EVALUTION OF GROUNDWATER QUALITY AND ITS SUITABILITY FOR DRINKING PURPOSE IN BUDHGAON, KAVALAPUR AND KARNAL VILLAGES OF SANGLI DISTRICT, MAHARASHTRA, INDIA

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Abstract

Groundwater is essential for any life support system. It is not only basic need for human existence but also a vital input for all development activities. The present hydro-geochemical study was confined to Budhgaon, Kavalapur and Karnal villages of Sangli district, Maharashtra (Lat.$16^0$52'30''N to $16^0$54'30''N and Long.$74^0$33'45''E to $74^0$37'30''E). Groundwater quality and its suitability for drinking purpose were examined by physico-chemical analysis of 56 dug well water samples. These parameters were used to assess the suitability of groundwater for drinking purpose by comparing with the WHO and ISI. These analyses reveals that the groundwater is not entirely fit for drinking with respect to Hardness, EC, Ca, Cl, Bicarbonates, Sodium and Sulphate. The physico-chemical analysis of these samples reveals that 98% groundwater samples of pre-monsoon season and 70% groundwater samples of post-monsoon season represents Na+K>Ca+Mg(alkalies exceed alkaline earth) hydrochemicalfacies. Similarly, 100% groundwater samples of pre-monsoon season and 84% groundwater samples of post-monsoon season reveals Cl+SO_4> HCO_3+CO_3 (strong acids exceed weak acid) hydrochemicalfacies. The 2% and 30% groundwater samples of pre-monsoon and post-monsoon seasons suggests Ca+Mg>Na+K (alkaline earths exceed alkalies) hydrochemicalfacies respectively. The 16% groundwater samples of post-monsoon season represent Cl+SO_4 (strong acids) hydrochemicalfacies. The chemistry of groundwater samples belongs to evaporation dominance (46%) and rock dominance (54%) of pre-monsoon season and evaporation dominance (64%) and rock dominance (36 %) of post-monsoon season.

Keywords: *Groundwater Quality, Sangli District, Hydro Chemical Facies.*

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1. INTRODUCTION

Water is essential to the existence of man and all leaving things. Groundwater occurs beneath the earth surface not only in single widespread aquifer but also in thousands of local aquifer systems. The quality of water is of great importance as it is commonly consumed and used by households. Rapid urbanization especially in developing countries like India has been affected the availability and quality of groundwater. The quality of groundwater is also varies with depth of water table, seasonal changes and composition of dissolved salts depending upon the sources of the salt and subsurface environment. Intensively irrigated agricultural discharges into the groundwater bring about considerable changes in the groundwater quality.

Groundwater chemistry in turn, depends on a number of factors, such as general geology, degree of chemical weathering, quality of recharge water and inputs fromsources other than water rock interaction. Such factors and their interactions result in a complex ground water quality.Panaskar et.al., 2007 [1], Yadav et.al., 2011[2], Krishna Anantha et.al., 2012 [3], Deshpande and Aher, 2012 [4], Narsimha and Anitha, 2013[5] and Pisal and Yadav, 2014 [6] have worked on the chemical aspects of groundwater from urban areas. The assessment of groundwater quality and its suitability for drinking is the objective of the present study by comparing the results against water quality standards laid down by the World Health Organization [7] and Indian Standards Institution [8].

2. STUDY AREA

The present study area is lies between Latitude 160 52'30" to 160 54'30" N and Longitude 74033'45"E to 740 37'30"E in Survey of India Toposheet number 47L/9 is covering an area of about 62 km2(Fig.1). The study area is covered by Deccan Volcanic basalt ofupper cretaceous to lower Eocene age. The average rainfall of study area is about 580mm. Krishna river is flowing from almost north to south in western boundary of the study area. The study area is more or less flat, having 100% irrigated land and receives the maximum water from dug wells.

3. MATERIALS AND METHODS

The groundwater samples were collected from 56 dug wells during pre and post-monsoon seasons of year 2013(Fig 2)

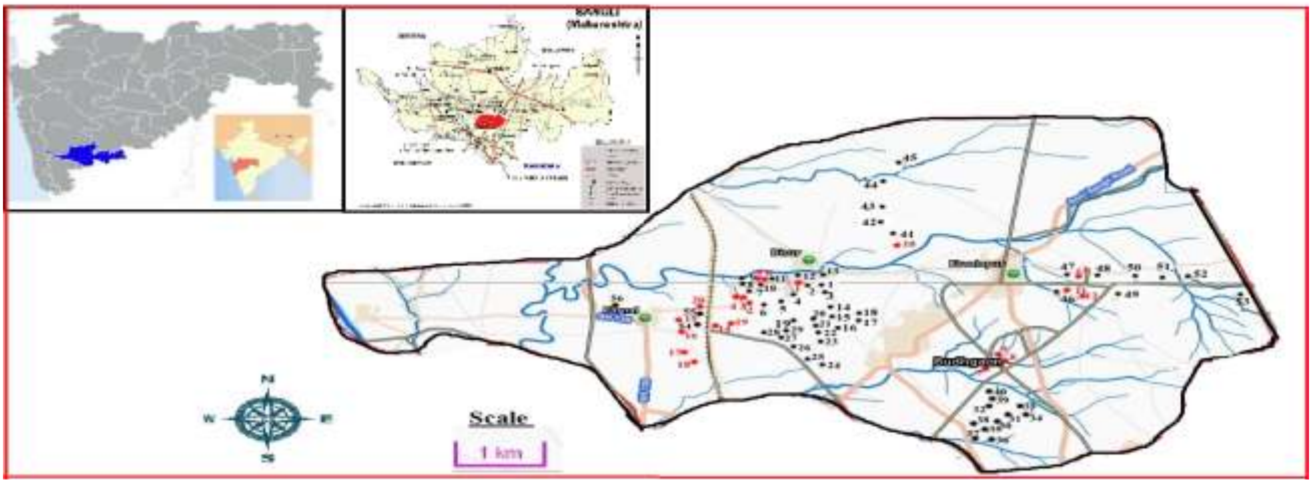


Fig. 1: Location map of study area.

The polythene bottles were used for sample collection. The different physical parameters like colour, odour, taste, foam and turbidity were measured at the time of collection of samples. The various chemical parameters were determined by using standard methods [9] (Table 1 and 2). The color, odor, taste and foam properties of dug well water samples were measured in the field. The turbidity is determined by selecting the calibration graph for the desired range and by placing the filter frame in position. Samples having the turbidity higher than 150 mg/L are tested by diluting the sample with water of very low turbidity and multiplied the result by dilution factor. The P^H and Electrical Conductivity (EC) were measured with the help of P^H meter and Conductivity meter respectively. The chemical parameters viz; Total Hardness(TH), Calcium(Ca), Magnesium(Mg), Bicarbonates(HCO_3), Carbonates(CO_3) and Chlorides(Cl) were determined by titration. The Sodium (Na) and Potassium (K) were found out by using Flame photometer. Sulphate(SO_4) was determined by using UV-Visible Spectrometer. The Total Dissolved Solids (TDS) were calculated by multiplying EC values with 0.64 [10].

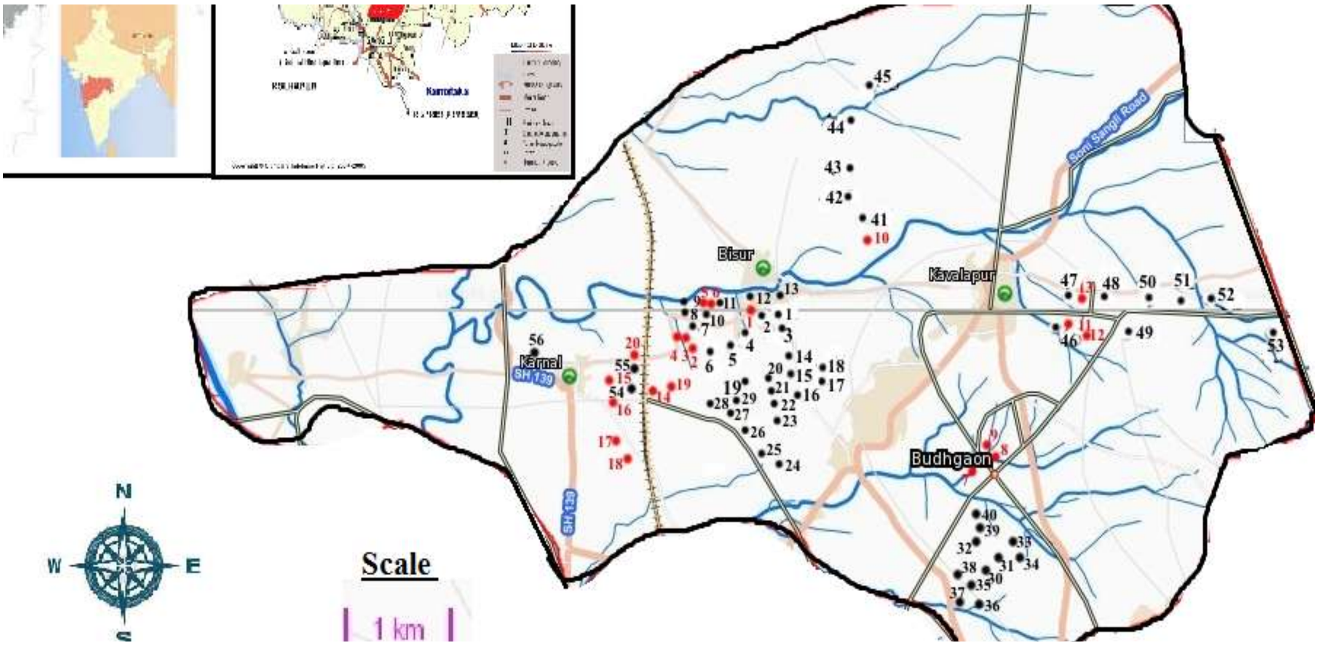


Fig. 2: Sample Location map of study area.

3.1 Groundwater Properties

3.1.1. P^H

The relative concentration of hydrogen ions in water indicates whether the water is acidic or alkaline in nature. P^H of dug well water samples varies from 6.11 to 8.00 for pre-monsoon season and in the post-monsoon season it varies from 6.78 to 8.25. The P^H of 80% water samples in pre-monsoon season and 91% in post-monsoon season ranges from 6.5 to 7.5. This shows that there is very little seasonal fluctuation of P^H values in the region.

Table 1: Concentration of different chemical parameters of bore well water of the study area (pre-monsoon season).

Parameters/ Sample nos.	P^H	EC (μ/cm)	TH	TDS	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl
			mg/L ←				→					
DW 1	7.11	1580	390	990	205.0	17.25	365.01	14.82	280.60	0	672.96	330.15
” 2	6.81	2930	450	1760	245.0	18.10	470.12	9.75	427.00	0	786.24	401.15
” 3	7.28	1440	410	1260	135.0	20.05	255.07	4.68	280.60	0	355.68	269.80
” 4	7.35	850	360	2390	105.0	11.30	195.04	4.68	231.80	0	215.04	230.75
” 5	7.62	320	380	1820	60.0	13.24	155.02	4.68	134.20	0	204.00	159.75
” 6	7.19	3390	610	2760	155.0	24.18	310.04	9.75	475.80	0	132.96	457.95
” 7	7.11	3250	630	2580	165.0	24.30	320.16	9.75	427.00	0	255.36	429.55
” 8	7.12	1850	410	1960	105.0	15.19	205.16	4.68	256.20	0	150.72	273.35
” 9	7.92	3560	640	2260	155.0	22.48	357.42	14.82	378.20	0	322.56	443.75
” 10	6.9	3580	610	1890	195.0	26.37	365.01	4.68	463.60	0	298.08	500.55
” 11	6.65	6360	910	2990	295.0	30.38	755.32	24.96	866.20	0	443.04	969.15
” 12	7.17	4700	810	2860	245.0	28.43	405.03	19.89	500.20	0	465.60	607.05
” 13	6.65	6380	920	2960	305.0	32.20	905.28	102.96	841.80	0	902.40	898.15
” 14	7.76	1790	390	1220	155.0	13.24	160.08	4.68	256.20	0	212.16	259.15
” 15	7.37	1860	495	1860	169.0	16.52	444.36	16.38	259.86	0	907.20	277.96
” 16	7.2	1900	470	890	62.4	15.31	433.78	43.68	263.52	0	716.16	269.44
” 17	7.11	1820	420	1260	135.0	15.55	244.95	9.75	256.20	0	356.64	259.15
” 18	7.36	760	360	1380	105.0	12.88	155.02	4.68	146.40	0	263.52	188.15
” 19	7.7	1400	500	1930	272.0	20.29	705.18	19.89	494.10	0	1146.24	571.55
” 20	7	1400	292	1860	164.0	19.32	760.38	19.89	634.40	0	1075.68	749.05
” 21	7.6	1400	295	1950	328.0	24.18	1161.50	29.64	1122.40	0	1515.84	781.00
” 22	7.4	1400	410	2680	270.0	24.30	1270.52	24.96	1085.80	0	1513.44	1111.15
” 23	7.4	1400	380	1760	322.0	19.32	755.32	34.71	628.30	0	1184.16	685.15
” 24	7.3	1410	474	1960	167.2	20.90	753.25	29.25	713.70	0	1179.36	784.55
” 25	7.8	1408	386	1820	118.0	19.93	683.56	25.35	817.40	0	1128.00	766.80
” 26	8	1396	520	980	204.0	18.59	725.42	23.01	927.20	0	1204.80	759.70
” 27	8	1408	450	2640	298.0	20.78	706.10	24.96	878.40	0	1199.04	635.45
” 28	7.6	1415	410	3600	323.6	19.68	673.90	17.55	707.60	0	1075.20	702.90
” 29	7.2	1408	360	1960	382.4	19.20	747.04	24.18	756.40	0	1027.20	678.05
” 30	7.16	4680	750	1860	305.0	20.29	705.18	19.89	494.10	0	1146.24	571.55
’’ 31	6.98	5310	820	2740	385.0	21.63	770.04	25.74	744.81	0	1259.04	1535.02
” 32	6.75	8350	810	2160	455.0	24.30	1270.52	24.96	1085.80	0	1513.44	1111.15
” 33	6.51	5180	790	3820	355.0	19.32	760.38	19.89	634.40	0	1075.68	749.05
” 34	6.62	6400	805	1960	392.0	24.06	1020.74	23.01	732.00	0	1210.56	1019.91
” 35	6.58	6200	900	2860	384.2	20.29	719.21	25.74	868.64	0	1647.36	860.87
” 36	5.49	4860	780	3140	385.0	17.98	686.32	33.15	625.25	0	1088.64	648.23
” 37	6.65	7860	890	1860	453.8	22.96	1362.52	33.93	1171.81	0	1569.12	1180.02
” 38	6.51	5580	815	2760	424.4	21.63	695.29	30.42	746.64	0	1375.68	767.86
” 39	6.65	4850	820	2930	375.0	19.32	755.32	34.71	622.20	0	1184.16	685.15
” 40	6.65	4850	820	2960	375.0	19.32	755.32	34.71	622.20	0	1184.16	685.15
” 41	7.14	6040	910	3100	305.0	30.38	787.29	19.89	719.80	0	947.04	770.35
” 42	6.87	7480	980	3120	345.0	32.20	885.27	29.64	841.80	0	1000.80	855.55
” 43	7.29	7350	960	4920	335.0	31.23	945.30	34.71	866.20	0	950.88	969.15
” 44	7.14	6430	810	4890	295.0	29.40	655.27	24.96	707.60	0	643.20	756.15
” 45	7.13	6100	830	4020	265.0	29.16	695.42	29.64	719.80	0	630.72	770.35
” 46	6.92	5160	710	4120	295.0	22.11	695.29	24.96	866.20	0	649.92	969.15
” 47	7.26	1340	520	3160	105.0	13.24	204.93	4.68	256.20	0	185.76	259.15
” 48	7.35	1960	490	1980	110.0	14.22	220.11	9.75	268.40	0	191.52	287.55
” 49	7.2	3850	620	2760	245.0	19.08	455.17	22.62	305.00	0	945.12	330.15
” 50	7.11	10040	990	3910	560.0	32.20	1555.72	34.71	1256.60	0	1703.04	1423.55
” 51	6.94	7890	910	6920	295.0	21.26	855.37	24.96	768.60	0	356.64	855.55
” 52	6.11	7470	890	6120	235.0	22.48	895.39	24.96	817.40	0	732.96	869.75
Parameters/	P^H	EC	TH	TDS	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl

Sample nos.		(µ/cm)	mg/L ←							→	
” 53	6.99	7650	920	3960	240.0	23.57	905.28	19.89	829.60	0	2462.40	883.95
” 54	7.12	1500	390	3720	115.0	13.00	255.07	9.75	353.80	0	127.68	344.35
” 55	8.81	2450	420	1620	195.0	15.07	295.09	9.75	414.80	0	107.52	528.95
” 56	7.24	2580	440	1980	155.0	19.32	620.08	9.75	549.00	0	511.68	599.95

Table 2: Concentration of different chemical parameters of bore well water of the study area (post-monsoon season).

Parameters/ Sample nos.	P^H	EC (µ/cm)	TH	TDS	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl
			mg/L ←					→				
DW 1	7.14	1620	410	980	75	21.38	810.52	5.07	353.8	0	1308.96	259.15
” 2	6.87	3460	650	2190	65	32.32	815.35	30.03	378.2	0	1201.44	113.25
” 3	7.21	3020	620	11`90	70	30.5	705.41	14.82	353.8	0	1111.68	287.55
” 4	6.95	3690	790	3340	120	27.46	555.22	24.96	436.76	0	525.12	502.33
” 5	7.27	4370	710	2750	215	18.35	775.33	24.96	475.8	0	1262.88	431.33
” 6	7.16	4520	810	2860	245	25.39	825.47	19.89	488	0	1509.12	401.15
” 7	7.2	4160	820	2630	200	36.57	655.27	14.82	500.2	0	1055.04	396.54
” 8	7.12	2760	420	1750	180	32.56	475.18	35.1	256.2	0	1043.04	259.15
” 9	7.38	4480	530	2780	180	32.32	785.45	30.03	500.2	0	1260.96	429.55
” 10	7.26	4210	626	2160	196	28.67	686.78	30.42	524.6	0	1349.76	421.03
” 11	7.18	5180	990	3250	240	35.96	756.7	30.03	512.4	0	1335.36	396.54
” 12	6.95	6940	990	3250	250	37.06	1840.92	35.1	500.2	0	3691.2	429.55
” 13	6.9	5920	995	3260	298	30.62	234.6	33.54	394.06	0	946.56	422.45
” 14	7.56	2710	590	2000	170	26	190.67	28.08	361.12	0	488.64	344.35
” 15	7.13	2610	490	1670	160	22.36	420.21	19.89	256.2	0	821.76	259.15
” 16	6.89	1360	480	890	50	21.38	395.14	54.99	256.2	0	544.8	259.15
” 17	7.18	3080	490	1500	205	26.24	265.19	40.95	378.2	0	42.24	361.75
” 18	7.24	2150	410	1420	175	25.39	275.08	10.14	374.54	0	295.68	111.83
” 19	7.23	3750	510	2430	290	28.31	590.41	35.1	402.6	0	1223.52	401.15
” 20	7.22	3330	530	2190	160	27.22	630.43	44.85	378.2	0	1159.2	287.55
” 21	7.17	3550	590	2320	310	30.25	410.32	30.03	427	0	921.12	325.54
” 22	7.15	5200	990	3380	280	32.32	885.5	19.89	475.8	0	1745.76	401.15
” 23	6.92	5080	990	2320	300	31.35	710.47	5.07	500.2	0	1357.92	145.55
” 24	7.22	4980	788	3260	190	28.43	525.32	5.07	475.8	0	907.68	287.55
” 25	7.46	3680	610	2420	130	27.22	730.48	10.14	390.4	0	1144.8	360.33
” 26	8.25	1460	390	980	185	21.38	535.21	5.07	256.2	0	1118.88	219.75
” 27	7.14	4680	890	3090	310	29.52	985.55	10.14	436.76	0	2137.44	315.95
” 28	7.14	4380	910	2190	355	39.61	570.4	39.78	475.8	0	2291.04	401.15
” 29	7.22	3250	710	2150	380	28.43	255.07	14.82	378.2	0	871.68	287.55
” 30	7.1	4290	820	2830	315	33.78	302.91	30.03	475.8	0	776.16	301.75
’’ 31	7.16	5260	990	3460	500	29.65	422.51	35.1	488	0	1255.2	429.55
” 32	6.92	7550	990	5030	450	36.33	795.34	44.85	597.8	0	1887.84	429.55
” 33	7.19	4520	890	2980	495	37.42	560.28	30.03	475.8	0	1778.4	287.55
” 34	7.71	4280	850	2800	365	36.57	610.42	39.78	436.76	0	1571.04	301.75
” 35	7.16	6840	990	4500	500	38.39	500.25	10.14	378.2	0	1567.68	395.12
” 36	7.17	4020	830	2640	505	38.64	435.16	24.96	390.4	0	1607.52	394.05
” 37	6.99	6030	990	3940	510	39.37	595.24	10.14	500.2	0	1698.24	401.15
” 38	7.10	6130	990	4000	515	34.51	640.32	30.03	512.4	0	1780.8	396.54
” 39	7.15	6300	990	4280	595	30.38	670.45	24.96	500.2	0	2021.28	401.15
” 40	7.11	6750	990	4520	410	31.47	1003.49	24.96	475.8	0	2422.08	287.55
” 41	6.82	7100	990	4800	480	39.61	570.4	24.96	475.8	0	1765.92	287.55
” 42	6.69	8140	990	5520	1700	33.29	3026.57	24.96	500.2	0	9430.56	539.6
” 43	6.9	8030	990	5360	1780	38.64	3001.5	24.96	524.6	0	9513.6	571.55
” 44	6.95	7580	990	5050	5	31.35	1210.72	44.85	549	0	4193.28	573.33
Parameters/ Sample nos.	P^H	EC (µ/cm)	TH	TDS	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl
			mg/L ←					→				

” 45	6.78	6850	990	4580	1130	31.47	1255.57	30.03	378.2	0	4184.16	401.15
” 46	6.99	6560	990	4350	860	29.52	1000.5	30.03	475.8	0	3205.92	429.55
” 47	7.30	1520	510	790	800	30.25	546.25	39.78	256.2	0	1573.92	259.15
” 48	6.88	2920	590	1950	350	24.42	515.2	39.78	268.4	0	1100.64	287.55
” 49	6.88	4340	810	2870	300	30.25	620.31	10.14	390.4	0	2196.96	330.15
” 50	7.69	6080	990	3930	635	39.61	1050.64	44.85	622.2	0	2905.92	578.65
” 51	7.11	11390	990	7580	735	39.85	1600.8	49.92	646.6	0	4128.48	685.15
” 52	7.14	9080	990	6040	835	41.43	865.49	14.82	719.8	0	2362.56	572.26
” 53	7.31	6260	990	4060	715	36.57	678.96	24.96	475.8	0	2792.64	301.75
” 54	7.46	2050	610	1360	825	32.56	615.25	30.03	256.2	0	1497.6	259.15
” 55	7.77	2660	620	1370	250	32.56	635.26	36.66	305	0	1492.8	287.55
” 56	7.27	3150	710	2050	260	33.53	670.45	36.66	378.2	0	2162.88	330.15

3.1.2. Electric Conductivity (EC)

Electric conductivityis the measure of water capacity to convey electric current. EC of dug well samples varies from320 µs/cm to 10040µs/cm in pre-monsoon season and 1360µs/cm to 11390µs/cm in post-monsoon season, which is very high. The EC value of 100% samples in pre and post-monsoon seasons are higher than permissible limit (Table 3).

Table 3: Classification of groundwater on the basis of Electric conductivity values

Conductivity range (µs/cm)	Classification	Pre-monsoon Season		Post-monsoon Season	
		No. of samples	%	No. of samples	%
<1500	Permissible	16	28	03	5
1500-3000	Not permissible	11	20	08	14
>3000	Hazardous	29	52	45	81

3.1.3. Total Dissolved Solids (TDS)

Total dissolved solids are the total amount of mobile charged ions, including minerals, salts or metals dissolved in given volume of water, expressed in units of mg/lit. The TDS of dug well samples in study area varies from 890 mg/lit to 6920 mg/lit in pre-monsoon season and 790 mg/lit to 7580 mg/lit in post-monsoon season. The higher value of TDS is attributed to application of agricultural fertilizer contributing the higher concentration of ions in to the groundwater (Table 4). The 95% samples are exceeding maximum permissible limit.

Table 4: Classification of groundwater on the basis TDS values

TDS	Classification	Pre-monsoon Season		Post-monsoon Season	
		No. of samples	%	No. of samples	%
150-300	Excellent	0	0	0	0
300-600	Good	0	0	0	0
600-900	Fair	1	2	0	0
900-1200	Poor	2	3	3	5
Above 1200	unacceptable	53	95	53	95

3.1.4. Total Hardness (TH)

The total hardness of dug well water samples in pre-monsoon season varies from 292 mg/lit. to990 mg/lit. and 390 mg/lit to 990 mg/lit. in post-monsoon season. It is seen that the total hardness of dug well water samples from post-monsoon season is higher compared to post-monsoon season. The 96% and 100% dug well water samples in pre-monsoon and post-monsoon seasons respectively are classified as very hard water (Table 5).

Table 5: Classification of groundwater on the basis Total Hardness values

Total Hardness as $CaCO_3$(mg/lit)	Water Class	Pre-monsoon Season		Post-monsoon Season	
		No. of samples	%	No. of samples	%
<75	Soft	-	-	-	-
75-150	Moderately Hard	-	-	-	-
150-300	Hard	02	4%	-	-
>300	Very hard	54	96%	56	100%

3.1.5 Calcium(Ca)

Calcium is naturally present in water. Calcium is determinant of water hardness, because it can be found in water as Ca ions. Calcium content in dug well water samples varies from 60 mg/lit to 560 mg/lit in pre-monsoon season and 50 mg/lit to 1780 mg/lit in post-monsoon season (Table 6).The 63% of samples from pre-monsoon season and 72% of samples from post-monsoon season exceed the maximum permissible limit. Calcium content in groundwater increases in post-monsoon season.

Table 6: Classification of groundwater on the basis Calcium values

Ca	Pre-monsoon Season		Post-monsoon Season	
	No. of samples	%	No. of samples	%
<75	2	3	4	7
75-200	19	34	12	21
>200	35	63	40	72

3.1.6. Magnesium (Mg)

A large number of minerals contain magnesium. Magnesium is washed from rocks and subsequently ends up in water. Magnesium has many different purposes and consequently may end up in water in many different ways. It adds up in the environment by use of fertilizers for agricultural practice and from cattle feed. The value of magnesium from dug well water samples ranges from 11.3 mg/lit. to 32.2 mg/lit. in pre-monsoon season and 18.35 mg/lit. to 41.43 mg/lit. in post-monsoon season. The 7% groundwater samples in pre-monsoon season and 64% in post-monsoon season exceeds the highest desirable limit. The 30 % of magnesium in post-monsoon season increases.

3.1.7. Chloride (Cl)

Chloride originates from sodium chloride which gets dissolved in water from rock and soil. The concentration of chloride in groundwater will increase if it is mixed with sewage or sea water. The chloride content in the study area varies from 159.40 mg/lit. to 1428.54 mg/lit. in pre-monsoon season and 113.26 mg/lit. to 685.15 mg/lit. in post monsoon season.

3.1.8. Alkalinity (Carbonates and Bicarbonate)

Alkalinity is the measure of the capacity of the water to neutralize a strong acid. The alkalinity in the water is generally imparted by the salts of carbonates, silicates etc. together with hydroxyl ions in free states. The bicarbonate alkalinity of dug well water samples varies from 146.4 mg/lit. to 1256.4 mg/lit. in pre-monsoon season and 256.2 mg/lit. to 729.8 mg/lit. in post-monsoon season.

3.1.9. Sodium(Na)

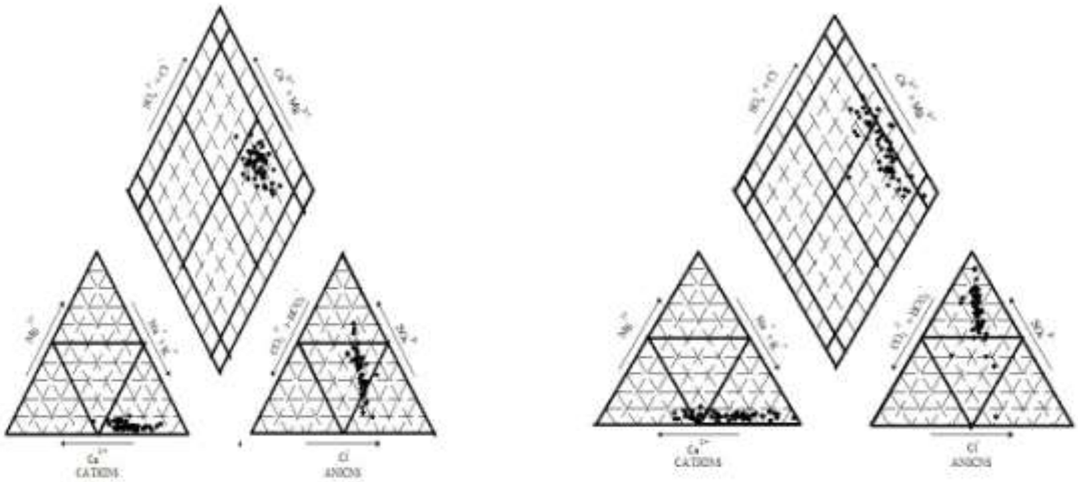
Sodium concentration in groundwater samples of study area is high as compare to Ca and Mg. The sodium content in dug well water samples varies from 195.04 mg/lit. to 1555.70 mg/lit. in pre-monsoon season and 190.67 mg/lit. to 3026.57 mg/lit. in post-monsoon season.

3.2 Classification of Groundwater based on Piper Trilinear Diagram

In order to understand the variation in hydro-chemical facies with space and time, the data has been plotted on the Piper Trilineardiagram [11].

It is seen from the Fig. 3.a that out of 56 dug well water samples of pre-monsoon season, 55 dug well water samples (98%) represent Na + K >Ca + Mg(alkalies exceed alkaline earth) and 1 dug well water sample(2%) belong to Ca+Mg>Na+K (alkaline earths exceed alkalies) hydrochemicalfacies. Similarly, 56 dug well water samples (100%) suggests Cl + SO_4 > HCO_3+CO_3 (strong acids exceed weak acids) hydrochemicalfacies.

From the Fig. 3.b, it is seen that out of 56 dug well water samples of post-monsoon season, 39 dug well water samples (70%) represents Na + K >Ca + Mg(alkalies exceed alkaline earth) and 17 dug well water samples (30%) suggests Ca+Mg>Na+K(alkaline earths exceed alkalies) hydrochemicalfacies. Similarly, 47 dug well water samples (84%) suggests Cl + SO_4 > HCO_3+CO_3 (strong acids exceed weak acids) and 9 dug well water samples (16%) represent Cl+SO_4 (strong acids) hydrochemicalfacies.



(a. Pre-monsoon season) (b. Post-monsoon season)

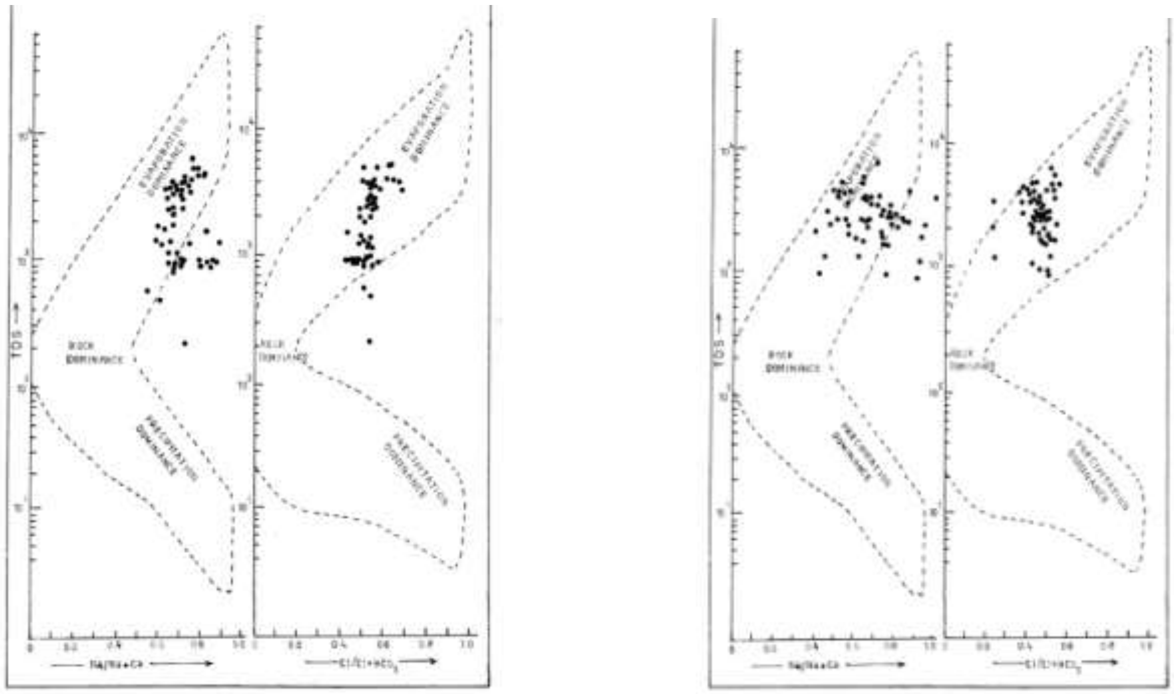
Fig. 3.a and b: PiperTrilinear diagram showing analysis of dug well water samples of the study area.

3.3 Chemistry of Groundwater based on Gibbs Variation Diagram

Gibbs variation diagram is useful to understand the chemistry of groundwater [12].

It is seen from the Fig. 4.a that out of 56 dug well water samples of pre-monsoon season, 26 dug well water samples (46%) belongs to evaporation dominance and 30 dug well water samples (54%) suggests rock dominance.

From the Fig. 4.b,it is observed that out of 56 dug well water samples of post-monsoon season, 36 dug well water samples (64%) represents evaporation dominance and 20 dug well water samples (36%) suggests rock dominance.



(a. Pre-monsoon season) (b. Post-monsoon season)

Fig.4.a and b: Gibbs Variation diagram of dug well water quality of the study area.

4. CONCLUSION

The analytical results shows 72 % and 95% of dug well water samples having higher concentration of EC values in pre-monsoon and post-monsoon seasons respectively. The TDS values of 98 % dug well water samples in pre-monsoon and 95% in post-monsoon season are with higher concentrations. Similarly, Ca values are higher in 63% and 72% dug well water samples of pre and post-monsoon seasons respectively. The concentration of Total hardness in pre and post-monsoon seasons in dug well water samples are 96 % and 100% in pre and post-monsoon seasons. Similarly Na,SO_4 andCl also shows higher concentration, which indicates signs of deterioration of water quality as per WHO and ISI standards. The proper drainage system is required where electrical conductivity (EC) is more than 1500µs/cm.A few dug well water samples the values of electrical conductivity and TDS are higher because of the application of heavy fertilizers for agricultural practices.

The Physico-chemical analyses of dug well water samples represents NA+K>Ca+Mg (Alkali exceed alkaline earth) hydro chemical facies and Cl+SO_4>HCO_3+CO_3(Strong acids exceed weak acids) hydro chemical facies. The Chemistry of ground water belongs to evaporation dominance (46%) and rock dominance (54%) of pre monsoon season and evaporation dominance (64%) and rock dominance (36%) of post monsoon season.

These chemical analysis of dug well water samples reveals that 98% groundwater samples of pre- monsoon season and 70% groundwater samples of post-monsoon season represent Na + K >Ca + Mg(alkalies exceed alkaline earth) hydrochemicalfacies. Similarly, 100% groundwater samples of pre-monsoon season and 84% groundwater samples of post-monsoon season suggests Cl + SO_4 > HCO_3+CO_3 (strong acids exceed weak acids) hydrochemicalfacies. The 2% and 30% groundwater samples of pre-monsoon and post-monsoon seasons suggests Ca+Mg>Na+K (alkaline earths exceed alkalies) hydrochemicalfacies. The 16% groundwater samples of post-monsoon season represent Cl+SO_4 (strong acids) hydrochemicalfacies.

Gibbs variation diagram suggests the chemistry of groundwater samples belongs to evaporation dominance (46%) and rock dominance (54%) in pre-monsoon season and evaporation dominance (64%) and rock dominance (36%) in post-monsoon season.

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