GROUNDWATER CHEMICAL QUALITY BULLETIN TAMILNADU AND UT OF PUDHUCHERRY

ABSTRACT

Ground water quality assessment of Tamilnadu and UT of Pudhucherry based on 2024 pre monsoon trend monitoring stations and highlighting the findings followed by groundwater contamination status.

CGWB, SECR, Tamil Nadu

1.0 INTRODUCTION

Evaluation of groundwater quality is as important as its quantity for assessment of groundwater resources. Groundwater is never pure and contains varying amounts of dissolved solids, the type and concentration of which depends on its source, surface and sub-surface environment and rate of groundwater movement. The chemical quality of groundwater is a function of the quality of the recharge water and the reactions that occur along its flow path, particularly between the moving fluid and the geologic materials. The concentrations of various chemical constituents in groundwater depend on the solubility of minerals present, the residence time and the amount of dissolved carbon dioxide. In addition to the natural changes, anthropogenic activities such as sewage disposal, agricultural practices, industrial pollution etc. also contribute significantly to changes in groundwater quality.

Groundwater has unique features, which render it particularly suitable for public water supply. It has excellent natural quality and is usually free from pathogens, colour and turbidity. Hence, it can be consumed directly without treatment. Due to frequent failure of monsoon, surface water resources cannot be relied as a sustainable source of water supply. This adds a greater demand on groundwater in different sectors. Groundwater is widely distributed and can be frequently developed incrementally at points near the water demand, thus avoiding the need for large scale storage, treatment and distribution system. Groundwater is particularly important as it accounts for about 88%safe drinking water in rural areas, where population is widely dispersed and the infrastructure needed for treatment and transportation of surface water does not exist. Groundwater plays an important role in agriculture and it is estimated that about 45%of irrigation water requirement is met from groundwater sources. Industrial demands for groundwater are also high, as many of its qualities (low salinity, low turbidity, lack of pathogens) makes it suitable for use either as raw water or after treatment. Unfortunately, the availability of groundwater is not unlimited nor is it protected from deterioration. In most of the instances, the extraction of excessive quantities of groundwater has resulted in drying up of wells, damaged ecosystems, land subsidence, salt-water intrusion, and depletion of the resource. Groundwater quality is being increasingly threatened by agricultural, urban and industrial wastes, which leach or are injected into underlying aquifers.

With the increasing pace of industrialization and urbanization, groundwater contamination has become a growing global concern. People contaminate groundwater and it needs to be protected by the people to ensure that clean and safe groundwater is available to the society now and in future. Once it is contaminated, it is very difficult to remediate. Contamination in groundwater will last for a very long time because of slow movement of groundwater. Furthermore, the time lag between introduction of a contaminant into the hydrologic cycle and its appearance in groundwater may deceive the public regarding its

real threat to the groundwater quality. In order to meet the demands of the growing population, there is an urgent need for proper study of changing groundwater quality including groundwater pollution. Pollution of water may be defined as "any undesirable change in physical, chemical, physiological or biological characteristics of natural water, directly or indirectly as the result of the activities of man so that they become less useful or will harmfully affect human life or that of any other desirable species, or industrial processes, living conditions or cultural assets or that may or will waste or deteriorate our water resources" (Handa, 1975- As quoted in CGWB 1996). The pollution can be point pollution or non-point pollution and in former, the pollution is caused at a point whereas in the latter, it is difficult to specify single point of entrance of pollutants.

Generally, shallow aquifers (Phreatic zone) are vulnerable for contamination than deeper or fractured zones. Municipal and industrial wastes, chemical fertilizers, herbicides and pesticides enter the soil, infiltrate into the aquifer and degrade groundwater quality. Other pollution sources include sewer leakage, faulty septic tank operation and landfill leachates. In some coastal areas, intensive pumping of fresh groundwater has caused salt- water intrusion into fresh water aquifers. Groundwater is less susceptible to bacterial pollution than surface water because the soil and rocks through which groundwater flows, screen out most of the bacteria. Bacteria, however, occasionally find their way into groundwater, sometimes in seriously high concentrations.

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

- To present current GW quality scenario, parameter wise for each district in through its National Hydrograph Network trend Monitoring Water Quality Stations of 2024
- To identify present day hot spots of poor-quality ground water through spatial variation analysis of latest 2024 quality data, providing insights for effective water quality management measures.

2.0 STUDY AREA

The state of Tamil Nadu has a geographical area of 1, 30,058 sq. km. and is situated between N. Latitudes 08o00" and 13o30' and E. Longitudes 76o15' and 80o18'. The state is bounded by the Bay of Bengal in the east, the Indian Ocean in the south, the state of Kerala in the west and the states of Karnataka and Andhra Pradesh in the north. For administrative purposes, the state is divided into 38 districts, 317 Taluks, 1202 Firkas and 16744 Revenue Villages. A major part of the Union Territory of Puducherry comprising Puducherry and Karaikal regions occurs as small enclaves in Tamil Nadu. Figure.1.0 shows the major aquifer and Administrative division of the State

The state of Tamil Nadu is divided into four physiographic unit's viz. (i) Coastal Plains, (ii) Eastern Ghats, (iii) Central Plateau and (iv) Western

Ghats. The coastal plains stretch over a distance of about 998 km. from Pulicat Lake to Cape Comorin, ranging in elevation between 2 and 30 m above mean sea level. The coastal plains are further sub-divided into (a) the Coromandel Coast comprising parts of the districts of Tiruvallur, Kancheepuram and Cuddalore, (b) the alluvial plain of Cauvery delta extending over Nagappattinam, Thanjavur Thiruvarur districts and (c) the dry southern plains comprising parts of Pudukkottai, Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari districts.

The chain of flat-topped hills of Javadis, the Shevroy, the Kalrayan and the Pachamalai hills, which are joining Cardamom hills in the south, form the Eastern Ghats. These hills rise steeply above plateau level to 1160 m above mean sea level in the Javadi hills and to 1645 m above mean sea level in the Shevroy hills.

Between the Eastern and Western Ghats lies the plateau area known as the "Central Plateau" comprising the districts of Erode and Coimbatore with elevations between 150 and 610 m above mean sea level thereby giving rise to an undulating topography. West of the region lies the broad Palghat gap between the Nilgiri and Anaimalai Hills. Between Cauvery River and the Palghat gap lies an extensive low plateau rising gradually from 120 to 180 m above mean sea level, along the tributaries of the Cauvery River, to 365 to 455 m above mean sea level in the west.

The plateau is fringed on the west by a group of high hills known as the Western Ghats, comprising the western part of the Nilgiri, Madurai and Kanyakumari districts. On the other side of the Palghat gap, the high mountains of the Peninsula dominate. These are the Nilgiri in the north, Anaimalai Hills, Palani and Cardamom hills in the south, with a summit level of 1830 to 2440 m above mean sea level rising sharply from the plateau.

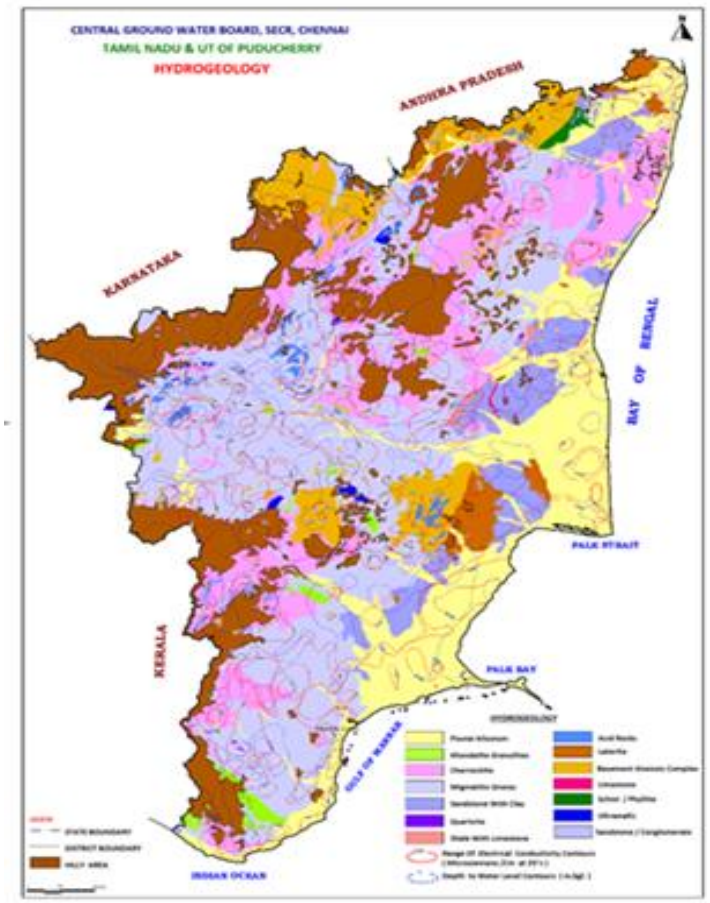


Fig.1.0: Map showing major aquifers of Tamilnadu and UT of Pudhucherry

3.0 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 the 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 groundwater. The probable causes of deterioration in ground water quality are depicted in Figure 2.

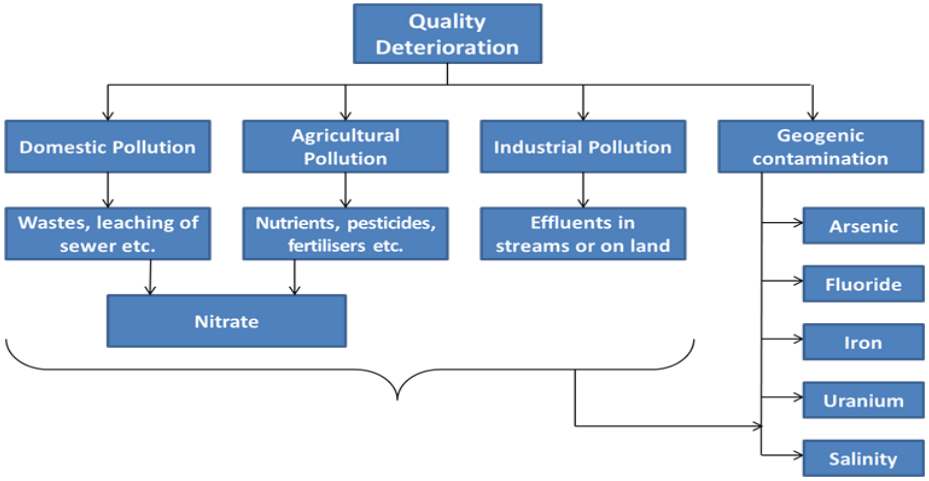


Figure 2: Schematic diagram illustrating the potential factors contributing to the degradation of groundwater quality

The chemical quality of shallow groundwater was monitored by the Central Ground Water Board, SECR, Chennai, during pre-monsoon in 2024 from trend monitoring 313 no. of station based on based on 2023 baseline pre-monsoon 1249 Water Quality stations located all over the state and UT of Pudhucherry (Figure 3.0). The district-wise distribution of water quality trend monitoring stations of CGWB is given in Table 1. The present bulletin is based on the Pre-monsoon May 2024 of water quality in network observation wells of CGWB in Tamilnadu and UT of Pudhucherry.

Fig 3.0: Map showing Groundwater Quality Trend Monitoring Stations in Tamilnadu and UT of Pudhucherry (2024)

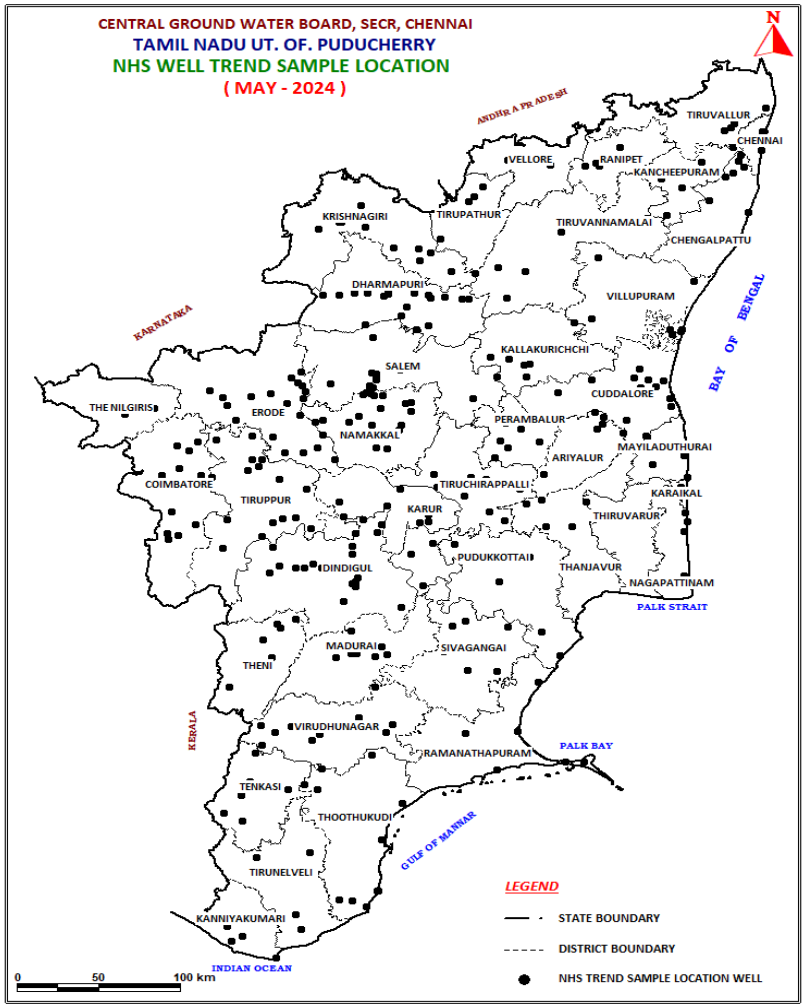


Table 1: District wise distribution of Water Quality Monitoring Trend Stations During May 2024

S. No	District	No of Trend Stations	S. No	District	No of Trend Stations
1	Ariyalur	5	17	Pudukkottai	5
2	Chennai	4	18	Ramanathapuram	8
3	Coimbatore	14	19	Salem	16
4	Cuddalore	13	20	Sivaganga	4
5	Dharmapuri	18	21	Thanjavur	5
6	Dindigul	20	22	Theni	8
7	Erode	29	23	Thiruvannamalai	8
8	Kancheepuram	11	24	Tirunelveli	12
9	Kanyakumari	5	25	Tiruppur	6
10	Karur	7	26	Tiruvallur	6
11	Krishnagiri	10	27	Trichy	11
12	Madurai	8	28	Tuticorin	10
13	Nagapattinam	7	29	Vellore	13
14	Namakkal	17	30	Villupuram	8
15	Nilgiris	2	31	Virudhunagar	10
16	Perambalur	6	32	UT of Pondicherry	7
				GRAND TOTAL	**313**

4.0 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 quality of groundwater in Tamilnadu and UT of Pudhucherry has been evaluated by sampling and analysis of water samples collected from National Hydrograph Station (NHS) or Groundwater Monitoring wells. The ground water samples are collected and analyzed for all the major inorganic parameters. 313 groundwater monitoring trend wells were monitored for water quality during May 2024. Out of which 313 no. of Water Quality Monitoring stations, 306 no. of stations from Tamilnadu state and 07 no. of monitoring stations from UT of Pudhucherry

4.1QUALITY ASSESSMENT OF GROUNDWATER IN UNCONFINED AQUIFERS

Unconfined aquifers are extensively tapped for water supply across the State and UT of Pudhucherry therefore; its quality is of paramount importance. The chemical parameters like Electrical Conductivity (EC), Nitrate and Fluoride are the main constituents defining the quality of ground water in unconfined aquifers. Therefore, presence of these parameters in ground water beyond the permissible limit in the absence of alternate source has been considered as groundwater quality hotspots.

Groundwater quality hot spot maps of the State have been prepared depicting three main parameters based on their distribution shown on the separate maps. These maps depict the spatial distribution of the following constituents in ground water tapping the unconfined aquifers. Therefore, the presence of these chemical constituents and the changes in chemical quality with respect to these in ground water in samples collected during pre-monsoon NHNS monitoring May 2024 are discussed below:

1. Electrical Conductivity (> 3000 µS/cm)
2. Nitrate (>45 mg/L)
3. Fluoride (>1.5 mg/L)

4.1.1 THE ELECTRICAL CONDUCTIVITY

Electrical conductivity (EC) 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 < 1500 µS/cm at 25 °C, is considered as fresh water, EC 1500–15000 µS/cm, is considered as brackish water and >15000 µS/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 500 mg/L (corresponding to EC of about 750 µS/cm at 25°C) that can be extended to a TDS of 2000 mg/L (corresponding to EC of about 3000 µS/cm at 25°C) in case of no alternate source. Water having TDS more than 2000 mg/L is not suitable for drinking purposes.

PRESENT SCENARIO OF ELECTRICAL CONDUCTIVTY (EC) VALUE IN GROUND WATER OF TAMILNADU STATE AND UT OF PUDHUCHERRY

Distribution of Electrical Conductivity (EC)

The EC value of ground water in the State varies from 155 µS/cm to 25300 µS/cm for Tamil Nadu and 821 µS/cm to 2590 µS/cm in UT of Pudhucherry during NHNS May 2024.

Grouping water samples based on EC values, it is found that 12.7 % of them have EC less than 750 µS/cm, 72.8 % have between 750 and 3000 µS/cm and the remaining 14.5% of the samples have EC above 3000 µS/cm in the state of Tamilnadu. However, UT of Pudhucherry all the trend stations comes between 750 µS/cm to 3000 µS/cm.

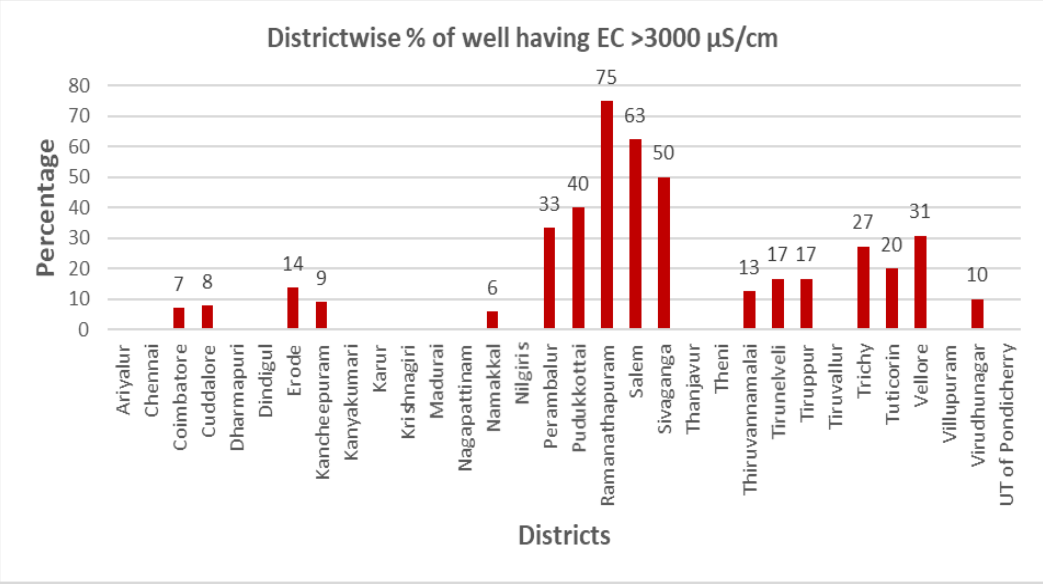


Table 2: District wise Range and distribution of EC in GW of Tamil Nadu and UT of Puducherry (May 2024)

S. No	District	No of samples analysed	Min	Max	Mean	(%) of samples		
						< 750	750 - 3000	>3000
1	Ariyalur	5	404	1229	769	60	40	0
2	Chennai	4	768	2690	1405	0	100	0
3	Coimbatore	14	270	3700	1633	14	79	7
4	Cuddalore	13	213	3830	1395	15	77	8
5	Dharmapuri	18	572	2460	1585	17	83	0
6	Dindigul	20	321	2640	1656	5	95	0
7	Erode	29	707	4190	1946	7	79	14
8	Kancheepuram	11	325	5900	1848	9	82	9
9	Kanyakumari	5	182	973	514	80	20	0
10	Karur	7	1049	2150	1536	0	100	0
11	Krishnagiri	10	1052	2810	1648	0	100	0
12	Madurai	8	256	2880	1872	13	88	0
13	Nagapattinam	7	586	2260	1160	29	71	0
14	Namakkal	17	676	3180	1533	6	88	6
15	Nilgiris	2	214	516	365	100	0	0
16	Perambalur	6	1661	5010	2862	0	67	33
17	Pudukkottai	5	1695	25300	7259	0	60	40
18	Ramanathapuram	8	1346	10680	5233	0	25	75
19	Salem	16	1915	6950	3520	0	38	63
20	Sivaganga	4	746	5800	2964	25	25	50
21	Thanjavur	5	491	1460	949	40	60	0
22	Theni	8	1158	2950	1890	0	100	0
23	Thiruvannamalai	8	1212	3690	2116	0	88	13
24	Tirunelveli	12	297	3285	1518	42	42	17
25	Tiruppur	6	422	4290	1902	17	67	17
26	Tiruvallur	6	870	2810	1707	0	100	0
27	Trichy	11	750	5500	2082	9	64	27
28	Tuticorin	10	523	5450	1994	30	50	20
29	Vellore	13	921	7131	2776	0	69	31
30	Villupuram	8	1033	1901	1424	0	100	0
31	Virudhunagar	10	155	3480	1651	20	70	10
32	UT of Pondicherry	7	821	2590	1429	0	100	0
Total		313						

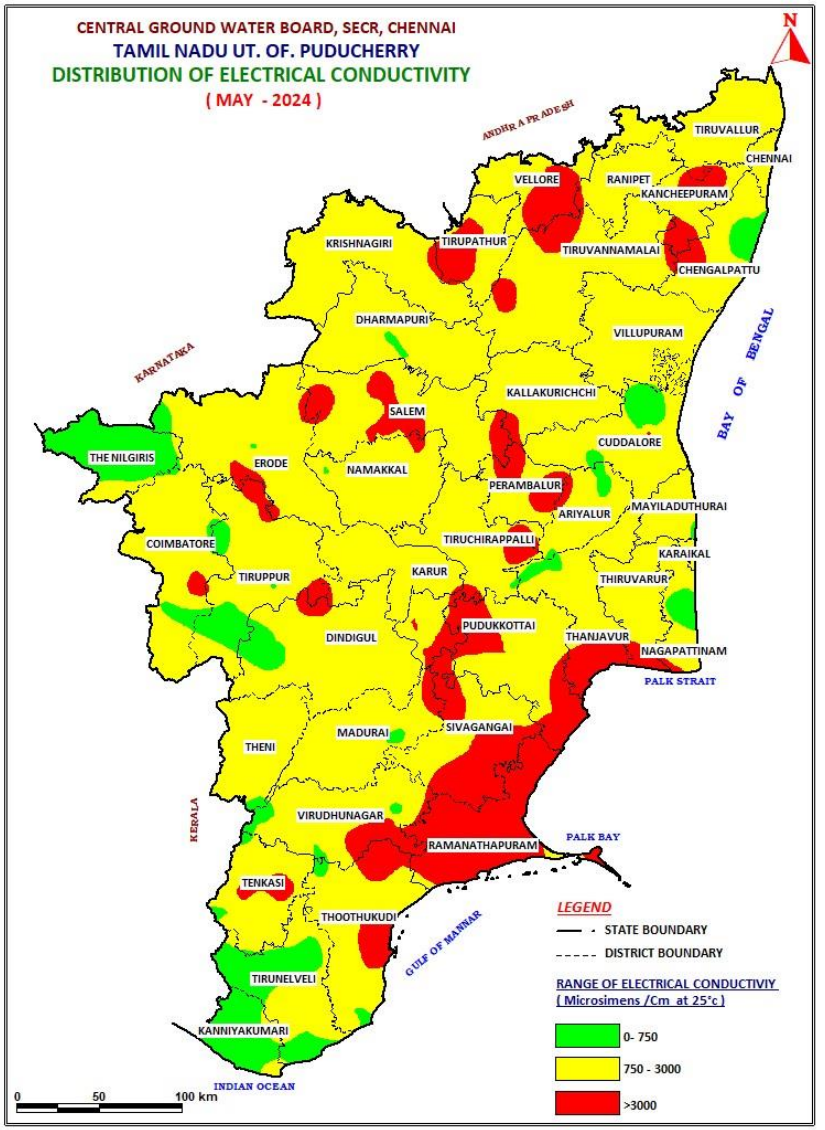


Fig 4: Map showing Distribution of Electrical Conductivity in Tamil Nadu State and UT of Pudhucherry (May2024)

PRESENT SCENARIO OF NITRATE CONCENTRATION IN GROUND WATER OF TAMILNADU STATE AND UT OF PUDHUCHERRY

4.1.2 NITRATE (NO_3)

Nitrate is a naturally occurring compound that is formed in the soil when nitrogen and oxygen combine. The primary source of all nitrates is atmospheric nitrogen gas. This is converted into organic nitrogen by some plants through a process called nitrogen fixation. Dissolved nitrogen in the form of NO_3 is the most common contaminant in groundwater. Nitrate in groundwater generally originates from non-point sources such as leaching of chemical fertilizers and animal manure, groundwater pollution from septic and sewage discharges, etc.

Some chemical and microbiological processes, such as nitrification and denitrification, also influence the nitrate concentration in groundwater. As per the BIS (2012) standard for drinking water, the maximum desirable limit of nitrate concentration in water is 45 mg/L with no relaxation. 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 in infants. Adults can tolerate slightly higher concentrations. The specified limits are not to be exceeded in the public water supply.

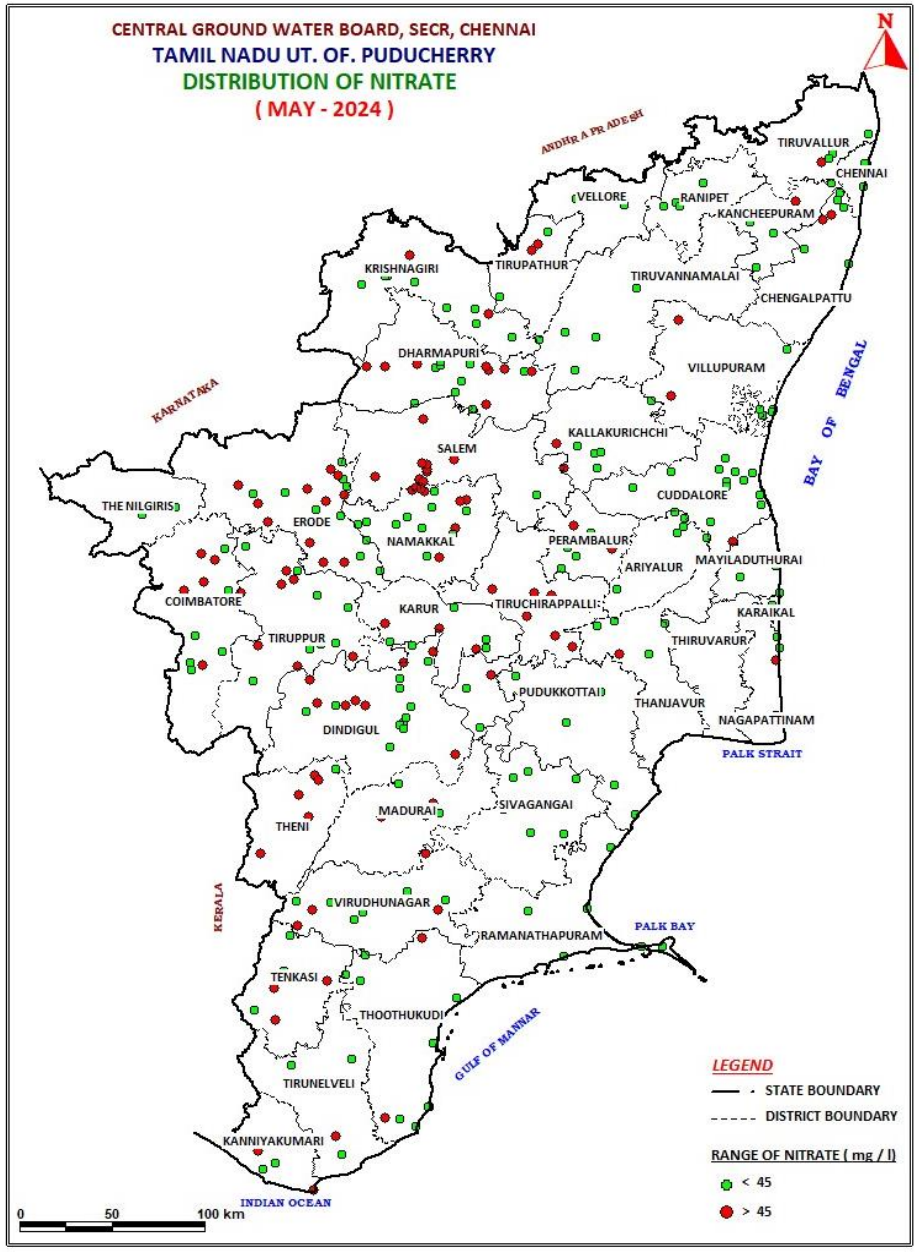


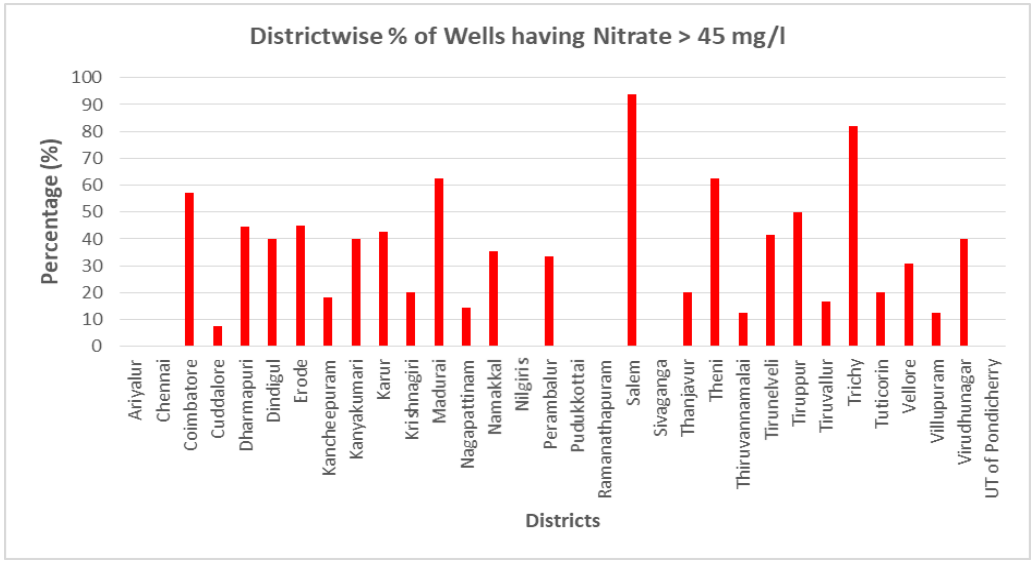
Figure 5: Distribution of Nitrate (> 45 mg/L) in Tamilnadu and UT of Puducherry (May 2024)

Table 3: District wise Range and distribution of Nitrate in GW of Tamil Nadu and UT of Puducherry (May 2024)

S. No	District	No of samples analysed	Permissible limit (mg/l)	Min	Max	Mean	No of samples < = 45 (%)	No of samples > 45(%)
1	Ariyalur	5	45	4	40	27	100	0
2	Chennai	4	45	1	14	7	100	0
3	Coimbatore	14	45	4	222	76	43	57
4	Cuddalore	13	45	1	48	8	92	8
5	Dharmapuri	18	45	1	107	45	56	44
6	Dindigul	20	45	2	172	41	60	40
7	Erode	29	45	5	185	58	55	45
8	Kancheepuram	11	45	1	87	19	82	18
9	Kanyakumari	5	45	13	53	35	60	40
10	Karur	7	45	2	178	59	57	43
11	Krishnagiri	10	45	1	101	30	80	20
12	Madurai	8	45	7	115	56	38	63
13	Nagapattinam	7	45	4	47	22	86	14
14	Namakkal	17	45	6	141	55	65	35
15	Nilgiris	2	45	8	41	25	100	0
16	Perambalur	6	45	7	105	46	67	33
17	Pudukkottai	5	45	4	23	10	100	0
18	Ramanathapuram	8	45	7	40	23	100	0
19	Salem	16	45	1	188	93	6	94
20	Sivaganga	4	45	3	39	21	100	0
21	Thanjavur	5	45	1	164	39	80	20
22	Theni	8	45	10	194	70	38	63
23	Thiruvannamalai	8	45	6	86	26	88	13
24	Tirunelveli	12	45	6	331	67	58	42
25	Tiruppur	6	45	4	63	36	50	50
26	Tiruvallur	6	45	1	50	11	83	17
27	Trichy	11	45	22	227	90	18	82
28	Tuticorin	10	45	1	297	53	80	20
29	Vellore	13	45	11	134	48	69	31
30	Villupuram	8	45	10	46	29	88	13
31	Virudhunagar	10	45	6	239	58	60	40
32	UT of Pondicherry	7	45	1	28	8	100	0
	Total	**313**						

Distribution of Nitrate (NO_3)

The probable sources of nitrate contamination of ground water are excessive application of fertilizers, bacterial nitrification of organic nitrogen, and seepage from animal and human manure. In the State, nitrate in ground water samples varies from 1 to 331 mg/L. Approximate 62.7% of the samples, spread over of nitrate below 45 mg/L in Tamilnadu whereas 100% in UT of Pudhucherry followed by Tamilnadu has 37.3% samples more than permissible limit ie., >45mg/l. Spatial distribution of nitrate (Figure 5) indicates high nitrate >45 mg/L found throughout the state of Tamilnadu and UT of Pudhucherry. The number of samples analyzed per district, along with their minimum, maximum, and mean Nitrate values based on NHS 2024 trend location monitoring Data is given in Table 3.



4.1.3 FLUORIDE

Fluorine is a fairly common element but it does not occur in the elemental state in nature because of its high reactivity. Fluorine is the most electronegative and reactive of all elements that occur naturally within many types of rock. It exists in the form of fluorides in a number of minerals of which fluorspar, cryolite, fluorite and fluorapatite are the most common. Fluorite (CaF_2) is a common fluoride mineral.

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 ground water in small amounts. The occurrence of fluoride in natural water is affected by the type of rocks, climatic conditions, nature of hydrogeological strata and time of contact between rock and the circulating ground water. Presence of other ions, particularly bicarbonate and calcium ions also affect the concentration of fluoride in ground water.

BIS has recommended an upper desirable limit of 1.0 mg/L of F^- as desirable concentration of fluoride in drinking water, which can be extended to 1.5 mg/L of F in case no alternative source of water is available. Water having fluoride concentration of more than 1.5 mg/L are not suitable for drinking purposes.

The occurrences of fluoride in groundwater beyond permissible limit (1.5 mg/L) have also been shown in the map as in Figure 6. District-wise percentage of wells having fluoride >1.5 mg/L is shown as a bar diagram. The percentage of wells having fluoride more than the permissible limit of 1.5 mg/L was observed in the districts of Salem, Erode, Dharmapuri, Madurai, Dindugul, Krishnagiri, Theni, Tiruppur, Ranipet and Tenkasi district due geogenic activities.

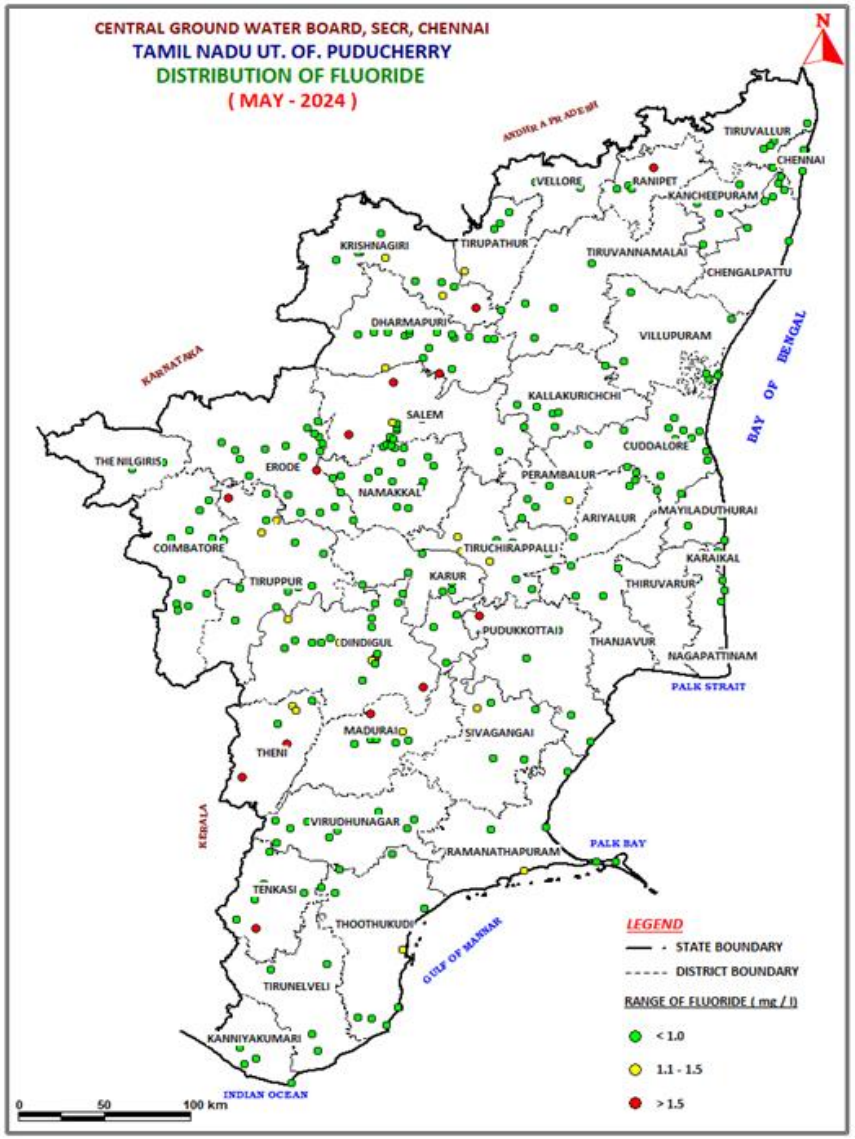


Figure 6: Map showing Distribution of Fluoride (> 1.5 mg/L) in Tamilnadu and UT of Pudhucherry (2024)

Distribution of Fluoride (F)

Fluoride in small amounts in drinking water is beneficial for dental health while in large amounts it is injurious. The fluoride content in ground water ranges from 0.04 to 3.97 mg/L in Tamilnadu and it varies from 0.18 to 1.74 mg/l in UT of Pudhucherry

BIS recommends that fluoride concentration up to 1.0 mg/L in drinking water is desirable, upto 1.50 mg/L is permitted and above 1.50 mg/L is injurious.

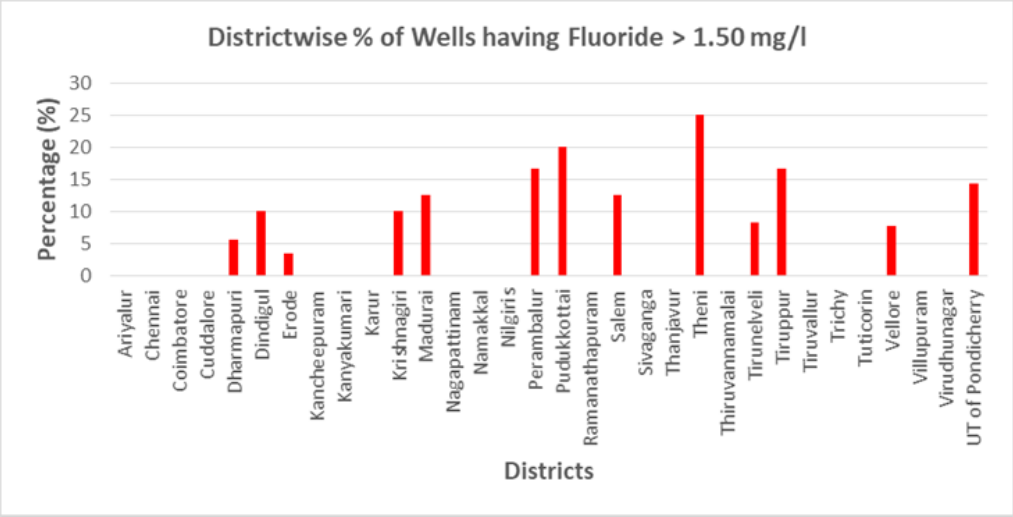


Table 4 given below provides for the number of samples analyzed per district, along with their minimum, maximum, and mean Fluoride values based on NHNS 2024 Data.

S.No	District	No of samples analysed	Permissible limit (mg/l)	Min	Max	Mean	No of samples <=1.5(%)	No of samples > 1.5(%)
1	Ariyalur	5	1.5	0.1	0.5	0.27	100	0
2	Chennai	4	1.5	0.19	0.27	0.23	100	0
3	Coimbatore	14	1.5	0.13	1.39	0.67	100	0
4	Cuddalore	13	1.5	0.04	0.47	0.2	100	0
5	Dharmapuri	18	1.5	0.17	1.68	0.71	94	6
6	Dindigul	20	1.5	0.16	3.27	0.95	90	10
7	Erode	29	1.5	0.1	1.86	0.47	97	3
8	Kancheepuram	11	1.5	0.08	0.8	0.39	100	0
9	Kanyakumari	5	1.5	0.05	0.48	0.25	100	0
10	Karur	7	1.5	0.35	1.03	0.65	100	0
11	Krishnagiri	10	1.5	0.35	1.87	0.85	90	10
12	Madurai	8	1.5	0.11	1.72	0.86	88	13
13	Nagapattinam	7	1.5	0.14	0.71	0.32	100	0
14	Namakkal	17	1.5	0.12	1.06	0.42	100	0
15	Nilgiris	2	1.5	0.06	0.1	0.08	100	0
16	Perambalur	6	1.5	0.22	1.51	0.78	83	17
17	Pudukkottai	5	1.5	0.1	2.37	0.78	80	20
18	Ramanathapuram	8	1.5	0.1	1.2	0.43	100	0
19	Salem	16	1.5	0.31	2.37	0.88	88	13
20	Sivaganga	4	1.5	0.21	1.4	0.75	100	0
21	Thanjavur	5	1.5	0.39	0.92	0.66	100	0
22	Theni	8	1.5	0.24	3.97	1.35	75	25
23	Thiruvannamalai	8	1.5	0.18	0.67	0.4	100	0
24	Tirunelveli	12	1.5	0.12	1.78	0.58	92	8
25	Tiruppur	6	1.5	0.18	2.25	0.92	83	17
26	Tiruvallur	6	1.5	0.19	0.83	0.51	100	0
27	Trichy	11	1.5	0.35	1.32	0.71	100	0
28	Tuticorin	10	1.5	0.07	1.23	0.39	100	0
29	Vellore	13	1.5	0.46	1.51	0.84	92	8
30	Villupuram	8	1.5	0.14	0.7	0.36	100	0
31	Virudhunagar	10	1.5	0.14	1.09	0.47	100	0
32	UT of Pondicherry	7	1.5	0.18	1.74	0.53	86	14
	Total	313						

Table 4: District wise Range and distribution of Fluoride in shallow GW of Tamilnadu and UT of Pudhucherry (May 2024)

DISTRICT WISE CONTAMINANT WISE STATUS SUMMARY BASED ON NHS 2024 PRE- MONSOON TREND MONITORING DATA

Table 5: District wise summary of Ground water quality contaminant status of Tamilnadu and UT of Pudhucherry (May 2024)

S.No	District	No of samples analysed	EC µS/cm at 25°C	NO3 (mg/l)	F (mg/l)
			> 3000	> 45	> 1.50
1	Ariyalur	5	0 (0%)	0 (100%)	0 (0%)
2	Chennai	4	0 (0%)	0 (100%)	0 (0%)
3	Coimbatore	14	1 (7%)	8 (57.14%)	0 (0%)
4	Cuddalore	13	1 (8%)	1 (7.69%)	0 (0%)
5	Dharmapuri	18	0 (0%)	8 (44.4%)	1 (5.56%)
6	Dindigul	20	0 (0%)	8 (40.0%)	2 (10%)
7	Erode	29	4 (14%)	13 (44.8%)	1 (3%)
8	Kancheepuram	11	1 (9%)	2 (18.1%)	0 (0%)
9	Kanyakumari	5	0 (0%)	2 (40.0%)	0 (0%)
10	Karur	7	0 (0%)	3 (42.8%)	0 (0%)
11	Krishnagiri	10	0 (0%)	2 (20.0%)	1 (10%)
12	Madurai	8	0 (0%)	5 (62.5%)	1 (12%)
13	Nagapattinam	7	0 (0%)	1 (14.2%)	0 (0%)
14	Namakkal	17	1 (6%)	6 (35.2%)	0 (0%)
15	Nilgiris	2	0 (0%)	0 (0.00%)	0 (0%)
16	Perambalur	6	2 (33%)	2 (33.3%)	1 (16%)
17	Pudukottai	5	2 (40%)	0 (0.00%)	1 (20%)
18	Ramanathapuram	8	6 (75%)	0 (0.00%)	0 (0%)
19	Salem	16	10 (63%)	15 (93.7%)	2 (12%)
20	Sivaganga	4	2 (50%)	0 (0.00%)	0 (0%)
21	Thanjavur	5	0 (0%)	1 (20.0%)	0 (0%)
22	Theni	8	0 (0%)	5 (62.5%)	2 (25%)
23	Thiruvannamalai	8	1 (13%)	1 (12.5%)	0 (0%)
24	Tirunelvel	12	2 (17%)	5 (41.6%)	1 (8%)
25	Tiruppur	6	1 (17%)	3 (50.0%)	1 (16%)
26	Tiruvallur	6	0 (0%)	1 (16.6%)	0 (0%)
27	Trichy	11	3 (27%)	9 (81.8%)	0 (0%)
28	Tuticorin	10	2 (20%)	2 (20.0%)	0 (0%)
29	Vellore	13	4 (31%)	4 (30.7%)	1 (7%)
30	Villupuram	8	0 (0%)	1 (12.5%)	0 (0%)
31	Virudhunagar	10	1 (10%)	4 (40.0%)	0 (0%)
32	UT of Pondicherry	7	0 (0%)	0 (0.00%)	1 (14%)
	Total	**313**	**44 (14%)**	**112 (35.78%)**	**16 (5.11%)**

Classification of samples based on this recommendation, it is found that 93 % samples have fluoride in desirable range and the remaining 7.0 % have fluoride above permissible limit i.e., 1.50 mg/L in Tamilnadu followed by from UT of Pudhucherry 86% % of samples have within desirable range and remaining 14 % of samples have above permissible limit. Map showing spatial distribution (Figure 6) of fluoride contents in ground water indicates that ground waters with fluoride above 1.50 mg/L are found mainly in the districts of Salem, Erode, Dharmapuri, Madurai, Dindugul, Krishnagiri, Theni, Tiruppur, Ranipet and Tenkasi districts are may be due to geogenic activities.

STATE SUMMARY

A summary of groundwater quality in the state of Tamilnadu and UT of Pudhucherry down by the number of samples collected from trend monitoring stations and the percentage of those samples that are contaminated with various parameters is given in Table No.5.

Table 6: Summary of Groundwater Quality in Tamilnadu and UT of Pudhucherry: Samples Collected and Contamination Percentage

State	Number of Samples Contaminated (% of samples)			
	Total no. of samples collected from trend monitoring stations	EC (>3000 µS/cm)	NO3 (>45 mg/l)	F (>1.50 mg/l)
Tamilnadu and UT of Pudhucherry summary	313	44 (14%)	112 (35.78%)	16 (5.11)

The groundwater quality assessment in Tamilnadu and UT of Pudhucherry revealed based on NHS May 2024 trend monitoring stations notable levels of contamination the parameters such as Nitrate emerged as the predominant contaminant with 35.78% of samples above permissible limits followed by Electrical conductivity 14% and Fluoride has 5.11 % of samples above permissible limits.

5.0 REMEDIAL MEASURES FOR NITRATE

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

a) Methods involving no treatment: In order to use any of these options the nitrate problem must be local-scale. Common methods are –

- Raw water source substitution
- Blending with low nitrate waters

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

b) Methods involving Treatment:

They are as follows

- Adsorption/Ion Exchange
- Reverse Osmosis
- Electrodialysis
- Bio-chemical Denitrification (By using denitrifying bacteria and Microbes)
- Catalytic Reduction/Denitrfication (using hydrogen gas)

The mechanism of nitrate pollution in subsurface porous unconfined/confined aquifer is governed by complex biogeochemical processes. Apart from recharge conditions, groundwater chemistry may be impacted by the mineral kinetics of water-rock interactions. Consequently, suitable nitrate removal technologies should be selected.

Nitrate is a very soluble ion with limited potential for co-precipitation or adsorption. This makes it difficult such as chemical coagulation, lime softening and filtration which are commonly used for removing most of the chemical pollutants such as fluoride, arsenic and heavy metals. According to King et al., 2012 nitrate treatment technologies can be classified in two categories in two categories, i.e. nitrate reduction and nitrate removal options. Nitrate removal technologies involve physical processes that does not necessarily involve any alteration of the chemical state of nitrate ions. Bio-chemical reduction options aim to reduce nitrate ions to other states of nitrogen, e.g. ammonia, or a more innocuous form as nitrogen gas. In-situ bioremediation is also effectively used in used in nitrate treatment of contaminated groundwater. Reverse Osmosis, catalytic reduction and blending are effective methods for nitrate removal from groundwater. For nitrate removal, operating trans-membrane pressure of RO unit generally ranges from 20 to 100 bar.

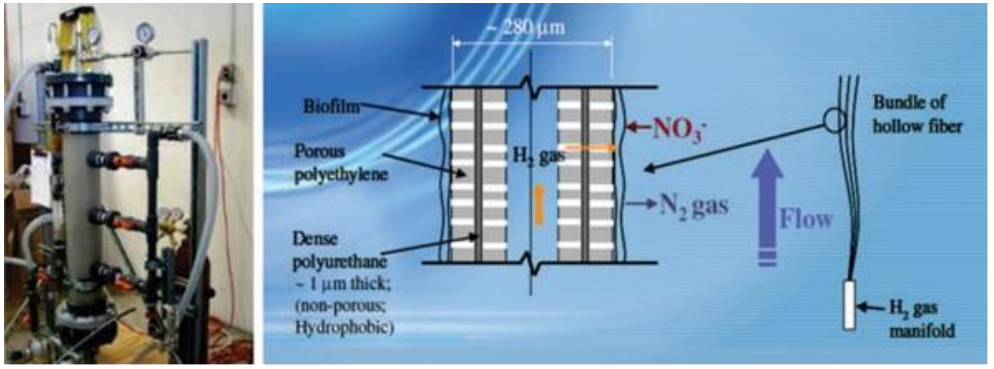


Fig.7 Advanced Nitrate Reduction Hollow Fibre Membrane Reactor (Source: Hand Book for Drinking Water Treatment, JJM, Ministry of Jal Shakti, Govt. of India)