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Research Paper

GROUND WATER QUALITY STUDY OF LOWER THRUMANIMUTTAR SUB BASIN NAMAKKAL DISTRICT TAMILNADU

Environmental Science

KEYWORDS : Groundwater, Hydrogeochemistry,Irrigation, salinity, Wilcox, USSL, SAR, Lower Thirumanimuthar, Sub basin, Tamilnadu.

Vignesh.J — Department of Applied Geology & Applied Geophysics, Indian School of Mines, (IIT-Dhanbad)

S.Kanagaraju — Department of Applied Geology & Applied Geophysics, Indian School of Mines, (IIT-Dhanbad)

S.Mohan — Department of Applied Geology & Applied Geophysics, Indian School of Mines, (IIT-Dhanbad)

A.Manikandan — Department of Applied Geology, Indian School of Mines, (IIT-Dhanbad)

INTRODUCTION

Water is considered by many as the 'Elixir of life', and it has been becoming the 'liquid gold' to be ' mined' for the very survival of our human race in as much as the surface (river, stream, and lake) and sub-terranean (ground water) water. Groundwater is the water found underground in the cracks and spaces in soils, sand and rocks. It is stored in and moves slowly through geological formation of soil, sand and rocks called aquifers. Groundwater plays an important role in human development (Industries, domestic supply and agriculture) and is an important resource in the world (Ayazi et al., 2010; Manap et al., 2012, 2013; Neshat et al., 2013; Pradhan, 2002). There has been a tremendous increase in the demand for fresh water due to growth in population and climatic change.

Groundwater geochemistry always contains small amount of different elements dissolved in it. The kind and quality of these elements depend upon the source for recharge of the groundwater, atmosphere, surficial environment, soil and strata (Suresh et al., 2010). Groundwater tend to have much higher concentrations of most constitutes than to surface waters, and deep groundwater that have been in contact with rock for a long time tend to have higher concentrations than shallow and or young waters. It is converted to divide dissolved constitute into major components cations (sodium, calcium, magnesium & potassium), anions (bicarbonate, chloride & sulphate) and the trace elements (Si, Fe, B, Sr, Ba, Fe, Ci, Al, Sc, Mn, Cu, Zn, As). These constituents are typically present at concentration in the range of a few mg/l to several hundred mg/l (Tahoora et al., 2010).

Agricultural, urban and industrial wastes are increasingly threatening groundwater quality, which is likely to become more serious issue then the quality in coming years. Considering the seriousness of the groundwater contamination and groundwater quality along the study area (Lower Thirumanimutharu) has been done by above mentioned chemical parameters and GIS based study (spatial distribution maps and multiple thematic maps.

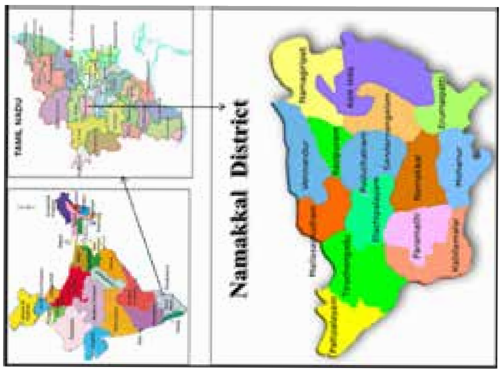

Fig.1. Study area of Lower Thirumanimuthar sub-basin

STUDY AREA

The study area falls within the geographic co-ordinate of The Namakkal District lies in the interior of Tamilnadu between the North Latitudes 11°00'00" to 11°36'10" and East Longitudes 77°40'00" to 78°30'00".Toposheet is derived from the Survey of India(SOI) topographical maps bearing no 58E/11, 58E/14, 58E/15, 58E/16,58I/2, 58I/3, 58I/4, 58I/6, 58I/7 and 58I/8 in 1:50000 scale. The Tirumanimuttar river is one of the minor tributaries of river Cauvery.Fig.1

The Tirumanimuttar rise in the southern flank of Shevaroys Hills and Manjavadi Ghat, and flows towards the North East of Namakkal . After it is flowing through Namakkal districts nearly 102 km it confluences with the river Cauvery at Kooduthurai in Paramathi Taluk of Namakkal district. The Tirumanimuttar has 14 small tributaries, of which 10 located in Salem and 4 are in Namakkal district. The following are the name of tributaries Ponniyar, Kannimarodai, Varattaru and Rajavaikkal.

MATERIALS AND METHODS

A total of 30 groundwater samples were collected from open wells (Shallow depth) of various locations which are extensively used for drinking and also irrigational purpose in the Lower Thirumanimuthar Sub-basin area were collected during Post-monsoon season (2013). The locations of groundwater sampling stations are shown in Fig.2.

The analyses were undertaken within 24 hours of the sampling exercise. The parameters, such as electrical conductivity (EC), pH and total dissolved solid (TDS) were measured in the field immediately after sampling using a conductivity meter, Elico pH meter and LCD digital TDS meter tester. The bottles were rinsed using the groundwater to be sampled. The samples were taken and stored in the acid-washed polyethylene bottles (APHA, 2005). The bottles were rinsed using the groundwater to be sampled. Also, the samples were filtered using a 0.45 m, acetate cellulose filter on site (APHA, 2005; Zealand N., 1998). The collected samples were kept at 10° C and transported to the laboratory. The samples were analysed for calcium, magnesium, potassium, sodium, bicarbonate, chloride and sulphate. The Calcium (Ca^{2}+) and Magnesium (Mg^{2+}) were determined titrimetrically using standard EDTA method, and Chloride (Cl^{-}) concentration was determined by silver nitrate ($AgNO_3$) titration (Vogel, 1968), and Sodium (Na) and Potassium (K) by Elico flame photometry (APHA, 1996) . The anions and bicarbonates (HCO3) were estimated with standard sulphuric acid. Sulphate ($SO4^{2-}$) was determined a gravimetrically by precipitating $BaSO_4$ from BaCl2. Analysed groundwater chemistry results are given in Table 1.

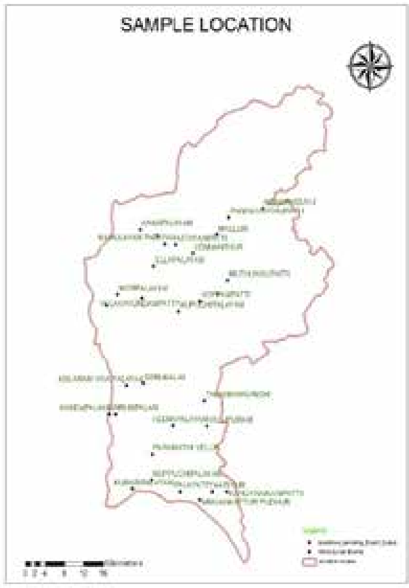

Fig.2. Sample Location

RESULT AND DISCUSSION

WATER QUALITY

The quality of groundwater is inferred through standard graphic representations as concentration of different ions in water samples. The resulting values are compared with WHO & BIS standards. The suitability of groundwater drinking and public health purpose hydrochemical parameters of the water samples are compared based on analysis of certain parameters like EC, Salinity hazard, Sodium percent and SAR value have been calculated for irrigation water quality.

CALCIUM

The limit of Ca for drinking water is specified as 200 mg/1 (WHO, 1992). In the study area, calcium was observed maximum of 408ppm at Karukkapuram and minimum at 28ppm in Pannamarathupatty. The result shows that nearly 50% of the samples are acceptable limit, 20.5% of the samples are allowable limit and 18.6% of samples are not potable. Table 2

MAGNESIUM

The maximum acceptable limit of Mg for drinking water is 50mg/1 (WHO, 1992). In the study area, the minimum Mg concentration observed in Kolaramavipalayam (5.368 ppm) and maximum is Karukkapuram (135 ppm). The result shows only 25.20% of samples are potable and other 13.82% of samples are not potable. Table 3

SODIUM

The sodium concentration was observed maximum of 920 ppm at Serukalai and minimum of 35.88 ppm at Panamarathupatty in the study area. In the study area, 81.11% of samples are potable.

POTASSIUM

In the study area, the Potassium ionic concentration found low as 4.69 ppm in Panamarathupatty where as it observed high concentration 361 ppm in Ariyur. When compare with the WHO (1993) standard, the concentration of Potassium for all the samples in the study area are within the Limit.

CHLORDE

The maximum acceptable limit of Cl for drinking water is 200mg/1 and maximum allowable limit is 600mg/1 (WHO,1992). The Chloride concentration was observed maximum of 831ppm at Ariyur and minimum of 28.4ppm at Muthukalipatty in the study area. In the study area 30.48% of samples are within permissible limit. Table 4.

BICARBONATE

In the study area, the minimum Bicarbonate concentration was observed of 42.7 ppm at Panamarathupatty and maximum of 815 ppm at Vallipuram.

SULPHATE

The maximum acceptable limit of SO4 for drinking water is 200mg/1 (WHO, 1992). Sulphate concentration was observed maximum of 1195ppm at Ariyur and minimum of 2.88ppm in Panamarathupatty in the study area. Table 5

MAGNESIUM RATIO (MR)

It is expressed as

$$MR = (Mg/ (Ca+ Mg))x\ 100$$

It may be described as the excess amount of Magnesium over Calcium and Magnesium amount where otherwise generally Ca and Mg will be in condition of equilibrium. Excess of Mg affects the quality of soils which is the cause of poor yield of crops. The Magnesium ratio varies from 54 to 91 ppm in the study area.

KELLEY'S RATIO (KR)

The level of sodium measured against calcium and magnesium is known as Kelley's ratio based on which irrigation waters can be rated according to Kelley (1946) and latter by paliwal (1967).

$$\text{Kelley's ratio} =(Na/\ (Ca+Mg))$$

Concentration of Sodium is irrigated waters is considered in excess and unsuitable. If it is more than one Kelley's ratio. Hence waters with Kelley's ratio of less than one are only suitable. Table 6. Kelley's ratio varies from 0 to 1.4 in the study area; hence, all the samples are suitable for irrigation, except two samples Sengattoor and Koottathupatty.

CORROSIVITY RATIO (CR)

The Corrosivity ratio is defined by the formula

$$CR= [Cl/35.5]+ 2[SO4/96]/2[HCO3+ Co3/100]$$

It denotes susceptibility of groundwater to corrosion and is expressed as ratio of alkaline Earth's to saline salts in groundwater. The effects of corrosion are losses in hydraulic capacity of pipes. The C.R values of the study area are less than 1. It is suitable for hydraulic capacity of pipes.

RESIDUAL SODIUM CARBONATE (RSC)

Residual Sodium Carbonate is defined as

$$RSC=(CO3 +HCO3) - (Ca+Mg)$$

RSC is defined as the excess of Carbonate and Bicarbonate amount over the alkaline Earth's chiefly Calcium and Mg, in excess of permissible limits affects irrigation adversely according to Eaton (1950) and Richards (1954). In the study area all the samples fall in safe category. Table 7.

WATER QUALITY BASED ON WILCOX

Wilcox proposed a classification in which percent sodium is correlated against electrical conductivity or total concentration of salts to find the suitability of water for irrigation. The chemical quality of water samples was studied from percentage of sodium is specific conductance on the Wilcox diagram. According to this classification, in the study area. Hence 57% of samples are fall in good to permissible field, 29% of samples are fall in doubtful to unsuitable field and 14% of samples are fall in unsuitable field in the study area.

WATER QUALITY BASED ON USSL DIAGRAM

U.S salinity laboratory also suggested diagram as show in fig for rating irrigation water where in the SAR is plotted against specific conductance. (EC) There are sixteen classes in the diagram. The water can affect the soil in terms of salinity hazard as low (C1), Medium (C2), high (C3), and very high (C4) similarly, hazard as low (S1), medium (S2), high (S3) and very high (S4) location of samples falling under various categories to shown in Table 8.

Based on USSL classification most of the samples are fall in the C3S1 and few sample fall in the C3S2 and C4S2 field which indicate the high salinity and alkali hazard restrict its suitability for irrigation, especially in soils with restricted drainage. In the study area 16% of samples are fall in C3S1 field of samples are fall in C3S2 5% field and 4% of samples fall in C4S2 field.

GIBB'S PLOT

Various workers have discussed mechanisms controlling the chemical compositions of water. It's well established that there is a close relationship between water composition and aquifer litho logy (Gibbs 1970). Gibbs plot distinguishes the interactions of ground water due to precipitation or rock or evaporation, which helps in understanding factors that control the chemistry of ground water. From ratio of 1) Na+K/Na+Ca+K and TDS and 2) Cl/Cl+HCO_3 and TDS. It is found that majority of the samples suggest interactions between rock and the percolating water into the sub surface.

GIBB'S PLOT FOR ANION

In the study area, Anion Gibb's plot, 79% of water samples fall under evaporation dominance. The remaining 21% of water samples fall under rock dominance. Based on Anions-Gibb's plot, in the study area percentage of water samples falling under evaporation dominance.Fig.2.

GIBB'S PLOT FOR CATION

In the study area, cation Gibb's plot, 82% of water samples fall under evaporation dominance. The remaining 18% of water samples fall under rock dominance.Fig.3.

Based on cation Gibb's plot, in the study area percentage of water samples falling under evaporation dominance.

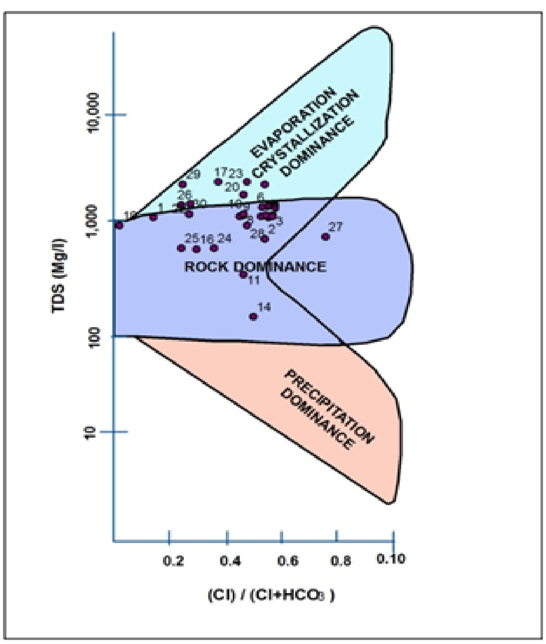

Fig.2 Gibb's plot for anion

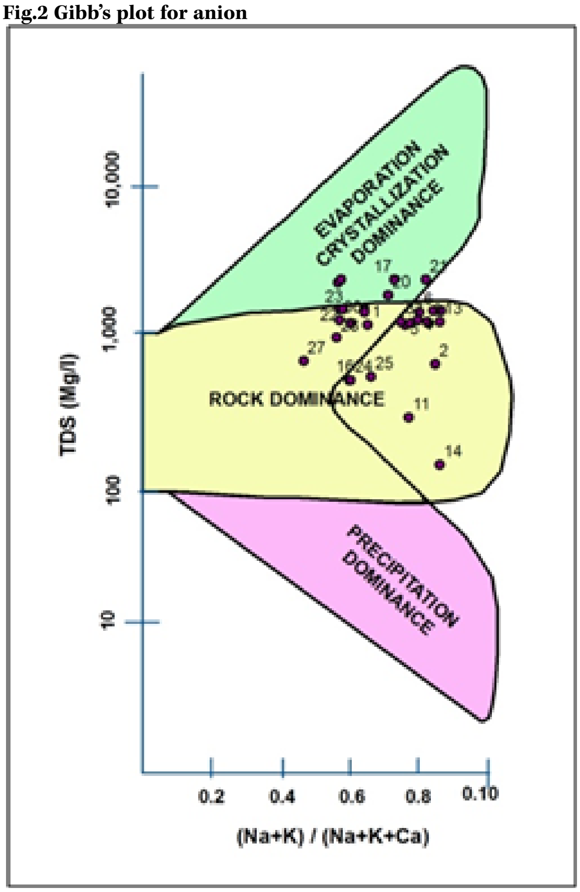

Fig.3 Gibb's plot for cation

HYDRGEOCHEMICAL FACIES

Hydrogeochemical facies are distinct zone that have cation and anion concentration describable with in defined composition categories (freeze et al 1979). The evolution of water and relationship between rock types and water composition can be evaluated by the trilinear piper (1983) diagram Figure (4.13.)

In figure the lower left ternary cation ternary, compresses the cation composition and similarly, the lower right ternary on anion ternary contrasts the anion composition. The cation and anion fractions.

Five distinct types of water have been identified on trilinear diagrams (Piper, 1994; Hills, 1940; Bach 1966)

There are

1 Ca-Mg –HCO3
2 Na-CL
3 Ca-Mg- So4
4 Na-Hco3
5 Mixed type (Ca-Mg-Na-K-Cl- So4-Hco3)

In the study area (fig. no.4.13) the Cation and anion plots indicate that most of the present samples fall in mixed type (Ca-Mg-Na-K-Cl- SO_4-HCO3) and few are falls in Ca Mg SO_4 types and one sample fall in Na-Cl type.

HYDROGEN ION CONCENTRATION (pH)

The pH is the hydrogen ion concentration, which express the intensity of acidity or alkalinity of the water. The pH value is the negative logarithm of the concentration of Hydrogen ions in moles per liter. Table 8.As per the WHO standards all the sam-

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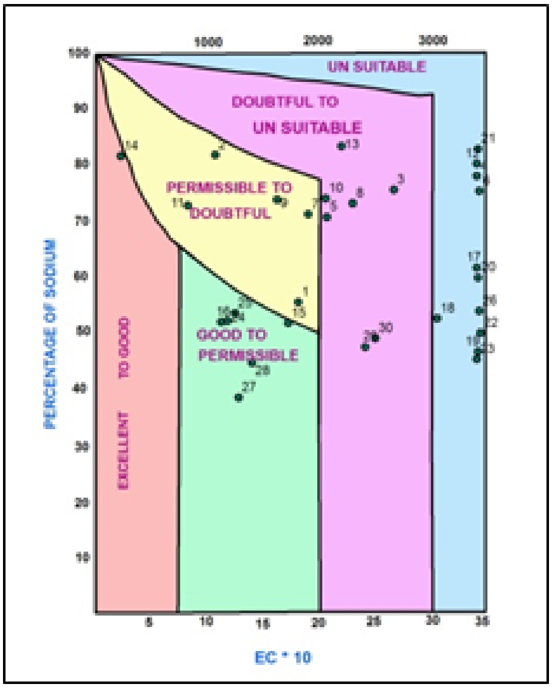
ples are falls within the recommended limit (6.5 to 9.5) for human consumption. In the study area, pH was observed the minimum pH value ranges from 6.73ppm Aravankatturpudhur and the maximum pH value ranges from 8.40 ppm at Paramathivellur.

BASED ON EC (Wilcox, 1955)

The conductivity measurements provide an indication of concentration. The maximum limit of EC in drinking water prescribed is 1500 /Cm (WHO, 1993).

In the study area 11 sample locations are shown permissible quality, 5 sample locations are show doubtful quality and 1 sample locations shown good water quality. The sample locations codes are given below (Table 10). In the study area, using GIS the distribution of EC was observed the minimum EC value ranges from 393 and the maximum EC value ranges from 7240-7400 at Attayampatty and Panamarathupatty.



PERCENTAGE OF SODIUM (Na %)

Sodium concentration is very important in classification of irrigation water because of sodium by the process of base exchanges replaces calcium in the soil which reduces the permeability of soil. The Na % (Doneen, 1962) is calculated as

Na % = (Na+ K/Ca+Mg+Na+K)x 100

The quality classification of irrigation water based on the values of Na% as proposed by Wilcox.

BASED ON WILCOX, 1948

In all natural waters present of sodium content in a parameter to assess it suitability for agricultural proposes (Wilcox,1948), Sodium combining carbonates can lead to the formation of alkaline soils, while sodium combining chloride from saline soils. Both these soils do not help growth of plants. A maximum of 60% sodium in ground water is allowed for agricultural purposes (Ramakrishnan, 1988) Table 11. In study area, was observed the minimum value ranges from 32.3at Serukalai and the maximum value ranges 73.53 Ellapalayam.

BASED ON EATON CLASSIFICATION

Based on Eaton classification (1950), in study area all the sample locations are safe quality .The sample location codes are given in the Table 12.

TOTAL HARDNESS (TH)

Hardness is mainly due to the presence of Bicarbonates of Ca and Mg ions. It is an important parameter in detection of water pollution. The presence Bicarbonates of Ca and Mg seem to cause the temporary hardness, white the permanent hardness is due to the Sulphate and Chloride.

TH= 2.497 Ca+ 4.115Mg

In study area, the total hardness are fall in the very hard quality. Table 13. In study area, TH was observed the minimum value ranges from 132ppm at Pannamarathupatty and the maximum value ranges 1440ppm at Karukkapuram.

TOTAL DISSOLVED SOLIDS (TDS)

As ground water moves and stays fix a longer time its flow path, increased in total dissolved concentrations and major ions normally occur (Norris et.al, 1992). Higher TDS shows longer residence period of water (Davis and dewiest, 1988) the samples taken from different location are mostly fall within 500 to 1500 ppm and potable for domestic use. In study area, the TDS show the samples are freshwater to Brackish water type and samples location codes are given below. Table 14

In the area, study using GIS the distribution of TDS was observed the minimum value ranges from and the maximum value ranges from 5180ppm.

SODIUM ADSORPTION RATIO (SAR)

Excess sodium in water reduces undesirable effects of changing soil properties and reducing soil permeability (Kelley, 1951). Hence, the assessment of sodium concentration while considering the suitability for irrigation. The formula is given below.

SAR= Na/ √(Ca+ Mg)/2

In study area, all the sample locations show excellent quality of water. In the study area, using GIS the distribution of SAR was observed minimum values ranges from 1.46 – 2.48ppm at and maximum values ranges from 5.58 – 13.48ppm.

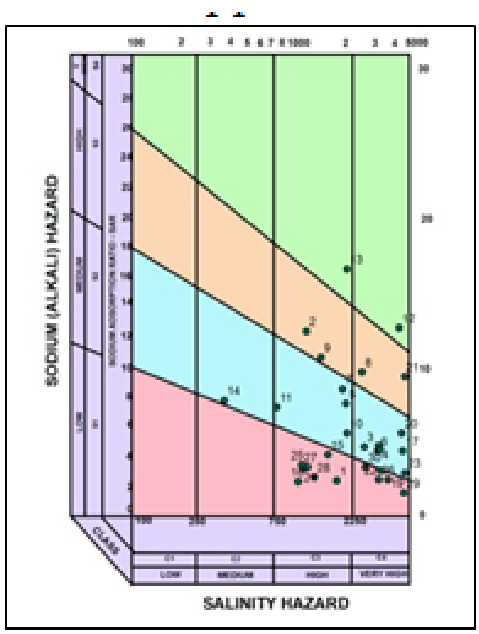


Fig.4 USSL Diagram

COLLIN' S BAR DIAGRAM

The vertical bar graph widely used in the groundwater studies for portraying chemical quality. Each analysis appears as a vertical bar having a height proportional to the total concentration of anion or cations, expressed in milli equivalents per liter (epm). The left half of a bar represents cations and the right half anions. These segments are divided horizontally to shown the concentration of major ions or group of closely related ions and identified by distinctive shading patterns.

DUROV DIAGRAM

The principle of the Durov plot is to permit the cation and anion compositions of many samples to be represented on a single graph, in which major groupings or trends in the data can be seen visually.

For the Durov plot, the cation and anion composition is considered in conjunction with a central rectangle. In addition, the Durov plot allows for the direct comparison of two other groundwater parameters, typically pH and the total dissolved solids (TDS).

The following principle ions are used in the calculations:

Cations (Positively charged)	Anions (Negatively charged)	
	Calcium	Bicarbonate
Magnesium	Carbonate	
Potassium	Chloride	
	Sulphate	

On the Durov plot, the left-hand triangle is for the cations. The calcium percentages are plotted along the top scale, following the grid lines extending in a NW-SW direction. The magnesium percentages are plotted following the vertical grid lines. The sodium plus potassium percentages are plotted along the bottom scale, following the grid lines extending in a NE-SW direction

The top triangle is for the anions. The chloride percentages are plotted along the left scale, following the grid lines extending in a NW-SW direction. The sulfate percentages are plotted following the horizontal grid lines. The bicarbonate percentages are plotted along the right scale, following the grid lines extending in a NE-SW direction. Table 16. In the study area, 54% of water fall within no contamination, the remaining water samples are within moderately contaminated.

SCHOELLER SEMILOGARITHMIC DIGRAM

In Europe, the semi logarithmic diagram developed by Schoeller is widely employed for comparing groundwater analyses. Here, the principal ionic concentration expressed in milli equivalents per liter are plotted on six equally spaced logarithmic scales. Thus straight lines join the points plotted. This graph shows not only the absolute value of each ion, but also the concentration differences among various groundwater analyses. Table 17.

Table 1. HYDROGEOCHEMICAL RESULTS OF THE SAMPLES TAKEN FROM THE LOCATIONS DURING POSTMONSOON-2013 (In epm)

S.NO	LOCATION OF SOURCE	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl
1	Kanganayakkanpatty	2.84	2.55	4.06	0.36	4.13	0	3.29	2.41
2	Ariyur	10.58	5.92	35.3	9.25	12.85	0	24.9	23.4
3	Kumaripalayam	2.25	0.98	5.91	1.02	1.83	0	4.19	4
4	Aravankatturpudhur	1.9	1.63	6.4	1.2	2.03	0	4.4	4.7
5	Palapatty	7.06	5.43	18.9	1.93	6.16	0	14	13.3
6	Kuppuchipalayam	2.2	1.48	6.33	0.72	2.09	0	4.84	3.83
7	Paramathivellur	7.27	5.72	21.36	1.59	6.42	0	18.02	11.5
8	Kandapalayam	10.67	5.75	28.2	2.13	9.5	0	23.2	14.1
9	Vallipuram	9.75	7.9	31.6	2.56	13.37	0	20.56	18
10	Thumbakurichi	2.43	1.95	7.48	0.97	2.88	0	5.97	4
11	Velakavundampatty	7.3	5.57	19.5	2.42	4.21	17.3	7.14	6.17
12	Serukalai	10.8	6.8	40	6.39	11.43	0	25.5	26.8
13	Kolaramvaavipalayam	10.7	0.44	39.13	8.95	11.05	0	25.8	22.3
14	Irumpalam	3.56	2.28	13.62	2.66	4.65	0	9.49	8
15	Koppampatty	10.82	8.59	12.54	0.91	4.18	16.9	2.21	9.3
16	Vennanthur	4.24	3.31	4.8	0.38	5.3	2.16	1.5	3.9
17	Attayampatty lake	6.2	5.57	11.65	1.12	3.81	15.5	1.04	4.14
18	Ellapalayam	10.5	10.32	15.3	1.02	4.71	19.2	3.36	9.84
19	Morpalayam	6.6	7.8	7.1	0.6	6.58	7.79	7.09	0.59
20	Kakapalayam	9.8	8.3	16.8	1.63	5.16	21	2.8	7.4
21	Veerapalayam	4.07	3.01	17.2	2.47	4.72	0	13.29	8.91
22	Chinnathampipalayam	6.8	5.9	7.6	0.6	3.4	13.9	1.06	2.4

23	Marulayampalayam	8.4	7.86	8	0.9	3.75	15.2	0.28	5.78
24	Mallur	6.2	4.5	7.3	0.4	2.9	12.1	0.79	2.5
25	Kandugula manikam	5.45	5.4	8.8	0.6	3.43	14.1	0.79	1.94
26	Muthukalipatty	2.6	1.9	3.8	0.3	1.45	5.8	0.3	0.8
27	Karukkapuram	20.4	11.14	14.08	0.97	3.91	15.8	6.28	20.8
28	Kuppuchipalayam	8.8	5.9	8.1	0.61	3.2	13.1	1.69	5.2
29	Panamarathupatty	1.4	0.87	1.56	0.12	0.7	2.9	0.06	0.31
30	Konamaduvu	6.6	4.59	7.3	0.46	3.22	13.1	0.58	2.01

Table 2 Calcium

S.No	LIMITING VALUES	POTABILITY NATURE	WATER SAMPLE LOCATIONS
1.	<75	Acceptable limit	8,9,10,11,12,13,14,16,26,29
2.	75- 200	Allowable limit	15,16,17,20,22,23,27,28,30
3.	>200	Not Potable	27,18

Table 3 Magnesium

S.NO	LIMITING VALUES	POTABILITY NATURE	WATER SAMPLE LOCATIONS
1.	<50	Acceptable limit	-
2.	50-150	Allowable limit	15,16,17,18,19,
3.	>150	Not Potable	20,22,23,25,26,27,28,29,30

Table 4 Chloride

S.NO	LIMITING VALUES	POTABILITY NATURE	WATER SAMPLE LOCATIONS
1.	<200	Acceptable limit	1,3,4,6,10,16,17,19,22,24,25,26,29,30
2.	200-600	Allowable limit	4,5,7,8,15,18,20,21,23
3.	>600	Not Potable	2,9,12,13,27

Table 5 Sulphate

S.NO	LIMITING VALUES	POTABILITY NATURE	WATER SAMPLE LOCATIONS
1.	<200	Acceptable limit	1,16,17,18,20,22,23,24,25,26,28,29,30
2.	200-400	Allowable limit	3,4,6,10,11,19,27
3.	>400	Not Potable	2,7,8,9,13,14,21

Table 6 Kelley's Ratio (RT)

S.NO	CLASSIFICATION	LIMITING VALUE	WATER SAMPLE LOCATIONS
1.	No Alkali Hazards	< 1	1-30
2.	Alkali Hazards	> 1	-

Table 7 Residual Sodium Carbonate

S.NO	WATER CATEGORY	LIMITING VALUE	WATER SAMPLE LOCATIONS
1.	Safe	< 1.25	1-30
2.	Marginally	1.25-2.50	14,23,26,28,29.
3.	Unsuitable	> 2.5	22,24,27.30

Table 8 Water Quality Based on USSL-Diagram

CATEGORY	WATER SAMPLE LOCATIONS
C1S1	1
C2S1	1
C3S1	16
C4S1	-
C4S2	4
C3S2	5
C3S3	1
C4S4	2

Table 9 Hydrogen Ion Concentration (pH)

S.NO	LIMITING VALUES	POTABILITY NATURE	WATER SAMPLE LOCATIONS
1.	<6.5	Not potable	-
2.	6.5 – 9.5	Potable	1-30
3.	>9.2	Not potable	-

Table 10 EC (Wilcox,1995)

EC VALUES	WATER SAMPLE LOCATIONS
Excellent < 250	-
Good 250 – 750	14
Permissible 750-2000	1,2,7,9,11,15,16,24,25,27,28
Doubtful 2000 – 3000	8,5,3 13,30
Unsuitable > 3000	4,6,12,17,18,19,20,21,22,23,26,29

Table 11 Na % (Wilcox,1948)

Na VALUES	WATER SAMPLE LOCATIONS
Excellent < 20	-
Good 20 – 40	5,7,8,12,13
Permissible 40 – 60	1,2,3,4,6,9,10,11,14,15,16
Doubtful 60 – 80	17,30
Unsuitable > 80	29

Table 12 Na % (Eaton, 1950)

% NA EATON, 1950	SAMPLE LOCATION CODES
Safe < 60	1 to 30
Unsafe > 60	-

Table 13 Total Hardbess

TOTAL HARDNESS	SAMPLE LOCATION CODES
Bad >26	-
Safe 0-55	-
Slightly hard 50 -100	-
Moderately Hard 101- 200	-8,9,11,29

Very Hard >200	1 – 30

Table 14 Total Dissolved Solid

TYPE OF WATER	TDS RANGE (mg/l)	SAMPLE LOCATION CODES
Fresh Water	0 – 1000	2,11,14,16,24,25,27
Brackish Water	1000 – 10000	12,17,18,19,20,21,22,23,26,29
Salt Water	10000 – 100000	-
Brine Water	>100000	-

Table 15 Collin' S Bar Diagram

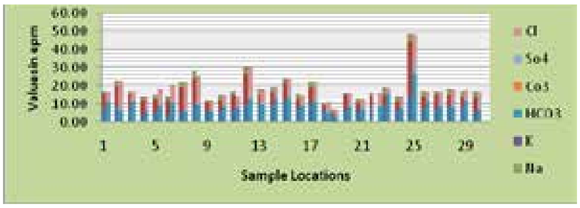


Table 16 BASED ON DUROV

S.NO	SEGMENTS	CLASSIFICATION	PERCENTAGE OF SAMPLES
1.	A	Pure	Nil
2.	B	No contamination	54%
3.	C	Moderately contamination	46 %
4.	D	Highly contamination	Nil

Table 17 Schoeller Semilogarithmic Digram

S.No	LIMITING VALUES	POTABILITY NATURE	WATER SAMPLE LOCATIONS
1.	<75	Acceptable limit	8,9,10,11,12,13,14,16,26,29
2.	75- 200	Allowable limit	15,16,17,20,22,23,27,28,30
3.	>200	Not Potable	27,18

CONCLUSION

The outcome of the research is given below.

- Geologically, the igneous and metamorphic group of rocks are occupying in the study area.
- The study area receives an annual rainfall of 785.4 mm.
- Based on the WHO limiting Standards, pH of all the samples are fall in permissible limits.
- TDS concentration are within the limiting value except four samples (irumbalam ,panamarathupatty,ariyur,mallur)
- Where as all the samples of the study area exceed the permissible limits. It may be due to the leaching of elements from the rocks
- Ca,K, SO4, and HCO3 Concentrations of the study area are observed and all the samples are within permissible limits.
- Mg and Na Concentrations of the samples are exceed limit. The high concentrations of Mg and Na in the groundwater samples is due total chemical weathering of feldspar minerals in the country rocks.
- Based on the Kelley's Ratio, SAR and RSC of the study area are occupied by the suitable groundwater for irrigational purpose.
- The general type of water was identified by plotting the analytical values in piper trilinear diagram. It shows that 67% water samples of the study area fall in the mixed type (Ca-Mg-Na-K-CI-SO4-HCo3), 23% of water samples of the study area fall in Ca-Mg-HCo3 field and 10% of water samples fall in Na-CI field. In the study area 70% of water samples of the study area fall in the mixed type (Ca-Mg-Na-K-CI-SO4-HCO3), 10% of water samples of the study area fall in Ca-Mg-HCO3 field and 20% of water samples fall in Na-CI field.
- The C.R values of the study area are less than 1. It is suitable for hydraulic capacity of pipes.
- The USSL diagram interpretation was used to understand the quality of water for irrigational purpose. In the study area, most of the sample on the C3S1 and few samples fall in the C3S2 and C4S2 field. Which indicates the high salinity and high alkali hazards.

- The Wilcox diagram interpretation was also used to understand the quality of water for irrigation proposes. In the study area 57% of samples fall in good to permissible field,29% of samples are fall in doubtful to unsuitable field and 14% of samples are fall in unsuitable field.
- From the Gibb's plot it was evidenced that the chemical constituents of water controlled by rock evaporation dominance but few samples fall in rock dominance
- From the durov diagram, 54% of samples are fall within no contamination and remaining 46% of samples are fall in moderately contamination