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RESEARCH ARTICLE

AN INVESTIGATION OF GROUNDWATER QUALITY AND ITS SUITABILITY TO IRRIGATE AGRICULTURE IN AND AROUND THANJAVUR TOWN, TAMIL NADU, INDIA – A GIS APPROACH

***Mithra, J. and Bashkaran, R.**

Department of Earth Sciences, Tamil University, Thanjavur-613010, Tamilnadu, India

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ABSTRACT

When many people think of a water source, they think of lakes, rivers and streams; in other words, surface water. However, of all of the usable freshwater in the world, approximately 97 percent of it is groundwater. The problems of water quality have become more important than the quantity, as the environmental problems are getting more serious in different parts of the world. A number of factors like geology, soil, effluents, sewage disposal and other environmental conditions in which the water happens to stay or move and interact with ground and biological characteristics. This study is made to evaluate the status of ground water quality and its suitability to irrigated agriculture. Characterization of physio-chemical parameters of groundwater from 11 different locations nearby the small scale industries and rice mills in and around Thanjavur town have been carried out. Water quality data used in the analysis include Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH) and Sodium Adsorption Ratio (SAR). Na-Ca-Mg water types are dominant in the study area.

INTRODUCTION

Ground water is an essential and vital component of our life support system. The ground water resources are being utilized for drinking, irrigation and industrial purposes. However, due to rapid growth of population, urbanization, industrialization and agriculture activities, ground water resources are under stress. There is growing concern on the deterioration of ground water quality due to geogenic and anthropogenic activities. Residential, municipal, commercial, industrial and agricultural activities affect groundwater quality. Contamination of groundwater results in poor drinking water quality, loss of water supply, high cleanup costs, high costs alternative water supplies and potential health problems. As the inadequate quantity of surface water does not fulfill the needs of the people, the search for and exploitation of groundwater is a must and it is the main source for agricultural, industrial, drinking and domestic purposes. Water quality data are utilized in the present study to analyze the groundwater in the year 2010 during pre-monsoon season. Hydro – geochemical data are used in the analysis, including Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH) and Sodium Adsorption Ratio (SAR).

Study area

The study region contain Thanjavur town and adjacent areas which is located 300 km away from Chennai, in the Cauvery Delta Zone of eastern part of Tamilnadu, India (Fig. 1).

***Corresponding author: Mithra, J.** Department of Earth Sciences, Tamil University, Thanjavur-613010, Tamilnadu, India.*

Though most of Thanjavur District is a level plain, watered by the Cauvery and tributaries, the taluk of Thanjavur is made up mostly of barren uplands sloping towards the east. To the south of Thanjavur town, the Vallam tableland, a small plateau interspersed at regular intervals by ridges of sandstone. The study area extends between North latitudes 10º 35' 0"- 10º 50' 0" N and east longitudes 79º 0' 0" – 79º 10' 0" E with an altitude of 59 m. The total population in the study area is about 2, 90,732 (Census of India 2011). The Cauvery delta zone has a tropical climate, and the average annual rainfall is 1,114mm. The average temperature varies between 36.6°c and 32.5°c in summer and between 25.5°c and 22.8°c during winter, respectively. The most important economic activity of this region is agriculture, and the major crops are paddy, sugarcane, coconut, plantain, etc. The irrigation system is mostly feed by the groundwater as well as the canal system (Grand Anicut Canal) in this study area. It consists of grand and upper anicuts across the Cauvery River.

MATERIALS AND METHODS

The location were identified which were used for drinking, household and agriculture purposes and the places where small scale activities are done. The ground water samples from the sampling locations were taken during the running of the Motor pumps in the bore well locations, open well samples was taken in the early morning from the sampling locations. The samples were stored in the pre-cleaned polythene bottles with air tite cap. Collected samples were transported to laboratory within few hours. Groundwater samples were analyzed based on standard methods (CHEEPO) and (WHO). The analyses were

carried out in the Regional Water Testing Laboratory, TWAD Board, Thanjavur. GIS software package Arc GIS 9.2 is used to map and analyze the data for the evaluation of groundwater quality.

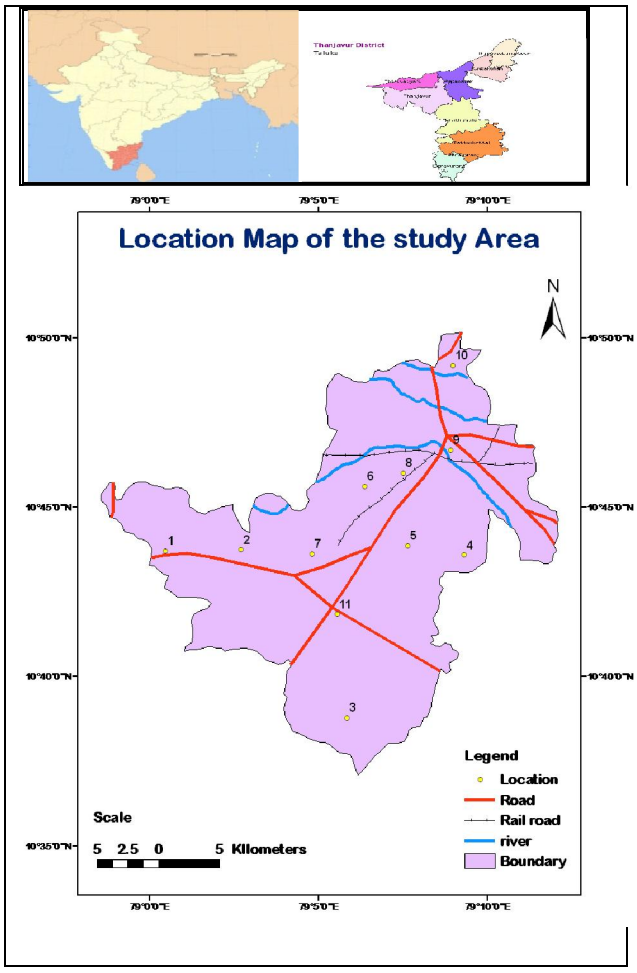

Fig. 1. Location map of the study area

RESULTS AND DISCUSSION

The quality standards for drinking water have been specified by the World Health Organization (WHO) in 1997. It has given the permissible and desirable limits of various elements in groundwater.

Electrical Conductivity (EC)

The conductivity measurements provide an indication of ionic concentrations. It depends upon temperature, concentration and types of ions present (Hem, 1985). Most of the salts in water are present in their ionic forms and capable of conducting current and conductivity is a good indicator to assess groundwater. The EC was observed maximum in S2 location (2470), minimum in S11 location (327). The concentration of EC value depends on the basic rock type, soil and the amount of rainfall received. 5 samples indicate good category (moderately salt concentration), another 5 samples indicate permissible category (high salt concentration) and the remaining sample have doubtful category (higher salt concentration). (Figure 2) (Table1).

Table 1. Classification of Irrigation Water Based on Electrical Conductivity

Water Class	EC (micromhos/cm)	Salinity Significance
Excellent	< 250	Water of low salinity is generally composed of higher proportions of calcium, magnesium and bi-carbonate ions.
Good	250 - 750	Moderately saline water, having varying ionic concentrations
Permissible	750 - 2250	High saline water consist mostly of sodium and chloride ions
Doubtful	>2250	Water containing high concentration of sodium, bi-carbonate and carbonate ions have high PH

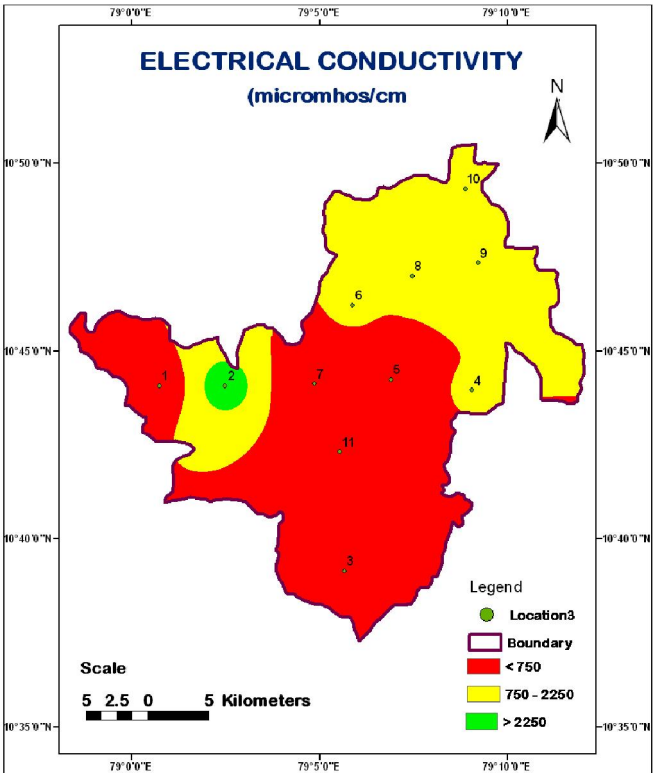

Figure 2.

Table 2. Classification of groundwater based on TDS (Davies and Dewiest 1966)

TDS	Water type	No. of samples
Up to 500	Desirable for drinking	4
500 - 1000	Permissible for drinking	5
< 3000	Useful for irrigation	2
>3000	Unfit for drinking and irrigation	-

TDS (Total Dissolved Solids)

The total dissolved solids in water ranged between 225 and 1694 mg/l. The TDS was observed maximum in S2 location (1694), minimum in S11 location (225) (Fig 3). In the classification based on Davies and Dewiest (1966), 4 samples are desirable for drinking, 5 samples are permissible for drinking and the remaining samples are useful for irrigation purposes based on TDS (Table 2).

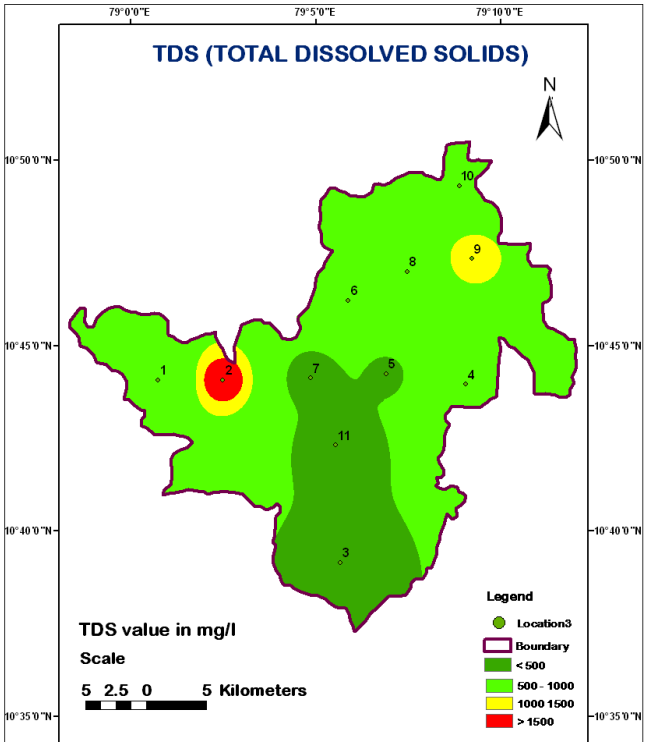

Figure 3.

Total Hardness

Hardness is an important criterion for determining the usability of water for domestic, drinking and many industrial supplies (Karanth 1987). Hardness can be classified as temporary due to carbonate and bicarbonates or permanent due to sulfate and chlorides of calcium and magnesium. Total hardness varies between 96 – 740 mg /l. The groundwater with total hardness (TH) value less than 75 mg/l is considered as soft. According to the classification using total hardness, 4 ground water samples show moderate quality, 5 samples come under hard class and the remaining samples under very hard category. (Table 3) (Fig. 4).

Table 3. Classification of the groundwater based on hardness

Total hardness (as CaCO3, mg/l)	Water classification	No. of samples
< 75	Soft	-
75 – 150	Moderately hard	4
150 – 300	Hard	5
>300	Very hard	2

Sodium Adsorption Ratio (SAR)

The Sodium Adsorption Ratio (SAR) was estimated based on the given formula

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

for the each location.

The calculated value of SAR in the study area varies between 6.3 and 42.7. The suitability of the water samples were evaluated by determining the SAR value and these were categorized into different irrigation classes based on salinity and alkalinity hazards. Sodium hazard of water classification was proposed by Richards (1954) (Table 4). In the study area 5 groundwater samples come under good water class suitable for irrigation, but 3 samples are unsuitable for irrigation.

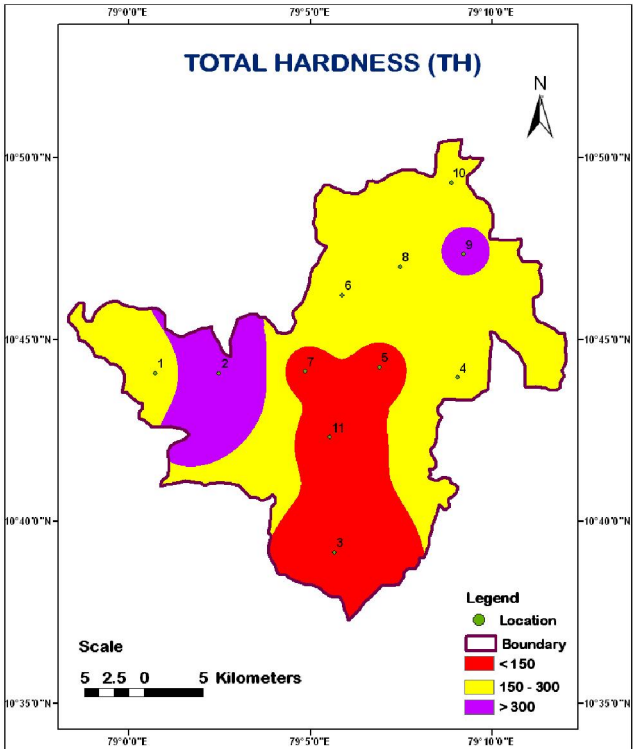

Figure 4.

Table 4. Irrigation Water Classification based on Sodium Adsorption Ratio

SAR	Water class	No. of samples
<10	Excellent	2
10 – 18	Good	5
18 – 26	Permissible	1
>26	Unsuitable	3

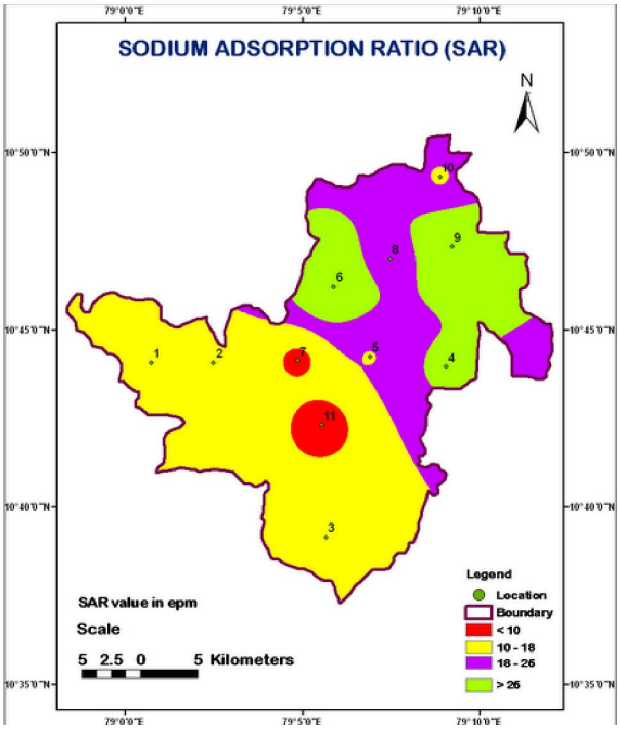

Figure 5.

U. S. Salinity Laboratory Water Classification

In the present study, specifications proposed by Kelly (1940), Paliwal (1967) and Wilcox (1955) have been used to assess the suitability of groundwater for irrigation. The values obtained for these specifications were presented in a diagrammatic form. In the diagram, 'C' denotes the level of electrical conductivity and 'S' denotes the level of sodium adsorption ratio. Electrical Conductivity in mmhos per centimetre at 25 ° C is plotted on X axis against SAR values on Y axis, Based on this, the water types have been divided into C1, C2, C3, C4 types on the basis of salinity hazard and S1, S2, S3, S4 types on the basis of sodium hazard. The analytical data use plotted on the US salinity diagram proposed by Richards (1954) (Figure 6). In the study area groundwater samples are fall in the field of C2S1, C3S1, C3S2 and C4S1 (Fig. 6) but most of the groundwater samples clustered in the field of C2S1. It shows that the field of C2S1 indicates medium salinity water to low sodium water which can be moderately suitable for irrigation purposes.

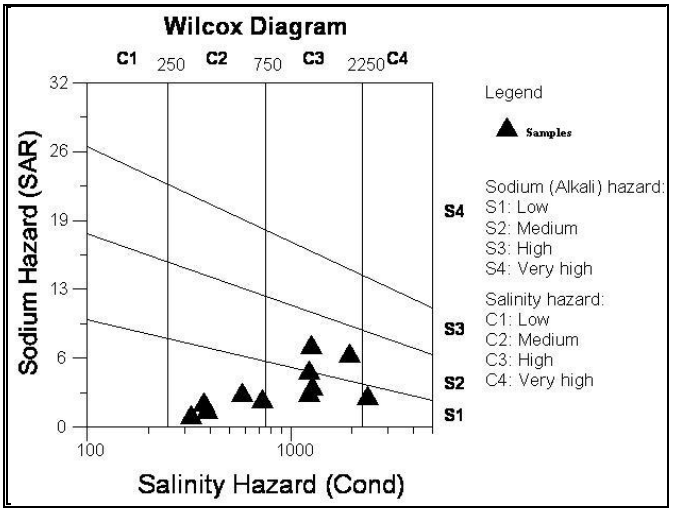

Figure 6.

Conclusion

Groundwater quality and its suitability for drinking and agricultural use in Thanjavur town and surrounding areas are evaluated. Groundwater is a major source of water for domestic, agricultural, small scale industries activities in the study site due to lack of surface water resources. EC value is very high in only one location so that this location not suitable for drinking and agriculture purpose because of high concentration of salt water. The TDS value is suitable for drinking in four locations only. In two locations, the Total hardness is very hard type and the remaining samples are moderately hard and hard type water. SAR values are unsuitable for irrigation in three locations. U.S. Salinity Laboratory diagram indicates most of the samples are moderately suitable for irrigation purposes. The highly polluted locations in the study region are the places which are adjacent to the Rice mill, Market places and Dumping of solid waste. The groundwater quality is impaired by man - made activities and also the small scale industries activities. Therefore proper and a long vision management are necessary to protect the valuable ground water resources in Thanjavur town and surrounding areas.

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