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Hydrogeochemical Investigation in Part of Gomukhi Sub Basin of Vellar Basin, Tamil Nadu, India

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ABSTRACT

Water samples were collected from different locations of Lower Gomukhi sub basin in vellar basin and analyzed to assess the major cation, anion and suitability for drinking purposes. Totally 22 groundwater samples were collected during post monsoon season in the year February 2014. Study area latitude 11° 30' to 11° 50', Longitude 78° 45' to 79° 15' toposheet no, 58 I/13, 14 and 58 M/1, 2. Geologically study area comprises of Charnockite and Hornblende biotite gneiss. Physical and Chemical parameters of groundwater such as pH, electrical conductivity (EC), total dissolved solids (TDS), are varied from 7 to 7.8, 409.37 to 1757.81 µs/cm, 262 to 1125 mgl. The concentration of major cations such as Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, *and anions* Cl^{-}, HCO_3^{-}, SO_4^{2+}, NO_3^{-}, *and* PO_4^{-} *are varied from 75 to 190 mgl, 18 to 98.7 mgl, 72 to 250 mgl, 3 to 36 mgl and 133 to 414 mgl, 200 to 480 mgl, 10 to212 mgl, 10 to 90 mgl, and 2 to 23 mgl respectively. The reconstructed diamond field of Piper represents* $Ca^{2+} > Mg^{2+}$ *and* $SO_4^{2-} >$ *Cl- facies and Gibb's plot shows rock water interaction field. Also all parameters were compared with WHO (2011) water quality standards for drinking.*

Keywords –
Hydrogeochemistry; Drinking Water

INTRODUCTION

Groundwater is the major source of fresh water, which is widely used for domestic, industrial and agricultural purposes in most parts of the world. It is now generally recognized that the quality of groundwater is just as important as its quantity. All groundwater contains salts in solution that are derived from the location and past movement of the water. The quality required of a groundwater supply depends on its purpose, particularly for drinking the groundwater should free from contamination. In many places, both the quality and quantity of water are already under pressure and the increase in population may push the resources to scarcity. Moreover, the quality of surface and groundwater is under serious threat due to over exploitation, anthropogenic, industrial developments etc., Apart from this, human activities such as contamination due to industrial effluents, landfills, application of fertilizers, etc., In this scenario, the present study is taken up to assess the groundwater chemistry and quality of Gomukhi Sub Basin of Vellar Basin, Tamilnadu.

In this study area groundwater in the hard rock is controlled by the secondary porosity such as lineament, joints, fracture etc. Groundwater is developed in this area open and dug well mostly by tapping weathered zone (S.Poongothai, 2003). In the study area over exploitation and groundwater occurs under semi-confined condition. Apart from this, human activities such as contamination due to industrial effluents, landfills, application of fertilizers, etc., In general, the groundwater quality is strongly dependent on bedrock geology and climate but may also be impacted in parts by pollution, particularly from agricultural and industrial sources.

STUDY AREA

The study area Gomukhi sub basin of Vellar basin is originated in the Kalrayan Hills, which is a major hill range of Eastern Ghats of India and the Gomukhi nadhi joins to the Manimuktha nadhi. Gomukhi sub basin bounded by Attur taluk in the west, Kallakurichi taluk, Tittakudi and Vrithachalem taluk in east. The study area lies between the North Lattitude 11°30' to 11°50' East Longitude 78°45' to 79°15' and fall survey of India toposheets 58I/13, 14 and 58M/1, 2. The extent of the sub basin is 331.98 km². The major rock types of the study area are charnockite and Hornblende biotite gneiss. The study area annual rainfall is 1109 mm and groundwater occurs under semi-confined condition. Groundwater in the hard rock region of the area is controlled by the secondary porosity such as lineament, joints, fracture etc. Groundwater is developed in this area from open and dug well mostly by tapping weathered zone (S.Poongothai, 2003).

METHODOLOGY

In the present study, totally 20 bore and open wells samples were collected during post monsoon season of February 2014. The samples were collected in a clean one liter polythene bottles as prescribed by Hem (1970), Brown et.at (1970). The analysis has carried out in the Department of Earth Sciences, Annamalai University for pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), major cations such as Ca^{+}, Mg^{+}, Na^{+}, K^{+}, and anions Cl^{-}, HCO_3^{-}, SO_4^{+}, NO_3^{-}, and PO_4^{-} . pH, (EC), and (TDS) was measured using Tech hand held instrument. The EC values are expressed in µS/cm 25°C. The $Ca^{2}+$, $Mg^{2}+$ and HCO_3^{-}, Cl^{-} were measured by volumetric method whereas Na^{+}, K^{+} measured using flame photo meter model Elico, CL-378. Further SO_4^{-} was measured using spectrophotometer model Elico, SL-171 minispec.

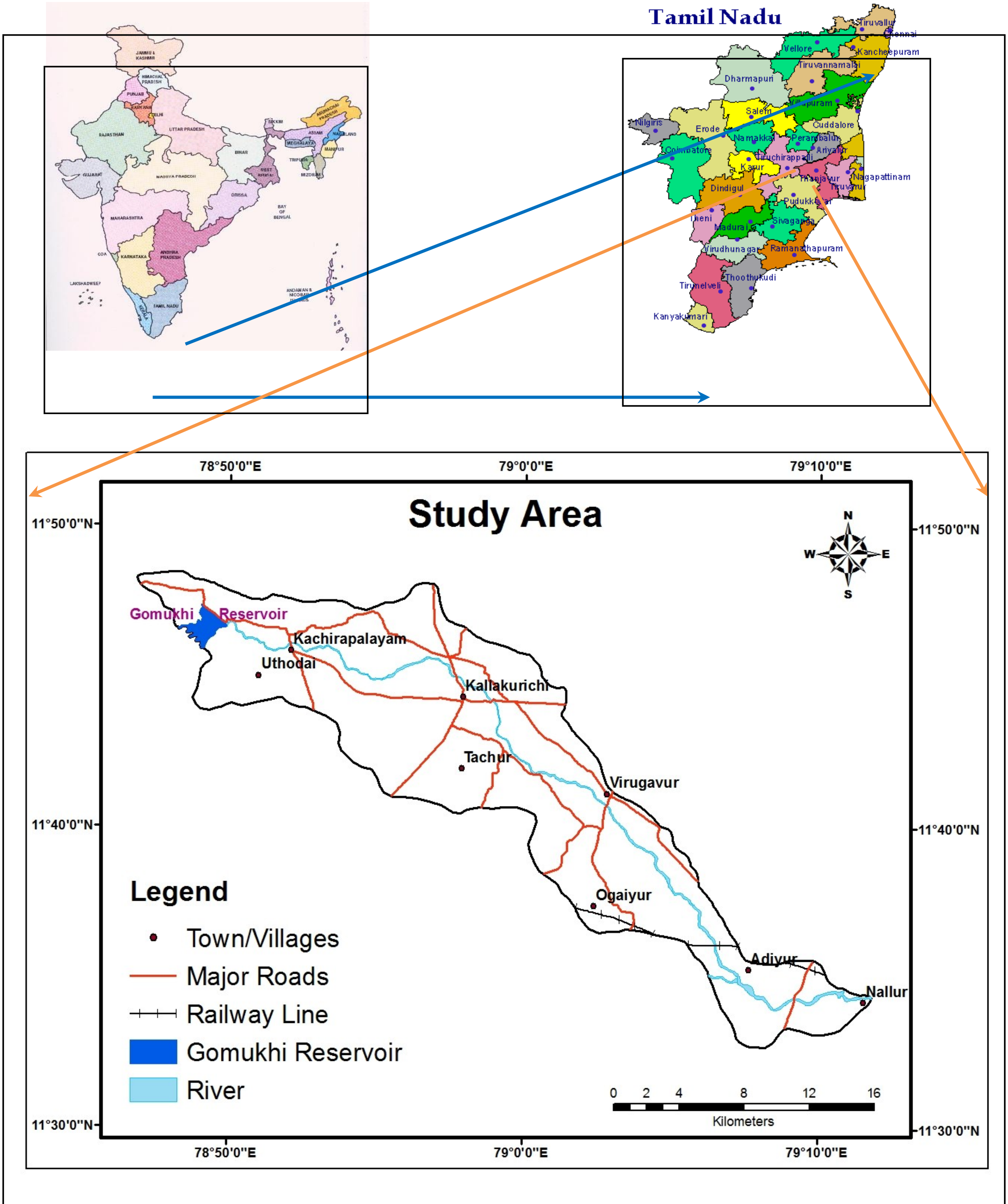

Fig - 1. Study Area Map

Except pH other parameters are expressed in Mg/l. The data have analyzed and interpreted using WATCLAST software (Chidambaram, et al, 2004). The groundwater facies and source of the ionic concentration were recognized from modified diamond field of Piper diagram and Gibb's plot. The analyzed groundwater samples are comparing with permissible limit for WHO (2011) drinking water standard.

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GEOLOGY

The study area geologically covered in Archean group of rocks in charnockite and Hornblende biotite gneiss (Fig-2).

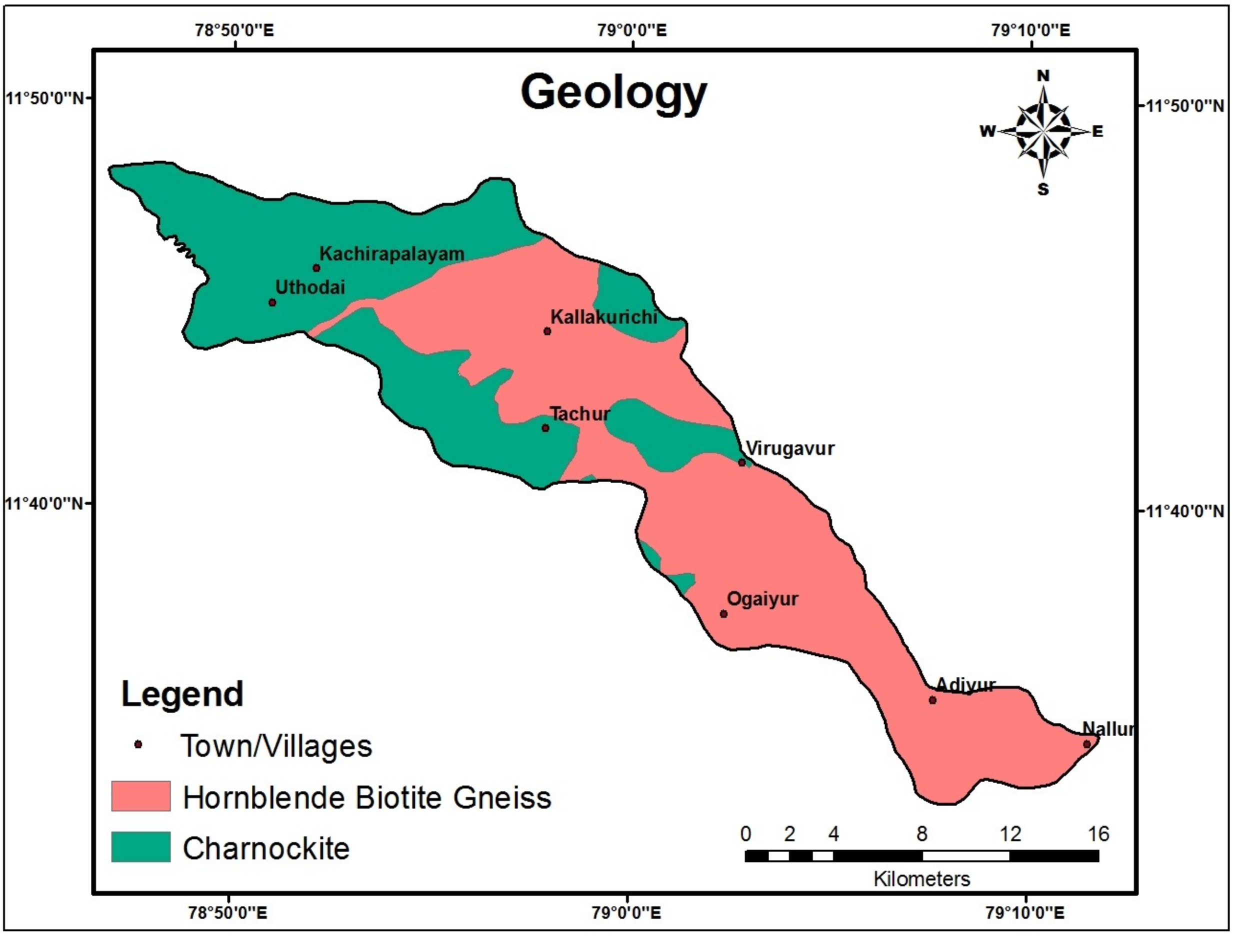

Fig-2. Geology Map

RESULT AND DISCUSSION

Power of Hydrogen (pH)

The pH of water is very important indication of its quality and provides important piece of information in many types of geochemical equilibrium or solubility calculations (Hem, 1985). No health-based guideline value is proposed for pH, nevertheless it usually has no direct impact on consumers and it is one of the most important operational water quality parameters. The study area pH range is 7 to 7.8 (Fig-4). In the study area all groundwater samples are within the permissible limit of 6.5 to 8.5 of WHO (2011) drinking water standard.

Electrical conductivity

Electrical conductivity is a measure of water capacity to convey the electrical current. According to Hem, 1985, the conductivity measurement provides an indication of ionic concentrations. It depends upon temperature, concentration and types of ions present. In the study area, EC is varied from 409.37 to 1757.81µS/cm (Fig-5). In the study area most of the groundwater samples are within the

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permissible limit of 1500 µS/cm and found above the limit in few locations.

Total Dissolved Solids

The principal ions contributing to TDS are bicarbonate, carbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium (EPA, 1976). Apart from that TDS also comprise small amounts of organic matter that are dissolved in water. Total dissolved solids concentration in the study area values varied from 262 to 1125 mg/l (Fig-6). In the study area all groundwater samples are within the permissible limit of 1500 mg/l of WHO (2011) drinking water standard.

Calcium

The Ca concentration in the study area varied from is 75 to 190 mg/l where it concentration found low as 75 mg/l in location 1 and observed high concentration of 190 mg/l (Fig-7) in location 6. The limit of Ca for drinking water is specified as 75 mg/l (WHO,2011).The result shows that except one location remaining all 21 samples are exceeding the limit. The concentration of Ca is due to interaction of minerals like feldspars minerals and weathering process.

Magnesium

The Magnesium concentration is varying from 18 mg/l to 98.7 mg/l (Fig-8). The limit of Mg for drinking water is 50 mg/l (WHO,2011). In this area nearly 50% of the samples are exceeding the limit. The high concentration of Mg observed in location number 6 whereas low concentration observed in groundwater sample location 17.

Sodium

The Sodium concentration is varying from 72 mg/l to 250 mg/l (Fig-9). The limit for drinking water is specified as 200 mg/l (WHO,2011). It is observed that the specified limit was exceeded in 5 sample locations. The sodium concentration in the ground water is due to the chemical weathering of feldspar minerals in the country rocks. Also, the agricultural activities may have significant influence on the concentration of sodium in ground water.

Potassium

Potassium is an essential element in humans and is rarely, if ever, found in drinking water at levels that could be a concern for healthy humans. In the study area the Potassium concentration is varying from 3 to 36 mg/l (Fig-10). The limit of K for drinking water is specified as 12 mg/l (WHO,2011) .When compare with the WHO,2011 standard, except seven sample locations, the concentration of potassium were within the limit. The Potassium concentration in waters is low because of the high degree stability of potassium bearing minerals.

Chloride

The Cl concentration is varying from 133 mg/l to 414 mg/l (Fig-11). The limit of chloride concentration for drinking water is specified as 600 mg/l (WHO, 1993). In the study area all groundwater samples are within the permissible limit of 600 mg/l of WHO (2011) drinking water standard. The high concentration of Cl noticed in location number 6, similarly low concentration found in groundwater sample location 28. High concentrations of Chloride give a salty taste to water and beverages.

Bicarbonate

Bicarbonate concentration of natural waters generally held within a moderate range by the effects of the carbonate equilibrium. The bicarbonate concentration in the study area values varied from 200 to 480 mg/l (Fig-12). The WHO (2011) Drinking water standard permissible limits 300 to 500 mg/l. All samples are within the permissible limit. The high concentration of HCO_3 noticed in location number 6 and low concentration found in groundwater sample location 1.

Sulphate

The Sulphate concentration is varying from 10 mg/l to 212 mg/l (Fig-13). The limit for drinking water is specified as 600 mg/l

International Journal of Research
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(WHO, 2011). In the study area all groundwater samples are within the permissible limit of 600 mg/l of WHO (2011) drinking water standard. The concentration of Sulphate in the groundwater mainly from rock sources, besides, sulphates could be introduced through the application of sulphatic soil conditioners (Karanth, 1987). The concentration of Sulphate is likely to react with human organs if the concentration exceeds.

Nitrate

Nitrogen compounds are the most widespread contaminants in subsurface environments, mainly originating from non-point and multi-point agricultural sources (Pang et al. 2013). The Nitrate concentration in the study area values varied from 10 to 90 mg/l (Fig-14) where Lower value observed in the sample location 12 and the higher value observed in the sample location 21. The WHO (2011) drinking water standard permissible limit is 45 mg/l in which nearly 42% of the sample locations are found above the limit.

Phosphate

Phosphorous is a soluble agricultural chemical that may be moved from point of application by surface runoff or move out of the soil surface layer with percolation. Its level in soil leachate can be 10 percent of surface runoff concentrations. The present study area the concentration of phosphate was varied from 2 mg/l to 23 mg/l (Fig-15) in groundwater.

Table – 1. Groundwater geochemical data (in mg/l) except EC and pH

S.NO	Location	Ca	Mg	Na	K	Cl	HCO3	SO4	NO3	Po_4	PH	EC	TDS
1	**Nallur**	75	63.6	124	10	168	200	122	60	2	7.8	967.18	619
2	**Katumailur**	80	25.2	72	14	133	242	16	30	5	7.7	1312.5	840
3	**Ogaiyur**	111	62	128	12	250	303.6	79	49	5	7.4	1132.81	725
4	**Adiyur**	115	82.7	125	11	253	302.6	148	69	3	7.6	409.37	262
5	**Idavakudi**	91	29.3	173	12	258	212	68	40	2	7.5	409.37	262
6	**Nagalur**	190	98.7	230	15	414	480	136	60	7	7.1	1281.25	820
7	**Virugavur**	120	67.7	212	8	310	333.6	151.3	35	4	7	1578.12	1010
8	**Satanur**	155	83	174	10	257	338	212	81	2	7.3	982.81	629
9	**Kachirapalayam**	84	43.2	233	10	210	313.8	181.8	62	23	7.7	1190.62	762
10	**Vadakunandal**	108	26.8	189	8	185	350	138.4	35	6	7.4	890.62	570
11	**Parigam**	132	40	189	6	252	329	127	30	4	7.2	690.62	442
12	**Uthodai**	120	24	179	12	210	304.7	110	10	5	7.4	928.12	594
13	**Nathamedu**	91	52.6	250	21	300	282	178	70	4	7.4	1234.37	790
14	**Siruvangur**	85	38	127	25	172	220	138	60	4	7.1	1757.81	1125
15	**V.Palayam**	138	54.3	104	8	175	309.4	151	33	3	7.3	784.37	502
16	**Niramathi**	114	96.8	74	18	312	207.4	140	30	3	7.1	1178.12	754
17	**Vilambar**	85	18	231	36	212	343.1	44	80	3	7.1	1484.37	950
18	**Tachur**	110	60.7	150	3	231	242.3	180	60	2	7.4	1403.12	898
19	**Ulagankathan**	132	87	102	10	300	321.6	74	48	2	7.3	1182.81	757
20	**Kadathur**	86	72.6	104	30	151	300.1	178	47	2	7.2	1039.06	665
21	**Kudiraichandal**	142	48	98	7	212	305.4	86	90	5	7.6	898.43	575
22	**Kallakurichi**	83	63.9	135	10	205	332	10	20	3	7.3	1523.43	975
	Min	**75**	**18**	**72**	**3**	**133**	**200**	**10**	**10**	**2**	**7**	**409.37**	**262**
	Max	**190**	**98.7**	**250**	**36**	**414**	**480**	**212**	**90**	**23**	**7.8**	**1757.81**	**1125**

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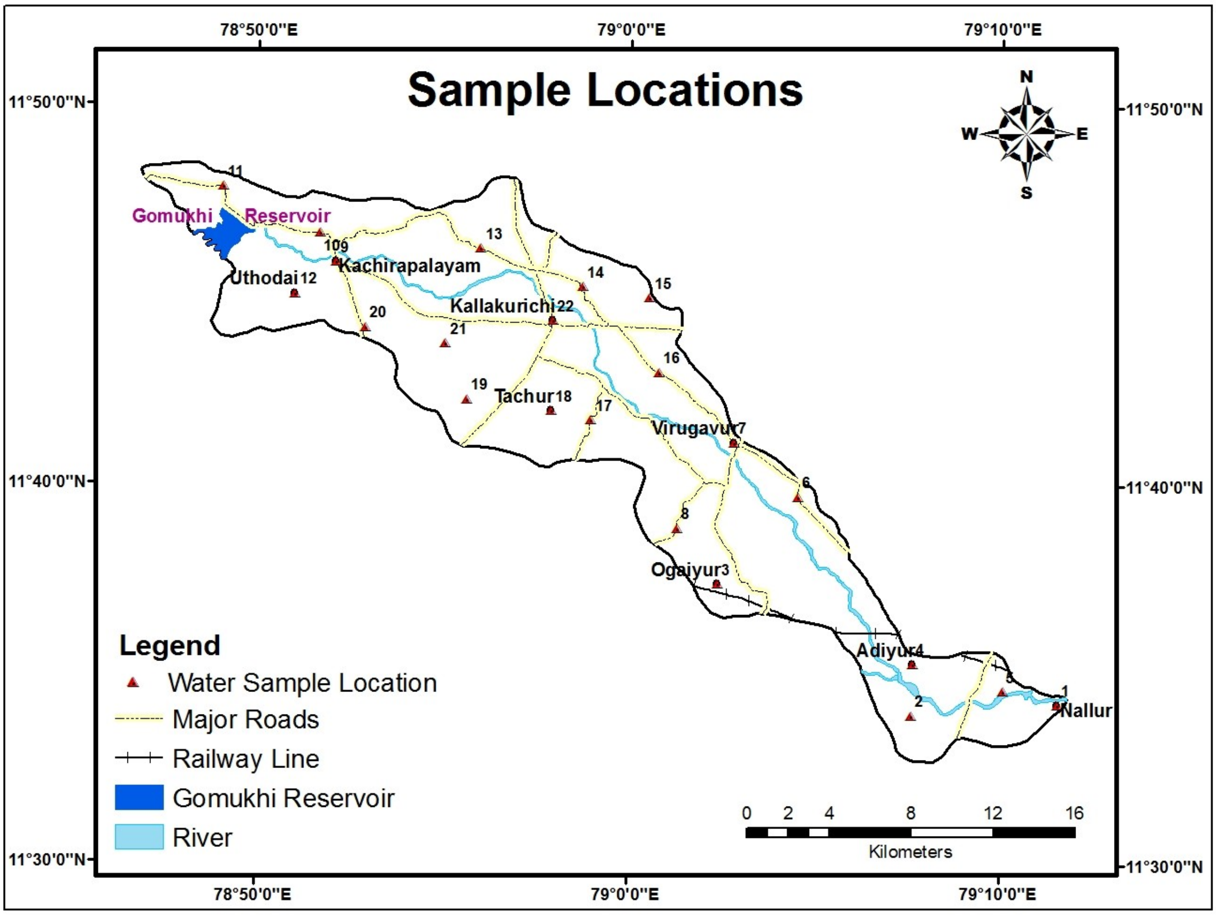

Fig-3. Sample Locations Map

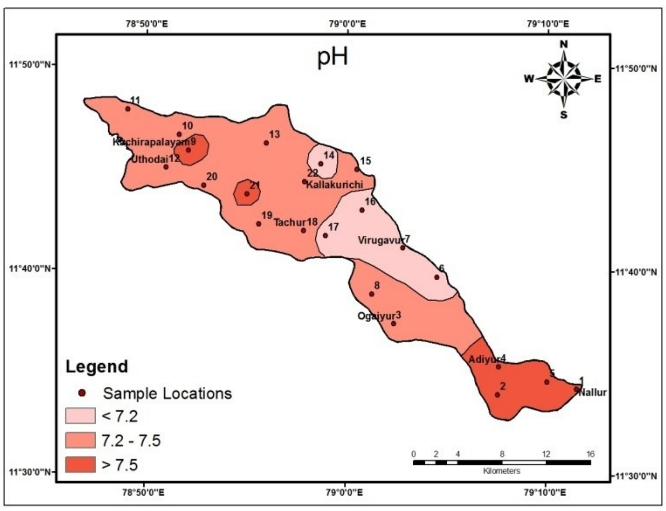

Fig-4. Spatial Variation of pH

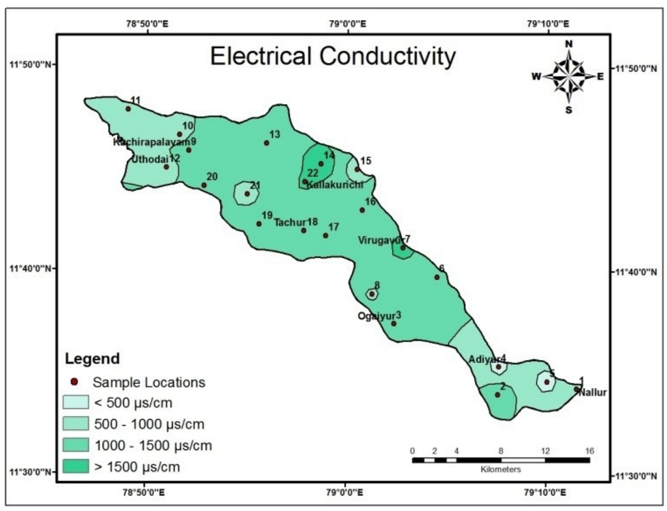

Fig-5. Spatial Variation of Electrical Conductivity

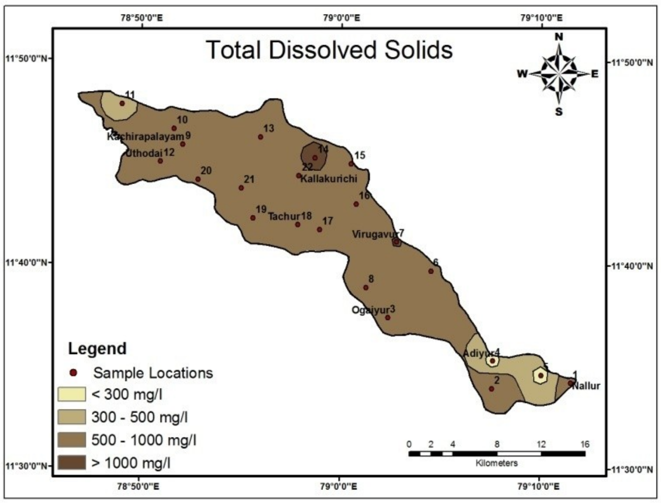

Fig-6. Spatial Variation of Total Dissolved Solids

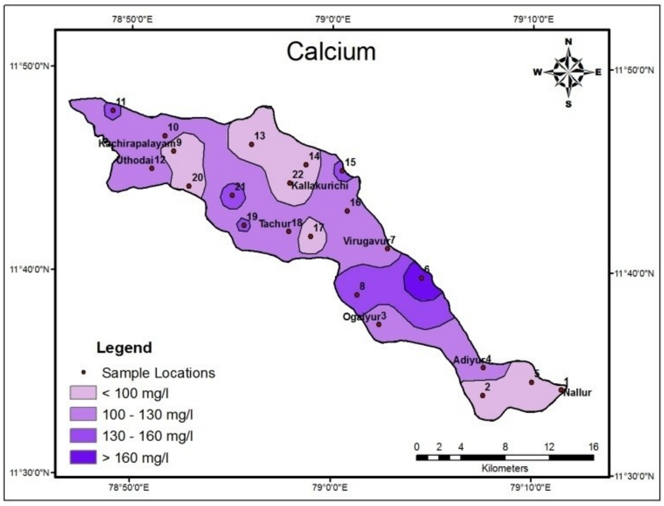

Fig-7. Spatial Variation of Calcium

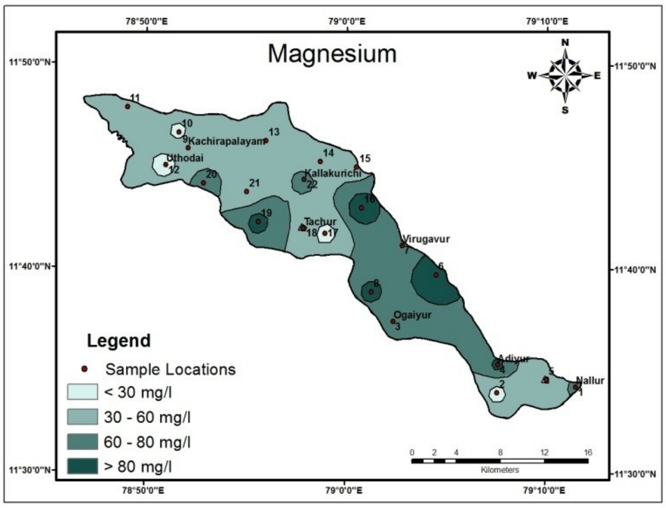

Fig-8. Spatial Variation of Magnesium

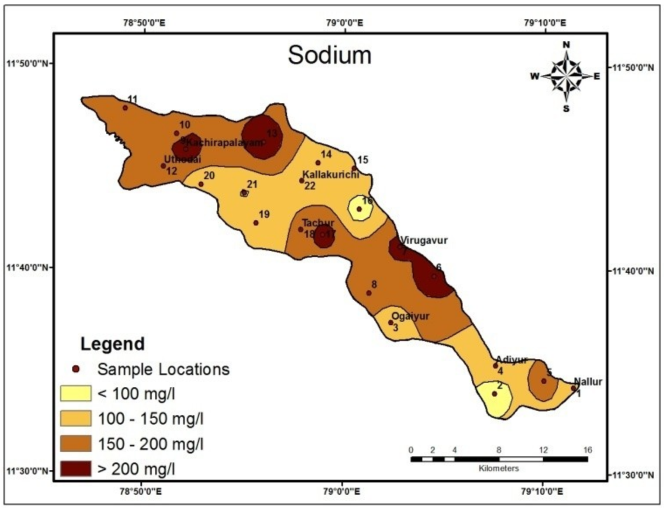

Fig-9. Spatial Variation of Sodium

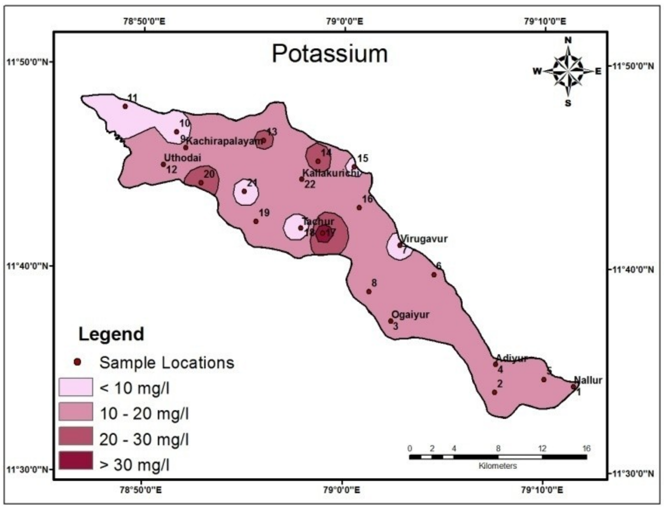

Fig-10. Spatial Variation of Potassium

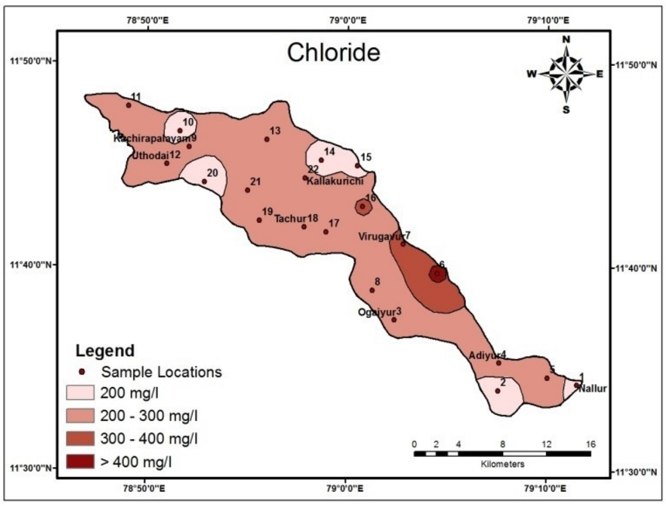

Fig-11. Spatial Variation of Chloride

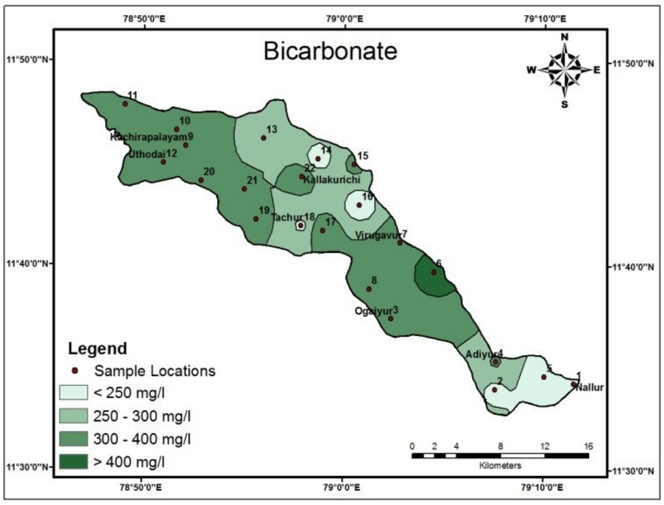

Fig-12. Spatial Variation of Bicarbonate

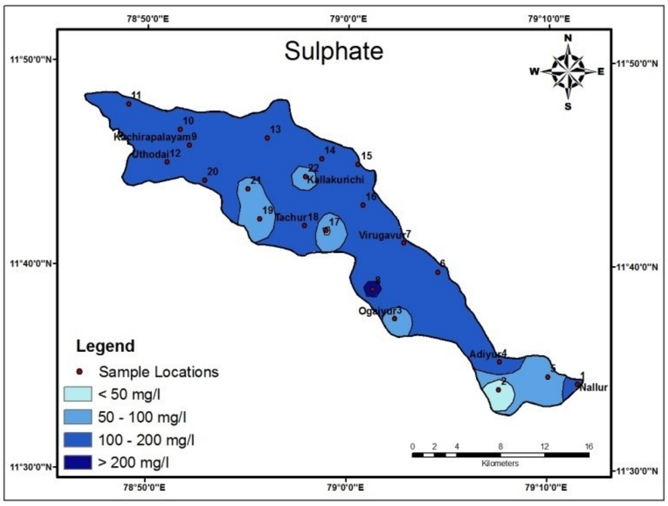

Fig-13. Spatial Variation of Sulphate

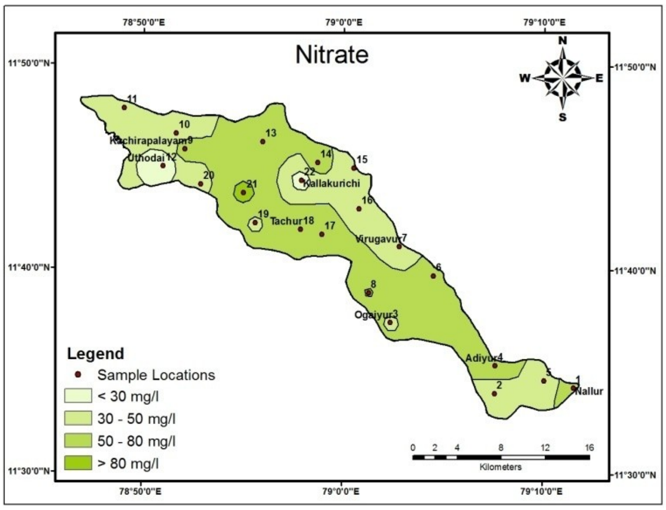

Fig-14. Spatial Variation of Nitrate

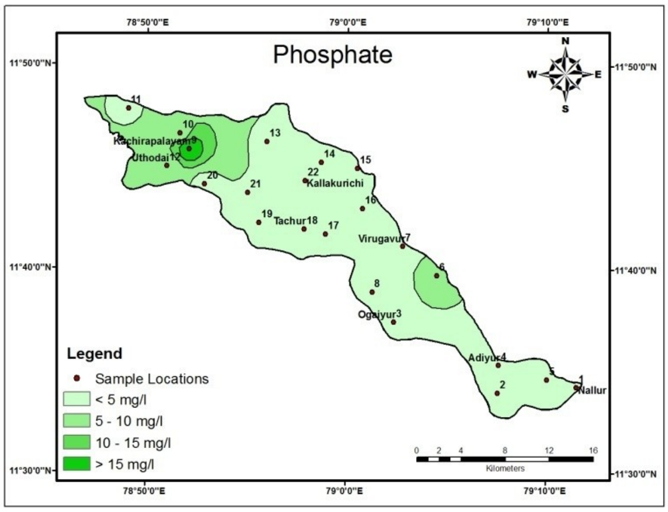

Fig-15. Spatial Variation of Phosphate

SODIUM ABSORPTION RATIO

The SAR is useful for judging the quality of water for the use of the agricultural purposes (Todd, 1980, Balasubramanian, 1986; Sastri and Lawrence, 1988). Richards(1954) classified the waters in relation to irrigation based on the ranges of SAR values. A more refined way of expressing the alkali hazard in irrigational water is shown by the U.S Salinity Laboratory (1954) diagram which takes into the relative activity of sodium in the exchange reaction in soil as expressed in terms known as SAR. The USSL diagram prepared for the groundwater samples of the study area is shown in the Figure-16, where the sodium adsorption ratio is plotted against specific conduction. In the study area most of the groundwater samples are fall in C3S1 category whereas few samples are fall in the C2S1.

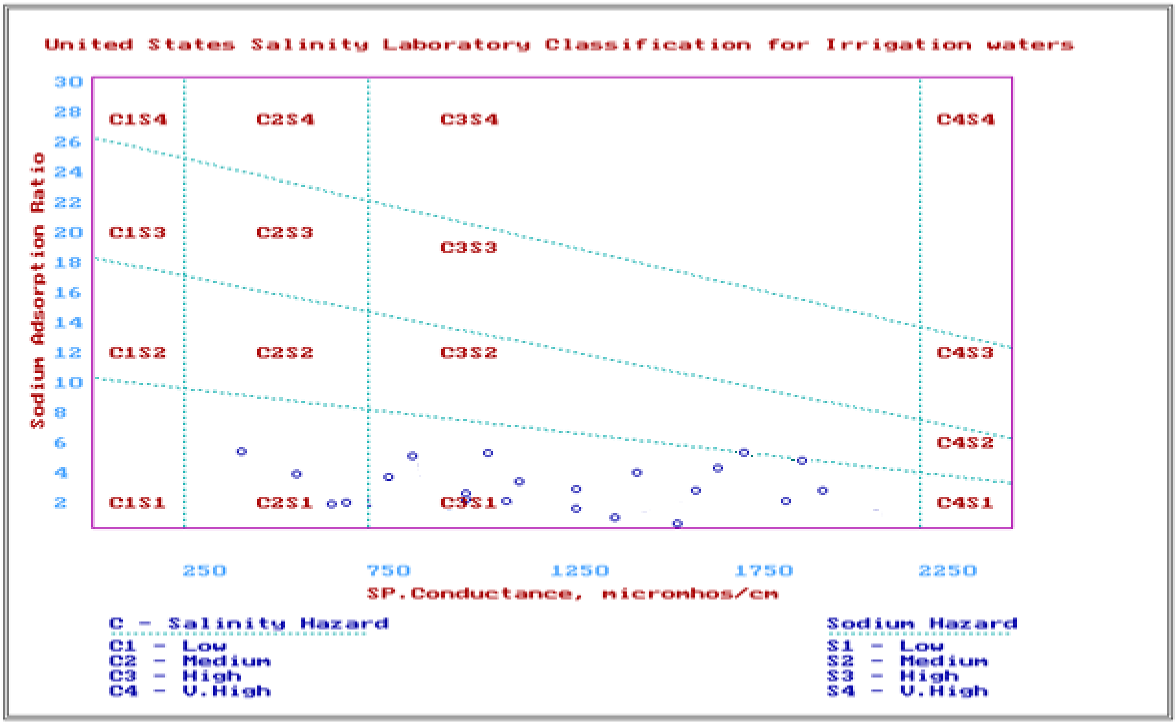

Fig – 16. USSL Diagram

HYDROGEOCHEMICAL FACIES

The hydrochmical facies classification is normally attempted using the trilinear diagram of Piper (1944). Nevertheless, the classification of hydrogeochemical facies and environment has been widely used by the reconstructed diamond field. The normal trilinear pattern has reconstructed in to diamond field by Lawrence and Balasubramanian, 1994. The diamond fields consist of 15 sub fields which represents the hydrogeochemical facies of the groundwater. The interpretation is very useful in bringing out the chemical relationships among ground waters in more definite terms (Walton, 1970). In the present study area, ground water samples have been plotted with reconstructed diamond field diagram as shown in Figure-17. Majority of the samples are fall in sub field 1 and 12. It shows that Ca+Mg + Na; SO_4+ Cl and which represent water contaminated with gypsum. Only one sample fall in sub field 2 which represent Ca + Mg;SO_4+ Cl & HCO_3+ CO facies.

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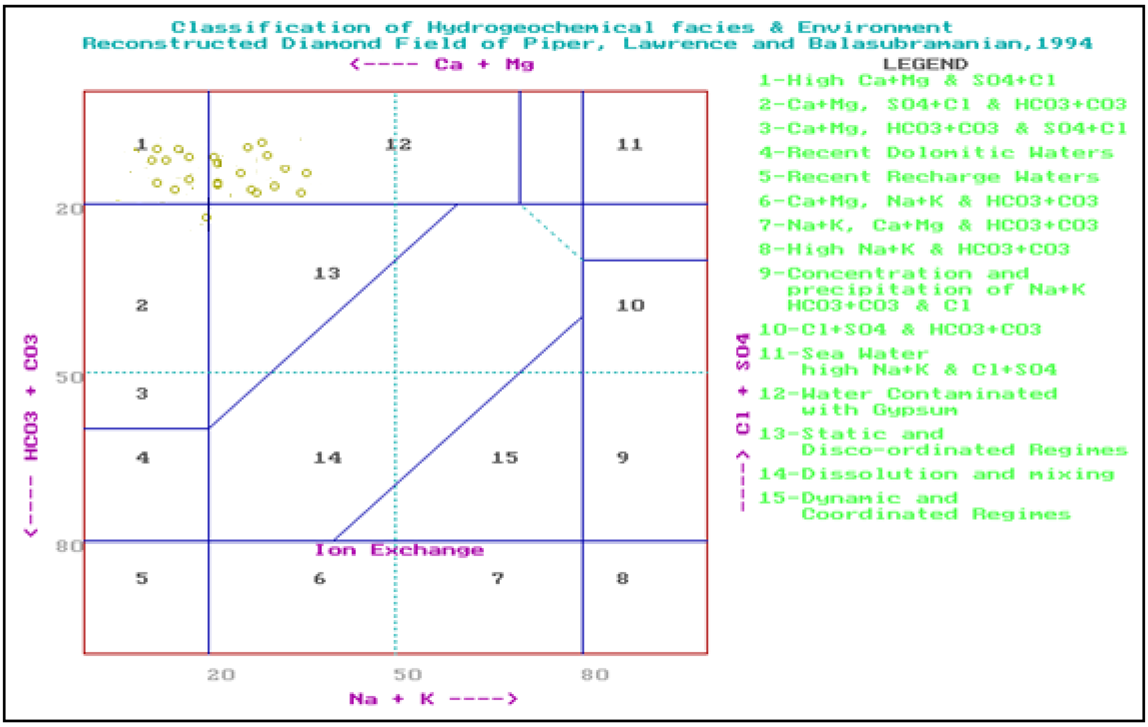

Fig – 17. Reconstructed diamond field of Piper diagram

GIBB'S RATIO

Mechanism controlling groundwater geochemistry is action between groundwater and aquifer mineral has a significant role in water quality which is useful to understand the genesis of water (Sillen 1967, Gibbs1970). In the present study, Gibb's ratio –I, Cl/Cl +HCO_3 for anions and ratio – II, Na +K/Na+K+Ca for cations of the samples plotted separately against respective values of total dissolved solids as shown in Figure-18. It could be confirmed that the chief mechanism controlling the chemistry of groundwaters of the study area are dominated by rock water interaction in the period and least representation from evaporation and precipitation category.

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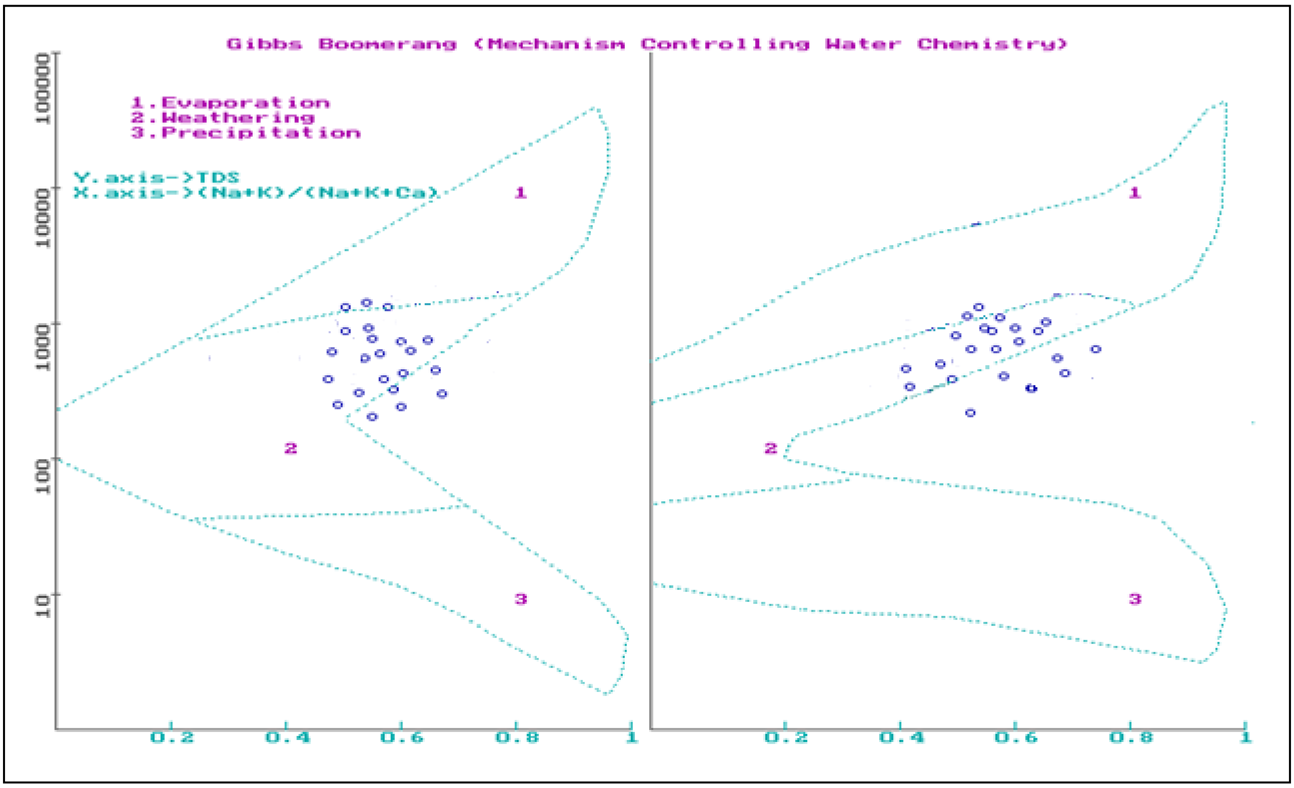

Fig – 18. Gibb's Diagram

CONCLUSION

The hydrogeochemical study of the part of the Gomukhi sub basin reveals that that most of the samples are not exceeding the maximum permissible limit of WHO (2011) for drinking water. In few locations the ionic concentration was noticed above the permissible limit. The higher amount of Mg, Na and K concentrations observed in certain sample locations are mainly from host rock formations of the study area, nevertheless unbalanced discharge and recharge, hydraulic characters and land use pattern of the study area also could be influenced. However, the concentrations of nitrate and phosphate are due to the agricultural practice and application of fertilizers. In the study area mostly groundwater permissible limit WHO (2011) drinking water standard, few sample was above limit. Study area was hard rock regions and over exploitations. USSL diagram depicts that groundwater of the area is suitable for irrigation purpose and groundwater facies identified is SO_4+ Cl which represent water contaminated with gypsum. Gibb's ratio was dominated by rock water interaction and least representation from evaporation and precipitation category.

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