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Original Research Paper

Spatial Distribution of Groundwater Quality Between Injambakkam-Thiruvanmyiur Areas, South East Coast of India

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ABSTRACT

The study aims to understand the distribution of groundwater quality in coastal regions from Injambakkam-Thiruvanmyiur areas, Chennai. Groundwater samples were collected from the coastal regions of Tamil Nadu. The objectives of the study are to determine the groundwater quality characteristics such as pH, alkalinity, electrical conductivity, chloride, hardness, total dissolved solids, dissolved oxygen and map the spatial distribution of groundwater quality in the study area by using open source software Quantum GIS (QGIS). The physico-chemical parameters and the quality of the water vary with space and thus mapping it with the GIS is an efficient way to draw conclusions about the study area. Inverse Distance Weighted (IDW) interpolation method was used to create various raster maps which show the spatial distribution. With the present study it is found that, most of the regions in the southern part of the study area have poor to very poor quality based on the Water Quality Index (WQI).

INTRODUCTION

Groundwater is used for domestic and industrial water supply and irrigation all over the world. In the last few decades, there has been a tremendous increase in the demand for freshwater due to the rapid growth of population and the accelerated pace of industrialization. Rapid urbanization, especially in developing countries like India, has affected the availability and quality of groundwater due to its overexploitation and improper waste disposal, especially in the urban areas. Ratnakanth Babu et al. (2011) used the weighted arithmetic mean method and revealed that the groundwater is polluted based on the Water Quality Index in parts of Guntur District, Andra Pradesh. Rajankar et al. (2010) identified that, water quality management has implicit an important role for sustainable development in India. Shankar et al. (2011) mapped the spatial distribution of groundwater quality in the Paravanar River sub basin, Cuddalore District, Tamil Nadu and found that most of the quality is in poor zone. Swarna Latha and Nageswara Rao (2010) documented that most of the groundwaters were in moderately polluted to severely polluted category as revealed by the WQI studies. According to Chaudhary et al. (1996), GIS is an efficient and effective tool in solving problems where spatial data are important and it is widely used for assessment of water quality and developing solutions for water resources related problems. As the groundwater quality and the physico-chemical parameters vary with space and time, mapping it with the use of GIS provides better understanding of their distribution throughout the area. The optimum groundwater quality level of the Konya city has been studied by Bilgehan Nas & Ali Berktay (2010). Zhu et al. (2001) produced a radon distribution map using the Krigging and GIS techniques in Belgium.

The present study aims to understand the distribution of groundwater water quality in coastal regions in Injambakkam-Thiruvanmyiur areas, Chennai. The objectives of the study are to determine groundwater quality characteristics such as pH, alkalinity, electrical conductivity, chloride, hardness, total dissolved solids, dissolved oxygen and to map the spatial distribution of groundwater quality in the study area by using Quantum GIS based on Inverse Distance Weighted (IDW) interpolation techniques. In this paper, we have opted the IDW technique rather than other techniques because it is one of the commonly used techniques for interpolation of the scattered points and also more influenced by the nearby points rather than the points which lies at distant.

STUDY AREA

The study area lies between the Latitude of 12°59'017"N, 12°54'830"N and Longitude 80°15'710"E, 80°15'020"E in the south east coast of Chennai (Fig. 1). It is located on a flat coastal plain known as the eastern coastal plains. The city has an average elevation of 6 meters (20 feet), its highest point being 60 m (200 ft) (Pulikesi et al. 2005). Further south of Chennai about 7 km, Thiruvanmyiur is situated as a small town on the eastern coastal plains and Injambakkam is further north of Thiruvanmiyur about 7 km. The eastern

Table 1: Sample locations with their GPS values.

Sample ID	Type of Well	Name of the station	Latitude	Longitude
S1	Bore well	Marudu Eswar Street	12°59'017"	80°15'710"
S2	Bore well	Bharathidasan Nagar	12°59'264"	80°15'381"
S3	Bore well	Thiruvaluvar Nagar	12°59'639"	80°15'839"
S4	Bore well	R.T.O Street	12°58'297"	80°15'546"
S5	Bore well	Venkateshwara Nagar	12°57'086"	80°15'700"
S6	Bore well	Palkalai Nagar	12°57'967"	80°15'432"
S7	Bore well	Periyar Street	12°57'612"	80°15'381"
S8	Bore well	Anna Salai	12°57'406"	80°15'322"
S9	Bore well	Kabalishwarar Nagar	12°57'037"	80°15'293"
S10	Bore well	Srinivasa Nagar	12°56'649"	80°15'226"
S11	Bore well	Vetuvankani	12°56'271"	80°15'160"
S12	Bore well	Hanuman Colony	12°57'406"	80°14'967"
S13	Bore well	Rajan Nagar	12°55'749"	80°15'068"
S14	Bore well	Bethalen Nagar	12°55'284"	80°15'074"
S15	Bore well	V.G.P	12°54'830"	80°15'020"

Table 2: Standards for quality of drinking water.

Parameter	WHO (2004)	Indian Standards
pH	6.5-8.5	6.5-8.5
Conductivity	-	-
Chloride	250 (mg/L)	250-1,000 (mg/L)
Hardness	500 (mg/L)	300-600 (mg/L)
Total dissolved solids	500 (mg/L)	500-2,000 (mg/L)
Dissolved oxygen	4 (mg/L)	-
Alkalinity	-	-

boundary of the study area is about 7 km from the coast of Chennai. A backwater runs through in the middle of the study area. The area is characterized by sand dunes, underlining crystalline rock of Archaean age. The upper most formation are coastal alluvium which is few meters thick and is underlain by thick sequences of crystalline rock. During the study it is noticed that most of the dug wells are tapping groundwater from recent alluvium at a depth ranging from 0.5 m to 9.8 m.

MATERIALS AND METHODS

The present study was carried out in the east coast of Tamilnadu between Injambakkam to Thiruvanmyiur areas along East Coast Road (ECR), Chennai. A total of 15 water samples from bore wells were collected and each sample was given ID such as S1 to S15. Here S1 stands for sample number 1 and similarly S15 for sample number 15. The location of the samples are collected by using a hand-held GPS (Table 1). These samples were analysed for different parameters by following the standard methods (APHA 1998). The de-

Table 3: Results of analysed physico-chemical parameters.

Sample ID	pH	EC	TDS	DO	Alkalinity	Hardness	Chloride
S1	7.9	1828.0	1980.0	8.5	160.0	280.0	260.2
S2	7.1	1651.0	1950.0	7.5	135.0	190.0	255.2
S3	7.5	1810.0	1990.0	8.5	125.0	295.0	282.3
S4	6.8	1875.0	2100.0	7.1	155.0	475.0	279.4
S5	6.9	1810.0	2140.0	7.5	115.0	550.0	307.7
S6	7.6	1304.0	2134.0	7.2	120.0	525.0	206.5
S7	7.1	1745.0	2130.0	8.3	120.0	640.0	368.7
S8	6.1	1876.0	2140.0	7.4	175.0	590.0	265.7
S9	7.2	1887.0	2190.0	7.9	135.0	485.0	297.8
S10	6.3	6780.0	2500.0	7.4	130.0	615.0	277.0
S11	7.4	6660.0	2455.0	7.2	125.0	550.0	271.7
S12	7.9	6690.0	2230.0	6.8	135.0	540.0	257.8
S13	6.5	6480.0	2256.0	7.9	115.0	530.0	247.3
S14	6.3	6590.0	2700.0	9.0	120.0	440.0	320.0
S15	7.9	8460.0	3150.0	9.0	115.0	420.0	297.7
Min	6.1	1304.0	1950.0	6.8	115.0	190.0	206.5
Max	7.9	8460.0	3150.0	9.0	175.0	640.0	368.7
Average	7.1	3829.7	2269.7	7.8	132.0	475.0	279.7

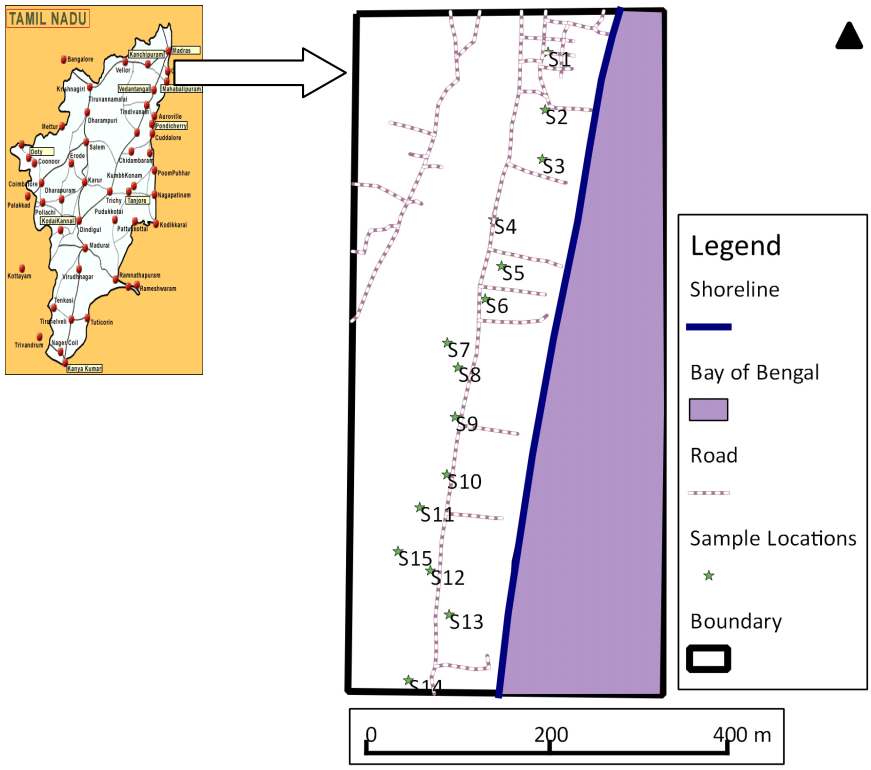

Fig. 1: Study area with sample location.

Table 4: Water quality parameters, BIS Standards and their weightages.

Parameters	V_s	V_{ideal}	Weightage(W_i)
pH	6.5-8.5	7	0.3027058
Chlorides (mg/L)	250	0	0.01
Total Hardness (mg/L)	300	0	0.0085766
Alkalinity(mg/L)	120	0	0.02144166
Dissolved Oxygen (mg/L)	4	14.6	0.64325
Total Dissolved Solids (mg/L)	500	0	0.005146
Electrical Conductivity (mmho/cm)	300	0	0.0085766

tails of the methods used in the study are given in the flowchart (Fig. 2). The current primary standards for drinking water based on WHO and the Indian Standards are given in the Table 2.

RESULTS AND DISCUSSION

Physico-chemical parameters: The analysed results of the various parameters of the study area are given in the Table 3. The most commonly measured chemical attribute of water is its acidity or pH. The pH of the samples lies within a minimum and maximum of 6.1 to 7.9 with an average of 7.4. In these samples, pH values show that some of the bore wells are acidic as well as alkaline in nature. Pure water is electrically non-conductive but groundwater invariably contains dissolved solids and thus, is conductive. Its conductivity depends on the concentration of dissolved solids. Electrical conductivity is measured using a conductivity meter and is the conductance of 1 cm of water. In the study area, the electrical conductivity ranges between 1304-8460 µS/cm with an average of 3829.7 µS/cm. Also, the electrical conductivity was found to be normal in sample S7 to S15, but the samples S1 to S6 have more electrical conductivity. The sum of all dissolved solids in a water sample is known as the Total Dissolved Solids (TDS). In the study area, the TDS ranges between 1950-3150 mg/L with an average of 2269.7 mg/L. The DO ranges between 6.8 and 9.0mg/L with an average of 7.8 mg/L. Samples S12 and S15 have the highest value of dissolved oxygen. The samples S4, S6, S9 and S13 have the lowest dissolved oxygen. In the study area, the alkalinity ranges between 1150 and 175 mg/L with an average of 132 mg/L; the samples S1, S2 and S12 have the highest alkalinity value. The samples of S4, S5, S8, S10, S14 and S15 have the lowest alkalinity value. Hardness in water is caused by dissolved calcium and, to a lesser extent, magnesium. It is usually expressed as the equivalent quantity of calcium carbonate WHO (2004). The hardness of water reflects the nature of the geological formations with which it has been in contact (Sawyer & McCarty 1978). In

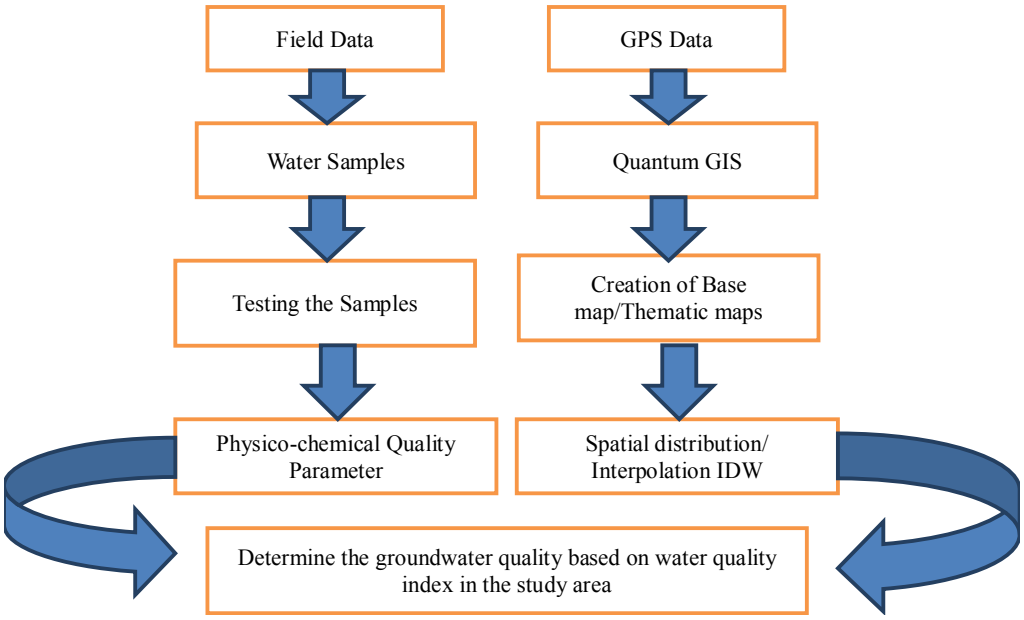

Fig. 2: Methodology flowchart showing various steps for the study.

Table 5: Calculated values of Water Quality Index.

S.No	pH	EC	Alkalinity	TDS	DO	TH	Chlorides	$\Sigma W_i \log_{10} q_i$	WQI=Antilog $[\Sigma W_i \log_{10} q_i]$
1	1.78	2.78	2.12	2.60	1.76	1.97	2.02	1.79	61.78
2	0.82	2.74	2.05	2.59	1.83	1.80	2.01	1.74	54.43
3	1.52	2.78	2.02	2.60	1.76	1.99	2.05	1.40	25.12
4	1.12	2.80	2.12	2.62	1.85	2.20	2.05	0.97	9.37
5	0.25	0.02	0.04	0.01	1.17	0.02	0.02	1.54	35.05
6	1.60	2.64	2.00	2.63	1.84	2.24	1.92	1.77	59.18
7	0.82	2.76	2.00	2.63	1.77	2.33	2.17	1.53	33.93
8	1.78	2.80	2.16	2.63	1.83	2.29	2.03	1.84	69.36
9	1.12	2.80	2.05	2.64	1.80	2.21	2.08	1.74	55.34
10	1.67	3.35	2.03	2.70	1.83	2.31	2.04	1.81	64.68
11	1.43	3.35	2.02	2.69	1.84	2.26	2.04	1.74	55.45
12	1.78	3.35	2.05	2.65	1.87	2.26	2.03	1.87	73.39
13	1.52	3.33	1.98	2.65	1.80	2.25	2.00	1.74	55.44
14	1.67	3.34	2.00	2.73	1.72	2.17	2.02	1.74	54.86
15	1.78	3.45	1.98	2.80	1.72	2.15	2.08	1.77	59.25

Table 6: Water quality index (WQI) for groundwater (Priti Singh & I.A. Khan 2011).

SNo	Water Quality Index	Description
1	0-25	Excellent
2	26-50	Good
3	51-75	Poor
4	76-100	Very Poor
5	>100	Unfit For Drinking

the study area, hardness ranges from 190-640mg/L, where, sample S2 has the lowest hardness value. The samples S7, S8 and S10 have the highest value of hardness. The other samples have a normal range of hardness value. The chloride value range in the study area is permissible. In the study area the chloride ranges between 206.5 and 368.7 mg/L with an average of 279.9 mg/L. The S6 sample has the highest contamination of chloride and S5 sample has lowest contamination of chloride. The spatial distribution

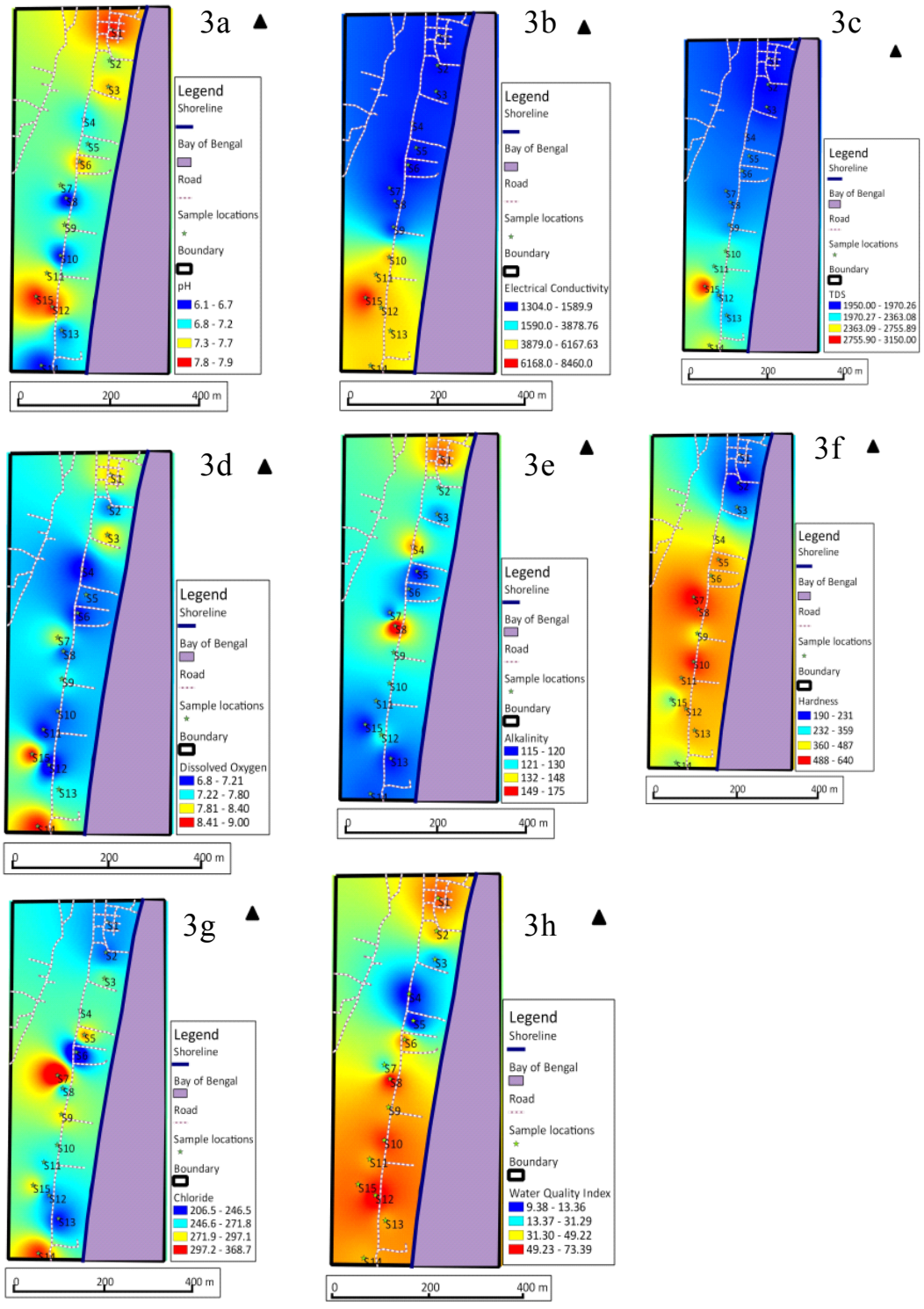

Fig. 3a, b, c , d, e, f, g: Spatial distribution of groundwater for the analysed parameters
h-Spatial distribution of groundwater based on WQI.

of the various parameters of the ground water such as pH, electrical conductivity, TDS, dissolved oxygen, alkalinity, hardness and chloride are shown in the Figs. 3 (a), (b), (c), (d), (e), (f), (g).

Water Quality Index (WQI): Water Quality Index (WQI) is defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water. Horton (1965) was first to suggest the concept of indices to represent gradation in water quality. WQI of ground waters collected at 15 different locations were calculated using the methods proposed by Tiwari & Mishra (1985). The water quality parameters, BIS Standards and the relative weightages are given in the Table 4. Table 5 shows the calculated values of Water Quality Index for each location. The spatial distribution map of groundwater quality is shown in the Fig. 3(h). The quality of the groundwater in the study is currently not bad as most of the sample locations are within the good index range of 26-50 (Table 7). Station 4 has the water quality of 9.37 which is in an excellent range. Station 12 is on the verge of good to bad range of water quality i.e. around 73.39.

CONCLUSION

From the study it is inferred that the pH in most of the well areas is in acidic and alkaline in nature. However, in most of the locations, the groundwater is suitable for drinking except one station which is on the verge of becoming contaminated. The study identifies that the saline water incursion can also be the main problem in the coastal area. From the WQI map it is clearly shown that the majority of the bore wells is poor to very poor in quality. Generally the study area is in the range of portable to the drinking water quality.

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