Assessment of Ground Water Quality in Thanajvur town and Adjacent areas, Thanjavur District, Tamilnadu _ India (Post-monsoon Season)

***J. Mithra 1 , R. Bhaskaran 2 and Sathis kumar 3,**
1.Research scholar,Department of Industries and Earth sciences, Tamiluniversity Thanjavur
2.Head of the Department and Guide Tamiluniversity, Thanjavur
3.Research scholar Civil Department National Institute of Technology Tiruchirappalli –15

Abstract

Groundwater constitutes about 30% of the world's total fresh water. Main source for domestic, agriculture and other activities mostly rely upon groundwater in Thanjavur town and the surrounding areas because the surface water is very minimize and the river water also available six month's only during the monsoon season. Groundwater quality in and around Thanjavur town especially adjacent to the small scale industries were analyzed. About 40 groundwater samples were collected and analyzed mostly from bore wells and few samples from dug wells in the year 2011 between February and March (ie.. post monsoon season). The parameters such as Ph, Ec, TDS, TH, HCo3, caco3, Na+, cl2+, so_4^{2+}, No_3, k^+, Ca^{2+}, Mg^{2+}, Cl^-,So_4^{2-} Fe, fluoride and Turbidity were analyzed.

NaCaMgCl and NaCaMgHco3 are major water types in the study area. Domestic activities, effluents from small scale industries especially from rice mill, wastages from fish and vegetable markets and the dumping of solid waste are the major sources causing pollution in thanjavur and the surrounding areas. Samples were analyzed with CHEEPO and WHO standards. The groundwater quality in the study site impaired by mainly due to TDS,TH, caco3,Na^+,cl2+,Mg^{2+}+,Ca^+ and Ec concentrations. 50% samples are not suitable for drinking purpose in the study site. The samples plotted in the piper diagram and the U.S.Salinity laboratory diagram were used to understand the chemical characteristics of groundwater in the study area. Therefore the study reveals that how the groundwater is contaminated by effluents from small scale industries and dumping of wastages from markets and domestic use wastages.

Keywords: Physio-chemical characteristics, Ground water quality, hydrochemical facies, Thanjavur town and adjacent areas.

I Introduction

Groundwater is an important source of water supply throughout the world. Its use in irrigation, industries and homes continues to increase in the world. Thanjavur city and the adjacent areas facing an acute shortage of good drinking water except good potable water supplied by the municipality. Generally, the concentrations of dissolved ions in groundwater are governed by lithology, groundwater flow, nature of geochemical reactions, residence time, solubility of salts, and human activities (Bhatt and Sakalani 1996; Karanth 1987; Nisi et.al. 2008; Schot and Van der Wal 1992). Moreover, the groundwater quality is mostly affected by either natural geochemical processes such as mineral weathering, dissolution/ precipitation reactions, ion exchange, or various man-made activities such as agriculture, sewage disposal, mining activities and industrial wastages etc. Low PH values can cause gastrointestinal disorder and this water cannot be used for drinking purposes (Laluraj and Gopinath 2006). TDS values are also considered as an important parameter in determining the usage of water, and groundwater with high TDS values is not suitable for both irrigation and drinking purposes (Fetters 1990; Freeze and Cherry 1979). The present study was carried out to evaluated the groundwater quality and its suitability for domestic and agriculture activities in Thanjavur town and adjacent areas in TamilNadu in India, as the groundwater is the only major source of water for agricultural and domestic purposes due to the lack of surface water and non- perennial nature of Cauvery river which is the major river in this area.

II Study area

The study region is Thanjavur town and adjacent areas which is located 300 km from Chennai, in the Cauvery Delta Zone of eastern part of Tamilnadu, India (Fig. 1). 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, is the Vallam tableland, a small pleateau insterpersed at regular intervals by ridges of sandstone. The study area extends between North latitudes 10°36' – 10°54'N and east longitudes 78°14' – 79°54' E with an altitude of 59 m, and it has an average elevation of 2 km and being developed in the adjacent villages. The total population in the study site is about 2,90,732 (Cencus of India 2011). The Cauvery delta zone has a tropical climate, and the average annual rainfall in study area is 1,114mm. The average temperature in this region 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 acitivity of this area is agriculture, and the major crops are paddy, sugarcane, coconut, plaintain, 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 anaicuts across the Cauvery River.

III Methodology

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 were 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). The analyses were carried out in the Regional Water Testing Laboratory, TWAD Board, Thanjavur.

IV Results and discussion

The analytical results of physical and chemical parameters of groundwater were compared with the standard guide line values as recommended By the WHO for drinking and public health purposes (Table.1). The concentrations of cations and anions are within the maximum allowable limits for drinking except a few samples.

V Evaluation of groundwater quality for domestic use

Hydrogen ion concentration (PH)

In the present study area the PH value ranged between 6.15 – 8.5. Normally for domestic uses, water having PH between 6 and 10 generally causes no problem. In the study area 43% of samples have acidic (<7), 43% of samples have alkaline (>7) character and the remaining samples have neutral. Groundwater with low PH values can cause gastrointestinal disorder and this water cannot be used for drinking purposes (Laluraj and Gopinath 2006).

VI Total dissolved solids (TDS)

Total dissolved solids (TDS) values are also considered as an important parameter in determining the usage of water, and groundwater with high TDS values is not suitable for both irrigation and drinking purposes (Fetters 1990; Freeze and Cherry 1979). To ascertain the suitability of groundwater for any purposes, it is essential to classify the groundwater depending upon their hydrochemical properties based on their TDS values, which are presented in (Table 3). Data shows 70% of groundwater samples in the study area representing fresh water and the remaining 30% samples representing Brackish water as per the WHO international standard. Below 500 mg/l of TDS, indicating low content of soluble salts in groundwater which can be used for drinking without any risk.

VII Total hardness

The total hardness for drinking water is specified as 300 mg/l. (ISI, 1991). The most desirable limit is 100 mg/l as per the WHO (1993) international standard. The water hardness is primarily due to the result of interaction between water and geological formations (Angino, 1983). Total hardness is varying from 42 to 740 mg/l in the study area. The table (4) shows that 12.5% of water samples fall in the category of soft, 37.5% of water samples fall in the category of moderately hard, 35% of water samples fall in the category of hard and the remaining 15% of water samples fall in the category of very hard in the study area.

VIII Evaluation of groundwater quality for agricultural use

Electrical conductivity (EC)

The conductivity measurements provide an indication of ionic concentrations. It depends upon temperature, concentration and types of ions present (Hem, 1985). In the study area measured EC values ranged from 158 to 2710 microsimens / cm in which 12.5% of water samples are representing Excellent, 40% are good, 35%are permissible and 12.5% samples are doubtful category of water classes(Table 5). The highest EC values which are classified as doubtful category are found in the areas nearer to rice mills, fish market and dumping of wastages.

IX U.S. Salinity (SAR)

While a high salt concentration in water leads to formation of saline soil, a high sodium concentration leads to development of an alkaline soil (singh, AK et al.). The sodium adsorbtion ratio (SAR) parameter evaluates the sodium hazard in relation to calcium and magnesium concentrations. The classification of water samples based SAR as per US salinity (USSL) for irrigation purpose is shown in Table 6. The United States of Salinity diagram (USSL, 1954) of the water is based on the EC and the sodium adsorption ratio(SAR). SAR can be calculated by the formula

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

In the study area groundwater water samples are fall in the field of C1S1, C2S1,C3S1, C3S2, C4S1 C4S2 and C4S3 (Fig.3) but most of the ground water samples clustered in the field of C2S1 and C3S2. It shows that the field of C2S1 indicates medium salinity water to low sodium water which can be moderately suitable for irrigation purposes and C3S2 indicates high salinity to medium sodium water type in which plants with good salt tolerance is suitable and this water may be used on organic soils with good permeability.

X Sodium Hazard:

Irrigation water containing large amounts of sodium is of special concern due to sodium is effects on the soil and poses a sodium hazard. Excess sodium in waters produces the undesirable effects of changing soil properties and reducing soil permeability. Hence, the assessment of sodium concentration is necessary while considering the suitability for irrigation. %Na was calculated by using the following formula

$$Na\% = \frac{Na \times 100}{Ca + Mg + Na + K}$$

where the quantities of all cations are expressed in milliequivalents per liter (epm).

The classification of groundwater was grouped according to percentage of sodium as Excellent (<20%), Good (20-40%), Permissible (40-60%), Doubtful (60-80%) and Unsuitable (>80%). Out of 40 water samples collected in the study area, based on percentage of sodium, 5% of the samples have good irrigation water, 42.5% of the samples have permissible irrigation water quality, 50% of samples have doubtful irrigation water quality and 2.5% of samples have unsuitable irrigation water quality (Table 7).

Magnesium ratio

It is expressed as Magnesium Ratio =

$$MR = \frac{Mg \times 100}{Ca + Mg}$$

Where all the ions are expressed in epm. Excess of magnesium affects the quality of soils which caused poor yield of crops. The magnesium ratio of gorund water varies from 22.2 to 52.9 epm. In thestudy area 95% samples have within the permissible limit but only 5% of samples have more than the permissible limit. High Mg ratio is due to surface water and subsurface water more reacted and passage through the limestone (Pandiyan et al., 2007).

XI Corrosivity Ratio (CR)

Corrosion is an electrolytic process that takes place on the surface of the metal, which severely attacks and corrodes away the metal surface. Most of the problems are associated with salinity and encrustation problems. Water samples having corrosive ratio less than 1 is considered to be non corrosive, while the value above 1 is corrosive. In the study area values indicate that 42.5% samples are non-corrosive and 57.5% samples are corrosive (Table 8).

XII Piper Trilinear classification

In order to understand the chemical characteristics of groundwater in the study region, groundwater samples were plotted in Piper trilinear diagram (piper 1944) using aquachem software (Fig.2). The piper trilinear diagram combines three area of plotting, two triangular areas (cations and anions) and an intervening diamond shaped area (combined fileld). Using this diagram water can be classified into different hydrochemical facies. It is evident from the majority of the samples of the study area belong to Na-Ca-Mg-Cl-Hco3 type followed by Na-Ca-Cl-Hco3. Few samples also belong to Na-Cl-Hco3 and Na-Ca-Mg-Hco3 hydrochemical facies in the study area.

XIII Conclusion

The results of groundwater investigation shows that the TDS values ranges from 111 to 1862 mg/l. and 28 locations have fresh water. As far as the PH value is concern, 85% of samples have either acidic (<7) or alkaline (>7) character and the remaining samples have neutral. The Total hardness exceeded the permissible limit only in 6 sampling points out of 40 in the study region. As far as the Ec concentration is concern, only 12.5% samples (5 locations) are representing the doubtful category. U.S. Salinity diagram shows that the field of C2S1 indicates medium salinity water to low sodium water which can be moderately suitable for irrigation purposes and C3S2 indicates high salinity to medium sodium water type in which plants with good salt tolerance is suitable and this water may be used on organic soils with good permeability. The data shows that Na% is doubtful irrigation water category in 20 locations (50%) and only one sampling location (2.5%) having unsuitable irrigation water category. Magnesium ratio value indicates that most of the samples (95%) are not harmful for irrigation. From the observations 23 locations have a corrosivity ratio of more than 1 in the study area. For cation concentrations, sodium type of water is predominated and the remaining is no dominant type. For anion concentrations, Cl- Biocarbonate type of water is predominated and the remaining is no dominant type.

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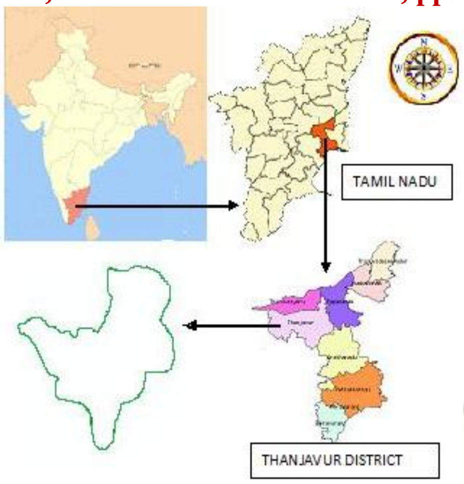
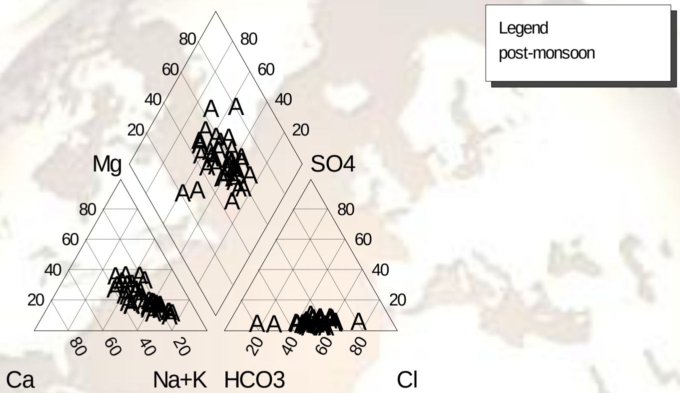


Location map of the study area Fig (1)

Fig (2) Piper Trilinear Diagram



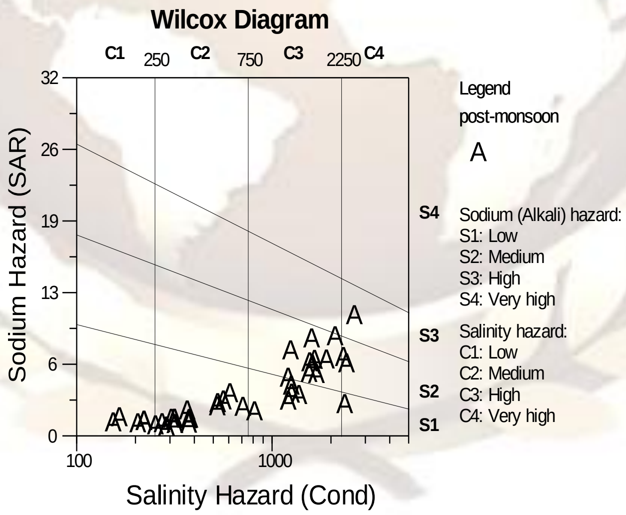


Fig (3)

Table 1. Drinking water specifications of the study area in comparisonwith WHO and CPHEEO (Central Public Health & EnvironmentalEngineering Organisation) Standards minimum,maximum,and mean ion concentration

Parameter	ph	tds	EC	Hco_3	Mg^{+2}	TH	Ca^{+2}	Na^+	K^+	No_3^-	Cl^-	F	So_4^{-2}	Po4
Minimum	6.15	111	158	20	3	42	8	18	1	0	0	0	0	0
Maximum	8.5	1862	2710	600	82	740	160	430	4	20	500	0.9	0.95	0.95
Average	7.02	697.4	1006.2	244.8	20.6	193.4	43.1	128.3	2.47	6.77	161.6	0.14	22.8	0.154
WATER QUALITY STANDARDS (maximum permissible limit)	6.5-8.5	2000	-	600	150	600	200	-	-	100	1000	1.5	400	-

Table 3: Nature of groundwater based on TDS values

TDS (mg/l)	Nature of water	Percentage of wells	Total no. of wells
<1000	Fresh water	70%	28
1000-10000	Brackish water	30%	12
10000-100000	Saline water	Nil	Nil
>100000	Brine water	Nil	Nil

Table 4: Classification of groundwater based on hardness

Total hardness as CaCo3(mg/l)	Water class	% of samples	Total no. of wells
<75	Soft	12.5%	5
75-150	Moderately hard	37.5%	15
150-300	Hard	35%	14
>300	Very hard	15%	6

Table 5: Quality of Groundwater based on Electrical conductivity

EC (micro mhos/cm)	Water class	% of samples	no. of wells
<250	Excellent	12.5	5
250-750	Good	40	16
750-2000	Permissible	35	14
2000-3000	Doubtful	12.5	5
>3000	Unsuitable	Nil	Nil

Table 6: Suitability of groundwater for irrigation based on SAR

SAR	Water class	No. of wells	% of samples
0-10	Excellent	15	34.88
10-18	Good	7	16.27
18-26	Fair	5	11.62
>26	Poor	13	30.23

Table 7: Suitability of groundwater for irrigation based on percentage sodium

%Na	Water class	No. of wells	% of samples
<20	Excellent	Nil	Nil
20-40	Good	2	5
40-60	Permissible	17	42.5
60-80	Doubtful	20	50

>80	**Unsuitable**	**1**	**2.5**

Table 8: Corrosivity Ratio of Groundwater

Corrosivity Ratio (CR)	**Water class**	**Post-monsoon**	
		No. of wells	**% of samples**
Below 1	**Non-corrosive**	**17**	**42.5**
Above 1	**Corrosive**	**23**	**57.5**