Hydrochemical Interaction of Major ions in Groundwater: A Case Study

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Research Article

Keywords: Cation exchange reaction, Silicate weathering process, bivariate plot

Posted Date: July 28th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-48757/v1

Version of Record: A version of this preprint was published on March 13th, 2021. See the published version at https://doi.org/10.1007/978-3-030-64136-8_14.

Abstract

Water is most important resource to sustain to progress life on the earth. Most of communities obtain their water recover from groundwater. Aquifer that can capable of holding fresh water. Nearly 80% of water resource used for human purposes. So water drain into the watershed of the study. The chemical composition of river eater is mainly depending upon many interrelated factor including geology, soil, topography and biological process. The continuous runoff of water may causes land use changes, therefore, hydro geochemistry of groundwater is sum of the total character. Water resource quality character is one of pollution problem comes when the concentration of the ions exceeds the acceptable limit. In this study area now a day the problem of environmental pollution increase day-to-day and anthropogenic influence paly concern role in groundwater. The aim of the present study explore the appraisal of physico-chemical characterization of groundwater water samples and their major ion interaction in hard rock of this study area. In this area that is quality character of water resource especially for drinking and domestic purposes it is depend on the constituent of water. Once, the concentration exceeds the permissible limit it causes health effect. Gibbs and missing plot were used to identify the source of major ions. The contribution of water pollution scenario can be confirmed by field studies by focusing on land use change, agriculture and settlement activities. The relationship between consider variable of ions were determined through correlation analysis. A better understanding of hard rock aquifer for water quality changes as development progress by geochemical studies of groundwater deliver is necessary.

Introduction

Groundwater is ultimate, most suitable fresh water, resource with around well-adjusted concentration of the salt for human depletion (Tewari et al.,2010). Temporal Changes in water quality exceptional are because an interaction of rock–water and oxydo-discount reactions at some stage in the separation of water thru the aquifers. By these processes toxic, nontoxic pollution and waterborne pathogens are the main water fine constraints which might be transported from recharge region to discharge place via aquifers through groundwater movement (Simge Varol et al.,2013). This study the composition of groundwater provides an insight of understating relationship between chemical weathering, evaporation atmospheric deposition. The polluted water has considerable negative impact on human also. The various factors have influenced on sub basin. Drainage pattern of an area depends on the course of stream and their tributaries. Drainage pattern is to locate characterization of vulnerable area and soil conservation measures. In this area, most influence factor is precipitation distributed by seasonal. The present research work is aim to evaluate physical chemical characterization of study area for identifying the source factor. Finally develop the contribution of chemical weathering and anthropogenic influence activities. The hydro chemical study reveals the suitability of water that is drinking, agriculture and had domestic purposes. Further, the possible changes water rock interaction. The chemical analysis in graphical form indicated to understand complex system. Gibbs proposed a simple model constructed with TDS and ions for represent the process interaction of rock water. A number of researchers have attempted to identify the interaction of controlling water chemistry and there is assessment the continuation of surface water into groundwater. Fluoride are that threaten water first-class that Fluoride publicity can produce an extensive kind of acute and continual consequences in human beings, such as dental fluorosis and bone ailment (Satheeshkumar et al., 2017). Fluoride absorbed with the aid of the human frame disturbs many methods and sometime is harmful. The hazard quotient (HQ) is widely used to symbolize health effects of poisonous metals and fluoride by using comparison in their revelation outcomes to a reference dose (Qu, C. S et al 2012 and Sun 2011 et al.,). This become documented in numerous studies through contemplating exposure eventualities of metal intake via contaminated water (Muhammad et al.,2011, ,Dou et al.,2012, Shah et al.,2019). Reliable opportunity, accordingly depends on the concentration of trace elements, which receives dissolved from the aquifer-bearing rocks thru complex hydrogeochemical manner by usage of groundwater as a potential and (Mukherjee et al.,2015). The facies of hydrogeochemical is accountable for water resource pollution, their strategies and deciphering unique indices had been usually used by a variety of techniques (Coetsiers et al.,2006; Srivastava et al.,2008;Das A et al.,2015,).

Study area

In this area, the source of water recharge from vaniyar river basin it receive maximum rainfall from yercaud region (Fig 1). It is maximum elevation of study area. It is cover shevroys hills. The lithology of the area is mainly consists of Granitic to biotite gneissic rock. The most of the red soil covered followed by block soil. Some place dyke and lineament present in the study area. They are most useful for groundwater targeting for water development and management. The Vaniyar river basin is one hard rock aquifer and it is cover mainly in south India of flowing non-perennial stream. This area is subtropical climate region.

Methods

GW samples were collected from different region into his study area. 2005 to 2014 data collected from PWD. The water quality parameter have analyzed into cations and anion. Generally, the groundwater samples show the specific charge balance between less than 10% by NICB test. The samples were analyzed for anion and cations. For the determination, water quality parameters like temperature, pH, electrical conductivity, total solids, total dissolved solids, cations (Sodium, Potassium, Calcium, Magnesium), anions (Bicarbonate , Nitrate , Sulphate, Chloride), total hardness in groundwater samples were subjected to Multivariate analysis. The evaluation of major cations are for most important ions, analytical precision turned into checked by the NICB, normalized inorganic charge stability (Kumar et al.,2010, 2016a, 2016b, 2016c).

Results And Discussion

Assessment of groundwater quality

Water samples from this study area are generally less than 10% which is estimated (Fig.2). The box plot is a simple visualization with respect maxima and minima identified by the data variation (Fig.3) of diverse region of the study area for the drinking purposes of groundwater quality assessed.

GW Quality for drinking Usage

One of the these techniques box plot which is used for to visually summarize and compare groups for drinking suitability at kompur and pappiredipatti in Figs 4 and 5. Both have good to moderate water quality in this region based on BIS standard.

Major ion variation in different water types are shown in fig 6. Scatter diagram shown in Fig.7 relation between Na vs Cl. Geology of the study area is primary factor for controlling the quality of natural water system. In the natural condition in the chemical composition, rainfall ranges between the temperatures of this region show in the process of evaporation.

Ludwig langelier plot is an appropriate grouping of cations and anions have been plotted as percentages. Generally, this type of Ludwig langelier is used to plot percentage of Na+K against percentage of HCO3+%SO4. In this plot, Ca+Mg and Cl their percentage are also fixed: Fig.7 plot displays relative ratios rather than absolute concentrations

Mechanisms controlling hydrochemical composition

The chemical components of water to their respective aquifers and the groundwater chemistry in the rock and their connection of including chemistry of the rock types, chemistry of brought on water, and rate of evaporation have been recognized. Gibbs (1970) diagram has illustrated in which ratio between dominant of anions and cations have plotted in opposition to the fee of Total Dissolved Solid. Anions [Cl/(Cl+ HCO3)] and Cations [(Na+K)/(Na+K+Ca)] as a function of TDS are broadly employed to dissolved chemical parts inclusive of precipitation fall in upper region mostly ,rock and evaporation dominance in lower region. (Gibbs1970) gibbs diagrams are representing the ratio. The chemical water data of groundwater samples are plotted inside the Gibbs diagram (Figs. 9). Influencing in weathering of rock-forming minerals of groundwater through dissolution of rock via which water is circulating through ions of the water.

Evaporation

Groundwater samples are indicates the relation between Na (meq/l) versus Cl (meq/l) in Fig.10 and Na/Cl (meq/l) versus EC in Fig.11. Both are shown evaporation is not major part of process. This process is slightly inclined relationship. The slightly elevated Na is indicating silicate weathering than evaporation. In this area Na is higher because of granite gneiss monitored by evaporation process.

Cation-exchange response

This process which control occurrence and distribution of ions using this reaction it can be identified which is contamination sources. Excess Cl over Na this demarcates ion exchange process (Fig.12).

Silicate weathering process

Evidence of silicate weathering can be elucidated by Relation between Ca+Mg versus HCO_3in Fig 13. This situation required CO3 alkalinity to be balanced by alkalis. Relation between Ca+Mg versus Total cationin Fig.14 and Relation between Na+K versus Total cationin Fig.15. The most of data points 1:1 equiline. The total cation are indicating silicate weathering when contribution higher in this case. Na probable source is silicate dissolution because it derived from silicate weathering. In this study the major source of cation and HCO3 occurred by silicate process of weathering and also Ca and Mg by common minerals in granitic gneissic rock.

Soil leaching indicated in Fig.16. The boxes represent in Fig.17 without any mixing, the tiers of approximate compositions of the three important supply end individuals such as carbonate dissolution, Silicate weathering and Evaporate dissolution) (after Zhu et al.,2011)

Conclusion

An examination are presented the geochemical analysis of the subsurface water using statistical technique and estimated the ability rate of the ground water sources in the southern India. The ground water qualities of the vaniyar river basin sample were analyzed. That all the groundwater samples belong to rock dominance to evaporation category and the results were confirmed with the gibbs diagram show upper basin control by rock dominance and lower basin controlled by few samples show evaporation due to weathering. The results found that the arrangement of the plenty of the major anions and cations is in the order Cl^{-} > HCO_3 >Mg^{-} > Na > Mg^{2+}> Ca^{2+}>SO^{4+}. The findings of this study will be of Vital to the water management government to recognize the hydrochemistry of the groundwater components inside the location for viable control.

Declarations

Competing Interests

The authors declare no competing interests

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Tables

Table.6.1 Groundwater quality data (2005-2014) in the study area (Average value in mg/l)

Villages	Season	TDS	NO2+NO3	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3	F	pH	EC
	SW	876	5.125	45.5	62.116	194.75	12.75	204	81.625	20.25	465.88	1.195	8	1560
	PM	826	10.90	33.5	61.616	184.5	6.1625	135	85.75	8.7	439.17	1.4228	8.2	1400
Kombur	PRM	1272	11	32	94.77	294	7	330	221	0	481.9		7	2210
	SW	832	19	85.75	40.70	144	17.125	207.75	103.75	0.0503	291.41	0.9514	7.8125	1415
	PM	913	16	72	31.416	168.28	54.28	208.71	156.85	11.52	272.24	0.588	7.9285	1492.8
Menasi	PRM	385	11	68	41.31	7	7	53	29	0.4024	214.58		7.3	730
	SW	790	14.5	32.5	45.410	194.37	6.375	118.87	99.5	6.4092	438.70	1.4942	8.05	1330
Salur	PM	536	9.66	28.333	37.867	115.83	4.85	101.5	44.166	6.1191	287.56	1.1325	8.15	936.66
	SW	899	7.6	74	80.676	126.8	19.2	243	139	0	364.78	1.108	7.86	1598
	PM	908	38.4	82	70.713	114.4	18	209	110.8	6.4091	237.09	0.88	8	1500
Beddur	PRM	1209	51	64	87.48	207	23	362	132	0	214.72		7.8	1890
	SW	1333	46.285	67.714	127.74	202.71	16.42	379.42	130.57	0	412.18	1.4685	7.8142	2280
	PM	1387	45.76463	60.857	120.86	169	14	317	136.71	7.7142	347.81	1.1463	7.8571	1955.7
Sunkarahalli	PRM	373	2	38	31.59	51	11	28	27	2.7001	287.24		8	680
Pappireddipatti	SW	685.	6.833	43.33	56.7	122.5	13.33	197.8	57.33	0.4267	308.71	1.3616	7.916	1211.
	PM	734.	14	46.33	55.48	133.6	15	211.5	64	0.3020	284.77	1.142	7.916	1271.
	PRM	704	17	38	47.38	152	6	39	84	0	524.6		7.6	1110
Kadathur	SW	1223	22.07	68.15	86.73	243.1	12.69	397.6	131.7	9.885	346.21	1.2853	8.015	2120
	PM	1341	28.10	63.42	102.8	255.5	14.14	474.4	132.0	3.428	309.8	0.8646	7.942	2222.
	PRM	1263	70	72	80.19	221	21	333	134	0	183		7.9	1920

Mullaivanam	SW	546.4	12	43.6	52.00	79.2	8.8	75.8	46.2	2.349	321.10	0.766	7.74	882
	PM	560	23.25	39	53.15	74	11.2	87	50.5	0.935	266.62	0.64	8.05	952.5
	PRM	681	6	100	43.74	87	10	234	36	0	286.7		7.2	1380
K.Vetrapatti	SW	506.6	8.6	40.4	42.28	78.8	5.4	93.4	90.6	19.75	183.95	1.404	7.96	890
	PM	847.3	23.88	64.22	68.22	88.22	7.56	207.5	87.88	7.300	228.32	1.2042	8.011	1303.
	PRM	324	11	58	43.74	5	8	60	30	0.428	114.55		7.6	710
Gopinathampatti	SW	401.7	10	37	30.37	61.25	5.25	61	45.25	3.053	204.73	0.9	8.275	695
	PM	835	40.25	90	60.44	104.5	8.25	181	68.25	0.509	272.57	0.8733	7.775	1377.
	PRM	1236	13	72	102.0	235	7	269	170	0	646.6		7.4	2220
Bairanaickanpatty	SW	658.2	29.4	64	46.899	94.8	8.2	109	51.8	0	307.44	0.984	7.74	1084
	PM	1179	35.940	48.666	81.103	194.33	10.3	283.16	67.833	16	324.28	0.6916	8.2833	1116.6
	PRM	1262	13	52	97.2	276	9	277	158	0	671		7.8	2130
Jammanahalli	SW	664.5	16	63.5	51.03	94.5	10.7	171.75	76	0	253.15	0.4725	8.05	1142.5
	PM	835	12.443	67	52.655	132.25	8.02	260.75	49.25	4.5	253.15	0.5135	7.875	1322.5
Gurubarahalli	SW	1154	27.333	102.66	84.24	174.66	9.66	420.66	144.33	0	189.1	0.7133	7.9666	1936.6
	PM	687.5	11.048	54	47.95	110.5	6.5	181	62.5	0	259.25	1.1565	8.05	1140
Sandapatti	SW	465.33	11.333	44.666	40.905	57	7.66	92	46.333	1.17	223.05	0.7333	7.9666	803.33
	PM	892.33	16.806	50	96.536	66	9.66	256.33	59.666	0	219.86	0.6013	7.9	1330
Regadahalli	SW	976.5	37	68	93.251	127.5	10.5	273.75	94.75	0	291.27	1.0175	8.025	1675
	PM	1059	34.515	68	56.206	111.66	26	146.66	46	0	339.63	0.558	7.8	1356.6
Ajjampatty	SW	735.75	18.5	30.5	44.955	164.2	13	138.2	87	3.9	345.87	1.1366	8.225	1247.5
	PM	604.33	15	26.666	51.84	118	8.36	103	28	9.82	374.58	1.093	8.3	1090
Mampatti	SW	278	1	40	24.3	37	2	32	12	0.78	209.19	1	7.6	570
	PM	1357	30.74	66.666	53.01	164.3	13.6	249.3	82.33	1.32	233.98	0.621	7.766	1486.6
A.Velampatti	SW	522.333	8.666	61.3333	36.04	76.6	7.33333	122.6	46	0.464	262.975	0.906	7.966	946.666
	PM	463.6	6.858	32.8	41.1	62.2	10.22	83	31	1.991	255.734	0.716	8.12	768
Veddakattamaduv	SW	981.333	12	37.3333	29.16	233	68.333	246	14	0	345.666	0.68	8	1406.33
	PM	1378	22	68	51.03	235	196	291	96	0	683.2	0.14	7.6	2200
Kilanur	SW	707	8	84	34.02	124	12	181	69	0	335.5	0.1	8	1230
	PM	694	8	68	34.02	138	14	152	48	0	408.7	0.18	7.4	1200
Veppampatti	SW	778	8	108	58.32	94	1.15	232	94	0	308.05	1.215	8.15	1435
	PM	727	16	112	68.04	62	0.1	202	72	0	280.6	1.4	8.1	1440

Table.6.2 Groundwater quality data (2005-2014) in the study area (average) in meq/l

Villages	Season	Na(meq/l)	K(meq/l)	Ca(meq/l)	Mg(meq/l)	Cl(meq/l)	SO4(meq/l)	CO3(meq/l)	HCO3(meq/l)
Kombur	SW	8.467	0.326	2.270	5.1103	5.746	1.7005	0.675	7.6375
	PM	8.021	0.157	1.671	5.0692	3.802	1.7864	0.29	7.19954
	PRM	12.78	0.179	1.596	7.7967	9.295	4.6041	0	7.9
Menasi	SW	6.260	0.437	4.278	3.3486	5.852	2.1614	0.0016	4.77722
	PM	7.316	1.388	3.592	2.5846	5.879	3.2678	0.3841	4.46306
	PRM	0.304	0.179	3.393	3.3986	1.492	0.6041	0.0134	3.51783
Salur	SW	8.451	0.163	1.621	3.7359	3.348	2.0729	0.2136	7.19193
	PM	5.036	0.124	1.413	3.1153	2.859	0.9201	0.2039	4.71421
Beddur	SW	5.513	0.491	3.692	6.6372	6.845	2.8958	0	5.98
	PM	4.973	0.460	4.091	5.8176	5.887	2.3083	0.2136	3.88685
	PRM	9	0.588	3.193	7.1970	10.19	2.75	0	3.52
Sunkarahalli	SW	8.813	0.420	3.378	10.509	10.68	2.7202	0	6.75714
	PM	7.347	0.358	3.036	9.9439	8.929	2.8482	0.2571	5.70187
	PRM	2.217	0.281	1.896	2.5989	0.788	0.5625	0.0900	4.70901
Pappireddipatti	SW	5.326	0.341	2.162	4.6647	5.572	1.1944	0.0142	5.0609
	PM	5.811	0.383	2.312	4.5647	5.957	1.3333	0.0100	4.66837
	PRM	6.608	0.153	1.896	3.8983	1.098	1.75	0	8.6
Kadathur	SW	10.57	0.324	3.400	7.1355	11.20	2.7451	0.3295	5.67570
	PM	11.10	0.361	3.165	8.4639	13.36	2.7514	0.1142	5.07927
	PRM	9.608	0.537	3.592	6.5972	9.380	2.7916	0	3
Mullaivanam	SW	3.443	0.225	2.175	4.2782	2.135	0.9625	0.0783	5.26398
	PM	3.217	0.287	1.946	4.3732	2.450	1.0520	0.0311	4.37088
	PRM	3.782	0.255	4.990	3.5985	6.591	0.75	0	4.7
K.Vetrapatti	SW	3.426	0.138	2.015	3.4785	2.630	1.8875	0.6586	3.01569
	PM	3.835	0.193	3.204	5.6132	5.846	1.8310	0.2433	3.74301
	PRM	0.217	0.204	2.894	3.5985	1.690	0.625	0.0142	1.87789
Gopinathampatti	SW	2.663	0.13	1.846	2.4989	1.711	0.9427	0.1017	3.35633
	PM	4.543	0.210	4.491	4.9729	5.098	1.4218	0.0169	4.46837
	PRM	10.21	0.179	3.592	8.3965	7.577	3.5416	0	10.6
Bairanaickanpatty	SW	4.121	0.209	3.193	3.8584	3.070	1.0791	0	5.04
	PM	8.449	0.264	2.428	6.6724	7.976	1.4131	0.5333	5.31612
	PRM	12	0.230	2.594	7.9967	7.802	3.2916	0	11
Jammanahalli	SW	4.108	0.274	3.168	4.1982	4.838	1.5833	0	4.15
	PM	5.75	0.205	3.343	4.3319	7.345	1.0260	0.15	4.15
Gurubarahalli	SW	7.594	0.247	5.123	6.9304	11.84	3.0069	0	3.1
	PM	4.804	0.166	2.694	3.9448	5.098	1.3020	0	4.25
Sandapatti	SW	2.478	0.196	2.228	3.365	2.591	0.9652	0.0393	3.65662
	PM	2.869	0.247	2.495	7.9421	7.220	1.2430	0	3.60437
Regadahalli	SW	5.543	0.268	3.393	7.6718	7.711	1.9739	0	4.775
	PM	4.855	0.664	3.393	4.624	4.131	0.9583	0	5.56776
Ajjampatty	SW	7.141	0.332	1.521	3.6984	3.894	1.8125	0.13	5.67
	PM	5.130	0.213	1.330	4.2649	2.901	0.5833	0.3275	6.14077
Mampatti	SW	1.608	0.051	1.996	1.9991	0.901	0.25	0.0260	3.42946
	PM	7.144	0.349	3.326	4.3611	7.023	1.7152	0.0441	3.83585
A.velampatti	SW	3.333	0.187	3.060	2.9654	3.455	0.9583	0.0154	4.31107
	PM	2.704	0.261	1.636	3.3874	2.338	0.6458	0.0663	4.19236
Veddakattamaduvu	SW	10.13	1.747	1.862	2.3990	6.929	2.9166	0	5.66666
	PM	10.21	5.012	3.393	4.1982	8.197	2	0	11.2
Kilanur	SW	5.391	0.306	4.191	2.7988	5.098	1.4375	0	5.5
	PM	6	0.358	3.393	2.7988	4.281	1	0	6.7
Veppampatti	SW	4.086	0.02	5.389	4.7980	6.535	1.9583	0	5.05
	PM	2.695	0.002	5.588	5.597	5.69	1.5	0	4.6

Figures

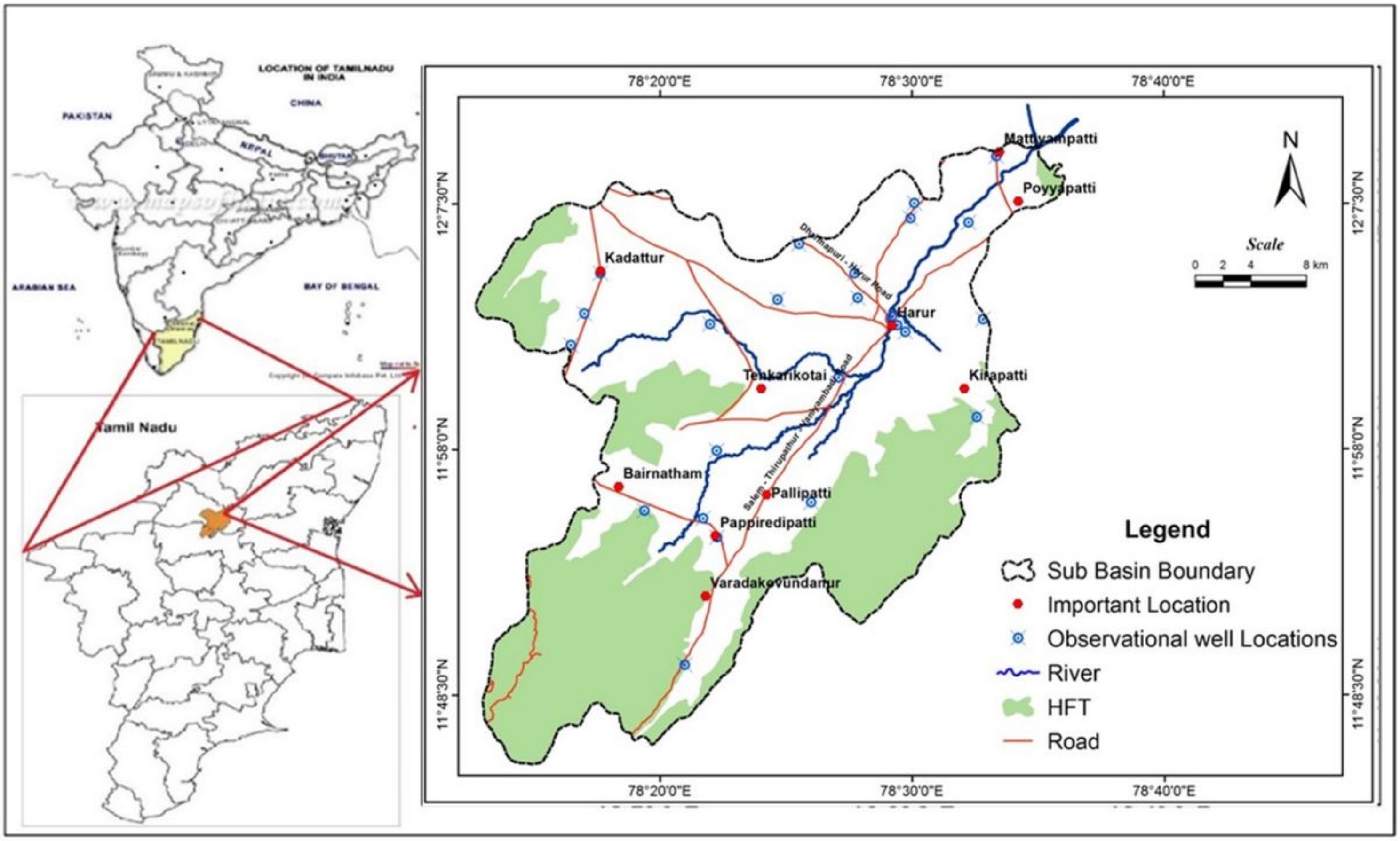

Figure 1

Location of the water level observational well area

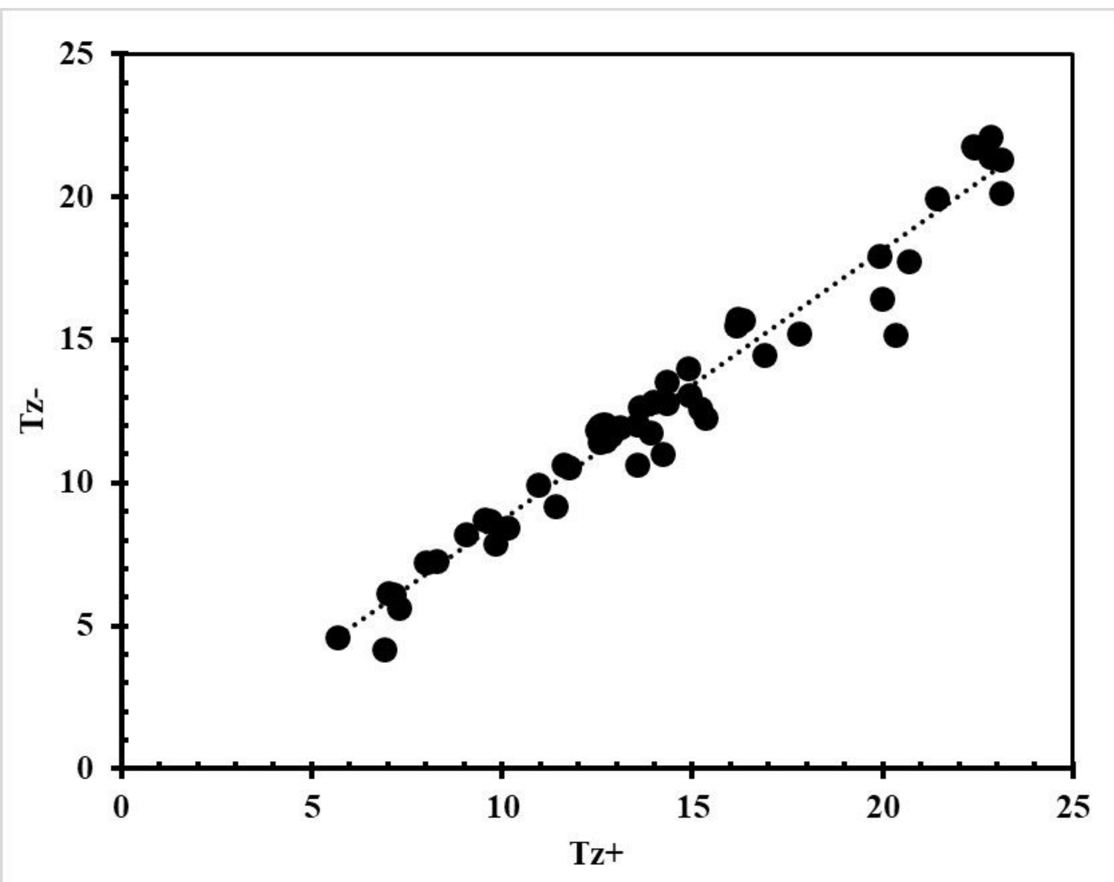

Figure 2

Sum of cation and anion (NICB<10%)

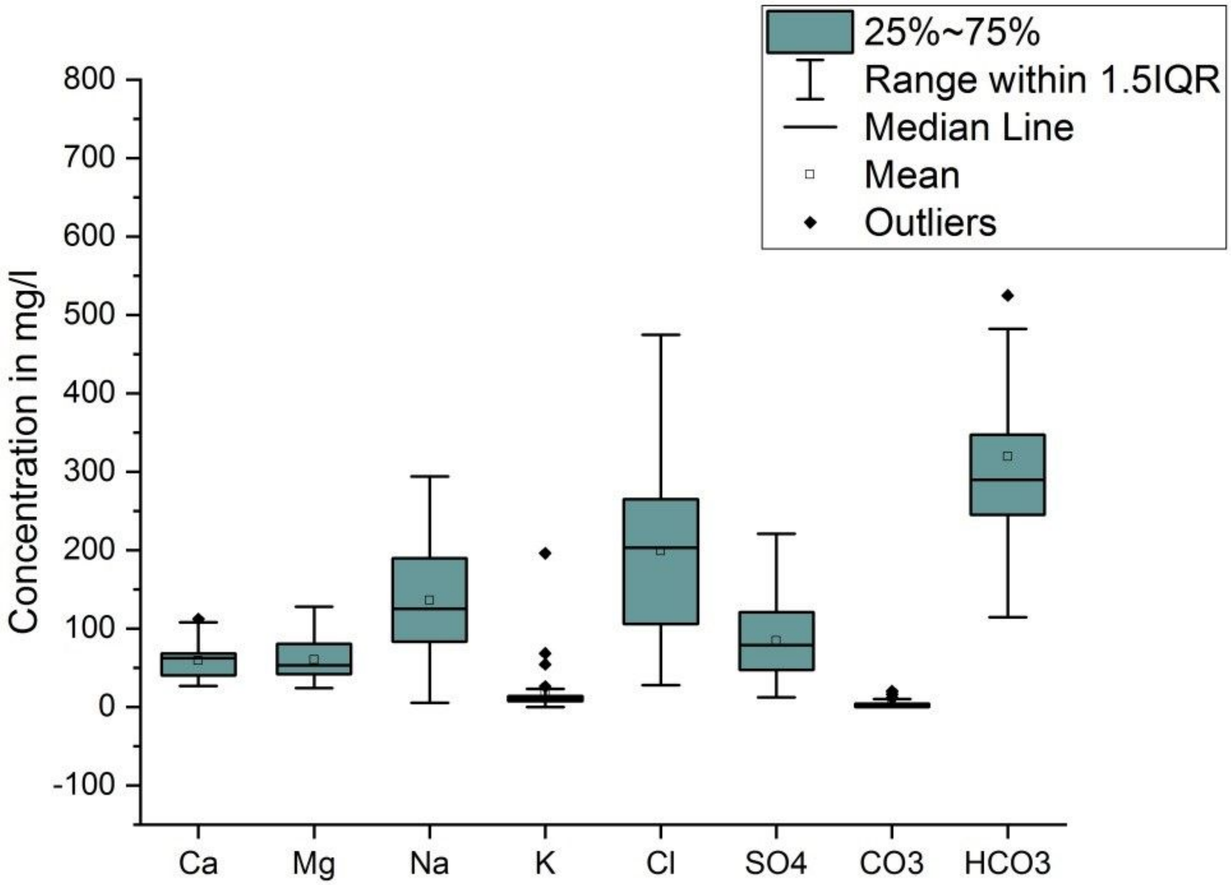

Figure 3

Box plot showing the variation of ionic concentration

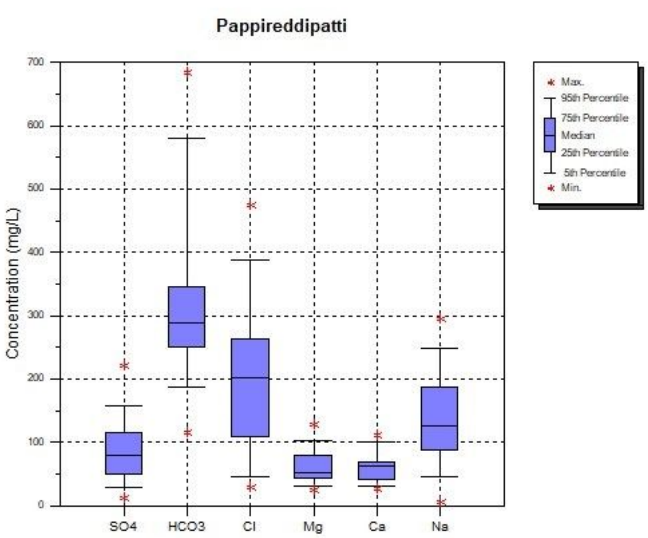

Figure 4

Box plot showing the variation of ions at kombur

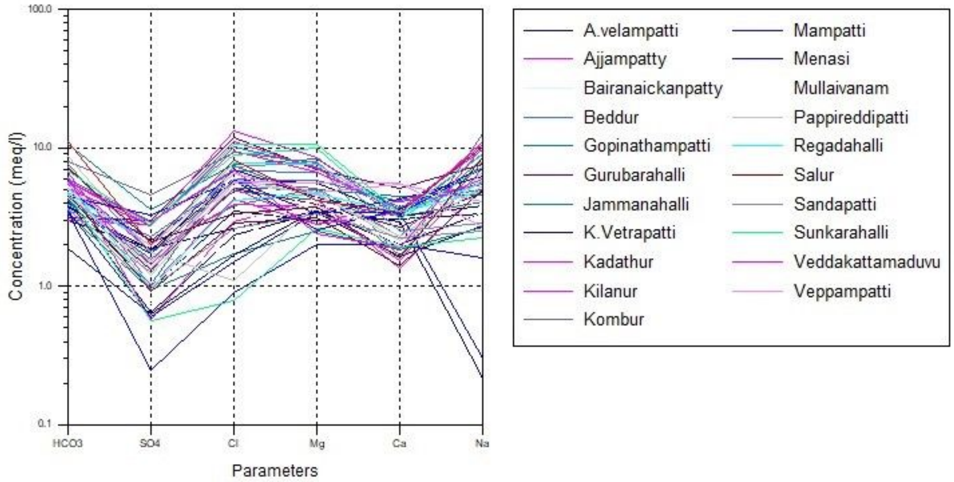

Figure 5

Schoeller diagram shown variation of major ions

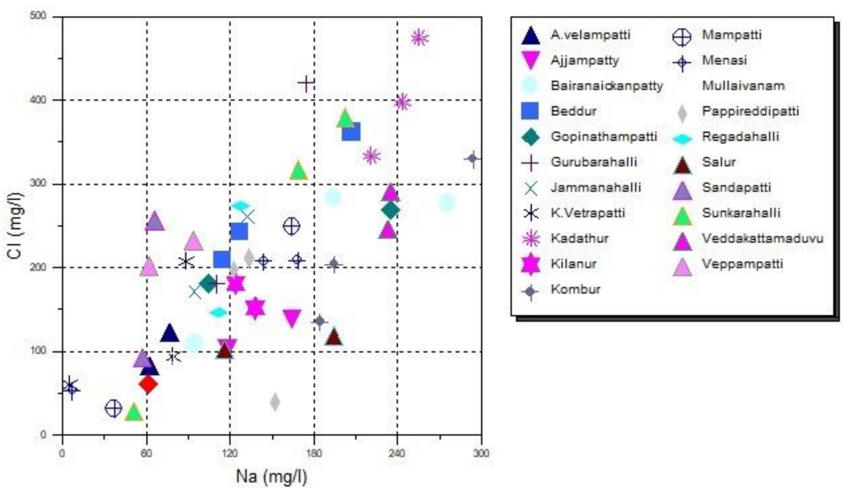

Figure 6

Scatter diagram shown Na vs Cl

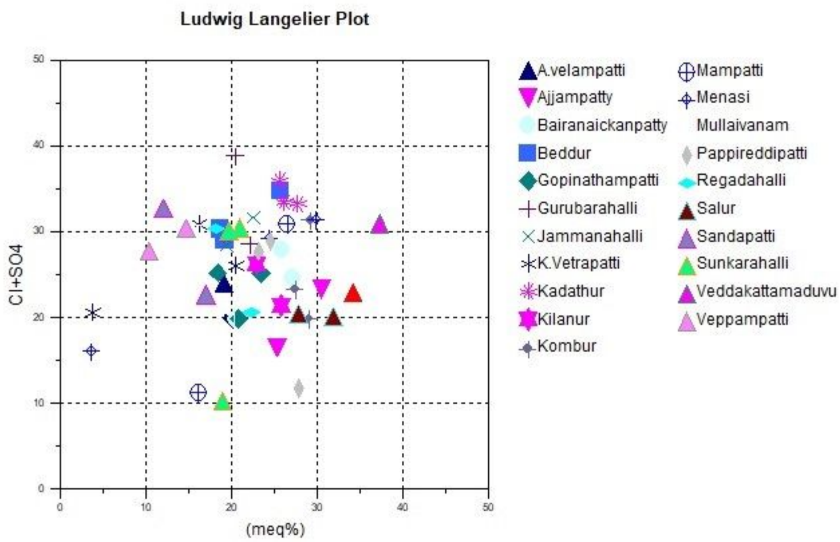

Figure 7

Ludwig langelier plot of Cl+SO4

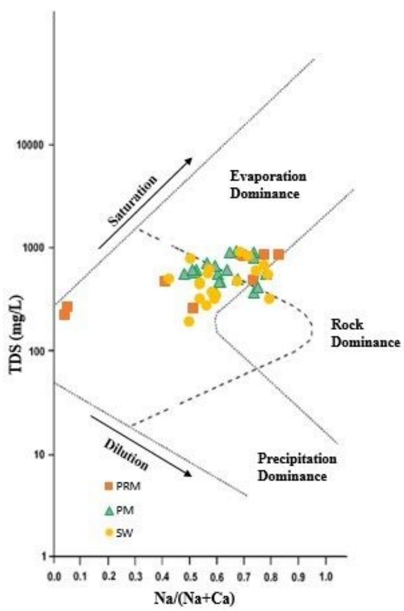

Figure 8

Gibbs ratio for cations (Gibbs,1970)

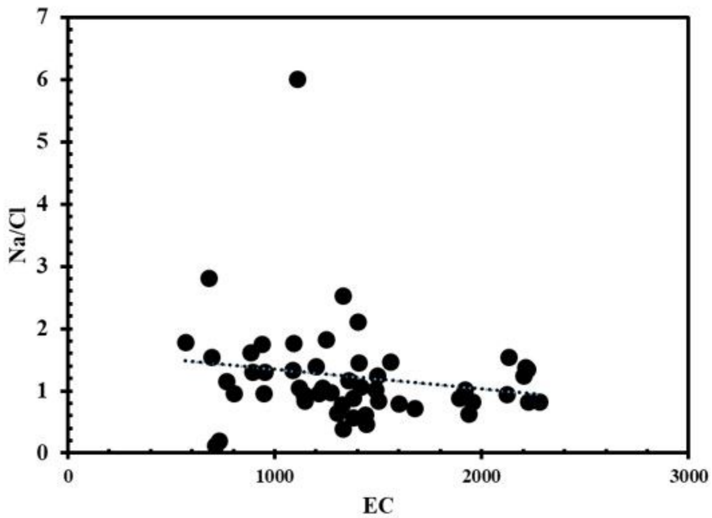

Figure 9

Relation between Na/Cl (meq/l) and EC

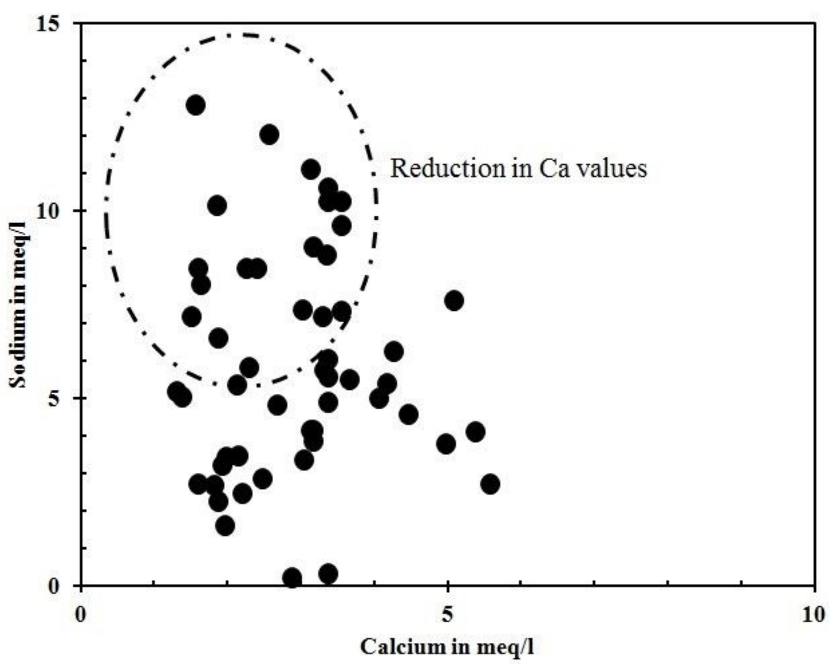

Figure 10

Cation exchange reaction between Ca and Na

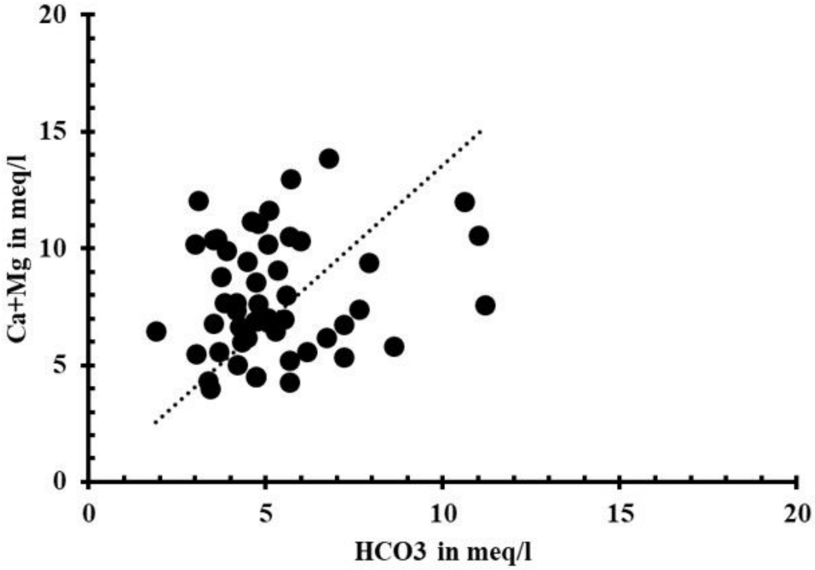

Figure 11

Relation between Ca+Mg versus HCO3

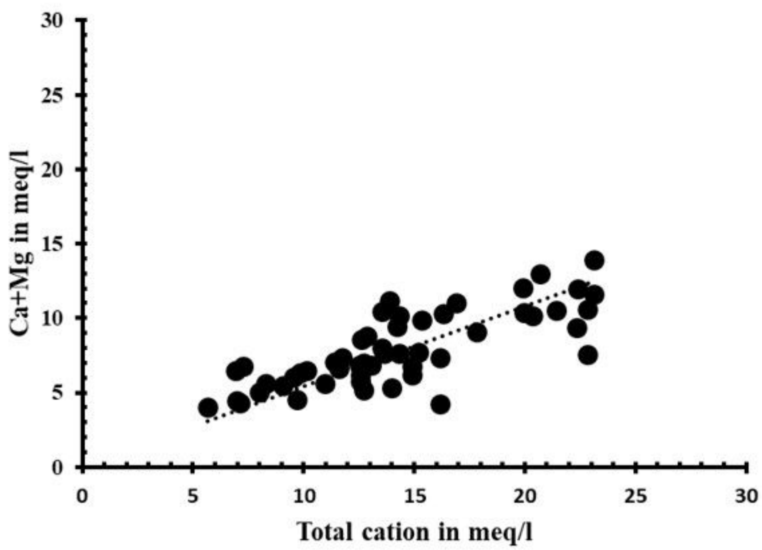

Figure 12

Relation between Ca+Mg versus Total cation

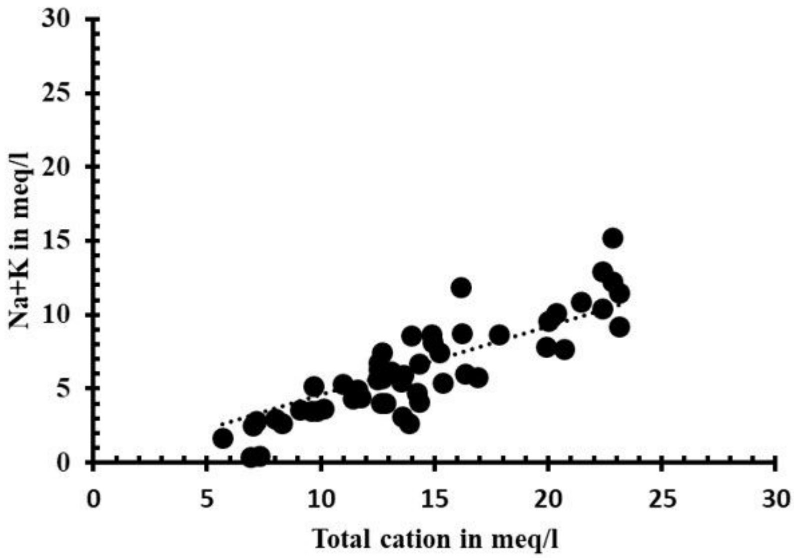

Figure 13

Relation between Na+K versus Total cation

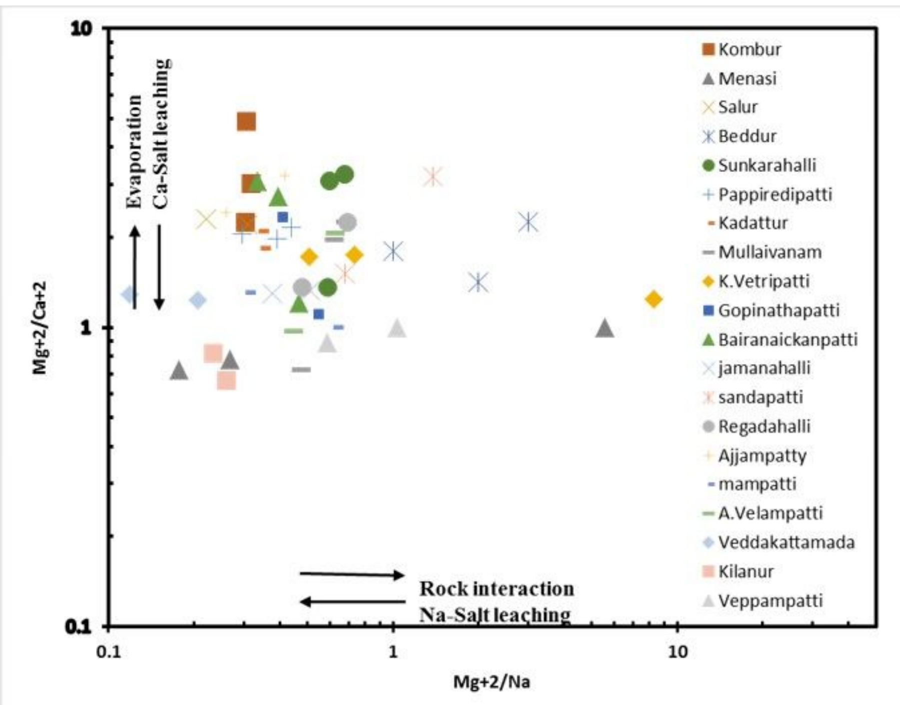

Figure 14

Bivariate plot (Webster,1994)

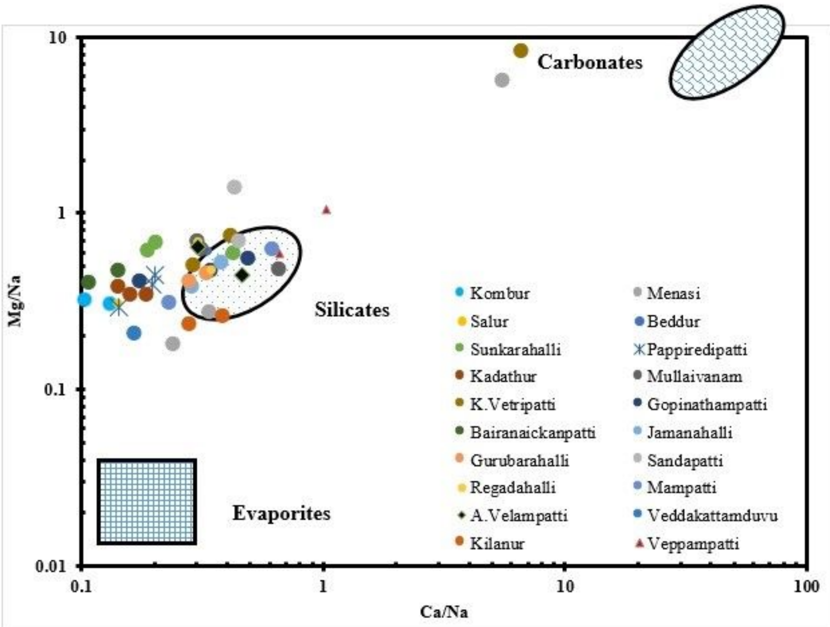

Figure 15

Mixing plots of normalized Ca2+ and Mg2+

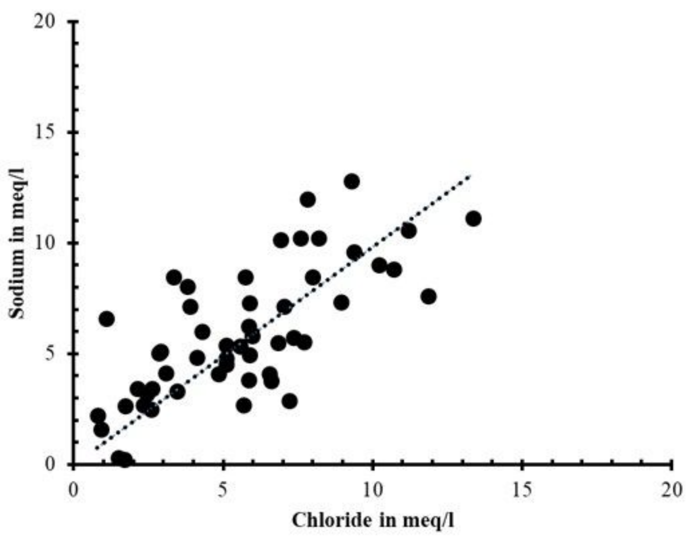

Figure 16

Fig.6.20 Relation between Na(meq/l) and Cl (meq/l)