GROUNDWATER CHEMICAL QUALITY BULLETIN

PUNJAB (PRE MONSOON-2024)

ABSTRACT

Pre-monsoon ground water quality assessment (2024) highlights the findings and groundwater contamination status.

CGWB, NWR, CHANDIGARH

1.0INTRODUCTION

Ground water is an important resource widely used for drinking, irrigation and industrial purpose. Ground Water plays an important role in the sustainable socio-economic development. In regions with scarcity of fresh surface water sources dependence on ground water increases exponentially. Punjab exemplifies such a region, where groundwater resources, as of 2023, constitute a modest 2% of the total. They fulfill substantial proportions of irrigation and drinking water needs. However, heightened reliance on groundwater across various sectors has resulted in declining water quality and dwindling water levels. The ground water quality is dependent upon chemical characteristic of rocks and minerals composition of aquifer material. Due to redox reaction, ions can be dissolved from minerals by dissolution and crystallization within aquifer and concentrate beyond permissible limits. Poor ground water quality can also be due to excessive use of fertilizers, urbanization and industrial effluent discharge. According to UNESCO more than 80% of health issues are caused due to consumption of poor-quality water. Inorganic contaminants including Salinity, Fluoride, Nitrate, Arsenic, Iron and Uranium are important in determining the suitability of ground water for drinking purposes.

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

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

1. To present current GW 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.

2.0STUDYAREA

Punjab State, spanning North latitudes 290 32’ and 32o31’ and East longitudes 73o50’ and 76o55, covers 50,362 sq. km, comprising 1.57% of India's total area. Predominantly characterized by alluvial deposits, it hosts older and newer types rich in clay, silt, and sand, with piedmont deposits and sand dunes in specific regions. While alluvial plains dominate and the Siwalik Tertiary system lies in the north-eastern part of the state. As per 2023 Groundwater resource assessment, Total Annual Ground Water Recharge of the State has been assessed as 18.84 bcm and Annual Extractable Ground Water Resource is 16.98 bcm. The Total Current Annual Ground Water extraction is 27.80 bcm and Stage of Ground Water extraction is 163.76 %.

Physiographically , State forms a part of vast Indo-Gangetic alluvial which can be divided into three parts: Ravi sub basin, Beas Sub basin, Satluj sub basin and , Ghaggar sub basin (Figure 1).Based on Exploratory drilling by CGWB down to approximately 300m, a fence diagram depicting Punjab State illustrates the boundary between fresh and saline groundwater (Figure 2). The northern-eastern, central region predominantly contains fresh groundwater, whereas the south-west parts exhibit thin fresh water layer underlain by saline water.

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

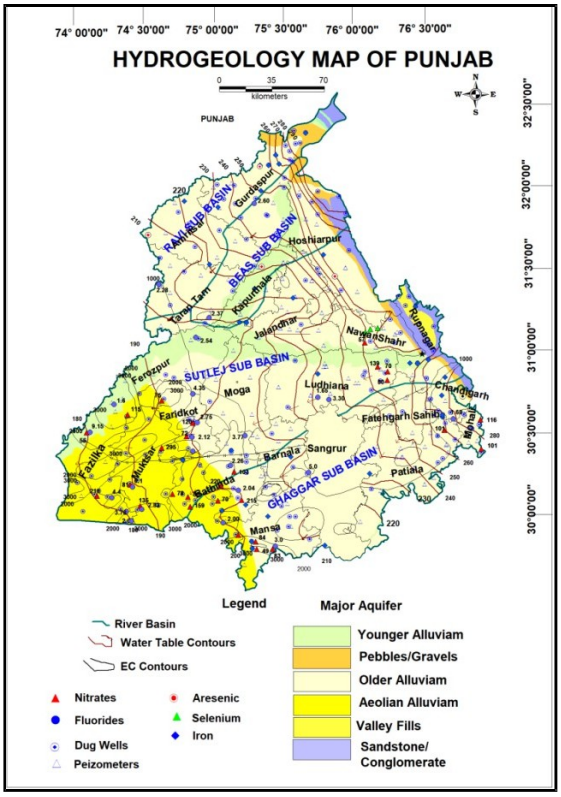
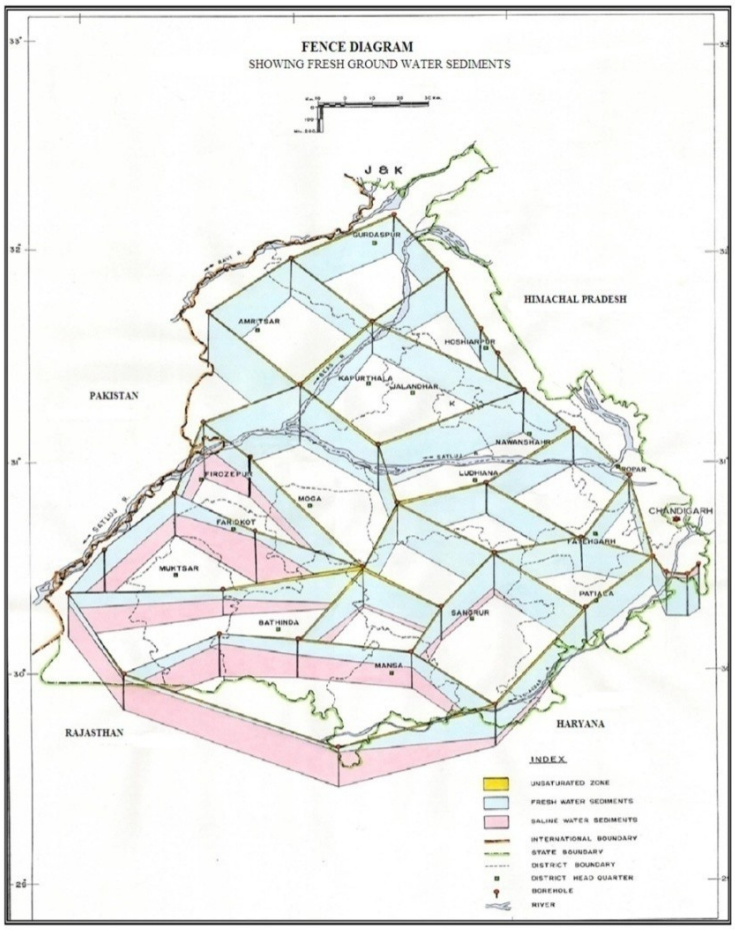


Figure-2: Map showing Fresh Saline Interface of Punjab



3.0 GROUNDWATER QUALITY MONITORING

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

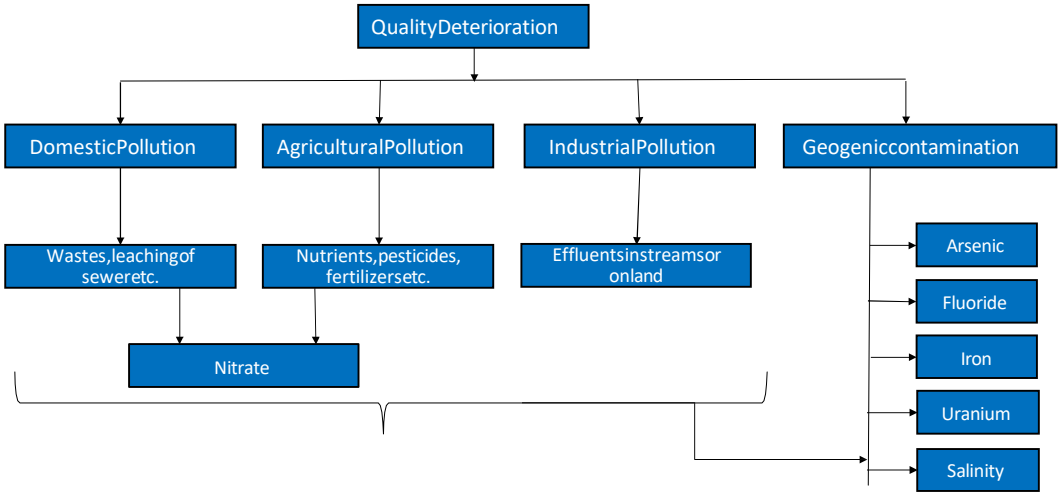


Figure-3: Schematic diagram illustrating the potential factors contributing to the degradation of ground water quality

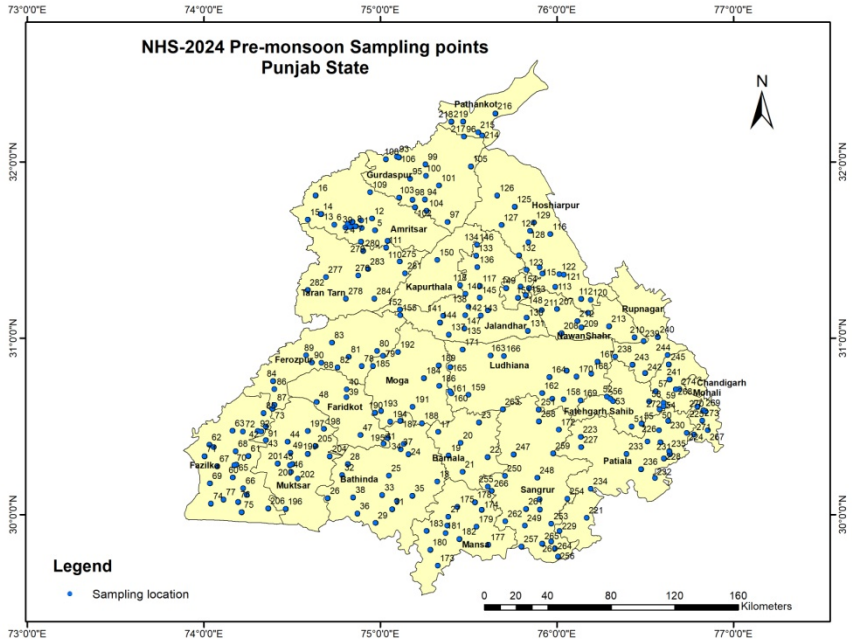


Figure-4: Map showing Spatial Distribution of Groundwater Quality Monitoring Stations-Basic in Punjab based on 2024 NHS

The chemical quality of shallow ground water of Punjab state is being monitored by Central Ground Water Board, NWR, Chandigarh twice in a year (Pre-monsoon and Post-monsoon) since 2023. The ground water samples were collected from 284 trend stations during pre monsoon for basic parameters and from 379 trend stations for Heavy Metals in 2024 (Figure 4 & 4A). The district-wise distribution of water Quality Monitoring Stations of CGWB are given in Table 1. The present bulletin is based on the water quality in net work stations of CGWB in year 2024 (Pre monsoon).

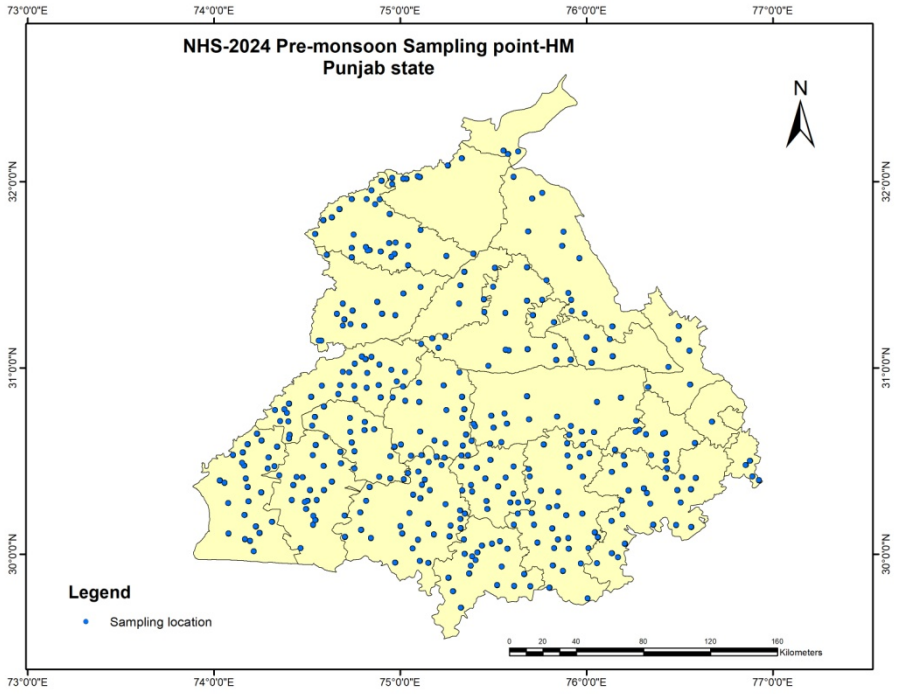


Figure- 4 A: Map showing Spatial Distribution of Groundwater Quality Monitoring Stations-HM in Punjab based on 2024 NHS Pre monsoon

Table1: District wise distribution of water Quality Monitoring Stations in Punjab

Sl. No.	District	No. of Water Quality Stations for Basic	Sl. No.	District	No. of Water Quality Stations for Heavy Metals
1	Amritsar	16	1	Amritsar	25
2	Barnala	7	2	Barnala	18
3	Bhathinda	15	3	Bhathinda	32
4	Faridkot	11	4	Faridkot	21
5	Fatehgarh Sahib	10	5	Fatehgarh Sahib	11
6	Fazilka	18	6	Fazilka	26
7	Ferozepur	15	7	Ferozepur	27
8	Gurdaspur	19	8	Gurdaspur	11
9	Hoshiarpur	18	9	Hoshiarpur	14
10	Jalandhar	18	10	Jalandhar	13
11	Kapurthala	8	11	Kapurthala	10
12	Ludhiana	17	12	Ludhiana	17
13	Mansa	11	13	Mansa	20
14	Moga	12	14	Moga	25
15	Muktsar	11	15	Muktsar	18
16	Nawanshahr	7	16	Nawanshahr	6
17	Pathankot	6	17	Pathankot	3
18	Patiala	18	18	Patiala	22
19	Rupnagar	8	19	Rupnagar	5
20	Sangrur	21	20	Sangrur	36
21	SAS Nagar	8	21	SAS Nagar	5
22	Tarantaran	10	22	Tarantaran	14
	Total	**284**		Total	**379**

4.0GROUNDWATER 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. However, occurrence of high concentrations of some water quality parameters such as Salinity (EC), Fluoride, Nitrate, and Uranium and the changes in water quality based on these parameters have been observed in the various parts of Punjab.

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 groundwater in unconfined aquifers.

1. Electrical Conductivity (>3000µS/cm)
2. Fluoride(>1.5mg/liter)
3. Nitrate(>45mg/liter)
4. Iron(>1.0mg/liter)
5. Arsenic(>0.01mg/liter)
6. Uranium(>30ppb)

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.

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 limit of 500mg/I (corresponding to EC of about 750 µS/cm at 25^0C) that can be extended toa TDS of 2000 mg/L

corresponding to EC of about 3000 µS/cm at 25^0C) in case of no alternate source. Water having TDS more than 2000 mg/L are not fit for drinking purpose.

Present Day Scenario in Punjab w.r.t Electrical Conductivity (EC)

Distribution of Electrical Conductivity (EC)

The EC value of ground waters in the State varies from 273 at Fatta Maluka, Sardulgarh block of Mansa district to 9945 µS/cm at Abohar, Abohar block of Fazilka district at 25°C. Grouping water samples based on EC values, it is found that 27.1 % of them have EC less than 750 µS/cm, 62 % have between 750 and 3000µS/cm and the remaining 10.9 % 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 patches but in high proportion is in northern parts of the State.

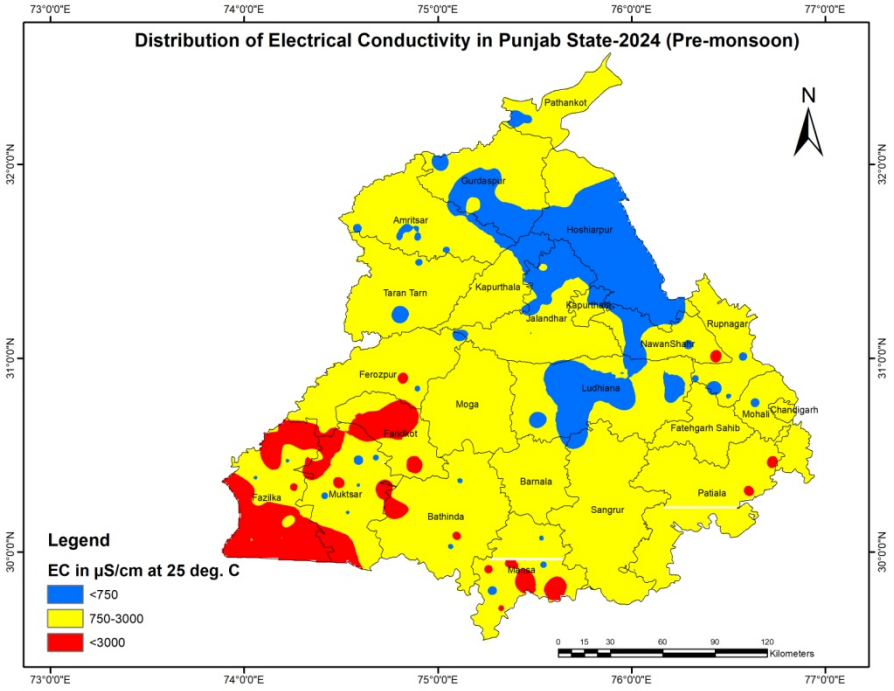


Figure 5: Map showing distribution of Electrical Conductivity in Punjab based on NHS 2024 Data

The ground water occurring in the southwestern part comprising of parts of Fazilka, Muktsar, Bhatinda, Mansa, Faridkot and Ferozpur, districts are mostly saline and is 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 Quartile 1, Quartile 2, Quartile 3 EC values based on NHS 2024 Data.

Table 2: District wise distribution of EC in shallow GW of Punjab

EC										
Sl. No.	**District**	**No. of Samples Analysed**	**Permissible Limit(µS/cm)**	**Desirable limit (µS/cm)**	**Q1**	**Q2**	**Q3**	**No. of Samples (%)**		
			EC					<750	750-3000	>3000
1	Amritsar	16	3000		591	858	1522	50	50	0
2	Barnala	7	3000		1191	1414	1615	0	100	0
3	Bhathinda	15	3000		1007	2024	2734	13.33	73.33	13.33
4	Faridkot	11	3000		2363	3657	4300	0	36	64
5	Fatehgarh Sahib	10	3000		865	1083	1381	10	90	0
6	Fazilka	18	3000		1818	2913	5543	11.11	44.44	44.44
7	Ferozepur	15	3000		887	1225	1922	20	67	13
8	Gurdaspur	19	3000		513	785	1376	47	53	0
9	Hoshiarpur	18	3000		518	571	720	83	17	0
10	Jalandhar	18	3000		660	798	945	33	67	0
11	Kapurthala	8	3000		599	949	1037	37.50	62.50	0
12	Ludhiana	17	3000		567	904	1043	35	65	0
13	Mansa	11	3000		663	2029	4048	27.27	27.27	45.45
14	Moga	12	3000		1191	1419	1501	0	100	0
15	Muktsar	11	3000		586	1016	4131	45.45	18.18	36.36
16	Nawanshahr	7	3000		563	936	1043	43	43	14
17	Pathankot	6	3000		624	878	1415	33	67	0
18	Patiala	18	3000		1065	1525	2462	5.56	83.33	11.11
19	Rupnagar	8	3000		573	716	1072	62.50	37.50	0
20	Sangrur	21	3000		1053	1285	2099	5	95	0
21	SASNagar	8	3000		962	1373	1413	0	100	0
22	Tarantaran	10	3000		750	1192	1426	20	80	0
		284								

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

Present Day Scenario in Punjab w.r.t NITRATE (NO_3)

Distribution of Nitrate (NO_3)

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 440mg/L.BIS permits a maximum concentration of 45mg/L nitrate in drinking water. Considering this limit, it is found that 73.2 % of the samples, spread over the entire State, have nitrate below 45 and 26.8 % have more than 45 mg/L. Spatial distribution of nitrate (Figure 6) indicates a considerable area of the southern and south western part of state have nitrate concentration exceeding 45 mg/L.

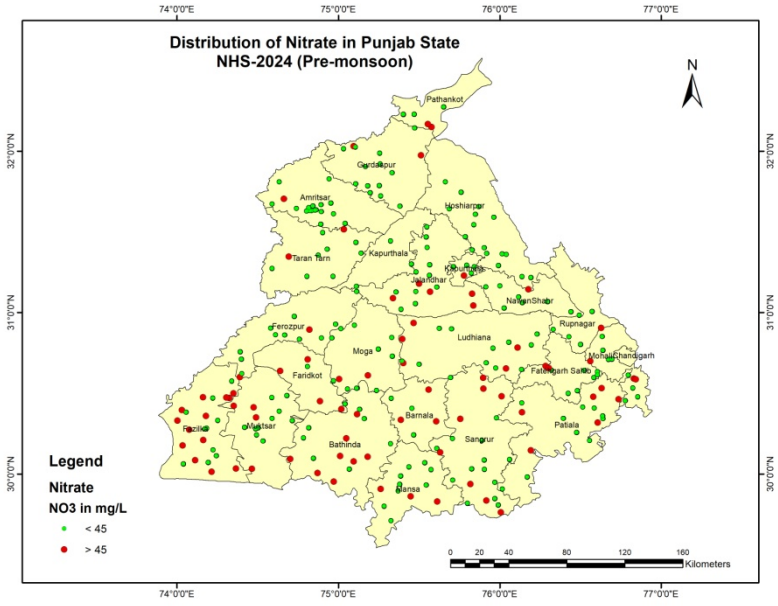


Figure 6: Map showing distribution of Nitrate in Punjab based on NHS 2024 Data

Table-3: District wise distribution of Nitrate in shallow GW of Punjab

Nitrate									
Sl. No.	**District**	**No. of Samples Analysed**	**Permissible Limit(mg/L)**	**Desirable limit (mg/L)**	**Q1**	**Q3**	**Q2**	**No. of Samples (%)**	
								<45	>45
1	Amritsar	16	45		0.0	0.35	7.91	94	6
2	Barnala	7	45		17	21	55	100	0
3	Bhathinda	15	45		26	52	170	47	53
4	Faridkot	11	45		44	84	110	27	73
5	Fatehgarh Sahib	10	45		6.4	18	72	70	30
6	Fazilka	18	45		24	49	130	44	56
7	Ferozepur	15	45		10	10	41	80	20
8	Gurdaspur	19	45		16	16	40	79	21
9	Hoshiarpur	18	45		2.2	2.2	11	94	6
10	Jalandhar	18	45		20	20	70	72	28
11	Kapurthala	8	45		0.0	0.0	19	88	13
12	Ludhiana	17	45		17	30	77	64.7	35.3
13	Mansa	11	45		3.9	11	61	73	27
14	Moga	12	45		16	27	40	83	17
15	Muktsar	11	45		2	15	44	82	18
16	Nawanshahr	7	45		0.00	17	38	100	0
17	Pathankot	6	45		0.00	7.8	84	67	33
18	Patiala	18	45		1.25	20	68	67	33
19	Rupnagar	8	45		0.78	8.75	29	88	13
20	Sangrur	21	45		19	35	86	67	33
21	SASNagar	8	45		1.6	10	46	75	25
22	Tarantaran	10	45		4.1	12	20	90	10
		284							

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 1.5mg/lin 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 (>5.0mg/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 Punjab 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 0.20 to 10.40 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 72.5 % samples have fluoride in desirable range, 11.7 % in the permissible and the remaining 15.8 % have fluoride above 1.50 mg/L. Map showing spatial distribution (Figure 7) of fluoride contents in ground water indicates that ground waters with fluoride above 1.50 mg/L are found mainly in Fazilka, Muktsar, Firozpur, Faridkot, Bathinda and Mansa SAS Nagar districts of the State. It is worth mentioning that high fluoride waters are encountered in areas where high salinity is encountered.

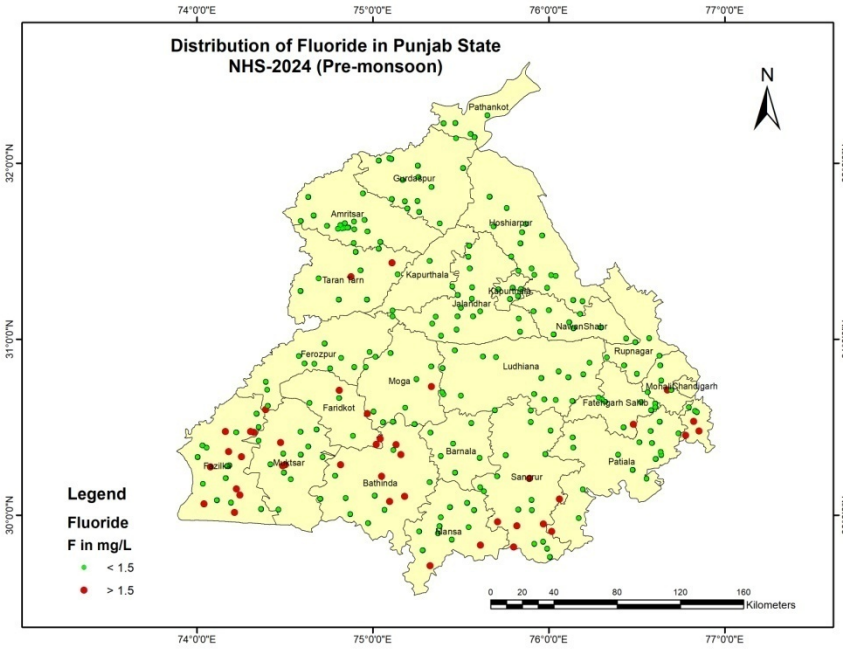


Figure 7: Map showing distribution of Fluoride in Punjab based on NHS 2024 Data

Table 4: District wise distribution of Fluoride in shallow GW of Punjab

Fluoride									
Sl. No.	**District**	**No. of Samples analysed**	**Permissible Limit (mg/L)**	**Desirable limit (mg/L)**	**Q1**	**Q3**	**Q2**	**No. of Samples (%)**	
								<1.50	**>1.50**
1	Amritsar	16	1.50	1.00	0.30	0.41	0.45	100	0
2	Barnala	7	1.50	1.00	0.50	0.50	0.63	100	0
3	Bhathinda	15	1.50	1.00	0.86	1.10	1.90	40	60
4	Faridkot	11	1.50	1.00	1.00	1.10	2.10	55	45
5	FatehgarhSahib	10	1.50	1.00	0.66	0.78	1.04	90	10
6	Fazilka	18	1.50	1.00	0.82	1.20	1.93	56	44
7	Firozepur	15	1.50	1.00	0.56	0.72	0.98	93	7
8	Gurdaspur	19	1.50	1.00	0.30	0.36	0.44	100	0

9	Hoshiarpur	18	1.50	1.00	0.44	0.61	0.71	100	0
10	Jalandhar	18	1.50	1.00	0.24	0.32	0.47	100	0
11	Kapurthala	8	1.50	1.00	0.60	0.72	0.76	100	0
12	Ludhiana	17	1.50	1.00	0.54	0.62	0.76	100	0
13	Mansa	11	1.50	1.00	0.58	0.72	1.50	82	18
14	Moga	12	1.50	1.00	0.41	0.61	1.43	75	25
15	Muktsar	11	1.50	1.00	0.32	0.54	1.20	82	18
16	Nawanshahr	7	1.50	1.00	0.56	0.64	0.74	100	0
17	Pathankot	6	1.50	1.00	0.39	0.51	0.69	100	0
18	Patiala	18	1.50	1.00	0.49	0.86	1.24	89	11
19	Rupnagar	8	1.50	1.00	0.52	0.62	0.75	100	0
20	Sangrur	21	1.50	1.00	0.63	1.01	1.80	71	29
21	SASNagar	8	1.50	1.00	0.74	1.40	4.10	50	50
22	Tarantaran	10	1.50	1.00	0.85	1.07	1.28	80	20
		284							

5.1. Arsenic

5.HEAVYMETAL

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 Punjab w.r.t ARSENIC

Distribution of Arsenic (As)

The arsenic content in ground water ranges from 0.0000 to 0.0677 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 7.38% samples have arsenic above 0.01 mg/L. Map showing spatial distribution (Figure 8) of arsenic content in ground water (2024) indicates that ground waters with arsenic above 0.01 mg/L are found mainly in Taran Taran, Amritsar and Gurdaspur districts of the State.

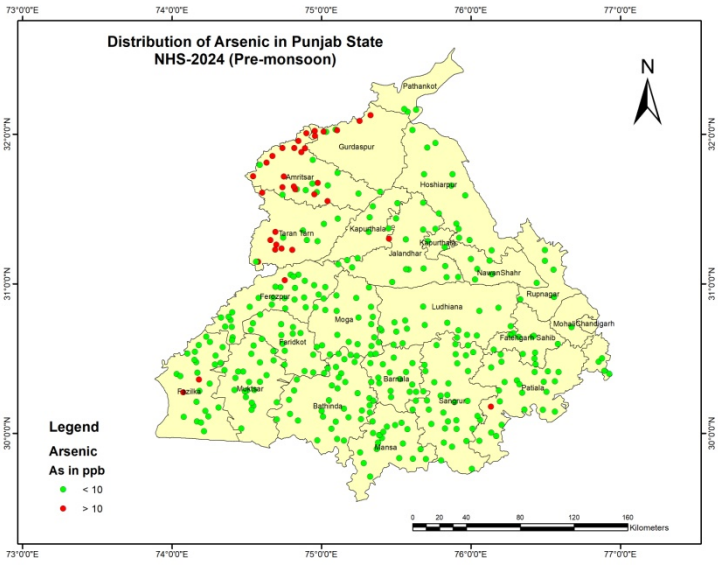


Figure 8: Map showing distribution of Arsenic in Punjab based on NHS 2024 Data

The Table 5 given below provides for the number of samples analyzed per district, along with their Quartile 1, Quartile 2, Quartile 3 Arsenic values based on NHS 2024 Data.

Table 5: District wise distribution of Arsenic in shallow GW of Punjab

Arsenic									
Sl. No.	District	No. of Samples Analysed	Permissible Limit(ppb)	Desirable limit (ppb)	Q1	Q3	Q2	No.ofSamples (%)	
								<10ppb	>10ppb
1	Amritsar	25	10		5.2212	17.5823	30.2527	64	36
2	Barnala	18	10		0.8543	0.9682	1.1831	100	0
3	Bhathinda	32	10		0.5280	0.9865	1.5768	100	0
4	Faridkot	21	10		0.5415	0.7392	1.8869	100	0
5	Fatehgarh Sahib	11	10		0.6800	0.7530	0.9230	100	0
6	Fazilka	26	10		0.3351	0.6491	2.0863	92	8
7	Firozepur	27	10		0.8031	1.3214	2.8503	96	4
8	Gurdaspur	11	10		0.6897	12.5069	32.4007	36	64
9	Hoshiarpur	14	10		0.4850	0.6670	2.4400	93	7
10	Jalandhar	13	10		0.5166	0.6918	1.6501	100	0
11	Kapurthala	10	10		0.7331	1.0274	1.7356	100	0
12	Ludhiana	17	10		0.6438	0.8857	1.1284	100	0
13	Mansa	20	10		1.0953	1.5171	2.2446	100	0
14	Moga	25	10		0.8128	1.0906	1.4042	100	0
15	Muktsar	18	10		0.7062	1.3753	2.4073	100	0
16	Nawanshahr	6	10		0.1460	0.3970	0.6030	100	0
17	Pathankot	3	10		0.0898	0.2240	0.5663	100	0
18	Patiala	22	10		0.4047	0.5061	0.7859	95	5
19	Rupnagar	5	10		0.4760	0.9460	1.7690	100	0
20	Sangrur	36	10		0.5235	0.6809	0.8262	100	0
21	SASNagar	5	10		0.3870	1.4160	2.1130	100	0
22	Tarantaran	14	10		1.4337	8.1549	24.6953	50	50
		379							

5.2 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 groundwater 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 groundwater is less than 1.0 mg/litre as per the BIS Standard for drinking water.

Present Day Scenario in Punjab w.r.t IRON

Distribution of Iron (Fe)

The iron content in ground water ranges from BDL to 5.1097 mg/L. BIS recommends that iron concentration upto 1.0mg/L in drinking water is acceptable. Classification of samples based on this recommendation; it is found that 3.43% samples have iron above 1.0mg/L. Map showing

spatial distribution (Figure 9) of iron content in ground water (2024) indicates that ground waters with iron above 1.50 mg/L are found mainly in Amritsar, Firozpur, Gurdaspur, Rupnagar and SAS Nagar districts of the State.

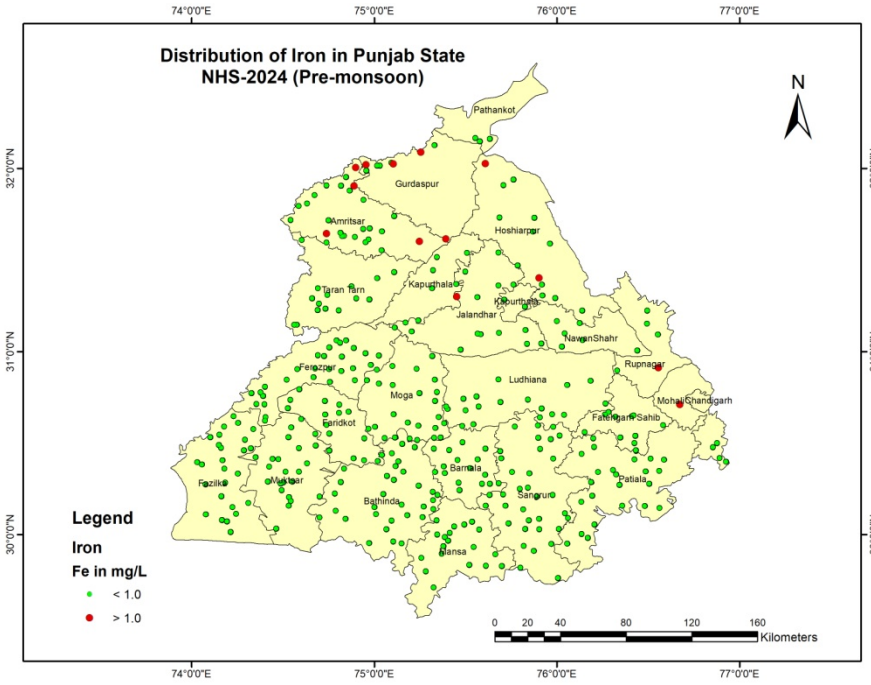


Figure 9: Map showing distribution of Ion in Punjab based on NHS 2024 Data

The Table 6 given below provides for the number of samples analyzed per district,alongwith their Quartile 1, Quartile 2, Quartile 3 Iron values based on NHS 2024 Data.

Table 6: District wise distribution of Iron (Fe) in shallow GW of Punjab

Iron(Fe)									
Sl. No.	District	No. of Samples Analysed	Permissible Limit(ppm)	Desirable limit (ppm)	Q1	Q3	Q2	No. ofSamples (%)	
								<1.00ppm	>1.00ppm
1	Amritsar	25	1.00		0.0000	0.0382	0.3746	84	16
2	Barnala	18	1.00		0.0018	0.0042	0.0102	100	0

3	Bhathinda	32	1.00		0.0018	0.0091	0.0364	100	0
4	Faridkot	21	1.00		0.0050	0.0105	0.0314	100	0
5	FatehgarhSahib	11	1.00		0.0160	0.0190	0.0310	100	0
6	Fazilka	26	1.00		0.0027	0.0114	0.0414	100	0
7	Firozepur	27	1.00		0.0079	0.0142	0.0336	100	0
8	Gurdaspur	11	1.00		0.0133	0.0875	3.7331	64	36
9	Hoshiarpur	14	1.00		0.0200	0.0260	0.3620	79	21
10	Jalandhar	13	1.00		0.0000	0.0000	0.0060	100	0
11	Kapurthala	10	1.00		0.0000	0.0000	0.0115	100	0
12	Ludhiana	17	1.00		0.0092	0.0189	0.0268	100	0
13	Mansa	20	1.00		0.0011	0.0155	0.0852	100	0
14	Moga	25	1.00		0.0077	0.0148	0.0291	100	0
15	Muktsar	18	1.00		0.0133	0.0307	0.0617	100	0
16	Nawanshahr	6	1.00		0.0060	0.0160	0.0770	100	0
17	Pathankot	3	1.00		0.0000	0.0000	0.3688	100	0
18	Patiala	22	1.00		0.0077	0.0106	0.0183	100	0
19	Rupnagar	5	1.00		0.0120	0.0170	1.5830	80	20
20	Sangrur	36	1.00		0.0042	0.0060	0.0112	100	0
21	SASNagar	5	1.00		0.0330	0.0760	1.3890	80	20
22	Tarantaran	14	1.00		0.0000	0.0000	0.0176	100	0
		379							

5.3 Uranium

Uranium occurs naturally in groundwater and surface water. Being naturally occurring uranium in groundwater and surface water poses 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.

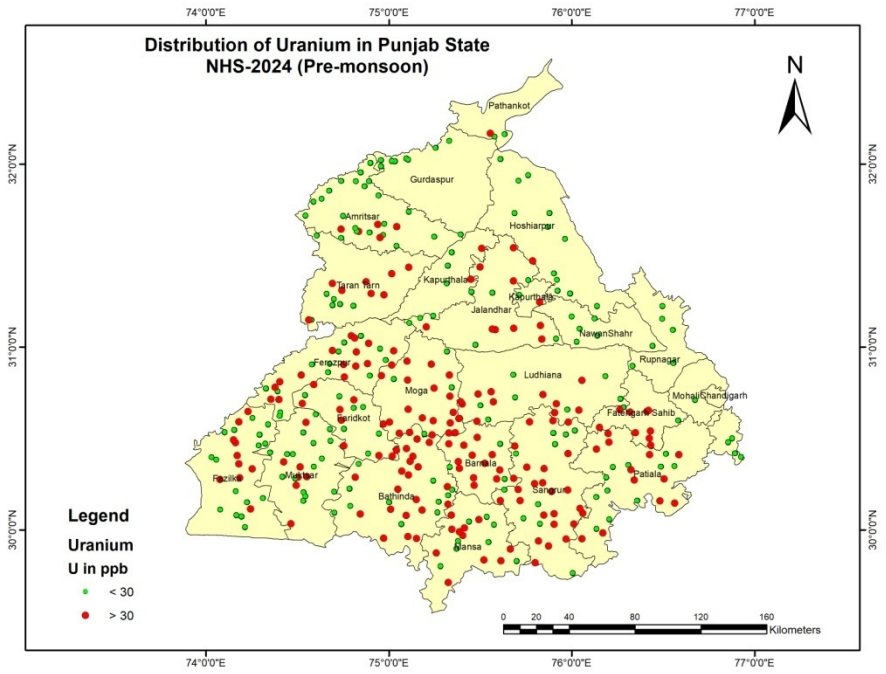


Figure 10: Map showing distribution of Uranium in Punjab based on NHS 2024 Data

Present Day Scenario in Punjab w.r.t URANIUM

Distribution of Uranium (U)

The uranium content in ground water ranges from BDL to 0.205 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 50.13% samples have uranium above 0.03 mg/L. Map showing spatial distribution of uranium content in ground water (2023) indicates that ground waters with Uranium above 0.03 mg/L are found mainly in Fazilka, Firozpur, Faridkot, Muktsar, Barnala, Bhatinda, Mansa, Moga, Patiala, Sangrur districts of the State.

The Table 7given below provides for the number of samples analyzed per district, along with their Quartile 1, Quartile 2, Quartile 3 Uranium values based on NHS 2024 Data.

Table 7: District wise distribution of Uranium in shallow GW of Punjab

Uranium									
Sl. No.	District	No. of Samples Analysed	Permissible Limit(ppb)	Desirable limit (ppb)	Q1	Q3	Q2	No.ofSamples (%)	
								<30ppb	>30ppb
1	Amritsar	25	30		1.9124	10.3735	24.0498	80	20
2	Barnala	18	30		31.9368	35.4952	44.7842	11	89
3	Bhathinda	32	30		13.5459	36.7635	76.8023	38	63
4	Faridkot	21	30		17.9657	31.8023	41.5678	48	52
5	Fatehgarh Sahib	11	30		31.3670	38.7420	40.6590	18	82
6	Fazilka	26	30		12.3537	17.8086	38.6397	62	38
7	Firozepur	27	30		16.2075	33.0784	44.0040	44	56
8	Gurdaspur	11	30		0.0000	0.8144	2.2515	100	0
9	Hoshiarpur	14	30		3.3240	7.9210	15.0940	100	0
10	Jalandhar	13	30		20.7654	33.6599	43.0299	31	69
11	Kapurthala	10	30		13.3617	28.4346	36.6073	60	40
12	Ludhiana	17	30		27.2382	35.5519	44.4188	41	59
13	Mansa	20	30		13.1345	28.8668	39.7447	50	50
14	Moga	25	30		31.9448	38.5770	48.7468	16	84
15	Muktsar	18	30		2.6065	9.6388	36.2605	72	28
16	Nawanshahr	6	30		9.6260	11.2780	17.4500	100	0
17	Pathankot	3	30		5.2573	19.1271	49.7118	67	33
18	Patiala	22	30		27.1734	31.5297	35.9493	45	55
19	Rupnagar	5	30		1.2240	3.8840	9.1060	100	0
20	Sangrur	36	30		28.4379	34.1793	46.4088	33	67
21	SASNagar	5	30		3.2560	4.6210	18.7200	100	0
22	Tarantaran	14	30		7.4059	40.9270	66.9554	43	57
		379							

District wise Contaminant wise Status Summary based on NHS 2024 Pre- Monsoon Data

6.SUMMARY

The Table 8 provides a detailed summary of groundwater quality across various districts in Punjab, focusing on basic parameters (electrical conductivity, nitrate, fluoride) and heavy metals (iron, arsenic, uranium).

Table 8: Summary of Groundwater Quality in various Districts of Punjab, highlighting Basic Parameters (Electrical Conductivity, Nitrate, Fluoride) and Heavy Metals (Iron, Arsenic, Uranium)-2024

Sl. No.	District	Total No. of Basic Samples	EC	NO_3	F	Total No. of Heavy Metals Samples	Fe	As	U
			µS/cm at 25ºC	mg/L	mg/L		ppm	ppb	ppb
1	Amritsar	16	0 (0%)	1(6%)	0(0%)	25	4(16%)	9(36%)	5(20%)
2	Barnala	7	0 (0%)	0(0%)	0(0%)	18	0(0%)	0(0%)	16(89%)
3	Bhathinda	15	2 (13.33%)	8(53%)	9(60%)	32	0(0%)	0(0%)	20(63%)
4	Faridkot	11	7 (64%)	8(73%)	5(45%)	21	0(0%)	0(0%)	11(52%)
5	Fatehgarh Sahib	10	0 (0%)	3(30%)	1(10%)	11	0(0%)	0(0%)	9(82%)
6	Fazilka	18	8 (44.44%)	10(56%)	8(44%)	26	0(0%)	2(8%)	10(38%)
7	Firozepur	15	2 (13%)	3(20%)	1(7%)	27	0(0%)	1(4%)	15(56%)
8	Gurdaspur	19	0 (0%)	4(21%)	0(0%)	11	4(36%)	7(64%)	0(0%)
9	Hoshiarpur	18	0 (0%)	1(6%)	0(0%)	14	3(21%)	1(7%)	0(0%)
10	Jalandhar	18	0 (0%)	5(28%)	0(0%)	13	0(0%)	0(0%)	9(69%)
11	Kapurthala	8	0 (0%)	1(13%)	0(0%)	10	0(0%)	0(0%)	4(40%)
12	Ludhiana	17	0 (0%)	6(35%)	0(0%)	17	0(0%)	0(0%)	10((59%)
13	Mansa	11	5 (45.45%)	3(27%)	2(18%)	20	0(0%)	0(0%)	10(50%)
14	Moga	12	0 (0%)	2(17%)	3(25%)	25	0(0%)	0(0%)	21(84%)
15	Muktsar	11	4 (36.36%)	2(18%)	2(18%)	18	0(0%)	0(0%)	5(28%)
16	Nawanshahr	7	1 (14%)	0(0%)	0(0%)	6	0(0%)	0(0%)	0(0%)
17	Pathankot	6	0 (0%)	2(33%)	0(0%)	3	0(0%)	0(0%)	1(33%)
18	Patiala	18	2 (11.11%)	6(33%)	2(11%)	22	0(0%)	1(5%)	12(55%)
19	Rupnagar	8	0 (0%)	1(13%)	0(0%)	5	1(20%)	0(0%)	0(0%)
20	Sangrur	21	0 (0%)	7(33%)	6(29%)	36	0(0%)	0(0%)	24(67%)
21	SASNagar	8	0 (0%)	2(25%)	4(50%)	5	1(20%)	0(0%)	0(0%)
22	Tarantaran	10	0 (0%)	1(10%)	2(20%)	14	0(0%)	7(50%)	8(57%)
		284	**31(10.92%)**	**76(26.76%)**	**45(15.85%)**	**379**	**13(3.43%)**	**28(7.39%)**	**190(50.13%)**

Basic Parameters:

- EC (Electrical Conductivity):10.9% of samples exceed permissible limits, with higher occurrences in districts like Fazilka (44.44%), Mansa (45.45%) and Muktsar (36.36%),
- NO_3 (Nitrate): 26.8% of samples exceed limits, with notable levels in Bhatinda, Fazilka, Faridkot, Muktsar, Mansa and Sangrur districts.
- F (Fluoride): Overall, 15.8% of samples surpass permissible levels, with varying percentages across districts.

Heavy Metals:

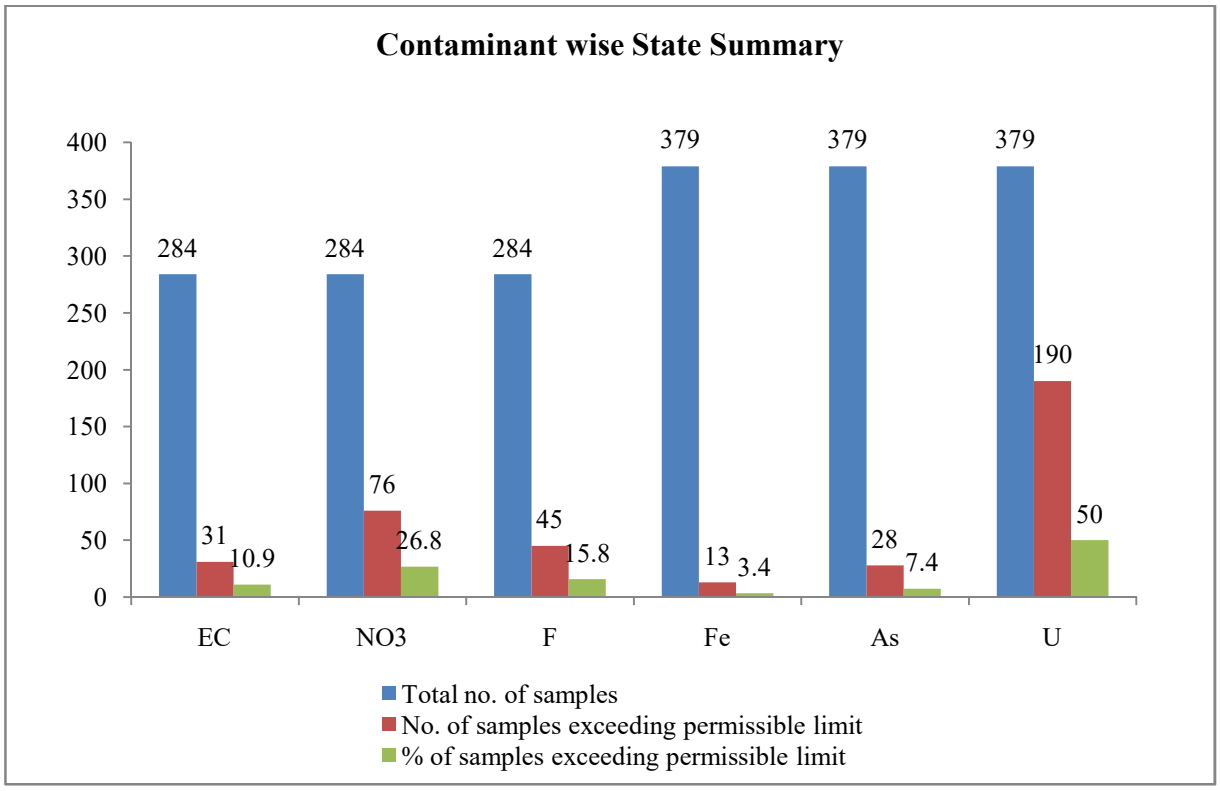
- Fe (Iron): Detected in 3.4% of samples, notably in districts like Amritsar (16%), Gurdaspur (36%) and Hoshiarpur (21%).
- As (Arsenic): Detected in 7.4% of samples, with minimal occurrences across districts.
- U (Uranium): Detected in 50.13% of samples, with significant levels in certain districts like Barnala (89%), Bhatinda (63%), Moga (84%), Mansa (50%), Muktsar (52%) and Sangrur (67%).

The Table 9 provides a summary of groundwater quality in the state of Punjab, broken down by the number of samples collected and the percentage of those samples that are contaminated with various parameters.

Table 9: Summary of Groundwater Quality in Punjab: Samples Collected and Contamination Percentage

		Number of samples contaminated (%age of samples contaminated)		
Punjab State Summary	Total no. of Basic samples	EC	NO3	F
	284	31 (10.9%)	76 (26.8%)	45 (15.8%)
	Total no. of HM samples	Fe	As	U
	379	13 (3.4%)	28 (7.4%)	190 (50.0%)

Graphical representation of the same is depicted here under



The groundwater quality assessment in Punjab revealed notable levels of contamination across various parameters. Uranium (U) emerged as the predominant contaminant, with 50.0 % of samples surpassing permissible limits, followed by Fluoride (F) at15.8%, and Nitrate (NO_3) at 26.8% while Arsenic (As) and Iron (Fe) exhibited lower levels of contamination,with7.4% and 3.4% of samples exceeding permissible limits, respectively.