EVALUATION OF GROUNDWATER CHARACTERISTICS IN AND AROUND KARAIKAL REGION, PONDICHERRY, INDIA

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Abstract: Groundwater samples, collected from different locations in the Karaikal region, are studied for their physicochemical characteristics. The present investigation focuses attention on the determination of physicochemical parameters such as pH, Electrical Conductivity (EC), Total Hardness (TH), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Chlorides (Cl), Sulphate (SO4-2) and Nitrate (NO3) for Groundwater suitability for domestic and irrigation purposes to be examined with WHO and BIS standards. Thus, the main objective of this study is to evaluate the quality of groundwater, especially in and around Karaikal region, where the groundwater is used for drinking and domestic purposes. Karaikal district is a growing tourism city of Puducherry Union Territory; it is surrounded by Industries and the increasing population has a demand for more water and hence it is necessary to assess the quality of ground water.

Index Terms - Groundwater – physicochemical characteristics – WHO – BIS.

I. INTRODUCTION

The cropping pattern of Karaikal is Rice and it is mainly based on the water availability from the river Cauvery and monsoon rains. In recent decades, due to the existence of monsoon uncertainty at catchment areas of river Cauvery, the supply of water from the reservoir is not only delayed, but also drastically reduced to very low levels. In order to overcome these problems, the Government of Puducherry had drilled Community borewells in Karaikal region. Apart from this community borewells, there are number of shallow borewells the farmers' holdings. Due to non – availability of water in time and quantity, supplementary irrigation sources from ground water are exploited on community sharing basis. However, due to proximity to sea, rich fossiliferous marine beds of the Pleocene age (at 54 to 77m) and Cuddalore sand stones of Miocene age (at 194 to 371m), the suitability of the community borewells are to be analyzed for sustainable cropping programme in this region. Hence, the underground water quality, in the Karaikal region where most of the agricultural activity is undertaken is analyzed to test its suitability for irrigation.

II. Degradation of water resources

The heavy use of the region's water resources is also leading to their degradation. India currently uses less than 38 percent of its total utilizable groundwater resources. But, due to intense exploitation in certain pockets, the water table is falling. Over exploitation of ground water has led to problems such as saline water intrusion and changes in the chemical quality of water.

Water Quality parameters and drinking water standards

Sl. No.	Parameters	BIS limits	Sl. No.	Parameters	BIS limits
1	Ph	6.5 – 8.5	4	Total hardness	300 mg/l.
2	Electrical Conductivity	5 milli mho.	5	Calcium	75 mg/l.
3	TDS	500 mg/l.	6	Magnesium	100 mg/l.

Sl. No.	Parameters	BIS limits	Sl. No.	Parameters	BIS limits
7	Sodium	200 mg/l.	11	Chloride	250 mg/l.
8	Potassium	-	12	Sulphate	200 mg/l.
9	Iron	0.3 mg/l.	13	Total alkalinity	200 mg/l.
10	Nitrate	45 mg/l.			

III. STUDY AREA

The Union Territory of Puducherry spread in an area of 490 Sq. Km. Which comprises four erstwhile French establishments of Puducherry, Karaikal, Mahe and Yanam. Karaikal District occupies an area of 157 square kilometres (61 Sq. miles). Karaikal town, situated 16 km. North of Nagappattinam and 12 km. South of Tharangambadi, is the regional headquarters. Karaikal region includes the Municipality of Karaikal and Communies of Neravy, Tirumalairajanpattinam, Thirunallar, Nedungadu and Kottucherry. The Union Territory of Puducherry consists of two districts, namely are Puducherry and Karaikal, situated at different geographical locations isolated from one another. Puducherry District comprises Puducherry, Mahe and Yanam regions. Karaikal region forms the Karaikal District. Karaikal region, situated about 130 Km. South of Puducherry, is sandwiched by Nagapattinam District of Tamil Nadu. It is located between 10º 49' and 11 º 01' N Longitudes and 79 º 43' and 79 º 52' E Latitudes.

Rainfall and Climate

The region receives the rain under the influence of both Southwest and Northeast monsoons. Most of the precipitation occurs in the form of cyclonic storms caused due to the depressions in Bay of Bengal, chiefly during Northeast monsoon periods. The normal annual rainfall of the Karaikal region is 1207.13 mm of which the Northeast monsoon contributes 69 percent and the Southwest monsoon contributes 21 percent. The study of rainfall distribution of the Karaikal region indicates a general increase in rainfall from inland towards coast, while the northeast monsoon shows a decrease in rainfall from the coast towards inland. The area receives maximum rainfall during the month of November. The region enjoys a humid and tropical climate. The mean monthly temperature varies between 31.8°C (May) and 21.7°C (March). The relative humidity is generally high above at 70% between August and April and minimum varying from 60 to 65% in the month of June and about 80% during the period October to April.

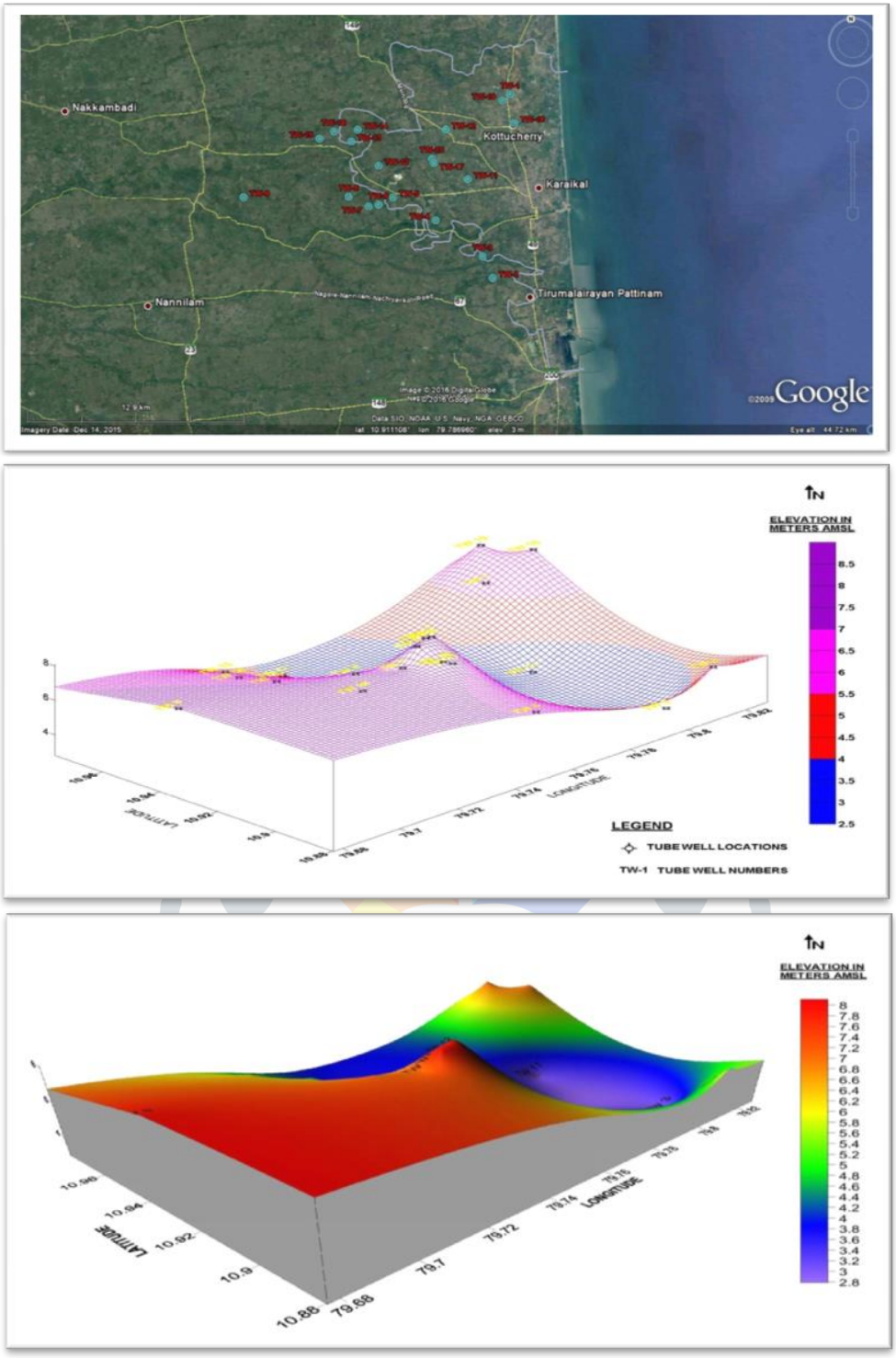
Topography

Forming part of fertile delta, the Karaikal region is completely covered by the distributaries of Cauvery River. Covered completely by a thick mantle of alluvium of variable thickness, the region is flat having gentle slope towards Bay of Bengal in the east. It is limited on the north by the Nandalar and on the south east by the Vettar. The group of rocks known as Cuddalore formations is found contiguous along with those in the Tanjore District.

Agriculture

The total geographical rural area of the district is 14035.56 hectares. The classification of area by different types of land use is indicated below: The percentage of cultivable area to total area and percentage of irrigated area to total cultivable area are 84.92, and 82.81 respectively. This shows the Karaikal as a predominantly an agricultural area. Higher production is possible due to the existence of the coastal alluvium soil very suitable for the cultivation of paddy and pulses. In the early days, agriculturists in Karaikal district had to depend on inundation following floods in Cauvery or local rainfall.

Station	Latitude	Longitude	Station	Latitude	Longitude
Keezhavanjur	N 10º 58'35.2"	E 79 º 49'36"	Vadthakudi	N 10º 55'59.5"	E 79 º 45'59.4"
Padudharkollai	N 10º 52'46.7"	E 79 º 48'32"	Vadapathi	N 10 º 57'38"	E 79 º 47'24.7"
Neravy	N 10º 53'29.5"	E 79 º 48'16"	Thamanangudy	N 10 º 57'30.4"	E 79 º 44'19.7"
Pettai	N 10º 54'46.1"	E 79 º 46'49.7"	Kannappur	N 10 º 57'51.7"	E 79 º 44'32.6"
Thennangudy	N 10º 55'36.3"	E 79 º 45'29.8"	Ambagarathur North	N 10 º 57'51.8"	E 79 º 43'45.5"
Madhur	N 10º 55'24.8"	E 79 º 45'00.3"	Ambaragathur (Kaliamman Koil Street)	N 10 º 57'40.6"	E 79 º 43'15.9"
V. Kottapadi	N 10º 55'23.3"	E 79 º 44'40.2"	Melasubbarayapuram	N 10 º 56'36"	E 79 º 46'55.8"
Thenbidagai	N 10º 55'45"	E 79 º 44'02.9"	Kottucherry ayyanar koil street	N 10 º 57'39.5"	E 79 º 49'39.8"
Pandaravadai	N 10º 56'00.6"	E 79 º 44'36.2"	Vadamattam	N 10 º 58'24.6"	E 79 º 49'19.8"
Sethur	N 10º 56'39.6"	E 79 º 45'06.6"	Kottucherry	N 10 º 56'44.4"	E 79 º 46'52.3"



Location of sample wells in Karaikal Region

Data analysis and Interpretation

Ground water potential zones can be located by proper selection of themes like geomorphology, geology, soil, slope, lineament density etc., and integration of the themes. Each thematic map is assigned weight ages based on their importance then; their influence over other parameter. The GIS is a computer automated spatial data management software that simplifies the input by organizing, analysing and mapping of large sets of complex geo-referenced information (Burrough, 1986). The GIS displays the location feature and provides a relational database capable of recording and analysing descriptive characteristics about the features.

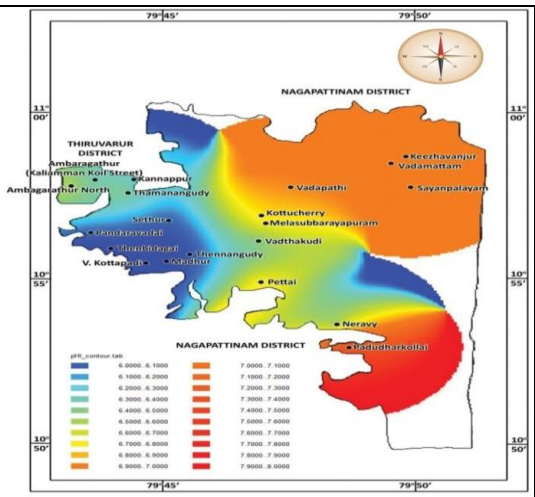
GIS Mapping

Thematic maps pertaining to pH, EC, TDS, TH, Calcium, Magnesium, Sodium, Potassium, Nitrate, Sulphate and Total Alkalinity for Pre monsoon and Post monsoon data are interpolated and analysed (scale 1:50000). The GIS Spatial Analyst provides a broad range of powerful spatial modelling and analysis features that allow creating, querying, mapping and analyzing the cell based raster data. GIS Spatial interpolation also allows performing the integrated vector-raster analysis. Using the GIS Spatial Analyst,

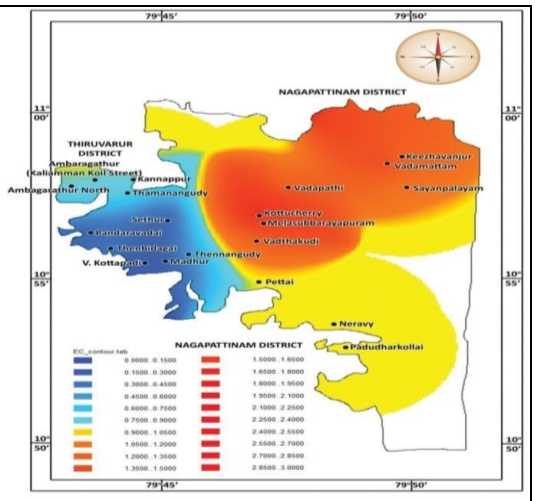
the information is derived the data, identify the spatial relationship, find suitable locations and calculate the accumulated cost of travelling from one point to another.

Sl. No	Well Location Name (Pre Monsoon)	PH	EC	TDS	Total Hardness	Calcium	Sodium	Potassium	Nitrate	Chloride	Sulphate	Total Alkalinity
1	Keezhavanjur	7.82	1.90	1235.00	72.00	5.60	46.22	0.59	2.40	560.00	12.00	290.00
2	Padidharkollai	8.12	1.31	851.50	60.00	3.86	37.70	0.59	2.00	440.00	15.00	248.00
3	Neravy	6.97	1.74	1131.00	412.00	6.42	34.98	0.40	2.00	360.00	48.00	0.00
4	Pettai	7.03	1.80	1170.00	280.00	11.15	34.50	3.41	0.00	320.00	30.00	0.00
5	Thennangudy	6.77	1.16	754.00	232.00	74.15	310.30	12.30	2.20	264.00	48.00	0.00
6	Madhur	6.71	0.58	377.00	128.00	17.59	92.56	6.18	2.00	96.00	3.00	0.00
7	V.Kottapadi	6.65	0.77	500.50	200.00	28.67	113.82	3.11	2.00	112.00	3.00	0.00
8	Thenbidagai	6.98	1.87	1215.50	360.00	92.90	522.50	4.80	2.00	388.00	45.00	0.00
9	Pandaravadai	6.68	0.90	585.00	232.00	29.32	115.73	11.94	0.00	156.00	27.00	0.00
10	Sethur	6.82	0.92	598.00	268.00	34.97	110.32	6.22	2.40	160.00	39.00	0.00
11	Vadthakudi	6.87	1.76	1144.00	360.00	73.0	431.40	20.50	0.00	404.00	105.00	0.00
12	Vadapathi	7.99	1.06	689.00	80.00	36.70	334.30	4.70	2.00	24.80	78.00	0.00
13	Thamanangudy	7.85	1.19	773.50	136.00	0.00	371.20	12.90	1.80	320.00	60.00	0.00
14	Kannappur	6.75	1.77	1150.00050	404.00	119.60	479.30	6.90	1.80	440.00	120.00	0.00
15	Ambagarathur North	7.76	1.16	754.00	84.00	76.80	451.20	9.20	1.80	160.00	30.00	0.00
16	Ambagarathur	6.7	1.6	1040.0	324.00	102.00	433.90	230.00	1.80	328.00	50.00	0.00
17	Melassubbarayapuram	7.17	1.90	1235.00	196.00	97.60	571.60	28.00	1.80	400.00	88.00	0.00
18	Kottucherry Ayyanar	7.1	1.3	903.50	164.00	72.20	439.50	17.60	1.60	252.00	66.00	0.00
19	Vadamattam	7.40	2.50	1625.00	256.00	124.60	743.30	26.20	1.60	660.00	88.00	0.00
20	Kottucherry	7.22	3.20	2080.00	296.00	134.20	786.40	38.10	0.00	912.00	100.00	0.00

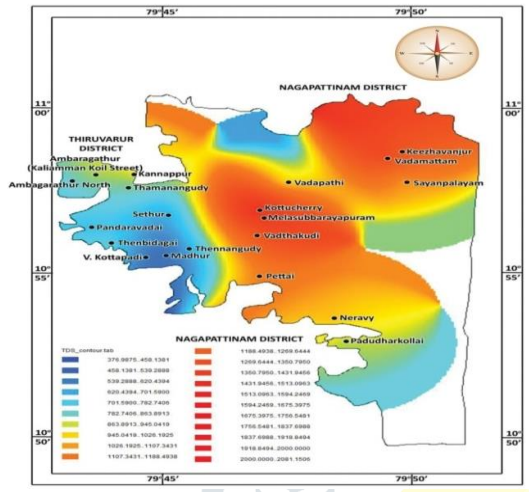
Sl. No	Well Location Name (Post Monsoon)	PH	EC	TDS	Total Hardness	Calcium	Sodium	Potassium	Nitrate	Chloride	Sulphate	Total Alkalinity
1	Keezhavanjur	7.82	1.90	1235.00	72.00	5.60	46.22	0.59	2.40	560.00	12.00	290.00
2	Padidharkollai	8.12	1.31	851.5	60.00	3.86	37.70	0.59	2.00	440.00	15.00	248.00
3	Neravy	6.97	1.74	1131.00	412.00	6.42	34.98	0.40	2.00	360.00	48.00	0.00
4	Pettai	7.03	1.80	1170.00	280.00	11.15	34.50	3.41	0.00	320.00	30.00	0.00
5	Thennangudy	6.77	1.16	754.00	232.00	74.15	310.30	12.30	2.20	264.00	48.00	0.00
6	Madhur	6.71	0.58	377.00	128.00	17.59	92.56	6.18	2.00	96.00	3.00	0.00
7	V.Kottapadi	6.65	0.77	500.50	200.00	28.67	113.82	3.11	2.00	112.00	3.00	0.00
8	Thenbidagai	6.98	1.87	1215.50	360.00	92.90	522.50	4.80	2.00	388.00	45.00	0.00
9	Pandaravadai	6.68	0.90	585.00	232.00	29.32	115.73	11.94	0.00	156.00	27.00	0.00
10	Sethur	6.82	0.92	598.00	268.00	34.97	110.32	6.22	2.40	160.00	39.00	0.00
11	Vadthakudi	6.87	1.76	1144.00	360.00	73.0	431.40	20.50	0.00	404.00	105.00	0.00
12	Vadapathi	7.99	1.06	689.00	80.00	36.70	334.30	4.70	2.00	24.80	78.00	0.00
13	Thamanangudy	7.85	1.19	773.50	136.00	0.00	371.20	12.90	1.80	320.00	60.00	0.00
14	Kannappur	6.75	1.77	1150.50	404.00	119.60	479.30	6.90	1.80	440.00	120.00	0.00
15	Ambagarathur North	7.76	1.16	754.00	84.00	76.80	451.20	9.20	1.80	160.00	30.00	0.00
16	Ambagarathur	6.79	1.60	1040.00	324.00	102.00	433.90	230.00	1.80	328.00	50.00	0.00
17	Melassubbarayapuram	7.17	1.90	1235.00	196.00	97.60	571.60	28.00	1.80	400.00	88.00	0.00
18	Kottucherry (Ayyanar	7.13	1.39	903.50	164.00	72.20	439.50	17.60	1.60	252.00	66.00	0.00
19	Vadamattam	7.40	2.50	1625.00	256.00	124.60	743.30	26.20	1.60	660.00	88.00	0.00
20	Kottucherry	7.22	3.20	2080.00	296.00	134.20	786.40	38.10	0.00	912.00	100.00	0.00



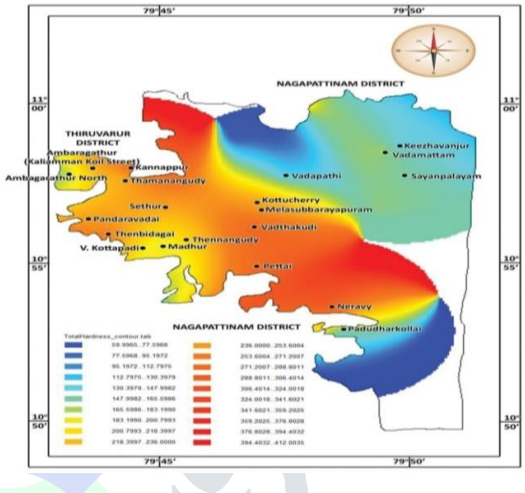
pH (Pre monsoon)



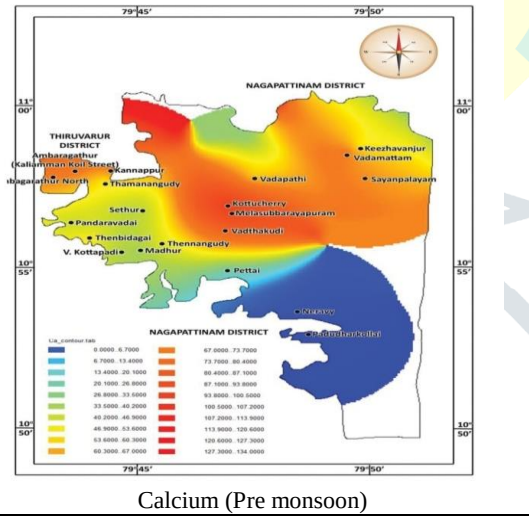
Electrical Conductivity (Pre monsoon)



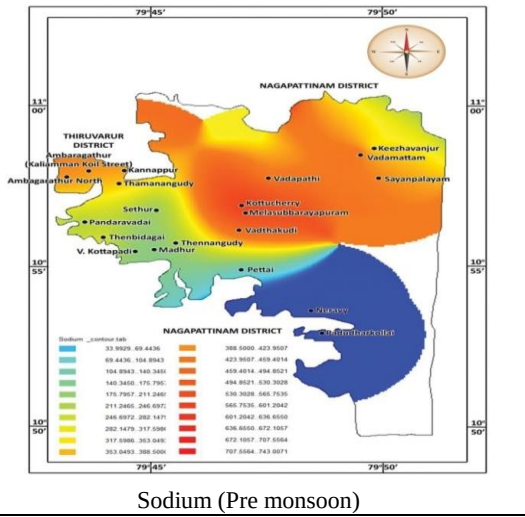
TDS (Pre monsoon)



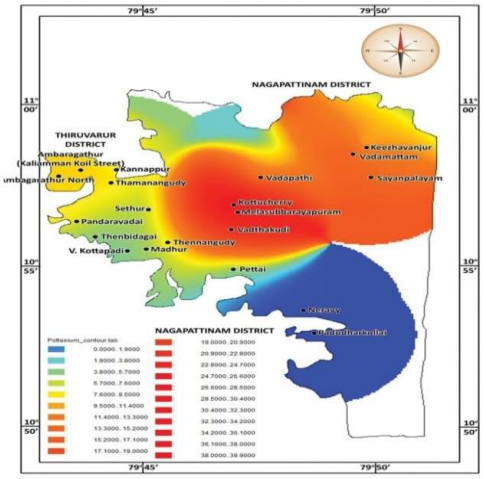
Total Hardness (Pre monsoon)



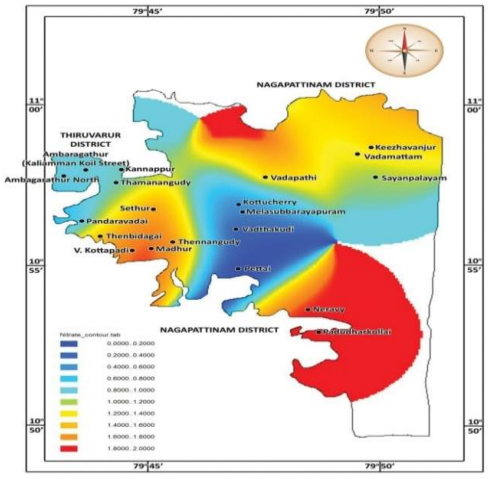
Calcium (Pre monsoon)



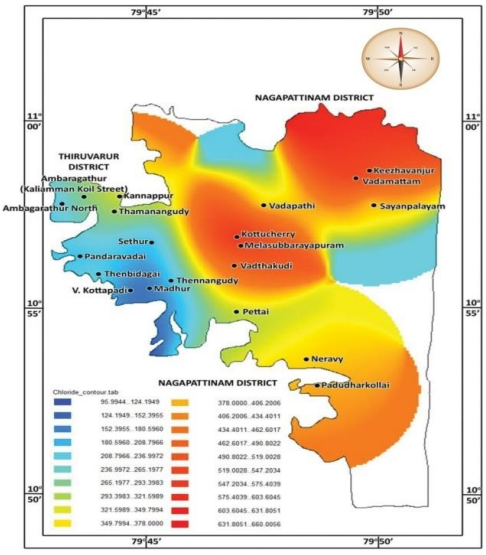
Sodium (Pre monsoon)



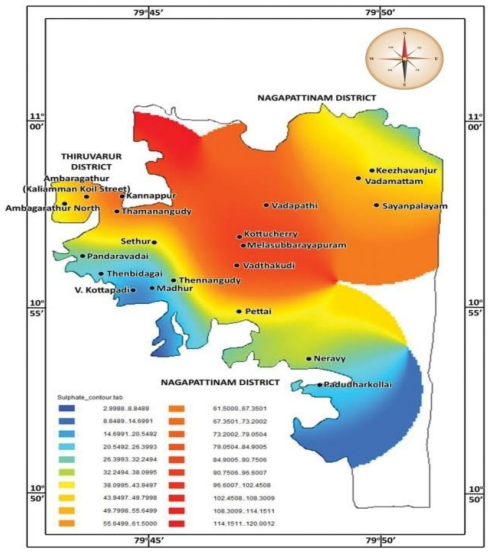
Potassium (Pre monsoon)



Nitrate (Pre monsoon)

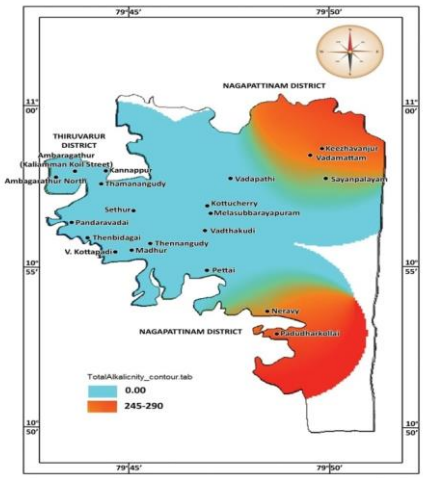


Chloride (Pre monsoon)

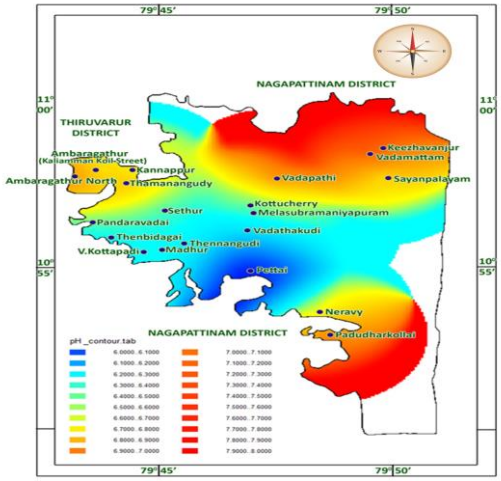


Sulphate (Pre monsoon)

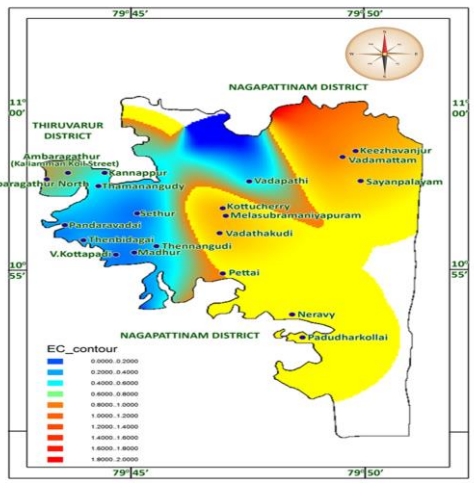
Total



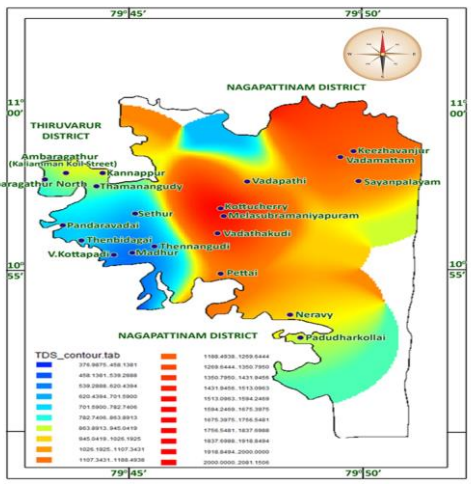
Alkalinity (Pre monsoon)



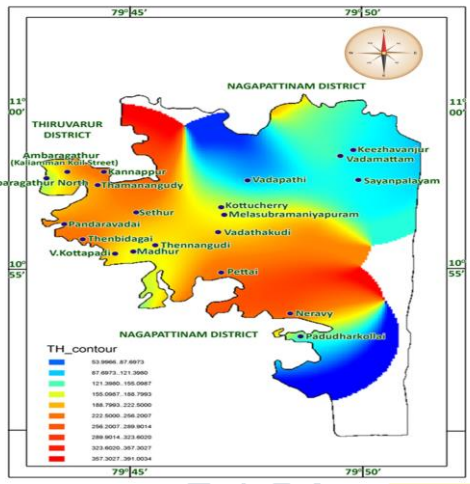
pH (Post monsoon)



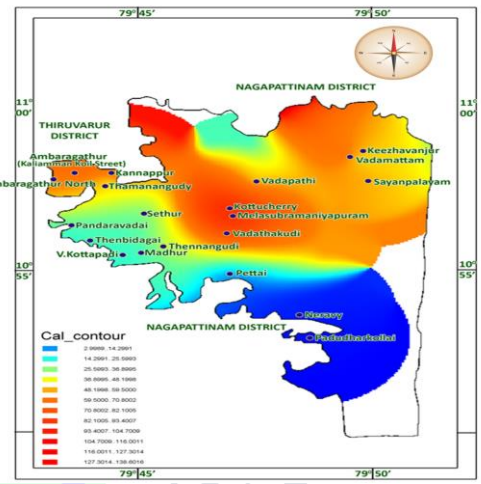
Electrical Conductivity (Post monsoon)



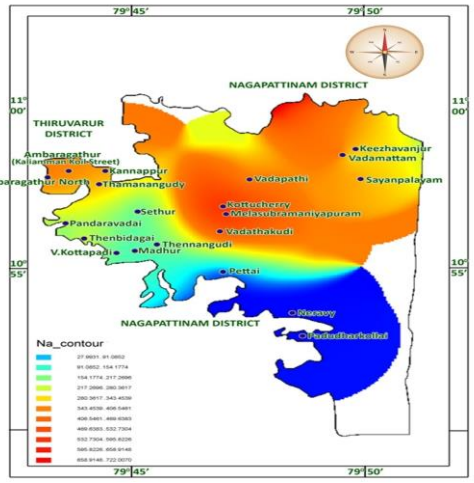
TDS (Post monsoon)



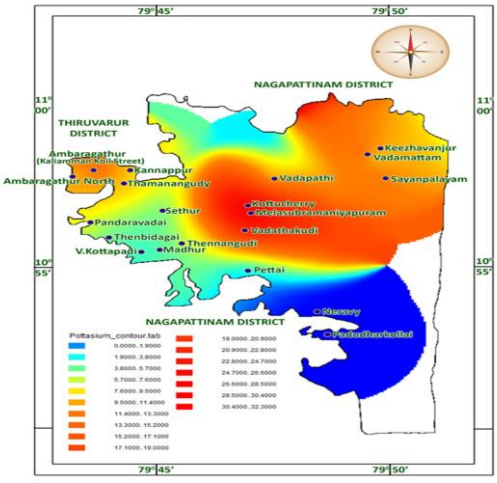
Total Hardness (Post monsoon)



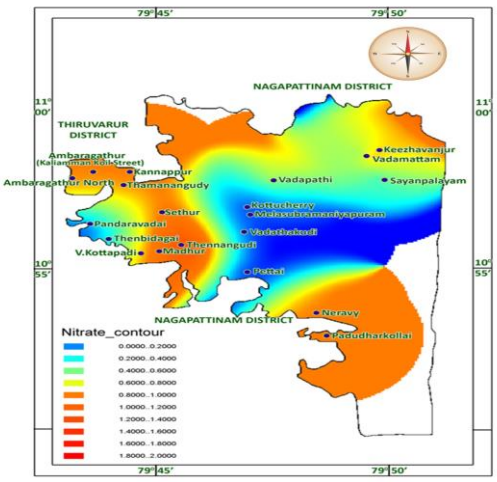
Calcium (Post monsoon)



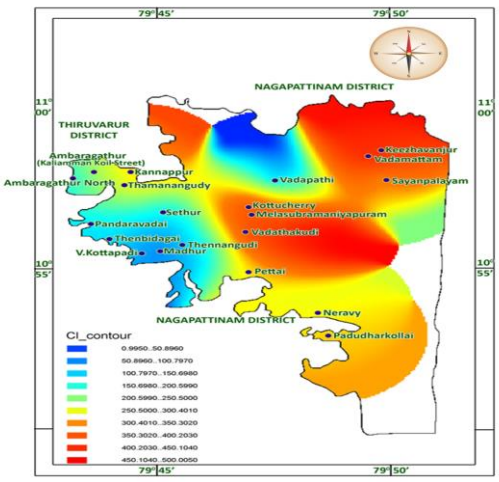
Sodium (Post monsoon)



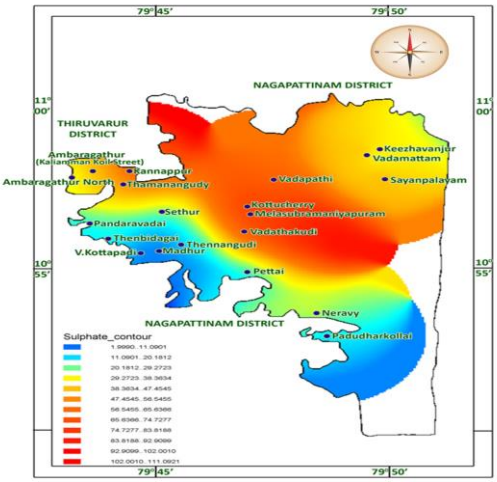
Potassium (Post monsoon)



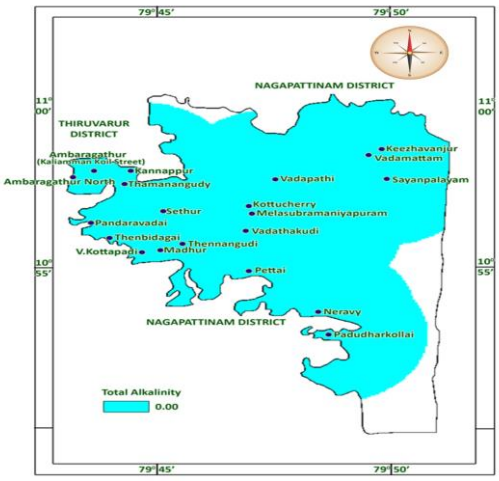
Nitrate (Post monsoon)



Chloride (Post monsoon)



Sulphate (Post monsoon)



Total Alkalinity (Post monsoon)

METHODOLOGY

Water samples were collected in clean polythene bottles from twenty bore wells and were assigned with code numbers. Before sampling, the motor was allowed to run for first 15 minutes and the water was collected in the sample bottles after rinsing with the same bore well water. The sample bottles were tightly capped and brought to the laboratory for further analysis. The water samples were analyzed for pH, EC and for their ionic composition. Sampling and analysis were carried out according to the standard methods prescribed by Bureau of Indian Standards.

Details of Data Collection

Bore-well water samples were collected in the various location of Karaikal district. Various field visits were conducted for the collection of primary data. The historical data on water quality were collected from the PWD Ground Water Division, Karaikal. The ground water quality resources have been computed jointly by central ground water board and state and surface water resources data centre (PWD, WRO, Govt. of Tamilnadu).

Methods adopted for chemical analysis of water samples

Sl. No.	Analysis	Methods	Sl.	Analysis	Methods
1.	Cl (mg/L)	Mohr's Titration	8.	Mg (mg/L)	Flame Photometric
2.	pH (mg/L)	pH Meter	9.	Alkalinity (mg/L)	Titration
3.	EC	Conductivity	10.	SO4 (mg/L)	Spectrometer
4.	TDS	Titration	11.	NO2+NO3	Titration
5.	K (mg/L)	Flame	12.	Salinity (%)	Hand Refractometer
6.	Na (mg/L)	Flame	13.	Hardness (mg/L)	Titration
7.	Ca (mg/L)	Flame			

RESULTS AND DISCUSSION

The results were compared with the limits proposed by the BIS for its suitability for agriculture purposes and drinking purposes.

pH

It is an indication of acidity the basicity of water. The result shows that the pH ranges between 6.65 and 8.12 in the Pre- Monsoon period and 6.51 and 7.87 in Post Monsoon period. The station S2 recorded the highest value of 8.12. However, it is within the permissible limit of BIS (6.5 – 8.5).

Electrical Conductivity

The Electrical Conductivity (EC) is the total parameter for dissociated substance. The recommended EC value for the irrigation purpose is 0 to 3 ds/m and for drinking purpose is less than 1 ds/m. The results revealed that the EC of ground water at almost all the locations of the study area was within the limit (except station S20 value 3.2) in Pre Monsoon period, whereas in the Post Monsoon period almost all the locations of the study area was within limit for agricultural and drinking purposes.

Total Dissolved Solids

Total Dissolved Solids (TDS) determination was used to assess the suitability of potential water supply for various uses. he result shows values ranging from 377 to 2080 in both pre-Monsoon period and Post-Monsoon periods. The values of the samples in all the stations are within the permissible limits (<1500 mg/L) except at stations S19 & S20.

Total Hardness

Total Hardness varies from 60 to 412 in the Pre-Monsoon period and 54 to 391 in the Post-Monsoon period. The Hardness is within the permissible limit (i.e. 300 mg/L) except at stations S3, S8, S11, S14 & S16.

Calcium

Calcium concentration ranges from 3.86 to 134.2 in the Pre-Monsoon period and from 3.20 to 126.8 in Post-Monsoon period. As per the standards, the desirable limit of Calcium concentration is 75 mg/l. The stations S8, S14, S15, S16, S17, S19 & S20 show values exceeding the BIS limits. All other stations have values within the BIS limits.

Sodium

Sodium concentration ranges from 34.5 to 786.40 in the Pre-Monsoon period and from 28.05 to 751.49 in the Post- Monsoon period. As per the standards, the desirable limit of Sodium concentration is 200 mg/l. The stations S5, S8, S11, S12, S13, S14, S15, S16, S17, S18, and S19 & S20 show values exceeding the BIS limits. All other stations have values within the BIS limits.

Potassium

Potassium concentration ranges from 0.4 to 230 in the Pre-Monsoon period and from 0.16 to 210.8 in the Post-Monsoon period. As per the standards, the desirable limit of Potassium concentration is 200 mg/l. All the stations have values within the BIS limits except station s16 value.

Nitrate

Nitrate concentration ranges from 0 to 2.4 in the Pre-Monsoon period and from 0 to 2.2 in the Post-Monsoon period. As per the standards, the desirable limit of Nitrate concentration is 45 mg/l. All the stations have values within the BIS limits.

Chloride

Chloride determination was used to control pumping of ground water from locations where the intrusion of seawater was a problem. Chlorides associated with sodium exert has salty taste when its concentration is more than 200 mg/L. As per the standards, the desirable limit of Chloride concentration is 200 mg/l. The stations S6, S9, S10, S12 & S15 are having values within the BIS limits. All other stations have values exceeds the BIS limits.

Sulphate

Sulphate concentration ranges from 3 to 120 in the Pre-Monsoon period and from 2.4 to 102 in the Post-Monsoon period. As per the standards, the desirable limit of Sulphate concentration is 200 mg/l. All the stations are having values within the BIS limits.

Total Alkalinity

As per the standards, the desirable limit is 200 mg/l. The S1, S2 stations have values exceeding the BIS limits. All other values are NIL.

CONCLUSION

The following are the conclusions of the present study:

- The analysis of the water quality parameters of the groundwater from 20 sample locations in Karaikal region, Puducherry state shows the pH, Potassium, Nitrate, Sulphate and Total Alkalinity values within the permissible limits.
- The TDS, EC, Hardness, Calcium, Sodium, Chloride values are above the desirable limits because of improper drainage system.
- During the Pre-monsoon period, the water samples recorded comparatively higher pollutants such as EC, TDS, Calcium and Hardness, etc. than in the Post-monsoon period.
- Higher value recorded in water sample indicates the pollution from fertilizer runoff from agriculture field, sewage and dumping of solid waste in river and river banks, industrial effluents, sewage let out by inhabitants in many places of Cauvery river basin.
- The study concludes that the water is not fit for drinking purpose during the Pre-monsoon period, but it can be used for all purposes only after undergoing treatment process.
- The farmers should be aware of the monsoon, weather forecasting so that they can prevent the utilization of fertilizer and pesticides.
- The general public also should be aware of disposing the plastic bags, polyethylene bottles in proper way, instead of throwing them into the river and river banks.
- Dumping of Municipal solid wastes leads to pollute the ground water. Alternate arrangements should be done in a war footing.
- Proper treatment and disposal of the effluent, proper drainage for the domestic and agricultural wastes, less usage of chemical and hazardous fertilizers, proper and hygienic maintenance of the sanitary conditions of the area and above all the inhabitants should be aware of the situation.

- ❖ Public should be given proper knowledge to be hygienic and they should have use potable water.

REFERENCES

1. **Ramalingam Mohan & Ramesh Kumar Selvan** (2014) Evaluation of Borewell water quality for crop production in Karaikal region, India
2. **Doneen LD.** 1963. Water quality for Agriculture Department of Irrigation, University of California, Davis, Pp: 48.
3. **Lal P and Singh KS.** 1974. Effect of qualities of irrigation water and fertilizers on soil properties, yield and nutrient uptake by wheat. Indian Journal of Agricultural Sciences 43, Pp: 392-400.
4. **S. Badal and Manisha** (2014) Assessment of Water Quality Index in Chhata Town, Mathura, India
5. **Mousumi Banerjee and Ambarish Mukherjee** (2007) "Status of water quality in the proximity of Deoghar town in the Jharkhand state of India"
6. **E. Vetrimurugan, L. Elango, N. Rajamohan** (2012) "Sources of contaminants and groundwater quality in the coastal part of a river delta Assessment of possible sources that control the groundwater quality"
7. **Sirajudeen J. and Abdul Vahith R.** (2013) "Application of water quality index for groundwater quality assessment in Tamil Nadu and Pondicherry, India
8. **G. Vijayakumar, M.A. Sivasangaran and V. Murugaiyan** (2012) "Studies on the pollution levels in Ariyankuppam backwater, Puducherry Region"
9. **Leena Deshpande** (2001) "Water quality analysis Laboratory methods"
10. **V. Dinakaran, Scientist-D,** (2008) "Technical report series of district groundwater brochure, Nagapattinam district, Tamil Nadu, by Central Ground Water Board, Chennai."
11. **M. Dinesh Kumar and Tushaar Shah** (2007) "Groundwater Pollution and Contamination in India the Emerging Challenge"