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BULLETIN

GROUND WATER QUALITY OF NAGALAND

Central Ground Water Board

केंद्रीय भूजल बोर्ड

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GOVERNMENT OF INDIA

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BULLETIN

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ABSTRACT

Periodic ground water quality assessment (2017-2024) highlighting the findings, significant trends and groundwater contamination status

1.0 INTRODUCTION

Groundwater is a primary source of water supply for irrigation, domestic and industrial. It is a crucial factor in India's socioeconomic growth. Despite possessing only 4% of the world's fresh water resources, India sustains over 16% of the global population and presently faces an acute water crisis. According to the safe water index survey, India ranks second to last among 123 countries. Though groundwater is less susceptible to pollution compared to surface water, reckless exploitation and overuse of groundwater resources may result in declining groundwater levels and diminished water quality. In addition, there is mounting concern about the degradation of groundwater quality caused by both geogenic processes and human activities. The potential contamination of groundwater used for public and rural domestic purposes is of particular concern. Furthermore, atmospheric precipitation, inland surface water, recharge water quality, and geochemical processes also impact groundwater quality. Groundwater contamination can have a significant impact on human health, economic development, and social well-being. In the Northeast, as in other parts of India, anthropogenic activities can negatively impact groundwater quality.

To effectively manage groundwater, it is necessary to have comprehensive data on its current and potential quality. Therefore, a thorough understanding of water resource quality in the State of Nagaland is paramount for prudent groundwater management. Furthermore, a 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 Nagaland State is lacking.

Our efforts in the present study are to fulfill the following objectives:

1. To present current Ground water quality scenario, parameter wise for each district
2. To identify present day hot spots of poor-quality ground water through spatial variation analysis of latest 2024 quality data.
3. To assess temporal variation of ground water quality showing improvement/deterioration during the period from 2017 to 2024, providing insights for effective water quality management measures.

2.0 STUDY AREA

Nagaland (Figure 1), located in northeastern India, shares borders with Assam, Arunachal Pradesh, Manipur, and Myanmar. Covering an area of 16,579 km², it is characterized by hilly terrain, with the Naga Hills, Patkai Range, and Barail Range forming the main geographical features. It has a total population of 19,90,036. Nagaland spreads within Latitude 93° 41'00" E to 93°50'10" E and Longitude 25°46'30" N to 25°58'30" N. Nagaland experiences a humid subtropical climate with heavy monsoon rains, receiving an average annual rainfall of 2,000 to 2,500 mm. This supports its diverse vegetation, including tropical and temperate forests. Nagaland's biodiversity is rich, with a variety of flora and fauna, and its forests are vital for the local economy. The state consists of 12 districts, with Kohima as the capital. The economy is primarily agricultural, with increasing interest in tourism. Despite developmental challenges, Nagaland's strategic location enhances its importance in both economic and geopolitical terms. The districts of Nagaland are Dimapur, Kohima, Mokokchung, Mon, Peren, Phek, Tuensang, Wokha, Zunheboto, Longleng, Kiphire, Noklak, Chümoukedima, and Tseminyu.

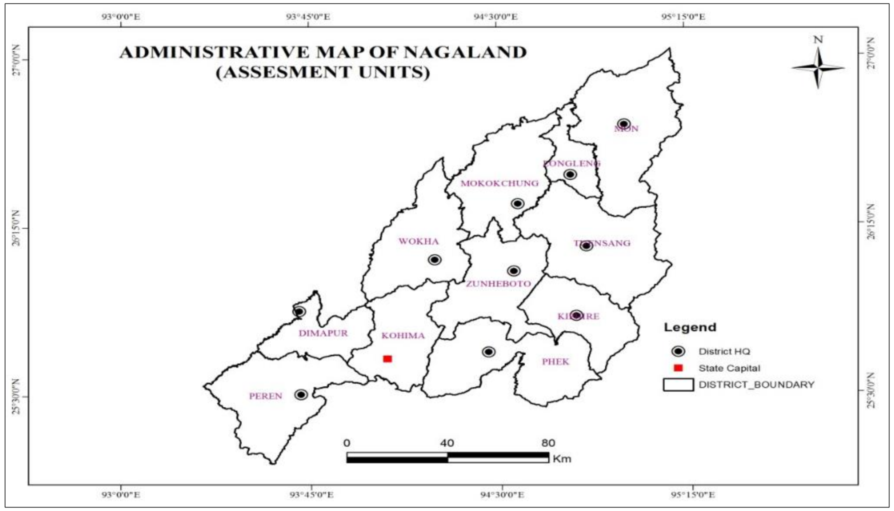

Figure 1. Administrative map of Nagaland

3.0 HYDROGEOLOGY

Nagaland consists of a narrow strip of hills running from east to southwest, bordered by the Assam plains to the north and northeast. The Naga Hills, part of the Indo-Myanmar orogenic belt, rise from the Brahmaputra valley at 2,000 feet, reaching over 6,000 feet towards the southeast and merging with the Patkai range along the Myanmar border, peaking at Mt. Saramati (12,552 feet). The region's Cenozoic sequence consists mainly of geosynclinal sediments. Geomorphotectonically, Nagaland is divided into four units due to the collision of the Indian and Myanmar plates: the Foreland, Belt of Schuppen, Kohima-Patkai Synclinorium, and the Eastern zone, including the Naga Hills Ophiolite. These formations contain complex interlayered sequences of metamorphic and ophiolitic rocks, representing significant tectonic processes.

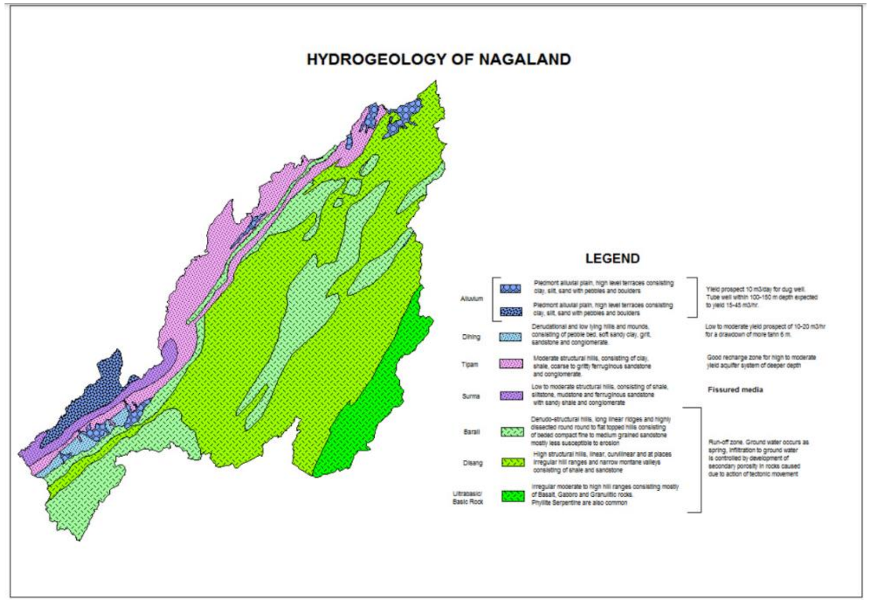

Figure 2. Hydrogeology map of Nagaland.

4.0 GROUND WATER QUALITY MONITORING

Monitoring of ground water quality is an effort to obtain information on chemical quality through representative sampling in different hydrogeological units. Ground Water is commonly tapped from phreatic aquifers. The main objective of ground water quality monitoring 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 probable causes of deterioration in ground water quality are depicted in Figure 3.

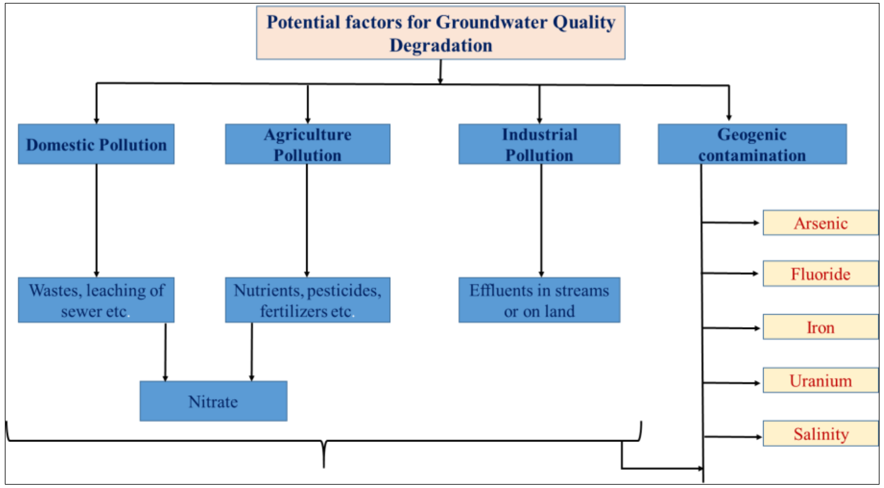

Figure 3. Schematic diagram illustrating the potential factors contributing to the degradation of groundwater quality.

The chemical quality of shallow ground water is being monitored by Central Ground Water Board. During pre-monsoon season, 2024 samples have been collected from 116 locations located at several districts in Nagaland (Figure 4).

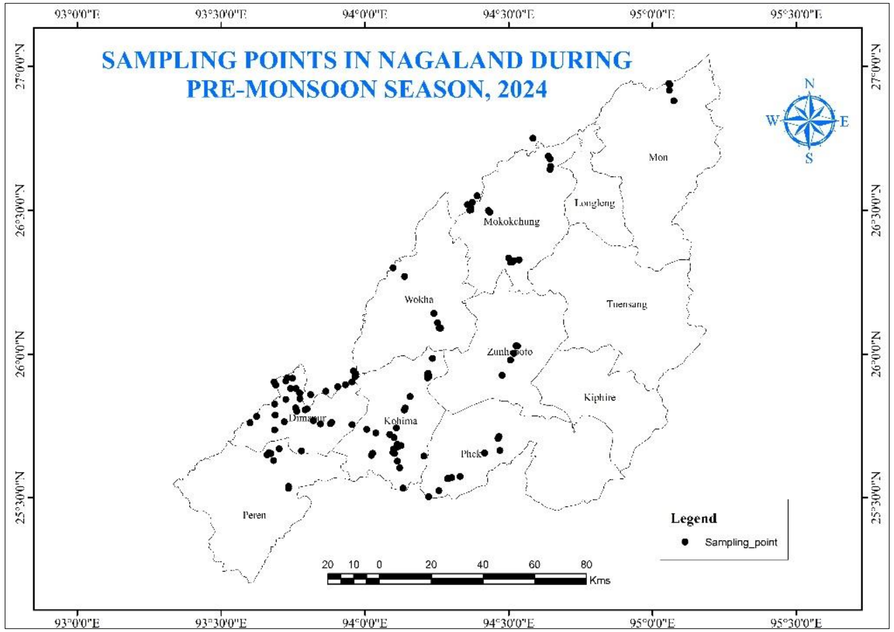

Figure 4. Ground water quality sampling locations in Nagaland.

4.0 METHODOLOGY

To establish the ground water chemistry, samples from Dimapur district have been collected during the month of March/April (pre-monsoon) which is generally a dry period, leading to maximum concentration of elements in the water samples and November (Post-monsoon). Standard procedures and guidelines of sampling, storing, and transferring were strictly followed as prescribed by American Public Health Association (APHA 2017). 1000 mL of samples were collected in high-density polyethylene bottles (HDPE) without preservatives for physical and major solutes analysis. On-site sampling and sample filtration using 0.45 µm membrane by syringe filtration technique in 60 mL HDPE bottles were carried out to analyze uranium and heavy metals. Immediately after filtration, 0.5 mL trace elemental grade HNO_3 acid is added as preservatives. Caution was being taken while bottling the samples to avoid interference from the air headspace.

Standard analysis procedures (APHA, 2017) were employed for analyzing the GW samples **(Table 1).** During the analysis, QA/QC protocols were followed, including blank run, external calibration, and standardization by NIST certified standard reference materials, retesting, etc.

Table 1: Analytical methods/equipment for Groundwater quality analysis.

Parameters	Method adopted	Instrument/technique used
PHYSICO-CHEMICAL		
pH	Electrometric method	pH meter
Conductivity	Electrometric method	Conductivity meter
Turbidity	Turbidimetric method	Nephalo-turbidity meter
TDS	Electrometric	Conductivity/TDS Meter
Alkalinity	Titrimetric method	(Titration by H_2SO_4)
Chloride (Cl)	Argentometric /Chromatographic method	(Titration by $AgNO_3$)/Ion Chromatograph
Sodium (Na)	Flame Emission Spectroscopy/ Chromatographic method	Flame photometer/ Ion Chromatograph
Potassium (K)	Flame Emission Spectroscopy/ Chromatographic method	Flame photometer / Ion Chromatograph
Total Harness	Titrimetric method	(Titration by EDTA)
Calcium (Ca)	Titrimetric method/ Chromatographic method	(Titration by EDTA)/ Ion Chromatograph
Fluoride (F^-)	Electrometric method/ Chromatographic method	Ion Meter/ Ion Chromatograph
Sulphate (SO_4^{-2})	Turbidimetric method/ Chromatographic method	UV-visible Spectrophotometer/ Ion Chromatograph
Nitrate (NO_3^-)	Ultraviolet screening/ Chromatographic method	UV-visible Spectrophotometer/ Ion Chromatograph
Phosphate	Molybdophosphoric acid/ Chromatographic method	UV-VIS Spectrophotometer / Ion Chromatograph
Dissolved Oxygen (DO)	Electrometric	DO meter
HEAVY METALS AND RADIOACTIVE URANIUM		
Uranium (U)	Plasma Spectroscopy/Fluorescence Spectrometry	ICP-MS/Uranium analyzer
Iron (Fe)	Colorimetric method/Atomic absorption spectroscopy/Palsma Spectroscopy	UV-visible Spectrophotometer/AAS
Arsenic	Hydride generation/ Plasma Spectroscopy	AAS/ICPMS
Cr, Mn, Fe, Ni, Cu, Zn, Se, Ag, Cd and Pb	Atomic Spectroscopy/ Plasma Spectroscopy	AAS/ICPMS

5.0 GROUND WATER QUALITY SCENARIO

The main objectives of ground water quality monitoring are to assess the suitability of ground water for drinking purposes as the quality of drinking water is a powerful environmental determinant of the health of a community. Bureau of Indian Standards (BIS) vide its document IS: 10500:2012, Edition 3.2 (2012-15) has recommended the quality standards for drinking water. The ground water samples collected from phreatic aquifers are analysed for all the major inorganic parameters and trace metals. Based on the results, it is found that ground water of the Nagaland is mostly of mixed cations and mixed anions 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 Iron have been observed in some parts of Dimapur.

5.1 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 2020 & 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)

5.1.1 THE 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. In general water having EC < 1500µS/cm, is considered as fresh water, EC 1500 –15000µS/cm, is considered as brackish water and >15000µS/cm is considered as saline water. 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 2000 mg/I (corresponding to EC of about 3000 µS/cm at 25°C) in case of absence of alternate source. Water having TDS more than 2000 mg/L are not suitable for drinking purposes.

PRESENT DAY SCENARIO IN NAGALAND
ELECTRICAL CONDUCTIVITY (EC)

Distribution of Electrical Conductivity (EC)

- The EC value of ground waters in the State varies from 22.7 at Longtho, Mangkolemba district to 1382 µS/cm at Zakesatho colony, Chumoukedima district at 25°C.
- Grouping water samples based on EC values, it is found that none of them have EC above 3000µS/cm and all samples are in between 22.7 to 1382 µS/cm.
- The map showing aerial distribution of EC (Figure 5) in pre-monsoon signifies that slightly high EC is concentrated in the south-western part of the state viz. Dimapur, Kohima and Phek.
- The Table 2 provides the number of samples analyzed per district, along with their minimum, maximum, and mean EC values and number of samples beyond 3000 µS/cm based on pre-monsoon NHS 2024 Data.
- Trend analysis (Table 3, Figure 6), of six years showing no significant change except in two locations in Dimapur district, two locations in Kohima district and one location in Phek district, showing concentration of EC more than 750 and less than 3000 µS/cm during pre-monsoon season, 2024. Increasing tendency is due to addition of more wells as well as addition of samples from other districts.

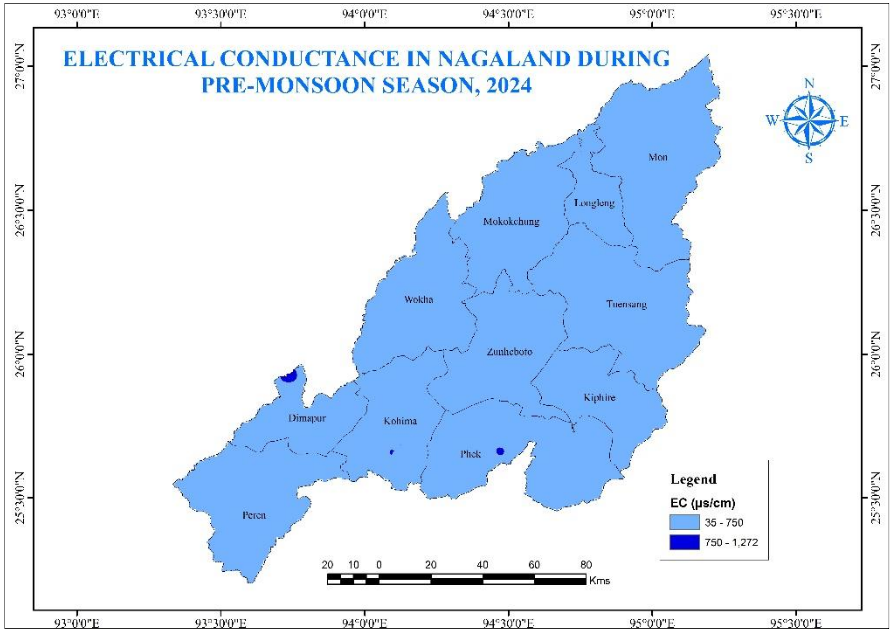

Figure 5: Map showing distribution of Electrical Conductivity in Nagaland based on pre-monsoon NHS 2024 Data.

Table 2: District wise EC distribution during pre-monsoon, 2024.

Electrical Conductivity (µS/cm)									
Sl. No.	District	No. of sample analysed	Permissible limit	Desirable limit	Min	Max	Mean	% of sample <=3000	% of sample >3000
1	Chumoukedima	11	3000.00	3000.00	58.56	534.00	270.61	100.00	0.00
2	Dimapur	13	3000.00	3000.00	167.50	1382.00	517.89	100.00	0.00
3	Kohima	19	3000.00	3000.00	90.13	1041.00	379.84	100.00	0.00
4	Mokokchung	23	3000.00	3000.00	22.70	442.80	207.00	100.00	0.00
5	Mon	4	3000.00	3000.00	48.62	85.23	66.91	100.00	0.00
6	Nuiland	8	3000.00	3000.00	57.75	646.30	198.96	100.00	0.00
7	Peren	9	3000.00	3000.00	111.00	500.30	248.81	100.00	0.00
8	Phek	12	3000.00	3000.00	139.00	882.80	374.05	100.00	0.00
9	Tseminyu	6	3000.00	3000.00	117.40	625.60	313.35	100.00	0.00
10	Wokha	6	3000.00	3000.00	100.10	353.20	194.22	100.00	0.00
11	Zunheboto	5	3000.00	3000.00	32.65	112.90	83.48	100.00	0.00
		116							

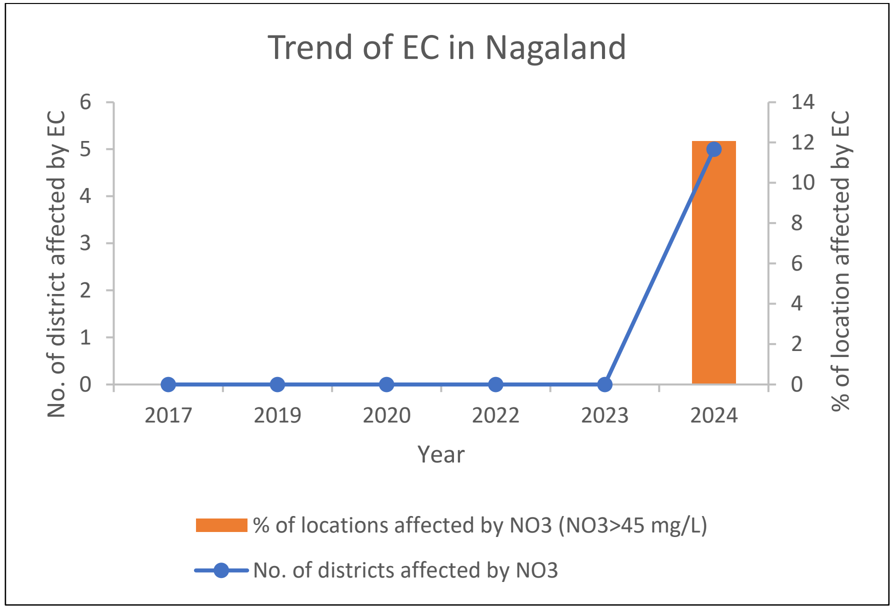

Figure 6: Trend of EC for 7 years.

Table 3: Periodic Variation in suitability classes of salinity in groundwater of Nagaland.

Periodic variation in suitability classes of Salinity in groundwater of Nagaland								
Parameter	Class	percentage of samples						Periodic Variation 2017-2024
		2017	2019	2020	2022	2023	2024	
		(n=13)	(n=8)	(n=2)	(n=8)	(n=17)	(n=116)	
Salinity as EC	<750 µS/cm	100.00	100.00	100.00	100.00	94.12	95.69	-4.31
	750-3000 µS/cm	0.00	0.00	0.00	0.00	5.88	4.31	4.31
	>3000 µS/cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5.1.2 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 methemoglobinemia particularly to infants. Adults can tolerate little higher concentration.

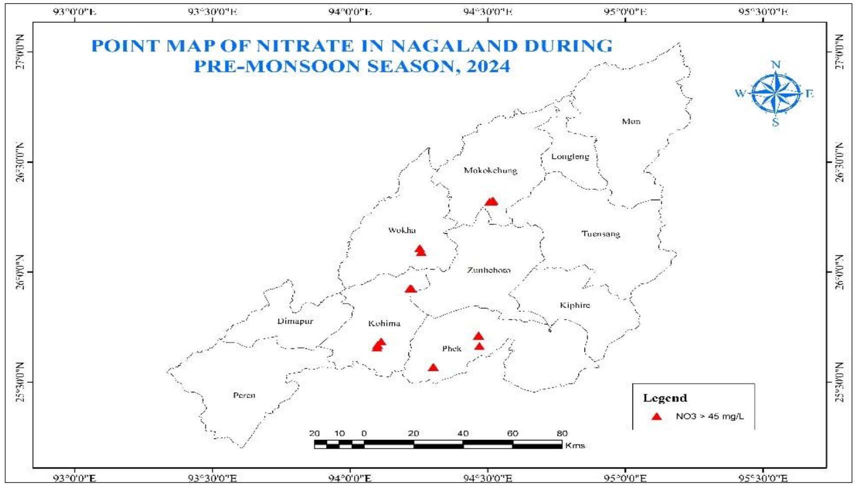

Figure 7: Map showing point location of nitrate in Nagaland based on pre-monsoon NHS 2024 Data.

PRESENT DAY SCENARIO IN NAGALAND NITRATE

Distribution of Nitrate

- The nitrate value of ground waters in the State varies from 0.05 mg/L at Razhephe, Chumoukedima district to 61.98 mg/L at Jail Colony, Kohima district.
- Grouping water samples based on Nitrate values, it is found that 12.07% of them have nitrate above the permissible limit of 45 mg/L.
- The map showing aerial distribution of nitrate (Figure 7) signifies that high nitrate concentrated is observed in five districts viz. Kohima, Mokokchung, Phek, Tseminyu and Wokha.
- The Table 4 provides for the number of samples analyzed per district, along with their minimum, maximum, and mean nitrate values and number of samples more than 45 mg/L based on pre-monsoon NHS 2024 Data.
- Trend analysis (Table 5, Figure 8), of six years showing no significant change except in fourteen locations in Kohima, Mokokchung, Phek, Tseminyu and Wokha district showing concentration of nitrate more than 45 mg/L. Increasing trend is due to addition of new wells from different districts.

Table 4: District wise Nitrate distribution during pre-monsoon, 2024.

Nitrate (mg/L)									
Sl. No.	District	No. of sample analysed	Permissible limit	Desirable limit	Min	Max	Mean	% of sample <=45	% of sample >45
1	Chumoukedima	11	45.00	45.00	0.05	7.00	1.73	100.00	0.00
2	Dimapur	13	45.00	45.00	0.20	10.28	3.22	100.00	0.00
3	Kohima	19	45.00	45.00	0.33	61.98	20.51	84.21	15.79
4	Mokokchung	23	45.00	45.00	0.84	56.59	13.39	86.96	13.04
5	Mon	4	45.00	45.00	2.36	10.36	6.19	100.00	0.00
6	Nuiland	8	45.00	45.00	0.09	8.44	1.70	100.00	0.00
7	Peren	9	45.00	45.00	0.54	25.31	7.68	100.00	0.00
8	Phek	12	45.00	45.00	0.20	56.33	22.75	66.67	33.33
9	Tseminyu	6	45.00	45.00	1.22	59.15	30.33	66.67	33.33
10	Wokha	6	45.00	45.00	0.50	52.47	19.36	66.67	33.33
11	Zunheboto	5	45.00	45.00	0.58	19.44	4.42	100.00	0.00
		116							

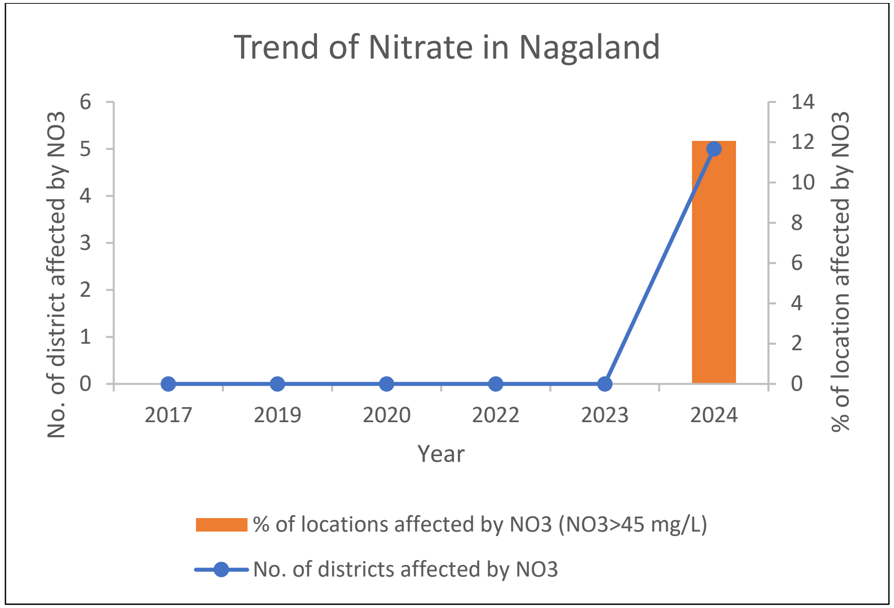

Figure 8: 6 years trend analysis graph of nitrate.

Table 5: Periodic Variation in suitability classes of nitrate in groundwater of Nagaland.

Periodic variation in suitability classes of Nitrate in groundwater of Nagaland								
Parameter	Class	percentage of samples						Periodic Variation 2017-2024
		2017	2019	2020	2022	2023	2024	
		(n=13)	(n=8)	(n=2)	(n=8)	(n=17)	(n=116)	
Nitrate as NO3	< 45 mg/L	100.00	100.00	100.00	100.00	100.00	87.93	-12.07
	>45 mg/L	0.00	0.00	0.00	0.00	0.00	12.07	12.07

5.1.3 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/acceptable 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 (upto1.0 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.

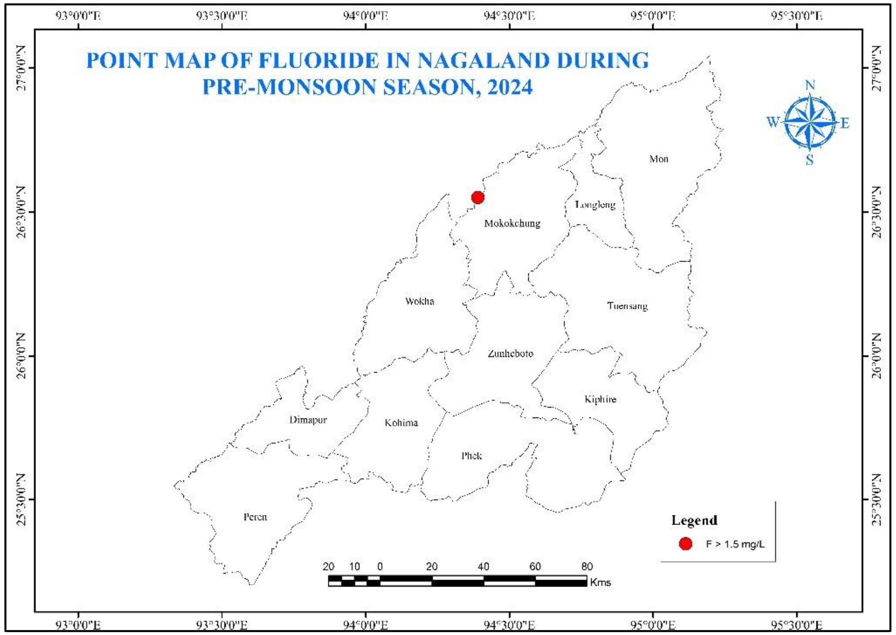

Figure 9: Map showing point location of Fluoride in Nagaland based on pre-monsoon NHS 2024 Data.

PRESENT DAY SCENARIO IN NAGALAND FLUORIDE

Distribution of Fluoride (F)

- The fluoride value of ground waters in the State varies from 0.0019 mg/L at Tseminyu village, Tseminyu district to 1.68 mg/L at Longpayimsen, Mokokchung district.
- Grouping water samples based on Fluoride values, it is found that 0.86% of them have fluoride above the permissible limit of 1.5 mg/L.
- The map showing aerial distribution of Fluoride (Figure 9) signifies that high fluoride concentrated is observed in Mokokchung district (one location).
- The Table 6 provides for the number of samples analyzed per district, along with their minimum, maximum, and mean fluoride values and number of samples more than 1.5 mg/L based on pre-monsoon NHS 2024 Data.
- Trend analysis (Table 7, Figure 10), of six years showing slight increasing trend in Fluoride content. Increasing trend is due to addition of new wells from several districts.

Table 6: District wise Fluoride distribution during pre-monsoon, 2024.

Fluoride (mg/L)									
Sl. No.	District	No. of sample analysed	Permissible limit	Desirable limit	Min	Max	Mean	% of sample <=1.50	% of sample >1.50
1	Chumoukedima	11	1.50	1.00	0.11	1.17	0.38	100.00	0.00
2	Dimapur	13	1.50	1.00	0.00	1.06	0.28	100.00	0.00
3	Kohima	19	1.50	1.00	0.07	0.38	0.05	100.00	0.00
4	Mokokchung	23	1.50	1.00	0.01	1.68	0.21	95.65	4.35
5	Mon	4	1.50	1.00	0.15	0.55	0.24	100.00	0.00
6	Nuiland	8	1.50	1.00	0.37	0.37	0.05	100.00	0.00
7	Peren	9	1.50	1.00	0.00	1.24	0.21	100.00	0.00
8	Phek	12	1.50	1.00	0.00	0.10	0.02	100.00	0.00
9	Tseminyu	6	1.50	1.00	0.00	0.00	0.00	100.00	0.00
10	Wokha	6	1.50	1.00	0.00	0.68	0.13	100.00	0.00
11	Zunheboto	5	1.50	1.00	0.00	0.00	0.00	100.00	0.00
		116							

Table 7: Periodic Variation in suitability classes of Fluoride in groundwater of Nagaland.

Periodic variation in suitability classes of Fluoride in groundwater of Nagaland								
Parameter	Class	percentage of samples						Periodic Variation 2017-2024
		2017	2019	2020	2022	2023	2024	
		(n=13)	(n=8)	(n=2)	(n=8)	(n=17)	(n=116)	
Fluoride as F	< 1.0 mg/L	100.00	100.00	100.00	100.00	100.00	96.55	-3.45
	1.0-1.50 mg/L	0.00	0.00	0.00	0.00	0.00	2.59	2.59
	>1.50 mg/L	0.00	0.00	0.00	0.00	0.00	0.86	0.86

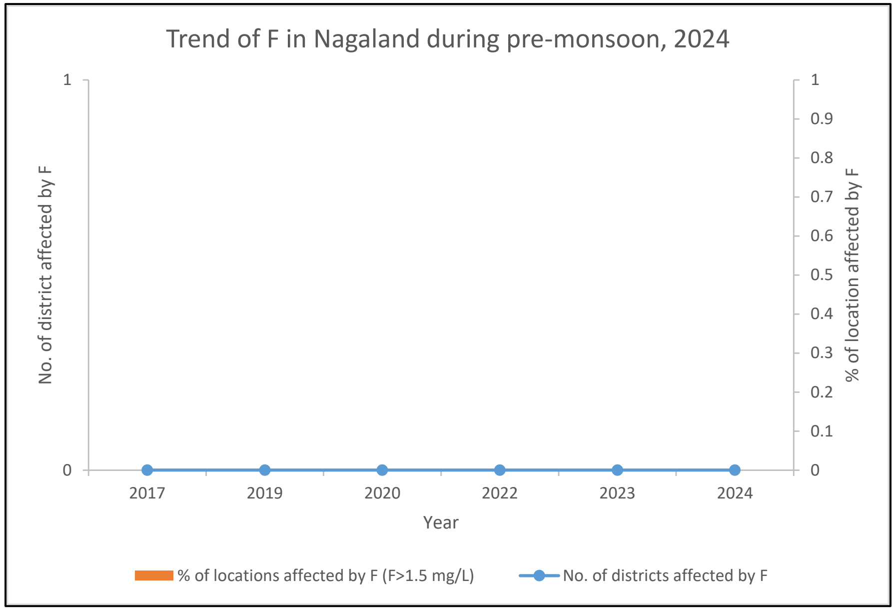

Figure 10: 6 years trend analysis graph of fluoride.

5.1.4 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/L as per the BIS Standard for drinking water.

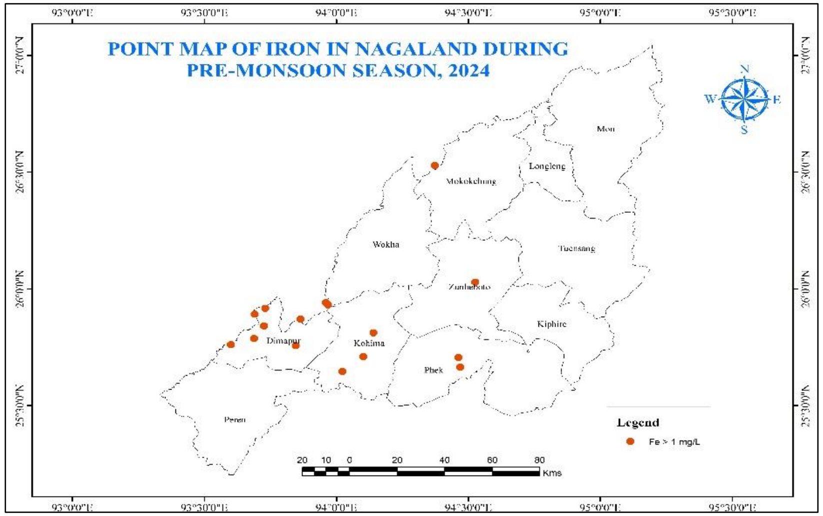

Figure 12: Map showing distribution of Iron in Nagaland based on pre-monsoon NHS 2024 Data.

PRESENT DAY SCENARIO IN NAGALAND: IRON

Distribution of Iron

- The iron value of ground waters in the State varies from 0.002 mg/L at Longtho, Mokokchung district to 7.22 mg/L at Chiechama, Kohima district.
- Grouping water samples based on Iron values, it is found that an average of 13.79% of them have iron above the permissible limit of 1.0 mg/L.
- The map showing aerial distribution of Iron (Figure 12) signifies that high iron concentrated is observed in most of the districts of Nagaland.
- The Table 8 provides for the number of samples analyzed per district, along with their minimum, maximum, and mean iron values and number of samples more than 1.0 mg/L based on pre-monsoon NHS 2024 Data.
- Trend analysis (Table 9, Figure 13), of six years showing first increasing then decreasing trend in Iron content. As more numbers of well have been added distribution was more accurately encountered and the trend shows the same.

Table 8: District wise Iron distribution during pre-monsoon, 2024.

Iron (mg/L)									
Sl. No.	District	No. of sample analysed	Permissible limit	Desirable limit	Min	Max	Mean	% of sample <=1.00	% of sample >1.00
1	Chumoukedima	11	1.00	1.00	0.02	2.76	0.56	81.82	18.18
2	Dimapur	13	1.00	1.00	0.05	4.45	1.06	69.23	30.77
3	Kohima	19	1.00	1.00	0.01	7.22	0.81	84.21	15.79
4	Mokokchung	23	1.00	1.00	0.00	6.90	0.36	95.65	4.35
5	Mon	4	1.00	1.00	0.00	0.00	0.00	100.00	0.00
6	Nuiland	8	1.00	1.00	0.03	5.46	1.54	62.50	37.50
7	Peren	9	1.00	1.00	0.07	0.59	0.23	100.00	0.00
8	Phek	12	1.00	1.00	0.04	2.05	0.47	83.33	16.67
9	Tseminyu	6	1.00	1.00	0.04	0.15	0.10	100.00	0.00
10	Wokha	6	1.00	1.00	0.02	0.18	0.08	100.00	0.00
11	Zunheboto	5	1.00	1.00	0.01	3.72	0.90	80.00	20.00
		116							

Table 9: Periodic Variation in suitability classes of iron in groundwater of Nagaland.

Periodic variation in suitability classes of Iron in groundwater of Nagaland								
Parameter	Class	percentage of samples						Periodic Variation 2017-2024
		2017 (n=13)	2019 (n=8)	2020 (n=2)	2022 (n=8)	2023 (n=17)	2024 (n=116)	
Iron as Fe	< 1.0 mg/L	100.00	100.00	0.00	75.00	82.35	86.21	-13.79
	>1.0 mg/L	0.00	0.00	100.00	25.00	17.65	13.79	13.79

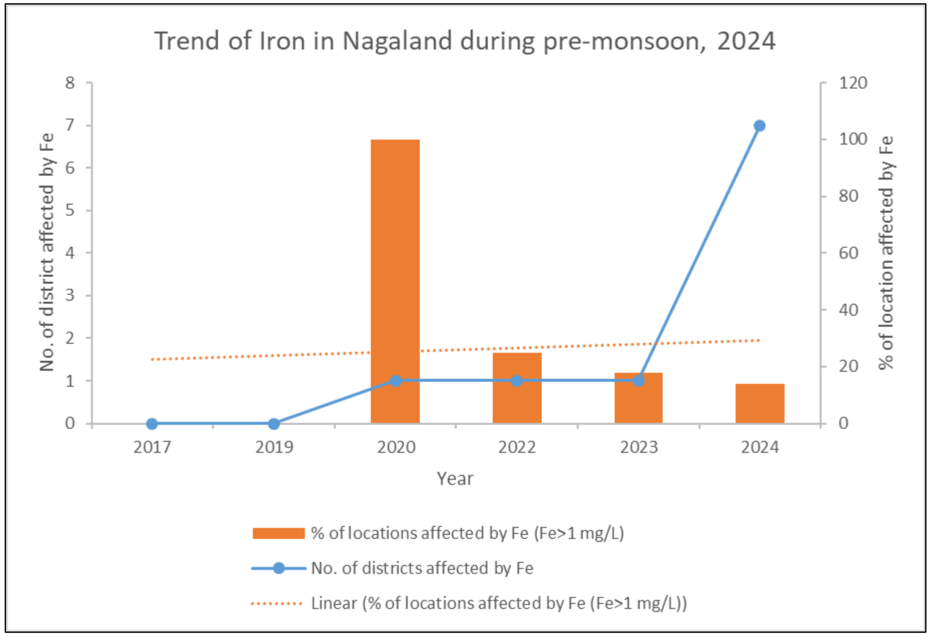

Figure 2: 6 years trend analysis graph of iron.

5.1.5 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 NAGALAND: ARSENIC

Distribution of Arsenic

- The arsenic value of ground waters in the State varies from 0.003 µg/L at Longtho, Mokokchung district to 0.0043 mg/L at Marwari Colony, Dimapur district.
- Grouping water samples based on arsenic values, it is found that none of the samples have arsenic above the permissible limit of 0.01 mg/L.
- The Table 10 provides for the number of samples analyzed per district, along with their minimum, maximum, and mean arsenic values and number of samples more than 0.01 mg/L based on pre-monsoon NHS 2024 Data.
- Trend analysis (Table 11, Figure 14), of six years showing similar trend in arsenic content since 2018.

Table 10: District wise Arsenic distribution during pre-monsoon, 2024.

Arsenic (µg/L)									
	District	No. of sample analysed	Permissible limit	Desirable limit	Min	Max	Mean	% of sample <=10	% of sample >10
1	Chumoukedima	11	10.00	10.00	0.03	1.34	0.37	100.00	0.00
2	Dimapur	13	10.00	10.00	0.06	4.27	0.71	100.00	0.00
3	Kohima	19	10.00	10.00	0.03	2.45	0.40	100.00	0.00
4	Mokokchung	23	10.00	10.00	0.00	0.56	0.11	100.00	0.00
5	Mon	4	10.00	10.00	0.00	0.00	0.00	100.00	0.00
6	Nuiland	8	10.00	10.00	0.03	3.02	1.01	100.00	0.00
7	Peren	9	10.00	10.00	0.05	0.57	0.17	100.00	0.00
8	Phek	12	10.00	10.00	0.08	3.45	0.69	100.00	0.00
9	Tseminyu	6	10.00	10.00	0.04	1.86	0.44	100.00	0.00
10	Wokha	6	10.00	10.00	0.01	0.13	0.06	100.00	0.00
11	Zunheboto	5	10.00	10.00	0.03	0.69	0.23	100.00	0.00
		116							

Table 11: Periodic Variation in suitability classes of Arsenic in groundwater of Nagaland.

Periodic variation in suitability classes of Arsenic in groundwater of Nagaland								
Parameter	Class	percentage of samples						Periodic Variation 2017-2024
		2017	2019	2020	2022	2023	2024	
		(n=13)	(n=8)	(n=2)	(n=8)	(n=17)	(n=116)	
Arsenic as As	< 0.01 mg/L	100.00	100.00	100.00	100.00	100.00	100.00	0.00
	>0.01 mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00

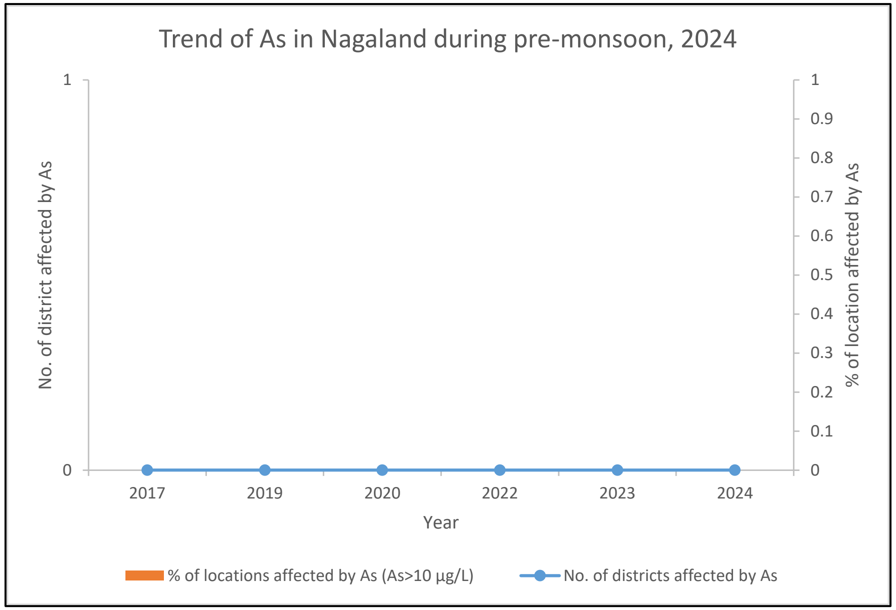

Figure 14: 7 years trend analysis graph of arsenic.

GROUND WATER QUALITY SCENARIO FOR AGRICULTURE IN NAGALAND

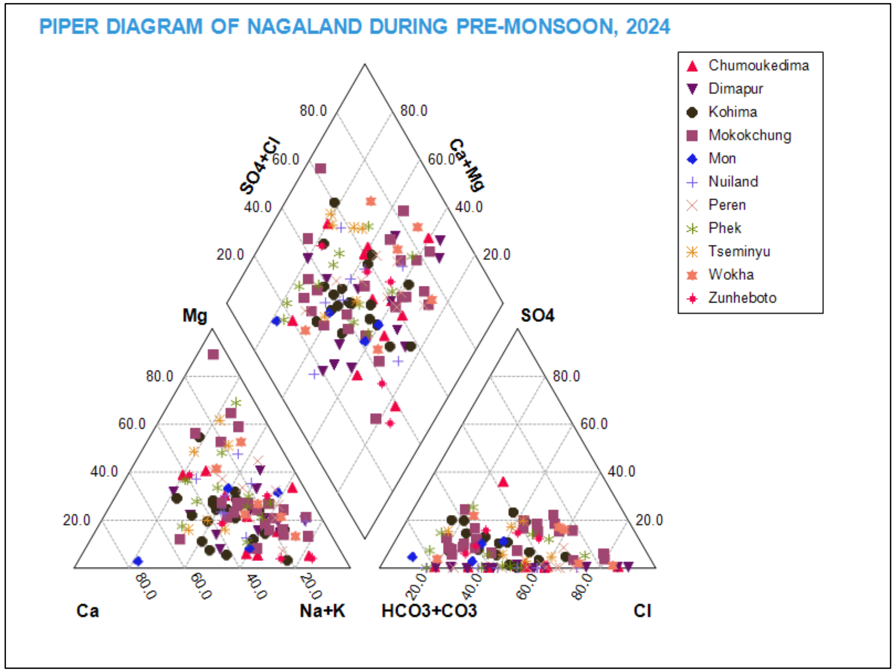

Figure 15: Piper diagram for classification of ground water in Nagaland.

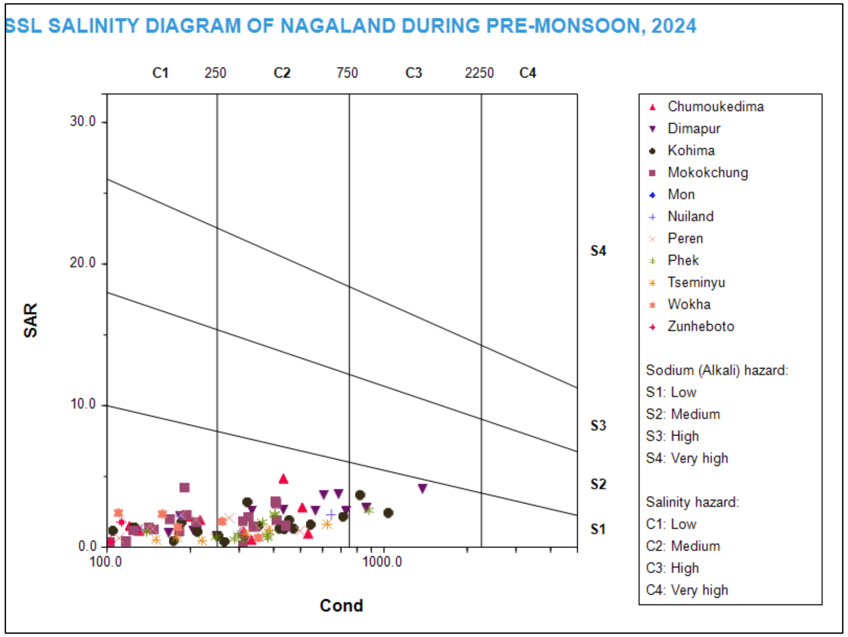

Figure 16: USSL salinity diagram for classification of ground water in Nagaland.

Table 12: Classification of ground water samples of Nagaland for irrigation purposes.

Parameters	Range	Classification	Number of samples
Salinity hazard (EC) (µS/cm)	<250	Excellent	61
	250-750	Good	50
	750-2000	Permissible	5
	2000-3000	Doubtful	0
	>3000	Unsuitable	0
Alkalinity hazard (SAR)	<10	Excellent	116
	10--18	Good	0
	18-26	Doubtful	0
	>26	Unsuitable	0
Percent Sodium (% Na)	<20	Excellent	4
	20-40	Good	38
	40-60	Permissible	47
	60-80	Doubtful	25
	>80	Unsuitable	2
Kelly's Index (KI)	<1	Suitable	72
	>1	Unsuitable	44
Residual sodium carbonate (RSC)	<1.25	Suitable	112
	1.25-2.5	Marginally suitable	4
	>2.5	Unsuitable	0
Soluble Sodium Percentage (SSP)	<50	Suitable	72
	>50	Unsuitable	44

DISTRICT WISE CONTAMINANT WISE STATUS SUMMARY BASED ON NHS 2024 DATA

As per the RSC value-based classification of irrigation water given by Lloyd and Heathcote, 96.55% samples are suitable for irrigation and 3.45% samples are marginally suitable for irrigation.

Table 13: Summary of Groundwater Quality in Various Districts of Nagaland, Highlighting Basic Parameters (Electrical Conductivity, Nitrate, Fluoride) and Heavy Metals (Iron, Arsenic, Uranium)

Summary of GW quality (Pre-monsoon 2023)								
District	Total no. of Basic samples	EC	NO3	F	Total no. of HM Samples	Fe	As	U
		(µs/cm) 25°C	mg/l	mg/l		ppm	ppb	ppb
Chumoukedima	11	0 (0%)	0 (0%)	0 (0%)	11	2 (18.2%)	0 (0%)	0 (0%)
Dimapur	13	0 (0%)	0 (0%)	0 (0%)	13	4 (30.8%)	0 (0%)	0 (0%)
Kohima	19	0 (0%)	3 (15.79%)	0 (0%)	19	3 (15.8%)	0 (0%)	0 (0%)
Mokokchung	23	0 (0%)	3 (13.04%)	1 (4.35%)	23	1 (4.35%)	0 (0%)	0 (0%)
Mon	4	0 (0%)	0 (0%)	0 (0%)	4	0 (0%)	0 (0%)	0 (0%)
Nuiland	8	0 (0%)	0 (0%)	0 (0%)	8	3 (37.5%)	0 (0%)	0 (0%)
Peren	9	0 (0%)	0 (0%)	0 (0%)	9	0 (0%)	0 (0%)	0 (0%)
Phek	12	0 (0%)	4 (33.33%)	0 (0%)	12	2 (16.7%)	0 (0%)	0 (0%)
Tseminyu	6	0 (0%)	2 (33.33%)	0 (0%)	6	0 (0%)	0 (0%)	0 (0%)
Wokha	6	0 (0%)	2 (33.33%)	0 (0%)	6	0 (0%)	0 (0%)	0 (0%)
Zunheboto	5	0 (0%)	0 (0%)	0 (0%)	5	1 (20%)	0 (0%)	0 (0%)
Total	116	0 (0%)	14 (12.07%)	1 (0.86%)	116	16 (13.8%)	0 (0%)	0 (0%)

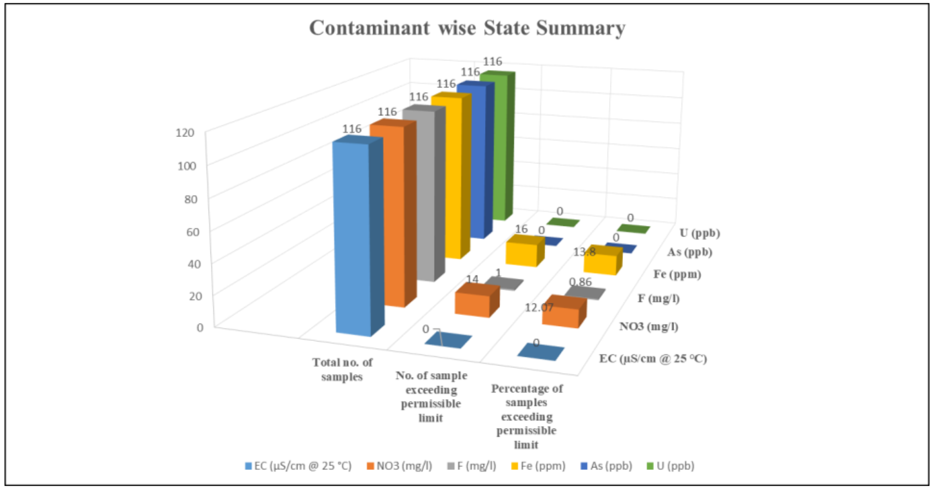

Figure 17: Graph showing contaminant wise state summary.

The groundwater quality assessment in Nagaland revealed no significant change in levels of contamination across various parameters. Iron (Fe) emerged as the predominant contaminant, with average 13.8% of samples crossing the permissible limits of 1.0 mg/L, followed by nitrate (12.07%). Occurrences of fluoride and arsenic exceeding permissible limits have not been observed in most location of the districts. The concentration of heavy metals viz. Uranium, Cadmium, Chromium, Zinc, Copper, Mercury, Selenium etc. are found out to be within the permissible limit of BIS.

DISTRICT WISE ASSESSMENT OF GW USING WATER QUALITY INDEX (WQI)

Water Quality Index (WQI) is being calculated for all the samples collected during pre-monsoon. The samples were classified accordingly as shown below:

Classification range of WQI	Water quality status	No. of samples	% of samples	Classification based on
<50	Excellent	102	87.93	Yenugu et al. 2020
50-100	Good	14	12.07	
101-200	Poor	0	0.00	
201-300	Very poor	0	0.00	
>300	Unsuitable for drinking	0	0.00	

Figure 18: Classification of sample based on WQI.

The WQI of the samples are mostly classified as excellent and good. Almost 87.93% samples are excellent and 12.07% samples are good.

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