GROUND WATER CHEMICAL QUALITY BULLETIN

BIHAR

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

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 Bihar 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 to 2024 providing insights for effective water quality management measures.

2.0 Study Area

Bihar is located in the eastern part of the country. Bihar state lies between 83º 20' and 88º 00' E Longitudes and 24º 15' and 27º 23' N Latitudes. It shares international border with Nepal in the north and is bounded in the east, west and south by West Bengal, Uttar Pradesh and Jharkhand states respectively. The state covers geographical area of 94,163 Sq.km and has its capital at Patna. Bihar is mainly a vast stretch of very fertile flat land. It is endowed with several rivers namely Ganga, Son, Bagmati, Kosi, Budhi Gandak, and Falgu. Central part of Bihar comprises of some small hills, for example the Rajgir hills. The topography of Bihar can be easily described as a fertile alluvial plain occupying the Gangetic Valley. The plain extends from the foothills of the Himalayas in the north to a few miles south of the river Ganges as it flows through the state from the west to the east. Bihar is richly endowed with water resources, both the ground water

resource and the surface water resource. It has considerable water supply from the rivers which flow within the territory of the State. Ganga is the main river which is joined by tributaries with their sources in the Himalayas. Rich farmland and lush orchards extend throughout the state.

Geomorphology -Bihar is divided into three parts, North Bihar Plain, Middle Gangetic Plain and South Bihar Plain.

3.0 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 program me 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 below Figure 1.

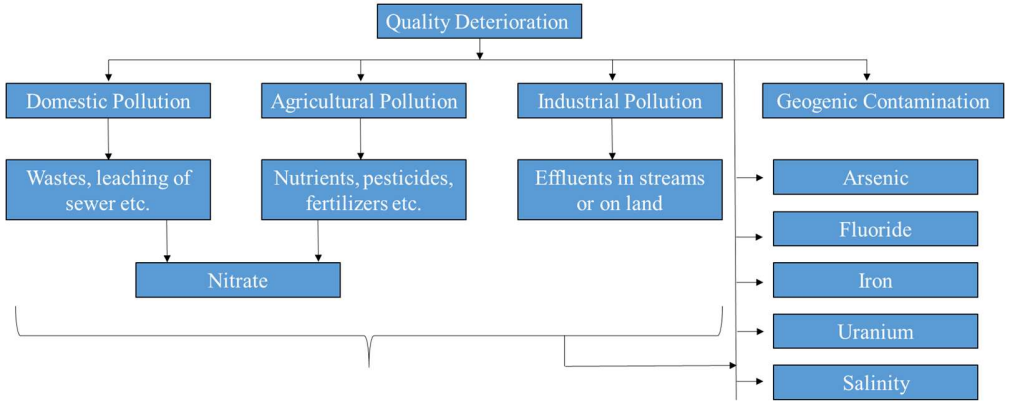

Figure 1: **Schematic diagram illustrating the potential factors contributing to the degradation of groundwater quality**

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 127 locations located over the state 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 consideration 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.

The present bulletin is based on the changing scenario in water quality in network monitoring wells of CGWB in year 2020 to 2024.

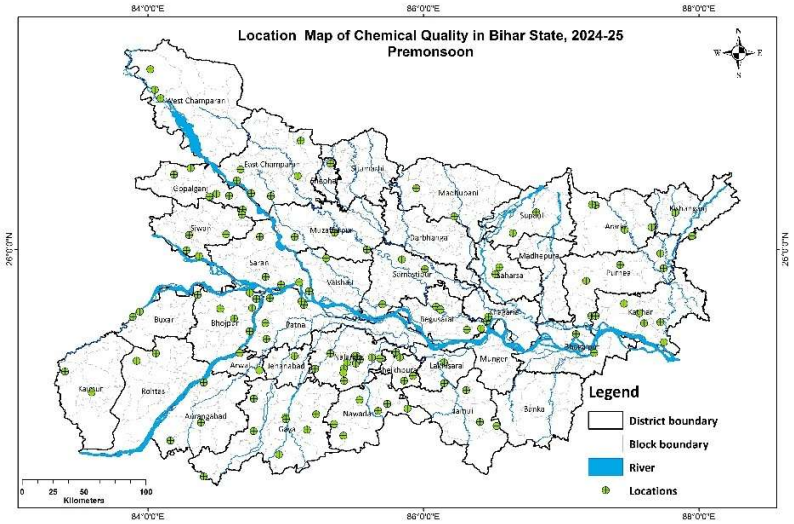

Figure 2 Map showing spatial distribution of 127 groundwater quality monitoring station in Bihar based on Trend sampling in 2024 (Pre-monsoon)

Table 1: 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
Araria	0	-	4	4	4
Arwal	3	-	3	3	3
Aurangabad	0	2	3	3	3
Begusarai	0	1	4	4	4
Bhagalpur	0	0	2	2	2
Bhojpur	5	6	7	7	8
Buxar	0	2	2	2	2
East Champaran	1	1	5	6	6
Gaya	3	5	8	7	8
Gopalganj	2	0	2	7	7
Jamui	0	0	4	2	4
Jehanabad	1	1	1	1	1
Kaimur	0	0	2	2	2
Katihar	1	0	6	5	6
Khagaria	0	0	2	2	2
Kishanganj	0	0	2	2	2
Lakhisarai	0	0	1	1	1
Madhubani	1	0	1	2	3
Muzaffarpur	3	2	2	3	3
Nalanda	9	10	13	13	13
Nawada	4	6	7	6	7
Patna	3	4	3	3	5
Purnia (Purnea)	2	0	5	3	5
Rohtas	0	0	2	2	2
Saharsa	0	0	2	1	2
Samastipur	0	2	3	3	3
Saran	4	2	5	5	5
Sheikhpura	1	3	3	3	3
Sheohar	0	0	1	1	1
Siwan	1	0	4	5	5
Supaul	0	0	2	2	2
Vaishali	1	0	1	1	1
West Champaran	0	0	3	9	3
Total	45	49	115	116	127

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 Bihar.

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 monitoring 2020 -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 at 25^{0}C, is considered as fresh water, EC 1500-15000 µs/cm at 25^{0}C is called brackish water and > 15000 µs/cm at 25^{0}C is called saline water and > 3000 µs/cm at 25^{0}C is called brine. Salinity exist 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 500 corresponding EC 750 µs/cm at 25^{0}C. TDS can be extended to 2000. (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.

Scenario of Bihar W.r.t Electrical conductivity (EC)

Distribution of Electrical conductivity (EC)

In Bihar EC varies from 237 – 4269 µs/cm at 25^{0}C. The maximum value of EC was found in Jehanabad district, Kako block, location Kako. Out of 127 samples, in 2 samples EC was more than 3000 µs/cm at 25^{0}C. Grouping water samples based on EC values, it is found that 27.6 % of them have EC less than 750 µS/cm, 70 % have between 750 and 3000 µS/cm and 2.4 % samples have shown EC values greater than 3000 µS/cm. The map showing spatial distribution of EC (Figure 4) 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.

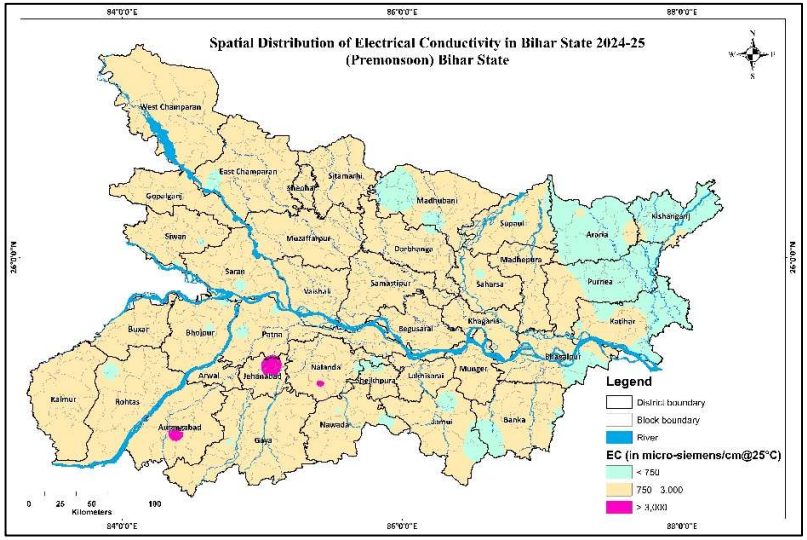

Figure 3: Map showing distribution of Electrical Conductivity Bihar based on NHS 2024 Data

Table 2: District wise Range and distribution of EC in shallow GW of Bihar

District	No. Of samples analysed	Permissible limit (µS/cm)	Min	Max	Average	No. Of samples (%)		
						<750	750-3000	>3000
Araria	4	3000	359	978	672.75	50	50	0
Arwal	3		598	813	737.3	33.3	66.7	
Aurangabad	3		1229	3316	2036.7	0	66.7	33.3
Begusarai	4		942	1852	1365.25		100	
Bhagalpur	2		567	1132	849.5	50	50	
Bhojpur	8		591	1548	1015.5	25	75	
Buxar	2		1841	1848	1844.5	0	100	
East Champaran	6		445	1608	1023	16.7	83.3	
Gaya	8		710	2640	1547.75	11.1	88.9	
Gopalganj	7		515	1584	1104.8	14.3	85.7	
Jamui	4		451	1682	874.75	50	50	
Jehanabad	1			4269				100
Kaimur	2		789	1597	1193		100	
Katihar	6		410	966	718.83	50	50	
Khagaria	2		1435	2260	1847.5		10	
Kishanganj	2		491	898	694.5	50	50	
Lakhisarai	1			1007			100	
Madhubani	2		400	579	489.5	100		
Muzaffarpur	3		871	2100	1382		100	
Nalanda	13		499	3971	1448.9	30.8	61.5	7.7
Nawada	7		508	1906	1085	28.6	71.4	
Patna	5		524	1014	778.2	40	60	
Purnea	5		237	1159	654.6	60	40	
Rohtas	2		626	770	698	50	50	
Saharsa	2		349	2182	1265.5	50	50	
Samastipur	3		1466	2959	2352		100	
Saran	5		693	1050	849.2	20	80	
Sheikhpura	3		769	2280	1474.7		100	
Sheohar	1			1165			100	
Siwan	5		700	1415	985.2	40	60	
Supaul	2		691	2134	1412.5	50	50	
Vaishali	1			1393			100	
West Champaran	3		797	1410	1018		1000	

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

To compare the sample collected during trend sampling in 2024, same sampling locations from 2020-2023, were taken into

consideration. In comparison to 2020 (Table 3,4), it has been observed that there is marginal increase in the number of Districts having EC more than 3000 µS/cm in 2024.

Table 3: Comparative change in number of locations having EC > 3000 µS/cm in various Districts

District	Number of locations having EC> 3000 µS/cm				
	2020	2021	2022	2023	2024
Araria					0
Arwal					0
Aurangabad					1
Begusarai			1		0
Bhagalpur					0
Bhojpur					0
Buxar					0
East Champaran			2		0
Gaya					0
Gopalganj					0
Jamui					0
Jehanabad			1	1	1
Kaimur					0
Katihar					0
Khagaria					0
Kishanganj					0
Lakhisarai					0
Madhubani					0
Muzaffarpur					0
Nalanda			2		1
Nawada					0
Patna					0
Purnia (Purnea)					0
Rohtas					0
Saharsa					0
Samastipur			1		0
Saran	1				0
Sheikhpura					0
Sheohar					0
Siwan				1	0
Supaul					0
Vaishali					0
West Champaran					0
Total	1	0	7	2	3

Table 4: Periodic variation in suitability Classes of groundwater Electrical Conductivity (EC) of Bihar

Parameter	Class	Percentage of samples					Periodic Variation 2020-2024
		2020	2021	2022	2023	2024	
		45	49	115	116	127	
Salinity as EC	<750 µS/cm	42.2	38.8	27	31.9	27.6	-14.6
	750-3000 µS/cm	55.6	61.2	67	66.4	70	14.4
	>3000 µS/cm	2.2	0	6	1.7	2.4	0.2

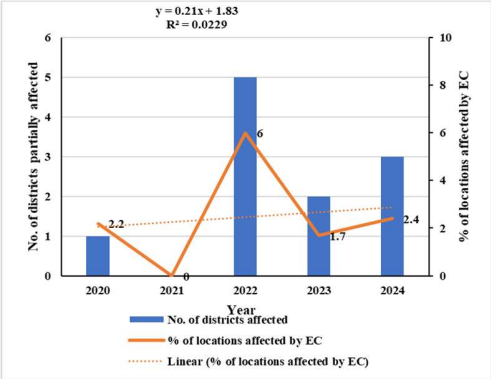

Figure 4. Graphical Representation of Periodic Variation in EC from 2020 to 2024

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 Bihar 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 2.14 to 195 mg/L. BIS permits a maximum concentration of 45 mg/L nitrate in drinking water. Considering this limit, it is found that 37.8 % of the samples, spread over the entire State, have nitrate below 45 and 6.28 % have more than 45 mg/L. Spatial distribution of Nitrate in the region is given in Figure 5.

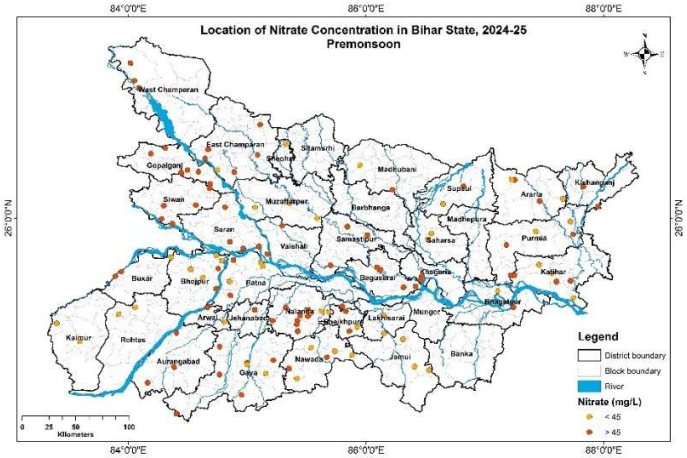

Figure 5. Map showing distribution of Nitrate in Bihar based on NHS 2024 Data

Table 5, given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean Nitrate values based on NHS 2024 Data.

Table 5: District wise Range and distribution of Nitrate in shallow GW of Bihar

District	No. Of samples analysed	Permissible limit (mg/L)	Min	Max	Average	No. Of samples (%)	
						< 45 mg/L	>45 mg/L
Araria	4	45	30	62	48	50	50
Arwal	3		40	68	56	33.3	66.7
Aurangabad	3		62	125	83.7		100
Begusarai	4		69	85	77		100
Bhagalpur	2		35	50.5	42.7	50	50
Bhojpur	8		8.6	61	30.4	62.5	37.5
Buxar	2		59.3	61	60.1		100
East Champaran	6		45	82	60.2	16.7	83.3
Gaya	8		35	195	104.1	25	75
Gopalganj	7		50	129	77.1		100
Jamui	4		10.6	34.2	18.6	100	
Jehanabad	1			188			100

District	No. Of samples analysed	Permissible limit (mg/L)	Min	Max	Average	No. Of samples (%)	
						< 45 mg/L	>45 mg/L
Kaimur (Bhabua)	2		11.3	31.4	21.4	100	
Katihar	6		2.14	66	37.5	50	50
Khagaria	2		71	92	81.5		100
Kishanganj	2		64	70	67		100
Lakhisarai	1			25.1		100	
Madhubani	2		45	65	55	50	50
Muzaffarpur	3		13	40	29.3	100	
Nalanda	13		30	175	79.8	30.8	69.2
Nawada	7		18	84	45.9	28.6	71.4
Patna	5		24	84	51.8	40	60
Purnea	5		4.06	91	49.2	40	60
Rohtas	2		9.7	10.7	10.2	100	
Saharsa	2		8.7	42	25.3	100	
Samastipur	3		62	93	75.7		100
Saran	5		60	130	91.2		100
Sheikhpura	3		32	155	76.3	66.7	33.3
Sheohar	1			16		100	
Siwan	5		55	104	77.6		100
Supaul	2		35	58	46.5	50	50
Vaishali	1			65			100
West Champaran	3		49	53	50.7		100

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

It has been observed (Table 6) 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 6: 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
Araria	-				2
Arwal	-				2
Aurangabad	-	1			3
Begusarai	-	1			4
Bhagalpur	-		1		1
Bhojpur	3		1	1	3
Buxar	-	1	1		2
East Champaran					5
Gaya	2				6
Gopalganj					7
Jamui					0
Jehanabad					1
Kaimur			1	1	0
Katihar	1				3
Khagaria					2
Kishanganj					2
Lakhisarai					0
Madhubani	1			1	1
Muzaffarpur		1		1	0
Nalanda	6				9
Nawada	1				2
Patna					2
Purnea	2				3
Rohtas					0
Saharsa				1	0
Samastipur				2	3
Saran	1	1			5
Sheikhpura					1
Sheohar					0
Siwan					5
Supaul					1
Vaishali					1
West Champaran					3
Total	18	5	4	7	79

Table 7: Periodic variation in suitability Classes of Nitrate in ground water of Bihar

	Class	Percentage of samples					Periodic Variation 2020-2024
		2020	2021	2022	2023	2024	
		45	49	115	116	127	
Nitrate as NO_3	≤ 45 mg/L	60	89.8	96.5	94	37.8	-22.2
	>45 mg/L	40	10.2	3.5	6	62.2	22.2

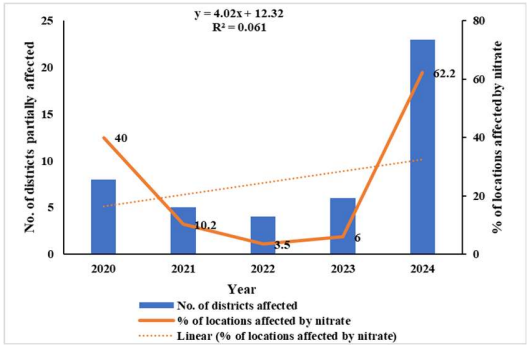

Figure 6. Graphical Representation of Periodic Variation in Nitrate from 2020 to 2024

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 BIHAR W. R. T Fluoride

<u>Distribution of Fluoride (F^-)</u>

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 0.15 to 2.4 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 60.6 % samples have fluoride in desirable range, 21.3 % samples were between 1-1.5 mg/L and the remaining 18.18 % 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 7) of fluoride contents in ground water indicates that ground waters with fluoride above 1.50 mg/L are found mainly in Bhojpur, Samastipur, Rohtas, Nalanda, Nawada, Gaya, Supaul, Jamui and Sheikhpura districts of the State.

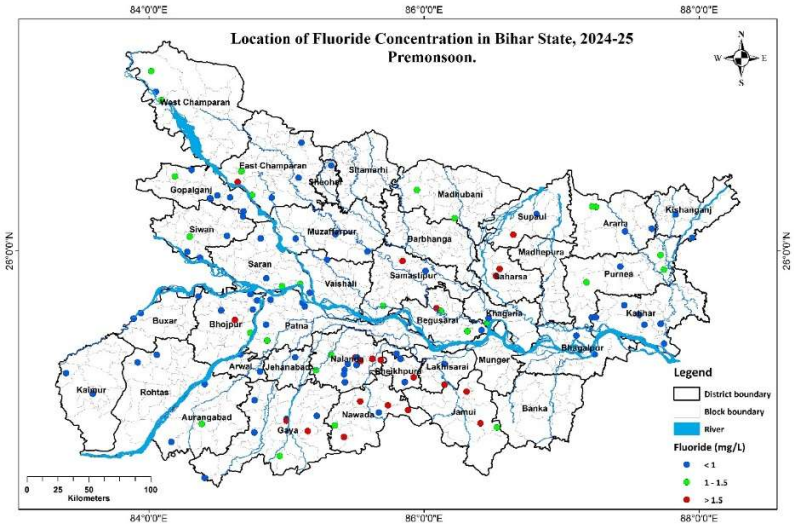

Figure 7 Map showing distribution of Fluoride in Bihar based on NHS 2024 Data

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

Table 8: District wise Range and distribution of Fluoride in shallow GW of Bihar

District	No. Of samples analysed	Permissible limit (mg/L)	Min	Max	Average	No. Of samples (%)	
						≤1.5 mg/L	>1.5 mg/L
Araria	4	1.5	0.71	1.42	1	100	
Arwal	3		0.19	0.58	0.4	100	
Aurangabad	3		0.74	1.11	0.89	100	
Begusarai	4		0.94	1.6	1.25	75	25
Bhagalpur	2		0.48	0.53	0.50	100	
Bhojpur	8		0.18	1.65	0.62	87.5	12.5
Buxar	2		0.66	0.72	0.69	100	
East Champaran	6		0.59	1.55	1.08	83.3	16.7
Gaya	8		0.36	2	0.97	75	25
Gopalganj	7		0.15	1.05	0.59	100	
Jamui	4		1.46	2.4	1.73	25	75
Jehanabad	1			0.64		100	
Kaimur	2		0.66	0.9	0.78	100	
Katihar	6		0.25	0.93	0.6	100	
Khagaria	2		0.99	1.33	1.16	100	
Kishanganj	2		0.62	0.77	0.70	100	
Lakhisarai	1			0.86		100	
Madhubani	2		1.21	1.31	1.26	100	
Muzaffarpur	3		0.68	0.99	0.87	100	
Nalanda	13		0.36	2.26	1.17	69.2	30.8
Nawada	7		0.82	2.13	1.71	28.6	71.4
Patna	5		0.56	1.31	0.78	100	
Purnia (Purnea)	5		0.47	1.4	0.93	100	
Rohtas	2		0.73	0.73	0.73	100	
Saharsa	2		1.72	1.82	1.77		100
Samastipur	3		0.92	1.66	1.23	66.7	33.3
Saran	5		0.16	1.14	0.66	100	
Sheikhpura	3		0.65	2.14	1.63	33.3	66.7
Sheohar	1			0.99		100	
Siwan	5		0.19	1.12	0.67	100	
Supaul	2		0.86	1.6	1.23	50	50
Vaishali	1			0.43		100	
West Champaran	3		0.72	1.07	0.94	100	

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

It has been observed (Table 9) that total number of districts affected by high fluoride has increased from 9 in 2023 to 23 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 9: 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
Araria					0
Arwal					0
Aurangabad					0
Begusarai					1
Bhagalpur					0
Bhojpur					1
Buxar					0
East Champaran					1
Gaya			1	3	2
Gopalganj					
Jamui			4	1	3
Jehanabad					
Kaimur					
Katihar					
Khagaria					
Kishanganj					
Lakhisarai					
Madhubani					
Muzaffarpur					
Nalanda			3		4
Nawada			5	2	5
Patna					
Purnia (Purnea)					
Rohtas					
Saharsa			2		2
Samastipur			1		1
Saran					
Sheikhpura			2	3	2
Sheohar					
Siwan					
Supaul			1		1
Vaishali					
West Champaran					
Total	0	0	19	9	23

Table 10: Periodic variation in suitability Classes of Fluoride in groundwater of Bihar

Parameter	Class	Percentage of samples					Periodic Variation 2020-2024
		2020	2021	2022	2023	2024	
		45	49	115	116	127	
Fluoride as F (1mg/L)	≤1	100	100	71.3	75	60.6	-39.4
	1-1.5			12.2	17.2	21.3	21.3
	>1.5			16.5	7.8	18.1	18.1

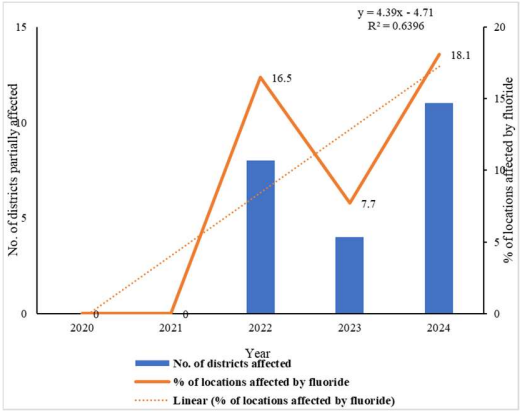

Figure 8. Graphical Representation of Periodic Variation in Fluoride from 2020 to 2024

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

Table 11 provides a detailed summary of groundwater quality across various districts in Bihar, focusing on basic parameters (Electrical Conductivity, Nitrate, Fluoride

Table 11. Summary of Groundwater Quality in Various Districts of Haryana, 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
Araria	4	0	2 (50)	0
Arwal	3	0	2 (66.6)	0
Aurangabad	3	1 (33.3)	3 (100)	0
Begusarai	4	0	4 (100)	1 (25)
Bhagalpur	2	0	1 (50)	0
Bhojpur	8	0	3 (37.5)	1 (12.5)
Buxar	2	0	2 (100)	0
East Champaran	6	0	5 (83.3)	1 (16.7)
Gaya	8	0	6 (75)	2 (25)
Gopalganj	7	0	7 (100)	
Jamui	4	0	0	3 (75)
Jehanabad	1	1 (100)	1 (100)	
Kaimur	2	0	0	
Katihar	6	0	3 (50)	
Khagaria	2	0	2 (100)	
Kishanganj	2	0	2 (100)	
Lakhisarai	1	0	0	
Madhubani	2	0	1(50)	
Muzaffarpur	3	0	0	
Nalanda	13	1 (7.7)	9 (69.2)	4 (30.8)
Nawada	7	0	2 (28.6)	5 (71.4)
Patna	5	0	2 (40)	
Purnea	5	0	3 (60)	
Rohtas	2	0	0	
Saharsa	2	0	0	2 (100)
Samastipur	3	0	3 (100)	1 (33.3)
Saran	5	0	5 (100)	
Sheikhpura	3	0	1 (33.3)	2 (66.7)
Sheohar	1	0	0	
Siwan	5	0	5 (100)	
Supaul	2	0	1 (50)	1 (50)
Vaishali	1	0	1 (100)	
West Champaran	3	0	3 (100)	
Total	127	3 (2.36)	79 (62.2)	23 (18.1)

- Electrical Conductivity (EC) 3 % of samples exceed permissible limits, with higher occurrences in districts such as Aurangabad, Jehanabad and Nalanda.

- Nitrate (NO_3) 62.2 % of samples exceed limits, with notable levels in Jehanabad, Gaya, Nalanda, Sheikhpura, Gopalganj and Siwan districts.

- Fluoride (F) Overall 18.1 % of samples surpass permissible levels, with varying percentages across Bhojpur, Samastipur, Rohtas, Nalanda, Nawada, Gaya, Supaul, Jamui and Sheikhpura districts

Table 12, provides a summary of groundwater quality in the state of Bihar, broken down by the number of samples collected and the percentage of those samples that are contaminated with various parameters.

Table 12. Summary of Groundwater Quality in Bihar: Samples Collected and Contamination Percentage

Bihar State Summary		Number of samples contaminated (% of samples contaminated)		
	Total number of Basic samples	EC	NO_3	F
	127	3 (2.36)	79(62.2)	23 (18.1)

Nitrate (NO_3) emerged as the predominant contaminant, with 62.2 % of samples surpassing permissible limits, followed by Fluoride at 18.1 % of samples exceeding permissible limits, respectively. Graphical representation of the same is depicted here in Figure 6.

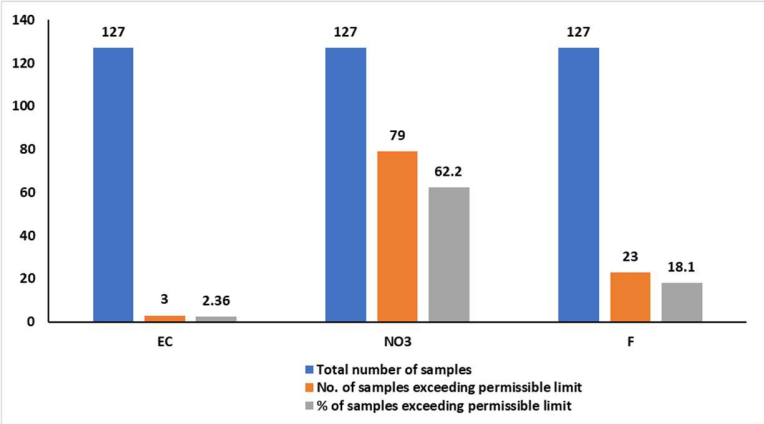

Figure 9. Graphical representation of state summary