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Original Research Paper

Groundwater Quality Assessment in Dindigul District, Tamil Nadu Using GIS

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ABSTRACT

Groundwater is a significant source of water in many parts of India, especially in semiarid and arid regions. About 50% of the total irrigated area is dependent on groundwater. Groundwater is the major source of drinking water in both urban and rural areas. Also, it is an important source of water for the agricultural and the industrial sectors. Groundwater quality is as important as the quantity. Poor quality of water adversely affects the plant growth and human health. Hence, the demarcation of groundwater quality is of vital importance to augment groundwater resources. The present study attempts to prepare the spatial variation map of the various groundwater quality parameters for Dindigul district, Tamil Nadu using Geographical Information System (GIS). GIS has been applied to visualize the spatial distribution of groundwater quality in the study area. The major water quality parameters such as pH, total dissolved solids, total hardness, calcium, magnesium, fluoride, chloride and sulphates etc. were analysed. The final integrated map shows three priority classes such as high, moderate and poor groundwater quality zones of the study area and provides a guideline for the suitability of groundwater for drinking purposes.

INTRODUCTION

Groundwater is widely distributed and is used for domestic, industrial and agricultural purposes throughout the world. Groundwater is a valuable natural resource that is essential for human health, socio-economic development and functioning of ecosystems (Steube et al. 2009). The chemical composition of groundwater is very important criteria that determine the quality of water. Water quality is very important and often degraded due to agricultural, industrial and human activities. The quality of groundwater is getting severely affected all over India. Contamination of groundwater can result in poor drinking water quality, loss of water supply, high clean-up costs, high costs for alternative water supplies, and/or potential health problems (Balakrishnan et al. 2011). Therefore, determination of groundwater quality is important to observe the suitability of water for a particular use (Arumugam & Elangovan 2009). Groundwater quality is a continuously changing phenomenon, variation occurs with time and space, so there is a need to check and revise the water quality parameters and maps, regularly with time and space. Variation in water quality at a specific point needs an advanced system which combines the spatial data of a point to the non-spatial data of that point and then to find out variation in water quality at that specific point. Geographical Information System is the only system which handles spatial data as well as non-spatial data, analyses and manipulates the data and performs the most advanced type of planning, management and mapping (Saeed et al. 2012). GIS is used for the spatial analysis and it is a powerful tool for representation and analysis of spatial information related to water resources (Selvam et al. 2013). The present study was carried out to spatially analyse the groundwater quality parameters in Dindigul District, Tamilnadu using GIS technique. Groundwater in and around Dindigul district is polluted due to discharge of untreated effluents from 80 functional tanneries (Mondal & Singh 2010). A total of 14 groundwater samples were collected and analysed for various physicochemical parameters. The physico-chemical parameters namely pH, total dissolved solids, total hardness, calcium, magnesium, fluoride, chloride and sulphates were analysed.

MATERIALS AND METHODS

Description of the study area: The present study was carried out in Dindigul District of Tamil Nadu State. Dindigul is an interior region of Tamilnadu. It lies on the banks of Kodaganar River. The Kodaganar River originates from the eastern slopes of the lower Palani hills. The study area is situated between 10°05'N and 10°9'N latitude and 77°30' E and 78°20' E longitude. The location of the Study area is shown in Fig. 1. The total area of Dindigul district is 6114 sq. km. There has been deterioration in groundwater quality due to overexploitation, excessive agriculture and untreated domestic as well as industrial effluents. Dindigul town is

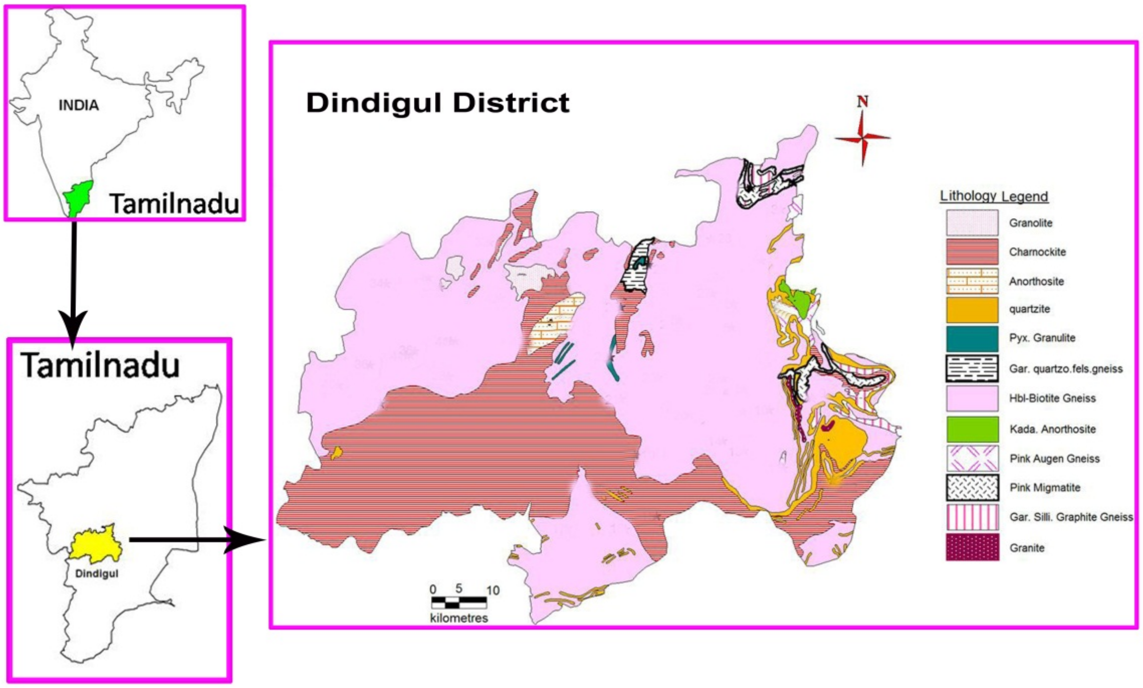

Fig. 1: Location map of study area.

located within the watershed. Dindigul is one of the important places for its tannery units (Mondal et al. 2011). It has more than 80 tannery units in and around the city and nearly 50 units are under processing of leather. It is the fact that the processing of leather requires large amount of freshwater along with various chemicals. Groundwater is the main source of drinking water in Dindigul (Mohamed Hanipha & Zahir Hussain 2013). The leather industry in and around Dindigul city pollute both surface and groundwater by discharging their wastes. The study area enjoys a tropical climate. The climate is influenced by the monsoon winds, which causes the precipitation on the study area. It has a hot summer and a mild winter. The district receives the rainfall under the influence of both southwest and northeast monsoons. The relative humidity, in general, during the year, is between 65 and 80 percent in the interior parts of the district, except during the northeast monsoon season, when it is over 80 percent. The normal annual rainfall over the district varies from about 700 mm to about 1600 mm.

Spatial analysis of groundwater quality: The primary task in groundwater quality mapping of Dindigul district is to identify regions of good, moderate and poor zones using GIS approach. The use of a GIS enables quantitative assessment of the consequences of heterogeneity in environmental systems over a broad range of spatial and temporal scales (Saro Lee et al. 2012). In spatial analysis the criteria for suitability and non-suitability of the water samples were explained. The groundwater samples, collected from 14 wells and tested for physico-chemical parameters, were compared with the water quality standards specified by the WHO and ISI. The base map collected was geo-referenced and digitized using Map Info 6.0 software and exported to Arc View 3.2a software for spatial analysis. The sample station locations and groundwater quality parameters in Dindigul district are shown in Table 1. Groundwater quality depends on various parameters such as pH, total dissolved solids, total hardness, calcium, magnesium, fluoride, chloride and sulphates etc. The above groundwater quality themes have been integrated and converted into grid with their corresponding weightage supporting groundwater quality by using Model builder option in Arc View 3.2a software. Finally, the entire model is run by using weighted overlay method.

Weighted index overlay analysis (WIOA): Weighted Index Overlay Analysis (WIOA) is a simple and straightforward method for combined analysis of multi class map. In this method, weights have been assigned to various classes of different themes like pH, total dissolved solids, total hardness, calcium, magnesium, fluoride, chloride and sulphates, according to the importance of these classes supporting groundwater quality. The weightage of each criterion was finalized on the basis of ranges of the maximum and minimum values given by the standard criteria (Lenin et al. 2008).

Table 1: Water quality details collected from the sampling stations.

Taluk	Village	Latitude	Longitude	TDS (mg/L)	Ca (mg/L)	Mg (mg/L)	Cl (mg/L)	SO_4 (mg/L)	F (mg/L)	pH	TH (mg/L)
Vedasandur	Kovilur	10°37'00"	78°05'00"	1022	56	119.00	262	48	0.78	8.2	630
Vedasandur	Landakottai	10°48'40"	78°09'50"	1189	32	77.76	418	62	1.5	8.2	400
Dindigul	Sanarpatti	10°16'53"	78°04'15"	343	30	26.73	74	14	0.63	8.2	185
Dindigul	Dindigul	10°22'30"	77°59'40"	1215	100	97.20	355	60	0.47	7.9	650
Nilakkottai	Valayapatti	10°09'28"	78°06'58"	1050	56	41.31	234	36	1.05	7.7	310
Nilakkottai	Batlagundu	10°08'58"	77°44'34"	288	48	34.02	50	5	0.32	8.1	260
Natham	Samudrapatti	10°12'30"	78°17'18"	776	44	75.33	284	22	1.18	8.2	420
Natham	Kalvelipatti	10°12'48"	78°13'02"	433	42	53.46	60	12	0.79	8.4	325
Kodaikanal	Pannaikadu	10°16'30"	77°37'33"	427	48	31.59	74	7	0.14	8.2	250
Kodaikanal	Perumalai	10°51'48"	77°32'53"	274	46	18.22	46	3	0.18	8.2	190
Palani	Melkaraipatti	10°35'27"	77°30'15"	3373	312	184.6	1290	264	0.41	8.0	1540
Palani	Thumbalapatti	10°32'02"	77°31'35"	747	72	75.33	135	19	0.79	8.2	490
Oddanchatram	Porulur	10°35'50"	77°37'42"	347	42	42.52	75	42	0.9	8.1	284
Oddanchatram	Koothampoodi	10°40'54"	77°40'50"	1283	84	46.17	255	58	0.35	8.2	400

Total weightages were divided into different potential zones such as good, moderate and poor depending on the final weight values assigned to polygons in the final layer. Based on these criteria the weightages and ranking for the major parameters are formed, which is shown in Table 2.

RESULTS AND DISCUSSION

The spatial and the attribute database generated are integrated for the generation of spatial variation maps of major water quality parameters like pH, total dissolved solids, total hardness, calcium, magnesium, fluoride, chloride and sulphates. Based on these spatial variation maps of these water quality parameters, an integrated groundwater quality map of the study area was prepared using GIS. This integrated groundwater quality map helps us to know the existing groundwater condition of the study area.

pH: pH is one of the important parameters of water and determines the acidic and alkaline nature of water. The pH of the good quality water ranges from 6.5 to 8. The spatial variation map for pH was prepared and presented in Fig. 2. It also shows that major part of study area has the pH value in the suitable range. The villages namely Pallapati, Snarpatti and Samutrapatti have the pH value in unsuitable range.

Total dissolved solids: It is essential to classify the groundwaters depending upon their hydrochemical properties based on TDS values for ascertaining the suitability of groundwater for any purpose. The TDS was classified into three ranges (0-500 mg/L, 500-1000 mg/L, >1000 mg/L). The spatial variation map for TDS was prepared based on these ranges and presented in Fig. 3. From the map it has been observed that major part of the study area has TDS values in the suitable range (500-2000mg/L). But the Western part of the district has an unsuitable range of >2000mg/L.

Table 2: Weightages and ranks assigned for different water quality parameters.

Sl.	Criteria	Parameter Range	Ranks	Weightages
1	pH	6.5 to 8	1	15%
		8 to 8.5	2	
		>8.5	3	
2	Total hardness (mg/L)	0-600	1	15%
		600-1000	2	
		>1000	3	
3	TDS (mg/L)	500	1	20%
		500 -2000	2	
		>2000	3	
4	Calcium (mg/L)	0-75	1	10%
		75 -200	2	
		>200	3	
5	Chloride (mg/L)	0-250	1	10%
		250-1000	2	
		>1000	3	
6	Fluoride (mg/L)	<1	1	10%
		>1.5	3	
7	Sulphate (mg/L)	0-200	1	10%
		200-400	2	
		>400	3	
8	Magnesium (mg/L)	0-30	1	10%
		30-100	2	
		>100	3	

Total hardness: The standard value of hardness ranges for a good quality water range is 300-600mg/L. Total hardness was classified to three ranges (0-300 mg/L, 300-1000, >1000 mg/L). The spatial variation map for total hardness was prepared based on these ranges and presented in Fig. 4. From the spatial variation map it was observed that major part of the district has suitable range (300-1000 mg/L). The most of

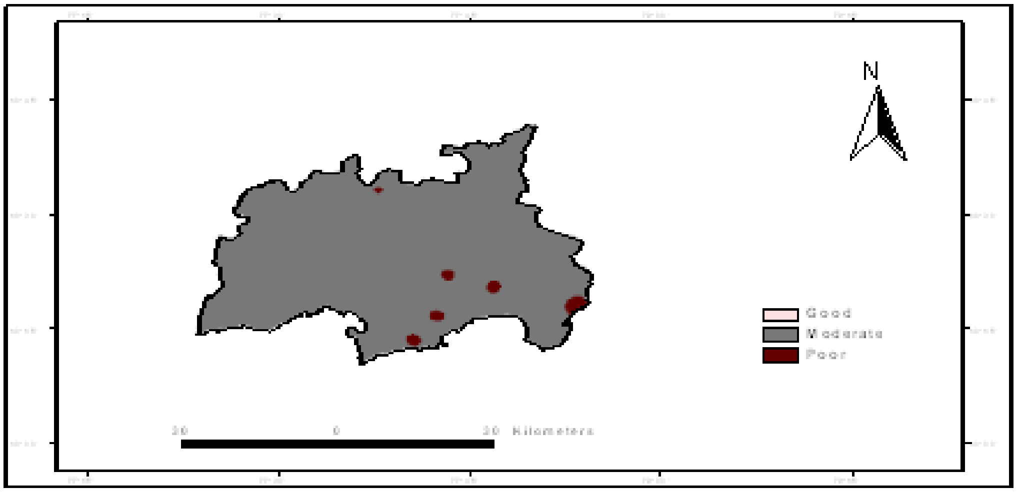

Fig. 2: Spatial variation map of pH.

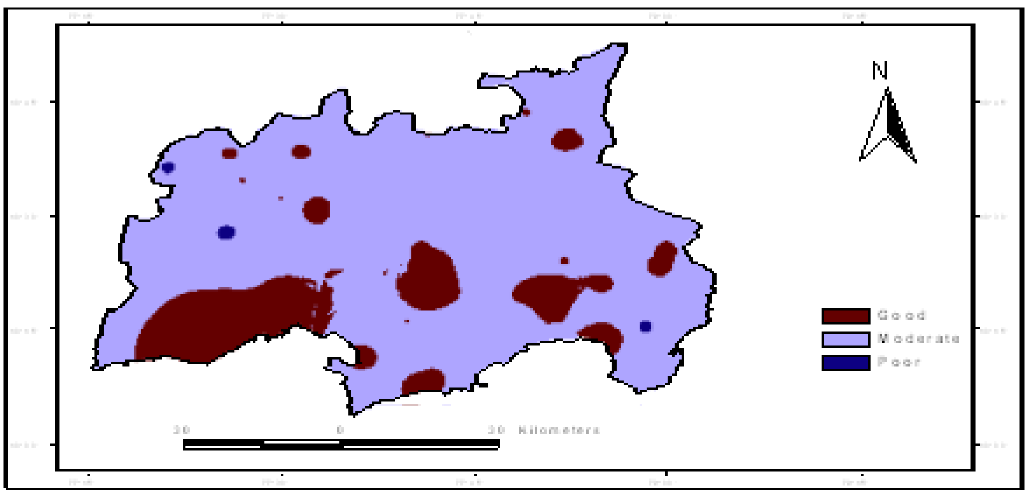

Fig.3: Spatial variation map of TDS.

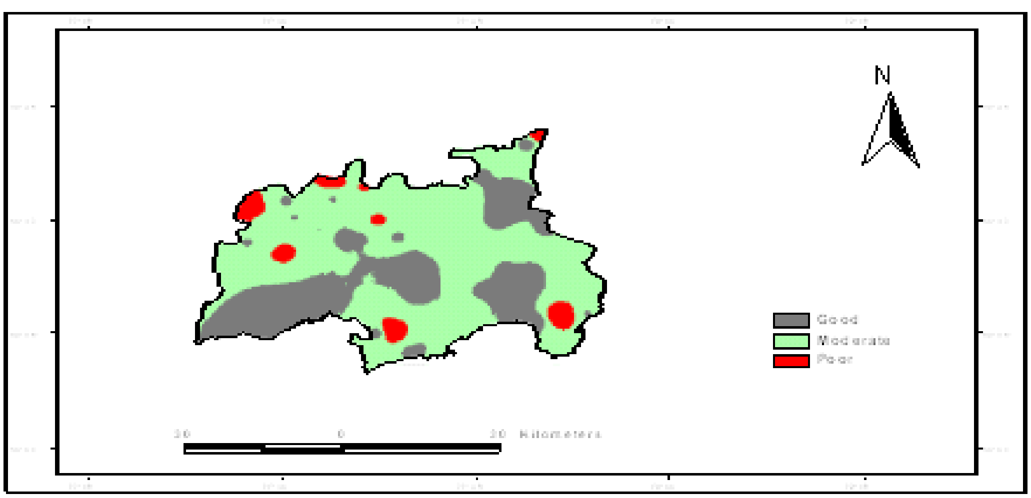

Fig. 4: Spatial variation map of Total hardness.

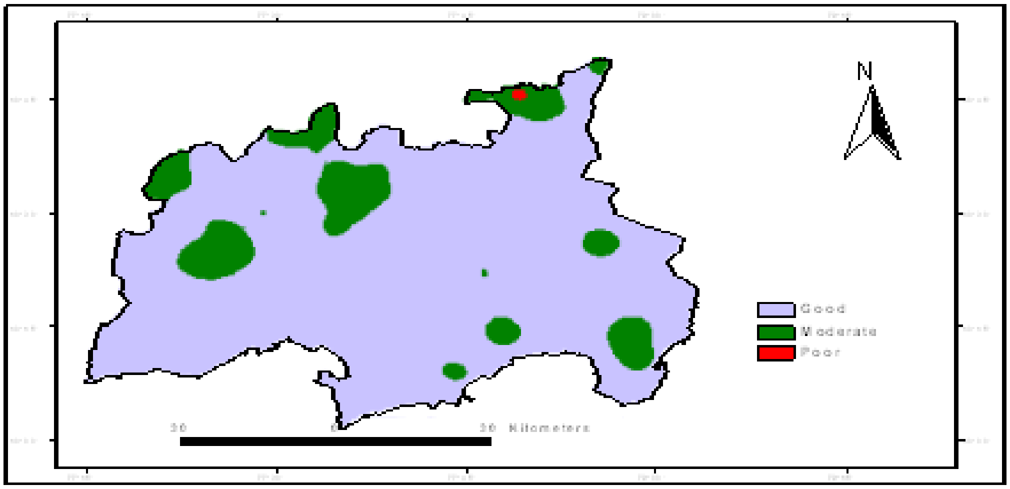

Fig.5: Spatial variation map of calcium.

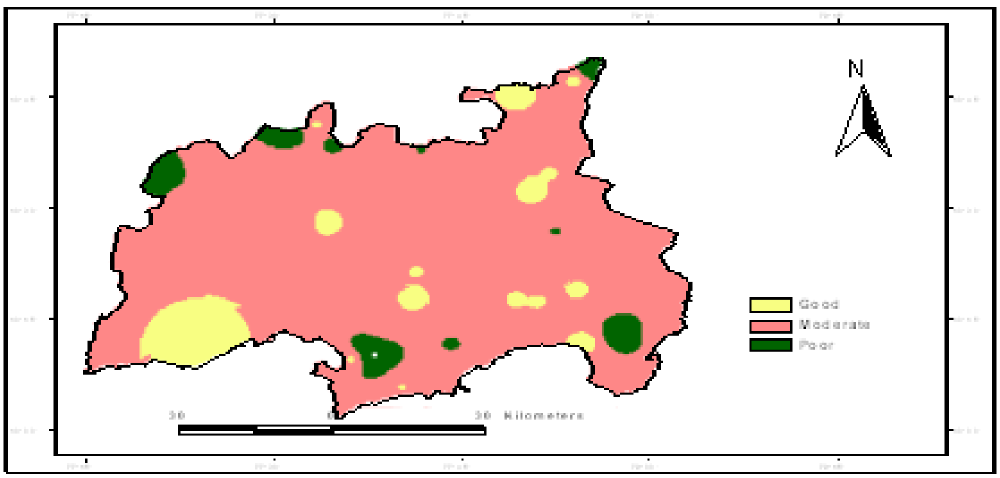

Fig.6: Spatial variation map of magnesium.

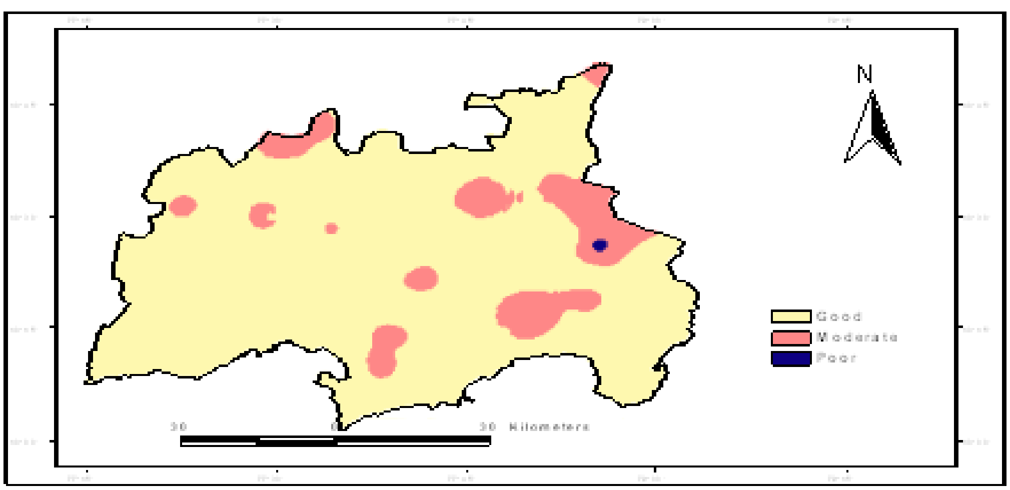

Fig.7: Spatial variation map of fluoride.

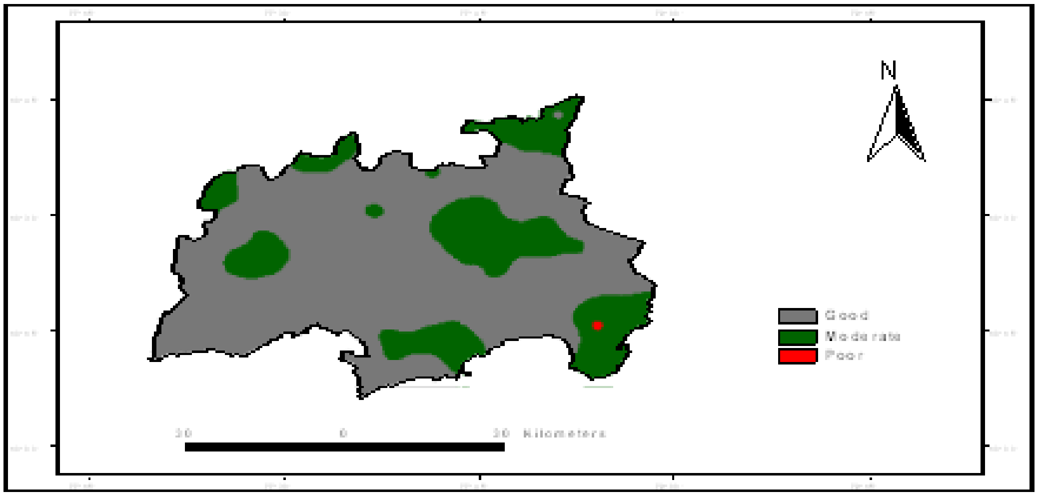

Fig. 8: Spatial variation map of chloride.

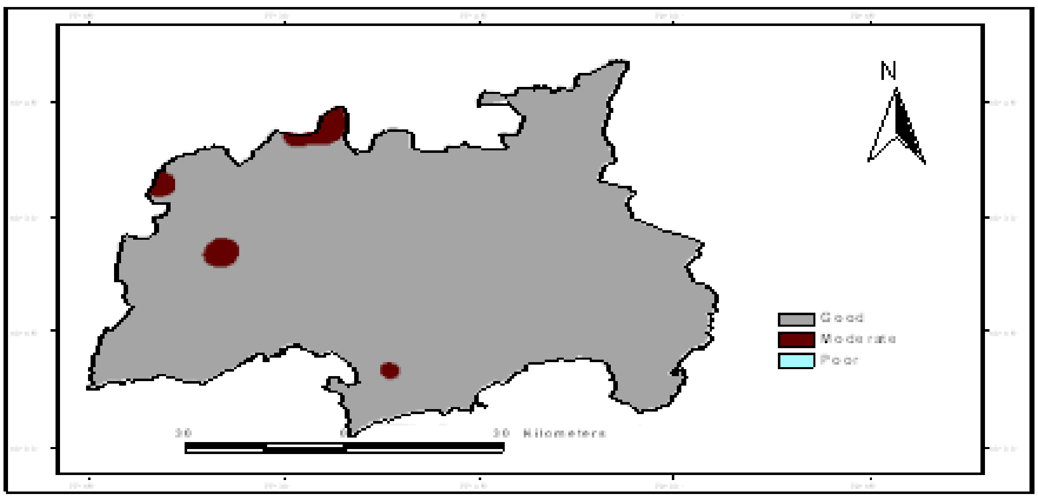

Fig. 9: Spatial variation map of sulphate.

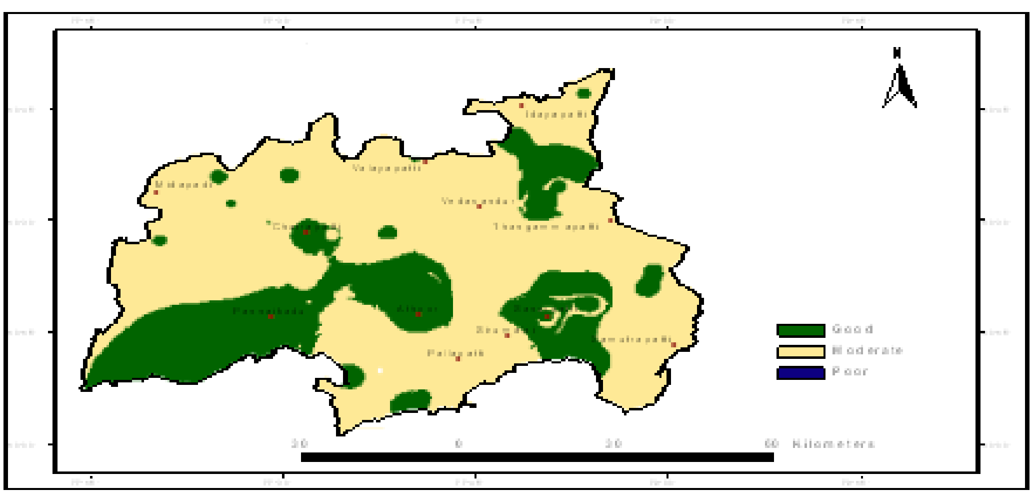

Fig. 10: Integrated groundwater quality map of study area.

the villages in Vedasandur taluk, located in northwestern part of the study area, have the unsuitable range of hardness.

Calcium: Calcium was classified into three ranges (0-75 mg/L, 75-200 mg/L, >200 mg/L) and based on these ranges the spatial variation map for calcium has been obtained and presented in Fig. 5. From the spatial variation map, it was observed that the Natham and Nilakkottai taluk have calcium values in the suitable range (0-75mg/L). It was observed that Midapati village and Ottanchatram block, located in the Western part of the study area, have the calcium value in the moderate range.

Magnesium: Magnesium is one of the abundant elements in rocks. It causes hardness in water. The spatial variation map for magnesium has been obtained and presented in Fig. 6. From the spatial variation map, it was observed that major part of the study area has magnesium value in the suitable range (30-100 mg/L).

Fluoride (F): The allowable fluoride concentrations in potable waters is 1-1.5mg/L. Concentrations higher than this can cause dental fluorosis, mild skeletal fluorosis and crippling skeletal fluorosis. Fluoride was classified to three ranges (0-1mg/L, 1-1.5 mg/L, >1.5mg/L). The spatial variation map for fluoride was prepared based on these ranges and presented in Fig. 7. It shows that major part of the study area has the fluoride value in the suitable range (1-1.5 mg/L). But the villages namely Thangammapatti and Thennampatti have the high fluoride concentration (>1.5 mg/L).

Chloride (Cl): Chloride is minor constituent of the earth's crust. Rain water contains less than 1 ppm chloride. Chloride in drinking water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt and saline intrusion (WHO 1993). Its concentration in natural water is commonly less than 100mg/L unless the water is brackish or saline (Fetter 1999). The standard value of chloride for a good quality water is 250-1000 mg/L. Chlorides can be classified into three ranges (0-250 mg/L, 250-1000, >1000 mg/L). The spatial variation map for chlorides was prepared based on these ranges and presented in Fig. 8. This figure clearly shows that the Palani and Natham taluk have good and moderate range of chloride.

Sulphates: Sulphate was classified into three ranges (0-200 mg/L, 200-400 mg/L, >400 mg/L) and based on these ranges the spatial variation map for sulphates has been obtained and presented in Fig. 9. The spatial variation map clearly shows that the study area has the sulphate value within the permissible limit.

Data integration using GIS: The spatial variation map of major groundwater quality parameters were integrated for Dindigul district and shown in Fig. 10. The groundwater quality has been classified quantitatively as good, moderate and poor depending on the final weightage values assigned to polygons in the final layer. From the map, it is evident that the most part of the study area is having moderate groundwater quality, while in the southern part of the study area the groundwater quality is in the good condition. The villages namely Thangammapatti, Pannaikadu, Athoor, Sanarpatti and Chatrapatti have excellent and good groundwater quality zones. The villages namely Vedasandur, Valayapatti, Kalvelipatti and Idayapadi have moderate groundwater quality zones. The villages namely Midapadi village of Palani taluk have poor groundwater quality zones.

CONCLUSIONS

The present study attempts to demarcate the groundwater quality zones of Dindigul district using GIS techniques. Weighted index overlay method was used to identify the groundwater quality zones. The groundwater quality of 14 wells randomly distributed in Dindigul district, Tamil Nadu was selected for the present study. The spatial variation map of major groundwater quality parameters such as pH, total dissolved solids, total hardness, calcium, magnesium, fluoride, chloride and sulphates were prepared using GIS approach. The spatial variation maps of major groundwater quality parameters were finally integrated. The final integrated map gives us the broad idea about the different quality zones. Groundwater quality maps are useful in assessing the usability of the water for different purposes. The results obtained provided the necessity of making the public, local administrator and the government to be aware on the crisis of poor groundwater quality prevailing in the area. The present study can serve as a guideline for planning future groundwater projects in the study area in order to ensure sustainable groundwater utilization.

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