GROUNDWATER CHEMICAL QUALITY BULLETIN

Telangana

ABSTRACT

Periodic ground water quality assessment (2019-24) highlighting the findings, significant trends and groundwater contamination status

CGWB-SR, Telangana

1. INTRODUCTION

Ground water is an important resource widely used for drinking, irrigation and industrial purpose. Ground Water plays an important role in the sustainable socio-economic development. In regions with scarcity of fresh surface water sources dependence on ground water increases exponentially. Telangana state exemplifies such a region, where groundwater resources, as of 2023, constitute a modest 5.1% of the total. They fulfil substantial proportions of irrigation and drinking water needs. However, heightened reliance on groundwater across various sectors has resulted in declining water quality and dwindling water levels. The ground water quality is dependent upon chemical characteristic of rocks and minerals composition of aquifer material. Due to redox reaction, ions can be dissolved from minerals by dissolution and crystallization within aquifer and concentrate beyond permissible limits. Poor ground water quality can also be due to excessive use of fertilizers, urbanization and industrial effluent discharge. According to UNESCO more than 80% of health issues are caused due to consumption of poor-quality water. Inorganic contaminants including Salinity, Fluoride, Nitrate, Arsenic, Iron and Uranium are important in determining the suitability of ground water for drinking purposes.

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

Numerous studies have been carried out on the poor quality of groundwater. However, an extensive temporal and spatial study of Telangana State is lacking. Our efforts in the present study are to fulfil the following objectives:

- To present current GW quality scenario, parameter wise for each district.
- To identify present day hot spots of poor-quality ground water through spatial variation analysis of latest 2024 quality data.
- To assess temporal variation of ground water quality showing improvement / deterioration during the period from 2019 to 2024, providing insights for effective water quality management measures

2. STUDY AREA

Telangana State is the 29th State (Act, 2014) formed in India covering geographical area of 1,12,077 Km^2 (after transferring 107 villages from Khammam district to residual Andhra Pradesh). It lies between NL 15° 48' and 19° 54'and EL77° 12' and 81° 50'.The state is bordered by Maharashtra in the north, Karnataka in the west, Andhra Pradesh in the south and east and Chhattisgarh state in the north-east.

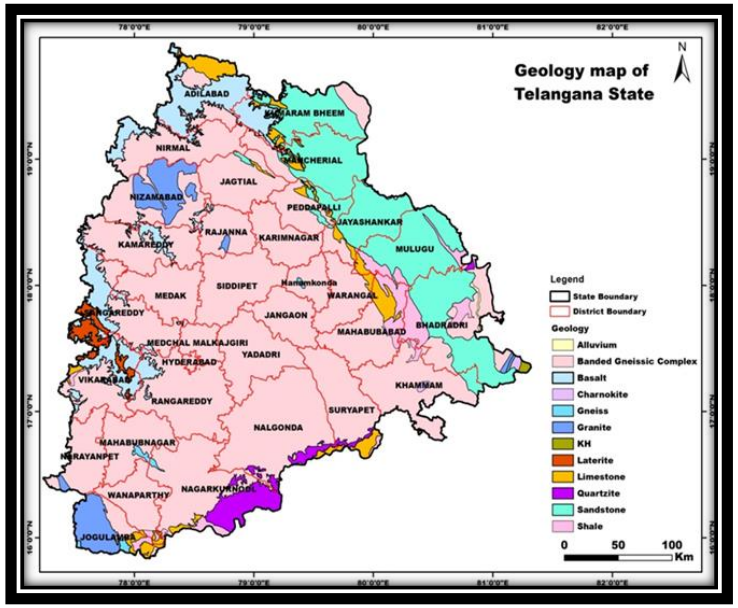

Figure 1: Map showing major aquifers and geomorphic divisions of Telangana State

Telangana state is characterized by wide range of geological formations from Archaean to Recent age (Figure-1). Nearly 81 % of the state area is underlain by hard rocks (consolidated formations) belonging to the Peninsular Gneissic Complex, Dharwar and Eastern Ghats of Archaean to Middle Proterozoic age, Pakhal Group of rocks belonging to Middle to Upper Proterozoic age and Deccan Traps. The remaining part ofthe state is underlain by semi consolidated sedimentary formations comprising Gondwanas, Tertiaries and Sub-Recent to Recent Unconsolidated Alluvium. As per 2023 Groundwater resource assessment, Total Annual Ground Water Recharge of the State has been assessed as 23.14BCM and Annual Extractable Ground Water Resource is 20.92BCM. The Total Current Annual Ground Water extraction is 14.42 BCM and Stage of Ground Water extraction is 38.65%.

The state is drained by two major rivers namely, Godavari and Krishna and their tributaries before entering into Andhra Pradesh state and finally to Bay of Bengal. There are 2 major basins and 13 sub basins in the state.

The major river basins are Godavari basin with 8 sub-basins namely, lower Godavari, Maneru, Manjira, middle Godavari, Penganga, Pranhita, Sabari and Wardha and Krishna basin with 5 sub basins namely, lower Bhima, lower Krishna, Munneru, Musi and Paleru (Fig.2). Apart from these, there are 2 other basins namely Tammileru

and Yerrakalva lying between Godavari and Krishna covering very small area. The River Godavari with its tributaries viz., Pranahita, Pedda Vagu, Manjira, Maner, Kinnerasani, Sileru and Pamuleru drain whole of northern Telangana. The Tungabhadra, Musi, Paleru and Maneru rivers drain southern part of the state.

The pattern of drainage is generally dendritic with wide valleys in western pediplain. Drainage of the Eastern Ghat is coarse and dendritic with steep and narrow valleys. Most of the smaller streams feed innumerable tanks.

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), SR, Hyderabad office has implemented a bi-annual groundwater quality monitoring program commencing in 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, from the National

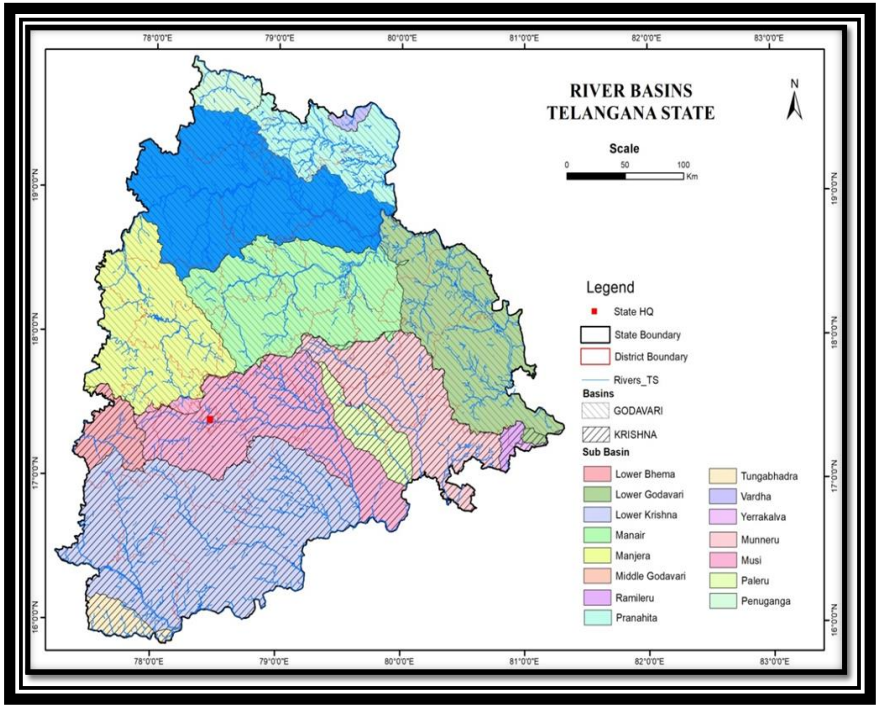

Fig.2: Drainage and River sub-basin map of Telangana state

Hydrograph Stations distributed across the state. In 2023 trend stations fixed with respect to samples based on 2022 background monitoring, the samples from these trend wells collected during both Pre and Post-Monsoon of each year up to 2027. During 2024 about 412 number of samples collected from the designated trend stations for Basic Parameters and 274 acidified samples from hotspot areas

for Heavy Metal analysis in Telangana State. This report presents a comparative analysis of groundwater quality trends observed in the years 2019, 2022, 2023 & 2024 within the CGWB observation well network. Spatial distribution of sampling locations has been given in figure 3 and the district wise numbers are furnished in table 1.

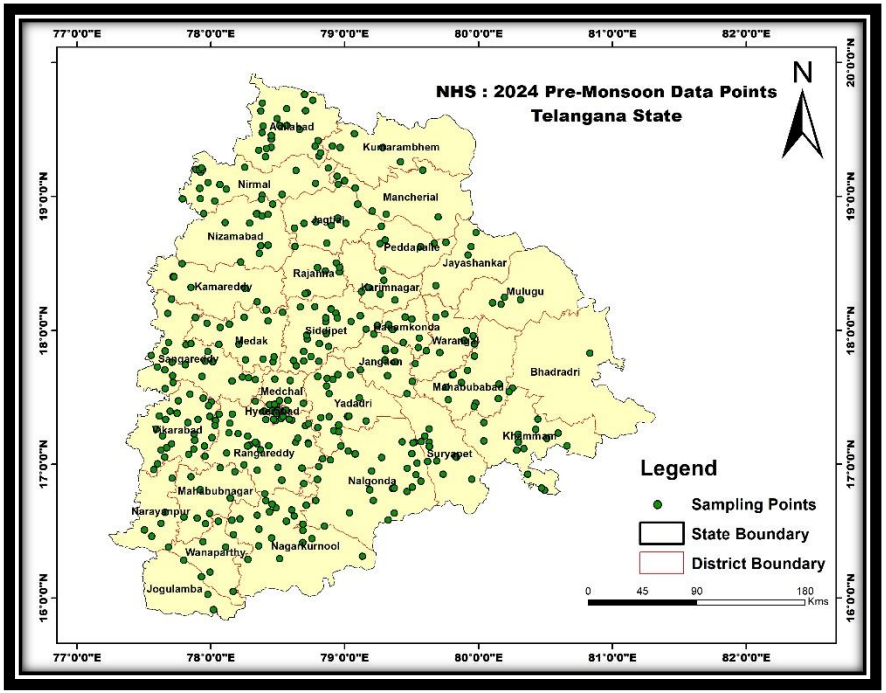

FIGURE 3: SPATIAL DISTRIBUTION OF BASIC PARAMETER SAMPLING LOCATIONS

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

Sl. No.	District	No. of water quality monitoring stations			
		2019	2022	2023	2024(Pre)
1	Adilabad	7	40	51	22
2	B.Kothagudem	16	38	69	2
3	Hanamkonda	4	13	18	7
4	Hyderabad	10	23	25	16
5	Jagtial	8	23	23	8
6	jangaon	13	27	42	11
7	J.Bhupalapally	6	9	14	3
8	Jogulamba Gadwal	8	15	15	5
9	Kamareddy	6	20	24	7
10	Karimnagar	5	23	23	7
11	Khammam	15	38	65	16
12	KB Asifabad	6	8	39	5
13	Mahabubabad	9	13	21	12
14	Mahabubnagar	8	27	24	9
15	Mancherial	7	16	32	11
16	Medak	12	33	37	12
17	Medchal Malkajgiri	4	14	19	5
18	Mulugu	10	19	21	4
19	Nagarkurnool	25	35	40	23
20	Nalgonda	22	47	79	27
21	Narayanpet	1	8	8	5
22	Nirmal	8	28	32	19
23	Nizamabad	5	39	41	12
24	Peddapalle	5	10	18	5
25	R. Sircilla	0	10	17	9
26	Rangareddy	16	66	70	33
27	Sangareddy	28	47	54	23
28	Siddipet	5	46	51	25
29	Suryapet	21	31	34	11
30	Vikarabad	18	49	59	28
31	Wanaparthy	9	22	22	5
32	Warangal	8	20	20	7
33	Yadadri Bhuvanagiri	18	35	43	18
	Total	343	892	1150	412

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 (Reaffirmed 2018) by the Bureau of Indian Standards.

Groundwater in Telangana predominantly exhibits a Calcium-Magnesium Bicarbonate (Ca-Mg-HCO3) 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 and uranium, within specific regions of Telangana. 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, and uranium. The subsequent sections will analyse the presence and temporal variations of these constituents in groundwater samples collected during the years 2019, 2022, 2023 and 2024 National Hydrological Survey (NHS).

1. Electrical Conductivity (> 3000 µS/cm) at 25 °C
2. Fluoride (>1.5 mg/litre)
3. Nitrate (>45 mg/litre)
4. Uranium (0.03 mg/L)

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 approximately 750 µS/cm at 25°C) for drinking water. In the absence of alternative sources, this limit can be relaxed to 2000 mg/L (approximately 3000 µS/cm at 25°C). Waters exceeding 2000 mg/L TDS are generally unsuitable for potable consumption.

Distribution of Electrical Conductivity (EC) During Pre-Monsoon 2024

The electrical conductivity (EC) of groundwater in the state exhibits a wide range, spanning from a minimum of 270 µS/cm at Mahadevpur1 in Jaishankar Bhupalapally district to a maximum of 19840 µS/cm at Boravalle in Jogulamba Gadwaldistrict. A categorization of groundwater samples based on EC reveals the following distribution:

- EC < 750 µS/cm – 19.65%
- EC 750- 3000 µS/cm- 77.39%
- EC > 3000 µS/cm- 2.7%

Figure 4 shows the spatial distribution of electrical conductivity in the phreatic aquifer of Telangana. Table 2 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. EC more than 3000 µS/cm was observed in parts of Jogulamba Gadwal, Khamam, Medak, Nalgonda, Rangareddy, Sangareddy and Yadadri Bhuvanagiri districts.

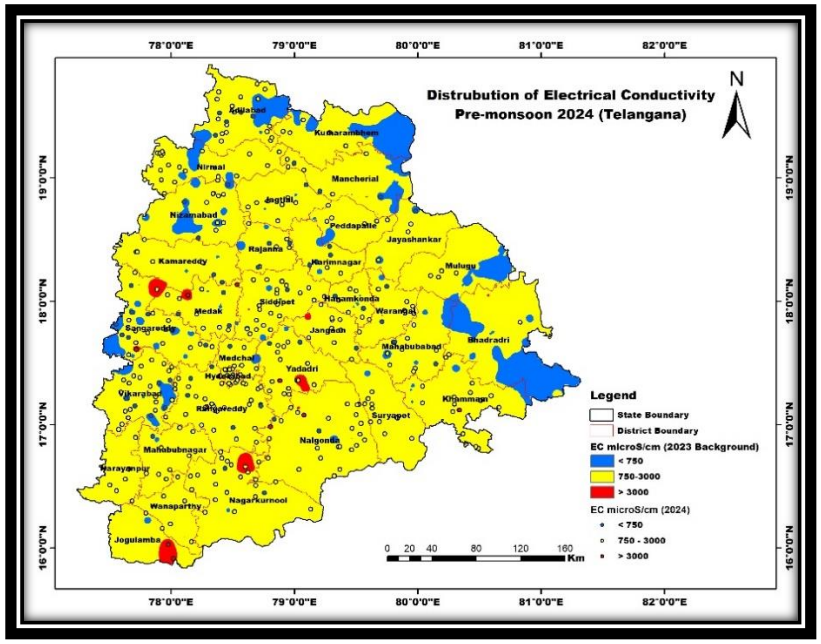

Figure 4: Spatial distribution of EC during May 2024

Table 2: District wise Range and distribution of EC in µS/cm in GW of Telangana

Sl No	Districts	No. of samples analyzed	Permissible Limit µS/cm	Min	Max	Mean	% of samples		
							<750 µS/cm	750-3000 µS/cm	>3000 µS/cm
1	Adilabad	22	3000	670	1420	947	22.7	77.3	0.0
2	Bhadradri Kothagudem	2	3000	1140	1460	1300	0.0	100.0	0.0
3	Hanamkonda	7	3000	380	1790	1253	28.6	71.4	0.0
4	Hyderabad	16	3000	810	1430	1110	0.0	100.0	0.0
5	J.Bhupalapally	3	3000	270	1690	1153	33.3	66.7	0.0
6	Jagtial	8	3000	702	1823	1131	12.5	87.5	0.0
7	Jangaon	11	3000	470	1900	1076	9.1	90.9	0.0
8	Jogulamba Gadwal	5	3000	2155	19840	6004	0.0	60.0	40.0
9	Kamareddy	7	3000	470	2480	1126	42.9	57.1	0.0
10	Karimnagar	7	3000	558	1707	979	57.1	42.9	0.0
11	KB Asifabad	5	3000	820	1650	1176	0.0	100.0	0.0
12	Khammam	16	3000	760	3560	1686	0.0	93.8	6.3
13	Mahabubabad	12	3000	510	1590	1082	25.0	75.0	0.0
14	Mahabubnagar	9	3000	578	2254	1496	11.1	88.9	0.0
15	Mancherial	11	3000	410	1580	1015	36.4	63.6	0.0
16	Medak	12	3000	572	4457	1996	16.7	66.7	16.7
17	Medchal Malkajgiri	5	3000	610	1940	1219	20.0	80.0	0.0
18	Mulugu	4	3000	870	1820	1498	0.0	100.0	0.0
19	Nagarkurnool	23	3000	460	2964	1518	8.7	91.3	0.0
20	Nalgonda	27	3000	750	9600	2118	0.0	92.6	7.4
21	Narayanpet	5	3000	1267	1750	1555	0.0	100.0	0.0
22	Nirmal	19	3000	763	1800	1179	0.0	100.0	0.0
23	Nizamabad	12	3000	400	1760	917	25.0	75.0	0.0
24	Peddapalli	5	3000	816	1726	1320	0.0	100.0	0.0
25	Rajanna Sircilla	9	3000	299	1360	819	44.4	55.6	0.0
26	Ranga Reddy	33	3000	380	3250	1266	15.2	81.8	3.0
27	Sangareddy	23	3000	300	5340	1109	43.5	52.2	4.3
28	Siddipet	25	3000	688	2232	1218	4.0	96.0	0.0
29	Suryapet	11	3000	920	2970	1540	0.0	100.0	0.0
30	Vikarabad	28	3000	320	1720	1023	21.4	78.6	0.0
31	Wanaparthy	5	3000	1135	2419	1594	0.0	100.0	0.0
32	Warangal	7	3000	440	2110	1244	28.6	71.4	0.0
33	Yadadri Bhuvanagiri	18	3000	680	4030	1758	5.6	83.3	11.1

TEMPORAL VARIATION OF EC IN GROUND WATER DURING THE PERIOD FROM 2019 TO 2024

Table 3 shows the temporal variation and the temporal comparison of districts wise no. of locations exceeding EC value of 3000 µS/ cm has been given in table 4. Trend of EC in the state in figure-5.

Table 3: Periodic variation in suitability Classes of groundwater in EC

Parameter	Class	Percentage of samples				Periodic Variation
		2019	2022	2023	2024 Pre	
		(n=343)	(n=892)	(n=1150)	(n=412)	
Salinity as EC	<750 µS/cm	14	20.7	19.6	15	1
	750-3000 µS/cm	78.4	75.8	77.4	82.3	3.9
	>3000 µS/cm	7.6	3.5	3	2.70	-4.9

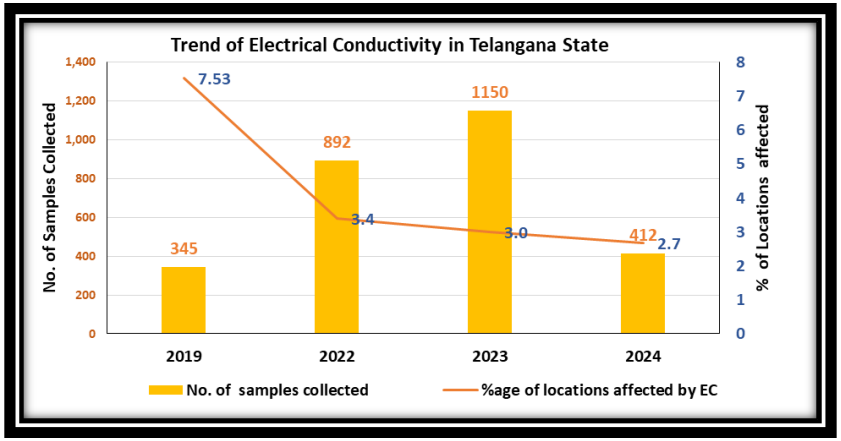

Fig-5: Trend of EC in Telangana State

Table 4: Comparative change in number of locations having EC > 3000 µS/cm in various Districts

Sl. No.	District	No. of locations having EC > 3000 µS/cm			
		2019	2022	2023	2024
1	Adilabad	0	0	0	0
2	Bhadradri Kothagudem	0	1	1	0
3	Hanamkonda	1	0	0	0
4	Hyderabad	0	0	0	0
5	J.Bhupalapally	0	0	1	0
6	Jagtial	0	0	0	0
7	jangaon	0	0	1	0
8	Jogulamba Gadwal	1	3	4	2
9	Kamareddy	0	1	0	0
10	Karimnagar	0	0	0	0
11	KB Asifabad	0	0	1	0
12	Khammam	3	4	3	1
13	Mahabubabad	0	0	0	0
14	Mahabubnagar	0	1	0	0
15	Mancherial	1	0	2	0
16	Medak	3	1	2	2
17	Medchal Malkajgiri	0	0	0	0
18	Mulugu	1	0	0	0
19	Nagarkurnool	1	2	1	0
20	Nalgonda	2	5	3	2
21	Narayanpet	0	1	0	0
22	Nirmal	0	0	0	0
23	Nizamabad	0	1	0	0
24	Peddapalle	0	0	3	0
25	R. Sircilla	0	0	0	0
26	Rangareddy	2	1	2	1
27	Sangareddy	2	2	3	1
28	Siddipet	0	0	1	0
29	Suryapet	4	2	0	0
30	Vikarabad	0	0	0	0
31	Wanaparthy	1	0	0	0
32	**Warangal**	**0**	**1**	**2**	**0**
33	Yadadri Bhuvanagiri	4	5	4	2
	Total	**26**	**31**	**34**	**11**

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 de-nitrification, 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 IN Telangana W.R.T NITRATE (NO_3) Primary anthropogenic sources contributing to nitrate contamination of groundwater include: excessive application of nitrogen-based fertilizers, bacterial nitrification of organic nitrogen compounds, and leaching from animal and human waste repositories. Atmospheric deposition of nitrogenous compounds also serves as a potential input. In the State, nitrate in ground water

samples varies from BDL to 250 mg/L. Highest nitrate value was observed at Jupally of Nagarkurnool district. BIS permits a maximum concentration of 45 mg/L nitrate in drinking water. Almost 34.7% of the samples exceeded the permissible limit of nitrate. Nitrate contamination was found majorly in Adilabad, J. Bhupalpalle, Rangareddy, Siddipet, Nalgonga, Jangaon, Vikarabad, Warangak, Khammam, adadri Bhuvanagiri, Medak etc. Table 5 shows the district wise details of samples exceeding the permissible limit. Figure 6 shows the occurrence of nitrate during Pre-Monsoon 2024.

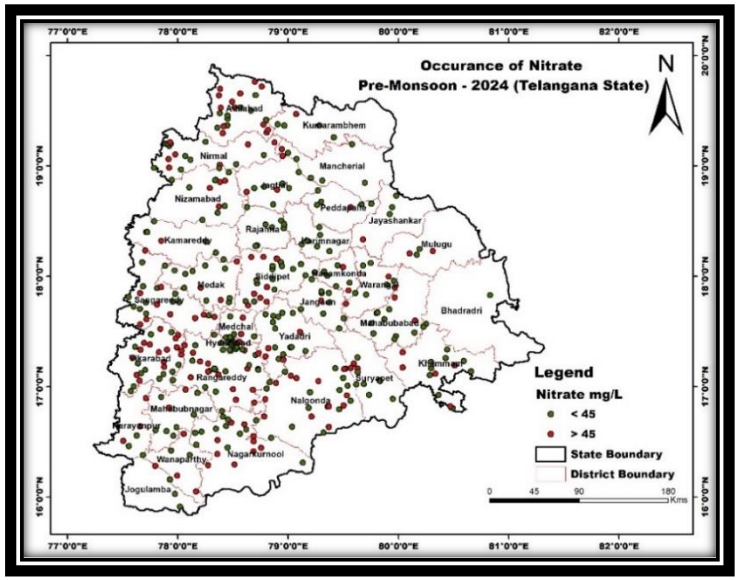

Fig 6: Occurance of Nitrate in GW (May-2024)

Table 5 District wise details of samples exceeding the permissible limit

Sl. No	District	No of samples analysed	Desirable limit mg/L	Permissible Limit (mg/L)	Min	Max	Mean	No. of samples (%)	
								>45	<45
1	Adilabad	22	45	No relaxation	10.1	133.5	65.6	59.1	40.9
2	Bhadradri Kothagudem	2	45	No relaxation	0.1	17.3	8.7	0.0	100.0
3	Hanamkonda	7	45	No relaxation	10.7	68.3	33.1	28.6	71.4
4	Hyderabad	16	45	No relaxation	4.2	40.1	16.9	0.0	100.0
5	J.Bhupalapally	3	45	No relaxation	0.0	134.1	57.0	33.3	66.7
6	Jagtial	8	45	No relaxation	0.7	121.5	28.8	25.0	75.0
7	Jangaon	11	45	No relaxation	1.7	67.6	21.4	9.1	90.9
8	Jogulamba Gadwal	5	45	No relaxation	6.2	88.0	29.5	20.0	80.0
9	Kamareddy	7	45	No relaxation	1.5	176.7	33.1	14.3	85.7
10	Karimnagar	7	45	No relaxation	2.4	32.3	12.8	0.0	100.0
11	KB Asifabad	5	45	No relaxation	23.3	45.8	34.0	20.0	80.0
12	Khammam	16	45	No relaxation	0.4	82.9	27.3	31.3	68.8
13	Mahabubabad	12	45	No relaxation	1.2	126.5	32.8	16.7	83.3
14	Mahabubnagar	9	45	No relaxation	1.5	161.1	38.2	22.2	77.8
15	Mancherial	11	45	No relaxation	2.3	118.5	30.5	27.3	72.7
16	Medak	12	45	No relaxation	1.2	208.4	48.6	25.0	75.0
17	Medchal Malkajgiri	5	45	No relaxation	3.3	126.5	51.5	60.0	40.0
18	Mulugu	4	45	No relaxation	17.1	62.3	41.8	50.0	50.0
19	Nagarkurnool	23	45	No relaxation	1.8	249.6	47.0	39.1	60.9
20	Nalgonda	27	45	No relaxation	2.8	206.0	72.1	55.6	44.4
21	Narayanpet	5	45	No relaxation	1.0	95.8	46.2	60.0	40.0
22	Nirmal	19	45	No relaxation	6.8	164.8	41.2	36.8	63.2
23	Nizamabad	12	45	No relaxation	2.1	124.5	37.8	33.3	66.7
24	Peddapalli	5	45	No relaxation	2.9	45.9	25.4	20.0	80.0
25	Rajanna Sircilla	9	45	No relaxation	0.1	43.5	16.0	0.0	100.0
26	Ranga Reddy	33	45	No relaxation	2.4	136.2	50.1	45.5	54.5
27	Sangareddy	23	45	No relaxation	2.7	209.2	56.5	43.5	56.5
28	Siddipet	25	45	No relaxation	0.6	240.0	57.3	40.0	60.0
29	Suryapet	11	45	No relaxation	4.6	95.6	31.6	27.3	72.7
30	Vikarabad	28	45	No relaxation	1.9	113.0	48.6	53.6	46.4
31	Wanaparthy	5	45	No relaxation	5.6	190.6	72.6	60.0	40.0
32	Warangal	7	45	No relaxation	0.5	144.6	41.9	28.6	71.4
33	Yadadri Bhuvanagiri	18	45	No relaxation	3.5	141.6	32.3	22.2	77.8

TEMPORAL VARIATION OF NITRATE DURING THE PERIOD FROM 2019 TO 2024

Table 6 and Figure-7shows the year wise variation of the percentage of samples exceeding the nitrate permissible limit and the district wise no. of locations exceeding the permissible limit has been given **in table 7.** The sharp rise in percentage of locations in 2023 is because of the selection of trend stations which were based on contamination.

Table 6: Periodic variation in suitability Classes of Nitrate in groundwater

Parameter	Class	Percentage of samples				Periodic Variation
		2019	2022	2023	2024 (Pre)	
		(n=343)	(n=892)	(n=1150)	(n=412)	
Nitrate as NO3	< 45 mg/L	56.8	60.6	72.5	65.3	8.5
	> 45 mg/L	43.15	39.3	27.5	34.7	-8.5

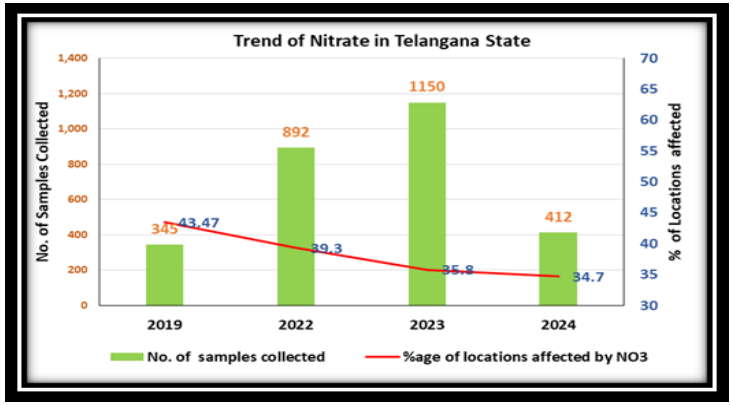

Fig-7: Trend of Nitrate in Telangana State

Table 7: Comparative change in number of locations having Nitrate > 45 mg/L in various Districts

Sl. No.	District	No. of locations having Nitrate> 45			
		2019	2022	2023	2024
1	Adilabad	5	25	24	13
2	Bhadradri Kothaguder	4	6	3	0
3	Hanamkonda	2	4	3	2
4	Hyderabad	2	3	0	0
5	J.Bhupalapally	3	3	2	1
6	Jagtial	3	6	4	2
7	jangaon	4	8	19	1
8	Jogulamba Gadwal	2	4	6	1
9	Kamareddy	2	9	9	1
10	Karimnagar	4	8	2	0
11	KB Asifabad	2	3	4	1
12	Khammam	8	12	12	5
13	Mahabubabad	3	6	2	2
14	Mahabubnagar	2	7	6	2
15	Mancherial	1	7	9	3
16	Medak	5	12	11	3
17	Medchal Malkajgiri	1	3	4	3
18	Mulugu	2	2	4	2
19	Nagarkurnool	13	11	14	9
20	Nalgonda	11	29	26	15
21	Narayanpet	1	3	3	3
22	Nirmal	5	15	7	7
23	Nizamabad	1	14	4	4
24	Peddapalli	2	3	4	1
25	Rajanna Sircilla	0	3	3	0
26	Ranga Reddy	14	33	44	15
27	Sangareddy	8	22	11	10
28	Siddipet	2	23	24	10
29	Suryapet	10	10	4	3
30	Vikarabad	8	23	22	15
31	Wanaparthy	5	3	3	3
32	Warangal	4	9	11	2
33	Yadadri Bhuvanagiri	9	22	12	4
	Total	148	351	316	143

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 IN Telangana W.R.T FLUORIDE (F)

An analysis of groundwater samples revealed that out of 412 collected samples 61.7% samples fell within the desirable range, 18.7% within the permissible range, and 19.7% exceeded the permissible limit. A geographical distribution map **(figure 8)** indicates that groundwater with excessive fluoride levels is predominantly found in the districts of Yadadri Bhuvanagiri, Warangal, Medchal Malkanjgiri, Khammam, jangaon, Nalgonda, Rangareddy, etc. It is to be noted that J.Bhupalapally, Jogulamba, Mahabubabad, Mulugu, Narayanpet etc found to be having fluoride less than permissible limit in all collected samples from different locations. The maximum concentration of 5.84 mg/L was observed at Anampet-PZ of Nalgonda district. The district wise maximum, minimum, mean and percentage of samples exceeding the permissible limit has been given in **table 8.**

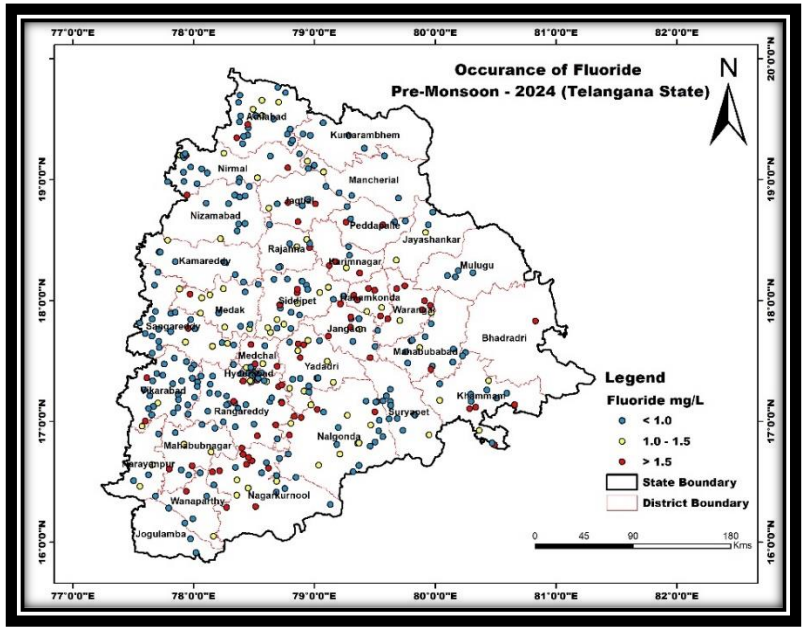

Figure 8: map showing distribution of fluoride based on NHS-2024 (Pre-Monsoon)

Table-8: **District wise details of samples exceeding the permissible limit**

Sl. No	District	No of samples analysed	Desirable limit mg/L	Permissible Limit (mg/L)	Min	Max	Mean	No. of samples (%)	
								>1.5	<1.5
1	Adilabad	22	1.5	1	0.1	3.0	0.9	9.1	90.9
2	Bhadradri Kothagudem	2	1.5	1	0.8	1.7	1.2	50.0	50.0
3	Hanamkonda	7	1.5	1	1.3	4.3	2.3	85.7	14.3
4	Hyderabad	16	1.5	1	0.4	1.7	0.9	6.3	93.8
5	J.Bhupalapally	3	1.5	1	0.0	1.0	0.6	0.0	100.0
6	Jagtial	8	1.5	1	0.8	2.4	1.5	50.0	50.0
7	Jangaon	11	1.5	1	0.4	2.3	1.3	45.5	54.5
8	Jogulamba Gadwal	5	1.5	1	0.2	1.0	0.5	0.0	100.0
9	Kamareddy	7	1.5	1	0.2	1.1	0.5	0.0	100.0
10	Karimnagar	7	1.5	1	0.3	3.8	1.4	42.9	57.1
11	KB Asifabad	5	1.5	1	0.2	0.9	0.6	0.0	100.0
12	Khammam	16	1.5	1	0.5	3.3	1.3	31.3	68.8
13	Mahabubabad	12	1.5	1	0.4	1.8	0.8	8.3	91.7
14	Mahabubnagar	9	1.5	1	0.2	2.1	1.0	22.2	77.8
15	Mancherial	11	1.5	1	0.2	2.4	1.0	9.1	90.9
16	Medak	12	1.5	1	0.4	2.4	1.1	8.3	91.7
17	Medchal Malkajgiri	5	1.5	1	0.5	2.5	1.4	40.0	60.0
18	Mulugu	4	1.5	1	0.3	1.0	0.5	0.0	100.0
19	Nagarkurnool	23	1.5	1	0.3	2.6	1.3	43.5	56.5
20	Nalgonda	27	1.5	1	0.4	5.8	1.4	22.2	77.8
21	Narayanpet	5	1.5	1	0.5	1.3	0.8	0.0	100.0
22	Nirmal	19	1.5	1	0.3	1.8	0.8	15.8	84.2
23	Nizamabad	12	1.5	1	0.2	1.0	0.7	0.0	100.0
24	Peddapalli	5	1.5	1	0.2	1.7	0.6	20.0	80.0
25	Rajanna Sircilla	9	1.5	1	0.0	2.0	0.8	11.1	88.9
26	Ranga Reddy	33	1.5	1	0.3	3.7	1.2	30.3	69.7
27	Sangareddy	23	1.5	1	0.1	2.0	0.6	4.3	95.7
28	Siddipet	25	1.5	1	0.3	2.2	1.1	12.0	88.0
29	Suryapet	11	1.5	1	0.2	1.3	0.5	0.0	100.0
30	Vikarabad	28	1.5	1	0.2	3.0	0.7	7.1	92.9
31	Wanaparthy	5	1.5	1	0.5	1.5	0.9	20.0	80.0
32	Warangal	7	1.5	1	0.8	2.5	1.7	71.4	28.6
33	Yadadri Bhuvanagiri	18	1.5	1	0.6	4.4	1.4	22.2	77.8

Table 9: Periodic variation in suitability Classes of Fluoride in groundwater.

Parameter	Class	Percentage of samples				Periodic Variation
		2019	2022	2023	2024 (pre)	
		(n=343)	(n=892)	(n=1150)	(n=412)	
Fluoride as F	< 1 mg/L	61.5	65	65.3	61.7	0.2
	1-1.5 mg/L	20.7	16.4	19.8	18.7	-2.0
	> 1.5 mg/L	17.8	18.6	14.9	19.7	1.9

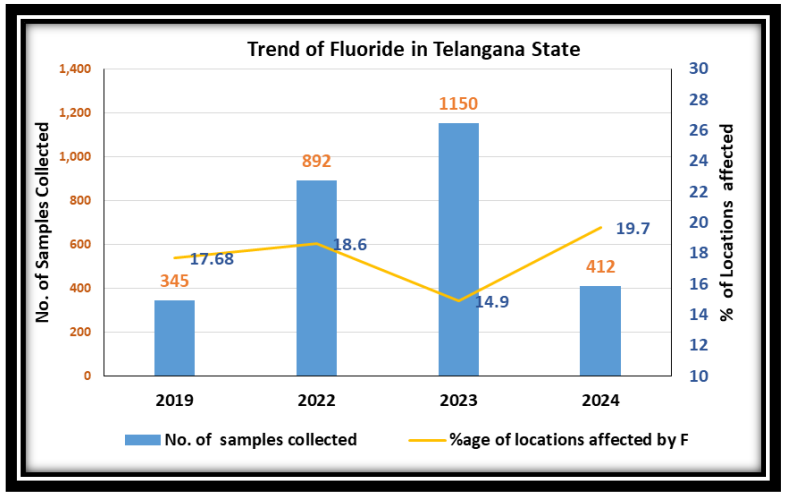

Fig-9: Trend of Fluoride in Telangana State

Table 10 shows the no. of locations affected by fluoride contamination from 2019 to 2024. Table 9 gives the Periodic variation in suitability Classes of Fluoride in groundwater and the trend analysis given in figure-9.

Table 10: Comparative Change in number of locations having F>1.5

Sr. No	District	No of Samples with F>1.5 mg/L			
		2019	2022	2023	2024
1	Adilabad	1	6	8	2
2	Bhadradri Kothagudem	3	3	5	1
3	Hanamkonda	1	3	5	6
4	Hyderabad	0	4	1	1
5	J.Bhupalapally	1	1	0	0
6	Jagtial	2	4	4	4
7	jangaon	2	7	12	5
8	Jogulamba Gadwal	2	1	0	0
9	Kamareddy	1	0	1	0
10	Karimnagar	0	6	1	3
11	KB Asifabad	0	2	5	0
12	Khammam	3	10	14	5
13	Mahabubabad	4	5	0	1
14	Mahabubnagar	3	8	4	2
15	Mancherial	3	5	2	1
16	Medak	2	4	6	1
17	Medchal Malkajgiri	0	3	7	2
18	Mulugu	0	1	0	0
19	Nagarkurnool	3	9	6	10
20	Nalgonda	5	8	14	6
21	Narayanpet	0	2	0	0
22	Nirmal	2	4	1	3
23	Nizamabad	0	2	5	0
24	Peddapalli	1	3	3	1
25	Rajanna Sircilla	0	3	4	1
26	Ranga Reddy	4	14	11	10
27	Sangareddy	2	7	1	1
28	Siddipet	1	9	9	3
29	Suryapet	2	3	8	0
30	Vikarabad	0	6	2	2
31	Wanaparthy	0	0	2	1
32	Warangal	5	9	9	5
33	Yadadri Bhuvanagiri	8	14	21	4

4.1.4 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 TELANGANA STATE

During 2019, 345 samples collected (188 samples collected from the effected districts Bhadradri Kothagudem, Hyderabad, Khammam, Mahabubnagar, Medak, Medchal Malkajgiri, Nagarkurnool, Nalgonda, Narayanpet, Nirmal, Ranga Reddy, Suryapet, Vikarabad, Wanaparthy & Yadadri Bhuvanagiri) from the monitoring stations of Telangana. Only 36 samples were found above 0.03 mg/L (30 ppb). During 2022 theses places were designated as hotspot with reference to Uranium, and about 428 samples were collected during Pre-Monsoon 2022, from these hotspot surroundings out of which

about 134 (31.3%) samples were observed more than 30 ppb. In 2024 about 274 samples were collected from theses hotspot surrounding and 77 (28.1%) samples were found above 30 ppb.

In 2024 the uranium content in ground water ranges from 0 to 1047 ppb (0 to 1.047 mg/L). The highest was recorded at recorded at Dammayyaguda (Kapara Mandal) of Medchal Malkajgiri district. Figure 10 shows the occurrence of uranium in ground water of the state during 2024 pre- monsoon.

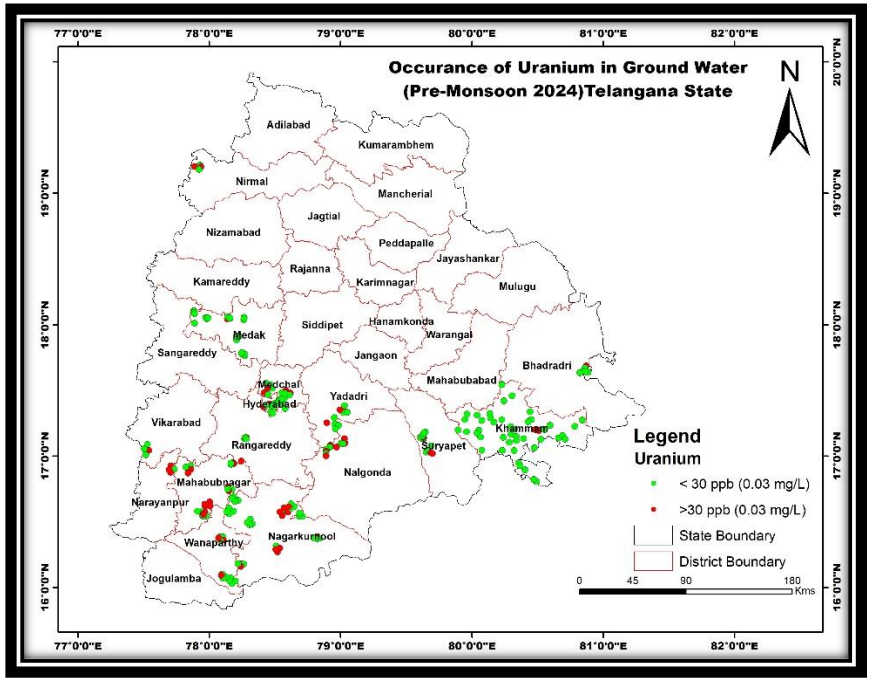

Figure 10: Occurrence of Uranium in Ground waters of Telangana during May-2024

Table 11 shows the district wise ranges, minimum, maximum, and mean of uranium. Table 12 and figure -11 shows the Comparative Change in number of Locations having U>30ppb and Periodic variation in suitability Classes of Uranium content in groundwater respectively during 2019, 2022 and 2024 pre-monsoon seasons. However, during 2022 and 2024 samples were only collected from trend stations.

Table 11: District wise Range and distribution of Uranium in Ground Water

Sl. No	District	No of samples analysed	Desirable limit ppb (µg/L)	Permissible Limit	Min	Max	Mean	No. of samples (%)	
								>30	<30
1	Bhadradri Kothagudem	8	30	No relaxation	3.300	44.500	12.400	12.5	87.5
2	Hyderabad	19	30	No relaxation	0.300	148.800	25.547	15.8	84.2
3	Khammam	47	30	No relaxation	0.000	41.900	7.103	4.3	95.7
4	Mahabubnagar	35	30	No relaxation	1.000	413.900	52.566	51.4	48.6
5	Medak	27	30	No relaxation	0.500	104.200	22.370	11.1	88.9
6	Medchal Malkajgiri	20	30	No relaxation	0.400	1046.500	26.800	25.0	75.0
7	Nagarkurnool	35	30	No relaxation	0.000	310.800	40.862	42.9	57.1
8	Nalgonda	15	30	No relaxation	0.000	77.400	29.493	33.3	66.7
9	Narayanpet	5	30	No relaxation	23.100	514.000	161.240	80.0	20.0
10	Nirmal	5	30	No relaxation	3.300	302.900	101.660	60.0	40.0
11	Ranga Reddy	5	30	No relaxation	10.200	35.300	20.740	20.0	80.0
12	Suryapet	23	30	No relaxation	4.500	79.300	27.113	39.1	60.9
13	Vikarabad	5	30	No relaxation	5.500	112.800	28.580	20.0	80.0
14	Wanaparthy	15	30	No relaxation	0.800	382.100	48.540	26.7	73.3
15	Yadadri Bhuvanagiri	10	30	No relaxation	2.300	77.300	25.190	30.0	70.0

Table 12: Periodic variation in suitability Classes of groundwater in Uranium

Parameter	Class	Percentage of samples			Periodic Variation
		2019	2022	2024 (pre)	
		(n=188)	(n=428)	(n=274)	
Uranium as U	< 30 ppb	80.9	68.7	71.9	-9.0
	> 30 ppb	19.1	31.3	28.1	9.0

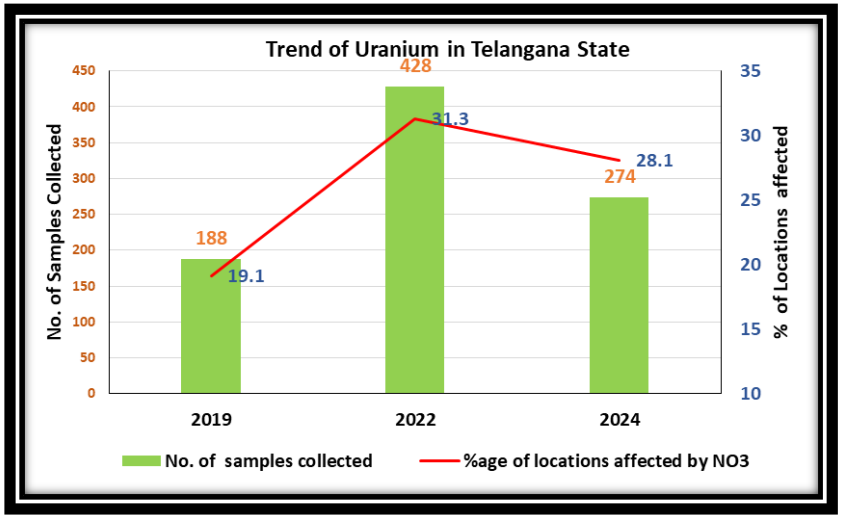

Fig-11: Trend of Uranium Hotspot districts in Telangana State

5. SUMMARY

The ground water quality during pre-monsoon season of 2024 has been compared with 2019, 2022 & 2023 pre-monsoon seasons. 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 2023 PRE- MONSOON DATA

The **Table 13** provides a detailed summary of groundwater quality across various districts in Telangana, focusing on basic parameters (electrical conductivity, nitrate, fluoride).

Basic Parameters:

• EC (Electrical Conductivity): 2.66% of samples exceed the limit of 3000 µS/cm at 25 C, was observed in parts of Jogulamba Gadwal, Khamam, Medak, Nalgonda, Rangareddy, Sangareddy and Yadadri Bhuvanagiri districts.

• NO3 (Nitrate): 34.7% of samples exceed limits, with notable numbers in Adilabad, J. Bhupalpalle, Rangareddy, Siddipet, Nalgonga, Jangaon, Vikarabad, Warangak, Khammam, adadri Bhuvanagiri, Medak etc.

• F (Fluoride): Overall, 19.7% of samples surpass permissible limits, with notable numbers in Yadadri Bhuvanagiri, Warangal, Medchal Malkanjgiri, Khammam, jangaon, Nalgonda, Rangareddy etc.

State Summery

The Table 13 & 14 provides a summary of groundwater quality in the state of Telangana, broken down by the number of samples collected and the percentage of those samples that are contaminated with various parameters.

No. of Samples Contaminated (%age of samples contaminated)				
Telangana State Summery (Pre-Monsoon)	Total No. of Basic Samples	EC	NO_3	F
	412	11 (2.66%)	143 (34.7 %)	81 (19.6%)

Table 13: Summary of Groundwater Quality in Telangana: Samples Collected and Contamination Percentag

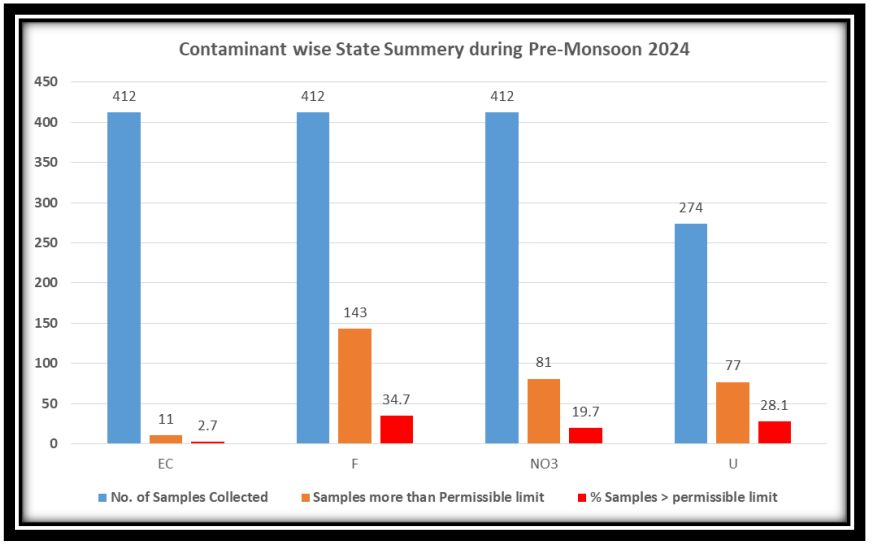

Table 14: Summary of Groundwater Quality in Various Districts of Telangana, Highlighting Basic Parameters (Electrical Conductivity, Nitrate, Fluoride & Uranium)

Districts	Total No. of Basic Samples	No of samples(% of samples) Over Permissible limit						Districts	Total No. of Basic Samples	U Above Permissible limit	
		EC		NO3		F					
		No	%	No	%	No	%			No	%
Adilabad	22	0	0.0	13	59.1	2	9.1	Adilabad	0	0	--
Bhadradri Kothagudem	2	0	0.0	0	0.0	1	50.0	Bhadradri Kothagudem	8	1	12.5
Hanamkonda	7	0	0.0	2	28.6	6	85.7	Hanamkonda	0	0	--
Hyderabad	16	0	0.0	0	0.0	1	6.3	Hyderabad	19	3	15.8
J.Bhupalapally	3	0	0.0	1	33.3	0	0.0	J.Bhupalapally	0	0	--
Jagtial	8	0	0.0	2	25.0	4	50.0	Jagtial	0	0	--
Jangaon	11	0	0.0	1	9.1	5	45.5	Jangaon	0	0	--
Jogulamba Gadwal	5	2	40.0	1	20.0	0	0.0	Jogulamba Gadwal	0	0	--
Kamareddy	7	0	0.0	1	14.3	0	0.0	Kamareddy	0	0	--
Karimnagar	7	0	0.0	0	0.0	3	42.9	Karimnagar	0	0	--
KB Asifabad	5	0	0.0	1	20.0	0	0.0	KB Asifabad	0	0	--
Khammam	16	1	6.3	5	31.3	5	31.3	Khammam	47	2	4.3
Mahabubabad	12	0	0.0	2	16.7	1	8.3	Mahabubabad	0	0	--
Mahabubnagar	9	0	0.0	2	22.2	2	22.2	Mahabubnagar	35	18	51.4
Mancherial	11	0	0.0	3	27.3	1	9.1	Mancherial	0	0	--
Medak	12	2	16.7	3	25.0	1	8.3	Medak	27	3	11.1
Medchal Malkajgiri	5	0	0.0	3	60.0	2	40.0	Medchal Malkajgiri	20	5	25.0
Mulugu	4	0	0.0	2	50.0	0	0.0	Mulugu	0	0	--
Nagarkurnool	23	0	0.0	9	39.1	10	43.5	Nagarkurnool	35	15	42.9
Nalgonda	27	2	7.4	15	55.6	6	22.2	Nalgonda	15	5	33.3
Narayanpet	5	0	0.0	3	60.0	0	0.0	Narayanpet	5	4	80.0
Nirmal	19	0	0.0	7	36.8	3	15.8	Nirmal	5	3	60.0
Nizamabad	12	0	0.0	4	33.3	0	0.0	Nizamabad	0	0	--
Peddapalli	5	0	0.0	1	20.0	1	20.0	Peddapalli	0	0	--
Rajanna Sircilla	9	0	0.0	0	0.0	1	11.1	Rajanna Sircilla	0	0	--
Ranga Reddy	33	1	3.0	15	45.5	10	30.3	Ranga Reddy	5	1	20.0
Sangareddy	23	1	4.3	10	43.5	1	4.3	Sangareddy	0	0	--
Siddipet	25	0	0.0	10	40.0	3	12.0	Siddipet	0	0	--
Suryapet	11	0	0.0	3	27.3	0	0.0	Suryapet	23	9	39.1
Vikarabad	28	0	0.0	15	53.6	2	7.1	Vikarabad	5	1	20.0
Wanaparthy	5	0	0.0	3	60.0	1	20.0	Wanaparthy	15	4	26.7
Warangal	7	0	0.0	2	28.6	5	71.4	Warangal	0	0	--
Yadadri Bhuvanagiri	18	2	11.1	4	22.2	4	22.2	Yadadri Bhuvanagiri	10	3	30.0
Total	412	11	2.7	143	34.7	81	19.7	Total	274	77	28.1

6. RECOMMENDATIONS & CONCLUSION

With respect to the tests carried out, the state of Telangana generally has good quality water according to drinking and domestic water standards. However, in a some localized areas, contaminants are found in the groundwater. The primary concern in Telangana is the high nitrate levels present in almost all districts, likely due to the use of fertilizers in agriculture, sewage, and other anthropogenic sources. Fluoride also as major contaminate as it is found in about 81 samples out of 412 samples during the pre-monsoon of 2024. Additionally, certain locations exhibit contamination from uranium, which can be attributed to geo-genic origins. As nitrate & Fluoride are the major contaminates found in groundwater of Telangana following remediation's recommended for the localities with high nitrate and fluorides.

Nitrate: For removal of nitrate both non-treatment techniques like blending and treatment processes such as ion exchange, reverse osmosis, biological de-nitrification and chemical reduction are useful. The most important thing is that neither of these methods is completely effective in removing all the nitrogen from the water.

- Methods involving no treatment: In order to use any of these options the nitrate problem must be local-scale. Common methods are:
  - Raw water source substitution
  - Blending with low nitrate waters

  This greatly reduces expenses and helps to provide safer drinking water to larger numbers of people.

- Methods involving Treatment: They are as follows:
  - Adsorption/Ion Exchange
  - Reverse Osmosis
  - Electrodialysis
  - Bio-chemical Denitrification (By using denitrifying bacteria and microbes)
  - Catalytic Reduction/Denitrification (using hydrogen gas)

  Complex biogeochemical processes govern the mechanism of nitrate pollution in subsurface porous unconfined/confined aquifer. Apart from recharge conditions, groundwater chemistry may be impacted by the mineral kinetics of water-rock interactions. Consequently, suitable nitrate removal technologies should be selected. Nitrate is a very soluble ion with limited potential for co-precipitation or adsorption. This makes it difficult to remove by processes such as chemical coagulation, lime softening and filtration, which are commonly used for removing most of the chemical pollutants such as fluoride, arsenic and heavy metals. According to King et al., 2012 nitrate treatment technologies can be classified in two categories in two categories, i.e. nitrate reduction and nitrate removal options. Nitrate removal technologies involve physical processes that does not necessarily involve any alteration of the chemical state of nitrate ions. Bio-chemical reduction options aim to reduce nitrate ions to other states of nitrogen, e.g. ammonia, or a more innocuous form as nitrogen gas. In-situ bioremediation is also effectively used in used in nitrate treatment of contaminated groundwater. Reverse Osmosis, catalytic

reduction and blending are effective methods for nitrate removal from groundwater.

Fluoride: The fluoride remedial measures broadly adopted are ex-situ techniques. They can be classified into three major categories.

- Adsorption and ion exchange
- Ion-Exchange resins
- Coagulation-precipitation
- Nalgonda Technique

The choice of method depends quantum of water to be treated i.e. domestic level or community level or large scale and implementation. It also depends on factors such as the level of contamination, water quality standards, and available resources. Combination approaches may also be necessary for effective contamination removal in some cases. In present day scenario, Reverse Osmosis (RO) Method using controlled TDS (TDS not less than 500 mg/l as per BIS acceptable value) seems economically and practically more feasible than other methods. Additionally, piped treated water supply in affected locations and method of dilution by employing Rainwater Harvesting method also seems effective.