Seasonal Variation of Physico-Chemical Parameters of Groundwater in Yerraguntla Area of YSR Kadapa DT, AP-India

ABSTRACT

People around the globe are in tremendous trouble because of unexpected changes in the physical, chemical, and natural states of the air, water, and soil. Due to the increased mortal population, industrialization, use of diseases, and man-made exertion water is heavily contaminated with different dangerous pollutants. Disposing of contaminated jewels, filtering soils, and mining processing lead to contamination of natural water. The quality of drinking water must be checked regularly. Because of this contaminated drinking water, the mortal population suffers from varied forms of waterborne diseases. The vacuity of good quality water is a necessary point for precluding the conditions and perfecting the quality of life. It's necessary to know the details about different Physicochemical parameters such as Hydrogen ion concentration, Electrical Conductivity, Total Dissolved Solids, Total Hardness, Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride, Sulphate, Phosphate, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, etc. for testing water quality. Yerraguntla area of YSR kadapa district was selected to determine the groundwater quality in rainy and summer seasons two times. In the present study, the results showed that most of the Physico-chemical parameters exceeded the admissible limits of WHO. The water Quality Index showed that groundwater is not suitable for drinking purposes in all locales of the study area. The correlation measure(r) showed the inter-relevance between various parameters that impact groundwater quality. Piper tri direct illustration showed that the groundwater of the area contains Ca- HCO_3 type of mariners. So, it's necessary to adopt sound water sanitation methods in the study area

Keywords: Industrialization, Contamination, Physico-chemical parameters, Water Quality Index, Correlation, Piper diagram, Purification.

1. INTRODUCTION

Groundwater refers to all the water enwrapping the voids, pores and crevices within geological conformations, which began from atmospheric rush either directly by downfall infiltration or laterally from gutters, lakes or conduits. Sands, clay, sandstones, and limestone conformations are the usual sources of groundwater force though some may be drawn from impervious jewels similar to determinedness when they've an over burden of beach or clay. Groundwater is a valued fresh water resource and constitutes about two- third of the fresh water reserves of the world [1]. The ground water force of the world is further than 2,000 times the volume of waters in all the world's gutters and further than 30 times the volume contained in all the world's fresh water lakes [2]. The Groundwater accounts for about 50 of beast and irrigation operation and just under 40 of water inventories, whilst in pastoral areas, 98 of domestic water use is from groundwater [3]. Application of groundwater as a source for domestic, external, agrarian and artificial conditioning continue to increase basically because of the heavy capital disbursement and conservation of face water development through heads especially in developing countries [4]. Another factor which is responsible for the attention being diverted to this source is bettered technology overload by deep borings in form of boreholes which satisfies WHO drinking water quality standards [5]. Groundwater is abstracted through hand-dug wells; hand- pump operated shallow- wells and a submersible pump operated deep wells or boreholes [6]. Groundwater is frequently high in mineral contents such as magnesium, calcium mariners, iron, and manganese depending on the chemical composition of the stratum through which the gemstone flows [7]. Artificial development results in the generation of artificial backwaters and the undressed water results in deposition and soil pollution. These waters have substantially inordinate quantities of heavy essences such as Pb, Cr, and Fe, and also heavy essences from artificial processes are of special concern since they produce habitual poisoning in submarine creatures [8]. The high presence of adulterants substantially organic matter in swash water is a result of an increase in natural oxygen demand [9], chemical oxygen demand, total dissolved solids, total suspended solids, and fecal coli form which make water infelicitous for drinking, irrigation, or any other use [10]. It is essential to test the water before it's used for drinking, domestic, agrarian, or artificial purposes. Water contains different types of floating, dissolved, suspended, and microbiological as well as bacteriological contaminations. Water must be tested with different physico-chemical parameters like temperature, color, odor, pH, turbidity, TDS, etc., while chemical tests should be performed for its Bio-chemical oxygen demand, chemical oxygen demand, dissolved oxygen, alkalinity, hardness, and other characteristics.

2. MATERIALS AND METHODS

2.1 STUDY AREA

Yerraguntla Municipal Town in YSR Kadapa district (Figure-2) is located in Andhra Pradesh (Figure-1). The area is located at 14.6333N and 78.5333E coordinates with an elevation of 152 meters. This is dominantly an arenaceous consisting of conglomerate quartzite and quartzite with shale formation of dolomitic limestones. The main factors that control the quality of water are associated with lithology and soil. Water quality may vary depending upon variations in geological formations

Figure- 1: Andhra Pradesh

Figure-2: Study area –Yerraguntla

2.2 SAMPLE COLLECTION

Ten water Samples from different areas of Yerraguntla area were collected in polythene bottles by following the standard protocols. The collected water samples were analyzed for different physico-chemical parameter such as for pH (Hydrogen Ion concentration), Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Bicarbonate (HCO_3^{-}), Chloride (Cl^{-}), Sulphate (SO_4^{2-}) Phosphate (PO_4^{3-}), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD).

2.3 METHODOLOGY

The physicochemical parameters of samples were analyzed according to the procedure prescribed by APHA [11] and BIS. pH was determined by pH meter; EC was determined by conductometer; TDS was determined by TDS meter; TH, Ca, Mg, HCO_3 & Cl were determined by titration method; SO_4, PO_4, F, NO_3, DO, BOD & COD were determined by UV-Vis Spectrophotometer

3. RESULT AND DISCUSSION

The quality of different groundwater samples has been carried out on Hydrogen ion concentration, Electrical Conductivity, Total Dissolved Solids, Total Hardness, Calcium, Magnesium, Sodium, Potassium, bicarbonate, Chloride, Sulphate, Phosphate, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, and the results are shown

3.1 pH

pH is a measure of the hydrogen ion concentration in water and indicates whether the water is acidic or alkaline. The measurement of alkalinity and acidity of pH is required to determine the corrosiveness of the water. The standard value of pH for drinking water by BIS is 6.5-8.5 while WHO is 6.5-9.2.

In YGL area, pH was determined in the range of 7.1-7.5 with a mean of 7.31 in monsoon and 7.5-7.8 with a mean of 7.72 in summer. In all seasons, pH was found within the permissible limit.

3.2 Electrical Conductivity (EC)

Conductivity is the ability of water to carry an electrical current. This ability mainly depends on the presence of anions and cations in water and also depends on mobility, valence of ions, and temperature. The most desirable limit of EC in drinking water is prescribed as 1500 µS/cm. Thus, the EC can be classified as type I, if the enrichments of salts are low (EC < 1500 µS/cm); type II, if the enrichment of salts is medium (EC: 1500 and 3000µS/cm) and Type III, if the enrichments of salts are high (EC > 3000 µS/cm)[3].

In YGL area, during monsoon season, EC was found in the range of 2043-3657µS/cm with a mean of 2821.5µS/cm. In this season, six samples fall under Type II and four samples fall under Type III. In the summer season, EC was found in the range of 1650-3338µS/cm with a mean of 2422.7µS/cm. During this season, eight samples fall under Type II and two samples fall under Type III.

3.3 Total dissolved solids (TDS)

Water source in its natural form itself might contain a variable quantity of inorganic salts dissolved in it. Degree of groundwater quality can be classified as "fresh", if the TDS is less than 1,000mg/L; "brackish", if the TDS is between 1,000 and 10,000mg/L; "saline", if the TDS is varied from 10,000 to 1,000,000mg/L; and brine if the TDS is more than 1,000,000mg/L.

In YGL area, monsoon, and summer seasons, TDS was found in the range of 1164-2005mg/L with a mean of 1499.1mg/L and 856-1417mg/L with a mean of 1120.7mg/L respectively. The groundwater quality of this area was categorized as "brackish" type in both seasons.

3.4 Total Hardness (TH)

Hardness is the property of water, which prevents the lather formation with soap and increases the boiling points of water [17]. The hardness of water mainly depends upon the amount of calcium or magnesium salts or both. In the YGL area, monsoon, and summer seasons, TH was found in the range of 742-1365 with a mean of 973mg/L and 513-1124mg/L with a mean of 777.9mg/L respectively. In both seasons, the TH of all samples was found above the permissible limit.

3.5 Calcium (Ca)

Calcium is directly related to hardness and is the chief cation in the water. In the YGL area, during monsoon and summer seasons, calcium was found in the range of 106-254mg/L with a mean of 172.2mg/L and 84-216mg/L with a mean of 142.7mg/L respectively. All samples in all seasons contained calcium above the permissible limit. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes, poor lathering, and deterioration of the quality of clothes.

3.6 Magnesium (Mg)

Magnesium is directly related to hardness In the YGL area, magnesium was observed in the range of 42-85mg/L with a mean of 61.5mg/L and 34-67mg/L with a mean of 51.5mg/L during monsoon and summer seasons respectively. During monsoon, magnesium was found above the WHO permissible limit in 70% of samples and above the BIS limit in all samples. In summer, magnesium was found above the permissible limit of WHO in 60% of samples and above the BIS limit in all samples.

3.7 Sodium (Na)

Sodium is used in the normal functioning of some processes in the human body and as such is an essential element, but its high concentration may adversely affect the cardiac, renal, and circulatory functions [18]. In the YGL area, during monsoon and summer seasons, sodium was found in the range of 82-154mg/L with a mean of 120.8mg/L and 57-126mg/L with a mean of 89.6mg/L respectively. All samples of this area contained sodium within the permissible limit during study period.

3.8 Potassium (K)

Natural waters normally contain low concentration of Potassium. High values of potassium may indicate some pollution of ground water. In YGL area, during monsoon and summer seasons, potassium was found in the range of 25-52mg/L with a mean of 35.6mg/L and 19-41mg/L with a mean of 26.8mg/L respectively. Potassium concentration in all samples was observed above the permissible limit during the study period.

3.9 Bicarbonate (HCO_3^-)

In the YGL area, during monsoon and summer seasons, Bicarbonate was found in the range of 486-754mg/L with a mean of 614.3mg/L and 384-633mg/L with a mean of 496.3mg/L respectively. All samples during all seasons contained bicarbonate more than the permissible limit.

3.10 Chloride (Cl^-)

Soil porosity and permeability also have a key role in building up the chloride concentration. Excessive chloride concentration increases rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply [19]. YGL area, chloride was observed in the range of 231-376mg/L with a mean of 291.4mg/L and 164-284mg/L with a mean of 217.6mg/L during monsoon and summer seasons respectively. During monsoon, chloride was found above the WHO permissible limit in all samples and above the BIS limit in 70% of samples. In summer, chloride was found above the permissible limit of WHO in 60% of samples and the BIS limit in 20% of samples. The higher values of chloride can cause corrosion and pitting of iron pipes and plates.

3.11 Sulphate (SO_4^{2-})

Sulphate occurs naturally in water as a result of leaching from gypsum and other common minerals. Sulphate content in drinking water exceeding 400 mg/L impart bitter taste and may cause gastrointestinal irritation and catharsis [18]. In the YGL area, sulphate was observed in the range of 74-232mg/L with a mean of 130.8mg/L and 54-136mg/L with a mean of 81.8mg/L during monsoon and summer seasons respectively.

3.12 Phosphate (PO_4^{3-})

Phosphate may occur in ground water as a result of domestic sewage, detergents, agricultural fertilizers and industrial waste water. The permissible limit of phosphate in drinking water is 1mg/L according to the WHO and the BIS guidelines.

In the YGL area, phosphate was observed in the range of 0.76-1.55mg/L with a mean of 1.144 and 0.74-1.99mg/L with a mean of 1.704mg/L during monsoon and summer respectively. Phosphate in 70% of samples during summer; 80% during monsoon, exceeded the permissible limit.

3.13 Dissolved Oxygen (DO)

Dissolved oxygen is important parameter in water quality assessment and biological processes prevailing in the water. The DO values indicate the degree of pollution in the water bodies. The higher value of dissolved oxygen can impart good aesthetic taste to drinking water.

In the YGL area, during monsoon and summer seasons, DO was found in the range of 6.12-8.09mg/L with a mean of 6.889mg/L and 5.34-6.65mg/L with a mean of 6.021mg/L respectively. The mean DO of all samples during all seasons was found above 6mg/L as per the prescribed level of the WHO and the BIS.

3.14 Biochemical Oxygen Demand (BOD)

BOD is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at a certain temperature over a specific period.

In the YGL area, BOD was observed in the range of 0.95-2.13mg/L with a mean of 1.332mg/L and 0.84-2.28mg/L with a mean of 1.437mg/L during monsoon and summer respectively. The BOD of all samples in all seasons was observed within the permissible limit.

3.15 Chemical Oxygen Demand (COD)

The COD test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of the COD determine the amount of organic pollutants found in surface water making COD a useful measure of water quality.

In the YGL area, COD was observed in the range of 1.39-3.56mg/L with a mean of 2.115mg/L and 1.45-2.44mg/L with a mean of 2.044mg/L during monsoon and summer respectively. COD of all samples in all seasons was observed within the permissible limit.

4 Water Quality Index (WQI)

The suitability of water sources for human consumption has been described in terms of Water quality index (WQI), is one of the most effective ways to describe the quality of water.

The water quality index can be classified into five types. WQI in the range of 0-25 is rated as “Excellent water quality” and graded as “A”. WQI in the range of 26-50 is rated as “Good water quality” and graded as “B”. WQI in the range of 51-75 is rated as “poor water quality” and graded as “C”. WQI with 76-100 is rated as “very poor water quality” and graded as “D”. WQI more than 100 is rated as “unfit for drinking” and graded as “E”.

In the YGL area, during monsoon season, sample S-03 was categorized as “*very poor water quality*” type. WQI value of 90% of samples was found more than 100 and hence fall under *“unfit for drinking*” type. Sample S-09 has highest WQI value (145.35) during this season. In summer season 20% of samples (S-03 and S-07) are categorized as *“very poor water quality*” and 80% of samples as *“unfit for drinking*”. Sample S-08 has highest WQI value (167.40).

5 Correlation coefficient (r)

The correlation analysis enables us to have an idea about the degree and direction of the relationship between the two variables under study. Karl Pearson’s coefficient, is a simplified statistical tool to show the degree of dependency of one variable to the other.

The statistical analysis of this area during monsoon season, pH showed a negative correlation with all parameters except K, PO_4^{-3} and F. EC showed a high positive correlation with TDS, TH, Ca, Mg, HCO_3^-, Cl, and SO_4^{-2} ($r > 0.8$). The TDS showed a strong correlation with the TH, Ca, Mg, HCO_3^-, Cl, and SO_4^{-2} ($r > 0.8$). TH was correlated strongly with Ca, Mg and HCO_3 ($r > 0.8$). HCO_3^-, Cl and SO_4^{-2} are strongly correlated to Ca ($r > 0.8$) and HCO_3^- was strongly correlated to Mg ($r = 0.834$). This suggests that these ions are major contributors to EC, TDS and TH.

A high positive correlation was observed between EC and TDS ($r = 0.991$) during the summer season signifying that the two parameters are almost directly proportional to each other. It also correlated strongly to TH, Ca, Mg, HCO_3^- and SO_4^{2-} ($r > 0.8$). A high positive correlation with $r > 0.8$ was observed by TDS and TH with Ca, Mg, Na, HCO_3^- and SO_4. HCO_3^- was strongly correlated to Ca and Mg ($r > 0.8$) and SO_4^{2-} was moderately correlated to Ca and Mg ($r > 0.7$). These ions contribute to hardness of water.

6 Piper Tri linear Diagrams

In YGL area, cation and anion triangles showed that no ions are dominant in all seasons. The groundwater of this area contained Ca-HCO_3 type of salts during all seasons according to diamond shaped field (Figure-1).

Conclusion

The overall water quality of the study area signifies that the groundwater is not suitable for drinking in studied seasons. The reason for dwindling quality of water in this region may be due to weathering of rocks and anthropogenic activities. The drinking water source in the study area was exposed to more than one of the anthropogenic sources of contaminations such as sewage percolation, septic tank and agricultural practices. Finally, it can be concluded that monitoring system is to be established to periodically evaluate the water quality. A registry of periodically evaluated water quality parameters of drinking water may be kept with local administration, for the benefit of public health providers, health professionals and the public.

Table-1: Physico-chemical parameters of YGL area during Monsoon

Parameter Sample	PH	EC	TDS	TH	Ca	Mg	Na	K	HCO_3^-	Cl^-	SO_4^{2-}	PO_4^{3-}	DO	BOD	COD
S-1	7.4	3542	2286	1365	254	85	148	44	754	356	204	1.26	6.12	1.08	1.56
S-2	7.5	3021	1834	897	167	54	82	38	669	289	155	1.15	6.87	1.15	2.12
S-3	7.2	2043	1316	769	106	42	104	33	548	231	74	1.02	6.56	1.46	2.44
S-4	7.3	2578	1708	956	192	64	102	25	601	326	136	1.36	6.34	2.13	3.56
S-5	7.4	2269	1462	742	132	48	126	29	496	244	88	1.06	6.25	1.89	1.78
S-6	7.2	3657	2389	1158	244	72	154	52	732	376	232	0.98	7.32	0.95	2.32
S-7	7.3	2474	1388	874	112	46	87	34	486	275	106	1.08	6.96	1.11	2.56
S-8	7.5	2582	1531	809	136	62	114	35	545	254	98	1.22	6.54	1.05	1.39
S-9	7.1	3065	2015	1034	204	74	152	30	675	322	111	1.55	8.09	1.36	1.98
S-10	7.2	2984	1845	1126	175	68	139	36	637	241	104	0.76	7.84	1.14	1.44

Table-2: Physico-chemical parameters of YGL area during Summer

Parameter Sample	PH	EC	TDS	TH	Ca	Mg	Na	K	HCO_3^-	Cl^-	SO_4^{2-}	PO_4^{3-}	DO	BOD	COD
S-1	7.8	3150	1764	1084	189	67	126	35	533	284	108	1.42	5.34	1.46	2.32
S-2	7.8	2564	1436	776	137	48	64	31	464	236	86	1.23	5.96	1.18	1.45
S-3	7.7	1650	1026	513	84	34	57	26	402	164	54	1.14	6.22	1.54	2.44
S-4	7.7	2260	1315	751	174	56	88	19	541	192	72	1.58	6.11	2.28	2.42
S-5	7.8	1946	1156	655	104	39	99	25	384	226	56	0.74	5.78	1.66	1.94
S-6	7.5	3338	1872	1124	216	62	118	41	633	268	136	1.16	6.11	1.32	2.02
S-7	7.6	1846	1056	610	92	41	63	23	443	234	74	0.88	6.23	1.22	2.12
S-8	7.8	2250	1274	675	114	55	82	27	503	166	82	1.99	5.69	1.45	1.56
S-9	7.7	2693	1592	807	168	61	103	19	522	181	92	1.65	6.12	1.42	2.11
S-10	7.8	2530	1526	784	149	52	96	22	538	225	58	0.98	6.65	0.84	2.06

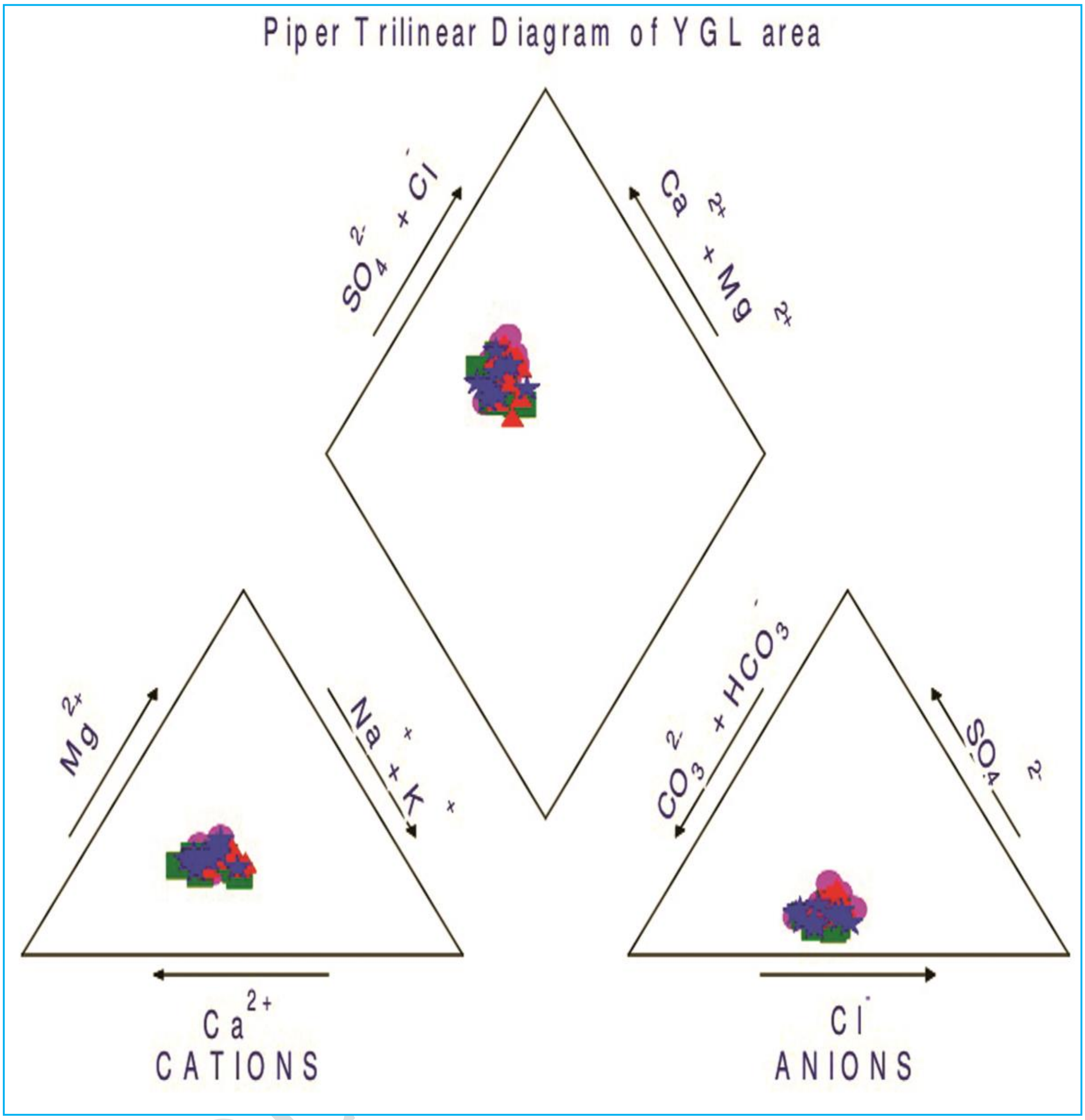
Table-3: Correlation matrix of groundwater samples of YGL area during Monsoon

Parameter	pH	EC	TDS	TH	Ca	Mg	Na	K	HCO_3^-	Cl^-	SO_4^{2-}	PO_4^{3-}
pH	1											
EC	-0.095	1										
TDS	-0.193	0.974**	1									
TH	-0.235	0.881**	0.882**	1								
Ca	-0.177	0.914**	0.970**	0.892**	1							
Mg	-0.155	0.848**	0.877**	0.891**	0.917**	1						
Na	-0.470	0.615*	0.704*	0.657*	0.690*	0.751*	1					
K	0.025	0.759*	0.695*	0.604*	0.558	0.436	0.415	1				
HCO_3^-	-0.174	0.916**	0.949**	0.859**	0.922**	0.834**	0.588	0.643*	1			
Cl^-	-0.174	0.807**	0.849**	0.721*	0.884**	0.724*	0.454	0.527	0.768*	1		
SO_4^{2-}	-0.154	0.882**	0.879**	0.754*	0.857**	0.659*	0.400	0.793*	0.815**	0.892**	1	
PO_4^{3-}	0.055	0.076	0.144	0.040	0.259	0.317	0.045	-0.358	0.168	0.422	0.051	1

Table-4: Correlation matrix of groundwater samples of YGL area during Summer

Parameter	pH	EC	TDS	TH	Ca	Mg	Na	K	HCO_3^-	Cl^-	SO_4^{2-}	PO_4^{3-}
pH	1											
EC	-0.183	1										
TDS	-0.167	0.991**	1									
TH	-0.244	0.975**	0.958**	1								
Ca	-0.284	0.923**	0.930**	0.924**	1							
Mg	-0.069	0.886**	0.878**	0.851**	0.890**	1						
Na	-0.052	0.789*	0.810**	0.837**	0.792*	0.780*	1					
K	-0.283	0.628*	0.567	0.682*	0.437	0.329	0.390	1				
HCO_3^-	-0.404	0.840**	0.844**	0.811**	0.900**	0.856**	0.636*	0.388	1			
Cl^-	-0.178	0.638*	0.595	0.740*	0.517	0.378	0.550	0.666*	0.358	1		
SO_4^{2-}	-0.502	0.868**	0.817**	0.872**	0.784*	0.757*	0.603*	0.743*	0.758*	0.568	1	
PO_4^{3-}	0.170	0.253	0.233	0.149	0.287	0.578	0.127	-0.074	0.391	-0.431	0.294	1

Figure-3: Piper Trilinear diagram for Ground water quality of YGL Area



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