Physico-chemical Analysis for Irrigation Water Quality of Veerapunayunipalle Mandal, YSR Kadapa District, Andhra Pradesh, South India.

C. Krupavathi, *S. Srinivasa Gowd, B. Pradeep Kumar, R. Maheswararao & P. Ravi Kumar

Abstract: The utilization of groundwater has greater than before very much in the recent Era in India, for the reason that huge amount of the area has slight access to run off water resources. Therefore, groundwater is utilized for drinking, industries, and irrigation purpose. Groundwater contaminants that may be in untreated water include microorganisms, inorganic contaminants such as salts and metals; organic chemical contaminants from industrial processes and petroleum use; pesticides and herbicides, hence, it is essential to determine the aptness of groundwater for the irrigation and drinking water purposes, depend upon the containing of chief ions, nutrients and trace elements in the groundwater. The groundwater is affected mostly where there is a human settlement, storage of the animal waste and domestic waste designed for irrigation water; the standard criteria take in salinity and ion toxicities. The presented area of the groundwater utilized for drinking and irrigation purpose based on the study, says that Indian standards for drinking purpose like Sodium Adsorption Ratio, Soluble Sodium Percentage, Permeability Index, Kelley's Ratio, Magnesium Ration, and Residual Sodium Carbonate are suggested suitable for irrigation represented by Wilcox and USSL diagrams. The Mechanism of controlling the ground water chemistry is mainly rock dominance present in the area says based on Gibb's diagram. Silicate weathering mainly and rarely calcium weathering present in this area and statistically also this shows variance in parameters.

Key Words: Ground water, Kelley's ratio, Wilcox and USSL diagram.

1. Introduction

Groundwater is a life-sustaining utilized component for human life social and financial welfare. The water quality of irrigation-depends upon many factors comprise the water quality, a type of soil, salt absorption capacity-of the plants, drainage pattern features of the soil and climatic conditions. Different kinds of ionic concentration controlled by mostly sources of groundwater recharge and related geological minerals are dissolved and through the flow of water (Srinivasa Gowd S (2005)). The immoderate amounts of dissolved ions are harmful to the health of humans and also affected too many plants or crops. Utilized organic fertilizers and pesticides to intensity much more crop production has become very common practice. All of this result in the deterioration of water quality (Singaraja et al., 2014; Das et al., 2015; Nagaraju et al., 2015). The minimum, maximum and mean of the physicochemical analysis of groundwater samples of this area during the months of January is given in Table 1.

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2. Study area

The study area is located in the Survey of India (SOI) Toposheet No's: 57J/06 & 57J/11on 1: 50,000 scale, and lies between 78^0 24'30"to $78^0$03'0"E and 14^0 30'0"to 14^0 35' 30" N with an aerial extent of 292.59 Sq.km. The Mogamureru River is a source of water for drinking and irrigation purpose, for the people, who are living on the two sides of the stream. The location map of the study region is shown in Figure 1.

2.1 Geology

The Dharwar Super Group (Archean) consists which is the oldest rocks of the Peninsular Gneissic Complex (Gneisses and Schist's) is overlaid by Cuddapah Super Group. The study area is predominantly comprised of Basic flows, Dolomite and Shale in Vempalle Formation, Quartzite, Conglomerate, and Tuff in Tadipatri Formation of the Cuddapah Super Group (Fig. 1).

3. Materials & Methods

Twenty-two samples are collected and analyzed for various physicochemical parameters in the laboratory. Total hardness and Chloride determined by using the titration method. Total Dissolved Solids and Electrical Conductivity determined by using conductivity meter and the pH is measured by using pH meter. The Sodium, Potassium, and Calcium are determined by using the flame-photometer method. Finally result represented as graphs and concluded based on graphs. Following flow chart (Fig. 2) depicts the methodology adopted for the study area.

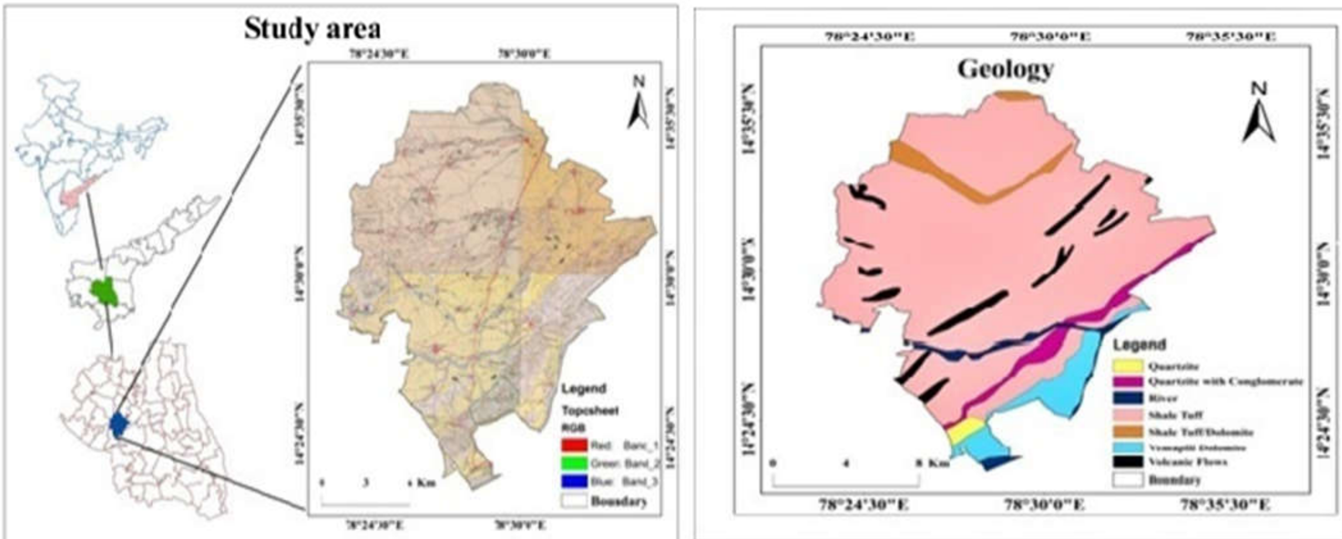

Figure 1: Location map and Geology of the study area

Figure 2: Methodology of the study area

4. Result and Discussion

The results of the analysis identify the geochemical processes and mechanisms of the groundwater used in the water quality and irrigation quality (Srinivasa Gowd S 2005). The maximum communal standards remain cast-off to assess water quality correlated to the health of ecosystems, the wellbeing of human contact, and water. Standards are expressed in Table 1. and the discussions are as follows.

4.1 Gibb's Diagrams (1970)

Groundwater in many aspects of the mechanism are still understood by using the Gibb's Diagrams. These diagrams suggested a chemical relationship of the Cations and Anions versus Total Dissolved Solids (TDS). Therefore, chemical components of water respectively such as chemistry of rock type, the chemistry of the precipitated and the rate of evaporation of water (Gibbs. R. J et al., 1970; Islam et al., 2013). Gibb's proposed two variation Anions ratio (I), Cations ratio (ii) (Table2). Which is dominated nature having of water indicating these diagrams. The anions and cations plotted diagrams are including predominantly rock type of the controlling chemistry of the groundwater (Fig. 3A & 3B).

Table 1: Physico –Chemical Parameters

S.No	pH	Cl	Ca	CO_3	Na	HCO_3	K	EC	Mg	TDS	Total Hardness
Units		Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	us/m	Mg/L	Mg/L	Mg/L
1	8.5	199	28	24	1.5	73	4.1	1334	90	667	439
2	8.3	830	104	36	27.6	61	5.2	3690	135	1840	817
3	8.0	604	92	48	8.2	85	3.6	2686	48	1339	427
4	3.5	734	52	48	3.5	88	5.2	1665	151	1240	750
5	8.0	199	40	36	0.5	67	3.1	1520	59	1264	342
6	8.0	575	152	54	22.3	63	3.3	2708	35	1374	525
7	8.1	944	100	60	277.1	69	5.0	3670	153	1840	878
8	8.3	284	32	24	222.9	76	0	2530	96	1264	476
9	8.6	334	132	30	14.0	79	5.0	2151	86	1073	683
10	8.4	497	36	42	38.8	77	5.2	3070	177	1540	817
11	8.1	476	156	54	24.6	80	3.3	2925	39	1456	549
12	8.1	597	80	30	40.0	98	1.3	4220	123	2130	708
13	8.1	753	80	24	18.2	100	6.2	3190	117	1590	683
14	8.1	753	80	-	2.5	104	3.3	5480	40	2730	366
15	7.8	454	28	-	7.7	108	5.3	1695	196	1360	878
16	7.7	241	40	-	3.0	76	5.0	1679	136	1380	659
17	7.9	156	164	-	15.8	84	3.3	1370	61	830	427
18	8.3	106	60	58	45.1	146	4.5	1426	64	930	415
19	8.5	185	40	28	20.3	76	4.9	2044	50	1217	305
20	8.9	547	20	38	20.3	195	5.0	1705	26	1053	159
21	8.5	284	52	55	46.4	171	8.5	2252	122	1226	634
22	8.5	227	12	43	15.3	185	6.2	1974	70	1160	317

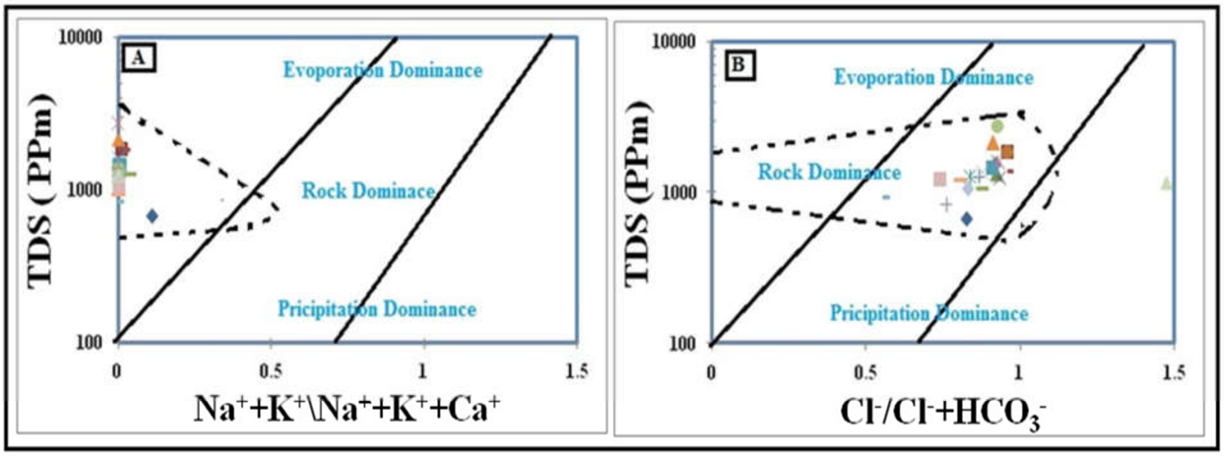

Figure 3: Gibb's plots in anions ratio (A) and cations ratio (B) of the study area.

4.3 Ionic ratio

The ionic ratio between total Cations (TZ^{+}) versus Na^{+} + K^{+} taken and plotted. This plot is indicating predominantly samples are following the equiline and below the line indicating geochemical processes in the silicate weathering (Fig 4A) and another ionic ratio plotted between total Cations (TZ^{+}) versus Ca^{2+} + Mg^{2+}. The samples are following the equiline and this is indicating both types of weathering silicate and carbonate (Fig4B) due to the presence of dolomite and quartzite (Hem. J. D et al., 1989).

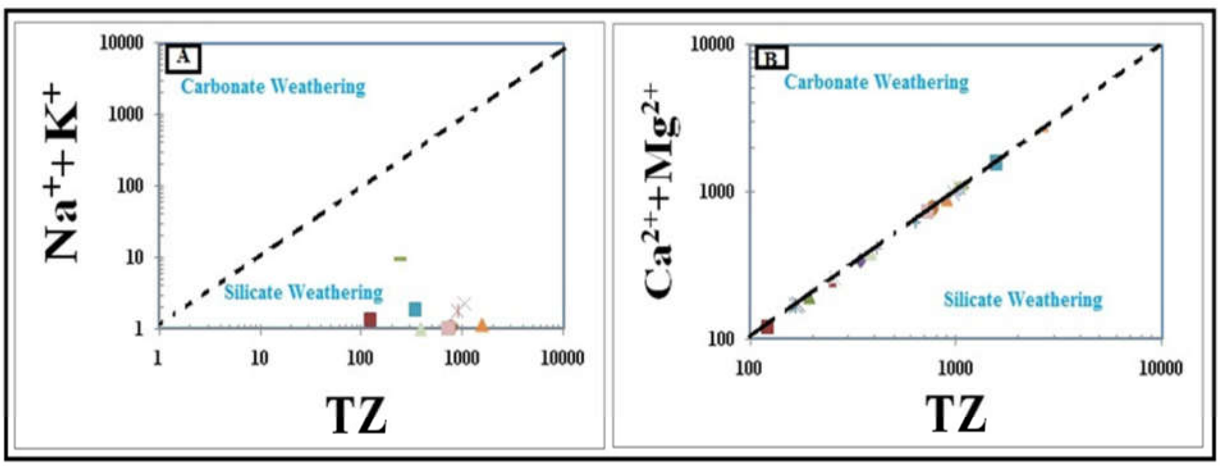

Figure 4: Ionic ratio in cations (A) and anion (B) of the study area

4.4 Scatter Diagrams

The scatter plots are mainly used in understanding the salinity of groundwater controlling process. The ionic ratio between variable ionic concentrations with various graphs is plotted. The sodium versus the chloride has been taken and plotted, this shows carbonate weathering due to calcareous rocks is the main source of ground water (Fig. 5A) and the sodium and chloride ($Na^{+}\backslash Cl^{-}$) ratio versus EC S/cm plotted, $Na^{+}\backslash Cl-$ ratio average 0.16 it is indicating silicate weathering because of sodium concentration (Fig. 5B). Ionic concentration of Ca^{2+} + Mg^{2+} versus HCO^{3-} is taken and plotted (Fig. 5C) and it is indicated carbonate weathering caused by dolomite presence predominantly (Ibraheem et al., 2017).

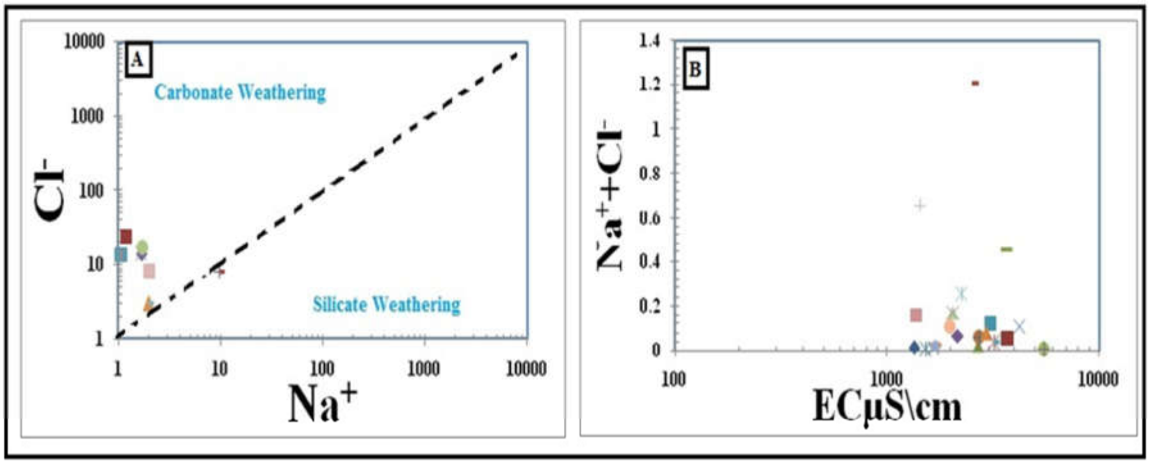

Figure 5A & 5B: Relationship between Na^+ vs. Cl^- and EC vs. Na^++Cl^-

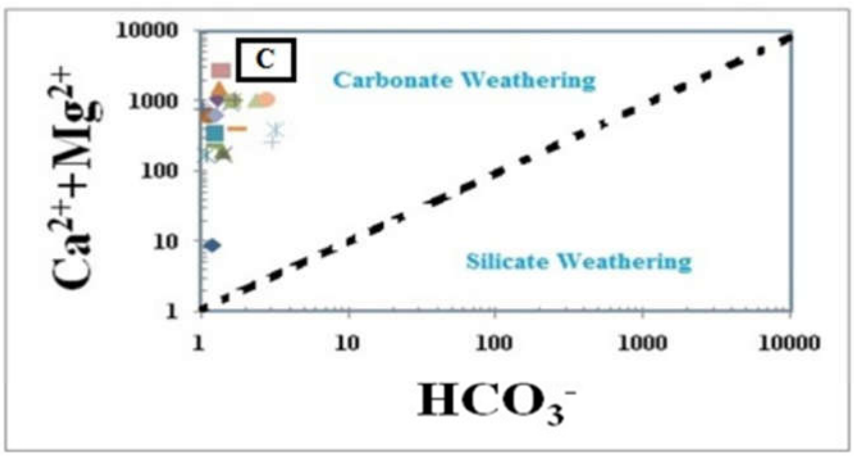

Figure 5C: Relationship between Ca^{2+} Mg^{2+} vs. HCO_3^-

Table 2. Variation of Irrigation Water Quality Standards

Irrigation Standard	unit	Minimum	Maximum	Average
Gibb's Ratio for Anions	Meq/l	0.55	1.47	0.01
Gibb's Ratio for Cations	Meq/l	0.01	0.04	0.9
SAR	Meq/l	2.2	36.99	18.74
% Na	%	0.02	3.98	0.54
TH		159	878	557
RSC	Meq/l	-2635.82	-6.8	-692.1
PI	Meq/l	0.1	13.1	1.3
MR	Meq/l	0.19	84.1	5.9
KR	Meq/l	0.00	0.04	0.004
EC	µS /Cm	1334	5480	2499
Chloride	Meq/l	2.99	26.6	12.8

4.5 Wilcox Diagram

Salts are supplied to soil by irrigation water, geological sources (soil parent material), fertilizers, pesticides. The soluble sodium percentage is important factor for the purpose of irrigation; the ground water is suitable or unsuitable (Wilcox et al., 1955). Generally, calcium and magnesium shows internal drainage released by mainly absorption of sodium. Soluble sodium percentage (SSP) (Raghunath 1987) was calculated using the following equation:

$$SSP = [(Na^{+} + K^{+})/ (Ca^{2+} + Mg^{2+} + Na^{+} + K^{+})] * 100$$

Where concentrations of all ions have been expressed in meq/L. The SSP calculated the study area samples are falls in excellent category (Table 3) and the SSP values versus the EC values are taken and plotted on the Wilcox diagram (Wilcox, 1948). Eight samples are falls in good to permissible category, ten samples are falls in doubtful to suitable category and four samples are falls in doubtful to unsuitable category (Fig. 6).

Table 3. Quality classification of water for irrigation

S.NO	Percent Sodium	Classification	No. of Samples
1	<20	Excellent	All samples
2	20 - 40	Good	-
3	40- 60	permissible	-
4	60-80	Doubt-full	-
5	>80	Unsuitable	-

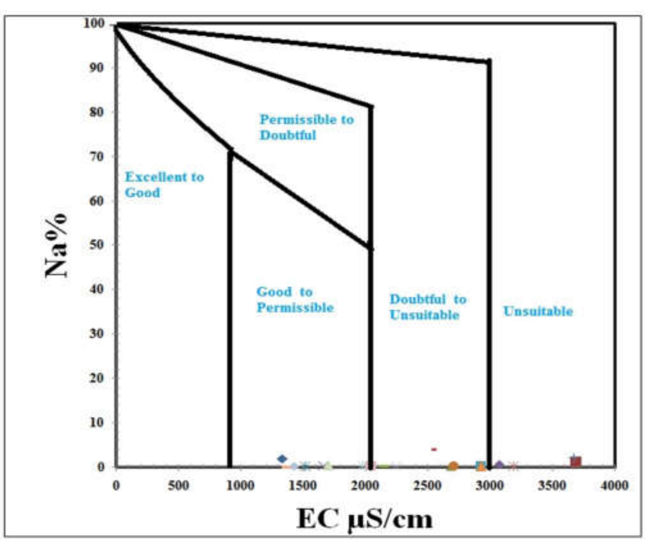

Figure 6: Wilcox diagram

4.6 USS Laboratory Diagram

The US Salinity Laboratory is a National Laboratory for research on sodium affected in soil for plant of water system. Reduce the values and productivity of considerable areas of land caused by saline and alkali soil condition. SAR allows assessment of the state of flocculation or of dispersion of clay aggregates in a soil. Sodium and potassium ions facilitate the dispersion of clay particles, while calcium and magnesium promote their flocculation. The behavior of clay influences the soil structure and affects the permeability of the soil that's directly depends the water infiltration rate. It is important to accurately know the nature and the concentrations of cations at which the flocculation occurs: critical flocculation concentration (CFC). The SAR parameter is also used to determine stability of colloids in suspension in water.

The formula for calculating the sodium adsorption ratio (SAR) is:

$$Na = \frac{Na}{\sqrt{\frac{Ca_x + Mg}{2}}}$$

Most Soil and water amendments in common use supply calcium directly or indirectly through an acid or acid-forming substance which reacts with soil lime ($CaCO_3$) to release calcium to the soil solution (Fig. 7).

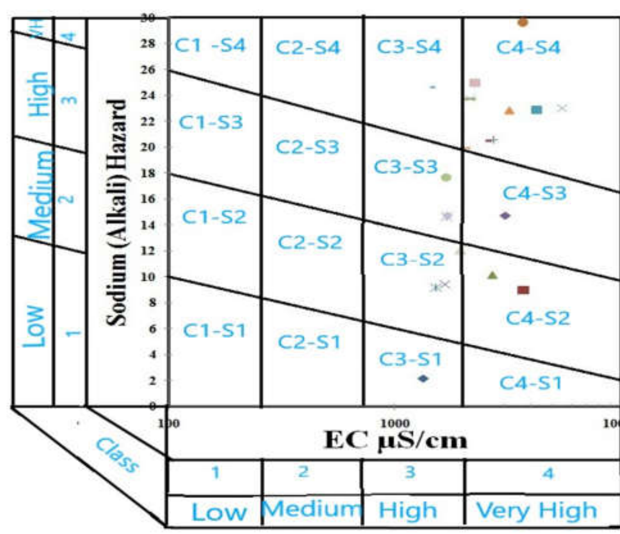

Figure 7: USS Lab Diagram

USSL diagram classified as five categories based on Salinity hazard then seven samples are falls in permissible (C3), twelve samples are falls in doubtful (C4), three samples are falls in unsuitable (C5). (Table 4) and also USSL diagram classified as five categories based on sodium hazard then four samples are falls in excellent categories (S1), six samples falls in good category (S2), eight samples falls in doubtful category (S3), four samples are falls unsuitable categories (S4) (Table 5).

Table 4: Salinity hazard classes

Salinity Hazard Class	EC in (µS /Cm)	Classification	Samples
C1	<250	Excellent	-
C2	250- 750	Good	-
C3	750-2000	Permissible	7samples
C4	2000-3000	Doubtful	12samples
C5	>3000	Unsuitable	3 samples

Table 5: Sodium Hazard classes based on USSL classification

Sodium Hazard Class	SAR in Equivalents per mole	Classification	Samples
<S1	<10	Excellent	4Samples
S2	10 – 18	Good	6 samples
S3	18–26	Doubtful	8 samples
S4 & S5	>26	Unsuitable	4 samples

4.7 Permeability index (PI)

Permeability index is also one of the criteria affected by the irrigation water; the salts are soluble reaction also found in the soil (Gupta and Gupta 1987). Permeability index varies from 0.1 to 13.1. The samples are falls class 1 indicating well for purpose of irrigation.

The formula for calculating the permeability index as fallows

$$PI = Na^{+} + HCO_3^{-} * 100/(Ca^{2+} + Mg^{2+} + Na^{+})$$

Where concentrations of all ions have been expressed in meq/L.

4.8 Kelley's Ratio

Kelley's Ratio is one of the important criteria for assessments of irrigation water quality. The Kelley's ratio in the more then1 (>1) is indicating high sodium concentration it is conceded as unsuitable for purpose of irrigation and less than 1 (<1) low sodium concentration it is considered as suitable for purpose of irrigation. Kelley's ratio variation between 0.00– 0.04 the less than 1 (Table 6).

Table 6: Kelly's Ratio

KR	Classification	No. Of Samples
< 1	Suitable	All samples
>1	Unsuitable	-

4.9 Magnesium Ratio

The magnesium high in groundwater whereas increasing magnesium pronominally decreases the crop yield (Paliwal 1972). The magnesium ratio average is 5.9 and one sample is excess 50 and except one all samples are suitable for purpose of irrigation.

$$MR = Mg^{2+} * 100/(Ca^{2+} + Mg^{2+})$$

Where concentrations of all ions have been expressed in meq/L.

4.10 RSC Index

The residual sodium carbonate (RSC) index of irrigation water or soil water is utilized to indicate the alkalinity hazard for soil. The RSC index is utilized to find the suitability of the water for irrigation in clay soils which have a high cation exchange capacity. When dissolved sodium in comparison with dissolved calcium and magnesium is high in water, clay soil swells or undergoes dispersion which drastically reduces its infiltration capacity (Doneen 1964; Freeze et al., 1979).

High RSC index water does no increase the osmotic pressure to obstruct the off take of water by the plant roots different high salinity water. Clay soils irrigation with high RSC index water leads to follow alkali soils formation. RSC should not be higher than 1 and preferably less than +0.5 for considering the water use for irrigation which is caused by Lime [Ca $(OH)_2$] can be present in natural water (BIS 1988).

The formula for calculating RSC index is:

$$\text{RSC index} = [HCO_3^{2-} + CO_3^{-}] - [Ca^{+} + Mg^{+}]$$

Table 7: Groundwater quality based on RSC (Residual Sodium Carbonate)

RSC Index	Classification	Samples
<1.25	Good	All samples
1.25–2.5	Doubtful	-
>2.5	Unsuitable	-

4.11 Statistical Analysis

The parameters variation can be studied also from the statistical, so this analysis is important for ground water.

4.12Standard Deviation (S):

The average value to actual value of deviation it is gives the standard deviation. The average value is taking square root of value and it is known as standard deviation. The Formula used for calculation of Standard Deviation as fallows

$$S = \frac{\sqrt{\sum (x-\square)^2}}{n}$$

4.13 Standard Error:

The Standard Error gives to standard deviation value square and accuracy value for squire root of the value calculated and it is called as Standard Error. The Formula used for calculation of Standard Deviation as fallows

$$S.E = \frac{\sqrt{S^2}}{n}$$

4.14 Percent Co-efficient variances: (% C.V.)

The percent Co- efficient variance gives to standard deviation by average value and multiple with hundred it is known as Percent Co-efficient variance (Table 8).

The formula used for the calculation of Standard Deviation is as follows

Table 8: Statistical parameters

Parameters	Min	Max	Average	SD	SE	CV
CO_3	0	2.0	1.10	0.3	0.1	23.1
HCO_3	1.0	3.2	1.60	0.4	0.1	22.2
Cl	3.0	26.6	12.8	2.9	0.60	22.3
Na	0.02	12.1	1.7	0.73	0.2	-99.3
Ca	1.2	2632	687	197.7	42.14	28.8
K	0	0.2	0.11	0.02	0.01	21.5
Mg	2.1	16.1	7.8	1.8	0.4	22.7

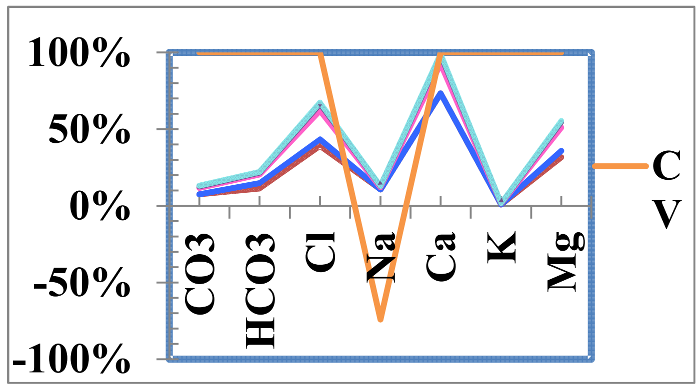

Figure 8: Relationship between Parameters and concentration

5. Conclusion

Table 9: Relative weight of chemical parameters

Chemical Parameters	Indian Standards	Study area Values
pH	6.5-8.5	7.7 - 8.9.
TDS (Total Dissolved Solids)	500-2,000	667-2730
Chloride	250-1,000	106-944
Total Hardness	300-600	159-878
Calcium	75-200	12-152
Bicarbonates	244-732	61-195
Magnesium	30-100	35-196

The study area assessment of the groundwater sample for purpose of drinking and irrigation depends upon the Indian standard ranges and it reveals that the pH is within the desirable limit. In the study area, ionic concentration falls in the order Cl>Na>Mg>Ca>HCO_3>CO_3>K in the ground water. The

Sodium, Magnesium, Potassium Calcium, Chloride, Carbonates and Bicarbonates are within the desirable limit hence the ground water is utilized for drinking and irrigation. The TDS, EC and Total Hardness are slightly exceeding ranges from the Indian standards (Table 9). So, the salinity hazard groundwater is also suitable for purpose of both drinking and irrigation but the soil continually used for long years to years may be increased problems of alkalinity and salinity. Mechanism of controlling the ground water chemistry in weathering affect and ionic ratio. The Gibb's diagrams are suggested the area falls predominantly rock dominance this is indicating chemical composition of the ground water depends upon it. The scatter diagrams are suggested that mainly deposition and dissolved the minerals of silicate and rarely calcium. The weathering of silicates and calcium mainly controlled by the ionic concentration of magnesium, sodium, and potassium. The ionic ratio suggested that mainly Calcium and Magnesium presented in the area, these ions come from the weathering of silicate. The groundwater analyzed like SAR, SSP, PI, KR, MR and RSC are under the suitability for purpose of irrigation is good to medium and some are falls the unsuitable category. Where the long year's utilized soil reputedly there is a created problem of alkalinity and salinity and in that situation says the ground water unsuitable for irrigation purpose.

ACKNOWLEDGEMENTS

The first author C. Krupavathi, greatly thankful to Department of Science and Technology (DST), Government of India, for financial support through Inspire programme (Sanction order No. DST/INSPIRE **Fellowship/2017/IF170787**) and also thankful to the Department of Geology, Yogi Vemana University, for necessary facilities for carrying out my research work.

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