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International Journal of Recent Scientific Research

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 8, Issue, 1, pp. 15346-15351, January, 2017

Research Article

GROUNDWATER QUALITY STUDIES FOR DRINKING AND IRRIGATION PURPOSES IN THE THANJAVUR DISTRICT, TAMIL NADU – AN GEOMATIC BASED APPROACH

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ARTICLE INFO

Article History:

Received 06th October, 2015
Received in revised form 14th November, 2016
Accepted 23rd December, 2016
Published online 28th January, 2017

ABSTRACT

Groundwater Quality identification in the shallow aquifer of Thanjavur district, regions based on the physicochemical parameter such as EC, pH, Ca, Mg, Na+K, CO_3, HCO_3, Cl, SO4 and TDS were demarcated the chemical features such as RSC, SAR, PI, MR, NCH, CR, Gibbs1, Gibbs2, CAI1, CAI2, NA%, TH were found different zones for irrigation, industrial and agricultural purposes were identified for further groundwater resource development. Water samples have collected 50 locations at various level such as bore and open wells and analyzed physiochemical parameters. Most of these samples are found to be drinking, irrigation, agricultural purposes and a few locations are found to be not suitable for domestic purposes. Out of 50 samples there are 5-10 samples are not suitable for drinking purposes remaining all locations well suited for irrigation and agricultural purposes.

INTRODUCTION

Groundwater is vital role of all human being particularly man across the world wide. Drinking water essential to life over the globe. It is formed in the form of aquifers, which are rocks that have the capacity of both storing and transmitting groundwater, in significant quantities (Todd, 1980).

Study area

The district and adjoining area Thanjavur is located between N $10^{0}8'0''$ to N $10^{0}48'0''$ and E $79^{0}9'0''$ to E $79^{0}15'0''$. The city is an important agricultural centre located in the Cauvery Delta and is known as the "Rice bowl of Tamil Nadu". Thanjavur district covered a total geographical area of 3602.86 Sq.Kms.

The principal reasons affecting the groundwater quality locals are over exploited, sand quarry, increases of population densities, recharges of subsurface drainages and unlimited of fertilizers to agriculture and allied fields and during the rainy seasons salty affected lands water intruded in surrounding areas.

Geology

The Geological formation of the Thanjavur district is made up of Cretaceous, Tertiary and Alluvial deposits and the major area is occupied by the Alluvial and Tertiary deposits. The Cretaceous formations occur as a small patch west and south - west of Vallam. In these formations have a very thick lateritic cap, consisting of impure lime stones and sand stones of silt, clay calcareous and argillaceous variety. In the coast, these formations are overlain by Cuddalored sand stone of Tertiary age. The Cuddalore sand stone of Tertiary age are well developed as best seen west of Grand Anaicut Canal and near Orathanadu. These sand stones are covered by a thin layer of wind blown sandy clays, unconsolidated sand, clay bound sands and mottled clays with the lignite seams. This tertiary formation is invariably capped by laterite. In the east, the alluvial deposits of the river Cauvery and its tributories lie over the Tertiary sand stone. They consist of sands, gravelly sands, clays and sandy clays. The thickness of these formations ranges from 30m to 400m.

Hydrogeology

Groundwater occurs under water table conditions exists semi-confined nature and groundwater exploration/exploitation through medium-deep tube wells and shallow circular wells. The water table various from 3-13m during pre monsoon periods whereas the static water ranges from 15-75m during the peak most of the irrigated land/agricultural lands cultivated mainly rivers like Cauvery is the most important river in the district and the tributaries of Cauvery, i.e. Coleroon river, Koraiyar river, Ariyar, Malattar channel, Uyyakondan channel

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also drain in this district. During non season periods area will be cultivated through artificial wells.

MATERIALS AND METHODS

A total fifty groundwater samples were collected in one-lier plastic containers in January 2014. Thirty five samples were collected from deep wells while the remaining fifteen samples were taken from shallow circular wells. Sensitive parameters such as pH, temperature and Electrical Conductivity (EC) and TDS were determined in the field. Standard laboratory methods were used for the determination of other biological, physical and chemical characteristics of the groundwater. The water samples were analyzed for different parameter like EC, pH, Ca, Mg, Na+K, HCO_3, Cl, SO_4, NO_3, F and TDS by adopting ISI standard and WHO procedures.

RESULTS AND DISCUSSION

Groundwater Chemistry

The summary of the results of the analysis of the hydrochemical parameters is presented in Table 1. It can be observed from the table that the pH in all the groundwater samples ranged from 7.08 to 8.7, with a mean of 7.89 indicating an alkaline condition. The pH values are all within the prescribed WHO (1993) limits of 6.5 to 8.5 for portable water. Table 1 also shows that the total hardness varied between 120mg/l and 5239mg/l, with a mean of 499mg/l, indicating that the groundwater in the study area is hard. TDS varied from 346 to 896 mg/l, with a mean of 621 mg/l. Groundwater containing TDS (>1000mg/l) may cause laxative and constipation effects.

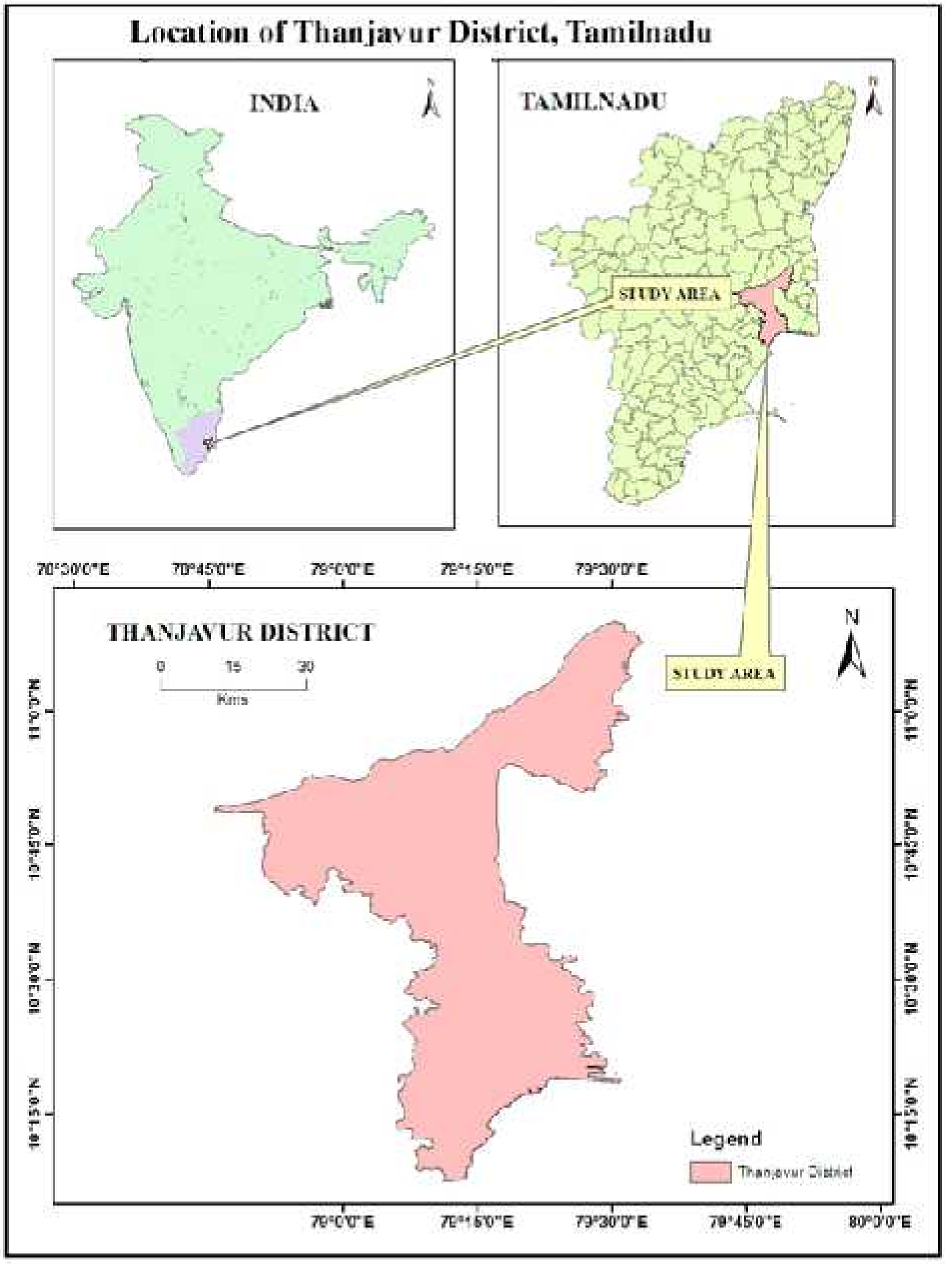

Fig.1 Location map of the study area

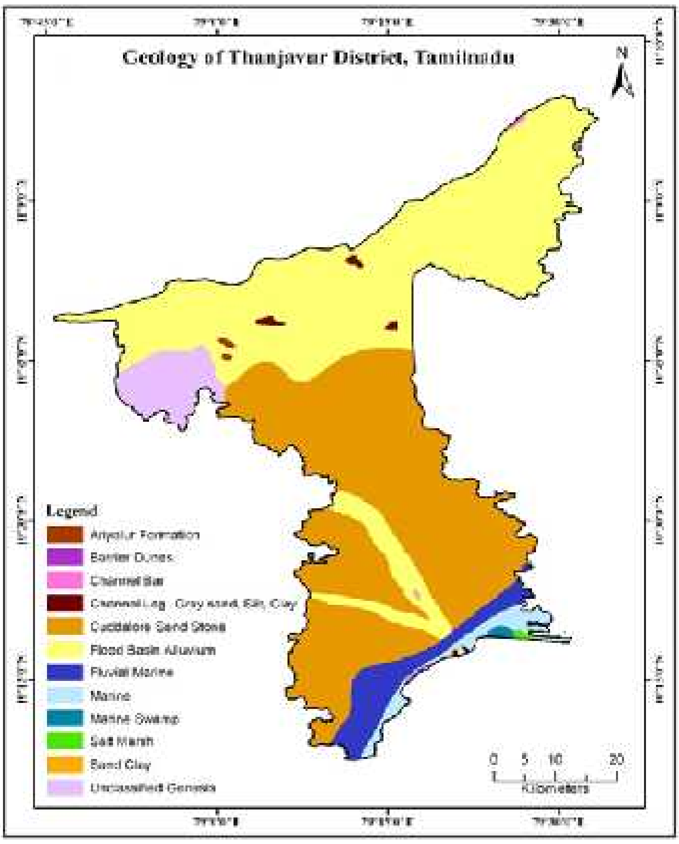

Fig.2. Geology map of the study area

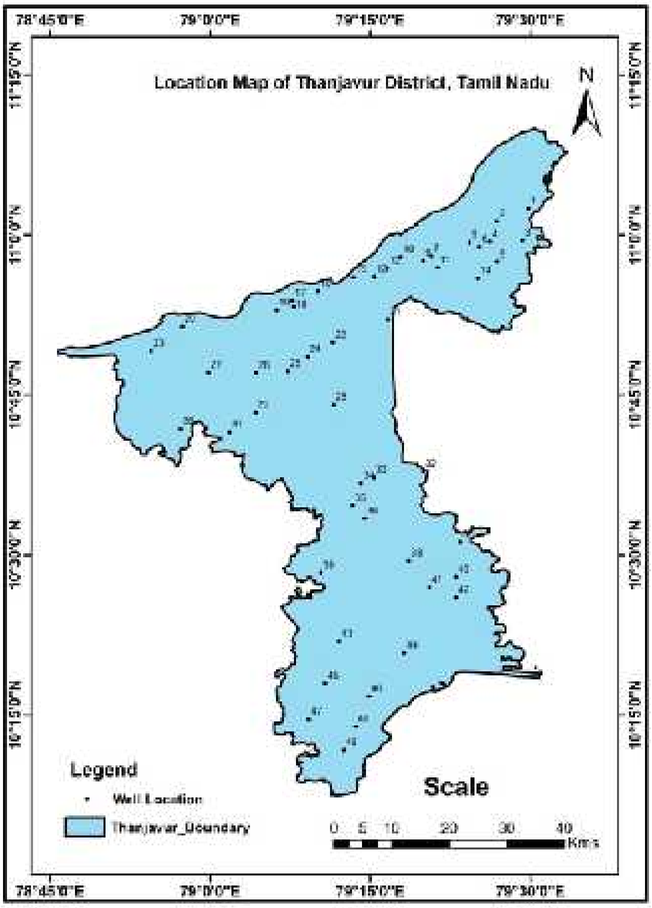

Fig.3. Well location of the study area

Table 1 Shows Geochemical Parameters of Thanjavur District, Tamil Nadu (in ppm)

Well No	Village	EC	pH	Ca	Mg	Na + K	HCO3	Cl	SO4	TDS
1	Kanjanur	1130	7.68	120	84	125.06	129	128	113	723
2	Govindapuram	1180	7.84	125	81	124.08	132	129	120	755
3	Paruthikudi	950	7.89	125	82	112.08	121	106	96	608
4	Thirupuvanam	1280	7.58	136	89	129.11	129	124	132	820
5	Manancheri	840	7.96	119	84	109.06	136	115	113	538
6	Ammachathram	1360	7.96	142	85	125.19	135	118	125	870
7	Baburajapuram	870	7.98	120	87	118.07	132	119	104	557
8	Aduthurai	1190	7.88	127	82	136.09	138	132	129	762
9	Swamimalai	1220	7.87	116	80	103.06	156	124	108	781
10	Thirumandankudi	880	7.26	125	69	118.09	116	116	89	563
11	Tharasuram	1250	8.06	118	81	103.11	112	124	81	800
12	Sundaraperumal Kovil	1330	8.24	128	89	105.09	132	122	89	851
13	Kapisthalam	940	7.49	118	67	116.12	136	113	81	602
14	Karuppur	860	7.82	119	89	116.08	129	119	108	550
15	Mettutheru	1220	7.57	116	64	125.14	126	118	86	781
16	Ganapathiagraharam	1360	7.21	118	68	117.13	106	120	87	870
17	Thingalur	750	8.48	118	82	119.12	129	128	98	480
18	Thirupazhanam	980	8.26	125	89	115.08	119	126	89	627
19	Thiruvaiyaru	1260	8.11	116	84	118.06	136	123	79	806
20	Veeramankudi	1520	7.69	116	59	120.08	129	126	82	973
21	Thirukarukavur	1250	8.26	128	72	108.12	124	118	87	800
22	Neithalur	1280	8.11	136	78	125.13	123	116	92	819
23	Ammanpettai	1400	8.72	124	78	113.08	129	111	82	896
24	Thittai	1360	8.06	120	79	110.08	116	119	89	870
25	Kezhavasal	1270	8.18	113	83	120.11	125	124	75	678
26	Palliagraharam	1250	7.96	108	72	110.07	132	124	84	800
27	Karanthai	1380	8.16	119	84	112.12	128	127	88	550
28	Soorakkottai	1290	7.82	149	85	154.07	152	152	109	698
29	Pillayarpatti	1220	8.12	128	89	116.06	136	128	98	525
30	Sengipatti	1120	8.24	118	86	118.18	122	120	83	717
31	Vallam	1190	8.21	116	82	113.13	118	119	80	762
32	Okkanadu Kezhayur	860	7.26	116	56	112.12	115	106	96	550
33	Muthukudikadu	1060	7.08	120	54	110.09	134	125	79	678
34	Pottalankudikadu	820	7.12	114	87	113.16	124	120	81	525
35	Kovilur	760	7.2	106	62	107.13	118	112	84	486
36	Kavarapattu	540	7.19	125	96	116.1	89	96	85	346
37	Vuthukuruchi	740	7.54	118	69	82.12	139	128	70	474
38	Karambayam	960	7.22	109	68	79.12	149	120	72	614
39	Thenmandalakottai	810	7.16	110	63	89.16	152	126	75	518
40	Veppankulam	970	7.46	110	62	81.08	143	129	74	621
41	Aathikottai	940	7.49	115	64	85.15	152	114	76	602
42	Kasangkadu	1090	7.59	118	89	115.09	118	124	98	698
43	Thiruchitrambalam	960	7.68	115	82	113.12	136	120	84	614
44	Kuruchi	870	7.48	116	85	116.1	125	119	90	557
45	Kalagam	1160	7.81	116	80	110.1	128	124	82	742
46	Kuruvikarambai	940	7.96	136	87	136.19	159	154	108	781
47	Punavasal	1220	7.59	113	87	114.09	119	116	83	781
48	Manakkadu	1360	7.64	142	88	135.06	156	142	112	717
49	Karambakkadu	1230	7.84	148	83	120.16	149	153	102	691
50	Kodivayal	970	7.84	152	82	124.05	158	149	106	678

Hydrochemical Facies

Ca-Mg-HCO3 Facies

This facies is described as earth alkaline water and it constitute about 70% of the total facies types in the area. It is typical of the deltaic basement complex environment with little or no mixing (Amadi, 1987 and Nton *et al*. 2007). It reflects the earliest phase of evolution of groundwater system and depicts groundwater of recharge zone. Tijani (1994) and Nton *et al*. (2007) reported that the chemical composition of this facies is due to the dissolution of silicate minerals (feldspar) in the bedrock and alumino silicate (andalusite) in the weathered regolith.

Na-K-HCO3 Facies

This facies constitutes about 10% of the total facies types. It is an alkaline water type and is usually referred to as exchange water because of the geochemical evolution through exchange process (Loehnert, 1970 and 1973; and Nton *et al*. 2007). The presence of appreciable amount of clay material (as cation exchanger) in the overburden unit and the apparently high residence time of flow promoted the active cation exchange and reaction, as represented in equation (1).

$$1/2Ca^{2+}\text{-}HCO_3 + Na\text{-}X \rightarrow 1/2Ca^{2+}\text{-}X_2 + NaHCO_3$$

(X-clay materials as cation exchanger)

Ca-Mg-Cl-SO$_4$ Facies

The facies falls within the alkaline earth water and constitutes about 10% of the water types. It is typical of the deltaic basement complex areas with limited groundwater mixing (Amadi, 1987; Nton *et al*. 2007). Sulphate and chloride are constituents of atmospheric precipitation (Davies and Dewiest, 1966), hence this facies is influenced by precipitation as well as dissolution of silicate minerals in the bedrock and aluminosilicate minerals in the weathered regolith (Tijani, 1994 and Nton *et al*., 2007) which releases the Ca^{2+} and Mg^{2+}.

Na-K-Cl-SO_4 Facies

This facies constitutes about 10% of the facies types. The occurrence of Cl^- and SO_4 reveals that this facies is influenced by precipitation, and Na and K which are released from the weathering of plagioclase from the bedrock.

Groundwater Quality for Drinking Purposes

Table 2 present a comparison of the results of the geochemical analysis of groundwater of the study area with the standard guideline values recommended by the World Health Organization (WHO, 2004) for drinking water purposes. It is observed from the Table that 15% of the samples show TDS values above the guideline value of 500mg/l while 15%, 40%, 50%, 35% and 15% of the samples are contaminated by heavy metals 100% and 35% of the groundwater samples have total hardness and NO_3 concentrations respectively above the stipulated guideline values.

Table.2 WHO International Standard (2004) have evolved a set of specification for water to be used for drinking purpose and these are presented in Table and compared with the analyzes samples.

Constituents	Limits of general acceptability	Allowable Limit	Analyzed samples Range
Dissolved solid (mg/L)	500	1500	474-896
pH	7-8	0.5-9.2	7.08-8.7
Chloride (mg/L)	200	600	96-154
Magnesium (mg/L)	50	150	54-96
Calcium (mg/L)	75	200	106-152
Total Hardness (mg/L)	300	600	346-896

Groundwater Quality for Irrigation Purposes

Sodium Adsorption Ratio (SAR) and Electrical Conductivity (EC)

Table.3. Groundwater quality

Water quality index	Range of values measured (mg/l)	Mean (mg/l)	WHO (1993) guideline value (mg/l)	No.of samples above the stipulated value
TDS	480 -896	688	500	
Total Hardness	0.01-1.8	0.905	100	
SO_4	132-70	101	250	

The sodium adsorption ratio (SAR) parameter evaluates the sodium hazard in relation to calcium and magnesium concentrations. SAR values ranged from 1.2 to 2.49. Values greater than the indicate groundwater is unsuitable for irrigation purposes (Vasanthaviger *et al*. 2010). There are unsuitable as sources of water for irrigation. According to the U.S. Salinity Laboratory Staff (1954) classified irrigation water according to SAR and EC as the indices of dissolved solid concentration. U.S. Salinity Laboratory diagram are could be seen from this figure .4. Most of the samples are falls under the C_3S_1 class (90%). Eight percent of water samples falls under C_2S_1. Remaining classified as C_1S_1 (2%) and C_4S_1 (2%).

Sodium Percentage (Na%)

Sodium in soils is considered vital for determining groundwater suitability for irrigation purposes because sodium reacts with soil to reduce its permeability and support little or no growth (Vasanthaviger *et al*. 2010). Sodium salts in soil, besides affecting the growth of plants directly, also affect soil structure, permeability and aeration which directly affect plant growth (Singh *et al*. 2008).

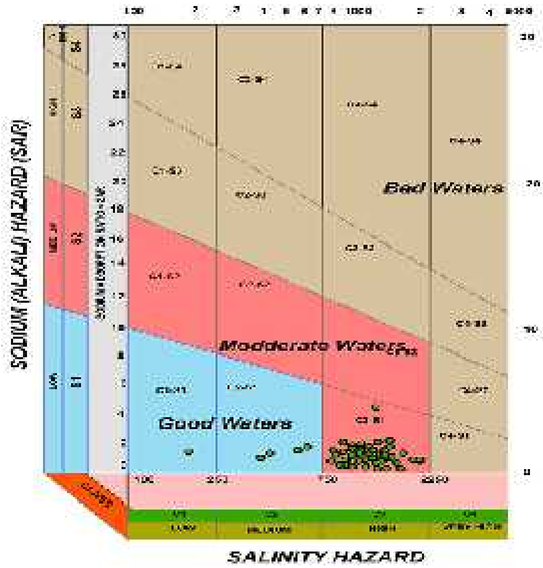

Fig.4 U.S.Salinity Classification of Groundwater for Irrigation (USSL, 1954) of the Study area

The Na% in the area ranged from 11.6% to 33.61%. The fifty samples of Groundwater respectively are suitable for irrigation purposes. The plot of Na% against EC (Wilcox, 1995) shows that the ground waters are of good to permissible quality Fig.5.

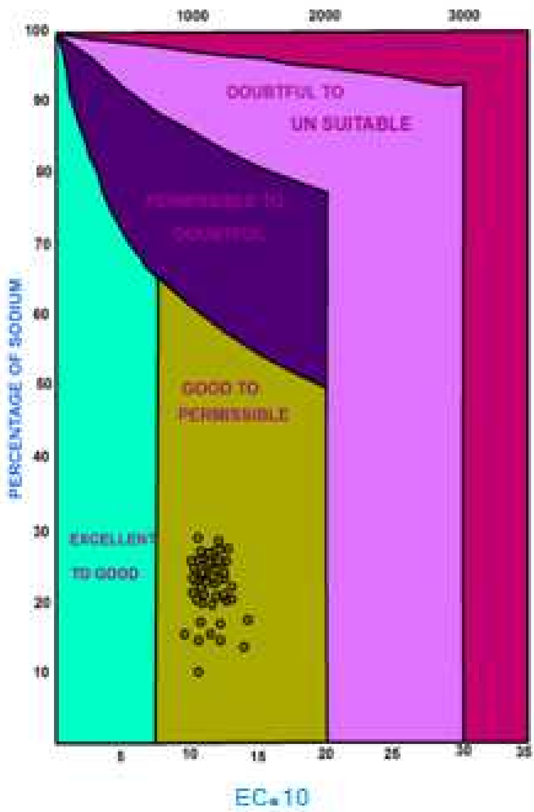

Fig.5 Wilcox (1995) diagram for the study area.

Table.4 Irrigation water quality parameters

Well No	SAR	NA%	Mg hazard (%)
1	2.14	29.66	53.57
2	2.13	39.7	51.66
3	1.13	11.6	18.19
4	2.11	28.45	51.88
5	1.86	26.94	53.78
6	2.04	27.86	49.68
7	1.83	24.46	62.24
8	2.31	31.14	51.56
9	1.61	22.6	62.24
10	2.11	30.13	47.64
11	1.78	26.29	53.11
12	1.74	24.99	53.39
13	2.11	30.71	48.33
14	1.8	24.29	62.25
15	2.32	32.98	47.64
16	1.2	20.52	48.73
17	2.05	29.07	53.4
18	1.92	27.04	53.98
19	1.99	22.75	37.37
20	1.11	19.42	45.62
21	1.89	27.62	48.13
22	2.12	29.17	48.59
23	1.9	28.06	50.91
24	1.91	21.7	52.04
25	1.9	25.89	62.26
26	2.01	29.73	52.38
27	1.92	27.49	53.78
28	2.49	31.69	48.47
29	1.93	29.91	53.39
30	2.01	28.39	54.59
31	1.96	28.18	53.83
32	2.14	31.9	44.31
33	2.09	31.46	42.61
34	1.66	32.91	49
35	2.04	30.97	44.84
36	1.9	26.31	55.87
37	1.48	24.05	31.64
38	1.46	23.75	31.12
39	1.67	26.61	36.21
40	1.53	24.99	33.3
41	1.57	25.15	33.57
42	1.95	27.56	37.9
43	1.97	28.26	54.04
44	2	28.3	39.46
45	1.92	27.91	38.7
46	2.24	29.8	51.32
47	1.96	33.61	55.94
48	2.19	29.05	50.52
49	1.75	26.86	48.02
50	2.01	27.35	47.06

CONCLUSIONS

The chemical composition of the groundwater of the study area is strongly influenced by the effective weathering of igneous and metamorphic rocks underlying the study area, along with anthropogenic activities like domestic wastes, automobile emission and phosphate fertilizers in the urban environment. The water is generally hard and contaminated by heavy metals and ions of health concerns, making it unsuitable for drinking and for use for domestic purposes. 30%, 70% and 10% of the groundwater samples fall within the medium, high and low salinity hazard respectively while Wilcox classification showed that the groundwater ranged from doubtful to excellent for irrigation uses.

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How to cite this article:

Shanthi, D and Sankar, K.2017, Groundwater Quality Studies for Drinking and Irrigation Purposes In the Thanjavur District, Tamil Nadu – An Geomatic Based Approach. *Int J Recent Sci Res.* 8(1), pp. 15346-15351.