IN THE HON'BLE NATIONAL GREEN TRIBUNAL,

PRINCIPAL BENCH, NEW DELHI

Original Application No. 10/2025

News Item Titled "Districts With Excess Nitrates In Groundwater At Seven Year High" Appearing In The Hindu Dated 01.01.2025

<u>Index</u>

23/06/26

Respondent No.3
(Central Ground Water Authority)

बिनोद कुमार ढोंडियाल / Vinod Kumar Dhaundiyal
प्रशासक / Administrator
केन्द्रीय भूमि जल प्राधिकरण / Central Ground Water Authority
जल संसाधन, नदी विकास एवं गंगा संरक्षण
Deptt. of Water Resources, River Development & Ganga Rejuvenation
जल शक्ति मंत्रालय / Ministry of Jal Shakti
भारत सरकार / Government of India

FILED BY:-

Through

Palce:- New Delhi

Date:- 23/06/2026

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STANDING COUNSEL (UOI)

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(1)

IN THE HON'BLE NATIONAL GREEN TRIBUNAL,

PRINCIPAL BENCH, NEW DELHI

Original Application No. 10/2025

News Item Titled "Districts With Excess Nitrates In Groundwater At Seven Year High" Appearing In The Hindu Dated 01.01.2025

REPORT ON THE PRE-MONSOON NATIONAL GROUND WATER QUALITY BULLETIN, 2025 ON BEHALF OF RESPONDENT NO. 3 (CENTRAL GROUND WATER AUTHORITY)

It is Most Respectfully Showeth:-

1. That the present report is being filed by Respondent No. 3 i.e. Central Ground Water Authority (CGWA) through Vinod Kumar Dhaundiyal , Aged 50 years, working as Administrator, having office at 18/11 Jam Nagar House, Man singh Road, New Delhi-110016, who is authorized and competent to file the same on behalf of the answering respondent no. 3.

2. That I am in my aforementioned official capacity, well conversant with the facts and circumstances of the present case on the basis of the documents and records available in the department. As such, I am competent and authorized to sign this report on behalf of Respondent No.3 i.e. Central Ground Water Authority (hereinafter referred to as "answering respondent").

3. That the answering respondent has already submitted its reply dated 14.10.2025 and additional reply dated 22.12.2025, enclosing the Annual Ground Water Quality Report 2024 prepared by the Central Ground Water Board (CGWB).

4. That, the Hon'ble Tribunal vide its order dated 24.12.2025 directed the answering respondent to place on record the report concerning the Baseline Water Quality Assessment.

5. That the matter last listed before this Hon'ble Tribunal on 08.04.2026, wherein the Hon'ble Tribunal considered the reply dated 07.04.2026 wherein it has been stated that analysis of background monitoring of groundwater samples have been duly undertaken and completed by the

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Regional Laboratories of the CGWB. The process of data compilation, scrutiny and validation shall be concluded by 10.04.2026.Thereafter, the CGWB shall prepare the Pre-Monsoon National Ground Water Quality Bulletin, 2025 in the last week of April. CGWA has sought some time to place on the said report before Hon'ble Tribunal. The Hon’ble Tribunal vide its order dated 08.04.2026 allowed the said prayer of the CGWA.

Accordingly, the Pre-Monsoon National Ground Water Quality Bulletin, 2025 has been prepared and published. The copy of the Pre-Monsoon National Ground Water Quality Bulletin, 2025 is attached herewith and marked as **Annexure-I.**

6. That the present report may kindly be taken on record and considered, and that the Hon'ble Tribunal may be pleased to pass appropriate orders and directions as deemed fit and proper in light of the facts and circumstances of the present case.

23/06/2026

Respondent No.3
(Central Ground Water Authority)

बिनोद कुमार ढोंडियाल / Vinod Kumar Dhaundiyal
प्रशासक / Administrator
केन्द्रीय भूमि जल प्राधिकरण / Central Ground Water Authority
जल संसाधन, नदी विकास एवं गंगा संरक्षण
Deptt. of Water Resources, River Development & Ganga Rejuvenation
जल शक्ति मंत्रालय / Ministry of Jal Shakti
भारत सरकार / Government of India

FILED BY:-

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Place:- New Delhi
Date - 23/06/2026

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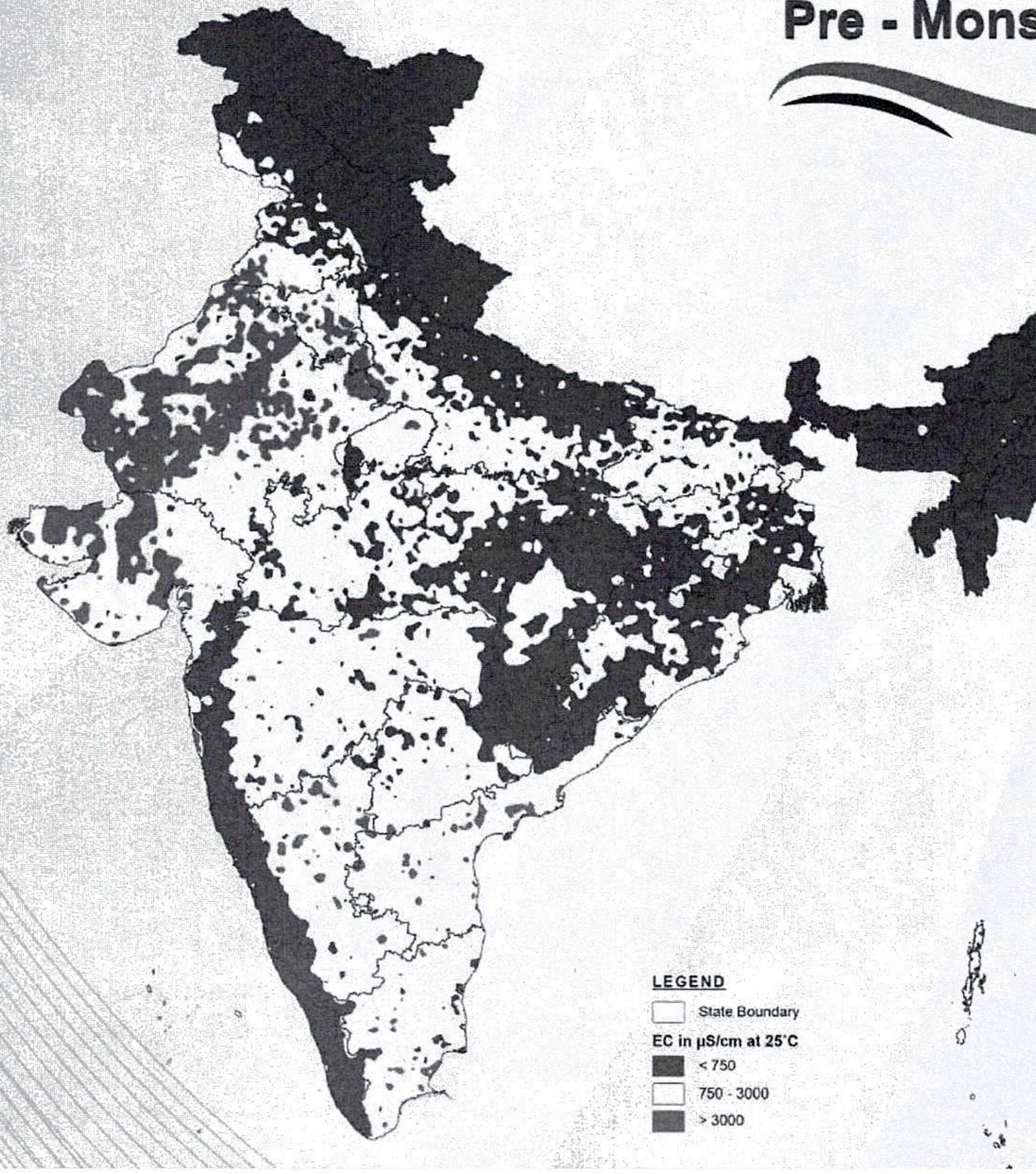
03

भारत सरकार
Government of India
जल शक्ति मंत्रालय,
Ministry of Jal Shakti,
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग,
Department of Water Resources,
River Development and
Ganga Rejuvenation

केंद्रीय भूमि जल बोर्ड
Central Ground Water Board

GROUNDWATER QUALITY BULLETIN OF INDIA

Pre - Monsoon 2025



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1.0 Introduction

All water contains some dissolved substances, regardless of its source. Even rainwater, which is often thought to be pure, contains small amounts of dissolved gases and minerals. As water moves through the natural water cycle, it comes into contact with air, soil, and rocks, picking up various substances from both natural processes and human activities.

In small amounts, many of these minerals are harmless and can even improve the taste of water. This is why some bottled waters have minerals added after treatment. However, when the amount of any substance becomes too high, it can affect water quality and may become unsafe.

Whether a substance is considered a contaminant depends on how much of it is present, how harmful it is, and how the water is being used—such as for drinking, farming, or industrial purposes. Regular monitoring of water quality is therefore important to ensure that it remains safe and suitable for use.

Evaluation of water quality involves assessing the presence and concentration of various physical and chemical constituents in groundwater to determine its suitability for intended uses such as drinking, agriculture, and industrial applications. Regular and systematic monitoring is essential for identifying emerging concerns and ensuring sustainable management of water resources.

A key advancement in this effort is the adoption of a **biannual (pre- and post-monsoon) assessment framework**, which enables a more comprehensive understanding of temporal variations in groundwater quality. This approach captures the influence of seasonal dynamics, particularly the impact of monsoonal recharge and associated geochemical changes, thereby providing a more holistic perspective on water quality trends across the country.

As per the Standard Operating Procedure (SOP), the earlier bulletins were based on the analysis of approximately **15,000 groundwater samples**. In comparison, the present bulletin utilizes a significantly expanded dataset comprising **around 23,610 water samples**, all of which are derived from **background monitoring stations**. This substantial increase in sample size enhances spatial coverage and improves the statistical robustness of the assessment, thereby providing a more reliable and representative evaluation of groundwater quality across the country.

Importantly, this expanded monitoring network also forms the basis for strengthening future assessments. As per the SOP, a minimum of **25% of these background monitoring stations**

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will be designated as trend monitoring stations, forming a core network for long-term water quality surveillance. This will enable systematic tracking of temporal changes and support more effective groundwater management strategies.

By integrating a larger and more representative dataset, and a forward-looking monitoring framework, this bulletin provides a comprehensive and robust assessment of groundwater quality. The findings are expected to support informed decision-making, policy formulation, and effective management of groundwater resources in the country.

2.0 Objectives of the Pre-Monsoon 2025 Groundwater Quality Monitoring

The primary objective of this groundwater quality monitoring is to assess the status of groundwater quality across India during the **Pre-Monsoon 2025** period, providing a comprehensive baseline for understanding spatial variability and supporting long-term monitoring of groundwater resources.

The specific objectives are as follows:

I. **Pre-Monsoon Groundwater Quality Assessment:** To evaluate changes in groundwater quality in pre-monsoon period, focusing on key water quality parameters such as Electrical Conductivity (EC), Fluoride, Nitrate, Iron (Fe), Arsenic (As) and Uranium (U).

II. **Identification of Contaminants:** To identify and assess the occurrence and concentration of potential contaminants in groundwater, which may pose risks to human health, agriculture and the environment.

III. **Regional Water Quality Trends:** To analyse regional variations in groundwater quality across different parts of the country, highlighting areas affected by localized geogenic and anthropogenic contamination, including known hotspots of arsenic, fluoride, uranium and other trace elements.

IV. **Establishment of Baseline for Seasonal and Long-Term Monitoring:** To generate a robust pre-monsoon baseline dataset that can be used for future comparison with post-monsoon conditions and for assessing temporal trends through designated trend monitoring stations.

V. **Strengthening Monitoring Framework:** To strengthen the groundwater quality monitoring network by utilizing data from background monitoring stations and to

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facilitate the identification and finalization of a minimum of **25% of these stations as trend monitoring stations**, in accordance with the Standard Operating Procedure (SOP), for long-term assessment of groundwater quality variations.

VI. **Policy and Decision Support:** This bulletin aims to strengthen groundwater quality assessment in India by providing a detailed and reliable pre-monsoon baseline data, thereby contributing to improved understanding of spatial patterns and supporting sustainable groundwater resource management at both regional and national levels.

This bulletin aims to strengthen groundwater quality assessment in India by providing a detailed and reliable pre-monsoon baseline data, thereby contributing to improved understanding of spatial patterns and supporting sustainable groundwater resource management at both regional and national levels.

3.0 Groundwater Quality Scenario in India – Pre-Monsoon 2025

The spatial distribution of groundwater quality monitoring stations (Fig. 1) indicates extensive nationwide coverage during the pre-monsoon 2025 period, with a total of 23,610 samples. The overlay with principal aquifer units demonstrates that sampling adequately represents diverse hydrogeological settings across the country, although relatively sparse coverage is observed in hilly and remote regions.

The groundwater quality assessment carried out across India for the **Pre-Monsoon 2025** period, based on the data analysis of **23,610 samples**, indicates that most groundwater sources are within the permissible limits prescribed by **BIS (IS 10500:2012)**. However, certain parameters were observed to exceed the permissible limits in a proportion of samples, warranting continued monitoring and appropriate management. The Bulletin presents the status of groundwater quality during the pre-monsoon season of year 2025 with respect to the following six parameters i.e. EC, Fluoride, Nitrate, Iron, Arsenic and Uranium.

- **Nitrate (NO_3^-)** was found above the permissible limit in 22.02% of samples, indicating localized influence of agricultural practices and other anthropogenic sources.
- **Fluoride (F^-)** exceeded permissible limits in 9.25% of samples.
- **Iron (Fe)** exceeded permissible limits in 9.17% of samples, respectively, suggesting localized geogenic contributions.

07

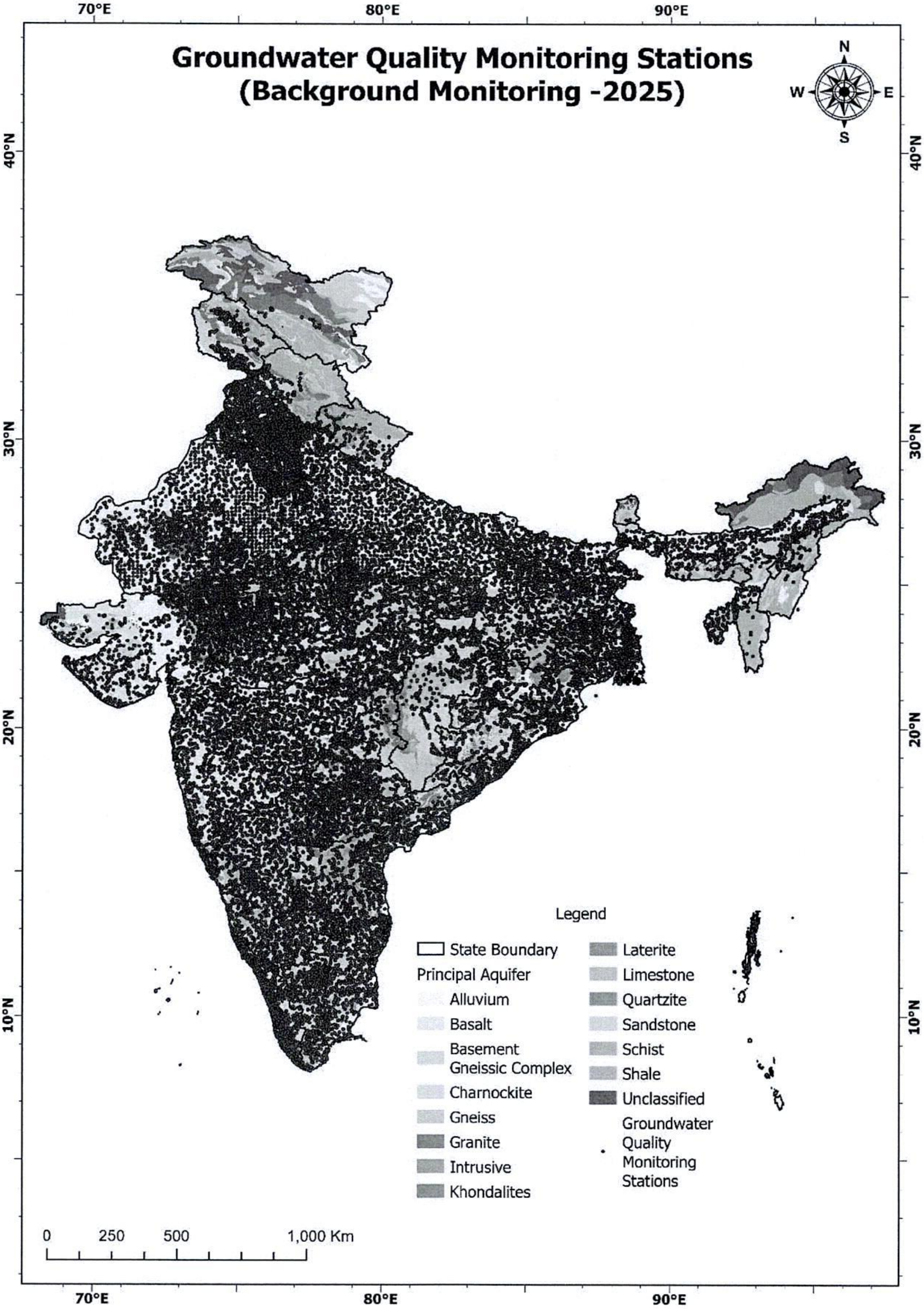

Figure 1: Nationwide Distribution of Background Groundwater Quality Monitoring Stations

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- **Electrical Conductivity (EC)** was above permissible limits in 7.23% of samples, indicating salinity-related concerns in certain regions.
- **Uranium (U)** exceeded permissible limits in 5.79% of samples.
- **Arsenic (As)** was found above permissible limits in 2.01 % of samples, primarily in known localized areas.

Table 1: The Bureau of Indian Standards guidelines for contaminants levels in drinking water.

Analyte	Acceptable Limit	Permissible Limit in Absence of Alternative Source	Health effects
EC (µs/cm at 25°c)	750	3000	Anaesthetic effect, may lead to Cardiovascular complications
F (mg/L)	1	1.5	Bone disease (pain and tenderness of the bones); children may get mottled teeth
Nitrate (mg/L)	45	No relaxation	High nitrate levels in drinking water can cause blue baby syndrome
Fe (mg/L)	1	No relaxation	Anaesthetic effect, promotes iron bacteria
As (µg/L)	10	No relaxation	Skin damage, increased risk of cancer
U(µg/L)	30	No relaxation	Increased risk of cancer, kidney toxicity

4.0 Electrical Conductivity (EC), Fluoride and Nitrate Levels in Groundwater Across India:

The column graph (Fig. 2) presents the concentrations of key parameters during the **pre-monsoon 2025** period.

It is observed that **nitrate** has the highest exceedance, with **22.02%** of samples above the permissible limit. **fluoride** shows exceedances in a moderate proportion **(9.25%)** of samples. **Electrical Conductivity (EC)** exceeds permissible limits in **7.23%** of samples, suggesting localized salinity-related issues.

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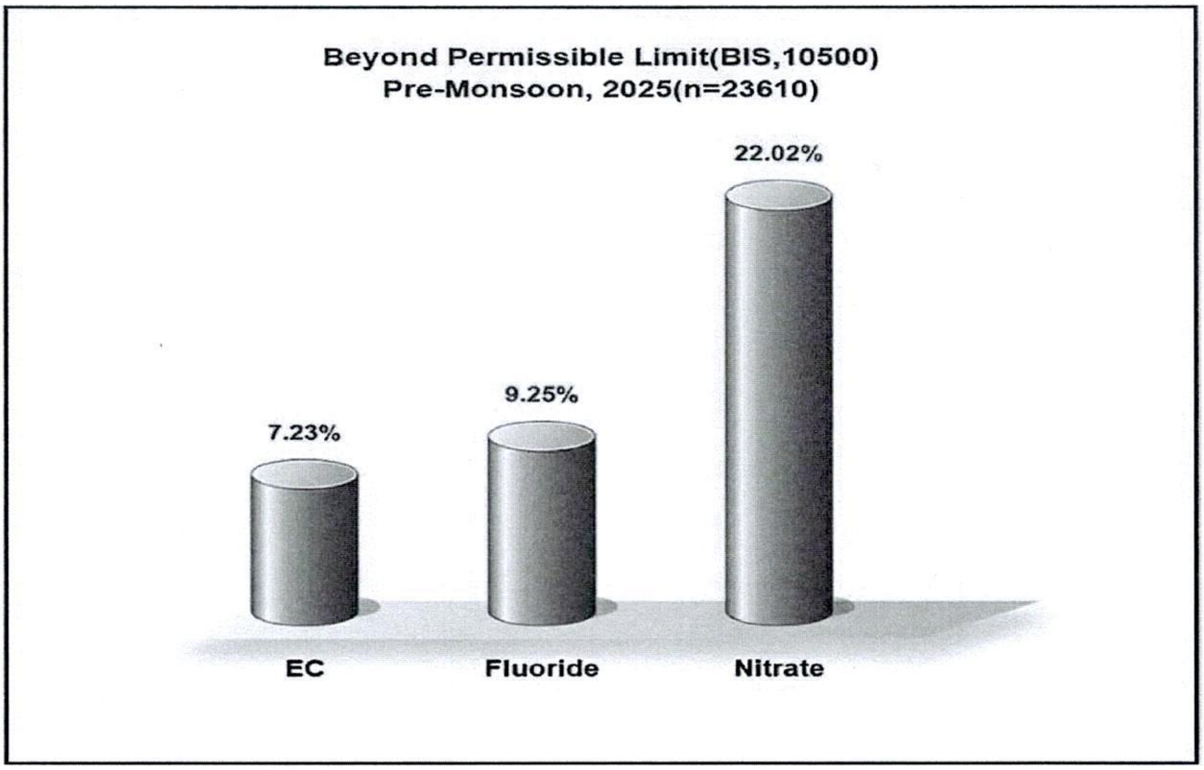

Figure 2: Percentage of Groundwater samples beyond permissible limit as per BIS,10500 (EC, Fluoride and Nitrate).

4.1 Electrical Conductivity (EC):

Electrical Conductivity (EC) refers to the ability of water to conduct electricity, which is influenced by the presence of dissolved substances, minerals, and chemicals. It serves as an indicator of the mineral content and salinity of groundwater. Essentially, the higher the concentration of dissolved materials in the water, the greater its conductivity. This property is important as it provides insights into the level of impurities in the water. The map (Fig. 3) shows the spatial distribution of **Electrical Conductivity (EC)** in groundwater across India during the **Pre-Monsoon 2025** period.

The state-wise distribution of samples exceeding the EC limit (>3000 µS/cm at 25°C) during Pre-Monsoon 2025 is presented in **Table 2**. It is observed that a large part of the country falls within the low to moderate EC range (<750 to 3000 µS/cm), indicating that groundwater in most regions is within acceptable limits with respect to salinity.

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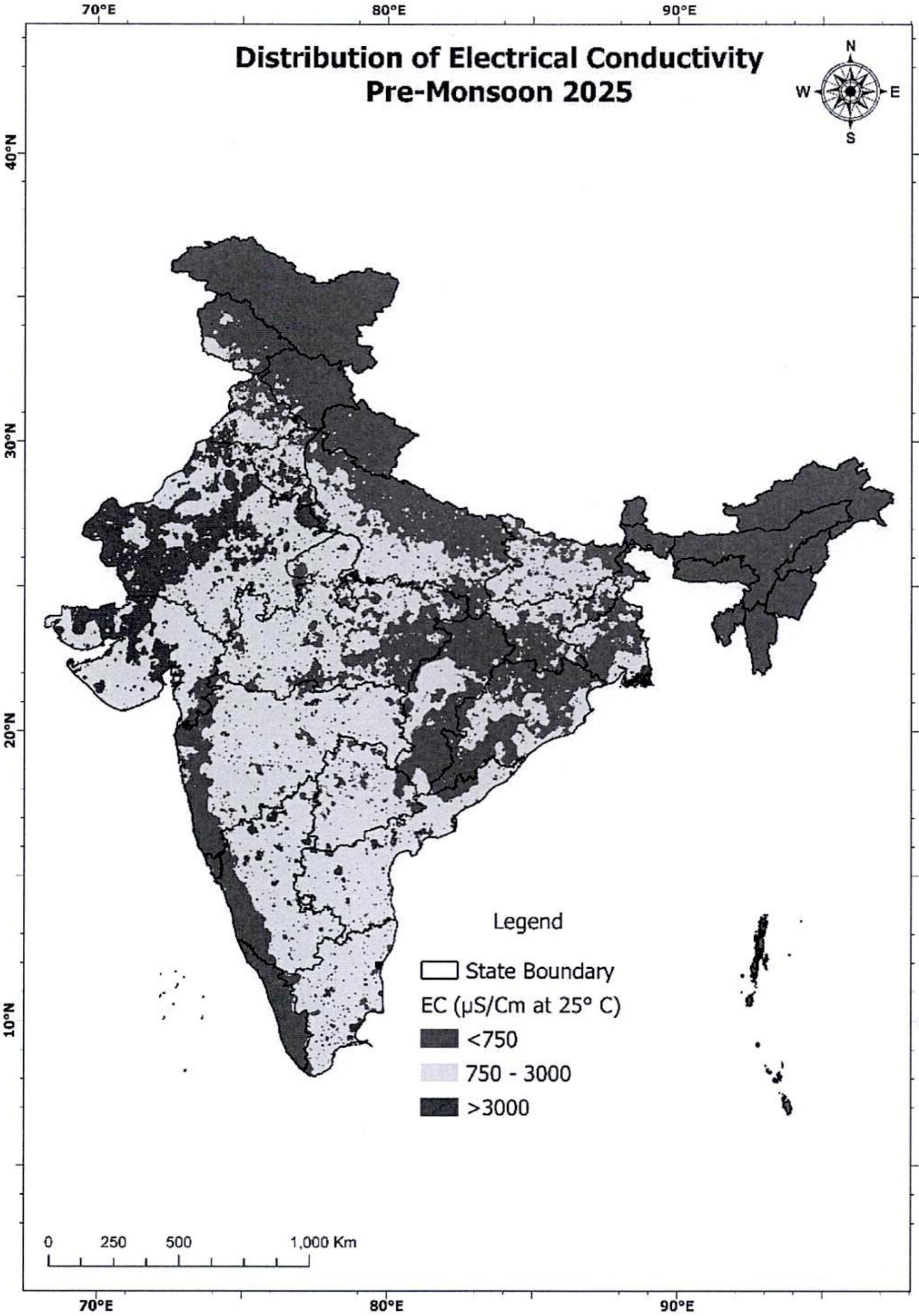

Figure 3: Spatial Distribution of EC in Groundwater – Pre Monsoon, 2025

Areas with low EC values (<750 μS/cm) are predominantly observed in parts of the Himalayan region, northeastern states, and some southern regions, suggesting relatively fresh groundwater conditions. The moderate EC range (750–3000 μS/cm) is widely distributed across central and peninsular India, indicating normal mineralization due to natural water–rock interaction. Higher EC values (>3000 μS/cm) are observed in localized pockets, particularly in parts of northwestern India (Rajasthan, Gujarat, and adjoining areas) and in some coastal and inland

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Table 2: State/UT-wise Summary of Groundwater Samples with EC above Permissible Limit (> 3000 µS/Cm at 25° C) during pre-monsoon 2025

Sl. No.	State/UT	No. of Samples Analysed (2025)	Samples Exceeding EC Limit (> 3000 µS/Cm at 25° C)	Exceedance %
1	Andaman and Nicobar Islands	112	0	0.00
2	Andhra Pradesh	1144	129	11.28
3	Arunachal Pradesh	44	0	0.00
4	Assam	528	0	0.00
5	Bihar	1025	6	0.59
6	Chandigarh	8	0	0.00
7	Chhattisgarh	599	1	0.17
8	Dadra and Nagar Haveli and Daman and Diu	19	1	5.26
9	Delhi	208	51	24.52
10	Goa	91	1	1.10
11	Gujarat	767	123	16.04
12	Haryana	837	188	22.46
13	Himachal Pradesh	198	0	0.00
14	Jammu & Kashmir	427	0	0.00
15	Jharkhand	561	1	0.18
16	Karnataka	1543	113	7.32
17	Kerala	699	1	0.14
18	Ladakh	20	0	0.00
19	Lakshadweep	29	3	10.34
20	Madhya Pradesh	2463	28	1.14
21	Maharashtra	2195	68	3.10
22	Manipur	3	0	0.00
23	Meghalaya	91	0	0.00
24	Mizoram	13	0	0.00
25	Nagaland	72	0	0.00
26	Odisha	1405	11	0.78
27	Puducherry	7	0	0.00
28	Punjab	831	72	8.66
29	Rajasthan	2183	718	32.89
30	Sikkim	4	0	0.00
31	Tamil Nadu	1252	125	9.98
32	Telangana	983	15	1.53
33	Tripura	86	0	0.00
34	Uttar Pradesh	1925	40	2.08
35	Uttarakhand	239	0	0.00
36	West Bengal	999	13	1.30
	Total	**23610**	**1708**	**7.23**

regions. These elevated values may be associated with factors such as arid climatic conditions, evaporation, salinity ingress, and geogenic influences.

Several states and Union Territories, particularly in the **Himalayan and northeastern regions** such as **Himachal Pradesh, Uttarakhand, Jammu & Kashmir, Arunachal Pradesh, Assam, Meghalaya, Nagaland, and Tripura**, show **no exceedance**, indicating predominantly low EC values and relatively fresh groundwater conditions.

4.1.1 Mitigation Measures for High EC Values:

- Encourage the collection and storage of rainwater to supplement groundwater resources, reducing the reliance on high-EC groundwater.
- Implement artificial recharge techniques like **recharge pits**, **percolation tanks**, and **check dams** to enhance groundwater levels and dilute the concentration of dissolved salts.
- For coastal regions affected by seawater intrusion, consider small-scale **desalination** plants to reduce the salinity levels of groundwater.
- Employ advanced water treatment techniques like **reverse osmosis (RO)**, **electrodialysis**, or **distillation** to remove excess salts and other contaminants from water.

4.2 Fluoride

Fluoride contamination has emerged as a serious global health risk, with millions of people affected by chronic exposure to high levels of naturally occurring fluoride in groundwater. While low concentrations of fluoride are beneficial for dental health, long-term exposure to elevated levels can lead to significant health issues.

The primary contributors to fluoride contamination are geogenic sources, such as fluoride-rich soils, geothermal hot springs, and volcanic rocks. Fluoride in groundwater primarily originates from the natural weathering and dissolution of fluoride-bearing minerals such as fluorite, apatite, biotite, and hornblende found in rocks like granite, gneiss, shale, and charnockite. Bureau of Indian Standards (BIS,10500) recommend a maximum fluoride concentration of 1.5 mg/L in drinking water to reduce health risks. Excessive fluoride intake can cause dental and skeletal fluorosis, as well as other health issues like arthritis, muscle damage, fatigue, joint problems, and various chronic conditions.

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The state-wise distribution of the number of water samples analysed, the number of samples exceeding the fluoride limit (F > 1.5 mg/L), and the number of locations with fluoride concentrations above 1.5 mg/L during pre-monsoon period are presented in Fig. 4 and Table 3.

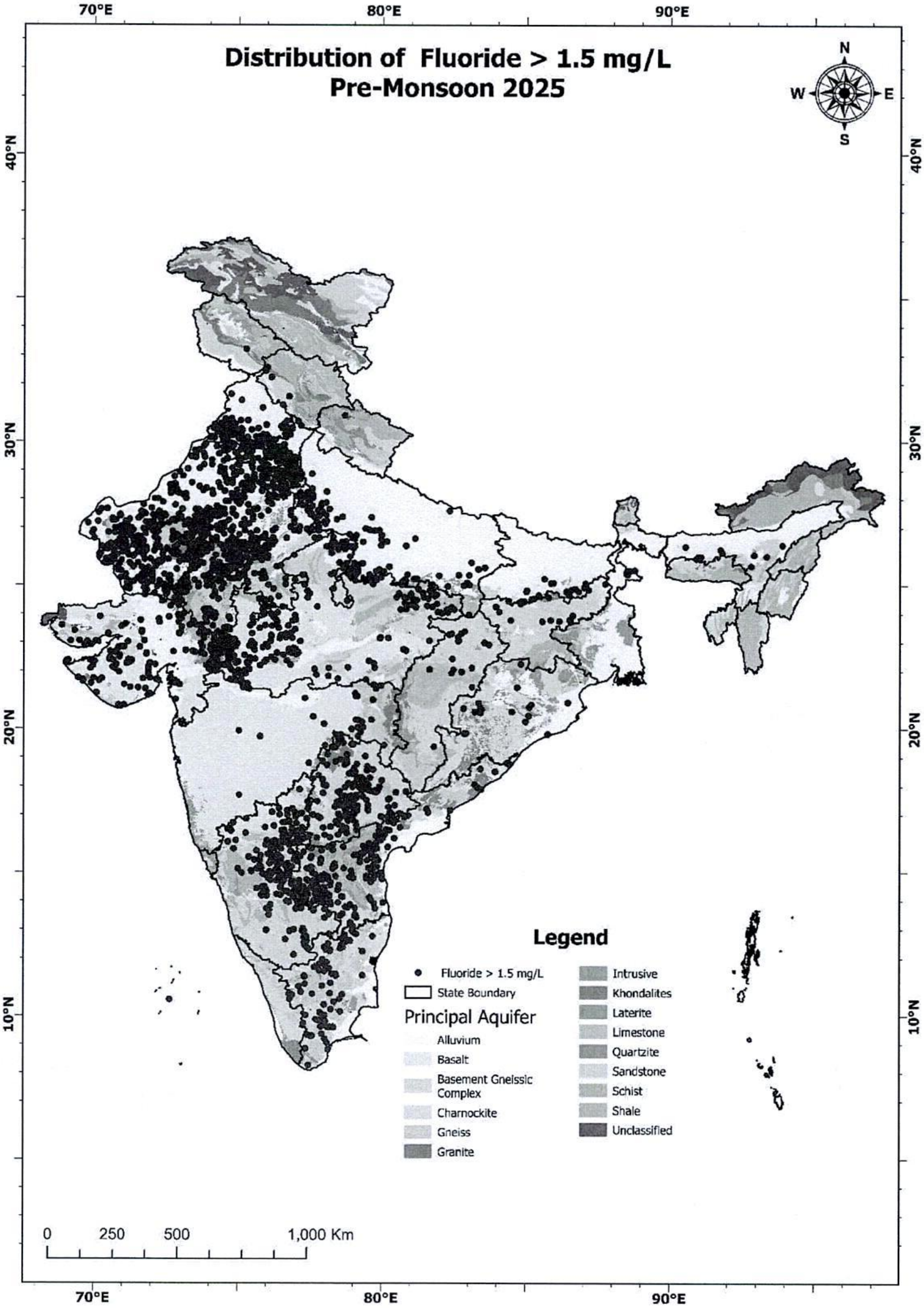

Figure 4: Spatial Distribution of Fluoride in Groundwater – Pre Monsoon, 2025.

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Table 3: State/UT-wise Summary of Groundwater Samples with Fluoride concentration above Permissible Limit (> 1.5 mg/L) during Pre-Monsoon 2025

Sl. No.	State/UT	No. of Samples Analysed (2025)	Samples Exceeding Fluoride Limit (> 1.5 mg/L)	Exceedance %
1	Andaman and Nicobar Islands	112	0	0.00
2	Andhra Pradesh	1144	181	15.82
3	Arunachal Pradesh	44	0	0.00
4	Assam	528	9	1.70
5	Bihar	1025	17	1.66
6	Chandigarh	8	0	0.00
7	Chhattisgarh	599	18	3.01
8	Dadra and Nagar Haveli and Daman and Diu	19	0	0.00
9	Delhi	208	26	12.50
10	Goa	91	0	0.00
11	Gujarat	767	130	16.95
12	Haryana	837	198	23.66
13	Himachal Pradesh	198	6	3.03
14	Jammu & Kashmir	427	2	0.47
15	Jharkhand	561	14	2.50
16	Karnataka	1543	186	12.05
17	Kerala	699	3	0.43
18	Ladakh	20	0	0.00
19	Lakshadweep	29	1	3.45
20	Madhya Pradesh	2463	218	8.85
21	Maharashtra	2195	26	1.18
22	Manipur	3	0	0.00
23	Meghalaya	91	1	1.10
24	Mizoram	13	0	0.00
25	Nagaland	72	0	0.00
26	Odisha	1405	17	1.21
27	Puducherry	7	0	0.00
28	Punjab	831	104	12.52
29	Rajasthan	2183	704	32.25
30	Sikkim	4	0	0.00
31	Tamil Nadu	1252	74	5.91
32	Telangana	983	155	15.77
33	Tripura	86	0	0.00
34	Uttar Pradesh	1925	89	4.62
35	Uttarakhand	239	1	0.42
36	West Bengal	999	5	0.50
	Total	**23610**	**2185**	**9.25**

The analysis of 23,610 groundwater samples indicates that 2,185 samples (9.25%) exceed the permissible limit of 1.5 mg/L for fluoride, suggesting localized fluoride contamination in groundwater across the country.

Fluoride exceedance shows variation across different States/UTs. Higher percentages of samples exceeding the permissible limit are observed in **Rajasthan (32.25%)**, followed by **Haryana (23.66%)**, **Gujarat (16.95%)**, **Andhra Pradesh (15.82%)**, and **Telangana (15.77%)**. This may be associated with natural (geogenic) factors, including the presence of fluoride-bearing minerals in aquifer systems.

In contrast, several states including Assam, Bihar, Odisha, West Bengal, and Maharashtra show low levels of exceedance (<2%), while many northeastern and Himalayan states (e.g., **Arunachal Pradesh, Nagaland, Sikkim**) report **negligible or no exceedance**, reflecting favourable hydrogeological conditions and low fluoride occurrence.

Overall, the results highlight that fluoride contamination in groundwater is primarily a regional issue, concentrated in arid and semi-arid regions of western and peninsular India, and requires targeted mitigation measures such as defluorination and alternative safe water supply in affected areas.

4.2.1 Remedial Measures for Fluoride Contamination

- Alternative Water Sources: Encourage rainwater harvesting or the use of surface water (where safe) in regions affected by high fluoride concentrations. This can reduce reliance on contaminated groundwater.
- Reverse Osmosis: Reverse osmosis (RO) systems are highly effective at removing fluoride, especially for household and small community applications.
- Nalgonda Technique: A low-cost, community-based method that involves adding lime and alum to contaminated water to precipitate fluoride, followed by filtration.
- High yielding wells with low fluoride concentrations should be identified. These high yielding wells containing low fluoride concentrations should be used to provide drinking water to communities with enriched fluoride wells.

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4.3 Nitrate

Nitrate contamination in groundwater is a commonly observed water quality concern, particularly in areas influenced by agricultural activities and sanitation practices. It generally arises from the leaching of nitrogen-based fertilizers, animal wastes, and effluents from septic systems into the subsurface. Owing to its high solubility and mobility, nitrate can persist in groundwater and spread over considerable distances under favourable conditions. Elevated concentrations may have implications for drinking water quality, including potential health concerns such as methemoglobinemia ("blue baby syndrome") in infants. These occurrences highlight the importance of regular monitoring and the adoption of appropriate management measures to help maintain safe and sustainable groundwater resources.

In several states across India, including Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Rajasthan, Chhattisgarh, Haryana, Odisha, Punjab, Tamil Nadu, Telangana, Uttar Pradesh, and Maharashtra, nitrate levels in groundwater have been found to exceed the 45 mg/L threshold recommended by the World Health Organization (WHO) and Bureau of Indian Standards (IS 10500) in pre-monsoon seasons (Fig. 5). The state-wise distribution of samples exceeding the Nitrate limit (>45 mg/L) during Pre-Monsoon 2025 is presented in **Table 4.**

Out of the 23,610 groundwater samples analysed, about 22.02% show nitrate concentration above the permissible limit of 45 mg/L, while the majority of samples remain within acceptable limits.

Variations in percentage of exceedance are observed across different States/UTs. Relatively higher percentages are noted in some states such as Maharashtra, Rajasthan, Karnataka, Delhi, and Andhra Pradesh. A few other states, including Jharkhand, Tamil Nadu, Madhya Pradesh, Haryana, and Telangana, also show occurrence of exceedance in a proportion of samples.

In several other States/UTs, the percentage of exceedance is comparatively low, and in some cases, no exceedance has been observed in the analysed samples. Overall, the results indicate that nitrate exceedance occurs in certain areas, while a substantial number of locations continue to have concentrations within the permissible limit. The variation may be influenced by local factors.

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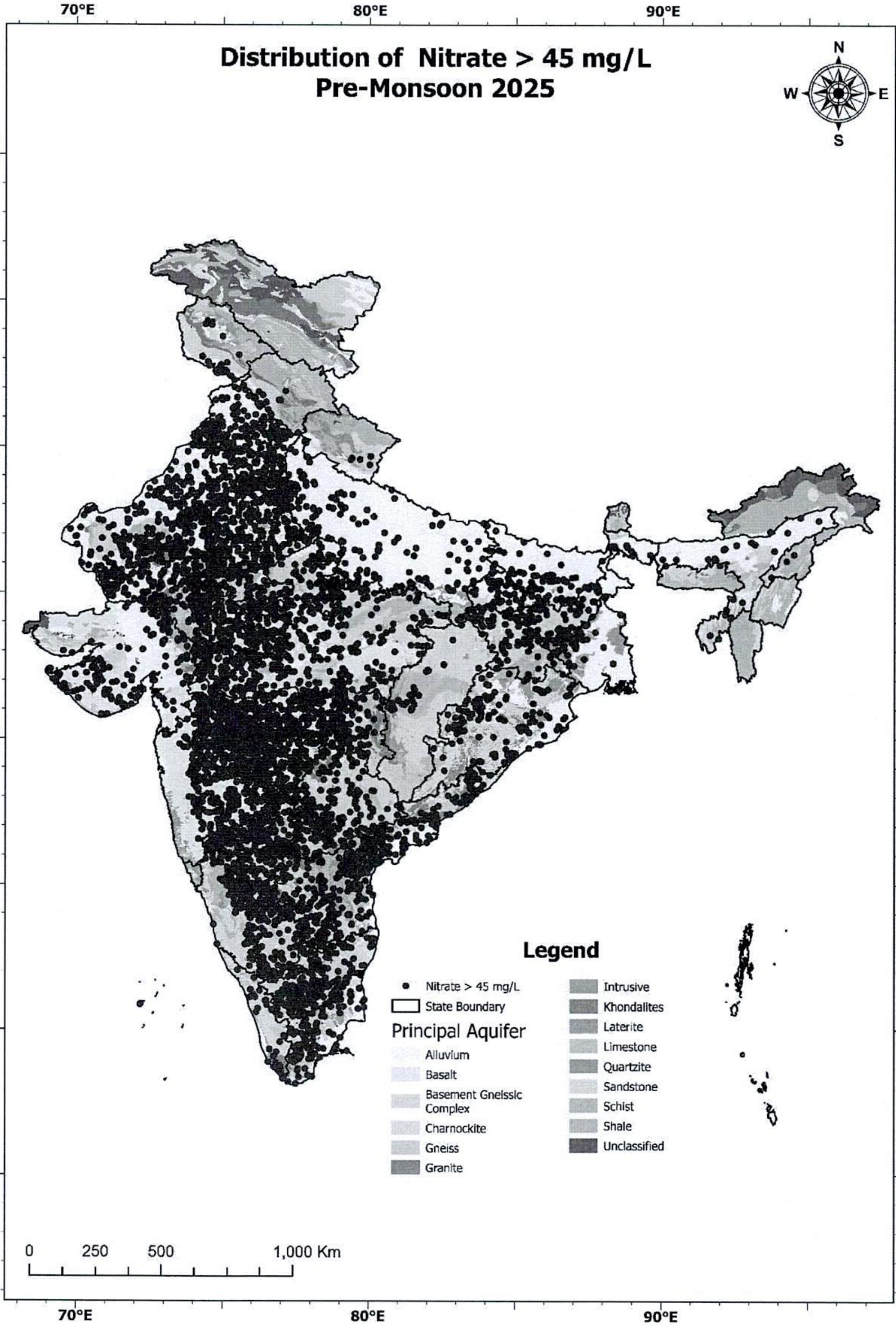

Figure 5: Spatial Distribution of Nitrate in Groundwater – Pre Monsoon, 2025.

(18)

Table 4: State/UT-wise Summary of Groundwater Samples with Nitrate concentration above Permissible Limit (> 45 mg/L) during Pre-Monsoon 2025

Sl. No.	State/UT	No. of Samples Analysed (2025)	Samples Exceeding Nitrate Limit (> 45 mg/L)	Exceedance %
1	Andaman and Nicobar Islands	112	1	0.89
2	Andhra Pradesh	1144	358	31.29
3	Arunachal Pradesh	44	3	6.82
4	Assam	528	19	3.60
5	Bihar	1025	117	11.41
6	Chandigarh	8	0	0.00
7	Chhattisgarh	599	26	4.34
8	Dadra and Nagar Haveli and Daman and Diu	19	1	5.26
9	Delhi	208	72	34.62
10	Goa	91	0	0.00
11	Gujarat	767	150	19.56
12	Haryana	837	176	21.03
13	Himachal Pradesh	198	22	11.11
14	Jammu & Kashmir	427	20	4.68
15	Jharkhand	561	141	25.13
16	Karnataka	1543	563	36.49
17	Kerala	699	32	4.58
18	Ladakh	20	0	0.00
19	Lakshadweep	29	4	13.79
20	Madhya Pradesh	2463	550	22.33
21	Maharashtra	2195	951	43.33
22	Manipur	3	0	0.00
23	Meghalaya	91	2	2.20
24	Mizoram	13	1	7.69
25	Nagaland	72	4	5.56
26	Odisha	1405	130	9.25
27	Puducherry	7	0	0.00
28	Punjab	831	166	19.98
29	Rajasthan	2183	911	41.73
30	Sikkim	4	0	0.00
31	Tamil Nadu	1252	320	25.56
32	Telangana	983	205	20.85
33	Tripura	86	4	4.65
34	Uttar Pradesh	1925	186	9.66
35	Uttarakhand	239	5	2.09
36	West Bengal	999	60	6.01
	Total	**23610**	**5200**	**22.02**

4.3.1 Remedial Measures and Recommendations (Nitrate):

Below are strategies and practices to prevent and mitigate high nitrate contamination in groundwater:

Efficient Fertilizer Management

- **Soil Testing**: Conduct regular soil tests to assess nutrient levels and determine precise fertilizer requirements. This ensures that fertilizers are applied in the correct amounts, reducing wastage.
- **Fertilizer Timing**: Apply fertilizers during periods when crops are most likely to absorb nutrients, minimizing the potential for nitrate runoff or leaching.
- **Use of Organic Fertilizers**: Encourage the use of organic fertilizers, which release nutrients more slowly and can help improve soil structure and water retention.

Septic System Maintenance

- **Regular Inspection and Maintenance**: Ensure that septic systems are inspected and pumped regularly to avoid leaks and overflow, which can contribute to nitrate contamination.
- **Proper Location**: Install septic systems at appropriate distances from wells and water sources to prevent contamination.

Proper Management of Animal Wastes

- **Manure Storage**: Properly store animal waste in sealed and impermeable structures to prevent nitrogen from leaching into the soil and groundwater.
- **Integrated Nutrient Management**: Incorporate animal waste into nutrient management systems to balance the application of organic and synthetic fertilizers, preventing excess nitrogen from entering the soil.

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5.0 Trace and Heavy Metal Concentrations in Groundwater (Pre-Monsoon 2025)

The column graph (Fig. 6) presents the concentrations of trace metal parameters above permissible limit during the **pre-monsoon 2025** period.

It is observed that **iron** has the highest exceedance, with **9.17%** of samples above the permissible limit. **Uranium (5.79%) and Arsenic (2.01%)** show exceedances in a moderate proportion of samples

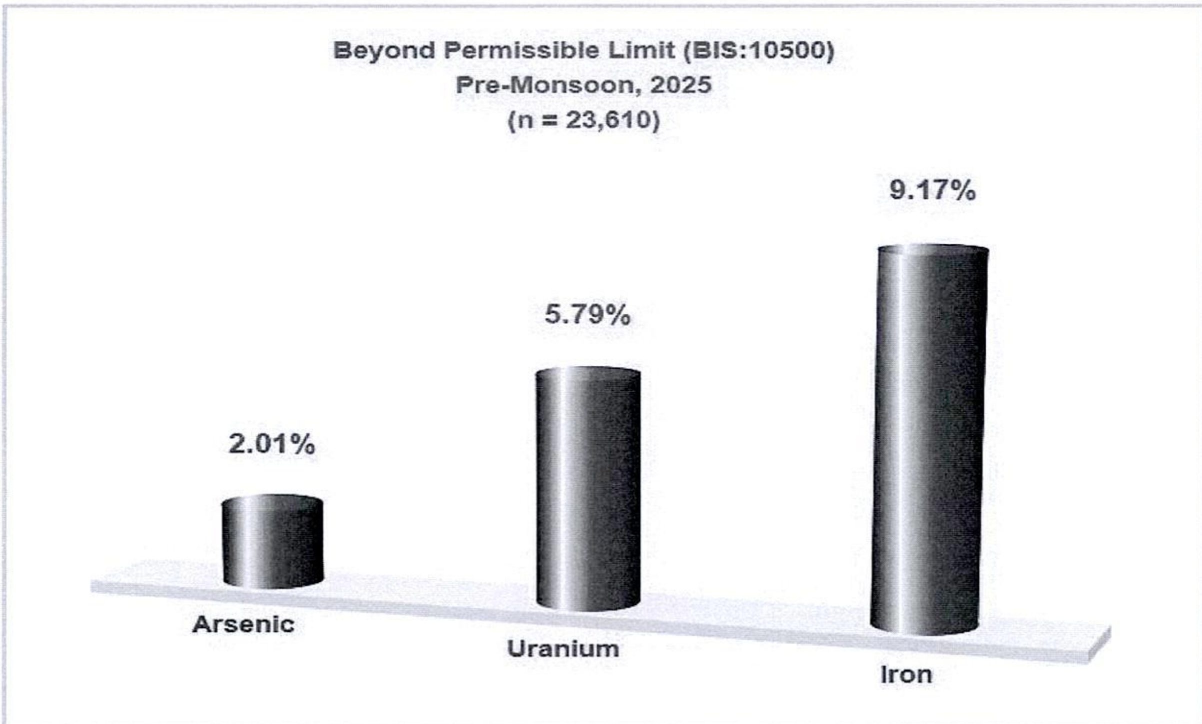

Figure 6: Percentage of Groundwater samples beyond permissible limit as per BIS, 10500 (Arsenic, Uranium and Iron)

5.1 Arsenic

Excessive and prolonged consumption of inorganic arsenic through drinking water is a major health concern, leading to a condition known as arsenicosis. This progressive and debilitating disease is marked by skin lesions, abnormal pigmentation, and the development of patches on the palms and soles. Chronic arsenic exposure can ultimately result in serious health outcomes, including skin and internal cancers.

In addition to its carcinogenic effects, long-term exposure to arsenic has also been linked to cardiovascular complications and an increased risk of diabetes. These health impacts underscore the critical need for monitoring and controlling arsenic levels in drinking water sources.

This highlights the varying geological settings responsible for arsenic contamination across different regions. Understanding these regional and geological variations is essential for developing targeted mitigation strategies and managing the risks associated with arsenic in drinking water sources.

Figure (Fig.7) presents the spatial distribution of arsenic concentrations exceeding 10 µg/L (ppb) in groundwater across India during the pre-monsoon 2025 period, overlaid on the principal aquifer systems. Out of the **23,610 groundwater samples analysed**, about **2.01%** show arsenic concentrations above the **permissible limit of 10 µg/L**, indicating that exceedance is **limited in extent at the national level**. The state-wise distribution of samples exceeding the Arsenic limit (>10 ppb) during Pre-Monsoon 2025 is presented in **Table 5**.

State-wise, relatively higher percentages are observed in **Assam (8.90%)**, **West Bengal (8.81%)**, **Bihar (5.95%)**, **Punjab (5.54%)**, and **Uttar Pradesh (5.19%)**. In most other States/UTs, the percentage of exceedance is comparatively low, generally below 3%, and in several cases, no exceedance has been observed.

From a spatial perspective, the occurrence of arsenic above the permissible limit appears to be **more common in parts of the Indo-Gangetic and Brahmaputra alluvial plains**, covering areas of **Assam, West Bengal, Bihar, and Uttar Pradesh**. This suggests a possible association with **alluvial aquifer systems of major river basins**, where geogenic processes under specific hydrogeochemical conditions may influence arsenic mobilization.

In contrast, regions dominated by **hard rock aquifers (peninsular India)** generally show **low occurrence**, indicating limited arsenic presence in these settings.

Overall, the results indicate that arsenic exceedance is **localized and region-specific**, while groundwater quality with respect to arsenic remains **within permissible limits in the majority of locations**.

(22)

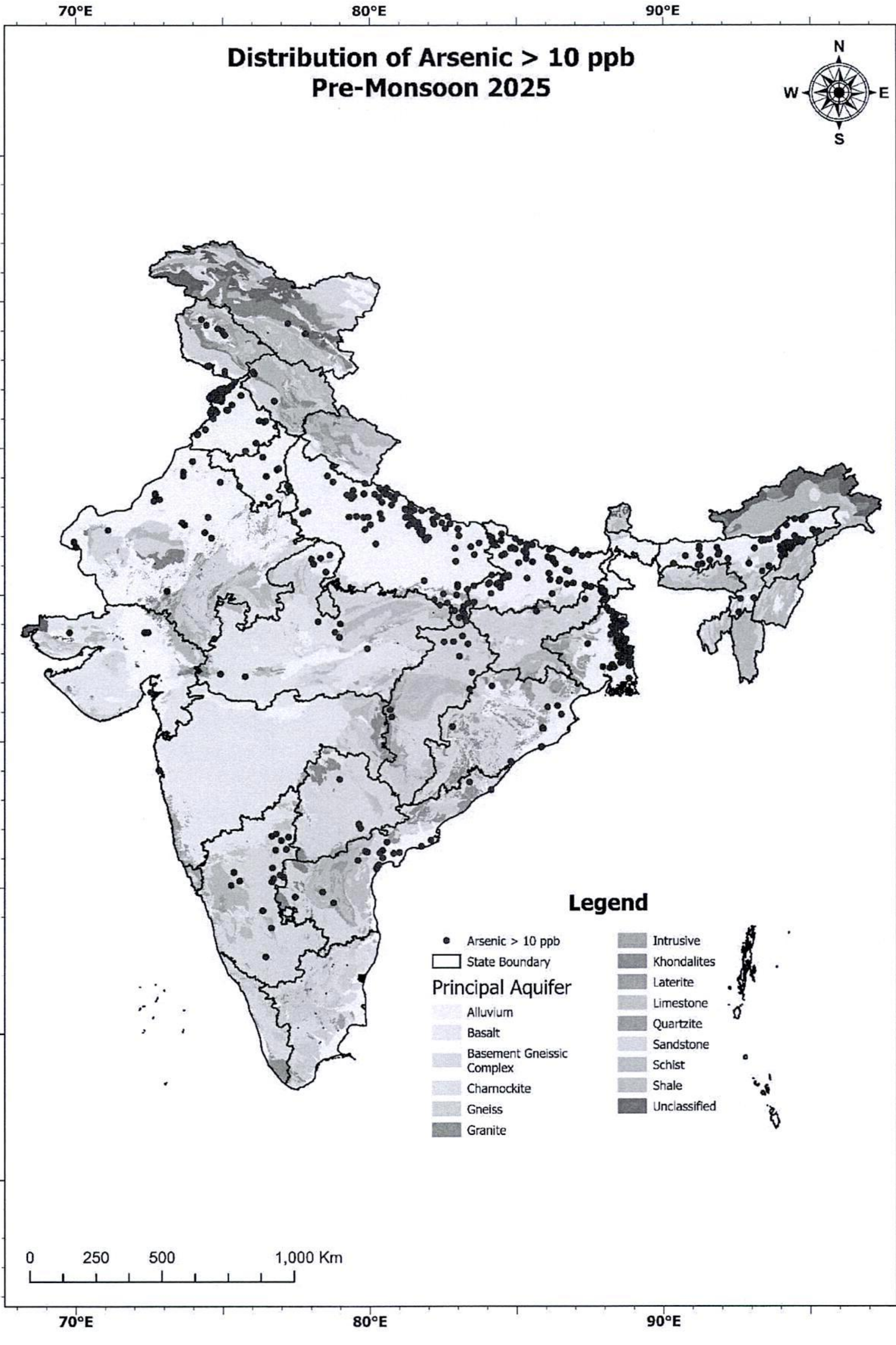

Figure 7: Spatial Distribution of Arsenic in Groundwater – Pre Monsoon, 2025.

Table 5: State/UT-wise Summary of Groundwater Samples with Arsenic concentration above Permissible Limit (Pre-Monsoon 2025).

Sl. No.	State/UT	No. of Samples Analysed (2025)	Samples Exceeding Arsenic Limit (>10 ppb)	Exceedance %
1	Andaman and Nicobar Islands	112	0	0.00
2	Andhra Pradesh	1144	20	1.75
3	Arunachal Pradesh	44	1	2.27
4	Assam	528	47	8.90
5	Bihar	1025	61	5.95
6	Chandigarh	8	0	0.00
7	Chhattisgarh	599	9	1.50
8	Dadra and Nagar Haveli and Daman and Diu	19	0	0.00
9	Delhi	208	5	2.40
10	Goa	91	0	0.00
11	Gujarat	767	4	0.52
12	Haryana	837	6	0.72
13	Himachal Pradesh	198	6	3.03
14	Jammu & Kashmir	427	12	2.81
15	Jharkhand	561	3	0.53
16	Karnataka	1543	17	1.10
17	Kerala	699	0	0.00
18	Ladakh	20	2	10.00
19	Lakshadweep	29	0	0.00
20	Madhya Pradesh	2463	13	0.53
21	Maharashtra	2195	1	0.05
22	Manipur	3	0	0.00
23	Meghalaya	91	0	0.00
24	Mizoram	13	0	0.00
25	Nagaland	72	0	0.00
26	Odisha	1405	12	0.85
27	Puducherry	7	0	0.00
28	Punjab	831	46	5.54
29	Rajasthan	2183	17	0.78
30	Sikkim	4	0	0.00
31	Tamil Nadu	1252	0	0.00
32	Telangana	983	4	0.41
33	Tripura	86	0	0.00
34	Uttar Pradesh	1925	100	5.19
35	Uttarakhand	239	0	0.00
36	West Bengal	999	88	8.81
	Total	**23610**	**474**	**2.01**

5.1.1 Remedial Measures and Recommendations (Arsenic):

Short-Term Mitigation

- Adoption of household treatment plants which are effective, efficient and low cost
- Conjunctive use of piped surface and GW
- Construction of hand pumps with removal plants
- Installing community water supply systems
- Replacement of shallow Arsenic affected wells with deep tube wells tapping arsenic safe zone.

Long-Term Mitigation

- Tapping alternate safe aquifer for drinking purposes
- Adoption of Mini water supply scheme attached with treatment plants
- Construction of deeper wells with cement sealing technique demonstrated by CGWB
- Adoption of rain water harvesting
- Public awareness and education
- Research and Development: To explore new and more efficient treatment technologies and strategies

Arsenic Remediation Mechanism

- Oxidation
- Precipitation
- Membrane Techniques
- Bioremediation

Oxidation is a pre-requisite process that converts more mobile form As (III) into comparatively stable As (V), and subsequent removal of As (V) takes place by employing adsorption/ sedimentation/filtration or other techniques.

5.2 Iron

Iron is a naturally occurring element commonly found in groundwater, especially in areas with iron-rich soils and rocks. It typically enters groundwater through the dissolution of iron-bearing minerals. The most common forms of iron in groundwater are ferrous (Fe^{2+}), which is soluble and clear, and ferric (Fe^{3+}), which forms reddish-brown precipitates.

While not harmful to health at low levels, high concentrations of iron can cause aesthetic and operational issues, such as metallic taste, staining of laundry and plumbing fixtures, and clogging of pipes and water systems. Iron levels above 1 mg/L are generally considered undesirable by drinking water standards.

Iron contamination in groundwater has been reported across several Indian states. The state-wise distribution of samples exceeding the Fe limit (>1.0 mg/L) during Pre-Monsoon 2025 is presented in **Table 6**. Data highlights the following:

- Out of the **23,610 groundwater samples analysed**, about **9.17%** show iron concentration above the **permissible limit of 1.0 mg/L**, indicating that exceedance is **limited at the national level**, with the majority of samples within acceptable limits.
- Relatively higher percentages of exceedance are observed in **Tripura (41.86%)**, **Assam (30.30%)**, **Uttar Pradesh (27.69%)**, **Bihar (26.63%)**, **West Bengal (24.72%)**, and **Uttarakhand (23.85%)**. Some other states such as **Odisha (14.80%)**, **Nagaland (11.11%)**, and **Chhattisgarh (9.85%)** also show occurrence of elevated iron in a proportion of samples.
- In most other States/UTs, the percentage of exceedance is comparatively low, generally below 10%, and in several cases, negligible or no exceedance has been observed.

From a spatial perspective, higher occurrence of iron is observed in parts of the **Indo-Gangetic and Brahmaputra alluvial plains and northeastern region (Fig. 8)**, which may be associated with **natural hydrogeochemical conditions**, such as reducing environments in aquifers. In contrast, many areas in peninsular India show relatively lower occurrence.

Overall, the results indicate that iron exceedance is **localized and region-specific**, while groundwater quality with respect to iron remains **within permissible limits in a large number of locations**.

(26)

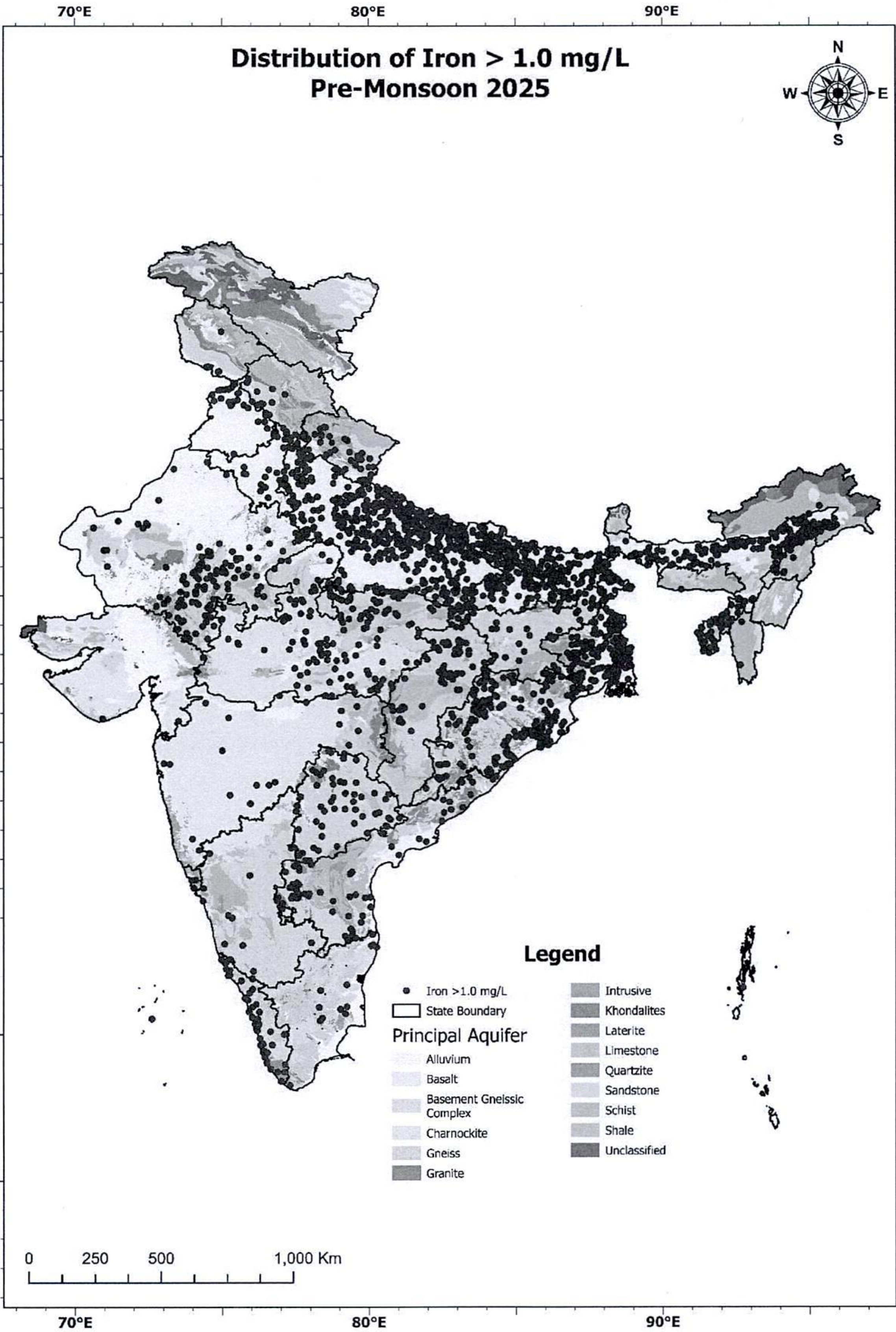

Figure 8: Spatial Distribution of Iron in Groundwater – Pre Monsoon, 2025

(27)

Table 6: State/UT-wise Summary of Groundwater Samples with Iron concentration above Permissible Limit (Pre-Monsoon 2025)

Sl. No.	State/UT	No. of Samples Analysed (2025)	Samples Exceeding Iron Limit (>1.0 mg/L)	Exceedance %
1	Andaman and Nicobar Islands	112	1	0.89
2	Andhra Pradesh	1144	62	5.42
3	Arunachal Pradesh	44	4	9.09
4	Assam	528	160	30.30
5	Bihar	1025	273	26.63
6	Chandigarh	8	0	0.00
7	Chhattisgarh	599	59	9.85
8	Dadra and Nagar Haveli and Daman and Diu	19	0	0.00
9	Delhi	208	6	2.88
10	Goa	91	3	3.30
11	Gujarat	767	3	0.39
12	Haryana	837	28	3.35
13	Himachal Pradesh	198	17	8.59
14	Jammu & Kashmir	427	7	1.64
15	Jharkhand	561	29	5.17
16	Karnataka	1543	12	0.78
17	Kerala	699	49	7.01
18	Ladakh	20	0	0.00
19	Lakshadweep	29	1	3.45
20	Madhya Pradesh	2463	130	5.28
21	Maharashtra	2195	20	0.91
22	Manipur	3	0	0.00
23	Meghalaya	91	2	2.20
24	Mizoram	13	2	15.38
25	Nagaland	72	8	11.11
26	Odisha	1405	208	14.80
27	Puducherry	7	0	0.00
28	Punjab	831	29	3.49
29	Rajasthan	2183	112	5.13
30	Sikkim	4	0	0.00
31	Tamil Nadu	1252	14	1.12
32	Telangana	983	52	5.29
33	Tripura	86	36	41.86
34	Uttar Pradesh	1925	533	27.69
35	Uttarakhand	239	57	23.85
36	West Bengal	999	247	24.72
	Total	**23610**	**2164**	**9.17**

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5.2.1 Remedial Measures and Recommendations (Iron):

- **Aeration and Filtration**: Oxidizing ferrous iron to ferric form followed by filtration.
- **Use of Iron Removal Plants (IRPs)**: Especially in rural or community water supply schemes.
- **Activated Media Filters**: Such as manganese greensand or catalytic carbon for small-scale use.
- **Chemical Oxidation**: Using chlorine, ozone, or potassium permanganate in severe cases.

5.3 Uranium

Uranium is a naturally occurring element that can be found in trace amounts in rocks, soil, and groundwater. Elevated concentrations in drinking water sources may pose potential health and environmental concerns due to its chemical toxicity and radioactive properties.

Out of the **23,610 groundwater samples analysed**, about **5.79%** show uranium concentration above the **permissible limit of 30 µg/L (ppb)**, indicating that exceedance is **limited at the national level**, with the majority of samples within acceptable limits.

Variations in exceedance are observed across States/UTs. Relatively higher percentages are noted in **Punjab (31.53%)** and **Haryana (19.47%)**, while **Uttar Pradesh (13.92%)**, **Andhra Pradesh (12.59%)**, **Telangana (10.78%)**, and **Karnataka (9.27%)** also show occurrence of exceedance in a proportion of samples. **Delhi (8.65%)**, **Bihar (6.54%)** and **Rajasthan (6.46%)** indicate moderate levels. In most other States/UTs, the percentage of exceedance is comparatively low, generally below 5%, and in several cases no exceedance has been observed in the analysed samples. From a broader perspective, the occurrence of uranium above the permissible limit appears more frequent in parts of **northwestern and peninsular India**, which may be influenced by **local geological and hydrogeochemical conditions**. In contrast, many regions, including the northeastern states, show negligible or no exceedance.

(29)

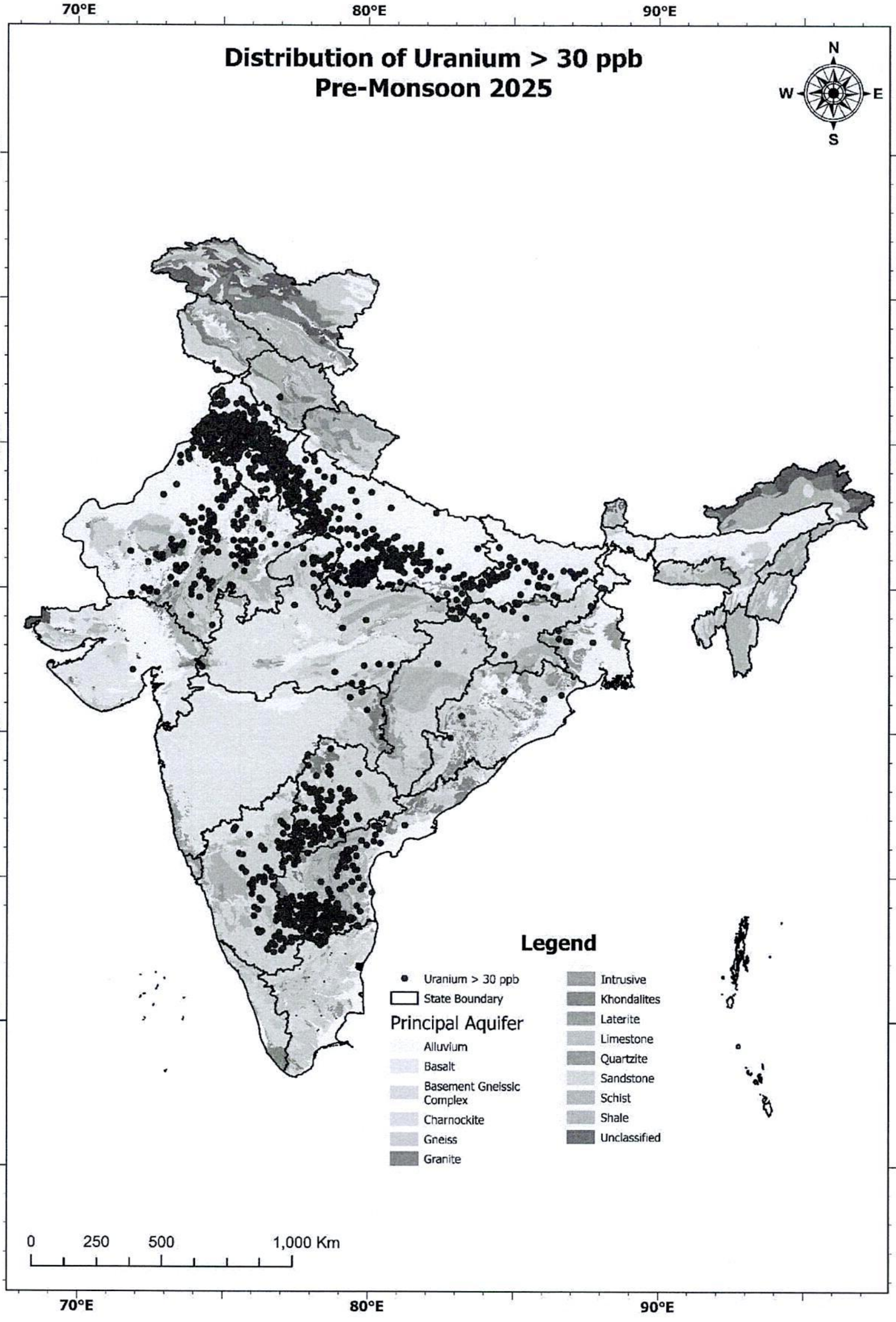

Figure 9: Spatial Distribution of Uranium in Groundwater – Pre Monsoon, 2025

(30)

Table 7: State/UT-wise Summary of Groundwater Samples with Uranium concentration above Permissible Limit (Pre-Monsoon 2025).

Sl. No.	State/UT	No. of Samples Analysed (2025)	Samples Exceeding Uranium Limit (> 30 ppb)	Exceedance %
1	Andaman and Nicobar Islands	112	0	0.00
2	Andhra Pradesh	1144	144	12.59
3	Arunachal Pradesh	44	0	0.00
4	Assam	528	0	0.00
5	Bihar	1025	67	6.54
6	Chandigarh	8	0	0.00
7	Chhattisgarh	599	1	0.17
8	Dadra and Nagar Haveli and Daman and Diu	19	0	0.00
9	Delhi	208	18	8.65
10	Goa	91	0	0.00
11	Gujarat	767	1	0.13
12	Haryana	837	163	19.47
13	Himachal Pradesh	198	1	0.51
14	Jammu & Kashmir	427	1	0.23
15	Jharkhand	561	8	1.43
16	Karnataka	1543	143	9.27
17	Kerala	699	0	0.00
18	Ladakh	20	0	0.00
19	Lakshadweep	29	0	0.00
20	Madhya Pradesh	2463	28	1.14
21	Maharashtra	2195	3	0.14
22	Manipur	3	0	0.00
23	Meghalaya	91	0	0.00
24	Mizoram	13	0	0.00
25	Nagaland	72	0	0.00
26	Odisha	1405	5	0.36
27	Puducherry	7	0	0.00
28	Punjab	831	262	31.53
29	Rajasthan	2183	141	6.46
30	Sikkim	4	0	0.00
31	Tamil Nadu	1252	0	0.00
32	Telangana	983	106	10.78
33	Tripura	86	0	0.00
34	Uttar Pradesh	1925	268	13.92
35	Uttarakhand	239	0	0.00
36	West Bengal	999	7	0.70
	Total	**23610**	**1367**	**5.79**

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5.5.1 Remedial Measures for Uranium Contamination

To reduce uranium concentrations in drinking water, the following treatment methods are recommended: Reverse Osmosis (RO), Ion Exchange, Activated Alumina and Coagulation and Filtration.

6.0 Summary

The assessment of groundwater quality during the pre-monsoon 2025 indicates that, at the national level, most parameters are within permissible limits, with exceedances observed only in a proportion of samples and varying across regions.

Among the three major parameters i.e. EC, F and Nitrate, nitrate (22.02%) shows relatively higher exceedance, followed by fluoride (9.25%) and electrical conductivity (EC) (7.23%). These parameters exhibit regional variability, with higher values observed in parts of northwestern, central, and peninsular India, likely influenced by local hydrogeological conditions and anthropogenic factors.

With respect to three trace metals i.e. As, F and U, the overall occurrence above permissible limits are generally low at the national scale. In conclusion, the groundwater quality assessment indicates that exceedances are observed for selected trace elements, with relatively higher occurrence of iron (9.17%) and uranium (5.79%) in certain regions, while arsenic (2.01%) is present at comparatively lower levels. These observations suggest localized influences on groundwater chemistry, possibly arising from geogenic and anthropogenic factors.

Spatially, certain parameters exhibit distinct regional patterns. Fluoride and EC are more prominent in arid and semi-arid regions, while nitrate shows wider occurrence, possibly linked to localized anthropogenic influences. Arsenic and iron are observed in parts of the Indo-Gangetic and Brahmaputra alluvial plains and northeastern region, whereas uranium occurrence is noted in parts of northwestern and peninsular India.

Overall, the results indicate that groundwater quality across the country is generally within permissible limits for most parameters, with exceedances being localized and region-specific. Continued monitoring, identification of vulnerable areas, and adoption of appropriate management and mitigation measures are important to ensure sustainable and safe use of groundwater resources.

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