Government of India
Central Ground Water Board
Department of Water Resources, RD & GR
Ministry of Jal Shakti

GROUNDWATER CHEMICAL QUALITY BULLETIN RAJASTHAN

Central Ground Water Board
Western Region
Jaipur

ABSTRACT

A comprehensive analysis of groundwater across Rajasthan 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, Copper, Cadmium. Analysis shows the temporal variation of these parameters during the period of 2021 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 224 of the water samples tested were found to be mineralised 39.29 % where electrical conductivity values exceeding 3000 µS/cm whereas around 12.05 % 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 42.86 % and 33.04 % of contaminated samples respectively. Among heavy metals iron appears to be prominent with 4.91% of the samples exceeding the permissible limit 1.0 mg/l . Uranium (7.59 %), Iron (2.36%), Arsenic (0 %), lead (3 location), and Manganese (1- location) are the other trace metals with elevated levels in the ground waters of the CGWB, WR, Rajasthan state.

1.0 INTRODUCTION

Water is the basis for all life forms and is a vital component for our life support system. Ground water plays an important role in domestic water supply, agriculture and for industrial use. Rajasthan State is under severe stress regarding ground water quantity and quality and its management.. 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, 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.

Every year CGWB, WR, Rajasthan 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 2021.

2.0 STUDY AREA

The State of Rajasthan comprising of 33 districts has a geographical area of 3,42,239 square kilometre (sq km) and is the largest State in the country. Administrative division map of Rajasthan is shown in Figure-1. It is situated between north latitudes 23°03' and 30°12' and east longitudes 69°30' and 78°17'. The ground water monitoring is being carried out through a network of observation wells- the National Hydrograph Network Stations (NHS).

The state has a fairly mature topography developed during the long period of denudation and erosion. The present physiography and landforms are greatly determined by geological formations and structures and is the product of the past fluvial cycle of erosion and the recent & continuing desert cycle of erosion. Physiographically the state can be divided into four units:

(a) Aravalli hill ranges (b) Eastern plains

© Western Sandy Plain and Sand Dunes

(d) Vindhyan Scarpland and Deccan Lava Plateau

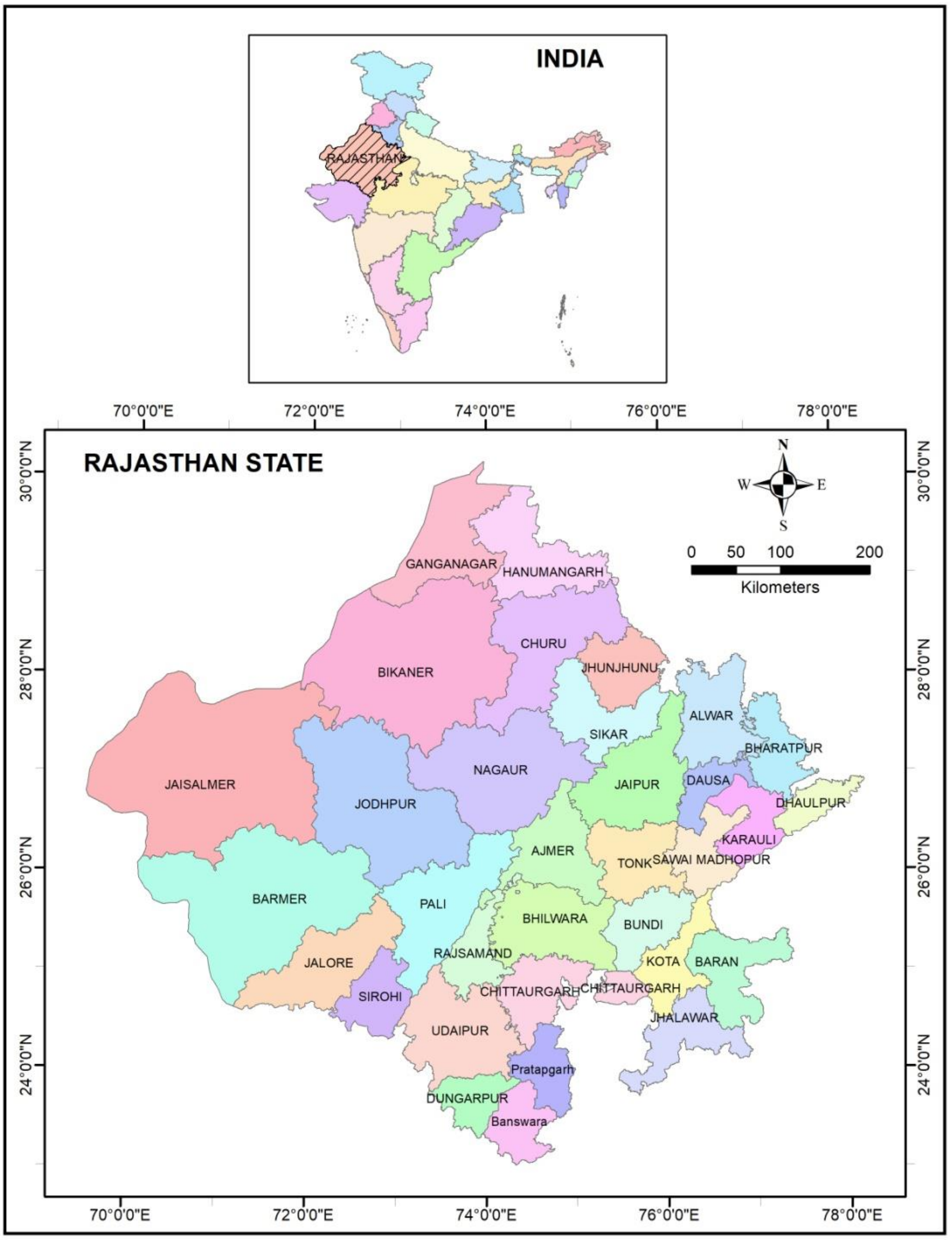

Figure 1: Administrative Divisions

The National Hydrograph Network Stations set-up is a system of spatially distributed observation points at which periodic monitoring of ground water and regime behavior viz. recording of water levels and temperature and collection of ground water samples for water (chemical) quality analysis are done. The main objectives of monitoring of water levels and water quality are to observe the rise and fall of ground water levels and to study changes in quality of water in space and time consequent to changes in the inputs and outputs. Database on ground water levels and quality created through this effort forms an important tool in the evaluation of optimum development and decision making on the various aspects of water resources management. The administrative division map is given in fig-1 . Presently 1266 NHS comprises of 709 dug well and 557 piezometers in the state are being monitored and are represented on map of Rajasthan in Figure-2.

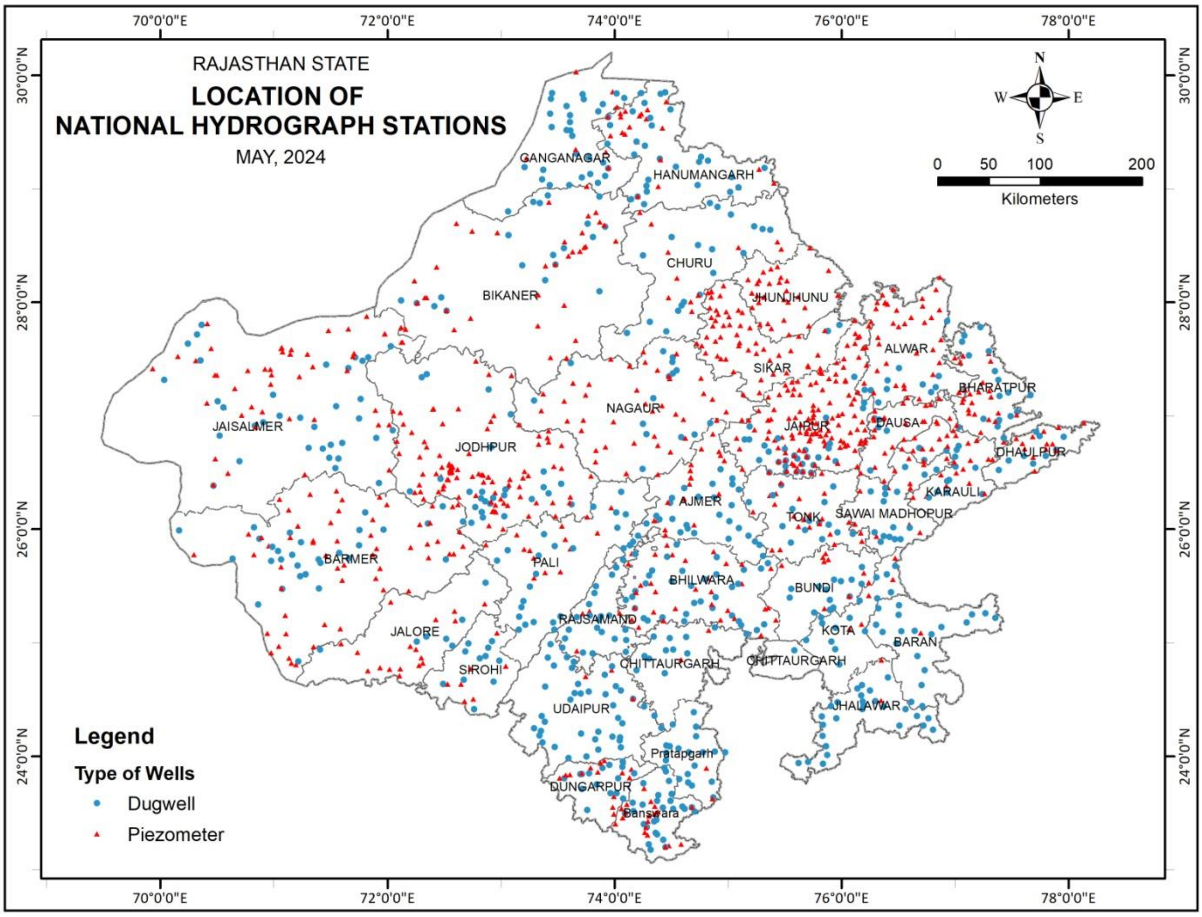

Figure 2: Location of National Hydrograph Stations

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 main objective of ground water quality monitoring programme is to get information on the distribution of water quality on a regional scale as well as create a background data bank of different chemical constituents in ground water. The Central Ground Water Board (CGWB), WR, Rajasthan office has implemented a bi-annual groundwater quality monitoring program since 2024. 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- 224 and for trace metals- 224 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 2021, 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.

. The probable causes of deterioration in ground water quality ae depicted in Figure 3

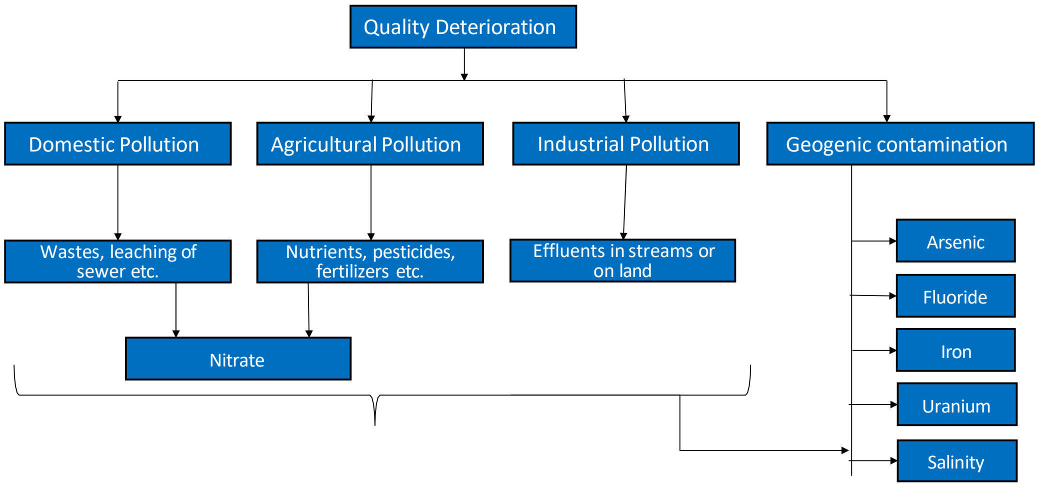

Figure 3: Schematic diagram illustrating the potential factors contributing to the degradation of groundwater quality.

The chemical quality of shallow ground water is being monitored by Central Ground Water Board twice in a year (Pre-monsoon and Post- monsoon) since 2024 through 224 locations located all over the state (Figure 4).

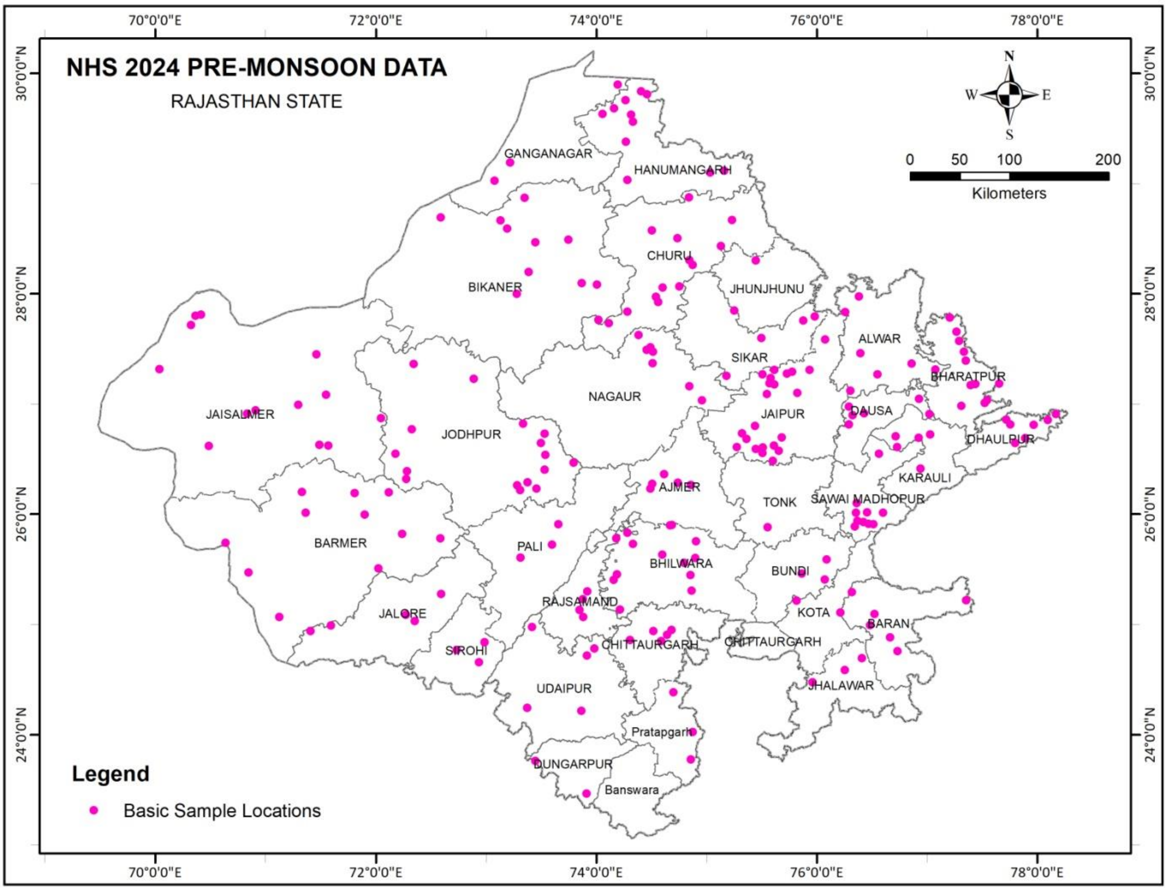

Figure 4: Map showing Spatial Distribution of Groundwater Quality Monitoring Stations in based on 2024 NHS

The district-wise distribution of water Quality Monitoring Stations of CGWB is given in Table 1. The present bulletin is based on the changing scenario in water quality in network observation wells of CGWB in year 2021 and 2024

Table 1: District wise distribution of water Quality Monitoring Stations

S. No.	District	Number of water quality monitoring stations			
		31.3.21	31.3.22	31.3.23	31.3.24
1	AJMER	24	25	14	5
2	ALWAR	10	26	15	7
3	BANSWARA	33	35	14	0
4	BARAN	17	19	5	6
5	BARMER	50	26	54	11
6	BHARATPUR	17	22	18	11
7	BHILWARA	37	55	27	13
8	BIKANER	24	25	37	10
9	BUNDI	9	11	9	3
10	CHITTAURGARH	12	17	5	5
11	CHURU	19	29	44	14
12	DAUSA	5	6	10	7
13	DHAULPUR	8	10	6	7
14	DUNGARPUR	15	13	4	2
15	GANGANAGAR	35	36	11	3
16	HANUMANGARH	30	28	16	11
17	JAIPUR	39	74	32	22
18	JAISALMER	26	24	33	13
19	JALORE	5	5	23	5
20	JHALAWAR	22	27	12	3
21	JHUNJHUNU	8	17	19	2
22	JODHPUR	35	30	72	16
23	KARAULI	11	15	11	5
24	KOTA	16	15	1	2
25	NAGAUR	17	12	39	7
26	PALI	14	17	19	3
27	PRATAPGARH	16	17	7	3
28	RAJSAMAND	23	22	15	5
29	SAWAI MADHOPUR	14	17	11	10
30	SIKAR	2	34	8	4
31	SIROHI	10	10	13	3
32	TONK	15	16	14	1
33	UDAIPUR	22	39	12	5
	TOTAL	640	774	630	224

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. Based on the results, The ground water quality in has indicated higher concentration of Electrical conductivity, Chloride, Nitrate and Fluoride vis-a-vis drinking water standards and the violation of Water quality standards have been observed at many places in surveyed districts of the State.

Groundwater in Rajasthan predominantly exhibits a majority of the samples in the Na-Cl field and some of the samples showed Ca-HCO3 type. Rest of them was fall in the Ca-SO4 and Mixed water types and some samples having fresh water quality when the total salinity of water is below 500 mg/l (corresponding to electrical conductance of 750 µs/cm at 25°C). They are of mixed cations and mixed anions type when the electrical conductance is between 750 and 3000 µs/cm and waters with electrical conductance above 3000 µs/cm are of sodium chloride (Na-Cl) type. However, other types of water are also found among these general classifications, which may be due to the local variations in hydro-chemical environments due to anthropogenic activities. Nevertheless, occurrence of high concentrations of some water quality parameters such as Salinity (EC), Fluoride, Nitrate, Iron and Uranium and the changes in water quality based on these parameters have been observed in the various parts of Rajasthan. 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

Unconfined aquifers are extensively tapped for water supply and irrigation across the state therefore; its quality is of paramount importance. The chemical parameters like TDS, Fluoride, Nitrate, Iron, Arsenic and Uranium etc are main constituents defining the quality of ground water in unconfined aquifers. Therefore, presence of these parameters and the changes in chemical quality with respect to these in ground water in samples collected during NHS monitoring 2021 & 2024 are discussed below.

1. Electrical Conductivity (> 3000 µS/cm)

2 Fluoride (>1.5 mg/litre)

3. Nitrate (>45 mg/litre)

4. Iron (>1.0 mg/litre)

5. Arsenic (>0.01 mg/litre)

6. Uranium (>30 ppb)

4.1.1 ELECTRICAL CONDUCTIVITY

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

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

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

PRESENT DAY SCENARIO IN RAJASTHAN W. R.T ELECTRICAL CONDUCTIVITY (EC)

Distribution of Electrical Conductivity (EC)

The EC value of ground waters in the State varies from 268 at Tidiyasar, Ratangarh Block,of Churu District , to 20000 µS/cm at Deeg , Deeg block of Bharatpur at 25°C. Grouping water samples based on EC values, it is found that 12.05 % of them have EC less than 750 µS/cm, 48.66 % have between 750 and 3000 µS/cm and the remaining 39.29 % of the samples have EC above 3000µS/cm. The map showing aerial distribution of EC (Figure 5) with intervals corresponding to limits as above indicates that less than 750 class of water occur throughout the state in few patches but in high proportion is in northern western parts of the State. The ground water occurring within permissible limit 2000 mg/l of TDS in the southern and some part in north east and most of part in south west comprising of parts of Ganganagar, Jhunjhunu, Sikar, Alwar, Sawaimadhopur, Kota, Karauli Bundi , Jhalawara, Udaipur, Chittorgarh, Pratapgarh , Rajasamand Dungarpur, Daulpur and Banswara district.

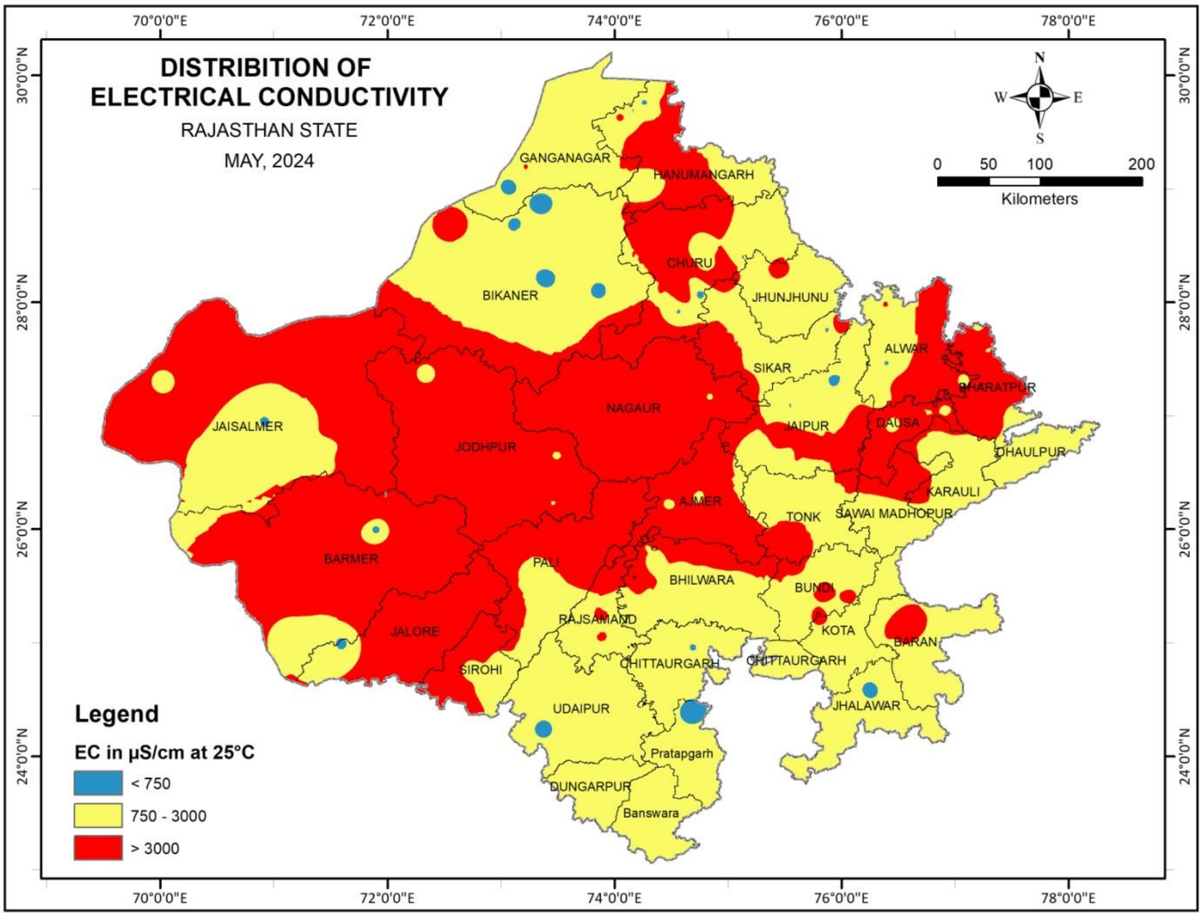

Figure 5: Map showing distribution of Electrical Conductivity in Rajasthan based on NHS 2024 Data

In Most of west Rajasthan in Jodhpur, Barmer, Jalore, Jaisalmer having saline water and in middle Rajasthan Nagaur ,Ajmer districts . Water of these areas not suitable for drinking purpose in terms of Electrical Conductance.

The Table 2 given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean EC values based on NHS 2024 Data (Pre). In comparison to 2021 (Table 3 TEMPORAL VARIATION OF EC IN GROUND WATER DURING THE PERIOD FROM 2021 TO 2024), it has been observed that there is marginal variation in the no. of Districts having EC more than 3000 µS/cm in 2024. Table 4 shows Periodic variation in suitability Classes of groundwater Electrical Conductivity (EC) of Rajasthan since 2021 to 2024 and the year wise variation of the percentage of samples exceeding the EC value of 3000 µS/cm has been given in table 5. Year wise periodic Variation in % locations affected by Electrical conductivity and trend of EC is increasing since 2021 shown in fig 6 .

Table 2: District wise Range and Percentage value of distribution of EC Pre-24 in shallow GW of Rajasthan

	district	No.of samples analysed	Permissible limit (µS/cm)	Min	Max.	Mean	Number of samples (Percent)		
							<750	750-3000	>3000
1	AJMER	5	3000	2020	8440	4076	0.00	40.00	60.00
2	ALWAR	7	3000	673	6900	2678	14.29	42.86	42.86
3	BANSWARA	0	3000	0	0	#DIV/0!	0.00	0.00	0.00
4	BARAN	6	3000	920	7200	2283	0.00	83.33	16.67
5	BARMER	11	3000	342	13140	4818	9.09	9.09	81.82
6	BHARATPUR	11	3000	1390	20000	5357	0.00	36.36	63.64
7	BHILWARA	13	3000	828	6530	2740	0.00	76.92	23.08
8	BIKANER	10	3000	275	3630	1435	40.00	50.00	10.00
9	BUNDI	3	3000	2540	3250	2983	0.00	33.33	66.67
10	CHITTAURGARH	5	3000	601	1700	1210	20.00	80.00	0.00
11	CHURU	14	3000	268	8210	3431	14.29	35.71	50.00
12	DAUSA	7	3000	1850	7600	3867	0.00	42.86	57.14
13	DHAULPUR	7	3000	640	3000	1586	14.29	85.71	0.00
14	DUNGARPUR	2	3000	750	800	775	50.00	50.00	0.00
15	GANGANAGAR	3	3000	472	3060	2031	33.33	33.33	33.33
16	HANUMANGARH	11	3000	430	7030	2538	36.36	27.27	36.36
17	JAIPUR	22	3000	594	6570	1889	13.64	72.73	13.64
18	JAISALMER	13	3000	377	11960	4061	7.69	38.46	53.85
19	JALORE	5	3000	429	16120	7756	20.00	20.00	60.00
20	JHALAWAR	3	3000	380	2720	1447	33.33	66.67	0.00
21	JHUNJHUNU	2	3000	2080	3180	2630	0.00	50.00	50.00
22	JODHPUR	16	3000	2210	12500	4993	0.00	18.75	81.25
23	KARAULI	5	3000	960	2400	1564	0.00	100.00	0.00
24	KOTA	2	3000	806	3080	1943	0.00	50.00	50.00
25	NAGAUR	7	3000	2730	9500	5716	0.00	14.29	85.71
26	PALI	3	3000	1250	4250	3027	0.00	33.33	66.67
27	PRATAPGARH	3	3000	390	2780	1800	33.33	66.67	0.00
28	RAJSAMAND	5	3000	641	7550	3688	20.00	20.00	60.00
29	SAWAI MADHOPUR	10	3000	698	15000	3197	10.00	80.00	10.00
30	SIKAR	4	3000	579	4650	2757	25.00	25.00	50.00
31	SIROHI	3	3000	2120	2670	2362	0.00	100.00	0.00
32	TONK	1	3000	3880	3880	3880	0.00	0.00	100.00
33	UDAIPUR	5	3000	660	1220	972	20.00	80.00	0.00
		224							

Table -3 TEMPORAL VARIATION OF EC IN GROUND WATER DURING THE PERIOD FROM 2021 TO 2024

S.No.	District	No. of locations having EC>3000 µS/cm			
		2021	2022	2023	2024
1	AJMER	9	3	6	3
2	ALWAR	1	3	2	3
3	BANSWARA	0	1	0	0
4	BARAN	0	0	0	1
5	BARMER	18	28	44	9
6	BHARATPUR	8	11	11	7
7	BHILWARA	16	10	12	3
8	BIKANER	8	13	15	1
9	BUNDI	3	3	1	2
10	CHITTAURGARH	1	1	1	0
11	CHURU	9	21	27	7
12	DAUSA	5	6	6	4
13	DHAULPUR	2	4	0	0
14	DUNGARPUR	0	0	0	0
15	GANGANAGAR	8	4	3	1
16	HANUMANGARH	10	8	8	4
17	JAIPUR	11	16	17	3
18	JAISALMER	15	19	21	7
19	JALORE	4	12	13	3
20	JHALAWAR	4	0	0	0
21	JHUNJHUNU	1	4	10	1
22	JODHPUR	17	35	50	13
23	KARAULI	3	5	6	0
24	KOTA	0	0	0	1
25	NAGAUR	7	14	29	6
26	PALI	6	7	9	2
27	PRATAPGARH	1	0	0	0
28	RAJSAMAND	3	5	2	3
29	SAWAI MADHOPUR	4	4	3	1
30	SIKAR	10	2	1	2
31	SIROHI	3	3	2	0
32	TONK	6	2	7	1
33	UDAIPUR	2	3	1	0
		195	247	307	88

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

Parameter	Class	Percentage of samples				Periodic variation
		2021	2022	2023	2024	PERIODIC Variation 2021-2024
		n=(774)	n=(809)	n=(630)	n=(224)	
Salinity as EC	<750 us/cm	15.37	11.07	8.51	12.05	3.32
	750-3000	56.58	61.44	57.80	48.66	7.92
	>3000	28.04	27.50	33.70	39.29	-11.25

Table- 5 : Year wise periodic Variation in % locations affected by Electrical conductivity

No. of Districts	year	No. of Districts	% of locations affected by **Electrical Conductivity**
29	2021	**29**	**28.04**
28	2022	**28**	**27.5**
26	2023	**26**	**33.7**
24	2024	**24**	**39.29**

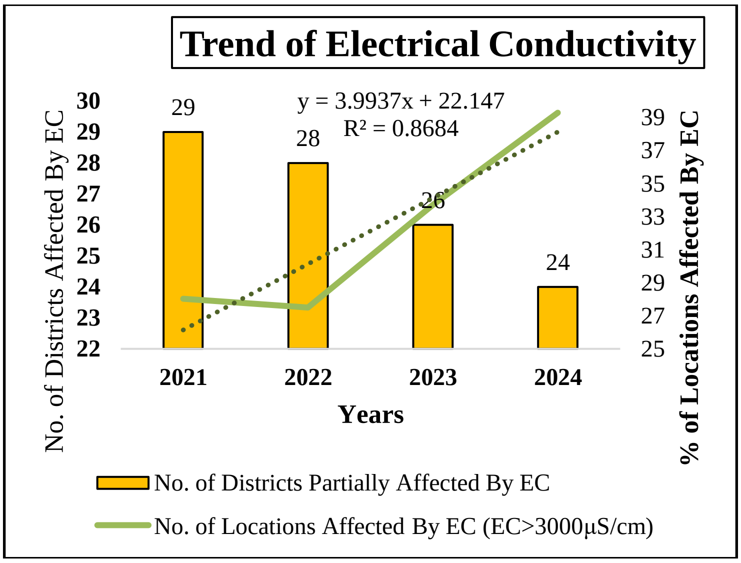

Fig: 6 Trend of electrical conductivity

4.1.2 NITRATE :

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

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

PRESENT DAY SCENARIO IN RAJASTHAN W. R.TNITRATE (NO_3)

Distribution of Nitrate (NO3)- The probable sources of nitrate contamination of ground water are through excessive application of fertilizers, bacterial nitrification of organic nitrogen, and seepage from animal and human wastes and atmospheric inputs. In the State, nitrate in ground water samples varies from BDL to 1202 mg/L. BIS permits a maximum concentration of 45 mg/L nitrate in drinking water. Considering this limit, it is found that 42.86 % of the samples, spread over the entire State, have nitrate beyond the acceptable limit. The distribution of nitrate in Rajasthan is given below in fig. 8 The chemical analysis results in the table - 6 given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean NO3 values based on NHS 2024 Data (Pre). In comparison to 2021 (Table 7 TEMPORAL VARIATION OF NO3 IN GROUND WATER DURING THE PERIOD FROM 2021 TO 2024), it has been observed that there is marginal variation in the no. of Districts having NO3 more than 45mg/l in 2024. Table 8 shows Periodic variation in suitability Classes of groundwater Nitrate (NO3) of Rajasthan since 2021 to 2024 and the year wise variation of the percentage of samples exceeding the NO3 value of 45mg/l has been given in table 9. Year wise periodic Variation in % locations affected by nitrate and trend of NO3 is increasing since 2021 shown in fig 7 .

Table - 6 N umber of samples analyzed per district, along with their minimum, maximum, and mean Nitrate values based on NHS 2024 Data (Pre).

S.No	district	No. of samples analysed	Permissible limit (45 mg/l)	Min	Max.	Mean	<45	>45
1	AJMER	5	45	1.10	140	78.22	20.00	80.00
2	ALWAR	7	45	9.00	320	94.14	28.57	71.43
3	BANSWARA	0	45	-	-	-	-	-
4	BARAN	6	45	23.00	65	36.83	83.33	16.67
5	BARMER	11	45	5.00	320	61.36	63.64	36.36
6	BHARATPUR	11	45	6.00	290	80.09	54.55	45.45
7	BHILWARA	13	45	1.00	165	83.46	30.77	69.23
8	BIKANER	10	45	3.00	420	97.10	60.00	40.00
9	BUNDI	3	45	8.00	210	114.33	33.33	66.67
10	CHITTAURGARH	5	45	0.00	80	29.00	80.00	20.00
11	CHURU	14	45	4.00	1202	321.50	28.57	71.43
12	DAUSA	7	45	0.40	1000	172.70	57.14	42.86
13	DHAULPUR	7	45	11.00	60	26.71	71.43	28.57
14	DUNGARPUR	2	45	4.40	7	5.60	100.00	0.00
15	GANGANAGAR	3	45	2.00	510	172.67	66.67	33.33
16	HANUMANGARH	11	45	2.00	410	58.00	81.82	18.18
17	JAIPUR	22	45	0.60	125	34.80	72.73	27.27
18	JAISALMER	13	45	1.00	520	130.15	53.85	46.15
19	JALORE	5	45	3.00	90	49.20	40.00	60.00
20	JHALAWAR	3	45	2.00	36	16.33	100.00	0.00
21	JHUNJHUNU	2	45	9.00	95	52.00	50.00	50.00
22	JODHPUR	16	45	7.90	385	59.93	75.00	25.00
23	KARAULI	5	45	0.50	256	64.04	80.00	20.00
24	KOTA	2	45	15.00	27	21.00	100.00	0.00
25	NAGAUR	7	45	25.00	608	244.71	28.57	71.43
26	PALI	3	45	7.00	98	42.83	66.67	33.33
27	PRATAPGARH	3	45	1.30	125	48.93	66.67	33.33
28	RAJSAMAND	5	45	2.00	70	28.80	80.00	20.00
29	S. MADHOPUR	10	45	10.00	252	121.90	20.00	80.00
30	SIKAR	4	45	9.00	380	171.00	25.00	75.00
31	SIROHI	3	45	22.00	180	82.00	66.67	33.33
32	TONK	1	45	120	120	120.00	0.00	100.00
33	UDAIPUR	5	45	0.30	60	16.20	80.00	20.00
		224						

Table 7: Temporal change in number of locations having Nitrate > 45 mg/l

S.No.	District	No. of locations having Nitrate > 45 mg/l			
		2021	2022	2023	2024
1	AJMER	10	12	6	4
2	ALWAR	3	10	6	5
3	BANSWARA	12	9	8	0
4	BARAN	4	6	3	1
5	BARMER	19	25	36	4
6	BHARATPUR	4	12	5	5
7	BHILWARA	25	17	13	9
8	BIKANER	10	16	12	4
9	BUNDI	1	2	1	2
10	CHITTAURGARH	5	6	3	1
11	CHURU	17	20	28	10
12	DAUSA	2	5	4	3
13	DHAULPUR	4	6	0	2
14	DUNGARPUR	2	2	0	0
15	GANGANAGAR	16	6	5	1
16	HANUMANGARH	8	11	9	2
17	JAIPUR	22	23	18	6
18	JAISALMER	10	11	13	6
19	JALORE	2	10	11	3
20	JHALAWAR	12	11	4	0
21	JHUNJHUNU	4	7	12	1
22	JODHPUR	18	31	41	4
23	KARAULI	5	8	7	1
24	KOTA	0	2	0	0
25	NAGAUR	7	16	19	5
26	PALI	7	7	9	1
27	PRATAPGARH	5	6	6	1
28	RAJSAMAND	0	6	6	1
29	S. MADHOPUR	7	8	5	8
30	SIKAR	19	5	4	3
31	SIROHI	5	7	5	1
32	TONK	5	5	8	1
33	UDAIPUR	8	11	6	1
		278	339	313	96

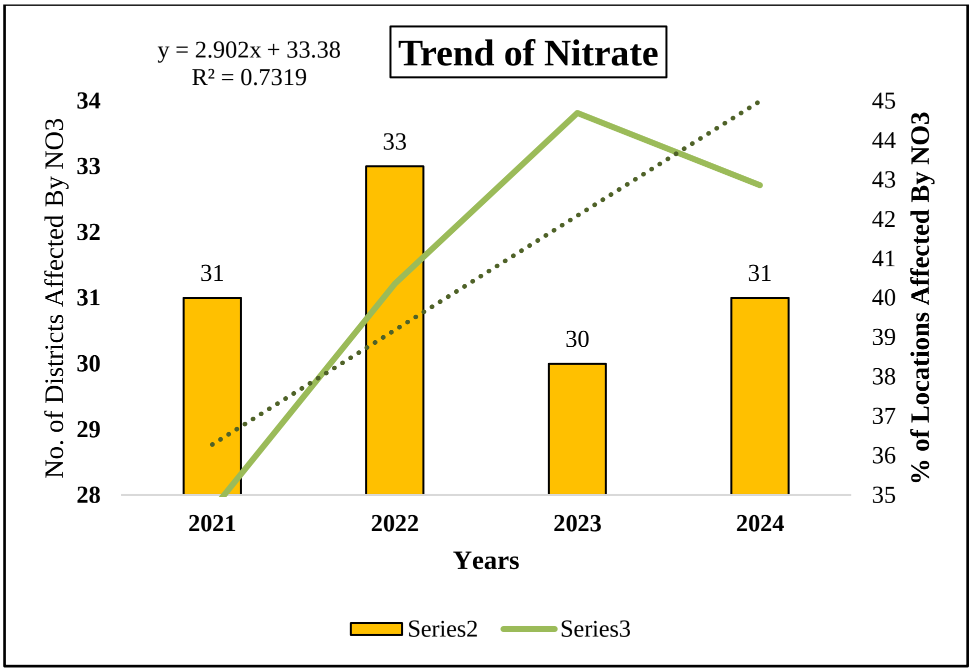

Fig 7: Trend of Nitrate since 2021-2024

Table 8: Periodic variation in suitability Classes of groundwater Nitrate (NO3) of Rajasthan

Parameter	Class	Pecrntage of samples				Periodic variation
		2021	2022	2023	2024	PERIODIC Variation 2021-2024
		n=(774)	n=(809)	n=(630)	n=(224)	
NITRATE	< 45 mg/l	65.37	59.64	55.31	57.14	8.23
	> 45 mg/l	34.63	40.36	44.69	42.86	-8.23

Table 9: Periodic variation in suitability Classes of Nitrate in groundwater of Rajasthan

No. of districts	**year**	**No. of districts**	% of locations affected by NO3
31	2021	**31**	34.63
33	2022	**33**	40.36
30	2023	**30**	44.69
31	2024	**31**	42.86

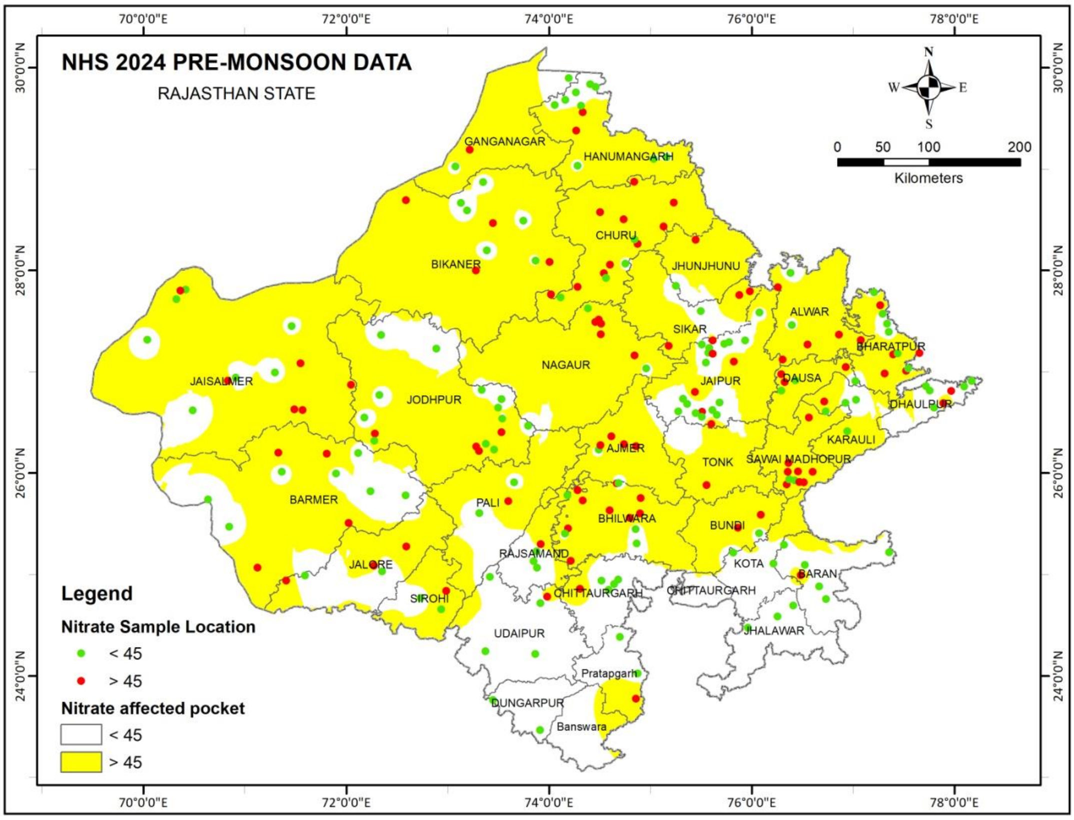

Figure 8: Map showing distribution of Nitrate in Rajasthan based on NHS 2024 Data

4.1.3 FLUORIDE-

Fluorine does not occur in the elemental state in nature because of its high reactivity. It exists in the form of fluorides in a number of minerals of which Fluorspar, Cryolite, Fluorite & Fluorapatite are the most common. Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. Most of the fluorides are sparingly soluble and are present in groundwater in small amount. The type of rocks, climatic conditions, nature of hydro geological strata and time of contact between rock and the circulating groundwater affect the occurrence of fluoride in natural water. BIS has recommended a desirable limit of 1.0 mg/l of fluoride concentration in drinking water and maximum permissible limit of 1.5 mg/l in case no alternative source of drinking water is available. It is well known that small amount of fluoride (**upto**1.0 mg/l) have proven to be beneficial in reducing tooth decay. However, high concentrations (>1.5mg/l) have resulted in staining of tooth enamel while at still higher levels of fluoride (> 5.0 mg/l) further critical problems such as stiffness of bones occur. Water having fluoride concentration more than 1.5mg/l is not suitable for drinking purposes. High Fluoride >1.5mg/l is mainly attributed due to geogenic conditions. The fluoride content in ground water from observation wells in a major part of the State is found to be less than 1.0 mg/l.

PRESENT DAY SCENARIO IN RAJASTHAN W. R.T Fluoride (F^-)

Distribution of Fluoride (F)

Fluoride in small amounts in drinking water is beneficial for the dental health while in large amounts it is injurious. The fluoride content in ground water ranges from 0.01 to 13.50 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 an analysis of groundwater samples revealed that 49.11 % of samples fell within the acceptable limit of < 1.0 mg/L 17.86 % between the acceptable and permissible range of 1.5 mg/L and 33.04% exceeded the permissible limit. that groundwater with excess fluoride levels is predominantly found in the districts of Bikaner (50%), Barmer (54.55%),, Nagaur (57.14%),, Jalore (60 %), Pali (66.67%), and Jhunjhunu (100%), districts in the state. It is notable that the western part of Aravalli are more fluoride content contaminated than eastern part of Aravalli in the state Baran, Bundi Dungerpur Jhalawar,Kota, Pratapgarh district are free from fluoride contamination. The maximum concentration of 13.50 mg/L was observed at Khandela in Sikar district in the state. Trend of fluoride since 2021 to 2024 is shown in fig 9 and distribution of fluoride in Rajasthan is given below in fig- 10. Table 10 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 11 shows the no. of locations affected by fluoride contamination from 2021 to 2024. Table 12 gives the Periodic variation in suitability Classes of Fluoride in groundwater samples of Rajasthan is worth mentioning that high fluoride waters are encountered in areas where high salinity is encountered.

.

.

Table 10: District wise Range and distribution of Fluoride in shallow GW of Rajasthan Pre-24

	district	No.of samples analysed	Permissible limit (1.5 mg/l)	Min	Max.	Mean	< 1.5 mg/l	> 1.5 mg/l
1	AJMER	5	1.5	0.55	1.85	1.31	60.00	40.00
2	ALWAR	7	1.5	0.56	2.20	1.10	85.71	14.29
3	BANSWARA	0	1.5	0.00	0.00	0.00	0.00	0.00
4	BARAN	6	1.5	0.25	1.10	0.73	100.00	0.00
5	BARMER	11	1.5	0.20	2.95	1.75	45.45	54.55
6	BHARATPUR	11	1.5	0.30	2.70	1.28	72.73	27.27
7	BHILWARA	13	1.5	0.05	4.05	1.43	69.23	30.77
8	BIKANER	10	1.5	0.20	12.80	3.70	50.00	50.00
9	BUNDI	3	1.5	0.40	0.85	0.60	100.00	0.00
10	CHITTAURGARH	5	1.5	0.45	1.75	1.04	80.00	20.00
11	CHURU	14	1.5	0.25	8.12	2.50	57.14	42.86
12	DAUSA	7	1.5	0.85	5.10	1.77	57.14	42.86
13	DHAULPUR	7	1.5	0.45	2.25	0.92	85.71	14.29
14	DUNGARPUR	2	1.5	0.30	0.90	0.60	100.00	0.00
15	GANGANAGAR	3	1.5	0.40	0.65	0.52	100.00	0.00
16	HANUMANGARH	11	1.5	0.30	3.05	1.43	54.55	45.45
17	JAIPUR	22	1.5	0.25	5.70	1.54	63.64	36.36
18	JAISALMER	13	1.5	0.35	2.28	1.26	61.54	38.46
19	JALORE	5	1.5	0.55	3.55	1.80	40.00	60.00
20	JHALAWAR	3	1.5	0.30	0.60	0.42	100.00	0.00
21	JHUNJHUNU	2	1.5	2.58	12.70	7.64	0.00	100.00
22	JODHPUR	16	1.5	0.02	4.21	1.36	62.50	37.50
23	KARAULI	5	1.5	0.40	1.64	0.81	80.00	20.00
24	KOTA	2	1.5	0.65	0.75	0.70	100.00	0.00
25	NAGAUR	7	1.5	0.30	3.10	1.74	42.86	57.14
26	PALI	3	1.5	1.15	4.55	2.55	33.33	66.67
27	PRATAPGARH	3	1.5	0.32	0.75	0.49	100.00	0.00
28	RAJSAMAND	5	1.5	0.45	6.30	2.12	60.00	40.00
29	SAWAI MADHOPUR	10	1.5	0.10	1.65	0.47	90.00	10.00
30	SIKAR	4	1.5	0.58	13.50	4.11	75.00	25.00
31	SIROHI	3	1.5	0.08	2.10	1.22	66.67	33.33
32	TONK	1	1.5	0.95	0.95	0.95	100.00	0.00
33	UDAIPUR	5	1.5	0.45	2.45	1.17	80.00	20.00
		224						

Table 11: Comparative Change in number of Locations having F > 1.5 mg/l

S.No.	District	No. of locations having Fluoride > 1.5 mg/l			
		2021	2022	2023	2024
1	AJMER	7	9	6	2
2	ALWAR	2	4	2	1
3	BANSWARA	0	7	6	0
4	BARAN	0	0	0	0
5	BARMER	5	17	23	6
6	BHARATPUR	4	6	6	3
7	BHILWARA	5	7	6	4
8	BIKANER	14	13	13	5
9	BUNDI	3	5	3	0
10	CHITTAURGARH	1	0	2	1
11	CHURU	8	11	21	6
12	DAUSA	1	3	2	3
13	DHAULPUR	0	0	1	1
14	DUNGARPUR	3	2	1	0
15	GANGANAGAR	1	8	4	0
16	HANUMANGARH	2	3	5	5
17	JAIPUR	13	5	17	8
18	JAISALMER	3	13	15	5
19	JALORE	4	11	16	3
20	JHALAWAR	3	2	1	0
21	JHUNJHUNU	2	5	12	2
22	JODHPUR	10	25	44	6
23	KARAULI	1	3	2	1
24	KOTA	0	1	0	0
25	NAGAUR	2	9	26	4
26	PALI	6	10	14	2
27	PRATAPGARH	0	1	1	0
28	RAJSAMAND	1	6	5	2
29	S. MADHOPUR	3	9	5	1
30	SIKAR	14	2	1	1
31	SIROHI	2	7	8	1
32	TONK	8	7	5	0
33	UDAIPUR	3	3	2	1
	Total	131	214	275	74

Table 12: Periodic variation in suitability Classes of Fluoride in groundwater of Rajasthan

Parameter	Class	Percentage of samples				Periodic variation
		2021	2022	2023	2024	PERIODIC Variation 2021-2024
		n=(774)	n=(809)	n=(630)	n=(224)	
Fluoride	< 1 mg/l	67.88	55.71	48.15	49.11	18.77
	1-1.5 mg/l	13.5	18.39	16.66	17.86	-4.36
	>1.5 mg/l	18.62	25.9	35.19	33.04	-14.42

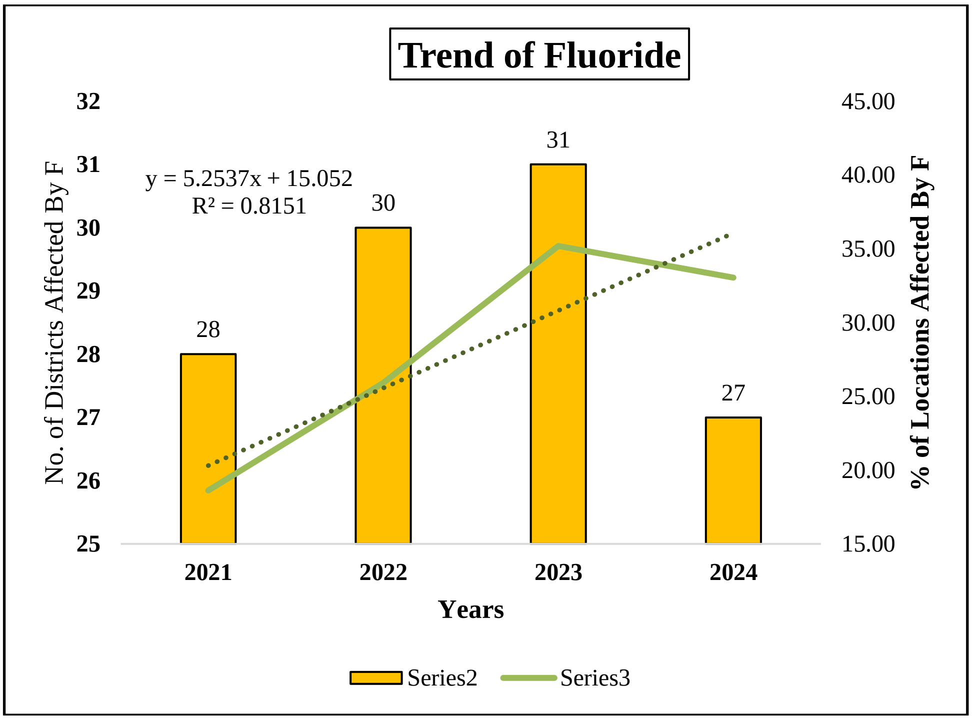

Fig-9 Trend of Fluoride since 2021 to 2024

No. of districts	year	No. of districts	% of locations affected by F
28	2021	*28*	*18.62*
30	2022	*30*	*25.90*
31	2023	31	35.19
27	2024	27	33.04

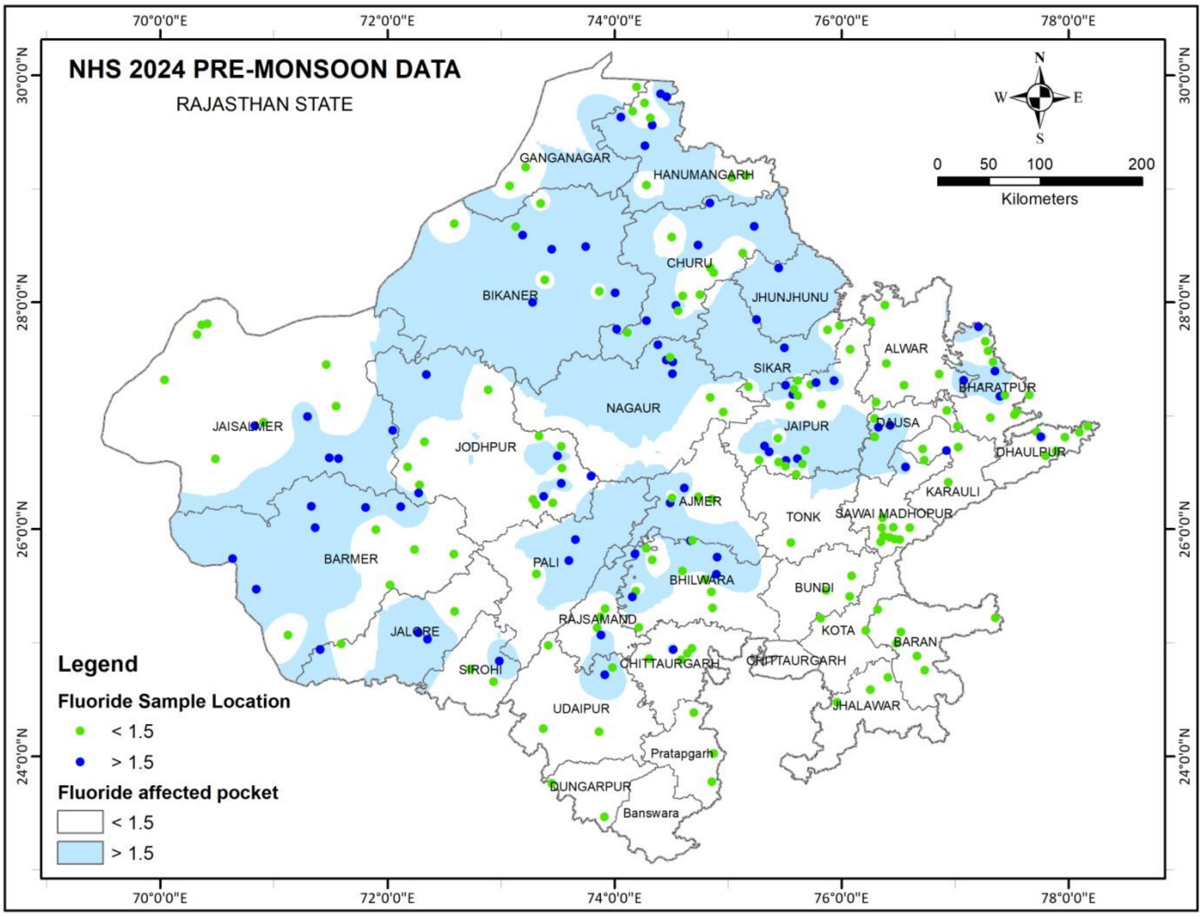

Figure 10: Map showing distribution of Fluoride in Rajasthan based on NHS 2024 Data

4.. Heavy Metal ;

4.1. Arsenic :

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

PRESENT DAY SCENARIO IN RAJASTHAN W. R.T ARSENIC (As)

Distribution of Arsenic (As)

The arsenic content in ground water ranges from BDL to 0.006 mg/L. BIS recommends that arsenic concentration up to 0.01 mg/L in drinking water is acceptable. Classification of samples based on this recommendation, it is found that no samples have arsenic value above than acceptable limit 0.01 mg/L.

4.2 Iron :

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

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

Iron occurrence scenario in RAJASTHAN :

The iron content in ground water ranges from BDL to 2.10 mg/L. BIS recommends that iron concentration up to 1.0 mg/L in drinking water is acceptable. Classification of samples based on this recommendation, it is found that 4.91% samples have iron above 1.0 mg/L. Map showing spatial distribution (Figure 9) of iron content in ground water (2024) indicates that ground waters with iron above 1.0 mg/L are found mainly in Bhilwara, Sikar,Sirohi, Chittaurgarh, Jaipur and Dungerpur districts of the State.

The distribution of nitrate in Rajasthan is given below in fig. 11. The chemical analysis results in the In comparison to 2021 (Table 13 from 2023 to 2024), it has been observed that there is marginal variation in the no. of Districts having Iron more than 1 mg/l in 2024. and trend of Iron is shown in fig 12 since 2023 to 2024

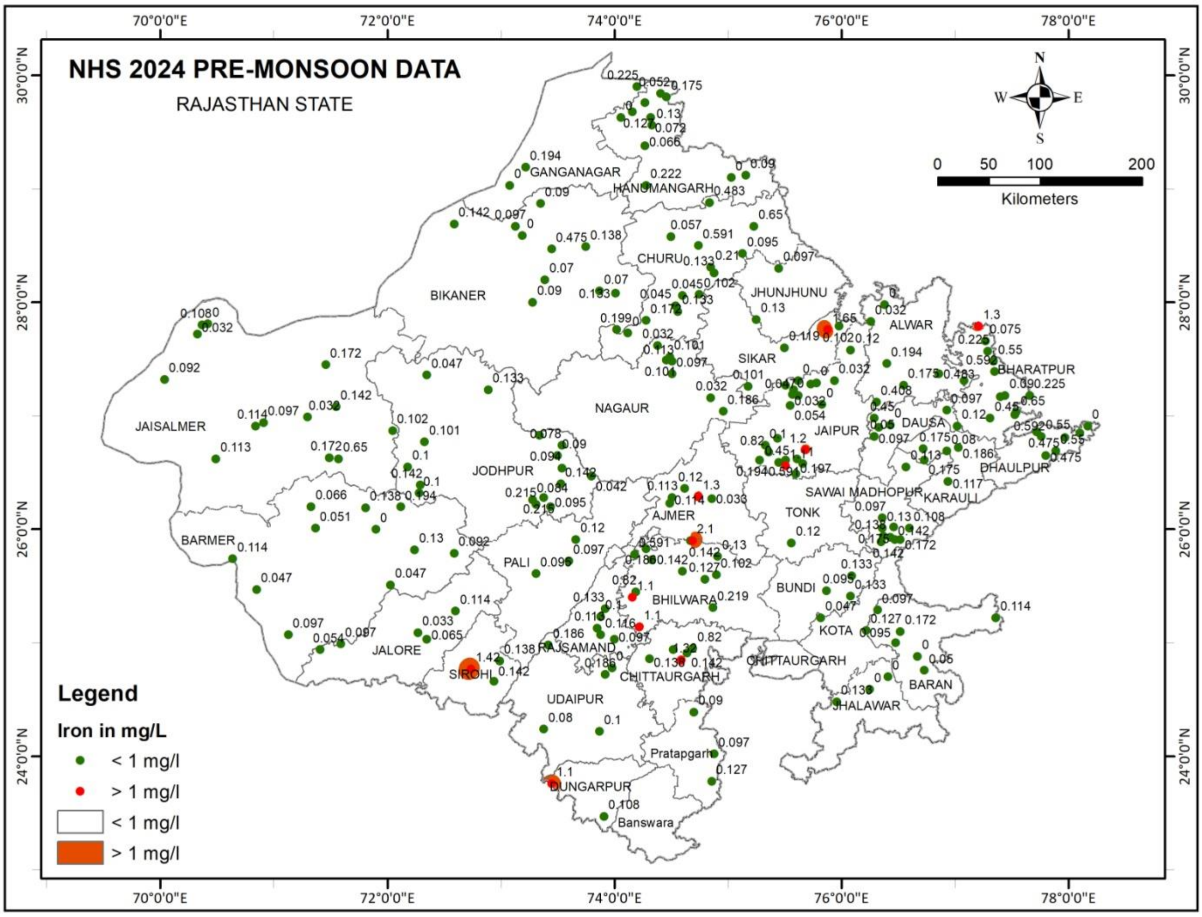

Figure 11: Map showing distribution of Iron in Rajasthan based on NHS 2024 Data

Table: 13 Periodic variation in suitability Classes of Nitrate in groundwater of Rajasthan

Year	Total Number of samples analysed	No. of districts affected by Fe	Total No of locations affected by Fe	% of locations affected by Fe (Fe > 1.0 mg/L
2023	**226**	**5**	**8**	3.54
2024	**224**	**7**	**11**	4.91

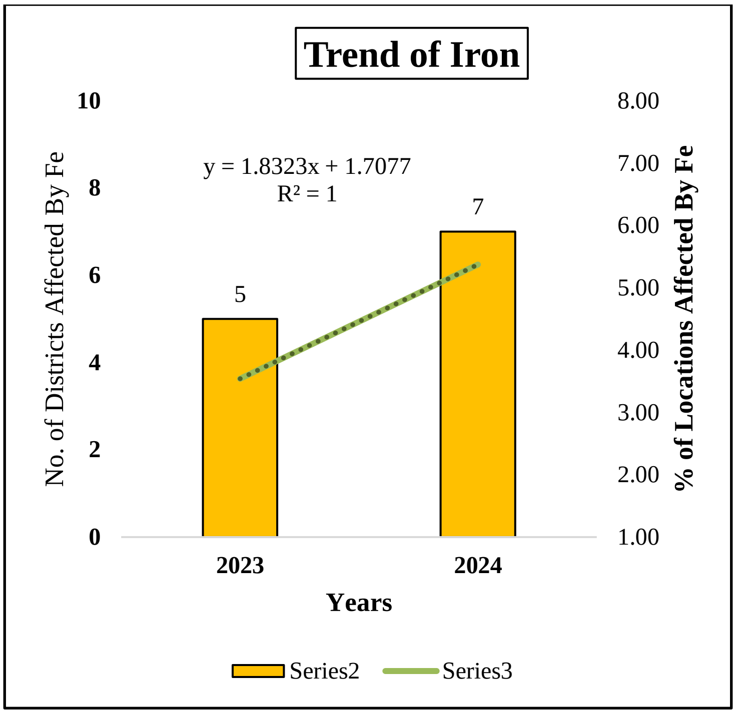

Fig : 12 Trend in iron in Rajasthan state during 2024

Parts of Districts affected by Iron :

(Fe >1.0 mg/l) - Bhilwara, Sikar, Sirohi, Chittaurgarh, Jaipur and Dungerpur districts of the State.

4.3 Uranium :

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

PRESENT DAY SCENARIO IN RAJASTHAN W. R.T Uranium (U)

Distribution of Uranium (U)

The uranium content in ground water ranges from BDL to 200 mg/L. BIS recommends that uranium concentration up to 0.03 mg/L in drinking water is acceptable. Classification of samples based on this recommendation, it is found that 7.59 % samples have uranium above 0.03 mg/L. Map showing spatial distribution of uranium content in ground water (2024) indicates that ground waters with arsenic above 0.01 mg/L are found mainly in Pali, Churu, Hanumangarh, Jalore, Rajsamand, Bikaner, Barmer, Jaipur and Jodhpur districts of the State.

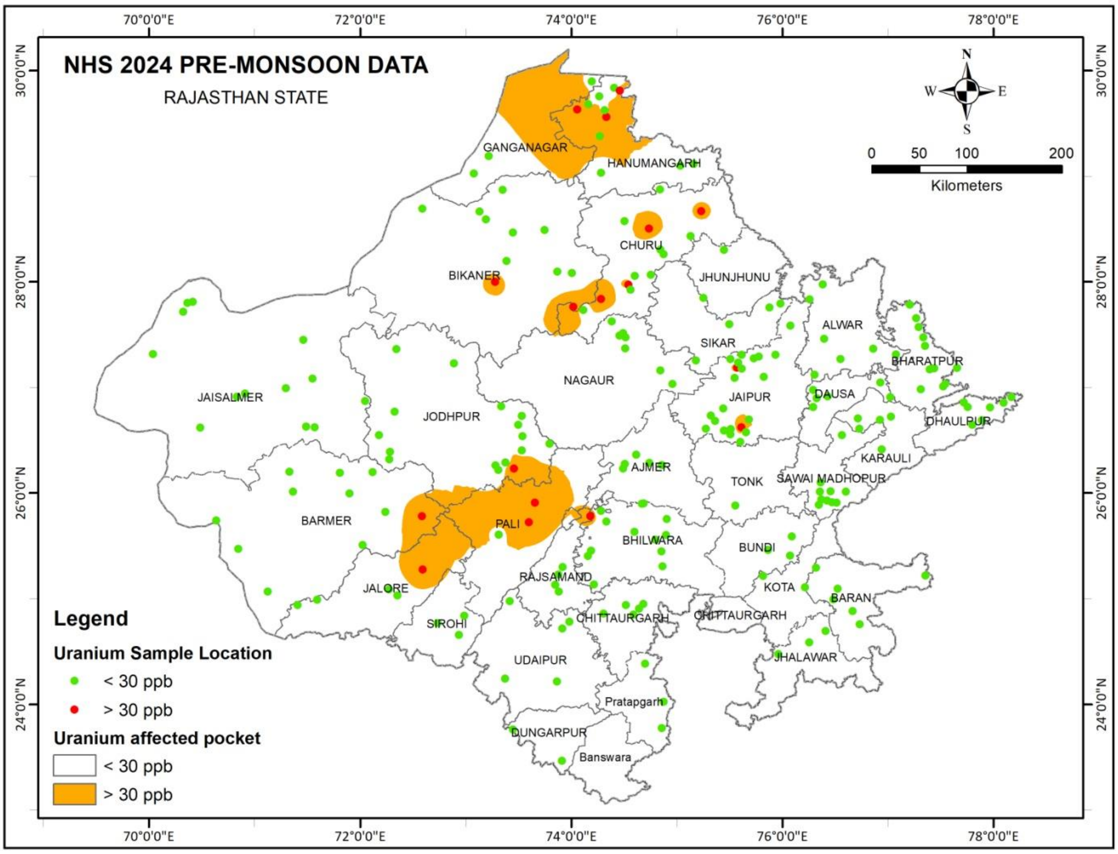

Figure 13: Map showing Locations and affected area having Uranium >0.03 mg/L(>30ppb) in ground water in Rajasthan state

The Table 14 given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean Uranium values based on NHS 2023 Data.

	district	No.of samples analysed	Permissible limit (30 ppb)	Min	Max.	Mean	< 30ppb	> 30ppb
1	AJMER	5	30	0	20	7.76	5	0
2	ALWAR	7	30	0	8	1.86	7	0
3	BANSWARA	0	30	0	0	#DIV/0!	0	0
4	BARAN	6	30	0	28	12.68	6	0
5	BARMER	11	30	0	54	15.27	10	1
6	BHARATPUR	11	30	0	29	13.91	11	0
7	BHILWARA	13	30	0	28	6.47	13	0
8	BIKANER	10	30	0	40	5.00	9	1
9	BUNDI	3	30	0	15	5.00	3	0
10	CHITTAURGARH	5	30	0	0	0.00	5	0
11	CHURU	14	30	0	71	28.07	9	5
12	DAUSA	7	30	0	29	17.43	7	0
13	DHAULPUR	7	30	0	10	1.43	7	0
14	DUNGARPUR	2	30	0	0	0.00	2	0
15	GANGANAGAR	3	30	5	20	11.00	3	0
16	HANUMANGARH	11	30	0	200	39.55	8	3
17	JAIPUR	22	30	0	110	13.86	20	2
18	JAISALMER	13	30	0	20	5.15	13	0
19	JALORE	5	30	0	50	22.00	4	1
20	JHALAWAR	3	30	0	10	3.33	3	0
21	JHUNJHUNU	2	30	0	10	5.00	2	0
22	JODHPUR	16	30	0	90	18.19	15	1
23	KARAULI	5	30	0	20	4.60	5	0
24	KOTA	2	30	0	0	0.00	2	0
25	NAGAUR	7	30	0	21	10.29	7	0
26	PALI	3	30	28	60	46.67	1	2
27	PRATAPGARH	3	30	0	0	0.00	3	0
28	RAJSAMAND	5	30	0	55	21.80	4	1
29	SAWAI MADHOPUR	10	30	0	0	0.00	10	0
30	SIKAR	4	30	0	0	0.00	4	0
31	SIROHI	3	30	0	10	6.00	3	0
32	TONK	1	30	25	25	25.00	1	0
33	UDAIPUR	5	30	0	15	5.40	5	0
		224						

Comparative Change from 2021 to 2024 in number of Locations having U>30ppb is given in table 15, Temporal variation of uranium in ground water during the period from 2021TO 2024, It has been observed (Table 16) that total number of locations affected by high Uranium have Variation since 2021 to 2024 and trend is shown in fig-14

Table 15: Comparative Change in number of Locations having U>30ppb

S.No.	District	No. of locations having Uranium > 30 ppb			
		2021	2022	2023	2024
1	AJMER	6	0	0	0
2	ALWAR	0	1	2	0
3	BANSWARA	0	1	0	0
4	BARAN	0	1	0	0
5	BARMER	2	3	9	1
6	BHARATPUR	0	7	5	0
7	BHILWARA	2	4	1	0
8	BIKANER	3	8	10	1
9	BUNDI	1	0	0	0
10	CHITTAURGARH	7	0	0	0
11	CHURU	3	6	11	5
12	DAUSA	0	4	3	0
13	DHAULPUR	2	0	0	0
14	DUNGARPUR	0	0	0	0
15	GANGANAGAR	2	7	5	0
16	HANUMANGARH	2	3	4	3
17	JAIPUR	10	9	5	2
18	JAISALMER	1	0	2	0
19	JALORE	1	1	4	1
20	JHALAWAR	0	0	0	0
21	JHUNJHUNU	3	5	4	0
22	JODHPUR	4	17	33	1
23	KARAULI	1	3	2	0
24	KOTA	0	0	0	0
25	NAGAUR	2	9	11	0
26	PALI	3	2	11	2
27	PRATAPGARH	2	0	0	0
28	RAJSAMAND	4	3	2	1
29	S. MADHOPUR	1	3	3	0
30	SIKAR	6	3	1	0
31	SIROHI	1	1	0	0
32	TONK	3	9	6	0
33	UDAIPUR	0	1	0	0
	TOTAL	72	111	134	17

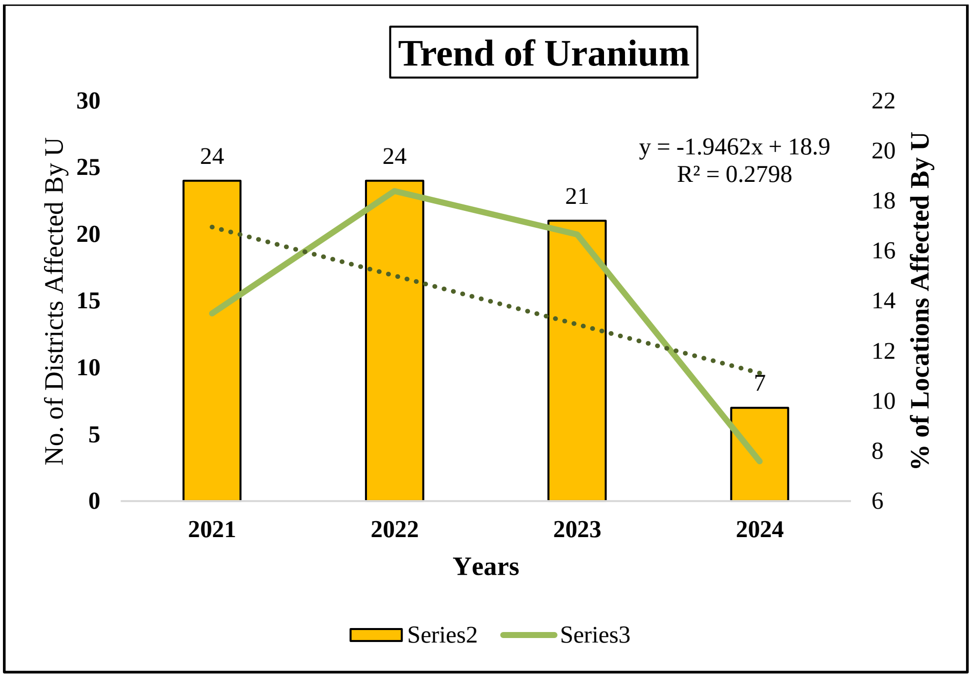

Fig – 14 Trend in uranium since 2021 to 2024 in Rajasthan state

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

Parameter	Class	Pecenrntage of samples				Periodic variation
		2021	2022	2023	2024	PERIODIC Variation 2021-2024
		n=(774)	n=(809)	n=(630)	n=(224)	
Uranium	< 30ppb	67.88	55.71	48.15	92.41	-24.53
	>30ppb	13.5	18.39	16.66	7.59	5.91

No. of districts	year	No. of districts	% of locations affected by U
24	2021	*24*	*13.5*
24	2022	*24*	*18.39*
21	2023	*21*	16.66
7	2024	*7*	7.59

5.. SUMMARY :

The analytical results show a concerning trend, Compared to 2021, more districts in Rajasthan had ground water samples exceeding permissible limits for Salinity, Nitrate, Fluoride, Uranium and Iron by 2024. This decline in water quality may stem from geo-genic or anthropogenic sources. While most samples from Central Ground Water Board observation wells meet drinking water standards for basic parameters and heavy metals, some exceed permissible limits, posing health risks with prolonged use.

DISTRICT WISE CONTAMINANT WISE STATUS SUMMARY BASED ON NHS 2024 PRE-MONSOON DATA. The Table 18 provides a detailed summary of groundwater quality across various districts in Rajasthan, focusing on basic parameters (electrical conductivity, nitrate, fluoride) and heavy metals (iron, Uranium.

Table 18: Summary of Groundwater Quality in Various Districts of Rajasthan, Highlighting Basic Parameters (Electrical Conductivity, Nitrate, Fluoride) and Uranium-

Districts	Total no. of Basic samples analysed-2024(PRE-Monsoon)	Samples exceeding permissible limit in number % age of samples			Samples exceeding permissible limit in number of % samples
		EC	NO3	F	U
AJMER	5	60.00	80.00	40.00	-
ALWAR	7	42.86	71.43	14.29	-
BANSWARA	0	0.00	0.00	0.00	-
BARAN	6	16.67	16.67	0.00	-
BARMER	11	81.82	36.36	54.55	9.09
BHARATPUR	11	63.64	45.45	27.27	-
BHILWARA	13	23.08	69.23	30.77	-
BIKANER	10	10.00	40.00	50.00	10.00
BUNDI	3	66.67	66.67	0.00	-
CHITTAURGARH	5	0.00	20.00	20.00	-
CHURU	14	50.00	71.43	42.86	35.71
DAUSA	7	57.14	42.86	42.86	-
DHAULPUR	7	0.00	28.57	14.29	-
DUNGARPUR	2	0.00	0.00	0.00	-
GANGANAGAR	3	33.33	33.33	0.00	-
HANUMANGARH	11	36.36	18.18	45.45	27.27
JAIPUR	22	13.64	27.27	36.36	9.09
JAISALMER	13	53.85	46.15	38.46	-
JALORE	5	60.00	60.00	60.00	20.00
JHALAWAR	3	0.00	0.00	0.00	-
JHUNJHUNU	2	50.00	50.00	100.00	-
JODHPUR	16	81.25	25.00	37.50	6.25
KARAULI	5	0.00	20.00	20.00	-
KOTA	2	50.00	0.00	0.00	-
NAGAUR	7	85.71	71.43	57.14	-
PALI	3	66.67	33.33	66.67	66.67
PRATAPGARH	3	0.00	33.33	0.00	-
RAJSAMAND	5	60.00	20.00	40.00	20.00
SAWAI MADHOPUR	10	10.00	80.00	10.00	-
SIKAR	4	50.00	75.00	25.00	-
SIROHI	3	0.00	33.33	33.33	-
TONK	1	100.00	100.00	0.00	-
UDAIPUR	5	0.00	20.00	20.00	-
Total	224				

Basic Parameters:

EC (Electrical Conductivity):

Electrical conductivity in ground water Samples exceed limits in Tonk 100 % , Nagaur 85.71% Barmer 81.82 %, Jodhpur 81.25 % Bundi and Pali , Bharatpur 63.63%, Ajmer, Jalore Rajsamand each having 60% & Dausa 57.14% and Jaisalmer 53.84 %

NO3 (Nitrate): it is found that 42.86 % of the samples, spread over the entire State, have nitrate beyond the acceptable limit 45 mg/l . Nitrate above 45 mg/L are found mainly inTonk 100 %, Ajmer snd Sawaimadhopur each 80% , Sikar 75%, Alwar , Churu and Nagaur each 71.43% , Bhilwara 66.67% and Jalore 60%.

.

F (Fluoride):

fluoride contents in ground water indicates that ground waters with fluoride above 1.50 mg/L are found mainly in Bikaner(50%), Barme (54.55%),, Nagaur (57.14%),, Jalore (60 %),, Pali (66.67%), and Jhunjhunu (100%), districts of the State where 50 % samples beyond the permissible limit.

Heavy Metals:

Fe (Iron): ***(Fe >1.0 mg/l) –***

Bhilwara, Sikar,Sirohi, Chittaurgarh, Jaipur and Dungerpur, districts of the State. districts were effected from iron.

As (Arsenic): No Arsenic contamination was detected (Arsenic value above than acceptable limit 0.01 mg/L.) during re sampling in 2024.

U (Uranium): Detected in 7.59 % of samples, with significant levels in certain districts like Pali, Churu, Hanumangarh, Jalore, Rajsamand, Bikaner, Barmer, Jaipur and Jodhpur districts of the State.

The Table 19 provides a summary of groundwater quality in the state of Rajasthan, broken down by the number of samples collected and the percentage of those samples that are contaminated with various parameters

Table 19: Summary of Groundwater Quality in Rajasthan: Samples Collected and Contamination Percentage

		Number of samples contaminated (% age of samples contaminated)		
Rajasthan State Summary	Total no. of Basic samples	EC	NO3	F
	224	88 (39.29%)	96 (42.86%)	74 (33.04%)
	Total no. of HM samples	Fe	As	U
	224	11 (4.91 %)	Nil	17 (7.59 %)

STATE SUMMARY :

Graphical representation of the same is depicted hereunder in Fig 15

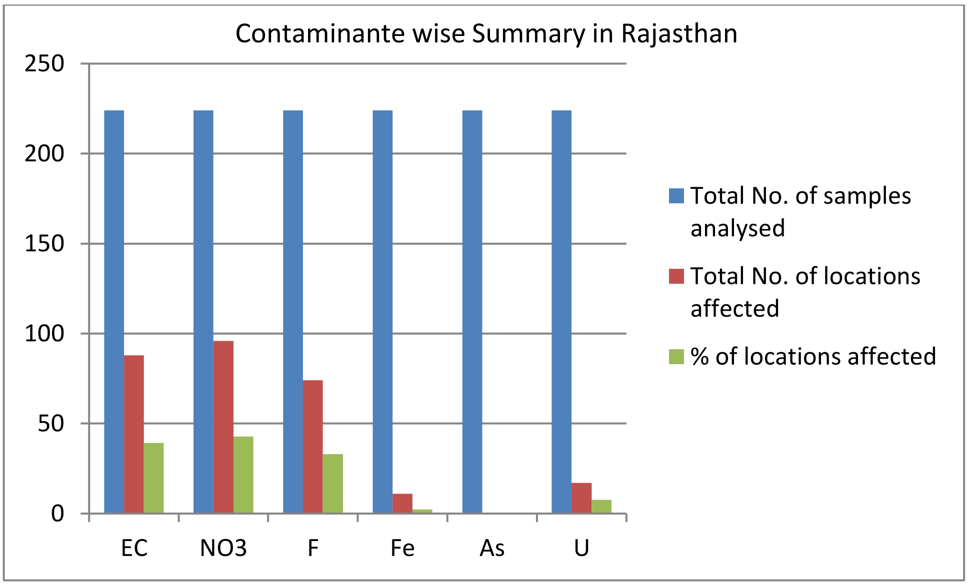

Figure 15: Graph showing contaminant wise state summary

The groundwater quality assessment in Rajasthan revealed notable levels of contamination across various parameters. Nitrate emerged as the predominant contaminant, with 42.86% of samples surpassing permissible limits, followed by electrical conductivity (EC) at 39.29%, F (33.04%) and uranium (U) at 7.59%. Nitrate (NO3) contamination was observed in 49.68% of samples, while iron (Fe) only 4.91 % and no arsenic (As) was detected in ground water of Rajasthan.

Recommendations :

1. **Regular water quality testing** is recommended for the locations where the water quality is found to be poor.
2. **Micro-level Studies** are recommended for the locations where the water quality is found to be poor.
3. The Water Quality can be improved by reducing the high concentrations of Fluoride, Nitrate and salinity in ground water through following Remedial measures methods:

A **Fluoride:** Fluoride impurity can be reduced or minimized by:

a. Using Alternate water sources
b. Surface water should be free from Biological or chemical pollution
c. Using Rainwater which is of low cost.
d. Using Low-fluoride content groundwater, if available.
e. De-fluoridation Techniques

Techniques for removal of Fluoride:

a) **Adsorption and ion exchange**

passage of water through a contact bed where fluoride is removed by ion exchange or surface chemical reaction with the solid bed matrix Absorbents used-activated alumina, carbon, bone charcoal and synthetic ion exchange resins

b) Coagulation/Precipitation

Addition of chemicals to form Fluoride precipitates-Ca and Al salts.
Must be added daily and forms a sludge

c) Distillation: Distillation units can also be used for treating the drinking water.

d) Membrane filtration

e) Reverse osmosis

f) Electrodialysis

g) Nalgonda Technique

It was developed by NEERI. It involves addition of aluminium salt, Lime and bleaching powder followed by rapid mixing, flocculation, sedimentation, filtration and disinfection.

The Nalgonda technique is commonly preferred at all levels because of its low price and ease of handling

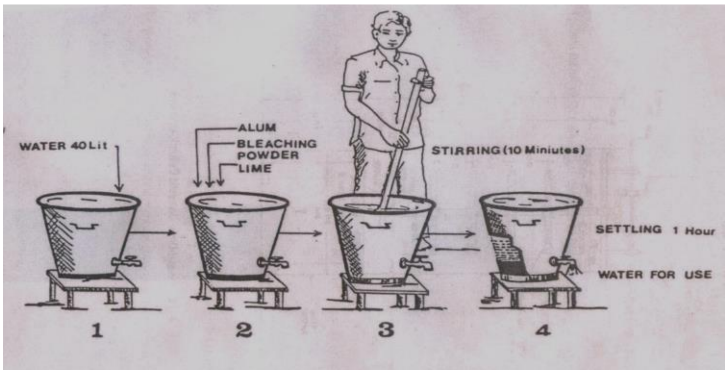

Fig.3. Defluoridation at Domestic Level

B **<u>Nitrate*: Nitrate impurity can be prevented or minimized by:*</u>**

a. Reverse osmosis method ,
b. Ion exchange method,
c. Electrolysis
d. Distillation
e. Bio denitrification.
f. Blending method with low nitrate waters

C. <u>Salinity: Salinity can be mininmized by following techniques:</u>

a. Distillation Methods-Based on vaporization of liquid water under boiling temperature. Pure water vapors are collected by condensation.
b. Membrane Technology-Passing the water through a semi permeable membrane:
c. Reverse osmosis.
d. Nano filtration.