# CLASSIFICATION OF SIGNIFICANT SOURCE CALCULATING GROUNDWATER CHEMISTRY IN HARD ROCK REGION OF OMALUR TALUK, SALEM DISTRICT, TAMILNADU

P. Anandhan[1*], S.Chidambaram[2], R.Manivannan[1], K.Srnivasamoorthy[3]

*1Departmen of Earth Sciences, Annamalai University, Annamalai Nagar.*

*2 Research scientist, Water Research Center, Kuwait institute for Scientific Research, Kuwait.*

*3 Department of Geology Puducherry University*

## ABSTRACT

*The geochemistry of the water percolated inside the aquifer is controlled by the availability of major and minor inorganic constituents in the soil and rock through which the groundwater passes. In a Hard rock terrain like Omalur horizontal permeability is unequal to vertical permeability. Hence the time of travel and residence differ, which is responsible for the major changes in the water chemistry. The chemical concentration of different ions present in the groundwater of the study area. A total of 17 samples were collected and analyzed for major cations and anions. The analytical precision for the measurement of major ions is about ±6% to ±9%. The total cations (TZ+) and total anions (TZ") balance (Allan Freeze and Cherry 1979) shows the charge balance error (E %) percentage. The error percentage is between ±2% to ±10%. The correlation coefficient between $TZ^+$ and TZ~ is generally occurring around 0.6 to 0.9. TDS/EC ratio ranges from 0.5 to 0.8. The role played by the other ions than those studied here for the cation and anion charge balance is lesser. Hence the composition and the range values of the ions are analysed and discussed in detail. The groundwater in the study area is colorless and odorless in most of the places.*

**Keywords:** *Geochemistry, Hard rock terrain, Major ions, Minor ions, Cations, Anions*

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## INTRODUCTION

Groundwater is a major source to cover drinking and domestic needs and therefore its exploration and accessibility assumes a great significance to scientists and society. Groundwater generally occurs in the weathered basement or regolith and the fractured rock. The presence of weathered and fractured quartzites and granites, generally associated with weathered zones may enhance the chances of high yielding boreholes. In the crystalline hard rock terrain, groundwater mostly occurs in the fractured basement rock ( Srinivasamoorthy 2009 and 2010) sandwiched in between the overburden and bedrock.

A large portion of the country is underlain by hard rock. The term “hard rock” commonly applies to hard and dense rocks with the main part of the groundwater flowing in secondary structures, mainly fractures. Groundwater in hard rock aquifers is essentially confined to fractured and/or weathered horizons. Therefore, extensive hydrogeological investigations are required to thoroughly understand groundwater conditions. The main purpose of this study is thus to understand the groundwater conditions in the hard rock areas in the Omalur Taluk, Salem District, Tamil Nadu, India by utilizing more systematic methods.

## REPERCUSSION

## STUDY AREA

Omalur Taluk of Salem district is an interior part of Tamil Nadu with an area of 666.88 $Km^2$ and is bounded by Dharmapuri district in the North, Tiruvannamalai in the Northeast, Villuppuram in the Southeast, Erode in the West and Namakkal in the South (Fig.1). The Omalur taluk lies between latitudes of 11°36’21” to 11°57’43” N, and longitudes of 77°52’57” to 78°14’36” E. The Omalur taluk is well National Highway No.47 from Salem to Bangalore is crossing through the study area. Broad gauge railway lines of Salem to Mettur and Mettur to Chennai cross the study area. There are a number of small roads connecting the major highways to various villages.

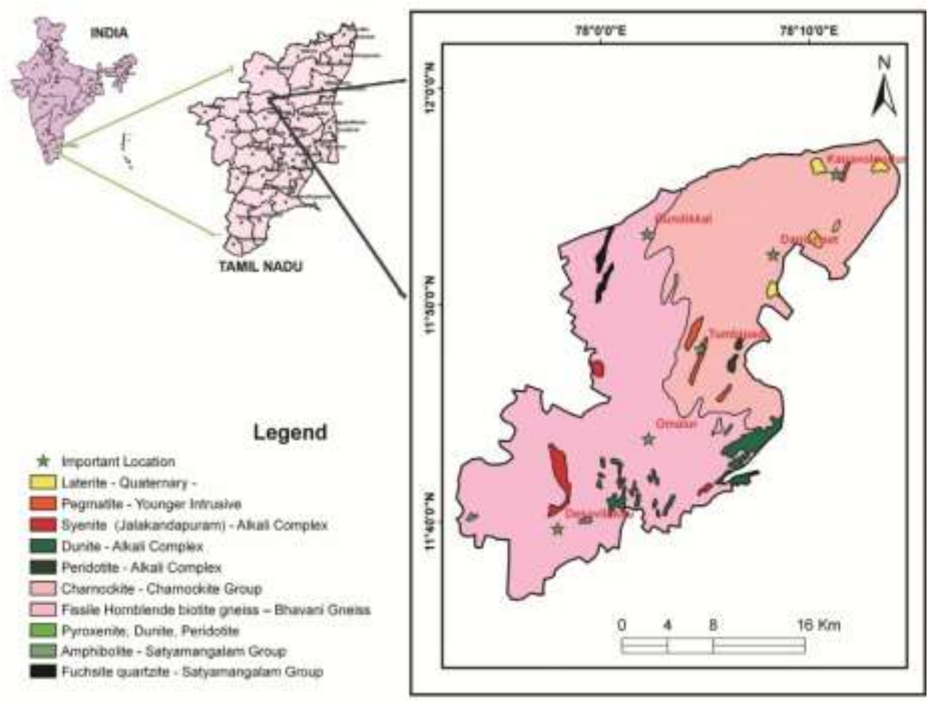


Fig.1 Location Map of the Study area.

## GEOLOGY

The Omalur taluk is characterized by fissile hornblende biotite gneiss, syenite and granite. The ultrabasic complex of this area is unique in its occurrence. The chromiferous layer ultramafic complex of dunite, peridotite, potassic members, basic granulites and magnesite occur in the NW portion of the study area (Fig.2). They occur amidst the highly metamorphosed rocks of granulite and amphibolite facies that have been subjected to repeated periods of deformation.

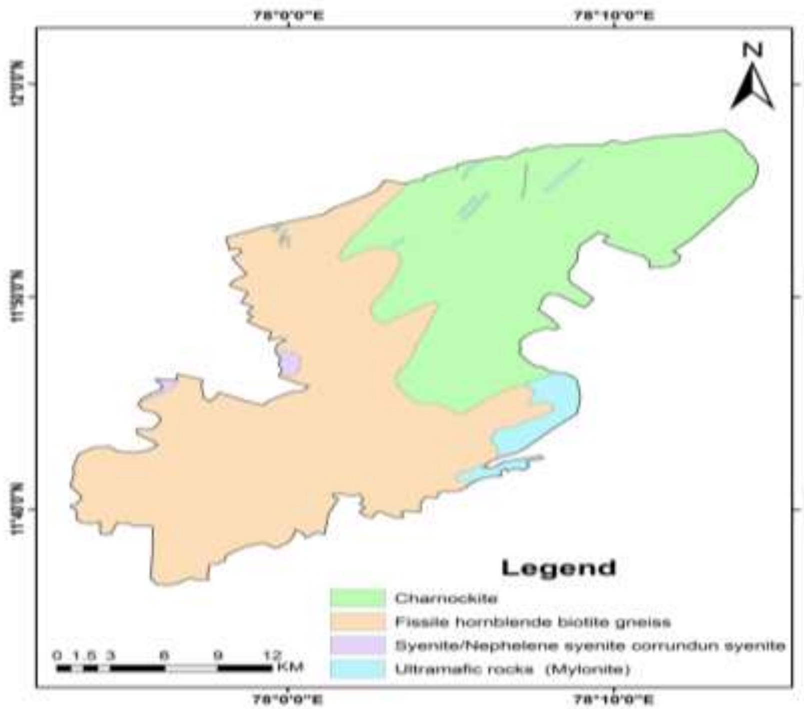


Fig.2 Geology Map of the study area.

## MATERIALS AND METHODS

Hydrogeochemical research requires proper site selection for collection of water samples and appropriate method of analysis. Sampling sites were located taking several factors into considerations like lithology, structure, geomorphology, and river influence, urban, agricultural and availability of wells. Sampling of groundwater has been carried out in Omalur taluk. The groundwater samples were collected during the premonsoon season. A total of 17 samples were collected (Table 1). Ground water sampling locations are shown in figure 1. One litre of water samples were collected in polyethylene bottle. Then it was sealed and brought to laboratory for analysis and stored properly ($4^oC$) before analysis. Water samples were analysed for major and minor ion concentration by using standard procedures (APHA 1998; Ramanathan 1992; Ramesh and Anbu, 1996, WHO (1984). Groundwater samples were collected in space and time and analysed for major and minor dissolved ions using standard procedures (Anandhan 1998, 2000 and 2016; Chidambaram 2014 and 15; Singaraja 2014; Ramanathan 2000). Groundwater in the study area is generally alkaline in nature with pH varies from 7.03 to 8.24 with an average of 7.71. EC is an indirect measure of ionic strength and mineralisation of natural water. EC of pure water is around 0.05 µs/cm (Hem,1989). EC ranges from 334 $µs/cm^2$ to 3620 $µs/cm^2$ with an average of 1931.35 $µs/cm^2$ (Tab.2). Total dissolved solids (TDS) which is generally the sum of dissolved ionic concentration varies between 295.95-1625.28 mg/1 with an average of 918.05 mg/1.

**Table.1 The Chemical concentration of different ions present in the ground water of the study area (Except pH and EC all the value in ppm)**

| pH | EC | Cl | Ca | Mg | Na | K | $HCO_3$ | $SO_4$ | $NO_3$ | F | $H_4SiO_4$ | TDS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.12 | 1545 | 177.25 | 90 | 72 | 27.5 | 4.5 | 244 | 1.27 | 13.87 | 0.001 | 21.5 | 651.891 |
| 7.75 | 2373 | 389.95 | 180 | 118.8 | 44.8 | 6.2 | 414.8 | 4.7 | 44.34 | 0.001 | 16.8 | 1220.391 |
| 7.03 | 500 | 79.762 | 38 | 7.2 | 11.9 | 2.1 | 176.9 | 0.56 | 23.14 | 0.001 | 15.6 | 355.163 |
| 7.57 | 3510 | 744.45 | 268 | 87.6 | 71.6 | 3 | 390.4 | 8.61 | 38.84 | 0.001 | 16.3 | 1628.801 |
| 7.85 | 1687 | 265.87 | 142 | 61.6 | 37.8 | 1.1 | 317.2 | 2.35 | 20.91 | 0.001 | 12.5 | 861.331 |
| 8.24 | 1475 | 177.25 | 78 | 19.2 | 49.3 | 14.7 | 335.5 | 1.06 | 34.38 | 0.001 | 18.9 | 728.291 |
| 7.53 | 3100 | 620.37 | 208 | 84 | 72.2 | 5.2 | 305 | 5.41 | 46.37 | 0.001 | 21.5 | 1368.051 |
| 8.17 | 3410 | 744.45 | 164 | 86.4 | 23.3 | 0.6 | 494.1 | 5.23 | 107.2 | 0.001 | 16.7 | 1641.981 |
| 7.69 | 1672 | 292.46 | 108 | 20.4 | 53.3 | 3.4 | 329.4 | 1.3 | 24.37 | 0.001 | 12.2 | 844.831 |
| 7.81 | 341 | 97.487 | 30 | 12 | 10.2 | 1.5 | 103.7 | 0.53 | 40.53 | 0.001 | 15.5 | 311.448 |
| 8.05 | 2960 | 451.98 | 156 | 18 | 79.2 | 5 | 439.2 | 2.02 | 121.16 | 0.001 | 32.6 | 1305.161 |
| 7.74 | 665 | 106.35 | 50 | 45.6 | 20.5 | 7.1 | 225.7 | 0.56 | 26.82 | 0.001 | 12.7 | 495.331 |
| 7.38 | 1411 | 186.11 | 104 | 20.4 | 35.1 | 3.3 | 250.1 | 1.27 | 14.59 | 0.001 | 13.2 | 628.071 |
| 7.38 | 1507 | 221.56 | 112 | 66 | 43 | 0.9 | 262.3 | 0.72 | 28.66 | 0.001 | 13 | 748.141 |
| 7.45 | 3620 | 664.68 | 174 | 27.6 | 94.4 | 14.9 | 311.1 | 6.78 | 67.31 | 0.001 | 36.9 | 1397.671 |
| 7.47 | 1026 | 159.52 | 76 | 14.4 | 28.8 | 2.2 | 152.5 | 1.81 | 18.74 | 0.001 | 12.6 | 466.571 |
| 7.79 | 2031 | 274.73 | 152 | 56.4 | 48.8 | 1.7 | 445.3 | 4.93 | 258.26 | 0.001 | 12.7 | 1254.821 |
| 7.03 | 341 | 79.762 | 30 | 7.2 | 10.2 | 0.6 | 103.7 | 0.53 | 13.87 | 0.001 | 12.2 | 258.063 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIN | 7.03 | 341 | 79.76 | 30 | 7.2 | 10.2 | 0.6 | 103.7 | 0.53 | 13.87 | 12.2 | 258.06 |
| MAX | 8.2 | 3620 | 744.45 | 268 | 118.8 | 94.4 | 14.9 | 494.1 | 8.61 | 258.3 | 36.9 | 1641.9 |
| AVG | 7.6 | 1843 | 318.55 | 120 | 45.82 | 42.33 | 4.33 | 294.49 | 2.75 | 52.41 | 17.41 | 898.11 |

**Table.2 Max, Min and Average for groundwater sample in study area.**

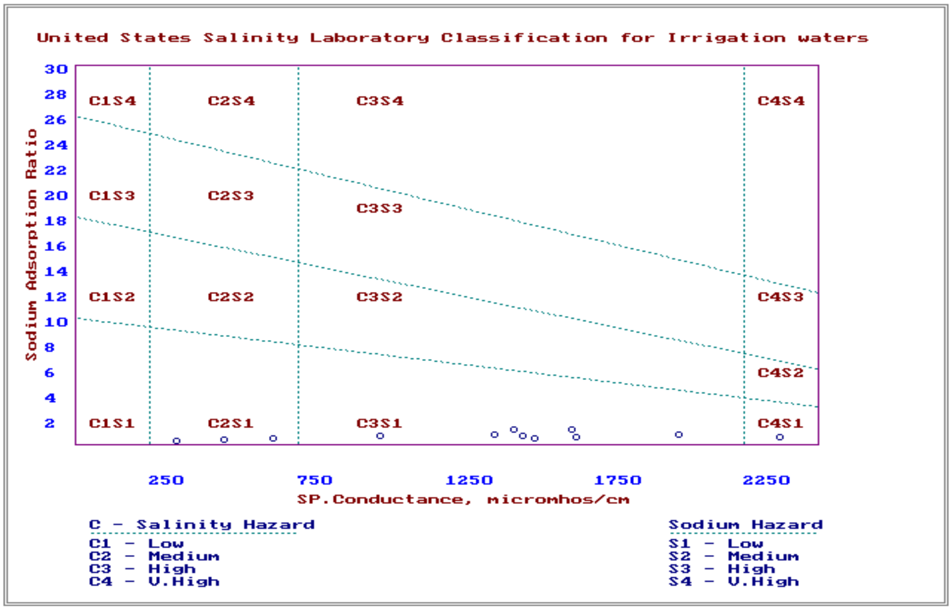


**Fig.3 USSL Diagram for the study areas**

When SAR (alkali hazard) and specific conductance (Salinity hazard) is plotted in USSL diagram USSL (1954), classification of water for irrigation purpose can be determined. Majority of samples fall in $C_3S_1$ zone indicating high salinity and low sodium hazard, satisfactory for plants having moderate salt tolerance on soils (Fig 3). Minor representation of samples is also noted in $C_2S_1$ zones indicates medium to high salinity waters.

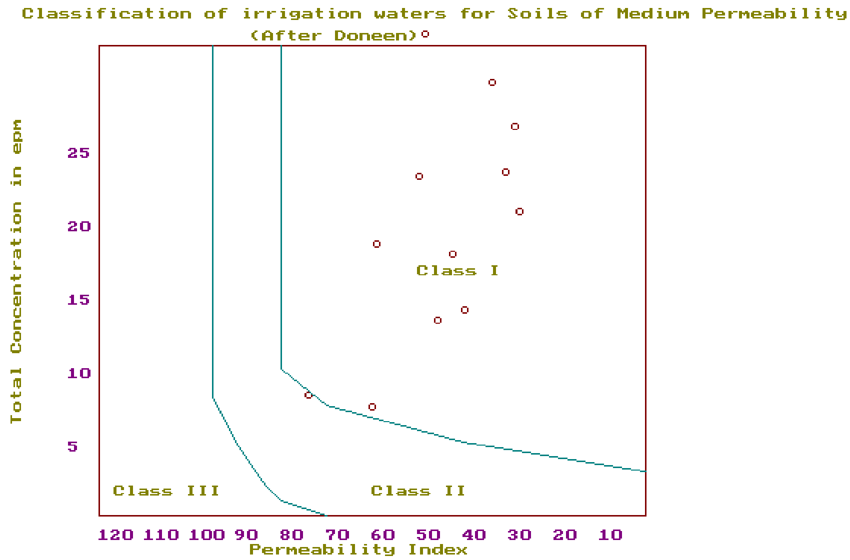


**Fig.4 Doneen Plot for the study area**

Permeability index is an important factor which influences quality of irrigation water, in relation to soil for development in agriculture. Based on permeability index Doneen (1948), classified the groundwater as class I, class II and class III to find out suitability of groundwater for irrigation purpose (Fig 4). Most of the samples fall in class I indicating water is good for irrigation purpose. Certain samples was noted class II indicates water is unfit for irrigation purpose.

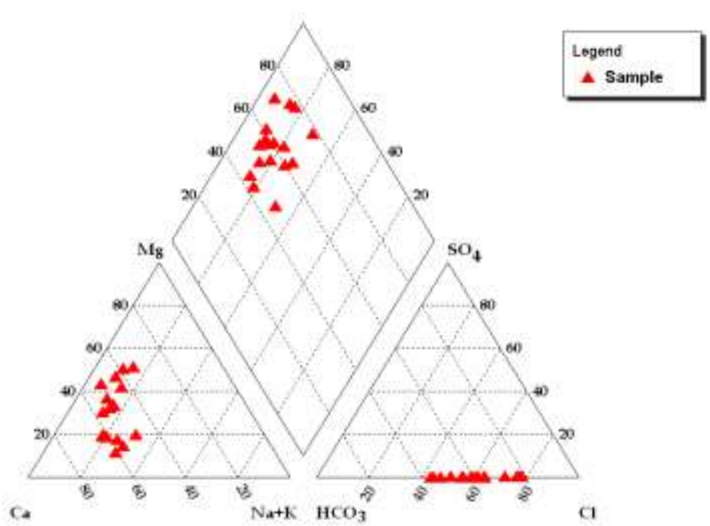


**Fig.5 Piper Trilinear plot for the study area**

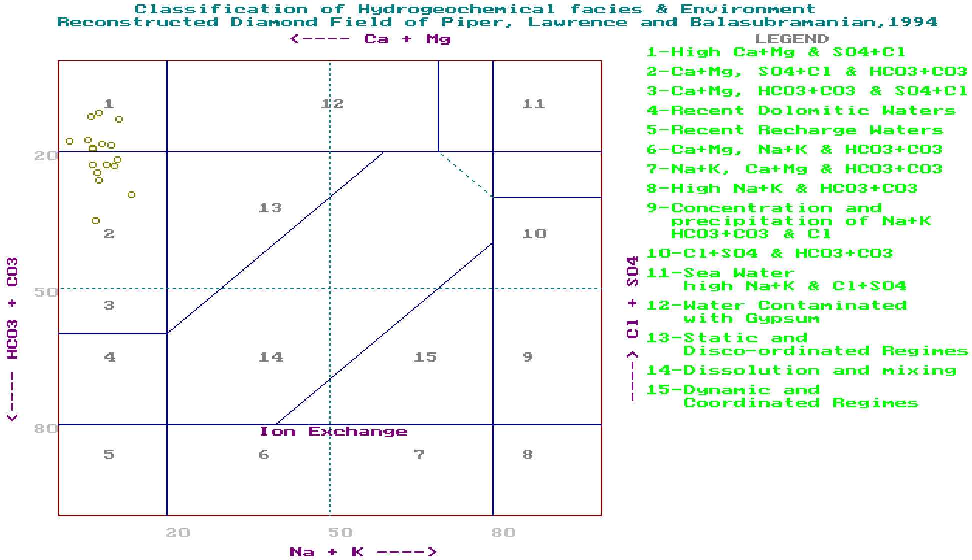


**Fig.6 Johnsons plot (Modified Piper) for the study area**

In Piper diagram (fig. 5) the sample fall into three major segments, representing three types of water i.e., Na-Cl, mixed Ca-Na-$HCO_3$ and mixed Ca-Mg-Cl. Majorities of the samples fall in Ca–Mg and Na-Cl, which indicates salinity nature in the groundwater.

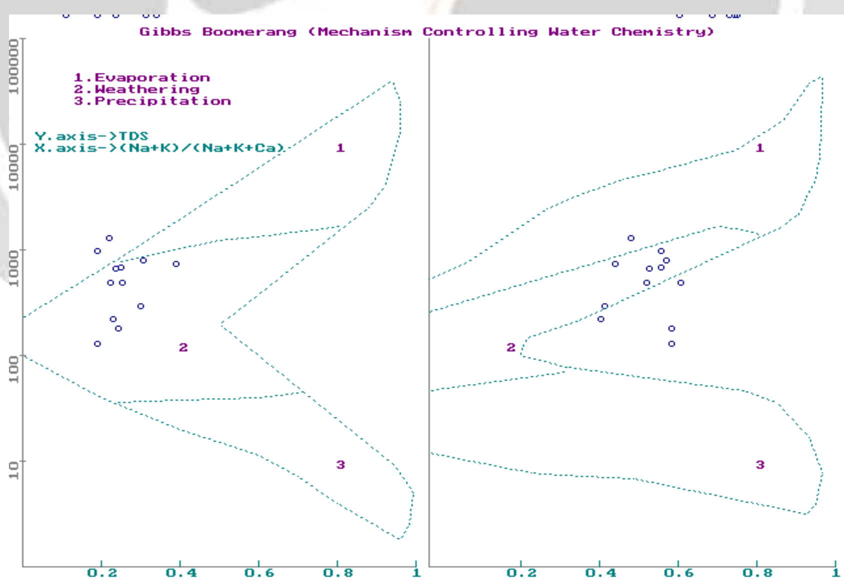


**Fig.7 Gibbs Diagram for the study area**

The modified Johnson's (Diamond) plot, Geochemistry of groundwater is influenced by geochemical reaction and mixing. Here cation is dominated by Na>Ca>Mg and anions by Cl>HCO3>SO4. Evolution of water is chiefly dependant on this relationship between rock types and water composition of anions and cations (Fig.6) (Jhonsons 1974). In figure samples fall in water contaminated by secondary precipitation and in static and discoordinated regimes and also noted in high Ca+Mg+SO4+Cl zone and HCO3+CO3 zones indicating weathering impact. In general alkali exceeds alkaline earth controlled by strong and weak acids.

Mechanism controlling chemistry of groundwater in the study area (Gibbs, 1970). In the study area, the ratios of (Na+K) / (Na+Ca+K) of the groundwater samples have been plotted against TDS. Similarly the ratios of C1/(C1 + $HCO_{3)}$ have been plotted against TDS and is shown in fig 7, show the similar nature of water. The density of the distribution of points is maximum in the centre and this indicates that mechanism controlling of groundwater is predominately due to water rock interaction.

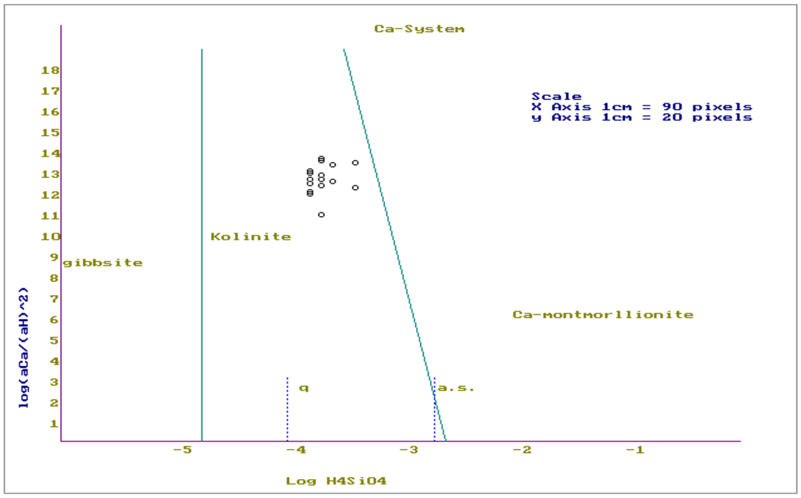


**Fig.8 Thermodynamic stability For Ca System for the study area**

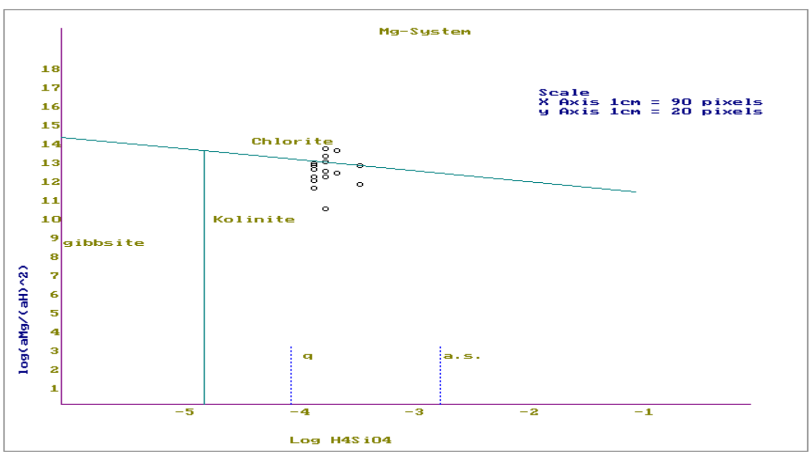


**Fig.9 Thermodynamic stability For Mg System for the study area**

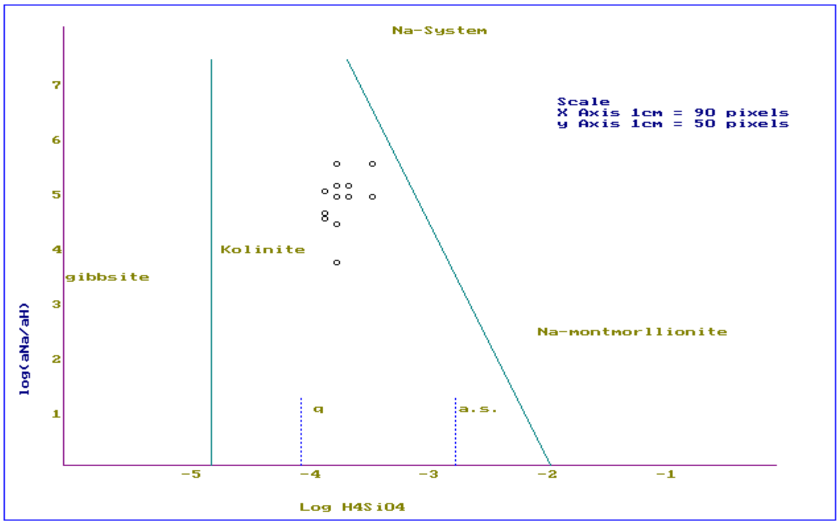


**Fig.10 Thermodynamic stability For Na System for the study area**

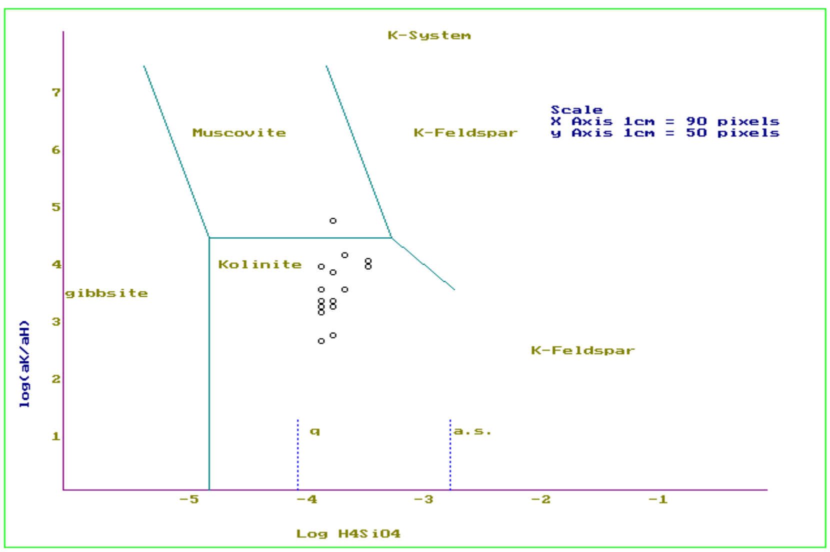


**Fig.11 Thermodynamic stability For K System for the study area**

Thermodynamic stability Diagram for Ca system, cluster of samples are stable with Kaolinite and it tends to move to Montmorllinite field indicates the movement of in OS along the groundwater flow path (Srinivasamoorthy 2011, Chidambaram 2013) (Fig 8). In Mg system, most of the samples stable with Kaolinite indicates incongruent dissolution of feldspar with minor representation in chlorite field (Fig.9). In Na system, initially samples stable with Kaolinite field and further it tend to move towards Montmorllinite due to the excess supply of cations and silica (Fig.10). In K system, movement of ions is well noted (Fig.11).

## CONCLUSION

Groundwater in the study area is generally acidic to alkaline in nature with pH ranging from 7.03 to 8.24 with an average of 7.71. EC ranges from 334 µs/cm$^2$ to 3620 µs/cm$^2$ with an average of 1931.35 µs/cm$^2$. Total dissolved solids (TDS) which is generally the sum of dissolved ionic concentration varies between 295.95-1625.28 mg/1 with an average of 918.05 mg/1. USSL diagram, classification of water for irrigation purpose can be determined. Majority of samples fall in $C_3S_1$ zone indicating high salinity and low sodium hazard, satisfactory for plants having moderate salt tolerance on soils. Minor representation of samples is also noted in $C_2S_1$ zones indicates medium to high salinity waters. Doneen Permeability index classification of groundwater shows most of the samples fall in class I indicating water is good for irrigation purpose. Certain samples was noted class II indicates water is unfit for irrigation purpose. Gibbs boomerang shows that majority of samples falls in weathering dominant zone but few representations fall away from boomerang zone shows impact of secondary salt precipitation. Thermodynamic stability diagram for Ca system, cluster of samples are stable with Kaolinite and it tends to move to Montmorllinite field indicates the movement of in OS along the groundwater flow path. In Mg system, most of the samples stable with Kaolinite indicates incongruent dissolution of feldspar with minor representation in chlorite field. In Na system, initially samples stable with Kaolinite field and further it tend to move towards Montmorllinite due to the excess supply of cations and silica. In K system, movement of ions is well noted.

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