EVALUATION OF GROUNDWATER QUALITY IN BHOGAVATI RIVER BASIN, KOLHAPUR DISTRICT, MAHARASHTRA, INDIA

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Abstract

The assessment of groundwater quality of bore wells of the Bhogavati river basin (latitude $16^0$19'45" N to $16^0$44'30" N and longitude $73^0$50'15" E to $74^0$11'50"E) in Kolhapur District, Maharashtra, India was carried out and 40 dug well water samples were collected. The physico-chemical analyses of these water samples reveal that 90% and 92.5% groundwater samples represent Ca+Mg (alkaline earth) hydrochemical facies in pre and post-monsoon seasons respectively, whereas, 10% of groundwater samples in pre-monsoon season and 7.5% of groundwater samples in post-monsoon season represent Ca+Mg > Na+K (alkaline earths exceed alkalies) hydrochemical facies. Similarly, 82.5% groundwater samples of pre-monsoon season and 77.5% groundwater samples of post-monsoon season represent $Cl+SO_4 > HCO_3+CO_3$ (strong acid exceeds weak acid) hydrochemical facies, while 17.5% groundwater samples of pre-monsoon season and 22.5% groundwater samples of post-monsoon season belong to $HCO_3+CO_3 > Cl+SO_4$ (weak acid exceeds strong acid) hydrochemical facies. On the basis of Gibbs diagram the chemistry of groundwater belongs to precipitation dominance in pre-monsoon season and rock dominance in post-monsoon season.

Keywords: *Bhogavati River Basin, Groundwater Quality, Hydrochemical Facies, Parameters.*

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1. INTRODUCTION

Groundwater is the almost source of water in drought prone monsoon semiarid or arid regions, for drinking domestic, industrial and irrigation purpose. Groundwater never found in pure state. As water come from the atmosphere CO_2 and failing on the ground carbonic acid as a powerful corrosive agent. It react with geomaterial and acquires a certain characteristics before entering in the ground its chemical properties may changes from its place of entry to the point of exit. Natural quality of water depends upon its interaction with rocks and various geochemical reaction.

Due to excessive use of pesticides, fertilizers for agriculture, industrial waste water, domestic waste water etc. pose serious problem of water pollution. [1] Therefore, water quality monitoring of various sources is very essential to know the status so as to suggest safety measures. Groundwater is mostly chemically non-polluted when drawn from greater depth. Human beings have made aquifer as their prime requisite due to unavailability of reliable source of water as that of the groundwater. So during past several decades, groundwater quality has emerged as one of the most important and confronting environmental issue [2]. Water quality analysis is one of the most important aspects in groundwater studies. The hydrochemical study reveals quality of water that is suitable for drinking, agriculture and industrial purposes. According to National Water Policy, (2012) both surface and groundwater should be regularly monitored and program should be undertaken for the improvement of water quality. The main objective of this paper is to carry out a hydrochemical appraisal of groundwater in Bhogavati river basin of Kolhapur district, Maharashtra, India. This includes the determination of the general water quality, major ionic constituents, hydrochemical facies, geochemical processes responsible for changes, and variations in the groundwater quality.

2. STUDY AREA

The Bhogavati river basin lies between latitude $16^0$19'45''N to $16^0$44'30''N and longitude $73^0$50'15''E to $74^0$11'50''E in Survey of India Toposheet numbers 47 H/15, 47 L/2 and 47 L/3. The area of Bhogavati river basin is about 440 km^2 (Figure 1). The Bhogavati river is one of the major tributary of the Panchaganga river and Panchaganga river is a tributary of river Krishna. The study area is covered by Deccan volcanic basalt of Upper Cretaceous to Lower Eocene age. The climate of the area comes across as an amusing blend of the coastal and inland climate of Maharashtra. The temperature of the area ranges between 10^0C and 40^0C. The average annual rainfall of the area is about 4800 mm.

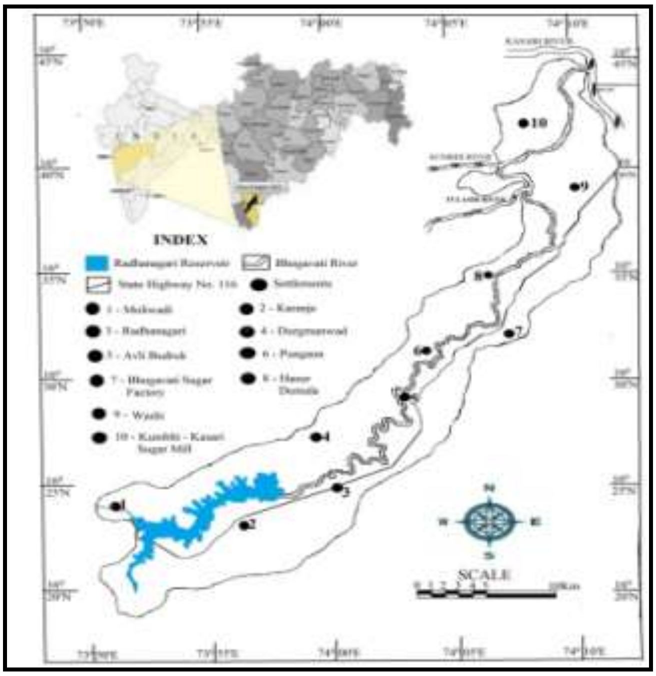

Fig 1: Location Map of the study area.

3. METHODOLOGY

Groundwater samples were collected from 40 bore wells during pre and post- monsoon seasons of the year 2013. (Figure 2). The polythene bottles were used for sample collection. The samples were analyzed in the laboratory for various physicochemical parameters by standard procedures [3], [4] and [5] (Table 1 and 2). The analysis of total alkalinity (TA), total hardness (TH), Calcium (Ca^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Bicarbonate (HCO_3^{-}) and Chloride (Cl^{-}) were determined by titration. The pH, EC and TDS were calculated by using pH meter, EC meter and TDS meter respectively.

Fig 2: Dug well location map of the study area

4. RESULT AND DISCUSSION

The concentrations of Sodium (Na^{+}) and potassium (K^{+}) in the groundwater were measured by using flame photometer. The spectrophotometer was used for the determination of SO_4.

4.1 Hydrogen Ion Concentration (pH)

The pH of water is measured in the field at the time of collection of samples. The combination of CO_2 with water forms carbonic acid, which affects the pH of the water. The pH of groundwater samples is varies from 6.0 to 9.7 and 5.6 to 9.9 in pre monsoon and post- monsoon seasons respectively (Table 1 and 2), which indicates that some groundwater samples in both the seasons are slightly alkaline in nature. (Table 3).

4.2 Electrical Conductivity (EC)

Electrical Conductivity is the measure of water capacity to convey electric current. The EC of groundwater samples is varying from 116.7 µmhos/cm to 2046.5 µmhos/cm and 104.4 µmhos/cm to 1659.8 µmhos/cm in pre-monsoon and post-monsoon seasons respectively (Table 1 and 2), which shows that in both the seasons only 2 groundwater samples exceeds most desirable limit given by WHO International standards (2004) (Table 3).

4.3 Total Dissolved Solids (TDS)

TDS is the concentrations of all dissolved minerals in water indicates the general nature of salinity of water. The TDS ranges between 361.9 mg/l to 2183.6 mg/l for pre -monsoon season, while it varies from 313.4 mg/l to 2131.7 mg/l in post-monsoon season (Table 1 and 2). The TDS values of groundwater samples in the pre-monsoon season are found to be higher as compared to the post -monsoon season. Increase in TDS in pre- monsoon season confirms the interference drawn about higher EC values in this season. It is observed that 2.5% and 7.5% groundwater samples in pre and post-monsoon seasons respectively have exceeded maximum allowable limit prescribed by the drinking water standard of WHO (Table 3).

4.4 Total Hardness (TH)

The hardness of groundwater samples is in the range of 204 mg/l to 1591 mg/ lit in pre-monsoon season and 190.7 mg/l to 1577.9 mg/ lit in post-monsoon season (Table 1 and 2). Groundwater with TH <75 mg/l, 75-150 mg/l, 150-300 mg/l and >300 mg/l are classified as soft water, moderately hard water, hard water and very hard water respectively [6]. The 45% and 37.2% groundwater samples are having very hard water in pre and post-monsoon seasons respectively. (Table 3).

4.5 Calcium (Ca)

Calcium is determinant of water hardness, because it can be found in water as Ca ions. In the study area Ca content in the groundwater samples varies from 81.6 mg/l to 924.8

mg/l and 72.3 mg/l to 918.2 mg/l in pre and post-monsoon seasons respectively (Table 1 and 2). The Ca content in 60% and 57.5% groundwater samples were beyond the maximum permissible limit prescribed by WHO and ISI (Table 3).

4.6 Magnesium (Mg)

A large number of minerals and rocks contain magnesium and it dissolves in surface and groundwater. It adds up in the environment by use of fertilizer for agricultural practices and from cattle feed [7]. The values of Mg in groundwater samples range between 54 mg/l to 698.4 mg/l and 46.9 mg/l to 691.8 mg/l in pre and post- monsoon seasons respectively (Table 1 and 2). The Mg content in 67.5% and 82.5% groundwater samples were crosses the maximum permissible limit in pre-monsoon and post-monsoon seasons respectively prescribed by WHO (Table 3).

4.7 Sodium (Na)

Sodium concentration in groundwater samples of study area is low as compare to Ca and Mg. Sodium content is varies from 4 mg/l to 90.5 mg/l and 2.3 mg/l to 84.9 mg/l in pre and post-monsoon seasons respectively (Table 1 and 2). The sodium concentration of groundwater samples both in both seasons were within the safe limit (Table 3).

4.8 Potassium (K)

The main source of K in groundwater is weathering of potash silicate minerals and use of potash fertilizers for agriculture practices. The potassium content in groundwater samples ranges in between 0.4 mg/l to 65 mg/l in pre-monsoon season and 0.2 mg/l to 61 mg/l in post-monsoon season (Table 1 and 2). In groundwater samples K concentration does not exceeds the maximum permissible limit prescribed by WHO and ISI (Table 3).

4.9 Total Alkalinity

Total alkalinity is the total concentration of bases in water expressed as parts per million (ppm) or milligrams per liter (mg/l) of calcium carbonate (CaCO3). These bases are usually bicarbonates (HCO3) and carbonates (CO3), and they act as a buffer system that prevents drastic changes in pH. An alkalinity value varies from 44.5 mg/l to 284 mg/l in pre- monsoon season and 23.5 mg/lit to 274.7 mg/l in post-monsoon season. (Table 1 and 2). The Total alkalinity of groundwater samples in both seasons were within the safe limit (Table 3).

4.10 Bicarbonate (HCO_3)

The values of HCO_3 are in the range of 44.5 mg/l to 284.8 mg/l in pre-monsoon season and 9.5 mg/l to 274.7 mg/l in post-monsoon season (Table 1 and 2). The bicarbonate values of groundwater samples in both seasons were within the safe limit (Table 3).

4.11 Sulphate (SO_4)

Sulphate ions usually occur in natural waters. In the study area SO_4 content in the groundwater samples varies from 8.7 mg/l to 95.7 mg/l and 7.2 mg/l to 93.3 mg/l in pre and post-monsoon seasons respectively (Table 1 and 2). The concentrations of SO_4 are within safe limit (Table 3).

4.12 Chloride (Cl)

Chloride originates from rocks and soil which gets dissolved in water. Chloride content in the groundwater samples ranges between 27 mg/l to 167.6 mg/lit in pre-monsoon season and 16.3 mg/l to 157.8 mg/l in post- monsoon season. (Table 1 and 2). This reveals that Cl content in groundwater samples does not exceed the maximum permissible limit prescribed by WHO and ISI (Table 3).

4.13 Hydrogeochemical Facies

The evaluation of hydrochemical parameters of groundwater can be understood by plotting the concentration of major cations and anions in the Piper Trilinear diagram. It helps in recognizing various hydrogeochemical facies in a groundwater environment [8]. The physico-chemical analyses of these water samples reveal that 90% and 92.5% groundwater samples represent Ca+Mg (alkaline earth) hydrochemical facies in pre and post-monsoon seasons respectively, whereas, 10% of groundwater samples in pre-monsoon season and 7.5% of groundwater samples in post-monsoon season represent Ca+Mg > Na+K (alkaline earths exceed alkalies) hydrochemical facies. Similarly, 82.5% groundwater samples of pre-monsoon season and 77.5% groundwater samples of post-monsoon season represent $Cl+SO_4$ > HCO_3+CO_3 (strong acid exceeds weak acid) hydrochemical facies, while 17.5% groundwater samples of pre-monsoon season and 22.5% groundwater samples of post-monsoon season belong to HCO_3+CO_3 > $Cl+SO_4$ (weak acid exceeds strong acid) hydrochemical facies (Figure 3 and 4).

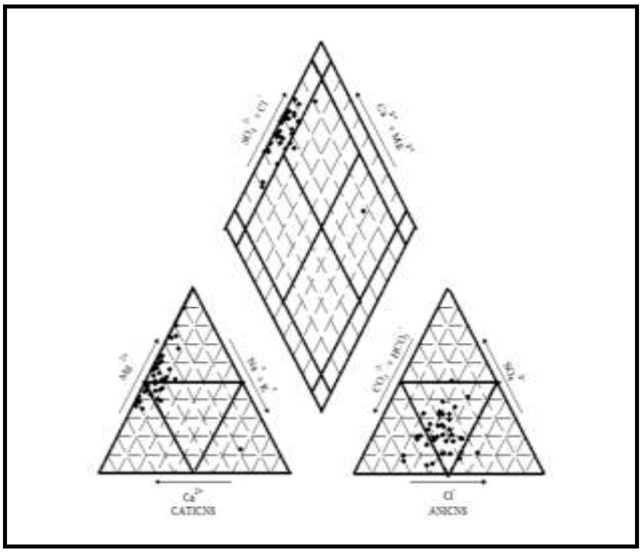

Fig. 3: Piper Trilinear diagram of groundwater quality (pre-monsoon season)

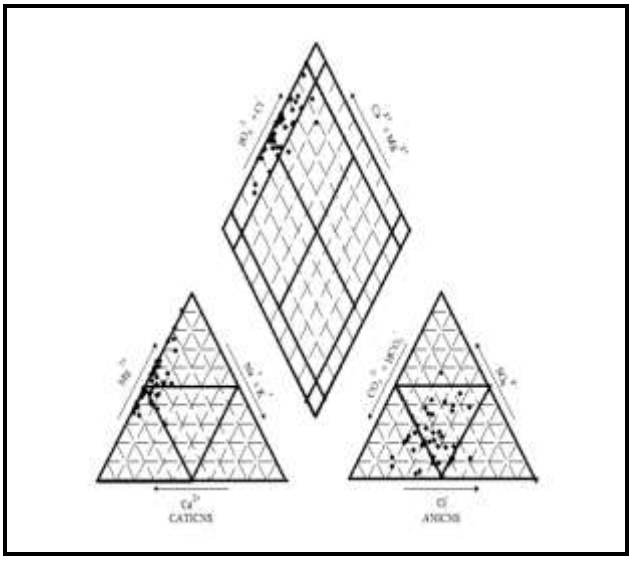

Fig. 4: Piper Trilinear diagram of groundwater quality (post-monsoon season)

4.14 Gibbs Diagram

The quality of groundwater is significantly changed by the influence of weathering and anthropogenic inputs. Gibbs's diagrams, representing the ratios of Na^{++}: (Na^{++} Ca^{++}) and Cl^-: (Cl) + HCO_3 as a function of TDS, are widely employed to assess the functional sources of dissolved chemical constituents, such as precipitation-dominance, rock-dominance and evaporation-dominance [9]. Three distinct fields such as precipitation dominance, evaporation dominance and rock– water interaction dominance areas are shown in the Gibbs diagram (Figure 5 and 6)**.** The chemistry of groundwater samples of study area belongs to precipitation dominance in pre-monsoon season and rock dominance in post-monsoon season.

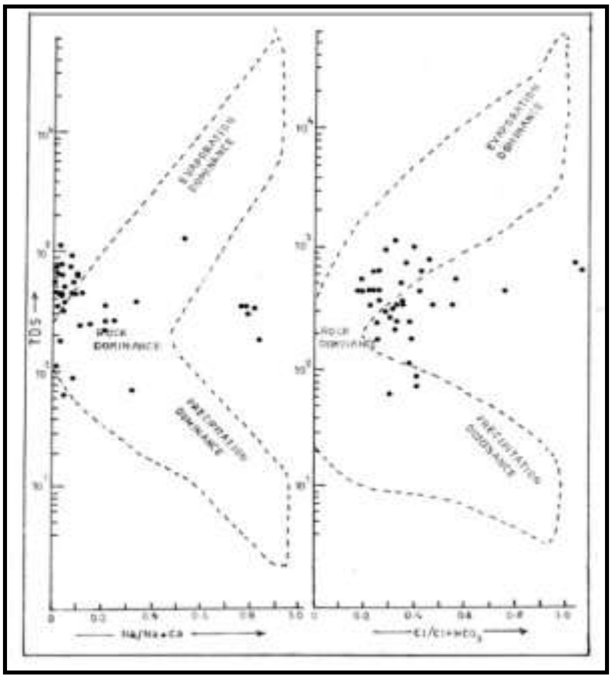

Fig. 5: Gibbs diagram of groundwater quality (pre-monsoon season)

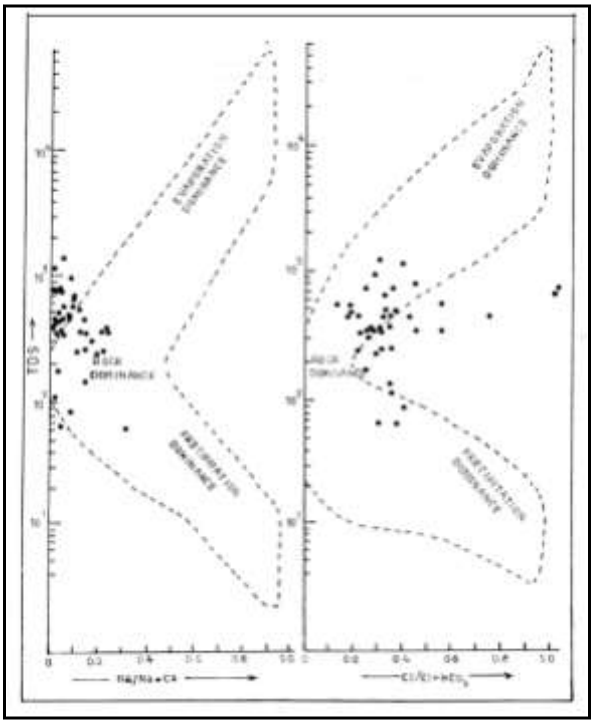

Fig. 6: Gibbs diagram of groundwater quality (post-monsoon season)

5. CONCLUSION

In the present investigation, interpretation of chemical analysis reveals that the groundwater is hard to very hard. The concentration of ions is maximum in pre-monsoon season as compare to post-monsoon season. The physico-chemical analyses of these water samples reveal that 90% and 92.5% groundwater samples represent Ca+Mg (alkaline earth) hydrochemical facies in pre and post-monsoon seasons respectively, whereas, 10% of groundwater samples in pre-monsoon season and 7.5% of groundwater samples in post-monsoon season represent Ca+Mg > Na+K (alkaline earths exceed alkalies) hydrochemical facies. Similarly, 82.5% groundwater samples of pre-monsoon season and 77.5% groundwater samples of post-monsoon season represent Cl+SO_4 > HCO_3+CO_3 (strong acid exceeds weak acid) hydrochemical facies, while 17.5% groundwater samples of pre-monsoon season and 22.5% groundwater samples of post-monsoon season belong to HCO_3+CO_3 > Cl+SO_4 (weak acid exceeds strong acid) hydrochemical facies. On the basis of Gibbs diagram the chemistry of groundwater belongs to precipitation dominance in pre-monsoon season and rock dominance in post-monsoon season.

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

Ppm pre	PH	EC	TDS	TH	Ca	Mg	Cl	HCO_3	CO_3	TA	Na	K	SO_4
BW1	8.3	491.4	527.8	299.2	108.8	190.4	39.8	76.2	44.0	120.0	6.2	0.9	45.3
BW2	6.0	116.7	505.7	340.0	95.2	244.8	34.1	68	0.0	68.0	5.1	1.1	43.5
BW3	7.0	150.6	361.9	204.0	122.4	81.6	32.7	44.5	0.0	44.0	12.7	6.9	46.2
BW4	6.2	182.6	449.6	313.0	217.6	95.4	36.9	56	0.0	56.0	4.9	0.3	24.4
BW5	9.7	423.6	440	218.0	81.6	136.4	35.5	60.4	60.0	120.0	29.0	6.5	13.0
BW6	8.2	730.5	508.4	245.0	149.6	95.4	54.0	132.7	0.0	132.0	28.2	23.7	8.7
BW7	7.1	822.7	1139.4	789.0	435.2	353.8	38.3	144.8	0.0	144.0	50.4	23.6	78.3
BW8	7.0	1479.8	1847	1392.0	693.6	698.4	85.2	216.3	0.0	216.0	63.5	6.6	68.5
BW9	7.4	726.7	943.8	666.0	435.2	230.8	39.8	156.9	0.0	156.0	22.6	3.5	39.7
BW10	7.8	715.4	968.6	680.0	503.2	176.8	41.2	124.2	0.0	124.0	54.0	6.2	47.3
BW11	9.6	683.4	459.4	245.0	149.6	95.4	72.4	32.2	28.0	60.0	17.5	8.6	38.2
BW12	7.1	700.4	926.7	680.0	489.6	190.4	38.3	140	0.0	140.0	10.3	1.2	41.9
BW13	7.0	1235.0	1372.9	1074.0	530.4	543.6	71.0	196	0.0	196.0	6.2	0.4	10.4
BW14	8.1	293.7	763.6	612.0	95.2	516.8	27.0	60.6	0.0	60.0	4.0	1.1	42.9
BW15	7.7	606.2	742.6	530.0	272.0	258.0	42.6	104.8	0.0	104.0	17.7	1.8	30.1
BW16	7.9	1016.6	820.4	490.0	312.8	177.2	36.9	194.9	0.0	194.0	54.2	6.9	21.7
BW17	7.2	1188.0	1259.3	952.0	680.0	272.0	73.8	76.3	24.0	24.0	24.3	14.7	79.1
BW18	9.1	1073.1	564.17	272.0	163.2	108.8	72.4	56.87	32.0	32.0	19.9	3.7	90.3
BW19	7.1	1747.1	1916.2	1360.0	748.0	612.0	167.6	252.6	0.0	252.0	29.1	4.6	87.3
BW20	7.6	538.4	725.9	517.0	272.0	245.0	39.8	116.5	0.0	116.0	7.9	2.3	26.9
BW21	7.8	670.2	493	326.0	176.8	149.2	54.0	72.8	0.0	72.0	8.2	4.9	11.4
BW22	6.7	700.4	864.8	666.0	421.6	244.4	45.4	88.2	0.0	88.0	6.4	0.4	43.8
BW23	9.3	519.6	522.6	245.0	163.2	81.8	62.5	52.5	0.0	52.0	45.9	12	87.5
BW24	6.5	433.0	827.5	490.0	258.4	231.6	38.3	88.7	0.0	88.0	89.5	65	41.6
BW25	6.7	1142.8	1291.8	938.0	598.4	339.6	98.0	176.3	0.0	176.0	7.9	0.3	56.7
BW26	8.1	357.7	556.3	272.0	149.6	122.4	44.0	92	0.0	92.0	40.5	8.4	83.4
BW27	7.5	120.5	438.9	190.0	136.0	54.0	32.7	48.1	0.0	48.0	64.8	7.3	80.6
BW28	6.9	395.4	889.2	612.0	408.0	204.0	34.1	100.5	0.0	100.0	54.6	27.4	45.8
BW29	6.5	1261.4	1003.8	680.0	503.2	176.8	113.6	144.8	0.0	144.0	13.4	3.9	33.7
BW30	6.7	790.7	737.4	490.0	326.4	163.6	65.3	128.9	0.0	128.0	16.1	1.3	21.2
BW31	8.1	389.7	437.6	245.0	81.6	163.4	46.9	76	0.0	76.0	15.2	1.2	37.3
BW32	8.1	849.1	492.5	258.0	122.4	135.6	99.4	84.2	0.0	84.0	8.4	1.6	24.9
BW33	6.8	1027.9	1206.4	898.0	503.2	394.8	76.7	152.6	0.0	152.0	6.5	0.6	57.3
BW34	7.9	568.6	520.8	259.0	149.6	109.4	42.6	96.4	0.0	96.0	33.6	10.5	62.9
BW35	7.0	611.9	655.5	449.0	285.6	163.4	55.4	104.7	0.0	104.0	8.7	2.9	19.9
BW36	6.5	504.6	662.6	435.0	272.0	163.0	54.0	64.4	0.0	64.0	54.1	12.5	28.2
BW37	7.3	482.0	734	462.0	258.4	203.6	41.2	100	0.0	100.0	61.6	23.6	30.4
BW38	7.0	602.5	915.6	598.0	299.2	298.8	45.4	92.3	0.0	92.0	90.5	26.9	47.6
BW39	6.9	2046.5	2183.6	1591.0	924.8	666.2	125.0	284.8	0.0	284.8	60.7	11.6	95.7
BW40	7.8	278.6	464.1	286.0	190.4	95.6	39.8	64.7	0.0	64.0	35.1	10.2	12.6

(All values are in mg/l except EC in µmhos/cm and pH)

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

Ppm Post	PH	EC	TDS	TH	Ca	Mg	Cl	HCO_3	CO_3	TA	Na	K	SO_4
BW1	7.9	446.0	468.6	283.4	100.9	182.5	28.9	65.4	34.0	99.4	4.5	0.7	43.8
BW2	5.6	753.2	467.4	328.8	89.6	239.2	25.5	59.7	0.0	59.7	3.4	1.2	43.2
BW3	6.6	104.4	313.4	190.7	115.7	74.9	23.0	34.6	0.0	34.6	11.2	6.2	41.2
BW4	5.7	158.2	407.8	301.4	211.8	89.6	28.2	47.5	0.0	47.5	2.4	0.2	22.4
BW5	9.9	410.6	369.5	199.4	72.3	127.1	23.3	48.0	48.0	96.0	22.8	6.2	11.9
BW6	7.8	721.7	455	229.3	141.8	87.6	43.2	121.5	0.0	121.5	23.6	21.7	7.8
BW7	6.6	744.4	1081	775.5	428.4	347.0	28.6	134.5	0.0	134.5	42.8	20.6	72.5
BW8	6.5	1411.3	1793.8	1378.8	687.0	691.8	75.7	206.7	0.0	206.7	56.0	4.6	65.5
BW9	7.0	687.0	893.9	652.0	428.2	223.8	29.8	146.3	0.0	146.3	17.6	3.3	37.9
BW10	7.4	668.1	912.3	665.2	495.8	169.4	30.8	113.9	0.0	113.9	45.2	6.1	43.7

BW11	9.8	645.2	393.9	226.4	140.3	86.1	60.2	20.0	22.0	42.0	14.7	8.0	32.8
BW12	6.7	658.5	879.1	666.6	482.9	183.7	28.7	130.6	0.0	130.6	7.8	1.0	37.7
BW13	6.0	1224.6	1324.6	1060.8	523.8	537.0	61.4	186.7	0.0	186.7	2.3	0.2	7.2
BW14	7.7	250.8	710.6	596.5	87.4	509.0	16.3	49.5	0.0	49.5	2.3	1.0	37.4
BW15	7.8	576.1	692	515.2	264.6	250.6	32.3	93.9	0.0	93.9	14.6	1.5	26.7
BW16	7.5	994.9	758.5	474.9	305.2	169.6	26.4	183.7	0.0	183.7	35.1	6.3	24.7
BW17	6.9	1108.9	1122.9	938.4	673.2	265.2	64.1	9.5	14.0	4.5	20.3	14.3	74.4
BW18	8.7	982.8	450.2	254.5	154.4	100.0	60.7	11.5	28.0	16.5	17.9	3.3	88.7
BW19	6.8	1659.8	1861.5	1346.4	741.2	605.2	157.8	242.5	0.0	242.5	20.5	4.2	83.3
BW20	7.2	511.5	676.8	502.5	264.8	237.8	29.6	106.1	0.0	106.1	5.6	2.1	23.6
BW21	7.6	658.8	446.5	311.1	169.3	141.7	43.5	61.8	0.0	61.8	6.7	4.2	11.7
BW22	6.3	656.6	816.3	653.4	415.3	238.1	36.2	79.0	0.0	79.0	3.5	0.2	37.7
BW23	8.9	432.1	464	227.2	154.3	72.9	50.6	40.4	0.0	40.4	41.5	11	84.4
BW24	6.1	391.4	777	477.8	252.3	225.5	29.3	79.2	0.0	79.2	84.8	61	38.8
BW25	6.6	1086.1	1244.5	925.3	592.0	333.2	88.7	166.9	0.0	166.9	3.5	0.1	53.5
BW26	7.7	274.3	504.2	256.5	141.9	114.7	33.3	81.6	0.0	81.6	35.9	8.2	80.9
BW27	7.9	439.9	393.5	175.8	128.9	46.9	22.6	38.2	0.0	38.2	61.4	7.1	80.5
BW28	6.4	349.6	841.5	599.0	401.5	197.5	24.6	90.8	0.0	90.8	51.3	27.2	42.2
BW29	6.0	1227.7	959.9	667.8	497.1	170.7	104.5	135.2	0.0	135.2	10.1	3.5	32.8
BW30	6.3	769.5	690.1	477.3	320.1	157.3	56.0	119.0	0.0	119.0	13.4	1.6	16.4
BW31	7.6	352.4	387.2	229.5	73.8	155.6	36.1	65.5	0.0	65.5	12.4	1.8	34.4
BW32	7.7	824.2	443.4	242.6	114.7	127.9	88.7	73.6	0.0	73.6	6.7	1.5	22.6
BW33	6.4	970.6	1159.8	885.1	496.8	388.4	67.3	142.9	0.0	142.9	3.4	0.9	53.7
BW34	7.4	387.0	464.4	244.0	142.1	101.9	32.2	85.8	0.0	85.8	23.2	10.9	60.9
BW35	6.9	319.3	610.9	435.8	279.0	156.8	45.8	94.7	0.0	94.7	6.7	2.3	18.7
BW36	6.0	179.6	613.5	422.8	265.9	156.9	44.9	55.2	0.0	55.2	50.3	11.5	22.8
BW37	6.4	163.6	679.5	448.1	251.5	196.7	31.3	90.4	0.0	90.4	56.0	20.6	26.6
BW38	6.6	214.3	867.3	584.7	292.5	292.1	35.8	82.6	0.0	82.6	84.9	26.0	46.8
BW39	6.7	1065.7	2131.7	1577.9	918.2	659.6	115.4	274.7	0.0	274.7	52.6	11.2	93.3
BW40	7.4	454.2	414	271.1	183.0	88.2	29.4	53.9	0.0	53.9	32.4	10.9	8,8

(All values are in mg/l except EC in µmhos/cm and pH)

Table 3: Comparison of chemical quality standards with groundwater samples.

Sr. No.	Water Quality Parameters	WHO International Standards (2004)		Indian Standards (ISI 10500, 1993)		Range in the study Area	
		Most Desirable Limit	**Max. Allowable Limit**	**Highest Desirable**	**Max. Permissible**	**Pre-monsoon Season**	**Post-monsoon Season**
1	pH	6.5	8.5	6.5 – 8.5	6.5 – 9.5	6.0 – 9.7	5.6 – 9.9
2	EC	1400	-	-	-	116.7 – 2046.5	104.4 – 1659.8
3	TDS	500	1,500	500	2,000	361.9 – 2183.6	313.4 – 2131.7
4	TH	100	500	300	600	204 – 1591	190.7 – 1577.9
5	Ca^{2+}	75	200	75	200	81.6 – 924.8	72.3 – 918.2
6	Mg^{2+}	50	150	30	100	54 – 698.4	46.9 – 691.8
7	Na^{+}	-	200	-	200	4 – 90.5	2.3 – 84.9
8	K^{+}	-	12	-	-	0.4 – 65	0.2 – 61
9	TA	-	-	200	600	44 – 284.8	23.5 – 274.7
10	HCO_3^{2-}	-	-	-	-	44 – 284.8	9.5 – 274.7
11	SO_4^{2-}	200	400	200	400	8.7 – 95.7	7.2 – 93.3
12	C^{l-}	200	600	250	1000	27 – 167.6	16.3 – 157.8

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