GROUNDWATER CHEMICAL QUALITY BULLETIN, KARNATAKA, PRE- MONSOON 2024

ABSTRACT

A comprehensive analysis of groundwater across Karnataka was undertaken to evaluate contamination levels of specific basic and trace metal water quality parameters like Electrical conductivity, Nitrate, Fluoride, Uranium, Iron, Arsenic and Manganese. Analysis shows the temporal variation of these parameters during the period of 2019 to 2024 in pre-monsoon seasons. During 2023 and 2024 the trend stations were identified and sampling was carried out from these stations only.

During 2024 pre- monsoon, a total of 14.83 % of the water samples tested were found to be mineralised with electrical conductivity values exceeding 3000 µS/cm, whereas around 12.30 % having EC value less than 750 µS/cm could be marked as fresh in nature. However nitrate and fluoride appears as the prime concerns with 44.16% and 16.72% of contaminated samples respectively. Among trace metals Manganese appears to be the most prominent with 14.17% of the samples exceeding the permissible limit. Uranium (10.24%), Iron (2.36%), Arsenic (1.57%), Molybdenum (1 location), Selenium (3.15%) and Lead (1- location) are the other trace metals with elevated levels in the ground waters of the state.

Significantly higher levels of contaminations could be attributed to selective sampling from trend stations. Hence the analysis shows majority of the samples exceeding the permissible limits of various parameters as per BIS drinking water standards.

CGWB, SWR, Bengaluru

1.0 INTRODUCTION

Groundwater, a vital resource for socioeconomic development, provides potable water, irrigation, and industrial needs. Regions with limited surface water heavily rely on groundwater to meet their water demands. Excessive groundwater extraction, however, has depleted water levels and compromised water quality.

The geochemical properties of aquifers, influenced by rock and mineral composition, impact groundwater quality. Redox reactions can concentrate ions beyond safe limits. Anthropogenic activities like fertilizer use, urbanization, and industrial discharge further contaminate groundwater. Consumption of contaminated water leads to water-borne diseases, affecting a significant global population. Key inorganic contaminants in groundwater include salinity, fluoride, nitrate, arsenic, iron, and uranium. While arsenic contamination is less common in Karnataka, fluoride, nitrate, iron, and salinity are prevalent. Timely groundwater quality assessment is essential to protect public health.

Every year CGWB, SWR, Bengaluru collects water samples for analysis of crucial general parameters and trace metals in the month of May. Here an attempt has been made, aiming to

1. Present current ground water scenario of the state.
2. To mark the hotspots of poor- ground water quality.
3. To assess the trend or variation of water quality on a temporal basis using the water quality data of pre- monsoon season of the years 2024, 2023, 2022 and 2019.

2.0 Study Area

Karnataka is a south-western Indian state occupying a geographical area of 191,791 square kilometres. Bounded by the Arabian Sea to the west, Goa and Maharashtra to the north, Andhra Pradesh and Tamil Nadu to the east, and Kerala to the south, the state spans latitudes 11°31' N to 18°45' N and longitudes 74°12' E to 78°10' E. For administrative governance, the state is partitioned into 31 districts, which are further subdivided into 176 taluks.

Karnataka's hydrogeological landscape is characterized by a complex interplay of geological formations. The predominant lithological units encompass Precambrian crystalline rocks, represented by Peninsular Gneisses, Granites, and Dharwarian Schists, which constitute the bedrock of the state. Overlying these formations in the northern regions are the Deccan Trap basalts, a continuation of the extensive volcanic province. Sedimentary formations, including the Bhima and Kaladgi Groups, occupy relatively smaller areas in the northern districts. Recent alluvium is confined to coastal plains and river valleys. Figure 1, the Geological Map of Karnataka, provides a visual representation of these geological units. Hydrogeologically, Karnataka is primarily dependent on three aquifer systems:

Hard Rock Aquifers: Comprising Archean crystalline rocks and Deccan Traps, these aquifers exhibit varying degrees of porosity and permeability.

Sedimentary Aquifers: Primarily associated with the Bhima and Kaladgi formations, these aquifers offer potential for groundwater exploitation.

Minor Aquifers: Including laterites and alluvium, these formations contribute to local groundwater resources.

3.0 GROUND WATER QUALITY MONITORING

Groundwater quality monitoring involves sampling water from different aquifers to assess its chemical composition. It aims to understand regional water quality and create a baseline dataset for effective management and protection. The Central Ground Water Board (CGWB), SWR, Bengaluru office has implemented a bi-annual groundwater quality monitoring program since 2023. However, in earlier years sampling was only carried out during the month of May i.e., the pre-monsoon season. Water samples were collected for basic parameters- 317 and for trace metals- 127 in numbers from trend stations out of the National Hydrograph Stations distributed across the state during May 2024. This report presents a comparative analysis of groundwater quality trends observed in the years 2019, 2022, 2023 and 2024 pre-monsoon seasons within the CGWB observation well network. Spatial distribution of sampling locations has been given in figure 2 and 3 for basic and trace metals water quality parameters and the district wise numbers are furnished in table 1 and 2 respectively.

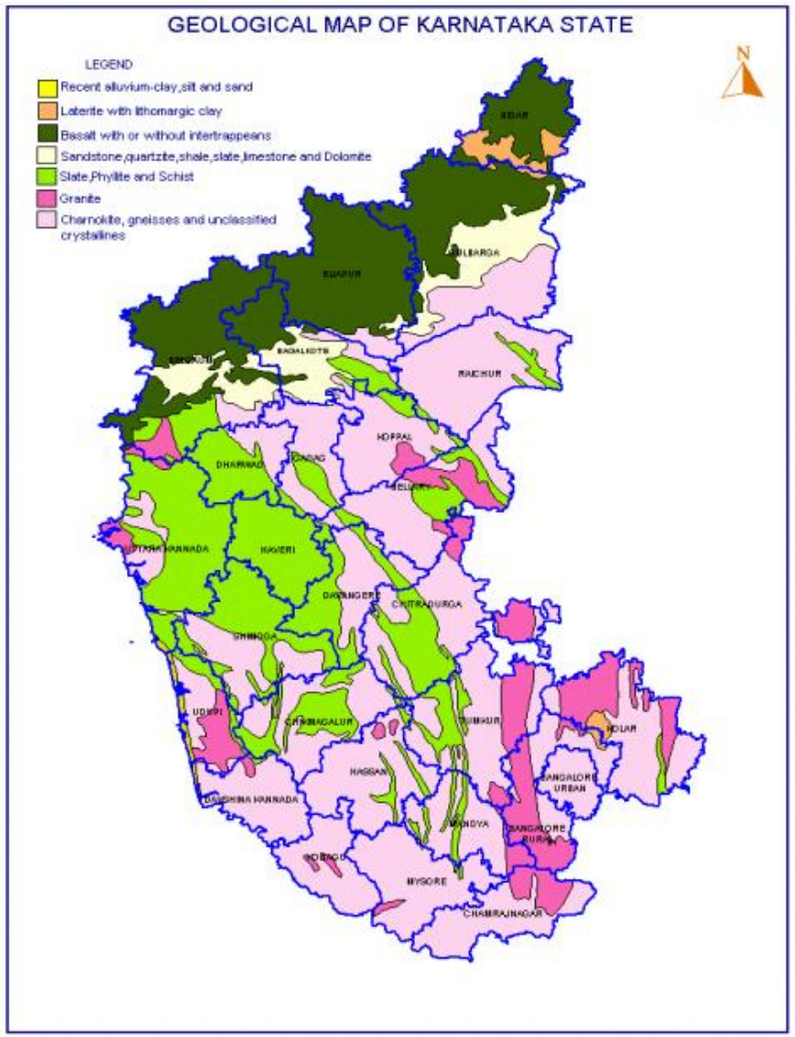


Figure 1: Geological Map of Karnataka

Table- 1 : District wise distribution of Basic water Quality Monitoring Stations

Sl.	District	No. of water quality monitoring stations			
		2019	2022	2023	2024
1	Bagalkot	14	26	7	15
2	Ballari	20	6	6	3
3	Belagavi	54	84	30	39
4	Bengaluru Rural	7	10	9	10
5	Bengaluru Urban	12	15	2	4
6	Bidar	16	18	6	8
7	Chamarajanagara	6	21	4	3
8	Chikkamagaluru	36	64	2	4
9	Chikkballapura	4	11	8	5
10	Chitradurga	9	28	19	10
11	Dakshina Kannada	86	90	0	1
12	Davanagere	35	24	20	8
13	Dharwad	5	22	9	8
14	Gadag	6	20	18	15
15	Hassan	42	71	2	6
16	Haveri	8	26	5	9
17	Kalaburagi	31	32	20	19
18	Kodagu	41	72	2	1
19	Kolar	19	24	22	15
20	Koppal	13	18	10	15
21	Mandya	30	41	21	20
22	Mysuru	28	59	22	18
23	Raichur	27	42	18	20
24	Ramanagara	11	26	5	2
25	Shivamogga	63	78	14	6
26	Tumakuru	22	44	14	12
27	Udupi	71	74	2	1
28	Uttara Kannada	63	80	3	2
29	Vijayanagara	0	19	4	2
30	Vijayapura	38	64	33	30
31	Yadgiri	16	15	8	6
	Total	833	1224	345	317

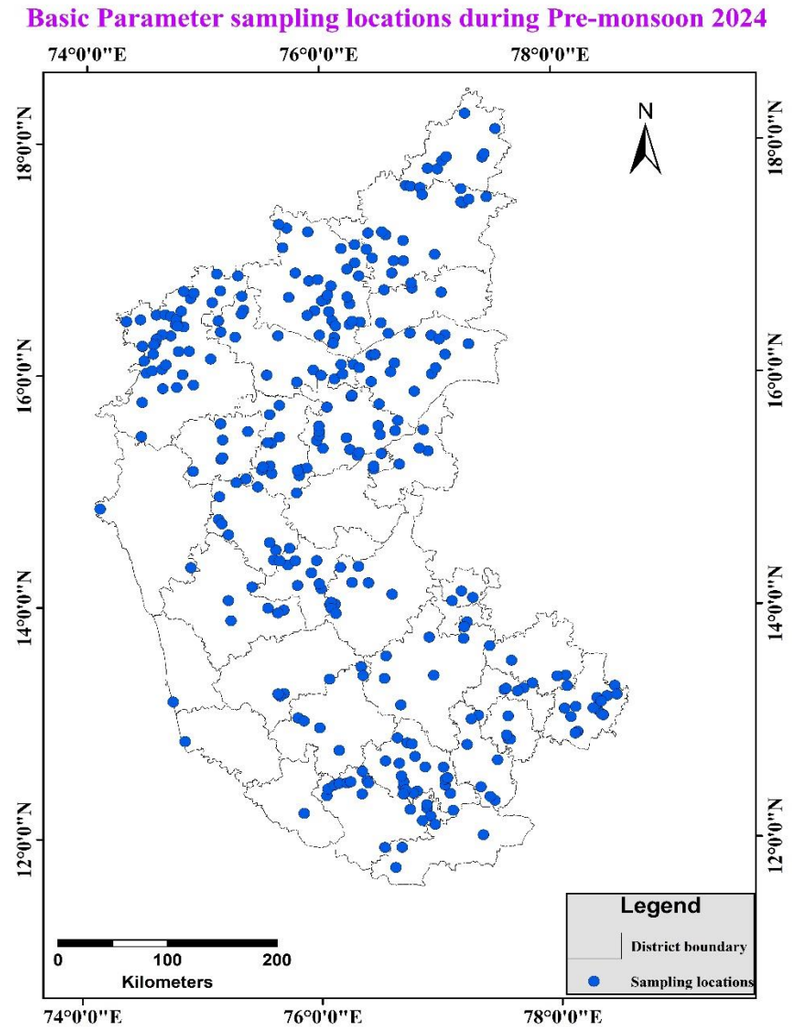


Figure 2: Ground water sampling locations for Basic parameters during May-2024

Table 2: District wise distribution of Basic water Quality Monitoring Stations- Trace metals

Sl No.	District	No. of samples collected		
		2019	2023	2024
1	Bagalkot	11	0	0
2	Ballari	18	1	2
3	Belagavi	54	4	4
4	Bengaluru Rural	7	0	2
5	Bengaluru Urban	11	1	2
6	Bidar	16	1	1
7	Chamarajanagara	6	1	1
8	Chikkamagaluru	36	2	2
9	Chikkballapura	4	1	2
10	Chitradurga	9	1	1
11	Dakshina Kannada	34	5	6
12	Davanagere	30	5	5
13	Dharwad	5	0	0
14	Gadag	6	1	1
15	Hassan	42	4	4
16	Haveri	8	1	1
17	Kalaburagi	31	2	3
18	Kodagu	40	1	1
19	Kolar	19	4	4
20	Koppal	13	10	10
21	Mandya	25	2	3
22	Mysuru	28	1	1
23	Raichur	27	22	24
24	Ramanagara	11	2	1
25	Shivamogga	51	9	8
26	Tumakuru	22	5	4
27	Udupi	66	8	8
28	Uttara Kannada	56	21	20
29	Vijayanagara	0	2	4
30	Vijayapura	35	0	0
31	Yadgiri	16	2	2
	Total	**737**	**119**	**127**

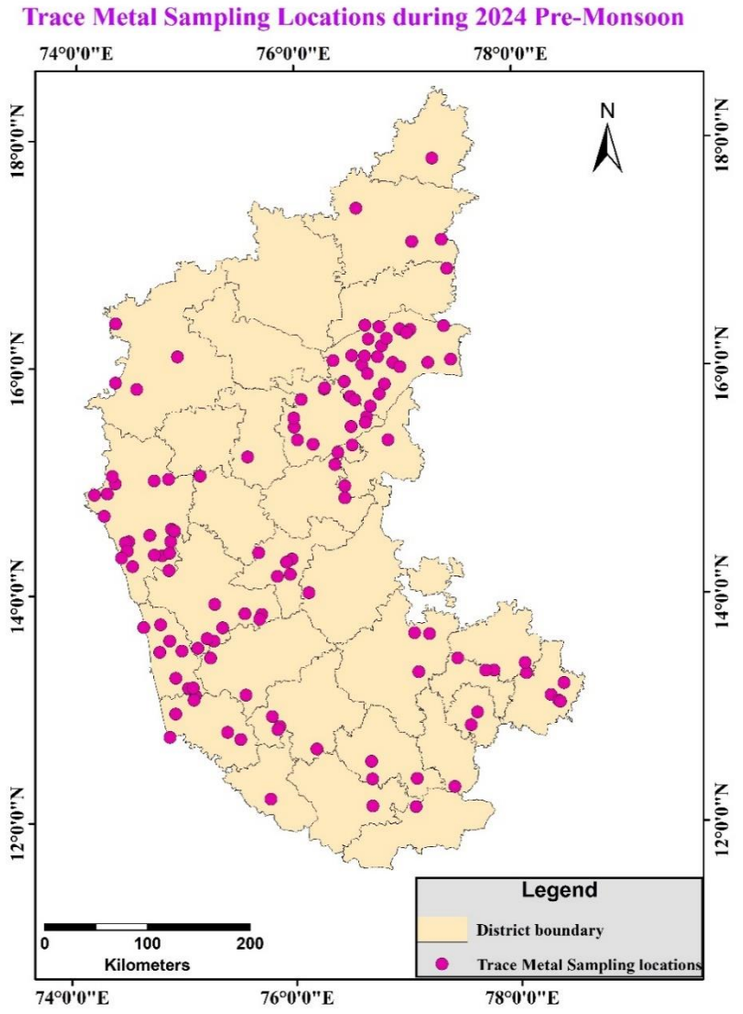


Figure 3: Ground water sampling locations for Trace Metals during May-2024

4.0 GROUND WATER QUALITY SCENARIO

The primary objective of groundwater quality monitoring is to assess its suitability for human consumption, given the established correlation between water quality and public health. In order to evaluate groundwater against prescribed standards, inorganic parameters including the trace metals are analysed in samples collected from phreatic aquifers, adhering to the guidelines outlined in IS:10500:2012 by the Bureau of Indian Standards.

Groundwater in Karnataka predominantly exhibits a Calcium-Magnesium Bicarbonate (Ca-Mg-HCO_3) facies when electrical conductivity (EC) values are below 750 µS/cm and in between 750 to 3000 µS/cm. Hence these waters could be considered as fresh in nature or having characteristics of rain water mostly. Waters with EC exceeding 3000 µS/cm typically exhibit a sodium chloride (Na-Cl) facies. Nevertheless, local hydro-geochemical variations induced by anthropogenic activities may result in deviations from these general classifications. Analysis reveals elevated concentrations of key water quality parameters, including salinity (EC), fluoride, nitrate, iron, manganese and uranium, within specific regions of Karnataka. These parameters exhibit spatial and temporal variability, necessitating further investigation to understand underlying causes and potential impacts.

4.1 QUALITY ASSESSMENT OF GROUNDWATER IN UNCONFINED AQUIFERS

Given the extensive reliance on unconfined aquifers for water supply and irrigation, their chemical quality is of critical importance. Key parameters influencing groundwater quality within these aquifers include TDS, fluoride, nitrate, iron, manganese, and uranium. The subsequent sections will analyse the presence and temporal variations of these constituents in groundwater samples collected during the years 2019, 2022 and 2023 National Hydrological Survey (NHS).

1. Electrical Conductivity (> 3000 µS/cm) at 25^0 C
2. Nitrate (>45 mg/litre)
3. Fluoride (>1.5 mg/litre)
4. Iron (>1.0 mg/litre)
5. Uranium (>30 ppb)
6. Manganese (>0.3 mg/litre)
7. Arsenic (> 10 ppb)

4.1.1 THE ELECTRICAL CONDUCTIVITY

Electrical conductivity (EC), a surrogate for Total Dissolved Solids (TDS) and salinity, quantifies the dissolved ion content of water. It reflects the combined ionic mobility of cations and anions, providing an indirect measure of water salinity. A general classification of water based on EC is as follows:

- Freshwater: EC < 1500 µS/cm
- Brackish water: EC 1500 - 15000 µS/cm
- Saline water: EC > 15000 µS/cm

While groundwater inherently contains varying levels of salinity influenced by aquifer lithology, mineral solubility, residence time, soil permeability, drainage conditions, rainfall, and climate, the Bureau of Indian Standards (BIS) recommends a TDS limit of 500 mg/L (equivalent to approx. 750 µS/cm at 25°C) for drinking water. In the absence of alternative sources, this limit can be relaxed to 2000 mg/L (approx. 3000 µS/cm at 25°C). Waters exceeding 2000 mg/L TDS are generally unsuitable for potable consumption.

PRESENT DAY SCENARIO IN KARNATAKA W.R.T EC IN KARNATAKA

The electrical conductivity (EC) of groundwater in the state exhibits a wide range, spanning from a minimum of 60 µS/cm at Gartikere, Shivamogga district to a maximum of 10100 µS/cm at Algur, Bagalkot district. A categorization of groundwater samples based on EC reveals the following distribution: EC < 750 µS/cm – 12.30%, EC between 750- 3000 µS/cm- 72.87% and EC > 3000 µS/cm- 14.83%.

Figure 4 shows the spatial distribution of electrical conductivity in the phreatic aquifer of Karnataka. Table 3 provides for the number of samples analysed per district, along with their minimum, maximum, and mean EC values based on NHS 2024 pre-monsoon data. Groundwater with EC values less than 750 µS/cm is majorly restricted to western coastal and hilly regions like Udupi, Dakshina Kannada, Uttar Kannada, Chikkamagaluru, Kodagu and Shivamogga. Ground water in most of the parts of the state falls in the EC range of 750 to 3000 µS/cm. Parts of Raichur, Chitradurga, Vijayapura, Bagalkot, Yadgiri, Gadag, Dharwad, Vijayanagara, Koppal, Belagavi and Ballari districts exhibit saline characteristics with EC values exceeding 3000 µS/cm, rendering it unsuitable for potable consumption. Table 4 shows the district wise no. of locations exceeding the value of 3000 µS/cm and the year wise variation of the percentage of samples exceeding the EC value of 3000 µS/cm has been given in table 5.

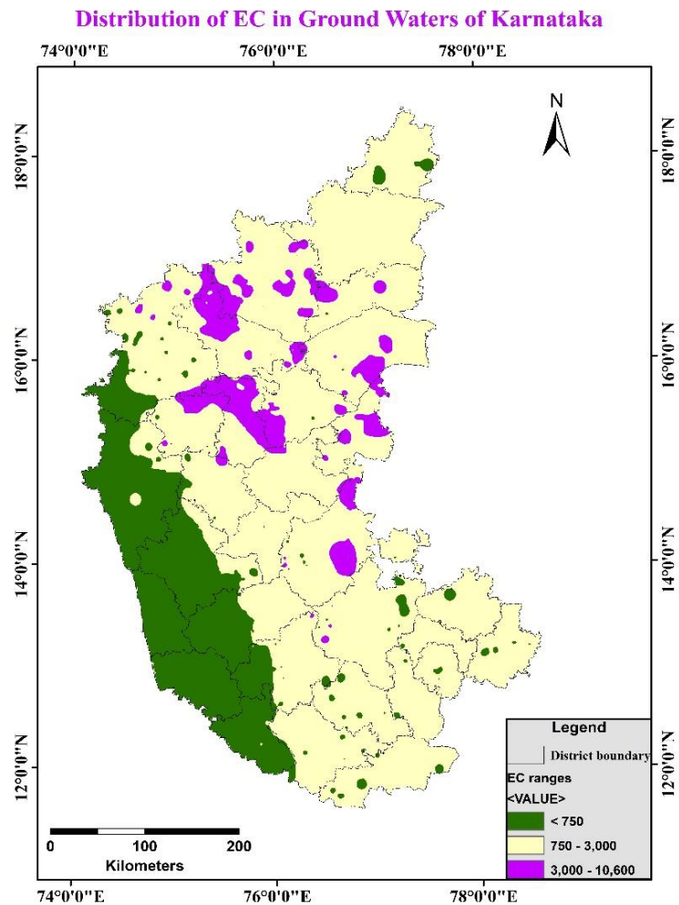


Figure 4: Distribution of EC in Ground waters of Karnataka during May-2024

Table 3: District wise Range and distribution of EC in µS/Cm at 25^0 C in shallow GW of Karnataka

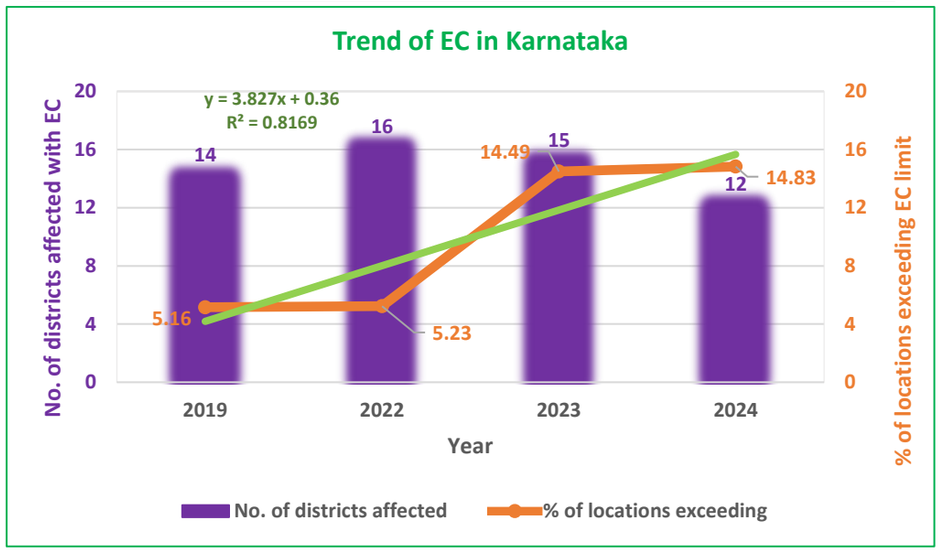
Sl.no	District	No of samples analysed	Permissible Limit (µS/Cm)	Min	Max	Mean	No. of samples (%)		
							<750	750-3000	>3000
1	Bagalkot	15	3000	106	10100	3229	0.0	60.0	40.0
2	Ballari	3	3000	106	8060	3618	0.0	66.7	33.3
3	Belagavi	39	3000	220	6520	1674	12.8	76.9	10.3
4	Bengaluru Rural	10	3000	777	2018	1510	0.0	100.0	0.0
5	Bengaluru Urban	4	3000	545	1748	1080	25.0	75.0	0.0
6	Bidar	8	3000	290	1245	834	37.5	62.5	0.0
7	Chamarajanagar	3	3000	172	2230	1943	0.0	100.0	0.0
8	Chikkamagaluru	4	3000	370	2000	863	75.0	25.0	0.0
9	Chikkballapura	5	3000	143	2042	1768	0.0	100.0	0.0
10	Chitradurga	10	3000	103	4140	2672	0.0	60.0	40.0
11	Dakshina	1	3000	510	510	510	100.0	0.0	0.0
12	Davanagere	8	3000	920	2790	1733	0.0	100.0	0.0
13	Dharwad	8	3000	200	8048	4016	0.0	50.0	50.0
14	Gadag	15	3000	100	8014	2677	0.0	66.7	33.3
15	Hassan	6	3000	420	2460	1135	50.0	50.0	0.0
16	Haveri	9	3000	292	2040	1496	11.1	88.9	0.0
17	Kalaburagi	19	3000	905	2990	1612	0.0	100.0	0.0
18	Kodagu	1	3000	125	1250	1250	0.0	100.0	0.0
19	Kolar	15	3000	170	3018	1477	20.0	73.3	6.7
20	Koppal	15	3000	425	5900	2303	6.7	66.7	26.7
21	Mandya	20	3000	240	2150	1042	35.0	65.0	0.0
22	Mysuru	18	3000	500	2280	1381	5.6	94.4	0.0
23	Raichur	20	3000	580	6600	2854	5.0	65.0	30.0
24	Ramanagara	2	3000	594	1391	993	50.0	50.0	0.0
25	Shivamogga	6	3000	60	1380	836	33.3	66.7	0.0
26	Tumakuru	12	3000	720	3720	1790	8.3	83.3	8.3
27	Udupi	1	3000	120	120	120	100.0	0.0	0.0
28	Uttara Kannada	2	3000	100	500	300	100.0	0.0	0.0
29	Vijayanagara	2	3000	110	2700	1900	0.0	100.0	0.0
30	Vijayapura	30	3000	600	5940	2596	3.3	63.3	33.3
31	Yadgiri	6	3000	350	3130	1568	16.7	66.7	16.7
	Grand Total	**317**					**12.3**	**72.9**	**14.8**

Table 4: Comparative Change in number of locations having EC > 3000 µS/Cm

Sl. No.	District	No. of locations having EC > 3000			
		2019	2022	2023	2024
1	Bagalkot	3	11	1	6
2	Ballari	4	2	1	1
3	Belagavi	5	4	5	4
4	Bengaluru Rural	0	0	0	0
5	Bengaluru Urban	0	0	0	0
6	Bidar	0	0	0	0
7	Chamarajanagar	0	0	1	0
8	Chikkamagaluru	1	1	1	0
9	Chikkballapura	0	0	0	0
10	Chitradurga	3	4	6	4
11	Dakshina Kannada	1	0	0	0
12	Davanagere	1	0	1	0
13	Dharwad	0	3	3	4
14	Gadag	1	9	8	5
15	Hassan	0	1	0	0
16	Haveri	0	1	0	0
17	Kalaburagi	2	0	0	0
18	Kodagu	0	0	0	0
19	Kolar	0	1	0	1
20	Koppal	4	3	4	4
21	Mandya	0	0	0	0
22	Mysuru	0	0	0	0
23	Raichur	5	3	5	6
24	Ramanagara	0	0	0	0
25	Shivamogga	0	0	0	0
26	Tumakuru	1	3	1	1
27	Udupi	1	0	0	0
28	Uttara Kannada	0	0	0	0
29	Vijayanagara	0	3	2	0
30	Vijayapura	10	13	8	10
31	Yadgiri	1	2	3	1
	Total	**43**	**64**	**50**	**47**

Table 5: Periodic variation in suitability Classes of groundwater in EC

Parameter	Class	Percentage of samples			
		2019	2022	2023	2024
		n= 833	n=1224	n= 345	n=317
EC in µS/cm	< 750	50.78	46.24	13.91	12.3
	750 - 3000	44.06	48.53	71.59	72.87
	> 3000	5.16	5.23	14.49	14.83



4.1.2 NITRATE

Nitrate, a naturally occurring species formed through the atmospheric nitrogen fixation process, is primarily introduced into groundwater via anthropogenic activities, including agricultural runoff (fertilizers and animal manure) and sewage discharge. The differentiation between natural and anthropogenic nitrate sources often presents analytical challenges. In-situ biogeochemical processes, such as nitrification and denitrification, significantly influence nitrate concentrations within the aquifer system. The Bureau of Indian Standards (BIS) has established a maximum permissible limit (MPL) of 45 mg/L for nitrate in drinking water. While nitrate itself exhibits relatively low toxicity, elevated concentrations pose a significant health risk, particularly for infants due to the potential for methemoglobinemia. Adults demonstrate a higher tolerance to nitrate exposure.

PRESENT DAY SCENARIO AND TEMPORAL VARIATION OF NITRATE IN KARNATAKA

In the State, nitrate in ground water samples varied from BDL to 909 mg/L observed at Bailuru of Ballari district. BIS permits a maximum concentration of 45 mg/L nitrate in drinking water. Almost 44.16% of the locations exceeded the permissible limit of nitrate. Apart from the majority of western coastal region and parts of Chikkamagaluru, Hassan, Shivamogga, excess nitrate concentration was seen in all over the state (figure 5). Table 6 shows the district wise maximum, minimum, mean and percentage of samples exceeding the permissible limit. Table 7 shows the district wise no. of locations exceeding the permissible limit and the year wise variation of the percentage of samples exceeding the nitrate permissible limit has been given in table 8.

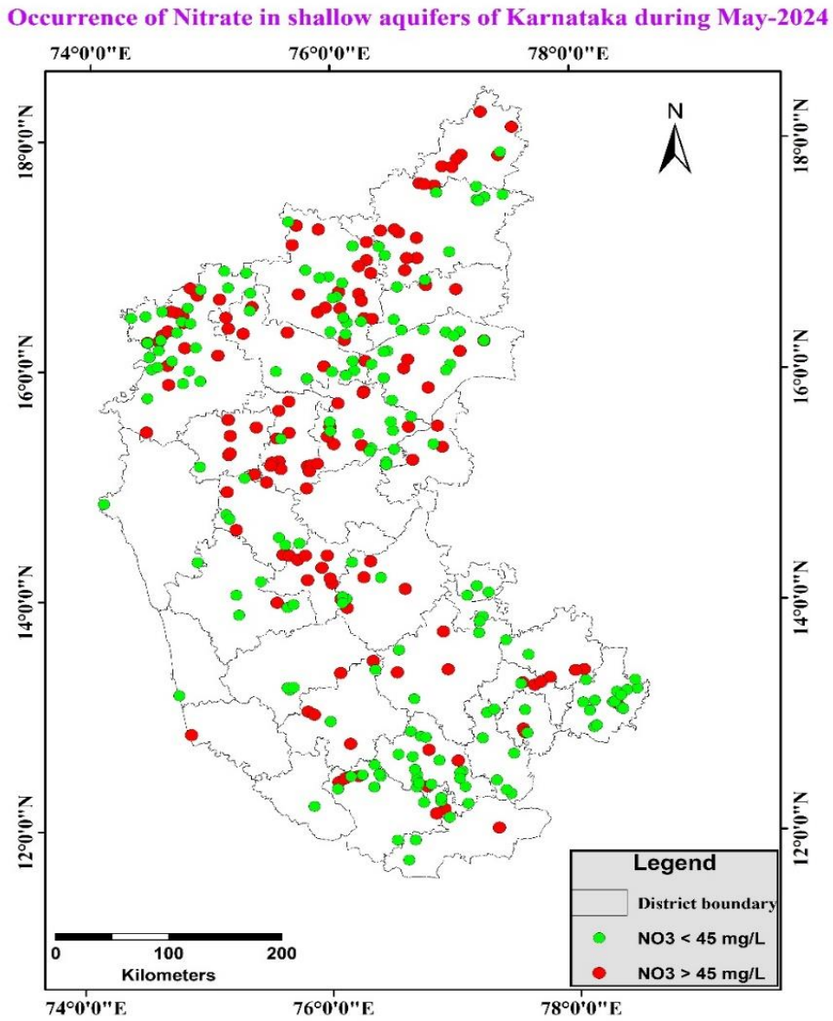


Figure 5: Occurrence of Nitrate in Ground waters of Karnataka during May-2024

Table 6: District wise Range and distribution of Nitrate in shallow GW of Karnataka

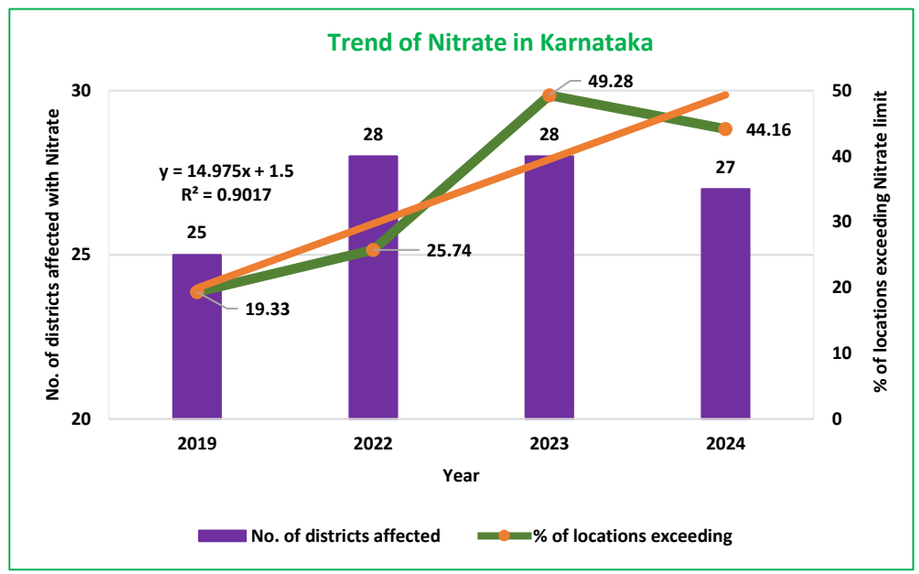
Sl. No	District	No of samples analysed	Desirable limit (mg/L)	Min	Max	Mean	No. of samples (%)	
							<45	>45
1	Bagalkot	15	45	3	128	51	53.3	46.7
2	Ballari	3	45	24	909	410	33.3	66.7
3	Belagavi	39	45	0	212	48	59.0	41.0
4	Bengaluru Rural	10	45	8	162	60	60.0	40.0
5	Bengaluru Urban	4	45	22	64	40	50.0	50.0
6	Bidar	8	45	28	125	74	12.5	87.5
7	Chamarajanagar	3	45	33	93	54	66.7	33.3
8	Chikkamagaluru	4	45	24	81	45	75.0	25.0
9	Chikkballapura	5	45	21	77	43	60.0	40.0
10	Chitradurga	10	45	5	218	65	50.0	50.0
11	Dakshina Kannada	1	45	79	79	79	0.0	100.0
12	Davanagere	8	45	49	292	130	0.0	100.0
13	Dharwad	8	45	3	173	122	12.5	87.5
14	Gadag	15	45	4	184	98	6.7	93.3
15	Hassan	6	45	11	74	47	33.3	66.7
16	Haveri	9	45	2	123	45	66.7	33.3
17	Kalaburagi	19	45	1	168	61	47.4	52.6
18	Kodagu	1	45	16	16	16	100.0	0.0
19	Kolar	15	45	1	63	17	93.3	6.7
20	Koppal	15	45	1	692	135	53.3	46.7
21	Mandya	20	45	2	161	33	85.0	15.0
22	Mysuru	18	45	4	221	49	72.2	27.8
23	Raichur	20	45	5	493	97	70.0	30.0
24	Ramanagara	2	45	3	3	3	100.0	0.0
25	Shivamogga	6	45	1	45	14	83.3	16.7
26	Tumakuru	12	45	2	188	37	75.0	25.0
27	Udupi	1	45	10	10	10	100.0	0.0
28	Uttara Kannada	2	45	2	42	22	100.0	0.0
29	Vijayanagara	2	45	12	246	129	50.0	50.0
30	Vijayapura	30	45	2	324	73	43.3	56.7
31	Yadgiri	6	45	10	111	44	66.7	33.3
	Grand Total	**317**					**55.8**	**44.2**

Table 7: Comparative Change in number of locations having Nitrate > 45 mg/L

Sl. No.	District	No. of location having NO3 > 45mg/L			
		2019	2022	2023	2024
1	Bagalkot	5	15	3	7
2	Ballari	5	5	2	2
3	Belagavi	22	32	11	16
4	Bengaluru Rural	5	9	6	4
5	Bengaluru Urban	7	2	0	2
6	Bidar	1	7	5	7
7	Chamarajanagar	2	5	3	1
8	Chikkamagaluru	2	0	0	1
9	Chikkballapura	1	7	4	2
10	Chitradurga	3	19	13	5
11	Dakshina Kannada	0	0	0	1
12	Davanagere	4	4	4	8
13	Dharwad	3	7	7	7
14	Gadag	3	11	13	14
15	Hassan	0	0	1	4
16	Haveri	0	5	3	3
17	Kalaburagi	20	17	13	10
18	Kodagu	0	2	2	0
19	Kolar	8	19	13	1
20	Koppal	4	7	7	7
21	Mandya	5	23	3	3
22	Mysuru	4	33	11	5
23	Raichur	7	13	13	6
24	Ramanagara	5	4	4	0
25	Shivamogga	3	3	1	1
26	Tumakuru	3	9	1	3
27	Udupi	2	2	1	0
28	Uttara Kannada	1	1	1	0
29	Vijayanagara	0	10	2	1
30	Vijayapura	29	39	18	17
31	Yadgiri	7	5	5	2
	Total	**161**	**315**	**170**	**140**

Table 8: Periodic variation in suitability Classes of groundwater in Nitrate

Parameter	Class	Percentage of samples			
		2019	2022	2023	2024
Nitrate in mg/L		n= 833	n=1224	n= 345	n=317
	< 45	80.67	74.26	50.72	55.84
	> 45	19.33	25.74	49.28	44.16



4.1.3 FLUORIDE

Fluorine, a highly reactive element, exists primarily as fluoride ions in mineral form. Through weathering and dissolution processes, these fluoride ions are released into groundwater. The concentration of fluoride in groundwater is influenced by geological factors including rock type, climate, and the duration of water-rock interaction. Excessive fluoride intake can lead to dental and skeletal fluorosis.

To safeguard public health, the Bureau of Indian Standards (BIS) has established permissible limits of 1.5mg/L and desirable limit of 1 mg/L for fluoride in drinking water. While low fluoride levels are beneficial for dental health, surpassing these limits poses significant health risks. Implementing effective de- fluoridation technologies is crucial in regions affected by high fluoride concentrations.

PRESENT DAY SCENARIO AND TEMPORAL VARIATION OF FLUORIDE IN KARNATAKA

An analysis of groundwater samples revealed that 63.72% of samples fell within the desirable range of < 1.0 mg/L, 19.56% between the desirable and permissible range of 1.5 mg/L and 16.72% exceeded the permissible limit. The geographical distribution map (figure 6) indicates that groundwater with excess fluoride levels is predominantly found in the districts of Gadag, Raichur, Ballari, Yadgiri, Tumakuru, Koppal, Bagalkot, Dharwad and Vijayapura. It is notable that the western coastal region and parts of the western districts are free from fluoride contamination. The maximum concentration of 4.58 mg/L was observed at Badakanakoppalu, Mysuru district. The district wise maxima, minima, mean and percentage of samples exceeding the permissible limit has been given in table 9. Table 10 shows the no. of locations affected by fluoride contamination from 2019 to 2024. Table 11 gives the Periodic variation in suitability Classes of Fluoride in groundwater samples of Karnataka.

Table: 9: District wise Range and distribution of Fluoride in shallow GW of Karnataka

Sl.No	District	No of samples analysed	Permissible Limit	Min	Max	Mean	No. of samples (%)	
			(mg/L)				<1.5	>1.5
1	Bagalkot	15	1.5	0.18	3.18	1.30	66.7	33.3
2	Ballari	3	1.5	0.85	1.88	1.35	66.7	33.3
3	Belagavi	39	1.5	0.02	1.24	0.36	100.0	0.0
4	Bengaluru Rural	10	1.5	0.17	1.50	0.83	100.0	0.0
5	Bengaluru Urban	4	1.5	0.12	0.69	0.46	100.0	0.0
6	Bidar	8	1.5	0.13	0.87	0.36	100.0	0.0
7	Chamarajanagar	3	1.5	0.05	0.53	0.36	100.0	0.0
8	Chikkamagaluru	4	1.5	0.03	0.18	0.09	100.0	0.0
9	Chikkballapura	5	1.5	0.68	1.53	1.25	80.0	20.0
10	Chitradurga	10	1.5	0.04	1.53	0.37	90.0	10.0
11	Dakshina Kannada	1	1.5	0.07	0.07	0.07	100.0	0.0
12	Davanagere	8	1.5	0.28	1.80	0.86	87.5	12.5
13	Dharwad	8	1.5	0.97	1.98	1.30	75.0	25.0
14	Gadag	15	1.5	0.55	2.04	1.49	40.0	60.0
15	Hassan	6	1.5	0.02	1.28	0.45	100.0	0.0
16	Haveri	9	1.5	0.00	1.75	0.78	88.9	11.1
17	Kalaburagi	19	1.5	0.10	2.26	0.75	89.5	10.5
18	Kodagu	1	1.5	0.62	0.62	0.62	100.0	0.0
19	Kolar	15	1.5	0.35	1.49	0.98	100.0	0.0
20	Koppal	15	1.5	0.04	2.21	1.03	80.0	20.0
21	Mandya	20	1.5	0.00	1.46	0.54	100.0	0.0
22	Mysuru	18	1.5	0.02	4.58	0.73	94.4	5.6
23	Raichur	20	1.5	0.10	3.77	1.60	60.0	40.0
24	Ramanagara	2	1.5	2.12	2.78	2.45	0.0	100.0
25	Shivamogga	6	1.5	0.15	1.23	0.44	100.0	0.0
26	Tumakuru	12	1.5	0.22	4.36	1.59	50.0	50.0
27	Udupi	1	1.5	0.06	0.06	0.06	100.0	0.0
28	Uttara Kannada	2	1.5	0.06	0.08	0.07	100.0	0.0
29	Vijayanagara	2	1.5	0.40	1.37	0.88	100.0	0.0
30	Vijayapura	30	1.5	0.00	3.66	1.05	76.7	23.3
31	Yadgiri	6	1.5	0.23	2.28	1.38	50.0	50.0
	Grand Total	**317**					**83.3**	**16.7**

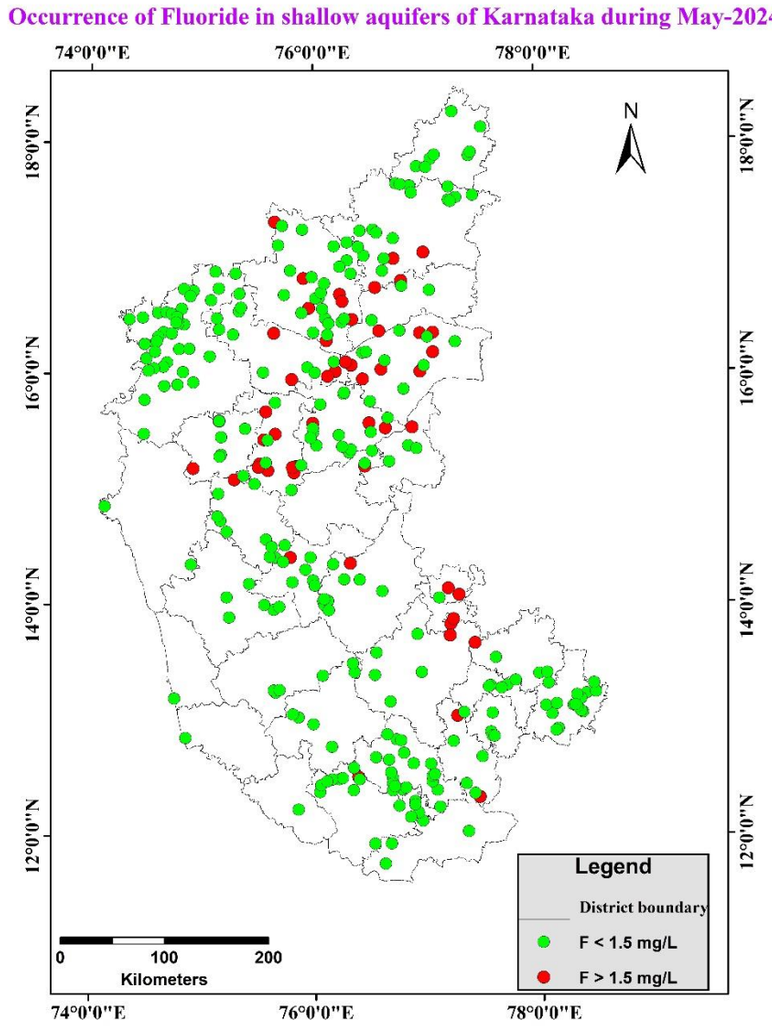


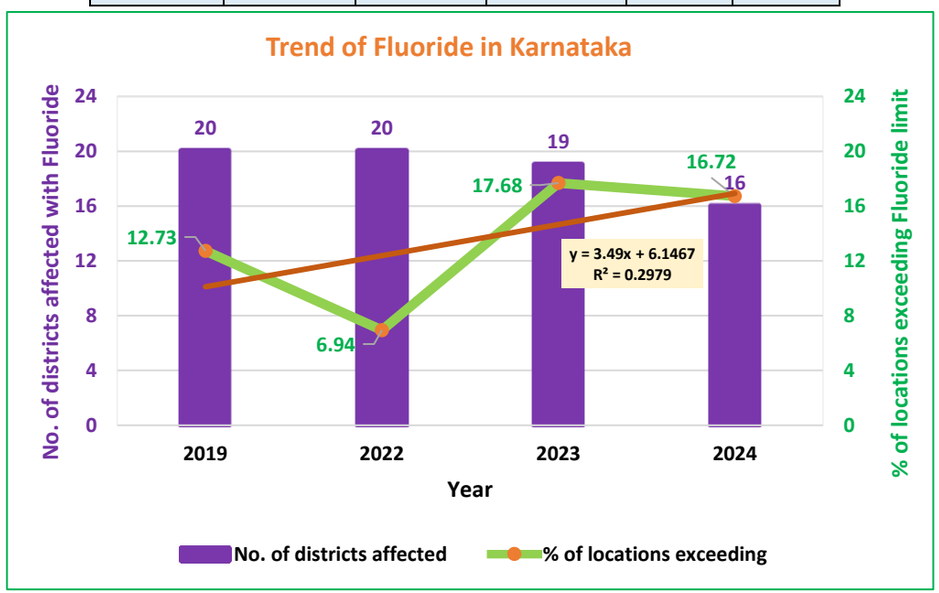
Figure 6: Occurrence of Fluoride in in Ground waters of Karnataka during May-2024

Table 10: Comparative Change in number of locations having Fluoride > 1.5 mg/L

Sl. No.	District	No. of location having F> 1.5 mg/L			
		2019	2022	2023	2024
1	Bagalkot	5	6	0	5
2	Ballari	9	1	4	1
3	Belagavi	0	0	0	0
4	Bengaluru Rural	0	0	1	0
5	Bengaluru Urban	2	0	0	0
6	Bidar	4	0	0	0
7	Chamarajanagar	0	0	0	0
8	Chikkamagaluru	1	2	0	0
9	Chikkballapura	0	3	1	1
10	Chitradurga	3	3	2	1
11	Dakshina Kannada	0	0	0	0
12	Davanagere	18	6	3	1
13	Dharwad	0	0	1	2
14	Gadag	3	6	9	9
15	Hassan	2	1	0	0
16	Haveri	2	0	1	1
17	Kalaburagi	6	4	1	2
18	Kodagu	0	0	0	0
19	Kolar	3	3	4	0
20	Koppal	5	6	4	3
21	Mandya	2	4	1	0
22	Mysuru	1	1	1	1
23	Raichur	13	16	9	8
24	Ramanagara	1	1	1	2
25	Shivamogga	0	1	0	0
26	Tumakuru	1	5	5	6
27	Udupi	0	0	0	0
28	Uttara Kannada	2	0	0	0
29	Vijayanagara	0	4	1	0
30	Vijayapura	12	7	7	7
31	Yadgiri	11	5	5	3
	Total	106	85	61	53

Table 11: Periodic variation in suitability Classes of groundwater in Fluoride

Parameter	Class	Percentage of samples			
		2019	2022	2023	2024
Fluoride in mg/L		n= 833	n=1224	n= 345	n=317
	< 1.5	87.27	93.06	82.32	83.28
	> 1.5	12.73	6.94	17.68	16.72



4.1.4 IRON

Iron is a ubiquitous element commonly encountered in both soil and groundwater matrices. Its solubility is dependent on its oxidation state, with ferrous iron (Fe^{2+}) exhibiting higher solubility compared to ferric iron (Fe^{3+}). Ferrous iron imparts a clear appearance to water, while oxidation to ferric hydroxide results in turbidity and characteristic reddish-brown coloration. The geochemical mobilization of iron into groundwater is primarily attributed to the weathering of iron-bearing minerals found in igneous, sedimentary, and metamorphic rocks. Hematite, magnetite, and sulphide ores are significant sources of iron. The Bureau of Indian Standards (BIS) has established a maximum permissible limit of 1.0 mg/L for iron concentration in potable water. Exceeding this threshold can adversely affect water quality parameters such as taste, odour, and aesthetic appearance.

PRESENT DAY SCENARIO AND TEMPORAL VARIATION OF IRON IN KARNATAKA

The iron content in ground water ranges from BDL to 2.939 mg/L, the highest was observed at Nujje of Uttara Kannada district. Out of the 127 samples analysed 3 samples exceeded the permissible limit as per BIS drinking water quality standards which accounts 2.36 %. Figure 7 depicts the distribution of iron in the shallow aquifers of Karnataka during May 2024. From the distribution map it is clear that high iron content is only limited to the 3 coastal districts, Uttar Kannada, Dakshina Kannada and Udupi. Table 12 shows the District wise range and distribution of Iron in the ground waters during May- 2024. Table 13 shows comparative Change in number of Locations having Fe > 1.0 mg/L and table 14, Periodic variation in suitability classes of Iron in groundwater during 2019, 2023 and 2024 pre-monsoon seasons.

Table 12: District wise Range and distribution of Iron in shallow aquifers of Karnataka

Sl. No.	District	No. of samples collected	Desirable limit mg/L	Min	Max	Mean	No. of samples (%)	
							Fe < 1 mg/L	Fe > 1 mg/L
1	Ballari	2	1	0.010	0.029	0.020	100.0	0.0
2	Belagavi	4	1	0.005	0.142	0.050	100.0	0.0
3	Bengaluru Rural	2	1	0.001	0.017	0.009	100.0	0.0
4	Bengaluru Urban	2	1	0.027	0.044	0.036	100.0	0.0
5	Bidar	1	1	0.000	0.000	0.000	100.0	0.0
6	Chamarajanagar	1	1	0.000	0.000	0.000	100.0	0.0
7	Chikkamagaluru	2	1	0.017	0.037	0.027	100.0	0.0
8	Chikkballapura	2	1	0.004	0.007	0.006	100.0	0.0
9	Chitradurga	1	1	0.025	0.025	0.025	100.0	0.0
10	Dakshina Kannada	6	1	0.004	1.182	0.219	83.3	16.7
11	Davanagere	5	1	0.006	0.368	0.081	100.0	0.0
12	Gadag	1	1	0.000	0.000	0.000	100.0	0.0
13	Hassan	4	1	0.015	0.524	0.158	100.0	0.0
14	Haveri	1	1	0.010	0.010	0.010	100.0	0.0
15	Kalaburagi	3	1	0.000	0.000	0.000	100.0	0.0
16	Kodagu	1	1	0.005	0.005	0.005	100.0	0.0
17	Kolar	4	1	0.003	0.072	0.025	100.0	0.0
18	Koppal	10	1	0.002	0.026	0.007	100.0	0.0
19	Mandya	3	1	0.002	0.028	0.012	100.0	0.0
20	Mysuru	1	1	0.005	0.005	0.005	100.0	0.0
21	Raichur	24	1	0.000	0.254	0.023	100.0	0.0
22	Ramanagara	1	1	0.006	0.006	0.006	100.0	0.0
23	Shivamogga	8	1	0.003	0.257	0.056	100.0	0.0
24	Tumakuru	4	1	0.006	0.216	0.062	100.0	0.0
25	Udupi	8	1	0.004	1.420	0.224	87.5	12.5
26	Uttara Kannada	20	1	0.001	2.939	0.208	95.0	5.0
27	Vijayanagara	4	1	0.000	0.011	0.006	100.0	0.0
28	Yadgiri	2	1	0.000	0.021	0.011	100.0	0.0
	Grand Total	**127**					**97.6**	**2.4**

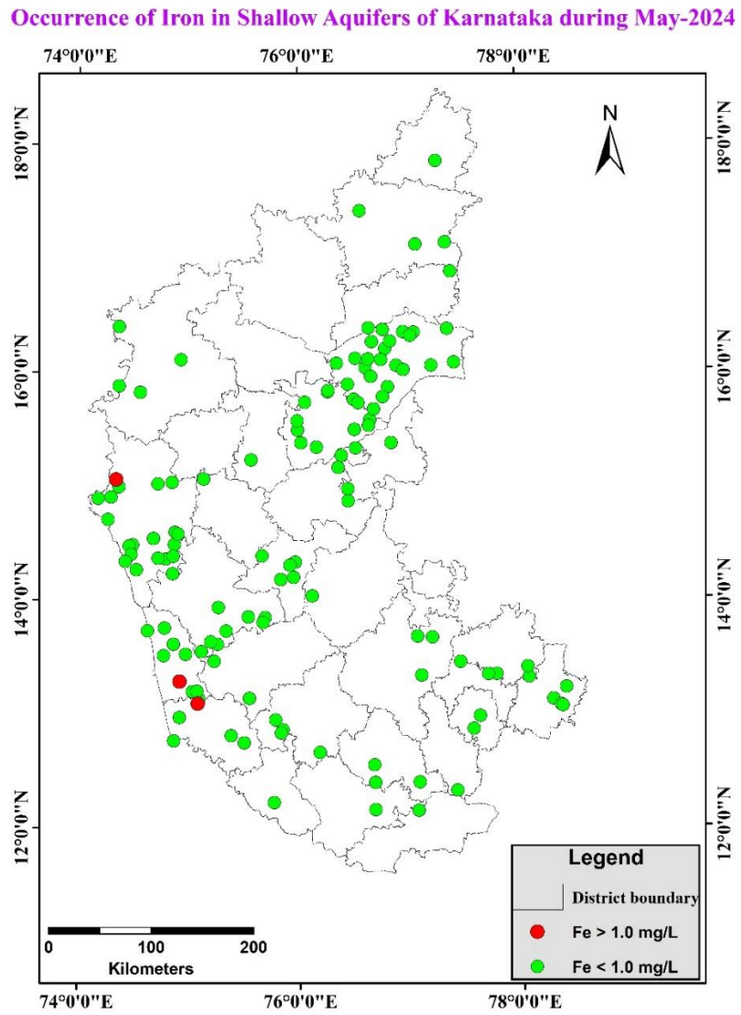


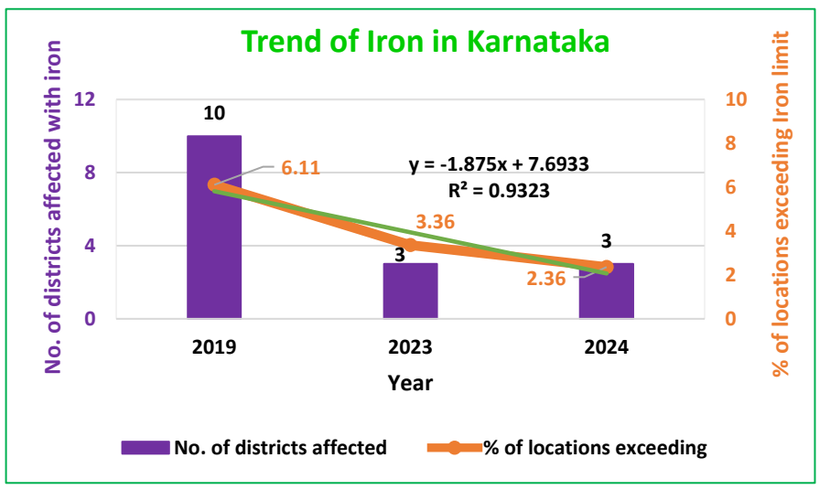
Figure 7: Occurrence of Iron in Ground waters of Karnataka during May-2024

Table 13: Comparative Change in number of locations having Iron > 1.0 mg/L

Sl. No.	Districts	No. of locations exceeding		
		2019	2023	2024
1	Chikkamagaluru	1	0	0
2	Dakshina Kannada	1	1	1
3	Hassan	2	0	0
4	Kolar	1	0	0
5	Koppal	3	0	0
6	Raichur	12	0	0
7	Shivamogga	5	0	0
8	Tumakuru	1	0	0
9	Udupi	6	2	1
10	Uttara Kannada	13	1	1
	Grand Total	**45**	**4**	**3**

Table 14: Periodic variation in suitability Classes of groundwater in Iron

Parameter	Class	Percentage of samples		
Iron in mg/L		2019	2023	2024
		n= 737	n=119	n=127
	< 1.0	93.89	96.64	97.64
	> 1.0	6.11	3.36	2.36



4.1.5 URANIUM

Uranium, a naturally occurring radioactive element, is ubiquitously present in both groundwater and surface water bodies. Anthropogenic sources, including nuclear industry effluents, coal combustion by-products, and phosphate fertilizer runoff, exacerbate natural uranium levels. Human exposure primarily occurs through ingestion of contaminated water and food, inhalation, and occupational contact. Exceeding the BIS standard of 30 ppb uranium in drinking water poses a significant health risk, with potential for chronic kidney damage.

PRESENT DAY SCENARIO AND TEMPORAL VARIATION OF URANIUM IN KARNATAKA

The uranium content in ground water ranges from 0 to 721.553 ppb recorded at Badavanahalli of Tumakuru district. Uranium concentration of more than 30 ppb has been recorded in 13 (10.24%) locations in the districts of Raichur, Tumakuru, Chikkballapura, Bengaluru Rural, Ballari, Vijayanagara and Kolar. Figure 8 shows the occurrence of uranium in the shallow aquifers of the state during 2024 pre- monsoon and table 15 shows the district wise ranges, minimum, maximum, and mean of uranium. Table 16 and 17 show the Comparative Change in number of Locations having U>30ppb and Periodic variation in suitability Classes of Uranium content in groundwater respectively during 2019, 2023 and 2024 pre-monsoon seasons. However, during 2023 and 2024 samples were only collected from trend stations.

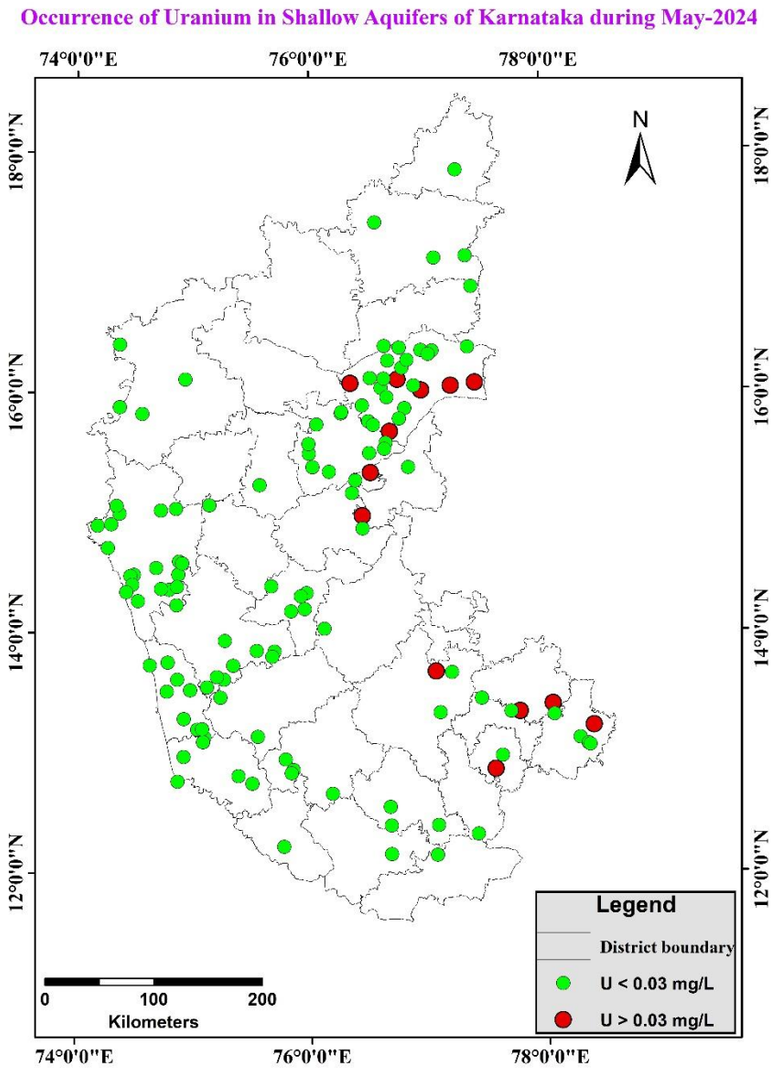


Figure 8: Occurrence of Uranium in Ground waters of Karnataka during May-2024

Table 15: District wise Range and distribution of Uranium in shallow aquifers of Karnataka

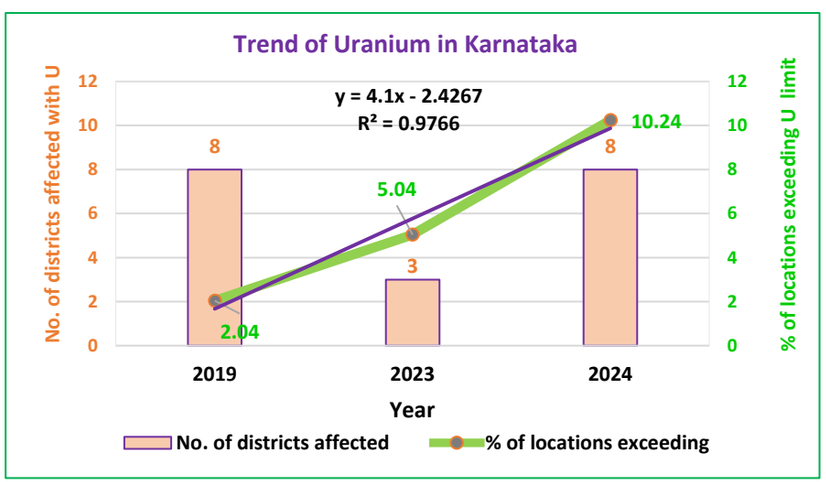
Sl. No.	District	No. of samples collected	Permissible limit in ppb	Min	Max	Mean	No. of samples (%)	
							U < 30 ppb	U > 30 ppb
1	Ballari	2	30	4.484	180.149	92.317	50.0	50.0
2	Belagavi	4	30	0.233	1.551	0.834	100.0	0.0
3	Bengaluru Rural	2	30	17.018	101.227	59.123	50.0	50.0
4	Bengaluru Urban	2	30	3.951	55.644	29.798	50.0	50.0
5	Bidar	1	30	0.000	0.000	0.000	100.0	0.0
6	Chamarajanagar	1	30	7.216	7.216	7.216	100.0	0.0
7	Chikkamagaluru	2	30	0.000	0.000	0.000	100.0	0.0
8	Chikkballapura	2	30	20.675	488.078	254.377	50.0	50.0
9	Chitradurga	1	30	13.652	13.652	13.652	100.0	0.0
10	Dakshina Kannada	6	30	0.000	0.000	0.000	100.0	0.0
11	Davanagere	5	30	1.421	8.871	4.225	100.0	0.0
12	Gadag	1	30	1.193	1.193	1.193	100.0	0.0
13	Hassan	4	30	0.000	0.683	0.229	100.0	0.0
14	Haveri	1	30	11.026	11.026	11.026	100.0	0.0
15	Kalaburagi	3	30	0.049	4.183	1.479	100.0	0.0
16	Kodagu	1	30	0.097	0.097	0.097	100.0	0.0
17	Kolar	4	30	3.153	191.088	58.566	75.0	25.0
18	Koppal	10	30	0.287	22.849	9.213	100.0	0.0
19	Mandya	3	30	0.603	3.040	2.117	100.0	0.0
20	Mysuru	1	30	0.436	0.436	0.436	100.0	0.0
21	Raichur	24	30	1.151	53.160	16.664	75.0	25.0
22	Ramanagara	1	30	0.909	0.909	0.909	100.0	0.0
23	Shivamogga	8	30	0.000	0.101	0.020	100.0	0.0
24	Tumakuru	4	30	0.088	721.553	181.882	75.0	25.0
25	Udupi	8	30	0.000	0.050	0.006	100.0	0.0
26	Uttara Kannada	20	30	0.000	0.855	0.067	100.0	0.0
27	Vijayanagara	4	30	0.787	353.108	96.702	75.0	25.0
28	Yadgiri	2	30	0.665	10.781	5.723	100.0	0.0
	Grand Total	**127**					**89.8**	**10.2**

Table 16: Comparative Change in number of locations having Uranium > 30 ppb

Sl. No.	Districts	No. of locations exceeding		
		2019	2023	2024
1	Ballari	3	0	1
2	Bengaluru Rural	2	0	1
3	Bengaluru Urban	1	0	1
4	Chikkballapura	0	0	1
5	Kalaburagi	1	0	0
6	Kolar	3	1	1
7	Mandya	1	0	0
8	Raichur	2	3	6
9	Tumakuru	2	2	1
10	Vijayanagara	0	0	1
	Total	**15**	**6**	**13**

Table 17: Periodic variation in suitability Classes of groundwater in Uranium

Parameter	Class	Percentage of samples		
Uranium in ppb		2019	2023	2024
		n= 737	n=119	n=127
	< 30	97.96	94.96	89.76
	> 30	2.04	5.04	10.24



4.1.6 MANGANESE

Manganese, an essential trace element, occurs naturally in the environment and is ubiquitously present in both groundwater and surface water. Anthropogenic activities, including mining, industrial processes, and agricultural runoff, contribute to elevated manganese levels. Human exposure primarily occurs through ingestion of contaminated water and food. Excessive manganese intake can result in Manganism, a neurological disorder characterized by symptoms resembling Parkinson's disease. As per BIS drinking water standards 0.3 mg/L is the permissible limit for manganese.

PRESENT DAY SCENARIO AND TEMPORAL VARIATION OF MANGANESE IN KARNATAKA

Manganese content in the shallow aquifer of the state varies in the range of 0 to 3.767 mg/L recorded at Anchedoddi of Mandya. A total of 18 (14.17%) locations found to exceed the permissible limit of 0.3 mg/L. Figure 9 depicts the spatial distribution and table 18 shows the district wise range and distribution of Manganese in shallow ground waters of the state during May-2024. Table 19 and 20 show the Comparative Change in number of Locations exceeding the permissible limit of manganese and variation in suitability Classes of Manganese in groundwater of Karnataka respectively during 2019, 2023 and 2024 pre-monsoon seasons. The no. of district affected in 2024 went up to 14 from 10 in 2023.

Table 18: District wise range and distribution of Manganese in shallow ground waters of Karnataka

Sl. No.	District	No. of samples collected	Permissible limit (mg/L)	Min	Max	Mean	No. of samples (%)	
							Mn < 0.3 mg/L	Mn > 0.3 mg/L
1	Ballari	2	0.3	0.001	0.170	0.086	100.0	0.0
2	Belagavi	4	0.3	0.022	0.798	0.284	75.0	25.0
3	Bengaluru Rural	2	0.3	0.001	1.700	0.850	50.0	50.0
4	Bengaluru Urban	2	0.3	0.034	1.573	0.804	50.0	50.0
5	Bidar	1	0.3	0.000	0.000	0.000	100.0	0.0
6	Chamarajanagar	1	0.3	0.000	0.000	0.000	100.0	0.0
7	Chikkamagaluru	2	0.3	0.039	0.215	0.127	100.0	0.0
8	Chikkballapura	2	0.3	0.009	1.012	0.510	50.0	50.0
9	Chitradurga	1	0.3	1.523	1.523	1.523	0.0	100.0
10	Dakshina Kannada	6	0.3	0.002	0.948	0.206	83.3	16.7
11	Davanagere	5	0.3	0.001	0.984	0.205	80.0	20.0
12	Gadag	1	0.3	0.000	0.000	0.000	100.0	0.0
13	Hassan	4	0.3	0.001	0.601	0.275	50.0	50.0
14	Haveri	1	0.3	0.259	0.259	0.259	100.0	0.0
15	Kalaburagi	3	0.3	0.000	0.001	0.000	100.0	0.0
16	Kodagu	1	0.3	0.437	0.437	0.437	0.0	100.0
17	Kolar	4	0.3	0.002	2.289	0.772	50.0	50.0
18	Koppal	10	0.3	0.000	0.017	0.003	100.0	0.0
19	Mandya	3	0.3	0.001	3.767	1.258	66.7	33.3
20	Mysuru	1	0.3	0.019	0.019	0.019	100.0	0.0
21	Raichur	24	0.3	0.000	0.077	0.010	100.0	0.0
22	Ramanagara	1	0.3	0.007	0.007	0.007	100.0	0.0
23	Shivamogga	8	0.3	0.002	0.388	0.064	87.5	12.5
24	Tumakuru	4	0.3	0.008	0.761	0.299	50.0	50.0
25	Udupi	8	0.3	0.010	0.167	0.059	100.0	0.0
26	Uttara Kannada	20	0.3	0.003	1.146	0.161	90.0	10.0
27	Vijayanagara	4	0.3	0.000	0.011	0.004	100.0	0.0
28	Yadgiri	2	0.3	0.000	0.004	0.002	100.0	0.0
	Grand Total	**127**					**85.8**	**14.2**

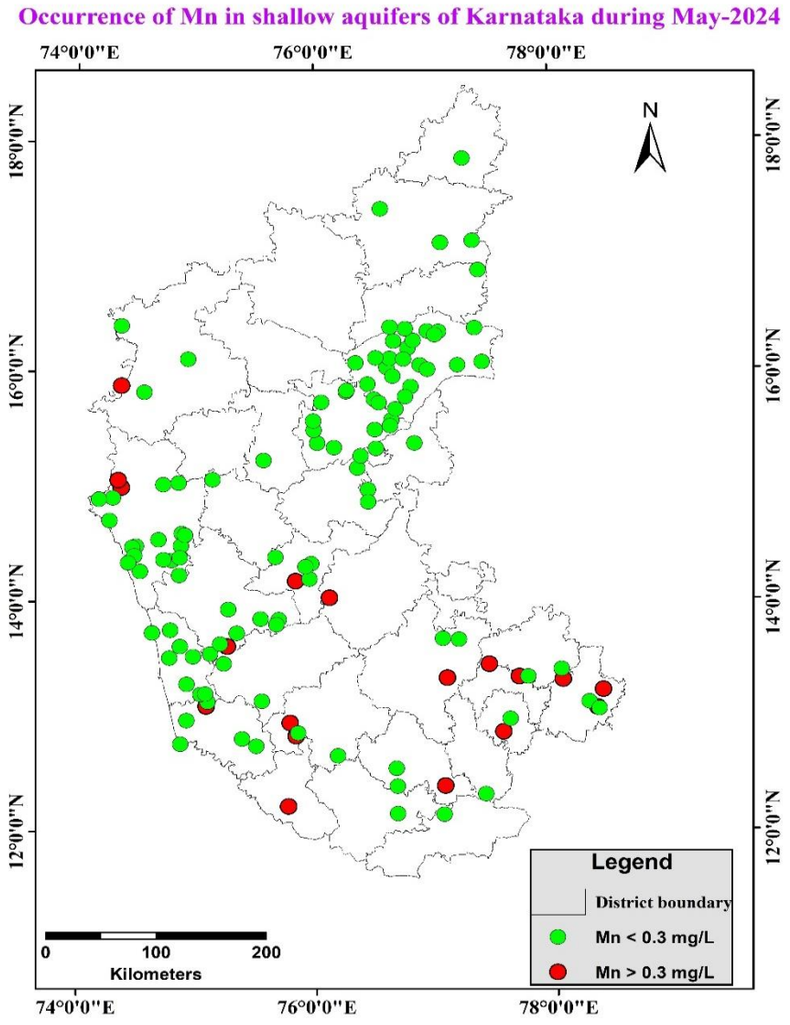


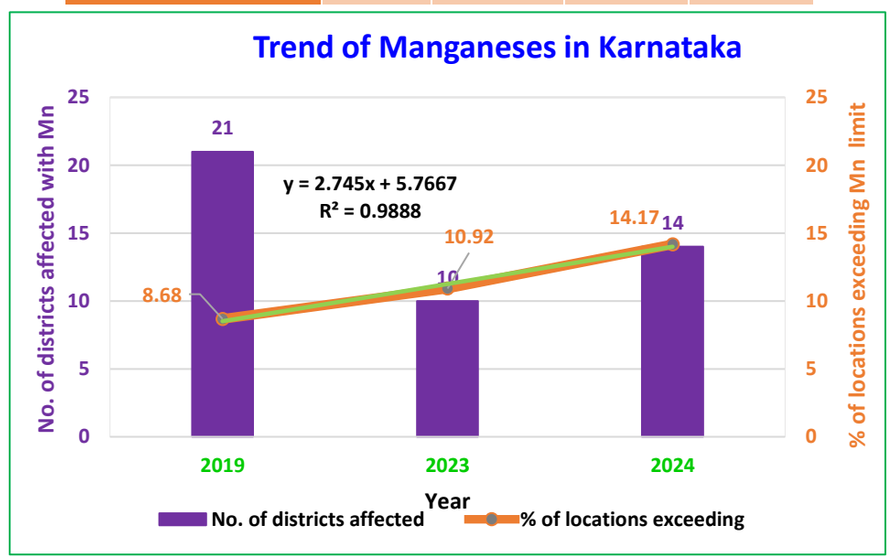
Figure 9: Occurrence of Manganese in Ground waters of Karnataka during May-2024

Table 19: Comparative Change in number of locations having Manganese > 0.3 mg/L

Sl. No.	Districts	No. of locations exceeding		
		2019	2023	2024
1	Belagavi	4	0	1
2	Ballari	4	0	0
3	Bengaluru Rural	0	0	1
4	Bengaluru Urban	1	0	1
5	Bidar	1	0	0
6	Chamarajanagar	1	0	0
7	Chikkamagaluru	1	0	0
8	Chikkballapura	0	0	1
9	Chitradurga	1	0	1
10	Dakshina Kannada	0	1	1
11	Davanagere	5	1	1
12	Hassan	3	0	2
13	Haveri	1	0	0
14	Kalaburagi	2	1	0
15	Kodagu	1	1	1
16	Kolar	4	1	2
17	Mandya	2	1	1
18	Mysore	1	0	0
19	Raichur	5	1	0
20	Shivamogga	8	3	1
21	Tumakuru	3	0	2
22	Udupi	2	0	0
23	Uttara Kannada	12	2	2
24	Vijayanagara	0	1	0
25	Yadgiri	2	0	0
	Grand Total	64	13	18

Table 20: Periodic variation in suitability Classes of groundwater in Manganese

Parameter	Class	Percentage of samples		
Manganese in mg/L		2019	2023	2024
		n= 737	n=119	n=127
	< 0.3	91.32	89.08	85.83
	> 0.3	8.68	10.92	14.17



4.1.7 ARSENIC

Arsenic, a naturally occurring element, is widely dispersed in the Earth's crust. This toxic substance can be found in various environmental components including water, air, soil, and food. It primarily exists in two forms: organic and inorganic. While natural processes such as volcanic eruptions and weathering contribute to arsenic release, human activities like mining, burning fossil fuels, and using arsenic-based chemicals for

agriculture and industry are also major contributors. Though the use of arsenic-containing pesticides and herbicides has decreased, its application in wood preservation persists. Arsenic contamination in drinking water poses severe health risks. Long-term exposure can lead to a range of adverse effects, including cancer, skin lesions, and cardiovascular disease. It can also impact neurological development, particularly in children. Additionally, arsenic can cause respiratory issues, reproductive problems, and damage to vital organs. The severity of these effects depends on the level of arsenic exposure and the individual's overall health. BIS has prescribed a permissible limit of 10 ppb for Arsenic in drinking water.

PRESENT DAY SCENARIO AND TEMPORAL VARIATION OF URANIUM IN KARNATAKA

The range of arsenic content in the ground waters of Karnataka varies from 0 to 20.58 ppb recorded at Hanchinal of Raichur district during the pre- monsoon season of 2024. All the samples lie within the permissible limit of drinking water standards of 10 ppb except for two locations Hanchinal and Shirhatti (10.658 ppb) of Gadag district. Figure 10 depicts the occurrence of arsenic in the shallow aquifer of the state and table 21 shows the district wise range and distribution of arsenic in the ground waters. It is observed that arsenic content of more than 10 ppb had been recorded during 2019, 2023 and 2024 in Raichur and Gadag districts. The no. of locations exceeding Arsenic concentration of 10 ppb came to 2 in 2024 from 4 in 2023. Table 22 and 23 show the Comparative Change in number of Locations having As > 10 ppb and variation in suitability classes of Arsenic content in groundwater of the state respectively.

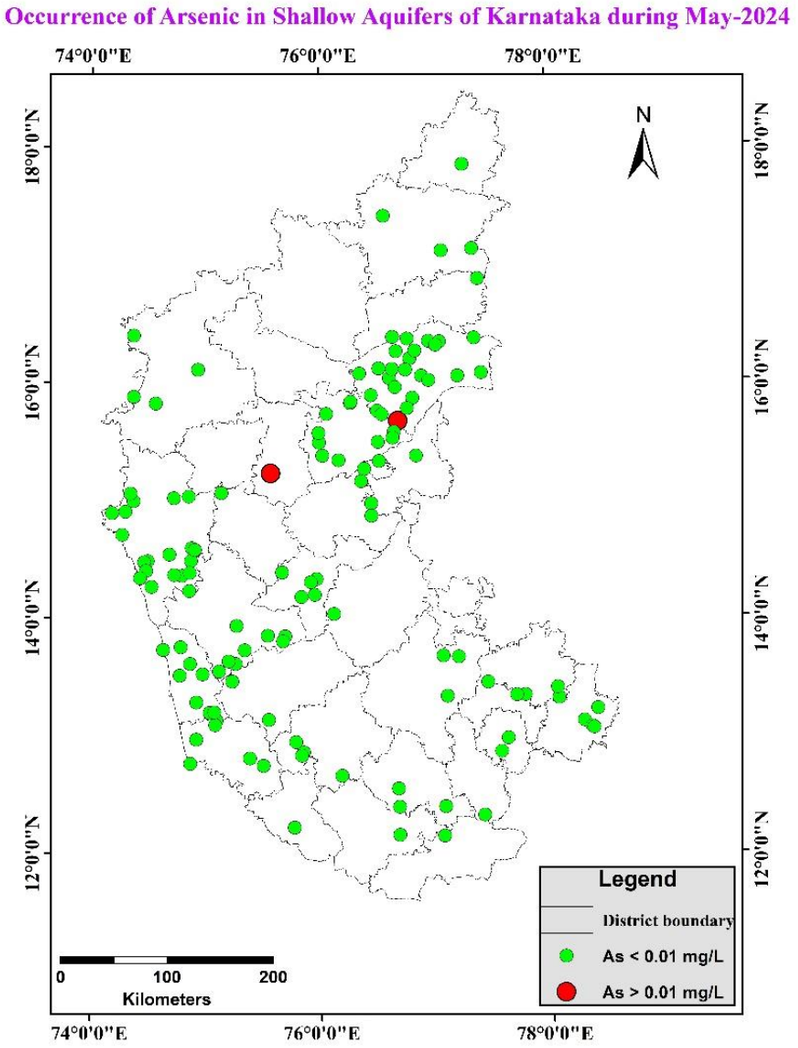


Figure 10: Occurrence of Arsenic in Ground waters of Karnataka during May-2024

Table 21: District wise range and distribution of Arsenic in shallow ground waters of Karnataka

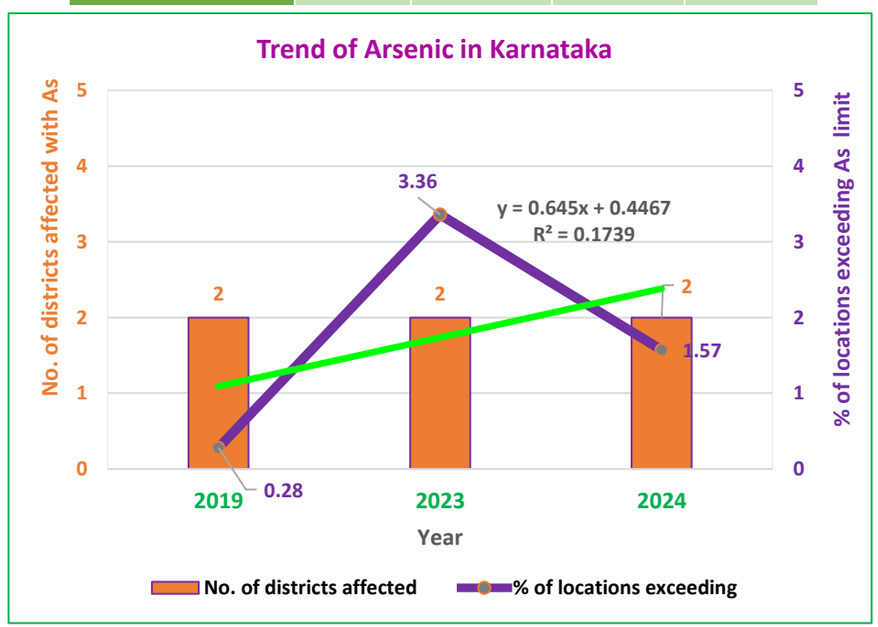
Sl. No.	District	No. of samples collected	Permissible limit (ppb)	Min	Max	Mean	No. of samples (%)	
							As < 10 ppb	As > 10 ppb
1	Ballari	2	10	0.157	3.460	1.809	100.0	0.0
2	Belagavi	4	10	0.054	0.989	0.351	100.0	0.0
3	Bengaluru Rural	2	10	0.013	0.489	0.251	100.0	0.0
4	Bengaluru Urban	2	10	0.147	0.315	0.231	100.0	0.0
5	Bidar	1	10	0.000	0.000	0.000	100.0	0.0
6	Chamarajanagar	1	10	0.399	0.399	0.399	100.0	0.0
7	Chikkamagaluru	2	10	0.000	0.000	0.000	100.0	0.0
8	Chikkballapura	2	10	0.363	0.535	0.449	100.0	0.0
9	Chitradurga	1	10	0.540	0.540	0.540	100.0	0.0
10	Dakshina Kannada	6	10	0.000	0.298	0.050	100.0	0.0
11	Davanagere	5	10	0.100	1.580	0.538	100.0	0.0
12	Gadag	1	10	10.658	10.658	10.658	0.0	100.0
13	Hassan	4	10	0.000	0.184	0.057	100.0	0.0
14	Haveri	1	10	0.367	0.367	0.367	100.0	0.0
15	Kalaburagi	3	10	0.000	0.065	0.022	100.0	0.0
16	Kodagu	1	10	0.000	0.000	0.000	100.0	0.0
17	Kolar	4	10	0.245	1.641	0.883	100.0	0.0
18	Koppal	10	10	0.000	1.800	0.431	100.0	0.0
19	Mandya	3	10	0.107	0.294	0.205	100.0	0.0
20	Mysuru	1	10	0.133	0.133	0.133	100.0	0.0
21	Raichur	24	10	0.134	20.580	2.759	95.8	4.2
22	Ramanagara	1	10	0.896	0.896	0.896	100.0	0.0
23	Shivamogga	8	10	0.000	0.691	0.092	100.0	0.0
24	Tumakuru	4	10	0.000	0.719	0.256	100.0	0.0
25	Udupi	8	10	0.000	0.128	0.016	100.0	0.0
26	Uttara Kannada	20	10	0.000	0.653	0.106	100.0	0.0
27	Vijayanagara	4	10	0.299	1.505	1.076	100.0	0.0
28	Yadgiri	2	10	0.016	0.425	0.221	100.0	0.0
	Grand Total	**127**					**98.4**	**1.6**

Table 22: Comparative Change in number of locations having Arsenic > 10 ppb

Sl. No.	Districts	No. of locations exceeding		
		2019	2023	2024
1	Raichur	1	3	1
2	Gadag	1	1	1
	Total	2	4	2

Table 23: Periodic variation in suitability Classes of groundwater in Manganese

Parameter	Class	Percentage of samples		
Arsenic in ppb		2019	2023	2024
		n= 737	n=119	n=127
	< 10	99.72	96.64	98.43
	> 10	0.28	3.36	1.57



5. SUMMARY

The ground water quality during pre-monsoon season of 2024 has been compared with 2019, 2022 and 2023 pre-monsoon seasons. The no. of districts affected has remained almost same for basic parameters like EC, Nitrate and Fluoride. However, the comparison of trace metals shows a significant decreasing trend of affected districts. This is mainly because of the reduced no. of sampling locations in 2023(119) and 2024(127) in compared to 2019 (737). Wide spread nitrate contamination has been a concern for the ground water of the state. Some of the sample exceeding one or more parameters, indicates the water is not suitable for human consumption without treatment.

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

Table 24 provides a detailed summary of groundwater quality across various districts in Karnataka, focusing on basic parameters (electrical conductivity, nitrate, fluoride) and trace metals (iron, arsenic, uranium and manganese).

Basic Parameters:

• EC (Electrical Conductivity): 14.83% of samples exceed the limit of 3000 µS/cm at 25^0 C, with higher occurrences in districts like Vijayapura (10 locations), Bagalkot (6), Raichur (6) and Gadag (5).

• NO3 (Nitrate): 44.16 % of samples exceed limits, with notable numbers in Vijayapura (17), Belagavi (16), Gadag (14), Chitradurga (13), and Kalaburagi (10).

• F (Fluoride): Overall, 16.72% of samples surpass permissible limits, with notable numbers in Gadag (9), Raichur (8) and Vijayapura (7).

Trace Metals:

- Fe (Iron): Detected in 3 locations i.e. 2.36 % of samples, in the districts of Dakshina Kannada (1), Udupi (1) and Uttara Kannada (1).
- As (Arsenic): Exceeded the permissible limit of 10 ppb in 2 locations i.e. 1.57 % of samples in the districts of Raichur (1) and Gadag (1).
- U (Uranium): Detected in 13 locations accounting to 10.24 % of samples, with a maximum of 6 locations in Raichur.
- Mn (Manganese): Exceeded the permissible limit in 18 samples which is 14.17% of the total samples. Manganese was detected in 14 district.

Table 25 provides a summary of groundwater quality in the state, broken down by the number of samples collected and the percentage of those samples that are contaminated with various parameters.

CONTAMINANT WISE STATE SUMMARY

The graphical representation in figure 11 shows the parameter wise summary of the quality of state's ground water in shallow aquifer. The analysis shows significant level of contamination of ground water of the state, nitrate being the predominant with 44.16%. Other major contaminants being Fluoride and Electrical conductivity, exceeding in 16.72% and 14.83% of the samples respectively. Trace metals exhibit a lower level of contamination with Mn (14.17%), U (10.24%), Fe (2.36%) and As (1.57%).

Table 24: District wise summary of GW quality of Karnataka during Premonsoon-2024

Sl. No.	District	Total no. of Basic samples	Samples exceeding the permissible limits						Total No. of Trace metals samples	Samples exceeding the permissible limits							
			EC (3000 µS/cm)		NO3 (45 mg/L)		F (1.5 mg/L)			Fe (1 mg/L)		Mn (0.3 mg/L)		U (0.03 mg/L)		As (0.01 mg/L)	
			No. of samples	%	No. of samples	%	No. of samples	%		No. of samples	%	No. of samples	%	No. of samples	%	No. of samples	%
1	Bagalkot	15	6	40.0	7	46.7	5	33.3	0	NA	NA	NA	NA	NA	NA	NA	NA
2	Ballari	3	1	33.3	2	66.7	1	33.3	2	0	0.0	0	0.0	1	50.0	0	0.0
3	Belagavi	39	4	10.3	16	41.0	0	0.0	4	0	0.0	1	25.0	0	0.0	0	0.0
4	Bengaluru Rural	10	0	0.0	4	40.0	0	0.0	2	0	0.0	1	50.0	1	50.0	0	0.0
5	Bengaluru Urban	4	0	0.0	2	50.0	0	0.0	2	0	0.0	1	50.0	1	50.0	0	0.0
6	Bidar	8	0	0.0	7	87.5	0	0.0	1	0	0.0	0	0.0	0	0.0	0	0.0
7	Chamarajanagar	3	0	0.0	1	33.3	0	0.0	1	0	0.0	0	0.0	0	0.0	0	0.0
8	Chikkamagaluru	4	0	0.0	1	25.0	0	0.0	2	0	0.0	0	0.0	0	0.0	0	0.0
9	Chikkballapura	5	0	0.0	2	40.0	1	20.0	2	0	0.0	1	50.0	1	50.0	0	0.0
10	Chitradurga	10	4	40.0	5	50.0	1	10.0	1	0	0.0	1	100.0	0	0.0	0	0.0
11	Dakshina Kannada	1	0	0.0	1	100.0	0	0.0	6	1	16.7	1	16.7	0	0.0	0	0.0
12	Davanagere	8	0	0.0	8	100.0	1	12.5	5	0	0.0	1	20.0	0	0.0	0	0.0
13	Dharwad	8	4	50.0	7	87.5	2	25.0	0	NA	NA	NA	NA	NA	NA	NA	NA
14	Gadag	15	5	33.3	14	93.3	9	60.0	1	0	0.0	0	0.0	0	0.0	1	100.0
15	Hassan	6	0	0.0	4	66.7	0	0.0	4	0	0.0	2	50.0	0	0.0	0	0.0
16	Haveri	9	0	0.0	3	33.3	1	11.1	1	0	0.0	0	0.0	0	0.0	0	0.0
17	Kalaburagi	19	0	0.0	10	52.6	2	10.5	3	0	0.0	0	0.0	0	0.0	0	0.0
18	Kodagu	1	0	0.0	0	0.0	0	0.0	1	0	0.0	1	100.0	0	0.0	0	0.0
19	Kolar	15	1	6.7	1	6.7	0	0.0	4	0	0.0	2	50.0	1	25.0	0	0.0
20	Koppal	15	4	26.7	7	46.7	3	20.0	10	0	0.0	0	0.0	0	0.0	0	0.0
21	Mandya	20	0	0.0	3	15.0	0	0.0	3	0	0.0	1	33.3	0	0.0	0	0.0
22	Mysuru	18	0	0.0	5	27.8	1	5.6	1	0	0.0	0	0.0	0	0.0	0	0.0
23	Raichur	20	6	30.0	6	30.0	8	40.0	24	0	0.0	0	0.0	6	25.0	1	4.2
24	Ramanagara	2	0	0.0	0	0.0	2	100.0	1	0	0.0	0	0.0	0	0.0	0	0.0
25	Shivamogga	6	0	0.0	1	16.7	0	0.0	8	0	0.0	1	12.5	0	0.0	0	0.0
26	Tumakuru	12	1	8.3	3	25.0	6	50.0	4	0	0.0	2	50.0	1	25.0	0	0.0
27	Udupi	1	0	0.0	0	0.0	0	0.0	8	1	12.5	0	0.0	0	0.0	0	0.0
28	Uttara Kannada	2	0	0.0	0	0.0	0	0.0	20	1	5.0	2	10.0	0	0.0	0	0.0
29	Vijayanagara	2	0	0.0	1	50.0	0	0.0	4	0	0.0	0	0.0	1	25.0	0	0.0
30	Vijayapura	30	10	33.3	17	56.7	7	23.3	0	NA	NA	NA	NA	NA	NA	NA	NA
31	Yadgiri	6	1	16.7	2	33.3	3	50.0	2	0	0.0	0	0.0	0	0.0	0	0.0
	Total	317	47	14.8	140	44.2	53	16.7	127	3	2.4	18	14.2	13	10.2	2	1.6

Table 25: Parameter wise summary of GW quality in Karnataka during Pre-monsoon 2024

Total no. of Basic samples	EC	NO3	F	Total no. of HM samples	Fe	Mn	U	As
317	47 (14.83%)	140 (44.16%)	53 (16.72%)	**127**	3(2.36%)	18 (14.17 %)	13 (10.24 %)	2(1.57 %)

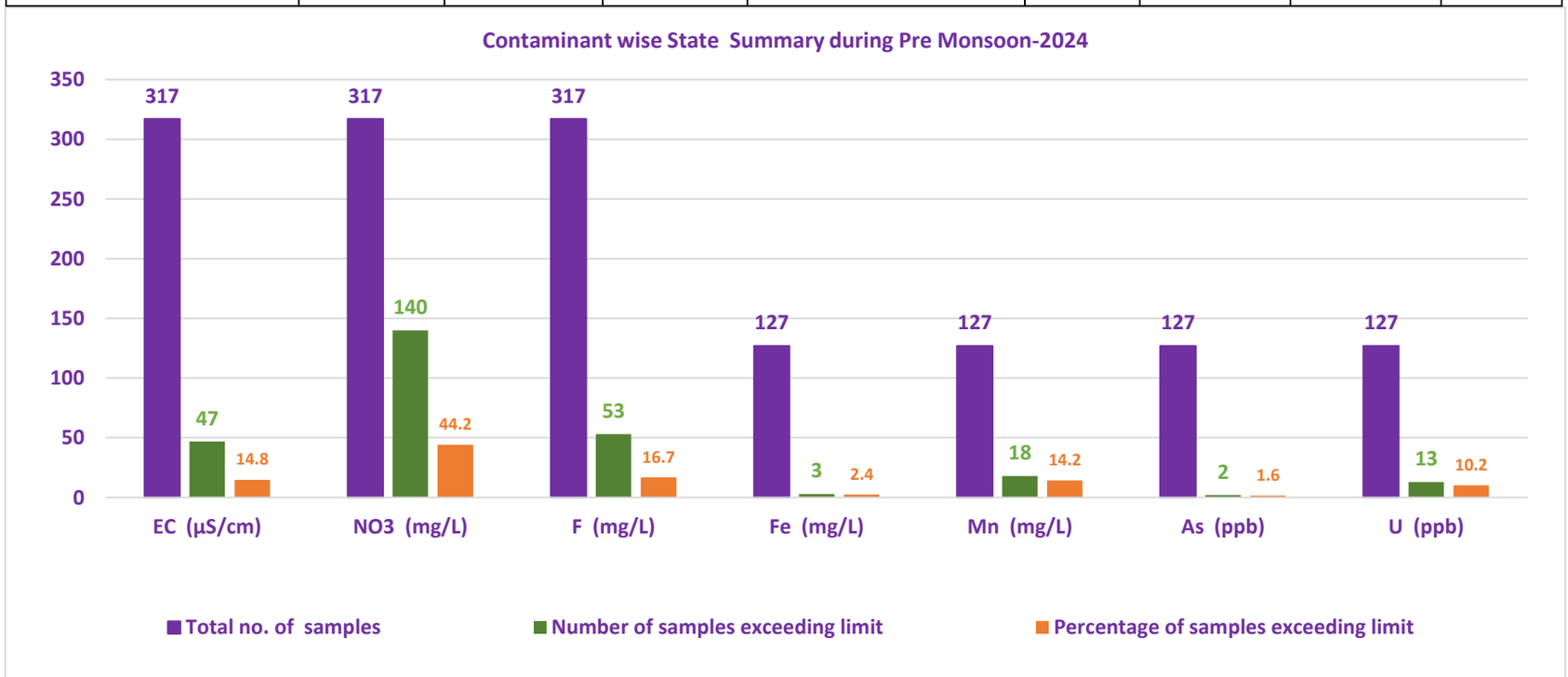


Figure 11: Contaminant wise Karnataka state summary during Pre Monsoon-2024