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Hydrogen chemistry for the Assessment of Groundwater Quality for Irrigation purpose in and around Byrapur Area, Karnataka, South India

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Abstract:

Hydrogen chemical characteristics and quality of groundwater in around Byrapur chromite mining area have been evaluated based on different indices for assessing groundwater for irrigation purpose. Groundwater samples were collected and analyzed for physiochemical parameters and major ions. The suitability of groundwater of the study area for irrigation is determined using different factors like Sodium percentage, Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Kelley's Ratio (KR), and Magnesium Ratio (MR).The results revealed that the groundwater is alkaline in nature. Irrigation water quality indicators like SAR, Na%, SSP, KR and MR reveal that the groundwater is suitable for irrigation purposes with few exceptions. As per the SAR classification all groundwater samples fall under safe category. On the basis of Wilcox diagram the groundwater samples of the study area are fit for irrigation purpose. The USSL classification shows that the water of the study area belongs to C2-S1 and C3-S1 classes suggesting good water for irrigation purposes. Gibb's diagrams show that all the samples fall in the rock dominance in both pre and post-monsoon season. The interpretation on the basis of available data has shown that the groundwater of the study area is suitable for irrigation purpose in both seasons.

Keywords: Groundwater; Irrigation water quality; Byrapur; Karnataka

1. INTRODUCTION

Groundwater plays a major role in the life style of mankind. Groundwater is an important source of water for irrigation in India where surface water source is insufficient and limited during the dry months of the year. The world wide rapid growth of population and increased industrial and agricultural activities led to the great demand for water from surface and ground. Hence, the potential of this resource and its quality should be evaluated thoroughly to generate baseline information for the welfare of the society. Groundwater is the primary source of water for drinking, domestic, industrial and agricultural uses. The quality of groundwater has major impact on human health. Slight change in water quality reflects improper functioning of water ecosystem (Thakkar and Gwalai, 1987). Indiscriminate disposal of anthropogenic, agricultural and mining wastes, unplanned application of agrochemical and fertilizers and public ignorance to environmental considerations caused excess accumulations of pollutants on the land and contamination of available surface and subsurface water resources (Singh, 2000; Subramanian, 2000). Agriculture is the single largest user of water accounting for eighty percent of all consumption. Many of the research works on groundwater quality with respect to drinking and irrigation purposes have been carried out in different parts of India. Due to dumping of overburden in and around mining areas causing water pollution. In view of the fact that of groundwater is intensively used for irrigation purpose, an effort is made in the current paper to discuss the hydrogeochemistry of groundwater to evaluate its suitability of agricultural use. This paper analyses various chemical parameter of groundwater in and around chromite mining area of Byrapur, Hassan district, Karnataka to find out it usability for agricultural purposes.

2. STUDY AREA

The study area, Byrapur (Lat.13^0 06' 20" to 13^0 06' 56" N; Long 76^0 24' 30" to 76^0 20' 40" E) is located in Hassan District, Karnataka (Fig 1). It is included in the Survey of India toposheet No. 57 C/8. Byrapur chromite area is an important mineralized zone in the Nuggihalli schist belt. The Nuggihalli schist belt is one of the ultramafics rich ancient belts in the Dharwar craton (Bidyananda *et al.,* 2003). The geological formations in this mineralized belt are amphibolite, serpentinite talc, tremolite schist, dunite and peridotite. The drainage pattern is dendritic to sub-dendritic. In this area the main soil types are black cotton, red soils, and red loamy, alluvial, brown and mixed soils. Agriculture is the main occupation of the people of the area. The important crops of this area are Paddy, cotton, coconut, groundnut, and commercial crops. Most of the crops are rain fed. The average annual rain fall of the study area is around 750 mm and the average temperature varies from 23^{o}C in the month of December and 40^{o}C in the month of May. The area also experiences the effect of S-W and N-E monsoons.

3. METHODOLOGY

Nineteen groundwater samples were collected for pre-monsoon and post-monsoon seasons of 2011 from dug wells and bore wells of Byrapur area Karnataka for assessing the groundwater quality. These water samples were collected in pre-cleaned polyethylene container of one liter capacity. The physico-chemical analysis of groundwater samples were carried out by adopting standard methods given by APHA (1985, 1992). pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured immediately after obtaining the groundwater samples in the field. The chemical parameters such as sodium (Na) and potassium (K) were estimated by flame photometer; calcium (Ca), magnesium (Mg), carbonates (CO_3), bicarbonates (HCO_3) and chloride (Cl) were analyzed by titrimetric method by following the standard techniques (APHA, 1985, 1992). Results of chemical analysis of groundwater samples along with physical parameters are represented in Table 1.The obtained results in mg/l were converted in equivalent per million (epm) to determine the groundwater quality for agricultural purpose.

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Table 1. Summary of hydrochemical data of Byrapur area, Karnataka

Physical & Chemical parameters	Pre-monsoon			Post-monsoon		
	Minimum	Maximum	Average of 19 samples	Minimum	Maximum	Average of 19 samples
pH	6.4	8.2	7.4	7.1	8.7	7.96
EC (*u*S/cm)	256	1260	690	345	1056	686
TDS (mg/l)	35	610	380	190	672	425
Ca (mg/l)	18	89	53	35	285	93
Mg (mg/l)	10	52	32	10	30	21
Na (mg/l)	13	80	37	10	88	32
K (mg/l)	2	12	5.66	2	12	4.9
Cl (mg/l)	19	130	67	15	278	87
HCO_3 (mg/l)	40	440	170	121	696	257
CO_3 (mg/l)	10	72	36	8	54	28.9

4. RESULTS AND DISCUSSIONS

The quality of groundwater is very important because it is the main factor which decides its suitability for domestic, industrial and agricultural purpose. Based on the physicochemical analysis, irrigation quality parameters were studied.

4.1 Hydrochemical Characterization

The pH of the analyzed samples ranges from 7.1-8.7 during the post-monsoon and 6.4-8.2 in the pre-monsoon season, indicating alkaline nature of the water. Electrical conductivity is the measure of capacity of solution or substance to conduct electric current. The conductivity of water increases with rise in temperature and varies with the amount of dissolved minerals in it (Arthur, 1995; Ballukraya and Ravi, 1999). It is an important criterion for determining the suitability of groundwater for irrigation. EC values varied from 345 to 1056 *u*S/cm for post-monsoon and 256-1260 *u*S/cm for pre-monsoon seasons. EC of pre-monsoon season is higher compared to post-monsoon season.

4.2 Major Ion Chemistry

The anion chemistry of the analyzed samples shows that Bicarbonates (HCO_3) and chlorides (Cl) are the dominant ions both in pre and post-monsoon seasons. The concentration of bicarbonate (HCO_3) varies in the range of 696-257 mg/l in the post- monsoon season and 40-440 mg/l during pre-monsoon periods. The concentration of carbonate (CO_3) varies in the range of 8-54 mg/l and 10-72 mg/l during the post and pre-monsoon periods respectively. Chloride concentration ranges from 15-278 mg/l in post-monsoon and 19-130 mg/l in pre-monsoon seasons.

Cationic Chemistry is dominated by sodium (Na) and calcium (Ca).The concentration of sodium in the post-monsoon samples was reported in the range of 10-88 mg/l. The concentration of the same ion in the pre-

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monsoon varies from 13-80 mg/l. The concentration of calcium (Ca) in the groundwater was reported to be in the range of minimum of 18 mg/l and maximum of 89 mg/l in pre-monsoon season whereas it was reported 35-285 mg/l in the post-monsoon season. Magnesium (Mg) contents ranges from 10-30 mg/l and 10-52 mg/l in post- and pre-monsoon seasons respectively. The concentration of potassium in the post-monsoon samples was reported in the range of 2-12 mg/l (average 4.9 mg/l) and concentration of the same ion in the pre-monsoon also varies from 2-12 mg/l (average 5.66 mg/l).

5. SUITABILITY OF GROUNDWATER FOR IRRIGATION PURPOSE

Groundwater is widely used for irrigation and its quality influences the growth of plant, fertility of soil. The suitability of groundwater for irrigation purpose depends upon various factors including the quality of water, soil structures, climate drainage characterization. The water used for irrigation is an important factor in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations. The salt present in the water affect in soil structure, permeability and aeration this affects the plant growth. The suitability of groundwater of the study area for irrigation is determined using different factors like Sodium percentage, Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Kelley's Ratio (KR), and Magnesium Ratio (MR), (Table 2 and 3). The correlation of the analytical data has been attempted by plotting different graphical representation such as Wilcox (1955, 1948), Gibb's diagram (1970), and US salinity diagram for the classification of water and to study the suitability of groundwater for irrigation.

5.1 Sodium Adsorption Ratio (SAR)

To determine the suitability of groundwater for irrigation use, the alkali hazards expressed as sodium adsorption ratio (SAR) was used The sodium adsorption ratio is an important parameter for determination of suitability of irrigation water because it is responsible for the sodium hazard (U.S. salinity laboratory Staff, 1973).Sodium contributes directly to the total salinity of the water and may be toxic to sensitive crops. The main problem with high sodium concentration is its effect on soil permeability. SAR of the groundwater has been estimated by using the following formula, and all the ions are expressed in epm.

$$SAR = Na/\sqrt{(Ca + Mg)/2}$$

The sodium adsorption ratio influence infiltration rate of water. The groundwater with SAR < 10 is considered as of excellent quality, between 10 to 18 is good, 18 to 26 is fair and above 26 to said to be unsuitable for irrigation (USSL, 1954; Wilcox, 1955; Ayers and Wescot, 1994).The SAR values of the pre-monsoon samples vary from 2.018-12.96 and during post-monsoon samples it shows a range from 0.905-12.323 (Table 2 and 3). During the pre-monsoon SAR values for sixteen water samples and during post-monsoon for 18 water samples are <10 and therefore considered as excellent quality for irrigation. During pre-monsoon three samples and in post-monsoon one sample the SAR value is between 10-18 and therefore considered as good quality for irrigation purpose (Table 2, and 3). Over all the water is excellent and good quality in study area according to the SAR classification.

5.2 Kelley's Ratio (KR)

Kelley's Ratio (KR) is determined for sodium hazard. It is the ratio of Na ions to Ca and Mg ions expressed in epm (Kelley's, 1951). It is expressed as KR= Na/ Ca + Mg. The Kelley's ratio has been calculated for the groundwater samples of the study area and presented in Table 2 and 3. The groundwater having KR <1 is considered to be good quality for irrigation, whereas KR >1 is considered to be unsuitable for irrigation and causes alkali hazard to the soil (Karnath, 1987). The Kelley's ratio was found in the range of 0.156-1.119 in pre-monsoon season, whereas 0.037-0.862 in post-monsoon season which is less than permissible rate of 1.0 (except one sample in pre-monsoon) indicating all the samples are of good quality for irrigation (Table 2 and 3).

5.3 Magnesium Ratio (MR)

Magnesium Ratio (MR) is calculated as MR = Mg x 100/ Ca + Mg

MR values of <50 are suitable for irrigation and MR values of >50 are unsuitable (Lloyd and Heathcoat, 1985). Excess amount of magnesium reduces the yield of crop. High magnesium contents in water can affect the quality of soil. The Magnesium ratio was found in the range of 14.084-56.521 in pre-monsoon season, whereas 3.389-37.5 in post-monsoon season. The magnesium ratio was found >50 in 3 water samples in pre-monsoon indicating that these 3 (15.78%) samples are not suitable for irrigation while 100% of post-monsoon samples which are <50 indicating all the samples are of good quality for irrigation.

5.4 Soluble Sodium Percentage (SSP)

Soluble Sodium Percentage (SSP) of groundwater samples of study area is determined by the following formula and all the ions are expressed in epm.

SSP = Na x 100/ Ca + Mg + Na

In Base Exchange process, calcium is replaced by sodium, which in turns lowers soil permeability. The SSP values of <50 indicate good quality and if it is more than 50 it indicates the unsuitable for irrigation. The SSP values of pre-monsoon water samples show the range of 13.541-52.816 and for the post-monsoon samples the range is 3.594-46.315. The SSP values of all the groundwater samples of the study area in post-monsoon are less than 50, which indicate good quality for irrigation purpose, and for one sample of pre-monsoon the SSP value is >50 indicate the unsuitable water for irrigation.

Table 2: Irrigational specification values of groundwater from the study area during Post-moon season

S.No	Na%	SAR	KR	MR	SSP	EC
1	32.432	3.849	0.370	35.185	27.027	530
2	35.344	6.085	0.478	15.384	32.758	528
3	33.870	6.172	0.476	16.666	32.258	750
4	19.310	4.564	0.208	10.00	17.241	1056
5	22.222	3.182	0.253	26.582	20.202	755
6	16.949	2.545	0.180	30.00	15.254	748
7	30.459	6.350	0.403	22.580	28.735	440
8	11.320	1.443	0.104	21.25	9.433	590
9	36.734	7.00	0.50	28.571	33.333	975
10	19.565	2.595	0.210	27.631	17.391	1050
11	28.318	2.932	0.215	31.182	17.699	862
12	20.769	3.296	0.226	18.867	18.461	500
13	19.580	2.550	0.162	19.512	13.986	412
14	24.242	2.828	0.222	23.456	18.181	700
15	4.901	0.905	0.037	3.389	3.594	345
16	34.883	6.368	0.482	17.241	32.558	520
17	33.333	4.570	0.336	27.173	25.203	840
18	28.378	3.402	0.321	37.5	24.324	425
19	51.578	12.323	0.862	26.470	46.315	982
Min	4.901	0.905	0.037	3.389	3.594	345
Max	51.578	12.323	0.862	37.5	46.315	1056
Avg	26.698	4.5803	0.330	22.834	23.041	686

Table 3: Irrigational specification values of groundwater from the study area during Pre-moon season

S.No	Na%	SAR	KR	MR	SSP	EC
1	27.433	4.060	0.317	32.926	24.074	460
2	35.664	7.225	0.532	56.521	34.751	540
3	20.952	2.018	0.156	20.481	13.541	735
4	36.774	7.428	0.530	28.571	34.666	475
5	53.896	11.916	1.00	14.084	50.00	1030
6	20.00	3.015	0.227	27.272	18.518	700
7	53.793	12.960	1.119	29.850	52.816	256
8	21.052	2.776	0.226	40.00	18.478	450
9	32.558	6.565	0.431	27.586	30.120	920
10	26.666	3.665	0.318	42.424	24.137	440
11	21.296	2.761	0.211	35.294	17.475	950
12	23.931	3.598	0.269	23.595	21.238	488
13	48.148	5.892	0.642	52.380	39.130	850
14	52.5	8.260	0.947	52.631	48.648	1260
15	19.417	2.328	0.180	42.168	15.036	925
16	49.523	9.714	0.943	24.528	48.543	550
17	47.368	7.8	0.78	30.00	43.820	629

18	23.404	3.166	0.263	41.666	20.879	568
19	44.878	10.643	0.707	21.238	41.450	610
Min	19.417	2.018	0.156	14.084	13.541	256
Max	53.896	12.96	1.119	56.521	52.816	1260
Avg	34.884	6.227	0.527	33.991	31.603	690

5.5 Sodium Percentage

Sodium concentration in groundwater has an important role in classification of irrigation water quality, because by the process of base exchanges, sodium replaces calcium in the soil and which reduces the permeability of soil. The sodium percentage (Doneen, 1962) is calculated as, Percent Sodium = (Na+K /Ca+Mg+Na+K) x100, it is expressed in epm. Percentage sodium of groundwater in the study area varies from 4.901-51.578 during post-monsoon and 19.417-53.896 during pre-monsoon period (Table 2 and 3). Based on Na% 6 samples (31.57%) are excellent category, 12 samples (63.15%) are good category and 1 sample (5.26%) is permissible category in post-monsoon season. In pre-monsoon season 2 samples (10.52%) are excellent, 10 samples (52.63%) are good and 7 samples (36.84%) are permissible category (Table 4). No sample is in doubtful and unsuitable category.

Table 4: Classification of Water based on Na%

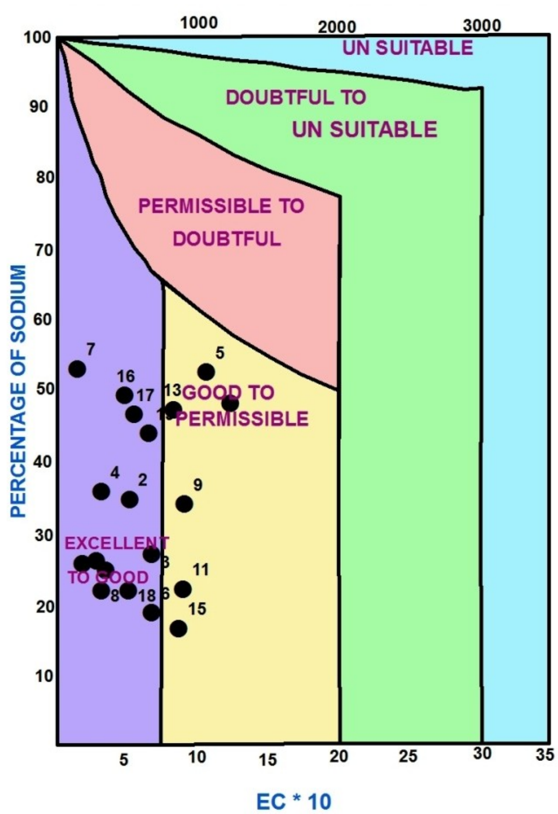
Na%	Water Class	No and Percentage of Samples in post-monsoon	No and Percentage of samples in pre-monsoon
Upto 20	Excellent	6 (31.57%)	2 (10.52%)
20-40	Good	12 (63.15%)	10 (52.63%)
40-60	Permissible	1 (5.26%)	7 (36.84%)
60-80	Doubtful	-	-
>80	Unsuitable	-	-

6. WILCOX DIAGRAM

Wilcox (1948, 1955) classified groundwater for irrigation purposes by correlating sodium percentage and electrical conductivity (EC). The classification of groundwater samples with respect to sodium percent and EC is shown in Fig 1a and 1b. From the Wilcox diagram it is evident that 13 samples (68.4%) and 11 samples (57.9%) fall in the field excellent to good in pre and post-monsoon seasons respectively, whereas 6 samples (31.6%) and 8 samples (42.1%) fall in the field of good to permissible for pre and post-monsoon seasons respectively which are suitable for irrigation purpose. No sample fall in unsuitable category for both the seasons (Table 5). The pre and post-monsoon results (Table 5) reveals that the groundwater is good for irrigation.

Table 5 Classification of water based on Wilcox

Season	Water Class	Sample Numbers	Total No. of Samples	Percentage
Pre-monsoon	Excellent to Good	1,2,3,4,6,7,8,10,12,16,17,18,19.	13	68.4%
	Good to Permissible	5,9,11,13,14,15.	6	31.6%
	Permissible to Doubtful	-	-	-
	Doubtful to Unsuitable	-	-	-
	Unsuitable	-	-	-
Post-monsoon	Excellent to Good	1,2,3,5,6,7,8,12,13,15,18.	11	57.9%
	Good to Permissible	4,9,10,11,14,16,17,19.	8	42.1%
	Permissible to Doubtful	-	-	-
	Doubtful to Unsuitable	-	-	-
	Unsuitable	-	-	-



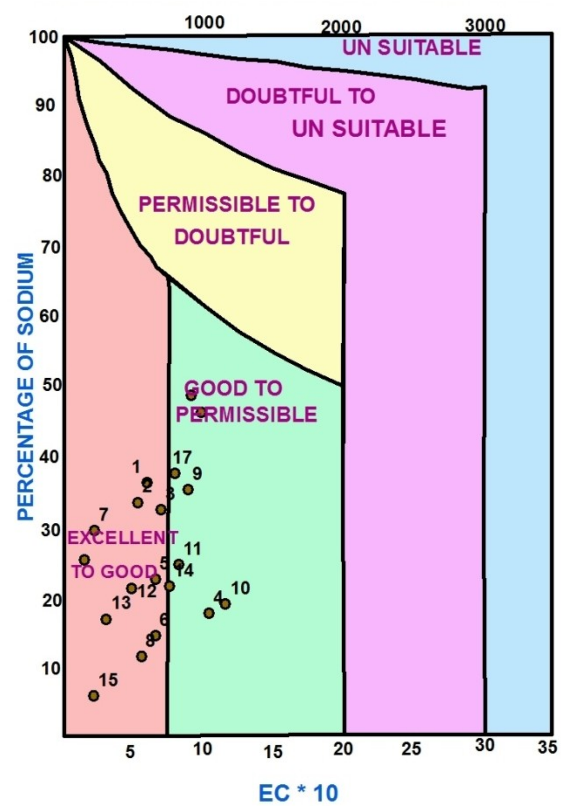


Fig.1a Wilcox (pre-monsoon)

Fig.1b Wilcox (post-monsoon)

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7. US SALINITY HAZARD DIAGRAM

The correlation between sodium adsorption ratio (SAR) and electrical conductivity (EC) is plotted on the US salinity diagram (USSL, 1954) (Fig 2a, and 2b). The two most significant parameters of sodium and salinity hazards indicate usability for irrigation purposes. The pre and post-monsoon USSL classification of groundwater in the study area is given in Table 6. From the Fig 2a it is evident that during pre-monsoon 8 samples (42.10%) fall under category of C2-S1 indicating medium salinity and low alkalinity hazard, 5 samples (26.31%) fall in the field of C2-S2 indicating medium salinity and medium alkalinity hazard, 3 samples (15.78%) are in the field of C3-S1 indicating high salinity and low alkalinity, 2 samples (10.52%) are in the field of C3-S2 indicating high salinity and medium alkalinity, and 1 sample (5.26%) is in C3-S3 indicating high salinity and high alkalinity. In the study area during pre-monsoon 11 samples (57.89%) are good, and 8 samples (42.10%) are moderate for irrigation. From the Fig 2b it is evident that, during post-monsoon 12 samples (63.13%) fall in the field of C2-S1 indicating medium salinity and low alkalinity which is good for irrigation, 5 samples (26.3%) are in the field of C3-S1 indicating high salinity and low alkalinity which good of irrigation, and one sample each (5.26%) in the fields of C3-S2 and C3-S3 categories which indicates moderate for irrigation. In pre and post-monsoon the groundwater samples predominantly occurred with in C2-S1 and C3-S1 categories in the study area and is suitable for irrigation purposes and the groundwater is excellent to good category

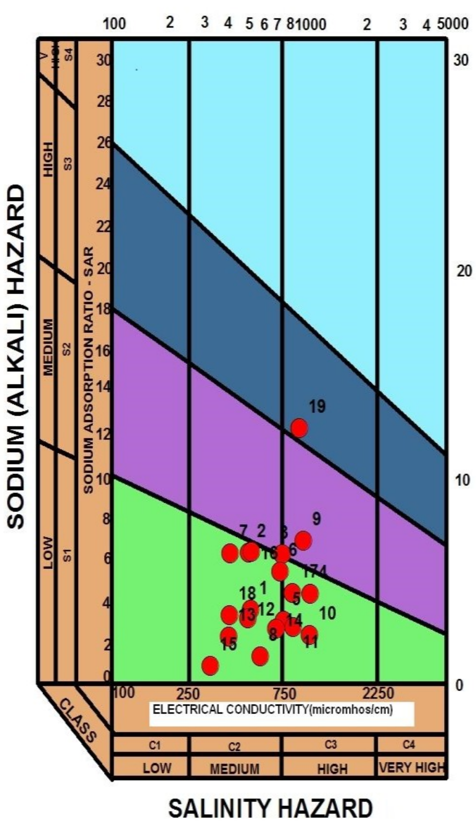

Fig.2a USSL Salinity (pre-monsoon)

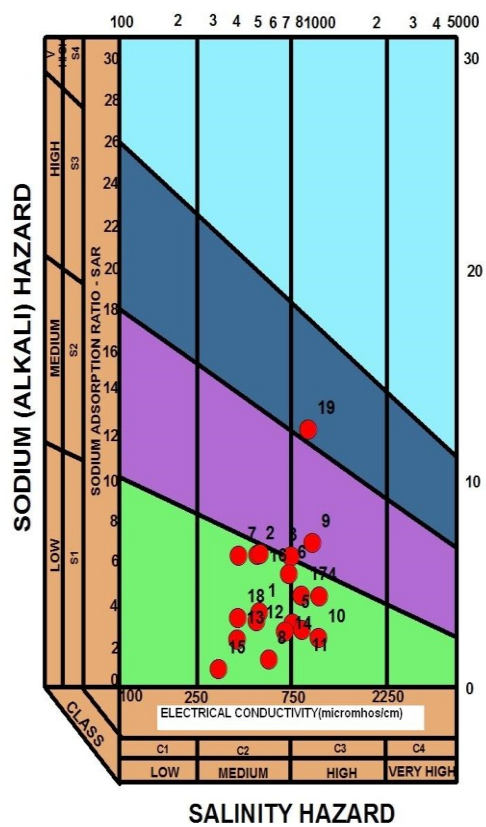

Fig.2b USSL Salinity (pre-monsoon)

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Table 6. USSL Classification

S.No	Category	Water Class	Sample Numbers		Total Number of Samples & Percentage			
			Pre-monsoon	Post-monsoon	Pre-monsoon		Post-monsoon	
1	C1-S1	Good	-Nil-	-Nil-	-Nil-	-Nil-	-Nil-	-Nil-
2	C2-S1	Good	1,3,6,8,10,12,17, 19.	1,2,3,6,7,8,12, 13,14,15,16,18.	8	42.10%	12	63.15%
3	C3-S1	Good	11,13,15.	4,5,10,11,17.	3	15.78%	5	26.3%
4	C2-S2	Moderate	2,4,7,16,18	-Nil-	5	26.31	-Nil-	-Nil-
5	C3-S2	Moderate	9,14	9	2	10.52%	1	5.26%
6	C3-S3	Moderate	5	19	1	5.26%	1	5.26%

Table 7. Gibb's ratio for cation and anion of the water samples and values of TDS (Pre-monsoon)

S.NO.	TDS	(Na+K)/(Na+K+Ca)	Cl/Cl+ $HC0_3$
1	279	0.36	0.33
2	350	0.56	0.24
3	460	0.25	0.10
4	298	0.45	0.11
5	200	0.58	0.38
6	450	0.26	0.43
7	178	0.62	0.12
8	288	0.31	0.37
9	586	0.40	0.10
10	251	0.39	0.19
11	607	0.29	0.21
12	313	0.29	0.38
13	533	0.66	0.37
14	485	0.70	0.74
15	610	0.29	0.49
16	35	0.57	0.30
17	400	0.56	0.23
18	298	0.34	0.40
19	360	0.51	0.37

Table 8. Gibb's ratio for cation and anion of the water samples and values of TDS (Post-monsoon)

S.NO.	TDS	(Na+K)/(Na+K+Ca)	Cl/Cl+ $HC0_3$
1	350	0.41	0.27
2	330	0.38	0.23
3	480	0.38	0.59
4	670	0.21	0.04
5	480	0.28	0.16
6	472	0.22	0.36
7	230	0.36	0.10

8	380	0.15	0.59
9	668	0.44	0.13
10	672	0.25	0.11
11	500	0.33	0.24
12	314	0.24	0.16
13	256	0.22	0.11
14	439	0.28	0.30
15	190	0.05	0.13
16	315	0.38	0.21
17	495	0.38	0.34
18	235	0.38	0.25
19	596	0.57	0.31

Table 9. Results of Gibbs Diagram

Field	Cations ((Na + K) / (Na + K + Ca))		Anions Cl / (Cl + HC0$_3$)	
	Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon
Evaporation-crystallization dominance	-Nil-	-Nil-	-Nil-	-Nil-
Rock dominance	All samples	All samples	All samples	All samples
Precipitation Dominance	-Nil-	-Nil-	-Nil-	-Nil-

8. GIBB'S DIAGRAM

The source of the dissolved ions in the groundwater can be understood by Gibbs diagram (Gibbs, 1970). The values of TDS Vs $Na^+ + K^+ / (Na^+ + K^+ + Ca^{2+})$ and $Cl^- / (Cl^- + HC0_3^-)$ are shown in the Table 7 and 8. It is a plot of $Na^+ + K^+ / (Na^+ + K^+ + Ca^{2+})$ Vs TDS and $Cl^- / (Cl^- + HC0_3^-)$ Vs TDS. Pre and post monsoon Gibb's diagrams are shown in Figs 3a, 3b, 4a, and 4b; and it shows that all the samples fall in the rock dominance in both pre and post-monsoon season. The Gibbs's diagrams suggest that chemical weathering of the rock forming minerals is the main processes which contribute the ions to the water. It is interesting to note that during pre-monsoon and post-monsoon, precipitation and evaporation has no dominating effect and there are no point falling within the precipitation dominating area. Anthropogenic activities may also increase the TDS value (Hem, 1991, Karanth, 1997). The results of pre and post – monsoon Gibb's classification of groundwater in the study area is given in Table 9.

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Fig.3a Gibbs cation plot for pre monsoon

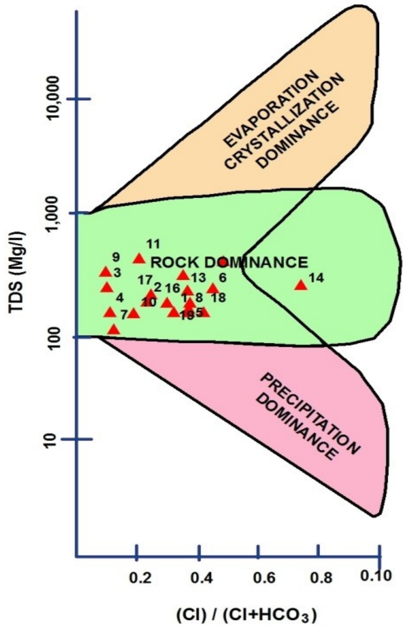
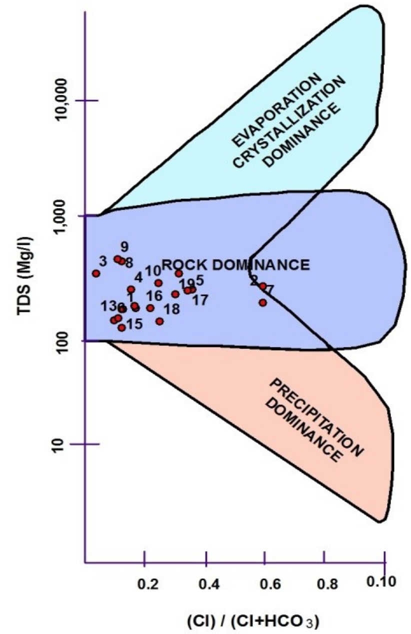


Fig.3b Gibbs cation plot for post monsoon



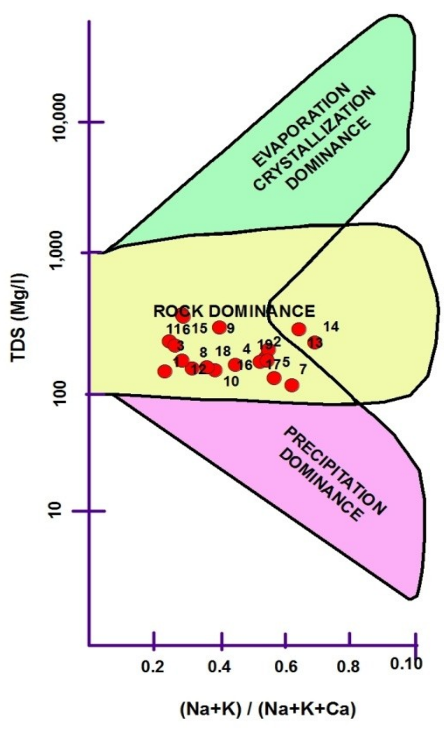


Fig.4a Gibbs Anion plot for pre- monsoon

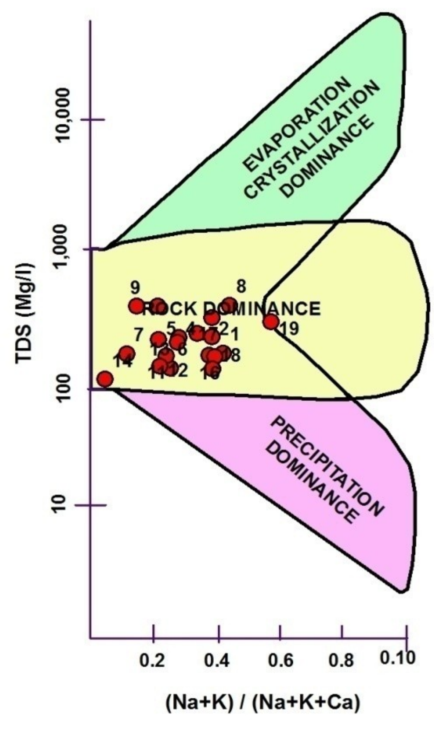


Fig.4b Gibbs Anion plot for post- monsoon

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9. CONCLUSIONS

Groundwater in the study area is generally alkaline in nature. The reason is low rainfall during pre-monsoon season. The water is excellent and good quality in study area according to the SAR classification. The Kelley's ratio suggests that all the samples are of good quality for irrigation. The Magnesium ratio was found >50 in 3 water samples in pre-monsoon indicating that these 3 (15.78%) samples are not suitable for irrigation while 100% of post-monsoon samples which are <50 indicating all the samples are of good quality for irrigation. The SSP values of all the groundwater samples of the study area in post-monsoon are less than 50, which indicate good quality for irrigation purpose, and in one sample of pre-monsoon the SSP value is >50 indicate the unsuitable water for irrigation. Based on USSL classification, both in pre and post-monsoon the groundwater samples predominantly occurred with in C2-S1 and C3-S1 categories in the study area and is suitable for irrigation purposes and the groundwater is excellent to good category. Based on Gibbs's diagrams it shows that all the samples fall in the rock dominance in both pre and post-monsoon season. The Gibbs's diagrams suggest that chemical weathering of the rock forming minerals is the main processes which contribute the ions to the water. The quality assessment for irrigation suitability shows that groundwater of the study area belongs to good to moderate category and can be used for irrigation. Overall majority of samples are showing their suitability for irrigation in pre and post-monsoon seasons.

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