Appraisal of Geochemical Parameters in the Arid Regions of Krishna River Basin in Sangli District of Maharashtra

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Abstract-

Several physical and chemical causes are active in changing the composition of the groundwater percolating through the soil and rocks. The watershed development is proven technology for harvesting good quality water. Thus, in this investigation a study was carried out to analyze the impact of watershed interventions, 48 water samples each has been studied for pre-monsoon and post- monsoon condition. The statistical summary of 19 hydro-geochemical parameters has been presented through this research investigation. The values of skewness for pH, Fe and F are negatively skewed which means that the graph of these parameters will be elongated more on the left side i.e. values are more concentrated towards the higher values. The values of kurtosis for NO_3/N, F and Na% are negative which means these values have less variation among themselves as compared to other parameters.

Introduction

1.1 Mineralogy and Geochemistry of Basalts in the Study area of Deccan Traps-

The study region falls under the Deccan traps of the Maharashtra. General setup of study region is made up of Jointed Vesicular Basalt (J.V.B). The Drought Prone Region (DPR) of Maharashtra consists of lava flows belonging to the Deccan Traps. In a triangular region between Pune-Buldhana and Dhule, compound pahoehoe flows predominate. In matured weathered profiles there is a low and uniform leaching of Si, Mn, P, Cu, Zn. In much matured weathering profile, Ti, V, Cr, Fe, Ni, Zr, and Nb are essentially immobile and tend to accumulate in soils or weathering products (Eggleton, et al., 1987). Weathering of basalts and lithological composition of basalts, thus produce soluble substances that dissolve in water and the movement of these through the lithosphere, hydrosphere and biosphere determines the dominance of particular ions in groundwater. (Duraiswami et.al.2012).

1.2 Geohydrology-

Basaltic lava flows belonging to the Deccan Traps are the dominant lithology of the DPR. Pahoeheo lava flows predominate in the northern districts of Nandurbar, Dhule, Jalgaon, Buldhana, Aurangabad, Jalna, Nashik Ahmednagar

and Pune while simple aa flows are present in the southern districts of Satara and Sangli. Summaries of hydro-geological aspects of flows from the Deccan Traps have been published by Kulkarni et al., (2000). The vesicular crust (vesicular basalt) is the main water bearing horizon in the compound flows. The interconnection between the vesicles and the degree of deposition of zeolites in the vesicles determines the aquifer parameters. In the study region of the KR22, KR25, KR34 and BM 114 of Sangli district, watershed lithology is composed of the vesicular basalts.

Hydro-geologically, dyke segments could be 'carriers' or 'barriers' and as such control groundwater movement locally in the DPR. These dykes meet the drinking water as well as agricultural needs of small and marginal farmers in the DPR of Maharashtra. In the study region of the Sangli district groundwater occurs in the unconfined conditions i.e. near to surface weathered or un-weathered vesicular/ fractured zone. Generally shallow dug wells and bore wells tap the water from semi unconfined aquifers. In the present study the continuous monitoring and recording of ground water levels in the 52 dug wells have been carried out in eight study Control and Experimental village. The water analysis for April- May, 2021 (Pre- monsoon) and November 2021 (Post-Monsoon) have been used in this study.

1.3 Hydro-geochemistry and Ground Water Characteristics in the Study area –

In general the rainwater contains Carbon dioxide, in turn acts as a powerful agent wherein has the properties to break up all the mineral matter when comes in contact and reaches the ground water to form new compounds such as CO_3, HCO_3, SO_4, Na, K, Ca and Mg, Soluble silicates and free Sio_2.

A number of studies have proved that, several physical and chemical factors are active in changing the composition of the groundwater percolating through the soil and rocks. Evaporation (Generally tend to be 7-8 mm/day in the Deccan trap area), Base Exchange, adsorption, oxidation of sulphides, and reduction of sulphates cause changes in their chemical composition. Based on the geochemistry about 49 samples were collected and analyzed using APHA-AWWA-(1975) manual for the dug-wells of the study area for the pre-monsoon season (May 2021) and 49 samples for post-monsoon (November 2021), the data was presented in Table No.1 and 2. Following parameters have been considered for analysis.

2. Results and Discussion-

2.1 pH:-

From the Table No 1 and 2 it is clear that, the pH value in the study dug wells for pre- monsoon season ranges from 7.6 to 8.9. The average, median, mode and standard deviation values of pH for all samples in pre-monsoon season are 8.3, 8.3, 8.4.and 0.29 respectively. In the post-monsoon the pH values have been recorded in the range of 7.1 to 8.8 whereas average, median, mode and standard deviation values of pH for all samples in post-monsoon season are 8.1, 8.2, 8.3 and 0.34 respectively. The pH values have been correlated with other parameters reveals that, only Co_3 has strong correlation with pH values. Observed values have been compiled WHO, ICMR and BSI standards, it is observed that, all the values are within

limits. The result indicates that the water samples are slightly alkaline in nature.

2.2 Conductivity (Ec):-

Conductivity is the capacity of water to carry an electrical current and varies both with number and types of ions in the solutions, which in turn is related to the concentration of the ionized form and hence contribute to conductance. Rough estimation of dissolved ionic contents of water sample can be made by multiplying specific conductance (in u Siemens/cm) by an empirical factor which may vary from 0.55 to 0.90 depending on the soluble components of water and on the temperature of measurement. The EC values in study region ranged from 400 to 2790 micromhos/cm. The average of EC is 1030 micromhos/cm for the pre-monsoon (May) season in the study region whereas the average, median, mode and standard deviation values of EC are 661, 513, 1440 and 378 micromhos/cm respectively. The EC values ranged between 301 to 2341 micromhos /cm for post-monsoon season (November) and average, median, mode and standard deviation values of EC are 909,778,487 and 490 micromhos/cm.

2.3 Total Dissolved Solids (TDS):- Total Dissolved Solids (TDS) in water predominantly consist of inorganic salts with minor amounts of organic matter. The Pre-Monsoon TDS of the ground water of the study area varied from 256 to 1780 mg/l and averages 660 mg/l., whereas the median, mode and standard deviation values for TDS are 513,1440 and 378 mg/l respectively for post- monsoon. The Post-Monsoon TDS of the ground water of the study area ranged from 249 to 1689 mg/l and averages 597 mg/l., whereas the median, mode and standard deviation values for TDS are 511, 312 and 336 mg/l respectively for post-monsoon (November). The TDS values were slightly reduced in post-monsoon season. Groundwater usually has higher TDS concentration than surface water because of the mineral pick up from the soil and rocks.

2.4 Hardness:-

The hardness of the ground water in the study area is ranging from 96 to 972 mg/l and averages 351.4 mg/l., whereas the median, mode and standard deviation values for TDS are 308, 492 and 190.30 mg/l respectively for pre-monsoon (May). The TDS values in post-monsoon season (November) are ranging between 79 mg/l to 831 mg/l. whereas the median, mode and standard deviation values for TDS (For Post-Monsoon) are 316, 632 and 190.04 mg/l respectively. Slightly declined values observed in post-monsoon season. Groundwater usually has higher TDS concentration than surface water because of the mineral pick up from the soil and rocks.

2.5 Alkalinity:-

In the present study, the total alkalinity of groundwater for pre-monsoon season ranged from 120 to 560 mg/l and averages 260 mg/l., whereas it was 124 to 549 mg/l for post-monsoon season. The alkalinity of groundwater is due to the salts of weak acids and strong bases.

2.6 Calcium:-

Calcium is one of the most abundant cations in the ground water samples from the area. The calcium concentration in the study area ranges from 8.0 to 330 mg/l. High calcium can be related to plagioclase and augite weathering in basalts. The average, median, mode and standard deviation values of Ca for pre-monsoon were 83.6, 75.2, 36.8 and 62.91 respectively. The Ca values in the post-monsoon ranging between 11 to 333 mg/l. Average value of Ca is 87.8 mg/l. The

median, mode and SD values are 64, 27 and73.66 mg/l respectively.

2.7 Magnesium (Mg): -

The Magnesium concentrations in the groundwater from the study area for pre-monsoon season (May) ranged between 6.8 mg/l to 121.50 mg/l. Its average being 34.6 mg/l. The Magnesium concentrations in the groundwater from the DPR are high and groundwater with up to 488 mg/l Mg is reported. Similarly Mg concentration for post-monsoon period is 5.8 to 127 mg/l, averages for 35.6 mg/l. Median, mode and standard deviation values are 35, 46 and 18.51 mg/l for the post- monsoon season have been recorded.

2.8 Percent Sodium (Na %) –

Excess sodium in ground waters is responsible for changing soil properties and reducing soil permeability (Kelley, 1951). In natural ground waters sodium normally combines with carbonates to form alkaline soils or it combines with chlorides to form saline soils, both detrimental to plant growth. Sodium content is usually expressed in terms of percent sodium (%Na) which is a sum of sodium and potassium divided by the sum of all major cations in groundwater. The percent sodium from the present study rages from 0 to 410 meql for pre-monsoon season. According to Ramakrishna (1998) a maximum of 60% sodium in groundwater is allowed for agricultural practices. In the study a total of 96 samples analyzed for both pre and post conditions. The observed values of sodium percent for post-monsoon (November) ranged between 13 to 410 meql. Median, mode and standard deviation values of Na % are 50, 32 and 91 meql for post-monsoon conditions. The percentage of sodium from groundwater is a function of electrical conductivity.

2.9 Chloride (Cl): -

A high chloride content may harm metallic pipes and structures as well agriculture production. The Cl is recorded between 32 mg/l to 758 mg/l, averages 151.8 mg/l.

2.10 Sulphates:-

The sulphate concentration in the groundwater ranges from 2 mg/l to 590 mg/l. These values average of 96.7 mg/l. Total Hardness affects the quality of ground water. The range of hardness in the study samples 256 mg/l to 1780 mg/l, which averages for 351.4 mg /l. the value of hardness, is observed to be within limit. The resulted values compiled with the various indices of Drinking water, Irrigation and Bureau of Indian Standards.

2.11 Residual sodium carbonate (RSC):-

RSC values are especially useful when the groundwater contain low salinity levels. RSC is calculated using the formula RSC = (CO_3+HCO_3) – (Ca+Mg) where all ionic concentrations are expressed in milli-equivalents per litre. In the study region, most groundwater samples show RSC values between 106.8 to 248.2 meq/l with average of 177.5 meq/l for pre-monsoon (May) season. The values of RSC for post-monsoon season ranging between 102.2 meq/l to 221.5 meq/l, with average of 68 meq/l. Depending upon the RSC values the groundwater can be classified into three categories i.e. good (<1.25 meq/l), medium (1.25 to 2.50 meq/l) and poor (>2.5 meq/l). Agriculture experts generally consider Residual Sodium Carbonate (RSC) superior to Sodium Absorption Ratio (SAR). Most of the water samples analyzed have higher values than permissible limits.

2.12 Sodium Adsorption Ratio (SAR):-

The SAR of groundwater samples from the study area ranged from 0.0 to 8.2

meql for pre- monsoon season (May) season averages for 2.2 meql and SAR values for post-monsoon are 0.4 to 8.2 meql averages for 1.7 meql. The SAR values are generally correlated to EC values for analyzing irrigation quality of water. The analysis for pre-monsoon season (May) revealed that, about 35 samples categorized as good and 13 sample as medium/ fair.

2.13 Iron (Fe):-

The presence of iron in natural water can be attributed to the dissolution of rocks and minerals, acid mine drainage, landfill leachate etc. In the present study iron is estimated by phenanthroline colorimetric method. The values of Fe in the study area for pre-monsoon season ranged between 0.1 to 1.4 mg/l with average of 0.7 and Fe values for post-monsoon season 0.1 to 1.2 with average of 0.7. The Fe values for both pre and post monsoonal seasons have been compiled with WHO, ICMR and GSDA standards, the values were found to be within limits.

2.14 Salinity:-

Richards (1954) has classified irrigation waters into four groups based on the electrical conductivity values and based on this classification scheme the ground water from the study region has been categorized

The values of skewness for pH, Fe and F are negatively skewed which means that the graph of these parameters will be elongated more on the left side i.e. values are more concentrated towards the higher side values. The values of kurtosis for NO_3/N, F and Na% are negative which means these values have less variations among themselves as compared to other parameters.

3. Correlations for various parameters of Groundwater quality in Study Area-

Correlation coefficient (CC) value of EC shows strong and weak positive correlation with Ca, Mg, Na, K, Na+K, Cl, SO_4, and TDS are 0.58, 0.58, 0.64, 0.53, 0.70, 0.89, 0.64 and 1.00 respectively for pre-monsoon conditions (May). In post-monsoonal season (Nov) correlation between EC and Ca, Mg, Na, K, Na+K, Cl, SO_4, and TDS are 0.68, 0.43, 0.57, 0.39, 0.59, 0.90, 0.69 and 0.99. There is not significant change in values excluding magnesium. This suggests that electrical conductivity depends on total dissolved solids which depend on salts such as NaCl, $CaCl_2$. These positive correlations indicate that the referred elements contribute to the groundwater salinization. The strong and weak positive correlation coefficient values of TDS with Ca, Mg, Na, K, Na+ K, Cl, and SO_4 are 0.58, 0.58, 0.64, 0.53, 0.70, 0.89 and 0.64 have been observed in the pre-monsoon water samples (May 2021). The TDS values in post-monsoon (November) correlated with Ca, Mg, Na, K, Na+ K, Cl, and SO_4 are 0.66, 0.46, 0.60, 0.36, 0.61, 0.89 and 0.99 respectively. CC values for SO_4 for EC, TDS, T/ALK and Na are 0.64, 0.64, 0.51 and 0.86 respectively in Pre-Monsoon season. The strong correlation between TDS and Ca, Mg, Cl and SO_4 have been observed, these values are 0.90, 0.52, 0.6 and 0.55 for the post-monsoon season (November). The mineralization would be expected to result from the increasing ionic concentrations due to both evaporation of recharge water and to the interaction, effects between the groundwater and the geological formations. (Hamzaoui- Azaza, 2009) Indeed, a strong positive correlation has been found between Cl and EC, TDS, T/HAR, Ca, Mg and K these values are

0.89, 0.89, 0.67, 0.53, 0.55 and 0.38 it can also be deduced that for most of the groundwater samples these parameters originate from a common source. In the post-monsoon (November) CC for Na against Na+K, SAR and Na% are 0.98, 0.87 and 0.67 respectively.

To correlate the chemical characteristics of the ground water, **Pieper's diagram** has been constructed for pre-monsoon (May) season (Figure No.1). Hydro chemical facies as described by the Piper (1994) can be used to denote the diagnostic chemical characteristics of water in hydrological system. Hydro-geochemical facies generally reflect the geochemical processes that are operated in the host rock water framework and is a good indicator of the pace and flow of the groundwater in response to the hydraulic gradient and geo-hydrological framework (Durasiswami, 2012). In the piper diagram cations are as percentage of total cations in meq/ lit, plot a single point on left triangle, while anions plot on right triangle. These two points are then projected in the central diamond shaped area. This single point is thus uniquely related to the total ionic distribution. In this method data for major ions (mg/ Lit) is converted into equivalents per million (epm) prior to plotting.

The major cations and anions have been plotted from the pre-monsoon ground water level have been plotted in order to understand the spatio-temporal variation in hydro-geochemical processes. To construct the Piper diagram (For May 2021 water samples), the relative abundance of cation with the % meq /L of Na^+, K^+, Ca^{2+}, and Mg^{2+} is first plotted on the cation triangle. The relative abundance of Cl^-, SO_4, and HCO_3+CO_3 is then plotted on the anion triangle. The two data points on the cation and anion triangles are then combined into the quadrilateral field that shows the overall chemical property of the water samples. From the analysis it is revealed that, pH values are alkaline in nature. Further it reveals that, alkaline earth exceeding the alkali metals and weak acids exceeding strong acids Ca + Mg > Na, K > HCO_3> Cl + SO_4 (Please see Diagram and Table No for Correlation indices).

A single piper diagram has greater potential to accommodate a large number of analyzed values without confusion and is convenient for showing the effects of mixing two waters from different sources. For the year 2021, Correlation Coefficient value of NO_3 has been showed strong positive correlation with Ca, and Cl which values are 0.39 and 0.35 respectively. Cl has been showed moderate positive correlation with Ca, Na, and SO_4 which values are 0.53, 0.40, and 0.37 respectively. The value CC value of Mg have strong correlation with Ec, TDS, T/HAR are 0.58, 0.58 and 0.59.

Overall the Strong values of CC of Mg against EC, TDS, HAR, The SO_4 against EC, TDS, T/ALK, Na, The HCO_3 against T/ALK and SO_4, The SAR values against Na, Na+K, SO_4 have strong correlation and responsible for changing water quality. As per the People in the study area it is believed in the experimental village the cropping pattern sequence is changed to cash crops and horticulture which in turn leads to overexploitation of surface and subsurface water. These sequences will definitely lead to negative changes in characteristics of groundwater.

4. Salinity and Alkali Hazard in the study region-

High EC indicates high salt concentration in irrigation waters that ultimately leads to the formation of saline soils. High salinity interferes with the absorption of water and nutrients by plants from the soils by reversal of osmotic gradients (Saleh ,1999 and Richards 1954) has classified irrigation waters into four groups based on the electrical conductivity values and based on this classification the ground waters from the study area have been categorized.

Out of total 48 analyzed for pre-monsoon (May) samples 16 (33%) samples categorized as good for EC, whereas 31 (65%) samples shown medium/ fair for EC. In post-monsoon 22 (46%) samples categorized as good and 26 (54%) samples were categorized as medium/fair for EC. These values have direct correlation with cropping pattern, in the experimental village general cropping pattern in the post condition of project is sugarcane crop since the year 2004. Excessive use of fertilizer and pesticide may lead to higher values of EC.

Sodium generally replaces calcium in soils irrigated by saline ground waters through the process of Base Exchange. High sodium in the soil reduces the permeability of soils owing to dispersion of clay particles. The effect of sodium on soil is known as sodium hazard or alkali hazard and is described as the Sodium absorption ratio (SAR). The SAR values of 35 (73%) samples is categorized as good and 13 samples (27%) values have the category of medium or fair. Alkali hazard has been identified with SAR values in Post-monsoon (November), all the 48 samples were categorized as excellent. All these values are within standard limits. The observed SAR value indicates the water quality is good for irrigation.

5. Summary of Water Quality Standards for Drinking –

In the context of development in all the sectors of Agriculture, Industry, Power generation, Inland Navigation, water resources have prime importance. In last 2-3 decades the dependency on the ground water has been bloomed to meet the demand. The Quality of water is of prime importance in irrigated agriculture and drinking. In India, about 15% of the cultivated land is facing the problem of soil salinity and alkalinity. Uppal, (1962) In India, the problem of rising water table due to canal irrigation dates back to as early as 1902 when a regular rise of water table at the rate of 8 to 34 cm per year was responsible to some extent for the development of soil salinity in canal irrigated tracts of undivided Punjab.

Analysis reveals that, excluding one sample all other samples for pH were found to be within the range of WHO and ICMR for both pre and post monsoon seasons. The average value of TDS is 660 mg/l in per monsoon which 596 mg/l which is slightly greater than permissible limit in pre conditions. The values of the hardness are slightly more than prescribed limits of WHO and ICMR standards. The desirable limits for these values are 600 mg/l when there is no alternate source. The average value of Chlorine is found to be 151 mg/l in pre-monsoon reduced up to 135 mg/l in post-monsoon, it is quite high than the WHO and ICMR value within the desirable limits prescribed by the GSDA. The iron values recorded are 0.2 mg/l in the pre-monsoon season. Hence it is observed that, watershed development is powerful tool to harness the good quality water.

6. References-

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Table No- 1. Statistical Summary of the GW Quality in the Study area Pre-Monsoon (May2021)

Parameters	Minimum	Maximum	Mean	Median	Mode	SD	Skewness	Kurtosis
pH	7.60	8.90	8.31	8.30	8.40	0.29	-0.40	0.32
EC	400.00	2790.00	1030.33	801.00	2250.00	585.04	1.30	0.83
TDS	256.00	1780.00	660.86	513.00	1440.00	374.40	1.28	0.77
T/HAR	96.00	972.00	351.36	308.00	492.00	188.34	1.04	1.20
T/ALK	120.00	560.00	260.82	216.00	288.00	123.66	0.97	0.06
Ca	8.00	329.60	83.62	75.20	36.80	62.27	1.74	4.12
Mg	6.80	121.50	34.58	33.05	46.66	19.43	1.77	6.75
Na	0.00	410.00	88.82	50.00	32.00	89.97	2.07	4.75
K	0.00	95.00	7.04	0.70	0.30	22.52	3.74	12.62
Na+K	0.00	410.30	95.84	51.00	290.00	99.09	1.80	2.71
Fe	0.10	0.30	0.21	0.20	0.20	0.06	-0.17	0.34

Cl	32.00	708.00	151.78	106.00	106.00	132.40	2.16	5.54
SO_4	2.00	590.00	96.67	46.00	30.00	126.88	2.75	8.04
CO_3	0.00	16.11	2.36	0.84	0.00	3.27	2.17	5.77
HCO_3	121.62	683.20	296.24	244.57	194.07	159.24	1.09	0.13
NO_3/N	0.30	20.00	8.55	8.20	6.50	4.70	0.36	-0.45
F	0.10	1.40	0.74	0.80	0.80	0.31	-0.03	-0.49
SAR	0.00	8.21	2.20	1.37	3.83	2.07	1.58	1.81
Na%	0.00	75.12	32.41	27.47	40.90	18.94	0.61	-0.36

Table No- 2. Statistical Summary of the GW Quality in the Study area Post–Monsoon (November, 2021)

Parameters	Minimum	Maximum	Mean	Median	Mode	SD	Skewness	Kurtosis
pH	7.10	8.80	8.13	8.20	8.30	0.34	-0.90	0.97
EC	301.00	2341.00	908.96	788.00	487.00	485.16	1.52	1.67
TDS	249.00	1689.00	596.84	511.00	312.00	332.33	1.62	2.05
T/HAR	79.00	831.00	354.67	316.00	632.00	188.10	0.96	0.21
T/ALK	124.00	549.00	247.06	204.00	288.00	106.33	1.28	1.26
Ca	11.20	333.00	87.78	64.00	27.20	72.91	1.90	3.70
Mg	5.77	127.00	35.57	34.99	46.66	18.32	2.44	11.91
Na	13.00	410.00	65.71	37.00	32.00	69.80	3.20	12.05
K	0.10	95.00	3.51	0.70	0.10	13.37	6.75	46.55
Na+K	13.10	410.30	71.02	43.00	29.50	75.49	2.82	8.73
Fe	0.10	0.30	0.22	0.20	0.20	0.07	-0.31	-0.10
Cl	29.00	611.00	133.39	94.00	46.00	118.49	2.33	5.90
SO_4	4.00	594.00	88.39	59.00	30.00	104.42	3.04	11.37
CO_3	0.00	13.11	2.82	1.80	0.00	3.19	1.18	1.17
HCO_3	119.20	667.50	274.44	240.42	194.07	136.67	1.47	1.65
NO_3/N	0.15	20.00	8.57	7.30	7.30	4.92	0.59	-0.39
F	0.10	1.20	0.67	0.70	0.50	0.29	0.11	-0.61
SAR	0.36	8.21	1.68	1.07	0.69	1.71	2.36	5.27
Na%	8.32	75.12	27.67	24.35	14.58	16.70	1.27	1.13

Table – 3. Classification of Groundwater of study area for irrigation purpose (Richards, 1954) for pre and post conditions.

Water Class	Salinity Hazard (Pre)			Alkali Hazard (Pre)		
	E.C. (µS/cm)	Number of samples	Percentage	SAR (epm)	Number of samples	Percentage
Excellent	Up to 250	00	00	Up to 10	00	00

Good	250-750	16	34	10-18	35	73
Medium/Fair	750-2250	31	65	18-26	13	27
Poor/Bad	>2250	01	2	>26	00	00
Water Class	Salinity Hazard (Post)			Alkali Hazard (Post)		
	E.C. (µS/cm)	Number of samples	Percentage	SAR (epm)	Number of samples	Percentage
Excellent	Up to 250	00	00	Up to 10	48	100
Good	250-750	22	46	10-18	00	00
Medium/Fair	750-2250	26	54	18-26	00	00
Poor/Bad	>2250	00	00	>26	00	00

Table No- 4 Summary of Water Quality Standards for Drinking –

Parameters	WHO (sapl) *	BSI (sapl) *	ICMR (sapl) *	Requirement (Desirable Limit) GSDA	Permissible limit in the Absence of alternate source	Average values observed. Pre-Monsoon	Average values observed. Post-Monsoon
pH	<8	7-8.5	7-8.5	6.5 to 8.5	No relaxation	8.3	8.1
TDS mg/1	1000	500	500	600	650	660	596
T/ HAR mg/1	300	300	300	300	600	351	354
T/ALK mg/l	200		200	200	600	260	247
Cl mg/1	70	250	75	250	1000	151	135
Ca mg/l	250	75	250	75	200	83	87.8
Mg mg/l	30	> 30	50	30	100	34	35.6
Iron mg/1	0.3	0.1	0.3	0.3	1	0.2	0.7
Sulphate mg/1	250	200	150	200	400	96.7	88.1

*Standards acceptable permissible limits
(WHO- World Health Organization, BSI- Bureau of Indian Standard (BIS), Specification IS - 10500-91, Revised 2003, ICMR- Indian Council of Medical Research, GSDA- Ground Water Survey and Development Agency)

Source - Central Board for the prevention and control of water pollution, New Delhi and GSDA.

Fig: - 1. Piper diagram for the water samples in the KR 25, KR 34, KR 22 and BM 114 Watershed