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ENVIRONMENTAL QUALITY OF GROUNDWATER IN KAGAL TALUKA, KOLHAPUR DISTRICT, MAHARASHTRA, INDIA.

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ABSTRACT- The authors has made an attempt to evaluate the environmental quality of groundwater in Kagal Taluka, Kolhapur District, Maharashtra, India and 59 dug well water samples were collected. The chemical analyses of dug well water samples reveal that 75% and 59% groundwater samples represent Ca+Mg>Na+K (alkaline earths exceed alkalis) hydrochemical facies of pre and post-monsoon seasons respectively, while 24% groundwater samples of pre-monsoon season and 41% groundwater samples of post-monsoon season belongs to Na+K>Ca+Mg (alkalis exceed alkaline earths) hydrochemical facies. Similarly, 94% groundwater samples of pre-monsoon season and 95% groundwater samples of post-monsoon season represent $Cl+SO_4>HCO_3+CO_3$(strong acid exceed weak acid) hydrochemical facies, while 5% and 4% groundwater samples belong to $Cl+SO_4$ (strong acid) hydrochemical facies of pre and post-monsoon seasons respectively. According to USSL salinity diagram the dug well water samples of pre-monsoon season represent C_3-S_2 to C_3-S_3 type suggesting high salinity hazard and medium to high sodium hazard for irrigation purposes. While the dug well water samples of post-monsoon season represent C_3-S_3 to C_3-S_4 type suggesting high salinity hazard and high to very high sodium hazard for irrigation purposes. On the basis of Gibbs variation diagram the chemistry of groundwater samples of pre and post-monsoon season is rock dominant.

Keywords- *Hydrochemical facies, Groundwater quality, Kagal taluka*

I. INTRODUCTION

Water is a valuable, limited resource and is essential for life. Groundwater is one of the earth's most widely distributed and important renewable perennial resources occurring beneath the earth surface. Also, groundwater is the essential component of the hydrological cycle, which facilitates that unique behavior of the water on the continent [1, 2]. It is well known that water is a universal solvent and dissolves minerals from the rock with which it comes in contact. So that, water during the course of its flow, acquires the properties of its surrounding conditions and becomes a source of elements present in the areas through which it flows. On the other hand, in some areas groundwater resources are at risk from the results of point and non-point source pollutants such as agricultural and industrial activates, animal waste and household chemicals run-off, failing septic systems, etc. [3, 4, 5, 6]. The rate of depletion of ground water levels and deterioration of ground water quality is of immediate concern in most of the country because of large scale disposal of urban and industrial wastes and use of chemical fertilizers and pesticides in agricultural fields.[7,8,9,10]

Groundwater is used for domestic supply, industries and agriculture in most parts of Kagal Taluka, Kolhapur district of Maharashtra. The fresh water is a finite and limited resource [11]. The utilization of water from ages has led to its over exploitation coupled with the growing population along with improved standard of living as a consequence of technological innovations [12, 13]. Contamination of groundwater also depends on the geology of the area and the changes in quality of groundwater response to variation in physical, chemical and biological environments through which it passes. Water management in agriculture is aiming for better tools to estimate risk assessment due to stricter legislation on soil and groundwater contamination, together with increasing population and demand in food production [14]. Therefore, in order to preserving the availability and quality of water resource, the monitor and assessment of water quality on regular basis is extremely important.

Piper developed a trilinear diagram for the characterization of the hydrochemical facies. SAR is an important parameter for determination of Suitability of irrigation water. The sodium hazard is typically expressed as the sodium adsorption ratio (SAR). This index quantifies the proportion of sodium (Na^+) to calcium (Ca^{++}) and magnesium (Mg^{++}) ions in a sample. USSL sodium hazard of irrigation water can be well understood by knowing SAR, where SAR is plotted against EC.[15]. Wilcox (1948)[16] used percentage sodium and electrical conductance in evaluating the suitability of groundwater for irrigation. The Percent Sodium is computed with respect to the relative proportions of cations present in water. Groundwater quality assessment of different quality parameters has been carried out by various researches [17,18,19,20,21,22]. This study conducted to made an attempt for to assess the groundwater quality in terms of drinking and agricultural uses for a rapidly developing villages located in the Kagal Taluka.

II. STUDY AREA

The Kagal town is situated 20km south of Kolhapur and lies at the coordinates 16°27'29"N and 74°19'24"E shown in Survey of India Toposheet Number 47 L/6. The Kagal Taluka lies between latitude16°16'N to 16° 30'N and longitude 74°02'E to 74° 33' E in Survey of India Toposheet numbers 47 L/2, 47 L/3, 47 L/6 and 47 L/7on a scale 1:50000. The Kagal taluka covers Dudhaganga and Vedganga river valleys with an area of about 547.50 km^2 and has an average elevation of 553 meters.

Figure 1. Location Map of the Area.

III. METHODOLOGY

The present study provides a detailed description of the chemical criteria of groundwater. Fifty nine representative samples were collected from dug wells during pre monsoon and post monsoon season. The various physical parameters were studied at the time of collection of samples like colour, odour, taste, turbidity and foam. Also the different chemical parameters like PH, Electrical conductivity, total hardness, calcium, magnesium, carbonates, bicarbonates and chlorides with the help of titration method by using standard methods [23]. The detailed physico-chemical parameters of pre and post monsoon seasons are shown in Table 1 and 2.

IV.RESULTS AND DISCUSSION

The pH value of dug well water of the study area ranges from 6.1 to 7.29 with an average value of 6.87 of pre monsoon season and 6.6 to7.29 with an average value of 6.85, which is within the permissible limit [24]. The EC value of irrigation water of the study area ranges from 765 to 1381 μS/cm and740 to 1370 μS/cm, average value is 1023.08 and 1016.71 μS/cm with respect to pre and post monsoon season respectively which is according to Wilcox [19] falls within the irrigation water quality classification stand 'good to permissible' in range. Figure 1. shows the Gibb's diagram drawn for groundwater samples if study area which lies in the rock dominance field. The study reveals that the quality of groundwater is affected by the parent rock/ aquifer. Here the plots are made against the ratio of (Na/ Na+ Ca) and (Cl/ Cl+ HCO_3) to know the mechanism controlling the chemistry of groundwater. On the basis of Gibbs variation diagram the chemistry of groundwater samples of pre and post-monsoon season is rock dominant.

Sodium Absorption Ratio (SAR)

SAR is an important parameter for determination of Suitability of irrigation water. The sodium hazard is typically expressed as the sodium adsorption ratio (SAR). This index quantifies the proportion of sodium (Na+) to calcium (Ca++) and magnesium (Mg++) ions in a sample. Sodium hazard of irrigation water can be well understood by knowing SAR. The sodium adsorption ratio (SAR) values of each water sample were calculated by using Richard (1954) [24] equation:

$$SAR = (Na^{+}\ meq/l) / \sqrt{[(Ca^{2+}\ meq/l) + (Mg^{2+}\ meq/l) /2}$$

Sodium adsorption ratio varied from 1.4 to 25.6 in pre monsoon season and 2.3 and 28.4 in post monsoon season. According to USSL salinity diagram the dug well water samples of pre-monsoon season represent C_3-S_2 to C_3-S_3 type suggesting high salinity hazard and medium to high sodium hazard for irrigation purposes. While the dug well water samples of post-monsoon season represent C_3-S_3 to C_3-S_4 type suggesting high salinity hazard and high to very high sodium hazard for irrigation purposes shown in Figure 2. Wilcox used percentage sodium and electrical conductance in evaluating the suitability of groundwater for irrigation. The Percent Sodium is computed with respect to the relative proportions of cations present in water, where the concentrations of ions are expressed in meq/l using the formula

$$\%Na= (Na^{+}+K^{+})/ (Ca^{2+}+Mg^{2+}+Na^{+}+K^{+})$$

The Wilcox diagram showing the position of the water samples is represented by Figure 3

Hill-Piper Diagram:

One method of comparing the results of chemical analyses of ground water is with a trilinear diagram [25] (Figure 4). This diagram consists of two lower triangles that show the percentage distribution, on the milliequivalent basis, of the major cations (Mg ++, Ca++, and Na+ plus K+) and the major anions (Cl-, SO_4^{2}-and CO_3^{2-}plus HCO_3^{-}) and a diamond-shaped part above that summarizes the dominant cations and anions to indicate the final water type. This classification system shows the anion and cation facies in terms of major-ion percentages. The water types are designated according to the area in which they occur on the diagram segments. The chemical analyses of dug well water samples reveal that 75% and 59% groundwater samples represent Ca+Mg> Na+K (alkaline earths exceed alkalis) hydrochemical facies of pre and post-monsoon seasons respectively, while 24% groundwater samples of pre-monsoon season and 41% groundwater samples of post-monsoon season belongs to Na+K>Ca+Mg (alkalis exceed alkaline earths) hydrochemical facies. Similarly, 94% groundwater samples of pre-monsoon season and 95% groundwater samples of post-monsoon season represent Cl+SO_4>HCO_3+CO_3(strong acid exceed weak acid) hydrochemical facies, while 5% and 4% groundwater samples belong to Cl+SO_4 (strong acid) hydrochemical facies of pre and post-monsoon seasons respectively.

V. CONCLUSION

Different physico-chemical properties of dug wells of Kagal Taluka were compared with the national and international water quality standards set for drinking and irrigation purpose. The ground water quality varies from place to place and with the depth of water table. The ground water abstraction sources and their surroundings should be properly maintained to ensure hygienic conditions and no sewage or polluted water should be allowed to percolate directly to ground water aquifer. The analysis of the samples indicated that, the type of water that predominates in the study area is Ca-Mg-HCO3-CO_3 type during both Pre and post monsoon seasons, based on hydro chemical facies. According to USSL salinity diagram the dug well water samples of pre-monsoon and post monsoon season respectively represent C_3-S_2 to C_3-S_3 type and C_3-S_3 to C_3-S_4 suggesting high salinity hazard and medium to high sodium hazard and high salinity hazard and high to very high sodium hazard for irrigation purposes. On the basis of Gibbs variation diagram the chemistry of groundwater samples of pre and post-monsoon season is rock dominant. Assessment of water samples from various methods indicated that groundwater in study area is chemically not suitable for drinking and agricultural uses.

Table 1: Chemical Parameters of dug well water samples from the study area (in pre-monsoon season)

DWN	pH	T	EC	TH	TDS	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4
		NTU	µS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	6.7	0	891	182	393	89.7	38	19	10.3	0.06	152	49.7	265
2	6.6	0	1100	242	530	123.4	42.8	103	7.3	0.08	204	72.42	356
3	6.6	1	971	198	465	96.1	3	145	5.6	0.08	196	63.9	458
4	6.7	1	1078	292	760	96.1	83.8	159	5.9	0.1	280	144.8	289
5	6.8	0	921	164	352	83.3	29.2	124	7.0	0.07	172	46.86	279
6	7	0	986	142	339	70.5	26.3	134	8.6	0.05	132	42.6	248
7	6.7	7	1117	204	389	96.1	40.9	168	9.7	0.08	204	45.55	259
8	6.9	1	1009	180	314	80.1	38.9	181	10.7	0.07	176	34.08	365
9	6.7	0	1078	158	330	88.1	23.3	124	9.2	0.06	148	45.44	249
10	6.6	0	938	166	359	76.9	34.1	104	9.7	0.06	156	78.1	265
11	6.5	1	958	114	273	70.5	12.6	112	8.12	0.04	116	38.34	421
12	6.9	0	890	96	190	49.6	16.5	122	8.6	0.03	92	19.88	367
13	6.7	0	740	282	460	147.4	47.7	120	9.8	0.09	224	176.0	396
14	6.9	1	860	158	36	73.7	32.1	119	5.9	0.06	156	34.08	403
15	6.5	1	1310	132	282	23.5	26.3	112	4	0.06	144	31.24	462
16	6.8	1	1350	138	310	75.3	21.4	157	5	0.06	156	38.34	309
17	6.9	0	1370	166	358	86.5	28.2	122	5.2	0.06	160	55.38	412
18	6.7	0	890	144	304	75.3	24.3	120	6.9	0.05	128	59.64	241
19	7.1	0	976	144	625	101	68.2	133	4.9	0.1	244	115.0	451
20	7.1	11	860	266	765	205.2	53.6	144	7.9	0.16	392	28.4	250
21	6.9	0	879	190	670	91.3	37	152	7.5	0.06	162	90.88	259
22	6.8	0	984	144	270	73.7	25.3	112	6.9	0.06	144	15.62	273
23	6.9	10	958	162	321	80.1	30.2	25	6.12	0.07	172	29.82	289
24	6.7	0	932	102	210	52.9	17.5	30	12.9	0.04	108	14.2	356
25	6.7	0	1012	64	170	40	9.7	121	10	0.02	64	32.66	364
26	6.9	1	1089	100	199	48	19.4	120	9	0.04	108	35.5	402
27	6.8	0	1048	150	325	72.1	29.2	111	12	0.05	140	51.12	249

28	6.8	0	1122	216	478	104.2	41.9	123	14	0.08	192	109.3	265
29	6.8	1	1048	106	427	49.6	21.4	139	10.7	0.03	88	29.82	297
30	6.9	0	1039	172	391	88.1	30.2	142	9.8	0.07	188	29.82	466
31	6.6	11	1042	204	461	102.6	37	178	8.9	0.08	200	99.4	429
32	6.9	0	909	142	408	70.5	26.3	171	9.2	0.07	168	59.64	199
33	6.7	2	1019	148	301	75.3	26.3	182	8.94	0.05	124	32.66	265
34	6.8	0	1014	158	354	68.9	35	176	7.45	0.05	124	66.74	246
35	7.0	0	1089	114	252	64.1	18.5	151	8.2	0.04	112	36.92	251
36	7.2	1	970	170	444	72.1	38.9	156	10.1	0.06	160	93.72	211
37	6.7	0	903	112	219	46.4	26.3	160	9.07	0.03	88	42.6	289
38	6.6	1	908	70	149	33.6	13.6	138	7.9	0.02	68	25.56	389
39	6.9	1	1098	168	376	94.5	24.3	121	8.9	0.06	156	56.8	379
40	6.7	2	1123	124	281	62.5	22.4	112	6.5	0.06	148	49.7	361
41	6.6	1	1035	132	303	64.1	25.3	124	7.2	0.04	116	61.06	306
42	7.2	1	932	192	422	94.5	36	124	8.1	0.08	200	71	319
43	6.6	0	948	42	72	20.8	7.7	56	8.7	0.01	32	18.46	470
44	6.8	19	908	130	145	64.1	24.3	64	5.7	0.04	104	45.44	364
45	6.7	1	998	106	242	51.3	20.3	78	7.7	0.03	92	55.38	408
46	7.0	0	1208	120	236	60.9	21.4	20	11.9	0.04	104	36.92	289
47	6.7	1	1049	124	305	72.1	16.5	10	10.1	0.05	132	38.34	456
48	7.1	3	1068	106	232	57.7	16.5	12	9.8	0.04	104	48.28	359
49	6.8	1	1078	78	170	46.4	9.7	125	2.3	0.03	80	35.5	503
50	7.2	1	1029	210	482	120.2	29.2	155	3.09	0.06	144	102.2	423
51	6.9	1	1045	238	583	120.2	42.8	152	6.7	0.08	200	156.2	326
52	6.8	0	1037	180	416	89.7	33.1	162	6.1	0.06	160	68.14	213
53	6.9	0	1019	240	670	117	45.8	106	5.9	0.09	224	127.8	279
54	6.9	0	1028	224	673	109	42.8	115	5.5	0.08	212	160.4	413
55	6.6	6	1018	230	535	110.6	16.2	121	8.7	0	196	96.56	291
56	6.2	5	1010	88	361	40	18.5	121	8.8	0.06	148	89.46	303
57	7.1	0	1021	100	200	49.6	18.5	144	9.01	0.03	76	49.7	327
58	6.8	0	1035	170	397	80.1	34.1	120	7.88	0.04	116	107.9	409
59	7.1	0	1041	58	88	33.6	7.7	105	7.12	0.01	40	17.04	412

Table 2: Chemical Parameters of dug well water samples from the study area (in post-monsoon season)

DWN	pH	T	EC	TH	TDS	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4
		NTU	µS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	6.98	0	1000	198	401	91	41	25	10.2	0	151	51.9	270
2	6.78	1	1129	274	535	125	42	66	7.5	0	201	75.1	350
3	6.69	3	985	201	467	95	9	108	5.7	0	201	61.9	468
4	6.89	3	1100	298	769	96	80.3	122	6.1	0	285	147.9	301
5	6.2	1	1000	171	359	85	32.1	88	7.2	0	177	49.6	285
6	7.12	0	1021	189	345	72	25	102	8.9	0	134	45.3	250
7	6.87	10	1129	212	391	98	40	113	10.2	0	202	45	260
8	7	4	1019	198	319	81.2	35.5	143	10.8	0	175	35	370
9	6.97	0	1080	161	332	89.8	24.3	89	10.1	0	149	49.3	249
10	6.14	2	950	171	361	78.2	31	74	9.9	0	155	82.9	270
11	6.61	5	969	121	279	70.5	15.6	84	9.1	0	119	39.9	425
12	7.1	2	903	101	198	47	18.7	84	8.1	0	97	23.5	378
13	6.78	0	765	289	469	139	45.6	82	9.9	0	29	182.1	402
14	6.89	3	871	161	48	72.6	33.3	84	5.8	0	159	39.2	406
15	6.79	3	1315	134	297	26.9	29.3	75	4.6	0	148	32.6	470
16	6.9	2	1368	139	312	78	2.5	119	5.1	0	154	39	308
17	7	3	1381	179	369	87.2	26.5	93	5.6	0	164	59.3	423
18	6.75	4	905	177	312	76.6	25.8	94	6.7	0	131	61.3	251
19	7.12	1	981	165	629	100	68.4	98	5.2	0	254	120.3	445
20	7.16	15	670	271	781	209	55.2	108	7.6	0	395	29.3	239

21	7	0	885	201	678	92.3	32	109	7.9	0	165	90	265
22	6.94	3	897	155	276	70	26.2	67	7.3	0	142	16.1	280
23	6.95	12	965	167	326	80.9	31	11	6.9	0	175	31.2	292
24	6.8	2	940	110	311	56.1	18.7	12	14.6	0	103	15.2	372
25	6.72	6	1016	76	178	42.7	10.9	84	12.3	0	69	32.6	356
26	7.01	4	1091	120	200	49	23.6	98	11.2	0	112	36.1	421
27	6.93	3	1051	161	329	73.6	29.9	126	12.3	0	145	51.2	252
28	6.87	2	1125	269	484	16.4	40.2	86	15.2	0	189	102	270
29	6.82	6	1056	112	432	49.2	22.8	94	11.2	0	89	30.2	302
30	7.2	7	1046	179	401	88.2	31.6	104	11.2	0	201	31.2	471
31	6.69	15	1049	209	465	101	39	139	9	0	203	101.2	435
32	6.97	2	915	147	412	85.1	25.9	132	9.6	0	171	60.3	203
33	6.81	4	1025	151	306	65.9	25.9	142	9.5	0	126	34.6	272
34	6.89	3	1020	162	359	69.9	34.8	154	8.6	0	127	68.6	251
35	7.16	2	1096	120	259	65.2	21.7	112	8.9	0	114	39.9	259
36	7.29	3	981	179	452	75.2	38.9	128	10	0	161	92.3	221
37	7	1	910	116	225	46.3	29.5	158	9.2	0	91	45.2	300
38	6.71	3	919	80	159	36.9	15.6	94	7.9	0	71	26.6	380
39	7.05	2	1100	179	384	98.3	25.9	79	9.01	0	155	59.3	385
40	6.79	3	1129	131	290	65.7	27.9	66	6.9	0	146	50.6	372
41	6.72	4	1045	136	309	65.2	28.1	83	7.2	0	113	62.3	309
42	7.9	5	940	203	429	90.9	34	87	8.2	0	201	72.1	321
43	6.1	1	952	52	79	21.6	7.8	108	8.6	0	35	19.2	481
44	6.88	20	908	141	145	66.5	25	128	5.9	0	105	49.2	370
45	6.88	2	1000	113	251	50.1	19	82	7.6	0	98	56.2	412
46	7.03	3	1213	127	239	69.2	22.1	75	12.3	0	106	37.2	292
47	6.81	2	1054	129	309	75.2	16.9	64	10.9	0	135	41	460
48	7.2	5	1075	111	235	59.8	19.3	26	10.1	0	109	49.2	372
49	6.87	6	1080	81	179	48.9	11.2	124	2.9	0	87	36.5	504
50	7.29	2	1026	225	485	122.1	91.2	119	3.6	0	151	109.2	429
51	6.93	2	1065	242	587	121.3	45.4	114	7.5	0	203	159	328
52	6.84	2	1041	190	420	90.1	33.7	208	6.9	0	160	69.2	222
53	6.18	2	1025	246	671	117.6	46.2	72	7.6	0	224	129.9	285
54	6.18	0	1032	228	675	109.2	43.9	78	6.6	0	215	167.2	415
55	6.78	6	1020	235	539	111.9	18.9	84	9.6	0	197	99.2	303
56	6.67	4	1000	92	369	48	19.9	84	7.9	0	149	85.2	310
57	7.19	2	1027	109	213	51.7	15	108	10.0	0	79	46.2	330
58	6.72	2	1045	178	402	80.7	36	116	8.99	0	114	107	412
59	7.19	1	1057	59	91	35.6	7.6	100	8.15	0	41	16.23	421

DWN: Dug Well No., T : Turbidity, TH: Hardness, EC: Electric Conductivity, TDS: Total Dissolve Solids.

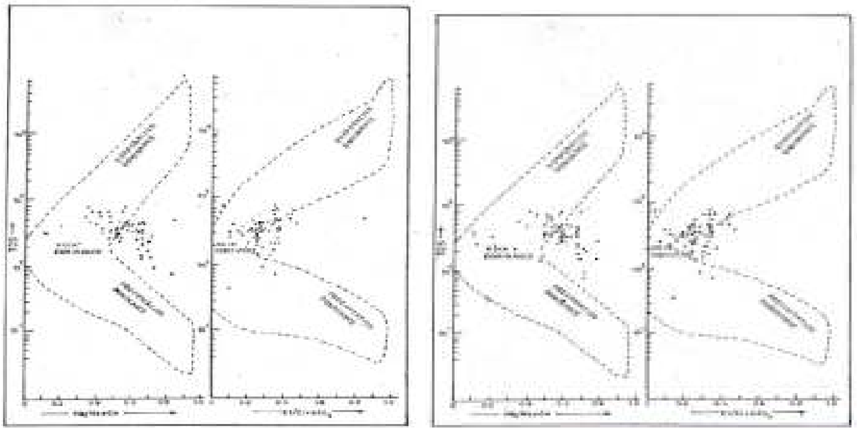

Fig. No. 1.Gibb's diagram showing the mechanism controlling groundwater chemistry
Pre monsoon season ***Post Monsoon season***

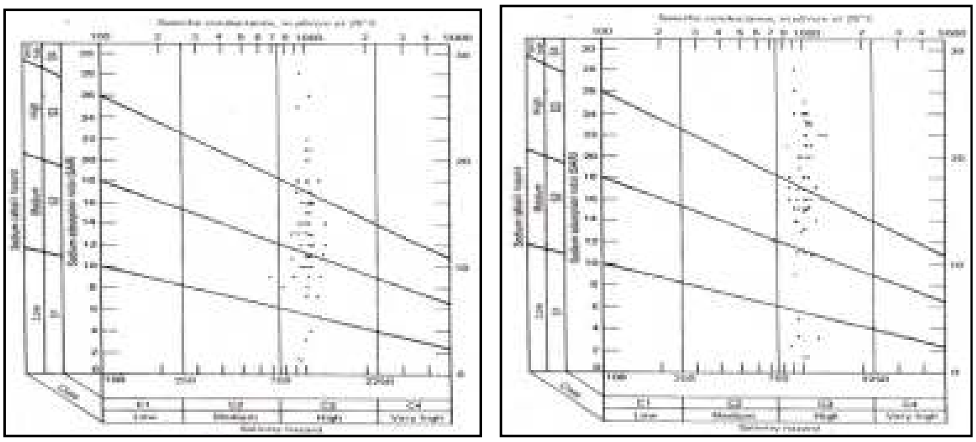

Fig. No.2. Salinity diagram of groundwater samples from the study area
Pre Monsoon season ***Post Monsoon season***

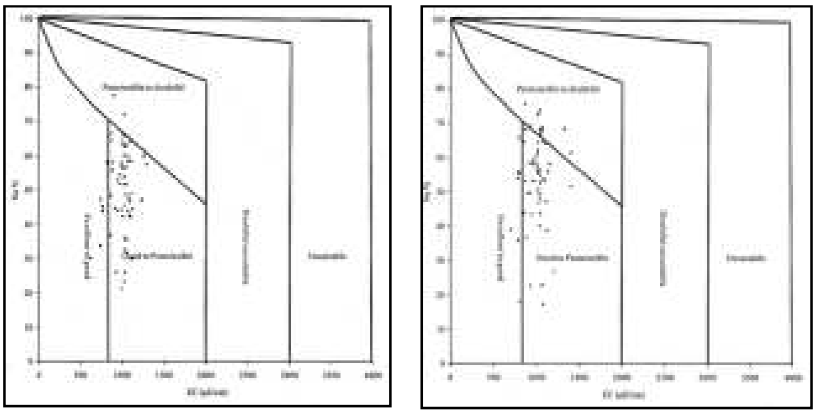

Fig. No. 3.Position of water samples on the Wilcox plots
Pre Monsoon season ***Post Monsoon season***

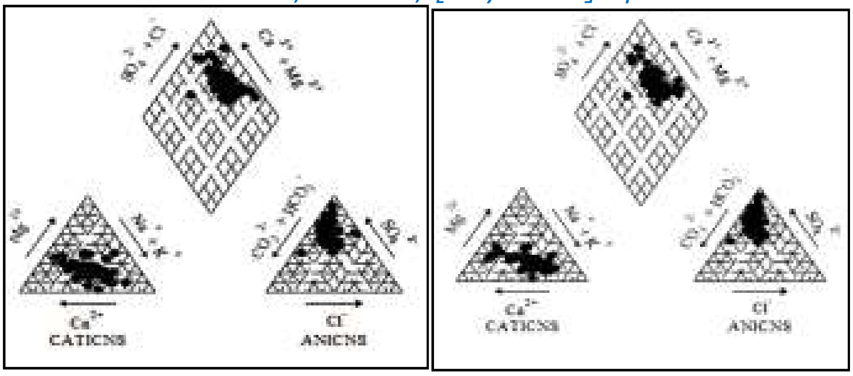

Figure 4. Piper diagram showing water quality classification of study area
Pre Monsoon season Post Monsoon season

VI. REFERENCES

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