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Physio-Chemical Characterization of Water Quality in Salinity Affected Area, Using GIS Spatial Mapping

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ABSTRACT

Water resources are finite natural resources and are precious national assets. No living organisms can survive without water; agriculture is dependent on surface and ground water resources. The major Tsunami of December 26, 2004 had a profound impact on the south eastern coast of India. The ground water and surface water resources have been pollute by Tsunami due to saline water incursion and deposited sand mud in the fields and ponds that served as irrigation and drinking sources. A key concern is the nature and extent of the tsunami impact on the water supply and, in more general, the water resources of these areas. In the coastal areas of southern India, the majority of the population, which is rural or semi-urban, is relying on groundwater for their domestic and agricultural activities. About 810 km of Tamilnadu line was worst affected and 11 district were affected by Tsunami. Out of these districts, Nagapattinam was affected badly and ground water has been polluted due to saline water incursion and increased the salinity level. Sirkazhi and Tarangampadi Taluks of Nagapattinam District are considered for this study. The study area was selected based on the Hydro geological properties.

A Study on Physio-Chemical parameters of water quality in the salinity affected areas of Nagapattinam District is taken up to evaluate its suitability for drinking and irrigation purposes. Ground water samples are to be collected from the salinity affected areas of Sirkazhi and Tarangampadi Taluks. The water samples collected are 10 samples from Sirkazhi and 10 Tarangampadi Taluks are analyzed for pH, Sodium, Total Hardness, TDS, Chloride, Turbidity, Dissolved Oxygen, Salinity. Geographic Information System (GIS) is used for spatial and temporal mapping of water quality in the study area. The analyzed parameters were verified for its toxicity levels with respect to BIS,WHO,ICMR standards, it is observed that the ground water is well within the permissible limit of pH, Salinity, Turbidity, DO prescribed by BIS, WHO, ISI, ICMR. Almost all other parameters like Chlorides (Cl), Sodium (Na), Hardness are exceeding the prescribed limit.

KEYWORDS: Groundwater quality, Physio-Chemical parameters, Salinity affected area, Geo Informatics system.

I. INTRODUCTION

Water is one the most important natural assets and plays a vital role for all living organisms and plants to survive in this world. Safe drinking water is the primary need of every human being. Fresh water has become a scarce commodity due to over exploitation and pollution of water. In this world one fifth of the water used is obtained from the ground water resources and in many areas groundwater is the only fresh source available; protection of the ground water quality has become a high priority management objective. The increasing necessity of water for domestic, industrial and agricultural prompts the exploitation of ground water and its key role in national budget planning. Groundwater forms an important resource of water in many cities and small towns especially in the developing countries, mainly as being inexpensive to exploit.

India being the second fastest growing economy and the second most populated country in the world, the level of urbanization is expected to rise at higher rate. It is observed that the majority of the urbanization is expected to rise along the coastal line. India has the coastal line of 7500km with 30 major cities and medium cities including 3 important metros and thousand of coastal villages. The human life along the coastal line mainly depends on groundwater; Ground water is the major natural resource of water supply for many urban and rural areas. It has several advantages over surface water like wide distribution and with purity. Systematic monitoring of ground water condition and water quality is essential to understand an aquifer in relation to condition and water quality is essential understand an aquifer under various hydro geological conditions. Study on ground water with hydro geological conditions reveals valuable information about the recharge and flow patterns of the aquifer system.

The magnitude and intensity of soil salinization and sea water intrusion increased rapidly, the intensive agricultural activities in the coastal deltas of Tamilnadu coupled with urbanization and industrialization leading to over exploitation of groundwater results in degradation of groundwater quality of the aquifer causing seawater intrusion into the coastal aquifers (Chandrasekaran et al., 2007) Hence saline intrusion is essential to this valuable resource management.

Since the quality of public health for the people in this coastal region depends to a great extent on the quality of drinking water, it was imperative to determine the quality of water in salinity affected area. The main objective of this study is to evaluate the Physio-Chemical characterization of water quality in salinity affected area and its variability over space using GIS spatial mapping. This study could be used to recommend suitable management strategies for sustainable development of coastal land, Irrigation fields and water resources in the study area.

II. STUDY AREA

Nagapattinam District, A Coastal District of Tamil Nadu, on the eastern coast, Bay of Bengal, 326 K.M, south of the State Capital, Chennai, 145 K.M from Trichy, A middle Town. The District Capital Nagapattinam lies between Northern Latitude 10.7906 degrees (10o 46'1.2" N) and 79.8428 Degrees (79o49'58.8" E) Eastern Longitude. Nagapattinam district was carved out by bifurcating the erstwhile composite Thanjavur district on 18.10.1991. Nagapatinam is a unique District with all its historical and cultural significance. This House the places of Worship belongs to Major faiths. Nagapattinam is one of the constituents of chola mandalam, acclaimed as the most prominent among the ancient Tamil Kingdoms. Its salient features more than anything else have contributed to the glory of the cholamandalam.

Saline water intrusion is the movement of seawater inland into fresh ground water aquifers as a result of higher seawater density than fresh water and heavy withdrawal of fresh water. A natural

equilibrium exists between discharging fresh ground water and sea water in a coastal aquifer. This interface is dynamic and depends on geological formations, hydraulic gradient, topography and the quantity of fresh water moving through the aquifer system.

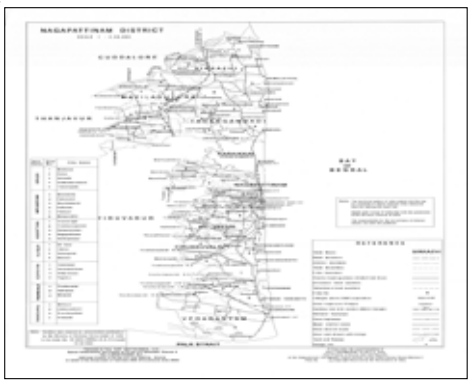



Figure 2.1: Shows the description of study area.

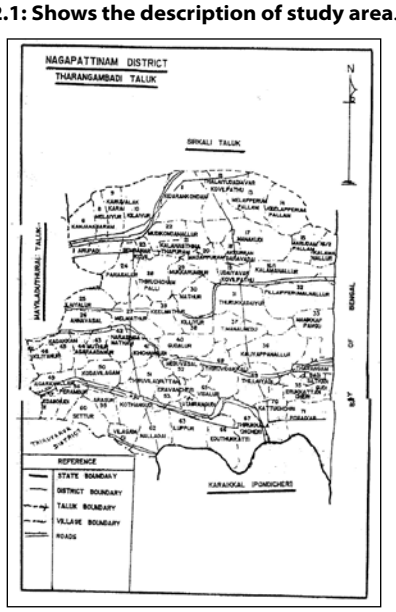

Figure 2.2: Shows village boundaries of Sirkazhi and Tarangampadi Taluk.

b) Hydrogeology of the Study Area

Nagapattinam district is predominantly underlain by Quaternary Fluvial-Marine formation; this includes mixture of sand, silt and clay. The entire area soil block comes under the sedimentary terrain. The district forms part of Cauvery river basin and delta with gentle slope 1 in 2000 towards Bay of Bengal. Clayey, Clayey loamy, Silty clay, Sandy clay, loamy, sandy loam are the predominant soil texture in the Cauvery delta region. The sedimentary formations in the district are represented by Miocene, Pliocene and Quaternary formations. Ground water occurs in these formations and is extracted by filter point wells, tube wells, shallow bore wells and infiltration wells, especially from the sandy aquifers (Arunachalam.S et al 2011).

The Pliocene and Quaternary shallow aquifers are represented by sand, gravel and clay. The aquifer is more clayey towards east and south eastern part of the district except the coastal stretch where the beach sands occur. Groundwater occurs in these formations under both water table and confined condition. The ground water is extracted by filter point wells, tube wells, shallow bore wells and infiltration wells especially in the sandy aquifers. The minimum and maximum water levels are observed to be 1m and 7m respectively.

The annual precipitation of 1200mm is distributed with 76% and 24% due to the effect of north-east monsoon and during other seasons, respectively. The northeast monsoon brings excess rain causing cyclonic storm once in two or three years causing a rise in the sea level to more than a metre that affects the inlands through backwater channels. Under these conditions the ground water table is affected by salinity. The ground water is used for both drinking and irrigation purposes. According to this study, the ground water samples of were collected from 10 various locations in Sirkazhi and Tarangampadi taluks of Nagapattinam district. While collecting samples, the locations of the sample acquisition points (latitude and longitude) were recorded by using geo positioning system (GPS).

III. MATERIALS AND METHODS

According to this study, the ground water samples of were collected from 10 various locations in Sirkazhi and Tarangampadi taluks of Nagapattinam district. While collecting samples, the locations of the sample acquisition points (latitude and longitude) were recorded by using geo positioning system (GPS).The collected water samples were analyzed for various water quality parameters were verified for its toxicity levels with respect to BIS, WHO, ICMR standards.

Table 3.1: Name of the sampling locations of Sirkazhi Taluk:

Sl. No	Sampling place	Latitude	Longitude
1	POOMPUHAR	N 11°8′25.42″	S 79°51′11.43″
2	VANAGIRI	N 11°7′51.2″	S 79°51′22.91″
3	MELAIYUR	N 11°9′45′	S 79°48′37.17″
4	NEITHAVASAL	N 11°10′6.7″	S 79°50′38.51″
5	KIZHAPERUMPALLAM	N 11°8′3.66″	S 79°50′8.02″
6	SIRKAZHI	N 11°14′29.78″	S 79°43′59.28″
7	TIRUVENGADU	N 11°10′35.2″	S 79°48′39.71″
8	MANGAIMADAM	N 11°11′21.47″	S 79°48′13.19″
9	RADHANALLUR	N 11°9′20.63″	S 79°48′2.57″
10	NAYAKARKUPPAM	N 11°10′51.81″	S 79°51′2.59″

Table 3.2: Name of the sampling locations of Tarangampadi taluk

Sl. No	Sampling place	Latitude	Longitude
1	PORAIYAR	N 11°1′11.14″	S 79°50′4.95″
2	TARANGAMPADI	N 11°1′34.07″	S 79°51′2.54″
3	ERUKKATTENCHERI	N 11°1′58.76′	S 79°49′49.69″
4	MANIKA PANGU	N 11°4′9.28″	S 79°51′9.33″
5	ANANDHA MANGALAM	N 11°4′18.23″	S 79°48′18.22″
6	KARUVILUNTHANATHAPURAM	N 11°8′40.78″	S 79°46′50.16″
7	PILLAIPERUMALNALLUR	N 11°5′14.24″	S 79°50′63″
8	THIRU KADAIYUR	N 11°4′29.44″	S 79°48′6.44″
9	AKKUR MUKUTHU	N 11°5′55.69″	S 79°47′58.64″
10	AANAI KOIL	N 11°4′52.96″	S 79°49′26.33″

The ground water samples collected from the study area were analyzed in the laboratory for Physio-Chemical parameters of water quality- pH, Chlorides (Cl-), Sodium (Na+), Hardness, Salinity, Turbidity and Dissolved Oxygen.

Table 3.3: Method adopted for analysis of water samples

S. No	Water quality Parameters	Method of Analysis
1	pH	pH meter
2	Turbidity	Turbidity meter
3	Chlorides	Mohr's method
4	Sodium	Flame photometer
5	Hardness	EDTA method
6	Salinity	Refractometer
7	Dissolved oxygen	Wrinkler's method

The concentrations of various chemical parameters are expressed in mg/l. the results of the water quality parameters are compared with standards of the WHO, BIS, ICMR, ISI.

Table 3.4: Drinking water quality standards

PARAMETERS	ISI(2005)		WHO(1984)		ICMR		BIS	
	HDL	MPL	HDL	MPL	HDL	MPL	HDL	MPL
pH	6.5-8.5	-	7.0-8.5	6.5-9.5	7.0-8.5	6.5-9.2	7.0-8.3	8.5-9.0
Chlorides(Cl) Mg/l	-	250	-	250	-	250	-	250
Sodium(Na) Mg/l		200		200				200
Hardness Mg/l	300	600	200	600	300	600	200	600
Salinity %	-	-	-	-	-	-	-	-
Turbidity NTU	5	10	-	-	-	25	5	10
DO %	8	15	8	15	8	15	8	15
Alkalinity Mg/l	200	600	-	120	-	-	200	600

IV. RESULTS AND DISCUSSION

The sample test results of the study area, Sirkazhi and Tarangampadi taluk in Nagapattinam district were summarized in Table 4.1 & 4.2 and Comparison of study area water quality parameters with various drinking water quality standards were presented graphically in Fig

Table 4.1: Groundwater quality parameters of Sirkazhi Taluk

Sl No	Name of the Sampling Place	Date of Sampling	pH	Chlorides [mg/lit]	Na [mg/lit]	Hardness [mg/lit]	Salinity [%]	Turbidity [NTU]	DO [mg/lit]
1	POOMPUHAR	7/12/2012	6.71	790	1200	800	8	Nil	7.1
2	VANAGIRI	7/12/2012	6.72	655	960	785	10	Nil	6.3
3	MELAIYUR	7/12/2012	6.77	900	610	652	3	43	7
4	NEITHAVASAL	7/12/2012	6.58	780	850	880	3	Nil	7.3
5	KIZHAP-ERUMPAL-LAM	7/12/2012	7.07	160	70	264	0	Nil	6.7
6	SIRKAZHI	7/12/2012	6.69	140	180	295	0	Nil	7.3
7	TIRUVEN-GADU	7/12/2012	7.03	920	780	980	4	Nil	7.3
8	MANGAIM-ADAM	7/12/2012	6.77	160	70	175	0	Nil	7.7
9	RADHANAL-LUR	7/12/2012	6.50	230	250	320	2	45	7.2
10	NAYA-KARKUPPAM	7/12/2012	6.64	1100	550	1050	4	Nil	7.6

Table 4.2: Groundwater quality parameters of Tarangampadi Taluk:

Sl No	Name of the Sampling Place	Date of Sampling	pH	Chloride [mg/lit]	Na mg/lit	Hardness [mg/lit]	Salinity [%]	Turbidity [NTU]	DO mg/l
1	PORAIYAR	8/12/2012	6.73	850	1050	780	6	Nil	6.4
2	TARANGAM-PADI	8/12/2012	6.72	500	785	720	10	Nil	6.3
3	ERUKKAT-TENCHERI	8/12/2012	6.75	620	450	500	3	Nil	7.2
4	MANIKA PANGU	8/12/2012	6.57	725	675	650	6	Nil	6.2
5	ANANDHA MANGALAM	8/12/2012	7.01	280	120	560	1	Nil	6.7
6	KARUVI-LUNTHAN-ATHAPURAM	8/12/2012	6.70	245	590	215	0	Nil	7.8
7	PILLAIPERU-MALNALLUR	8/12/2012	7.0	690	800	450	5	Nil	6.3
8	THIRU KADAIYUR	8/12/2012	6.77	175	210	273	2	Nil	7.4
9	AKKUR MUKUTHU	8/12/2012	6.52	320	445	600	6	Nil	7.2
10	AANAI KOIL	8/12/2012	6.61	475	960	750	3	Nil	7.1

Table 4.3: Comparison of Study area water quality parameters with BIS, WHO, ICMR standards

S. No	Parameters	BIS	WHO	ICMR	Study area Samples					
					Srikazhi Taluk			Tarangampadi		
					Min	Max	Avg	Min	Max	Avg
1	pH	6.5-8.5	6.5-8.5	7.0-8.5	6.5	7.07	6.748	6.52	7.01	6.738
2	Chlorides(Cl) Mg/l	250	250	200	140	1100	583.5	175	850	488
3	Sodium (Na) Mg/l	200	200	Nil	70	1200	552	120	1050	608.5
4	Hardness Mg/l	200 - 600	600	300	175	1050	620.1	215	780	549.8
5	Salinity %	Nil	Nil	Nil	0	10	3.4	0	10	4.2
6	Turbidity NTU	5 to 10	5	25	Nil	45	8.8	Nil	Nil	Nil
7	DO %	8 to 15	8 to 15	8 to 15	6.3	7.7	7.15	6.2	7.8	6.86



Fig 4.1 pH of water in sampling area

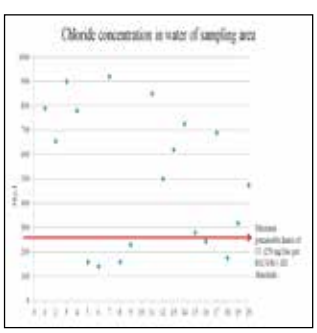

Fig 4.2 Chlorides of water in sampling area

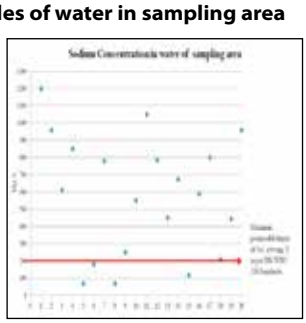

Fig 4.3: Sodium conc of water in sampling area

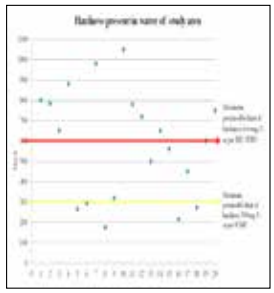

Fig 4.4: Hardness of water in sampling area

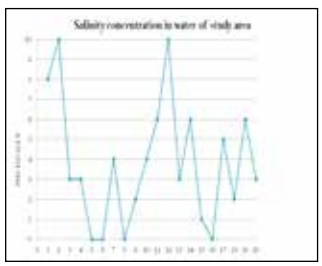

Fig 4.5: Salinity conc of water in sampling area Fig 4.6: Turbidity of water in sampling area

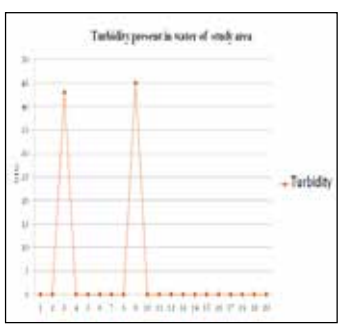

Fig 4.6: Turbidity of water in sampling area

pH

- The result showing that the pH, one of the primary water quality parameter is well within the prescribed limits in all the locations and in all the samples ranging from 6.50 to 7.07.In Sirkazhi taluk the minimum pH value of 6.50 is at Radhanallur and the maximum pH value of 7.07 is at Kizhaperumpallam and the average pH value is 6.748, In Tarangampadi taluk the minimum pH value of 6.52 is at Akkurmukuthu and the maximum pH value of 7.01 is at Anandha Mangalam and the average pH value is 6.738.

Hardness

- Water hardness is determined by the concentration of multivalent cations in the water. Multivalent cations are cations (positively charged metal complexes) with a charge greater than 1+. Usually, the cations have the charge of 2+. Common cations found in hard water include Ca2+ and Mg2+. In this study the hardness is ranging between 170 to 880 mg/l. As per WHO the Permissible limit of Hardness for drinking water is 150 mg/l, BIS, ISI and ICMR limit are 300 mg/l as the standard.Mangai Madam, Anandha Mangalam, kizhaperumpallam, Sirkazhi, Karuvilunthanathapuram, Thiru Kadaiyur are the places where the hardness values are well below the 300 mg/ l. According to United States Geological Survey uses the following classification into Hard and soft water, soft 0-60 mg/l , Moderately hard 61- 120 mg/l, Hard 121- 180, Very Hard > 181 mg/l. In this study all the samples exceeded 180 mg/l; excess hardness may cause health hazards.

Chloride (Cl^-)

- Ground water contains low chloride, the concentrations of chloride in the study area of Sirkazhi and Tarangampadi Taluks are varying from 140 to 1100 mg/l and 175 to 850 mg/l respectively. As per the BIS , ISI, WHO, ICMR the presence of chloride is well within the limits in Sirkazhi, Kizhaperumpallam, Mangaimadam, Radhanallur, Thirukadaiyur , Karuvilunthanathapuram and all other sampling locations were exceeding the permissible limit.

Sodium (Na^+)

- Sodium ion is ubiquitous in water because of the high solubility of many sodium salts. Groundwater typically contains higher concentrations of minerals and salts than surface Water. Large amount of sodium give a salty taste when combined with chloride. Sodium concentrations in the study area are varying from 70 to 1200 mg/l.

Dissolved Oxygen (DO)

- Dissolved oxygen (DO), a vital parameter in the stability of the aquatic eco-system, was within the prescribed norms (8 – 15 mg/lit). Dissolved oxygen (DO) refers to the volume of oxygen that is contained in water. The amount of oxygen that can be held by the water depends on the water temperature, salinity, and pressure. Oxygen is measured in its dissolved form as dissolved oxygen (DO), if more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken, or die.

Turbidity

- Turbidity is the cloudiness or haziness of water caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. Except Radhanallur, no other samples contain turbidity.

Salinity

- Salinity is the saltiness or dissolved salt content (such as chloride, magnesium and calcium sulfates, and bicarbonates) of a body of water or soil. The salinity levels in the study area are varying between 0 to 10 %.

Spatial mapping of water quality in the study area

The spatial variation of water quality parameters in the study area of Sirkazhi and Tarangampadi Taluks were presented in figure. By overlaying the village map, it is possible to identify the locations which are prone for contamination (Gnanachandrasamy et al., 2012).

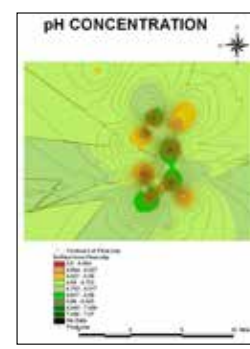

Figure 4.7 pH of water in study area Figure 4.8 Turbidity of water in study area

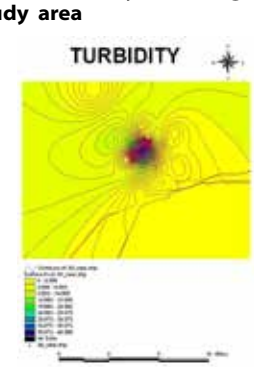

Figure 4.8 Turbidity of water in study area

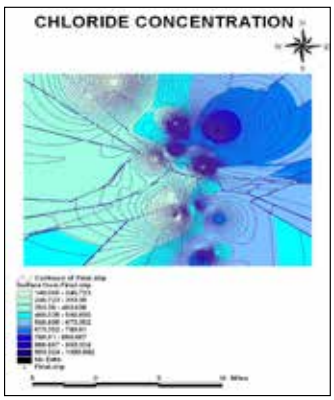

Fig 4.9 Chloride conc. of water in study area in study area

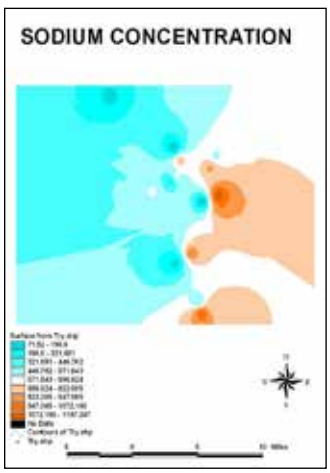

Fig 4.10 Sodium conc. of water in study area

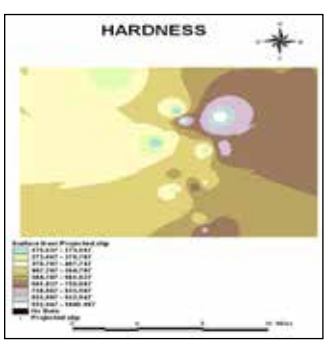

Fig 4.11 Hardness of water in study area

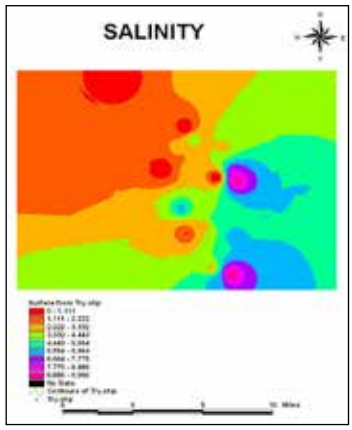

Fig 4.12 Salinity level of Water in study area

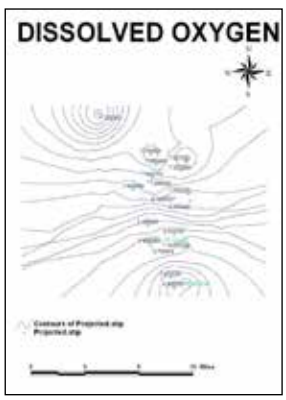

Fig 4.13 DO of water in study study area

V. CONCLUSIONS

In this study, Physical and chemical analysis of the groundwater samples collected from the coastal areas of Sirkazhi and Tarangampadi taluks of Nagapattinam District in Tamilnadu have been studied to explain the impact of sea water intrusion on the groundwater characteristics. It is observed that the ground water is well within the permissible limit of pH, Salinity, Turbidity, DO prescribed by BIS, WHO, ISI, ICMR. Almost all other parameters like Chlorides (Cl), Sodium (Na), Hardness are exceeding the prescribed limit. The tsunami impact changed entirely the coastal geomorphology along this region. The ground water quality parameters show very significant change due to saline water intrusion.

The spatial distribution of groundwater quality parameters were carried out through GIS spatial mapping techniques shows the quality of groundwater based on pH,Na+, Cl- , Total Hardness, Dissolved Oxygen, Turbidity, Salinity parameters. The tsunami impact changed entirely the coastal geomorphology along this region. The ground water quality parameters show very significant change due to saline water intrusion.

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