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Evaluation of groundwater eminence and its appropriateness for drinking and Agricultural use in the hard rock train of Tiruchirappalli Taluk, Tamil Nadu

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Abstract

During the last several decades, human economic activities, especially agriculture and industry have set a trend of consuming ever increasing amounts of fresh water. The regions like Tiruchirappalli district, has a higher density of population to be supported with water. Nearly greater than 50% of the day to day need of the people in this taluk including domestic, industrial, agricultural and partly drinking purpose is met by the groundwater resources only The increase of human population and the economic activities in the region grow in scale; the demand for large supplies of fresh water from various competing and users has increased. There are failures in monsoon and the rivers of this region are ephemeral. In this scenario number deep aquifers have been bored and heavily extracted, increasing the fragility of the system. Surface water present in the tank is also made use of during the rainy periods. This study has made a systematic approach to get an idea about hydrogeochemistry of the groundwater present in the area. To attain a panacea for water chemistry, ground water samples were collected in the Premonsoon seasons. A total of 20 groundwater samples were collected in this season and analyzed for 14 different water quality parameters and the result indicates, that higher EC and TDS values are observed in this region. 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. In the season HCO_3 $^+$ Cl dominates the anions, with few representations for SO_4. In both seasons Na+ K are the dominant ions. Bicarbonates derived from silicate mineral weathering are noted in the SW and Southern region. The electrical conductivity (EC) value varies from 369.37 µs/cm^2 to 4109.10 us/cm^2. On an average 1522.04 µs/cm^2 is observed in the region. As per Sodium Adsorption Ratio values 50% of the samples are suitable for irrigation. The Residual Sodium Carbonate indicates 60% of the samples fall in safe and 40% of the samples fall in unsafe zones and prolonged usage of this water will affect the crop yield. The Permeability Index of the groundwater indicates groundwater from the study area is moderate to good for irrigation purposes. Thermodynamic studies reveal that groundwater of the region are stable with Kaolinite stability field in all the silicate systems. Comparison of water quality to standards shows that the water can be used for drinking and for irrigation purposes except in few locations.

Keywords: Geochemistry, Major ion chemistry, Hydrogeochemistry, Irrigation, water quality

1. Introduction

Growing industrialization and urbanization coupled with rapid rise in population despite being an index of progress has been taken its tool on the available natural resources namely water, minerals etc. Since, the quality and quantity of surface and ground water is an important factor for the development of a country, proper attention and appraisal her to be paid for the conserving the natural resources.

The emerging global fresh water crisis in terms of water quality and quantity already felt in India. In recent years it has been recognized that the quality of water has to be in safer limits for utility. Geochemistry has shown to be most determinant, in water quality studies. The over drafting of ground water in our country due to the lack of surface waters during summer season has urged to need to undertake a detailed study on the quality and quantity of ground water in different parts of our country. Most of the ground water in Tamil Nadu has already been exploited in the past two decades. So, it is imperative to conserve the existing ground water resources. This study is an attempt to understand in detail the hydrogeochemical aspects of the Tiruchirappalli taluk.

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 Trichirappalli 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.

2. Study Area

Study area lies between 10° 46' and 10° 48' N latitude and 78°38' and 78°42'E longitude (Fig 1). The city is surrounded by Ariyamangalam city panchayat in east and by Abishekapuram and Piratiyur city panchayat's in west. All the two municipalities together with six city Panchayats named Thuvakudi, Ariyamangalam, Melakalkandarkottai, Tirverrumbur, Pirattiyur and K.Abisekapuram. Apart from these things, three village panchayats are also sited named cities Agglomeration areas.

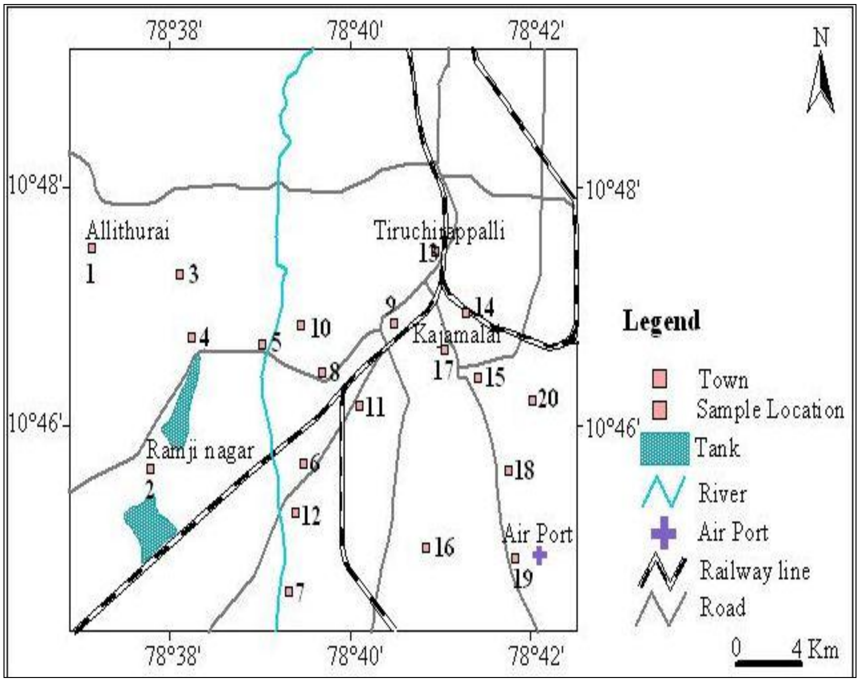
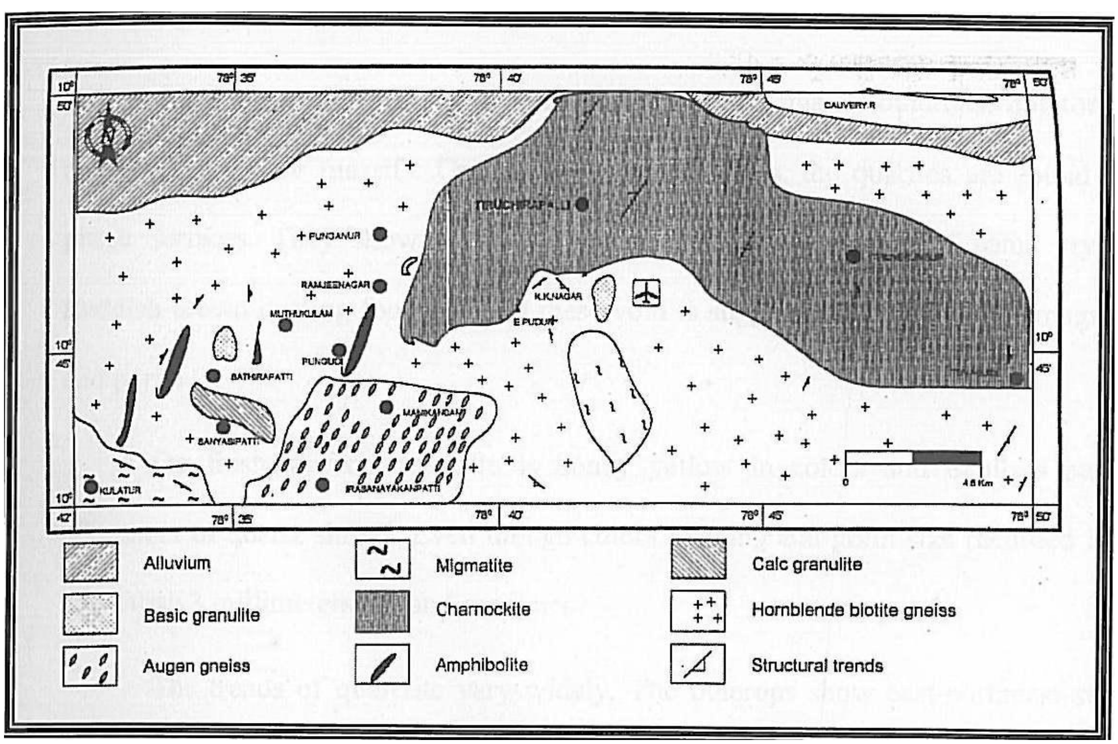


Fig 1: Location Map of the Study Area

Geology of the study area

Except alluvium and soils which are at recent age, the rest of the rocks exposed in the area belong to the Archean, cretaceous and tertiary formations of these rocks types (Fig 2). The Archaean rock occurs north and south of cauvery alluvium.

It is an established fact that the entire south Indian granulite terrain may classified into eastern ghat Mobil belt and southern cratonic granulite. These two broad terrains have been divided by a deep-seated fault (Subrahmanyam, 1982) the present study area falls in the border between the two classified units. Outcrops of metasedimentaries are mapped.



(After Muthukumar 2008)

Fig 2: Geology Map of the Study Area

3. Result and discussion

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 thiruchipalli taluk. The groundwater samples were collected from the premonsoon season. A total of 20 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 (4ºC) 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) [5, 10, 15].

Table 1: The Chemical concentration of different ions present in the ground water of the study area

PH	EC	CL	HCO3	Ca	Mg	H_4SiO_4	SO_4	Na	K	TDS
6.91	2255	487.44	488	160	0.1	106.2	3.2	199.5	56.7	1394.84
7.12	2428	753.31	335.5	100	12	136.23	2.2	266.4	12	1481.41
7.11	2202	576.1	396.5	120	36	161.2	2.2	85	47	1262.8
7.02	9490	2836	427	140	24	236.3	7.4	685.4	22	4141.8
7.39	2741	753.31	427	240	0	143.32	3.8	569	123	2116.11
7.44	3300	709	701.5	100	12	198.12	4.6	390	26	1943.1
7.37	570	88.625	213.5	60	84	21.6	1.2	12.8	2.1	462.225
7.21	3480	930.6	488	120	84	114.3	4.2	89.58	14.3	1730.68
7.19	826	132.9	335.5	100	0	32.3	1.4	102.36	63.1	735.26
7.17	1575	310.2	366	140	12	32.36	2.4	159.36	29.58	1019.54
7.07	1212	265.8	396.5	100	36	29.36	1	160.9	35.25	995.45
6.51	68.8	44.31	91.5	40	0	10.2	0.4	19.96	6.4	202.57
6.58	754	177.3	274.5	100	12	9	1.2	65.3	29.36	659.66
6.47	2490	620.4	427	140	60	25.3	2.4	288.2	36.3	1574.3
6.87	1999	531.8	366	140	24	23.2	1.4	32.14	23.2	1118.54
6.74	1298	265.9	305	120	12	11.3	1.4	39.93	14.6	758.83
7.13	1708	310.2	457.5	100	48	14.1	1.2	98.9	19.65	1035.45
6.7	2646	664.7	335.5	100	120	65.3	1	362.2	42.36	1625.76
7.11	1869	221.6	732	140	12	25.3	1.4	36.8	13.6	1157.4
6.93	1388	310.9	366	100	24	21.3	1	152.65	65.7	1020.25

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) [1, 2, 6, 9, 11, 12]. Groundwater in the study area is generally alkaline in nature with pH varies from 6.47 to 7.44 with an average of 7.002. 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) [8]. EC ranges from 68.8µs/cm to 9490 µs/cm with an average of 2214.99 µs/cm (Fig 2). Total dissolved solids (TDS) which is generally the sum of dissolved ionic concentration varies between 202.57 mgl^{-1} to 4141 mgl-1 with an average of 1321.8 mgl^{-1}.

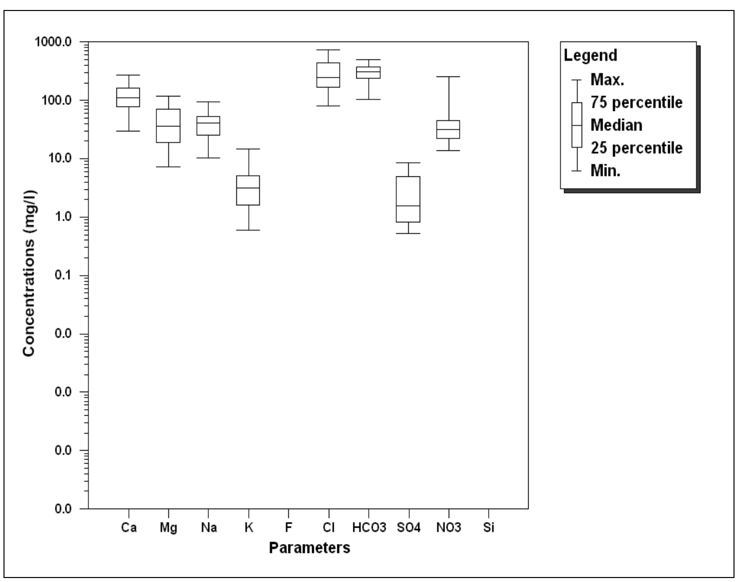


Fig 2: Box Plot for the Max, Min, Avg of the Chemical Constituents in Groundwater

When SAR (alkali hazard) and specific conductance (Salinity hazard) is plotted in USSL diagram USSL (1954) [14], 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 and C_3S_2 zones indicates medium to high salinity waters.

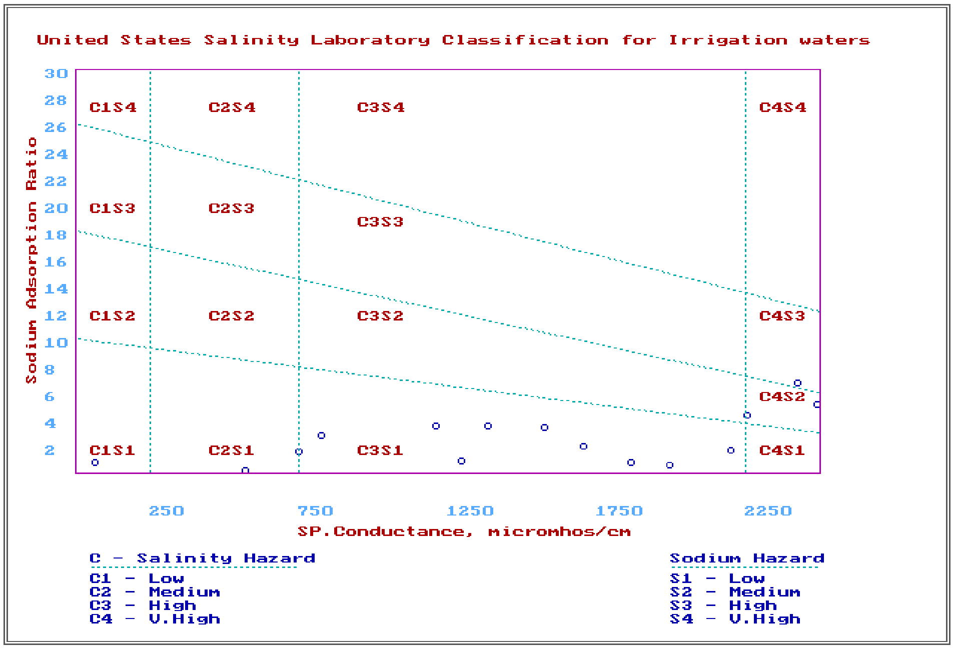


Fig 3: USSL diagram for the study area

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.

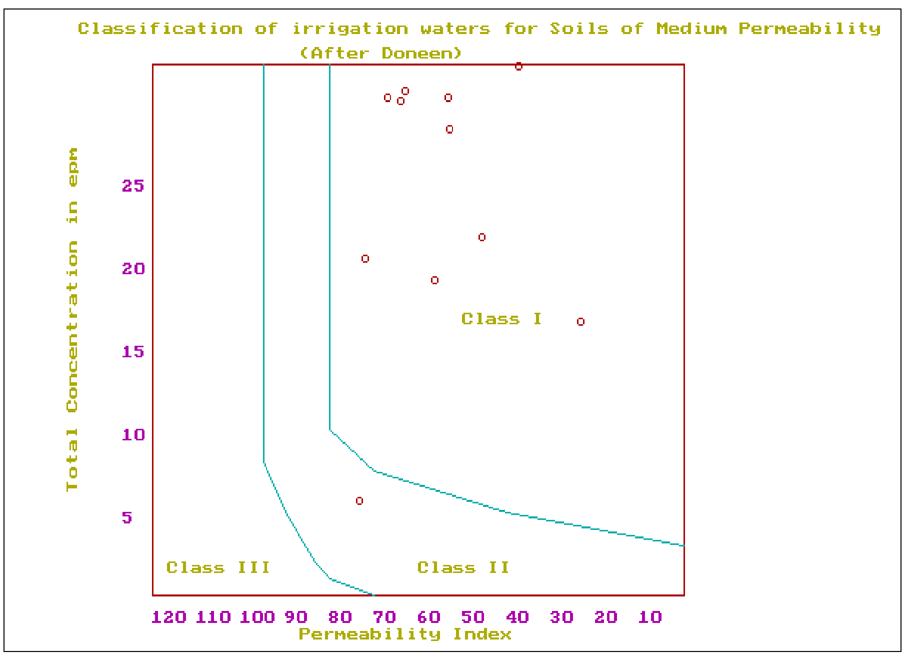


Fig 4: Permeability index map of the study area

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 $Cl>HCO_3>SO_4$. Evolution of water is chiefly dependant on this relationship between rock types and water composition of anions and cations (Fig.5) (Jhonsons 1974). In figure samples fall in water contaminated by secondary precipitation and in static and dis-coordinated regimes and also noted in high $Ca+Mg+SO_4+Cl$ zone and HCO_3+CO_3 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 $C1/(C1 + HC0_{3})$ have been plotted against TDS and is shown in Fig 6, 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.

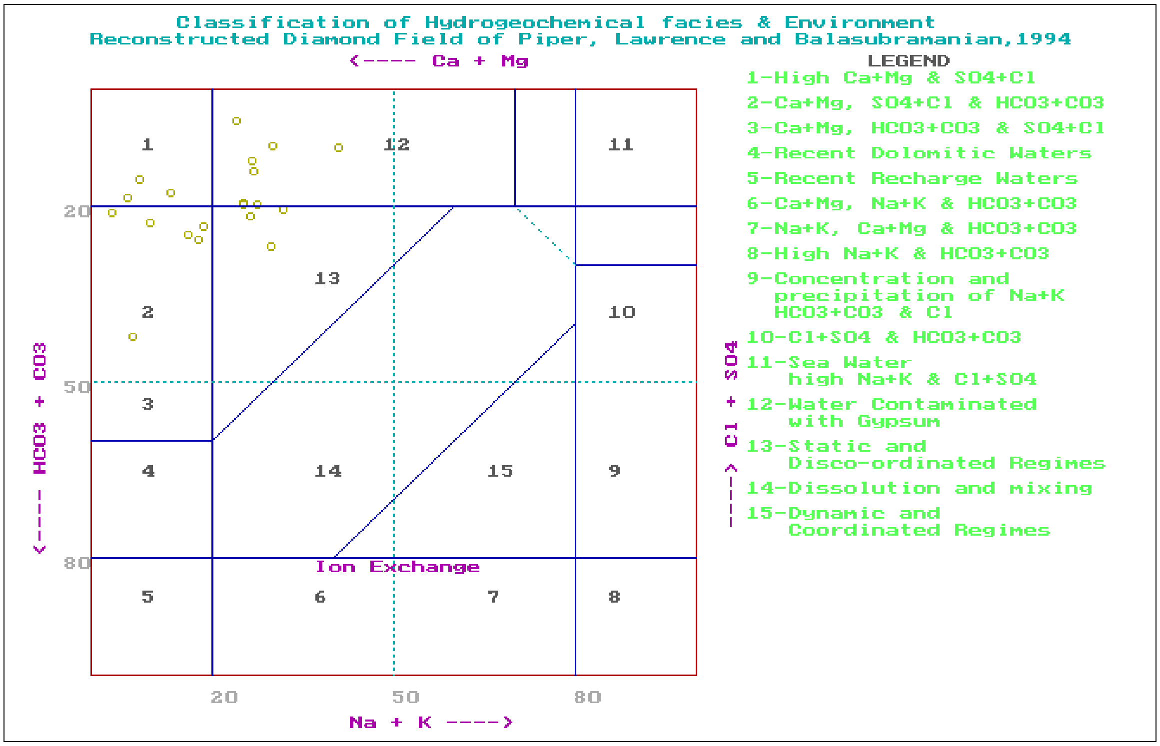


Fig 5: Modified diamond Johnson's plot for the study area

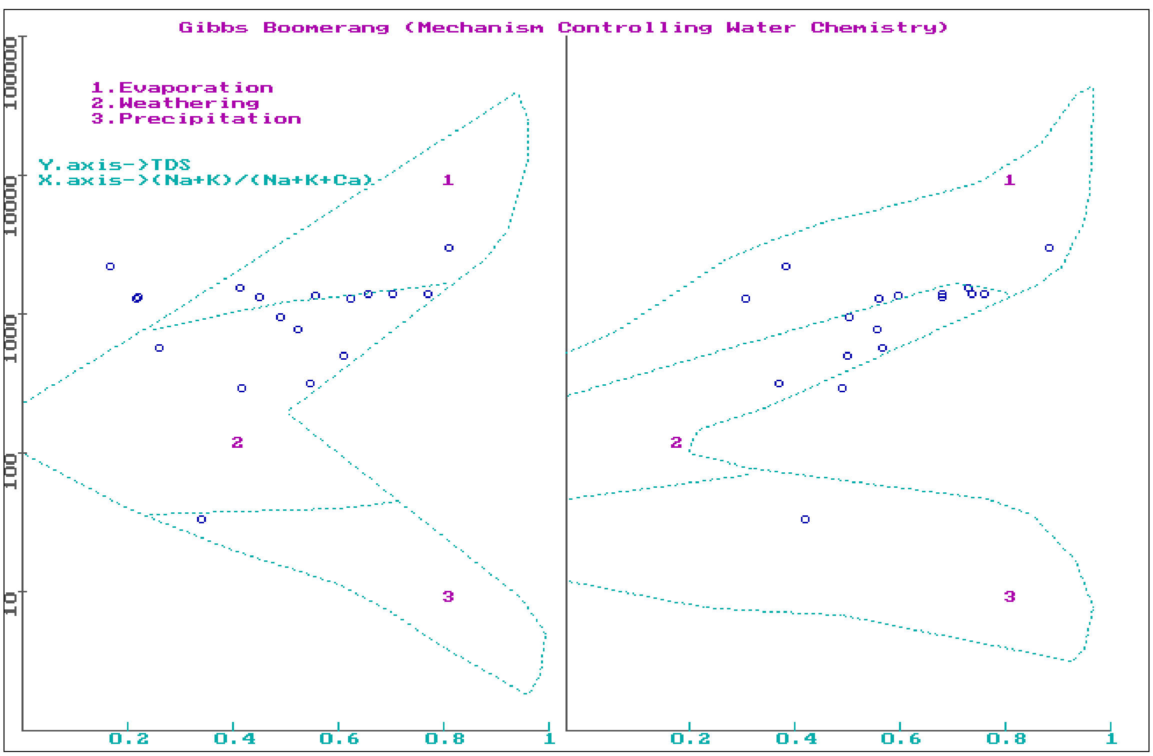


Fig 6: Gibbs diagram for the study area

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) [13, 7] (Fig 7). In Mg system, most of the samples stable with Kaolinite indicates incongruent dissolution of feldspar with minor representation in chlorite field (Fig.7). 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.8). In K system, movement of ions is well noted (Fig.8).

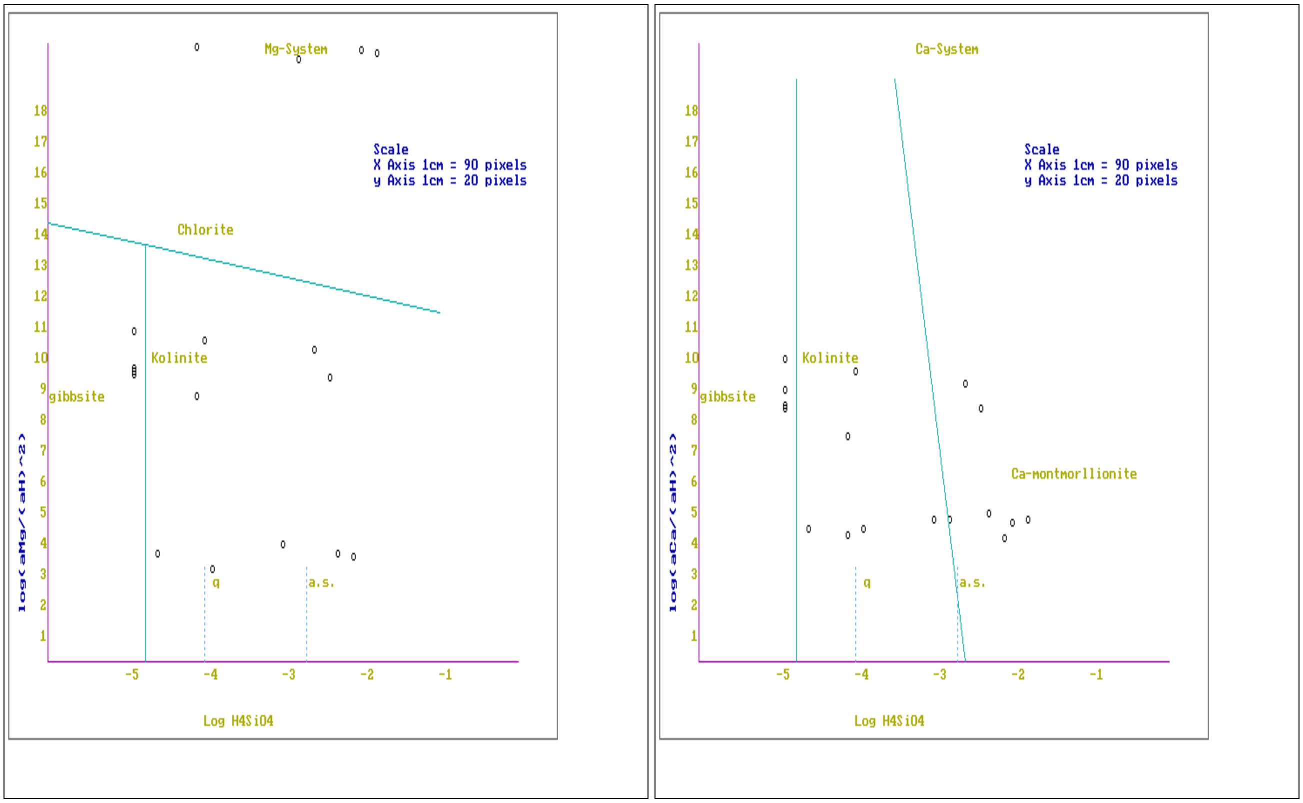


Fig 7: Thermodynamic stability diagram for Ca and Mg System

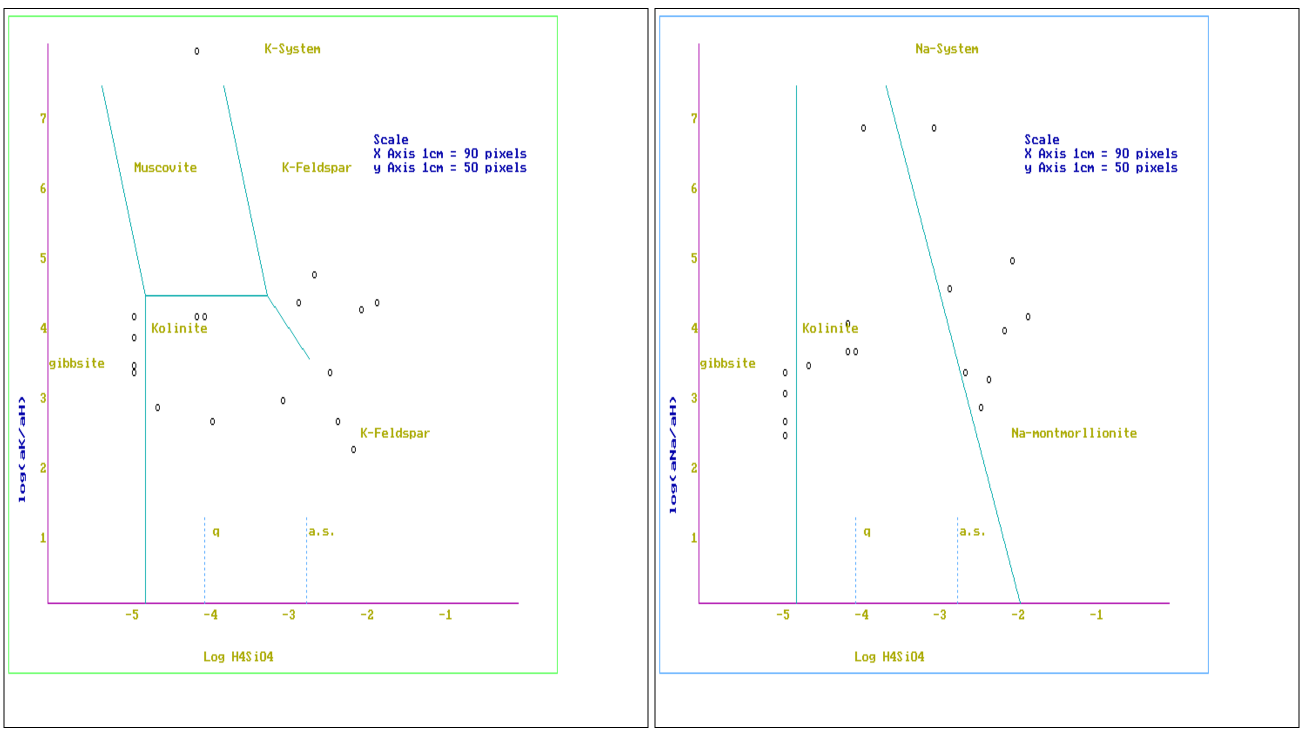


Fig 8: Thermodynamic stability diagram for Na and K System

4. Conclusion

Groundwater in the study area is generally acidic to alkaline in nature with pH ranging from 6.47 to 7.44 with an average of 7.002. EC ranges from 68.8µs/cm to 9490 µs/cm with an average of 2214.99 µs/cm. Total dissolved solids (TDS) which is generally the sum of dissolved ionic concentration varies between 202.57 mgl^{-1} to 4141 mgl-1 with an average of 1321.8 mgl^{-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 and C_3S_2 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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