trend sampling was done from the contaminated locations.

The fluoride remedial measures broadly adopted are ex-situ techniques. They can be Adsorption and ion exchange, Ion-Exchange resins, Coagulation-precipitation or Nalgonda technique.

Table 8: Comparative change in number of locations having Fluoride > 1.5 mg/L in various Districts

District	Number of locations having Fluoride > 1.5 mg/L				
	2020	2021	2022	2023	2024
Bokaro				1	3
Chatra			6	2	2
Deoghar					
Dhanbad				1	
Dumka					
Garhwa					
Giridih					1
Godda				1	1
Gumla					
Hazaribagh					1
Jamtara					
Khunti					
Koderma					
Latehar			1		
Lohardaga		1			
Pakur					
Palamu					1
Ramgarh	2				
Ranchi	2				
Sahibganj					
Simdega					
Total	4	1	7	5	9

Table9: Periodic variation in suitability Classes of Fluoride in groundwater of Jhakhand

	Class	Percentage of samples					Periodic Variation 2020-2024
		2020	2021	2022	2023	2024	
		54	63	113	136	138	
Fluoride as F	≤ 1 mg/L	92.6	95.2	85.8	90.4	74.7	-17.9
	1-1.5 mg/L	0	3.2	8	5.9	18.8	18.8
	> 1.5 mg/L	7.4	1.6	6.2	3.7	6.5	-0.9

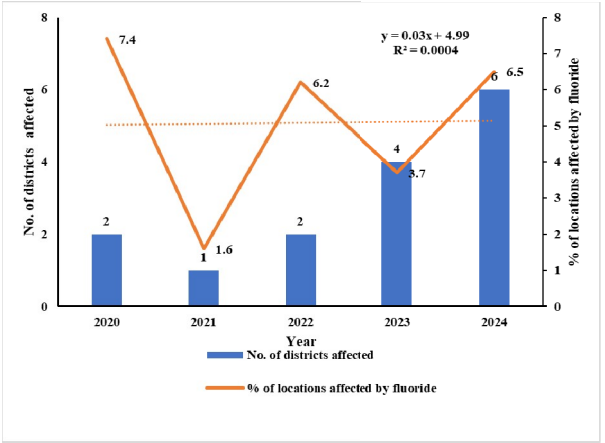

Figure 7. Graphical Representation of Periodic Variation in Fluoride from 2020 to 2024

DISTRICT WISE CONTAMINANT WISE STATUS SUMMARY BASED ON NHS 2024 PRE- MONSOON DATA

Table 10 provides a detailed summary of groundwater quality across various districts in Jharkhand, focusing on basic parameters (Electrical Conductivity, Nitrate, Fluoride).

Table 10. Summary of Groundwater Quality in Various Districts of Jharkhand, Highlighting Basic Parameters (Electrical Conductivity, Nitrate, Fluoride)

District	Total no. of Basic Samples	Samples exceeding permissible limit: In number (% of samples)		
		EC	NO_3	F
		µS/cm	mg/L	mg/L
Bokaro	8		6 (4.34)	3 (2.2)
Chatra	8		0	2 (1.5)
Deoghar	3		2(1.5)	
Dhanbad	7		7(5.1)	
Dumka	5		2(1.5)	
Garhwa	6		2 (1.5)	
Giridih	11		10 (7.24)	1 (0.7)
Godda	7		3 (2.2)	1 (0.7)
Gumla	1		1 (0.7)	
Hazaribagh	19		5 (3.6)	1 (0.7)
Jamtara	5		2 (1.5)	
Khunti	2		0	
Koderma	4		4 (2.9)	
Latehar	4		3 (2.2)	
Lohardaga	1		0	
Pakur	1		0	
Palamu	2		0	1 (0.7)
Ramgarh	9		0	
Ranchi	28		3 (2.2)	
Sahibganj	6		5 (3.6)	
Simdega	1		0	
Total	**138**	**0**	**55 (39.9)**	**9 (6.52)**

- Electrical Conductivity (EC) Nosamplesexceeded thepermissible limit of electrical conductivity.
- Nitrate (NO_3):39.9 % of samples exceed limits, with notable levels in Sahebganj, Bokaro, Dhanbad, Giridih, Jamtara and Koderma.
- Fluoride (F) Overall 6.52 % of samples surpass permissible levels, with varying percentages across Godda, Bokaro, Giridih, Chatra, Hazaribagh and Palamu districts

Table 11, provides a summary of groundwater quality in the state of Jharkhand, broken down by the number of samples collected and the percentage of those samples that are contaminated with various parameters.

Table 11. Summary of Groundwater Quality in Jharkhand: Samples Collected and Contamination Percentage

Jharkhand State Summary		Number of samples contaminated (% of samples contaminated)		
	Total number of Basic samples	EC	NO_3	F
		0	55 (39.9)	9 (6.52)

Nitrate (NO_3) emerged as the predominant contaminant, with 39.9 % of samples surpassing permissible limits, followed by Fluoride at 6.52 % of samples exceeding permissible limits, respectively. Graphical representation of the same is depicted here in Figure8.

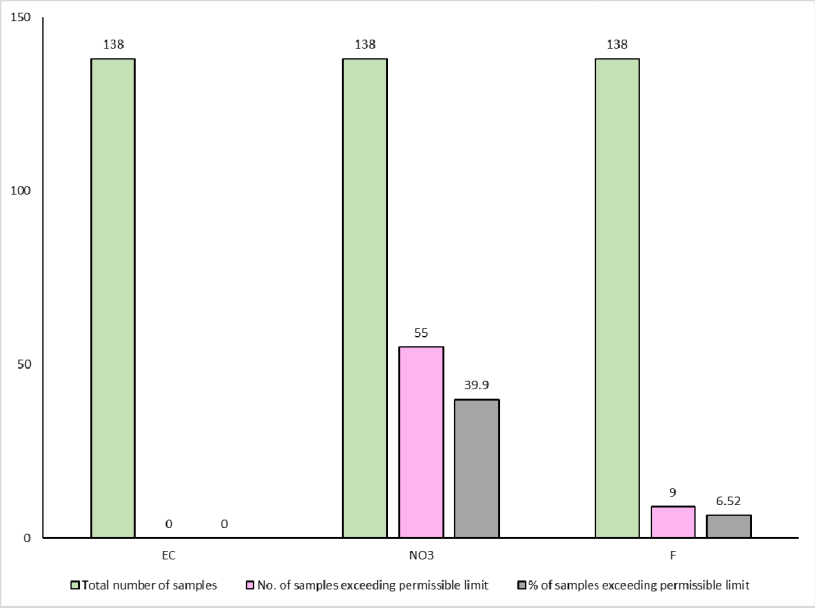

Figure8. Graphical representation of state summary