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HYDRO CHEMICAL ANALYSIS OF GROUND WATER QUALITY IN HYDERABAD AND RANGA REDDY AREAS OF A.P INDIAIN THE YEAR 2008

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Abstract:

Hyderabad is the capital city of Andhra Pradesh and the fifth largest city in India and Ranga Reddy District is located in the Central Part of the Deccan Plateau. These areas experience severe degradation of ground water quality due to various industries, canals and urban activities. An attempt was made to study the quality and suitability of ground water in these areas for drinking and irrigation purpose. Groundwater samples were collected from various locations from Hyderabad city limits and Ranga Reddy District during the pre and post monsoon period in the year 2008. These samples were analysed for physico chemical characters. The type of water that predominated in the study area was assessed based on hydro chemical facies. Besides, suitability of groundwater for drinking and suitability to irrigation was evaluated based on sodium adsorption ratio, percent sodium, residual sodium
Carbonate and the US salinity diagrams.

Keywords: Groundwater, Hydro chemical parameters, SAR, RSC, US salinity diagrams.

Introduction

Water quality analysis is one of the most important aspects in groundwater studies. The hydro chemical study reveals quality of water that is suitable for drinking, agriculture and industrial purposes. Further, it is possible to understand the change in (ISI, 1983 & Todd, D.K, 1980) quality due to rock water interaction or any type of anthropogenic influence. Groundwater often consists of seven major chemical spicies viz Ca^{+2}, Mg^{+2}, Cl^{-1}, HCO_3^{-1} Na^{+1}, K^{+1}, and SO_4^{-2}. The chemical parameters of groundwater plays a significant role in classifying and assessing water quality. Considering the individual and paired ionic concentration, certain indices are proposed to find out the alkali hazards. Residual sodium carbonate (RSC) can be used as a criterion for finding the suitability of irrigation waters. It was observed that the criteria used in the classification of waters for a particular purpose considering the individual concentration may not find its suitability for other purposes and better results can be obtained only by considering the combined chemistry of all the ions rather than individual or paired ionic characters (Handa. B.K, 1964 & Hem. J.D, 1985). Chemical classification also throws light on the concentration of various predominant cations, anions and their inter relationships. A number of techniques and methods have been developed to interpret the chemical data. Zaporozee (Zaporozee, 1972) summarized the various modes of data representation and has discussed their possible uses.

Presentation of chemical analysis in graphical form makes understanding of complex groundwater system simpler and quicker. Methods of representing the chemistry of water like Collin's bar diagram (Hem, J.D, 1985), radiating vectors of Maucha (Maucha, 1940), and parallel and horizontal axes of Stiff (Stiff Jr. H.A, 1940) have been used in many parts of the world to show the proportion of ionic concentration in individual samples. The objective of the present work is to discuss the major ion chemistry of groundwater of Hyderabad and Ranga Reddy district areas. In this case the methods proposed by piper, Back and Hans haw, Wilcox, Eaton, Todd (Todd, 1980) and USSL (US Salinity Laboratory) classification have been used to study the hydro chemical characteristics of groundwater of Hyderabad and Ranga Reddy district areas

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Study Area

Hyderabad is the capital city of Andhra Pradesh and the fifth largest city in India. This city located at 17° 26' 58'' of the Northern Longitude and 78° 28' 34'' of the Eastern Longitude. The total population of the Greater Hyderabad district is above 60 lakhs and the area of the city is 650 sq km. Ranga Reddy District is located in the Central Part of the Deccan Plateau and lies between 16° 30' and 18° 20' of North Latitude and 77° 30' and 79° 30' of East Longitudes. It covers an area of 7564.88 Sq. Kms. According to 2001 Census, the total population of the study area is 35, 75,064 and about 54.20% of which live in Urban Areas. The major sources of employment are industries, agriculture, horticulture and animal husbandry, which engage almost 80% of the workforce. The major industries are that of chemicals, oil, cotton, tools, lead batteries, food processing, pharmaceuticals, asbestos, foam, coir, and stone crushing. In this study area there are 497 Large and 23,642 Medium Scale Industries in the study area. Occurrence, movement and storage of groundwater are influenced by lithology, thickness and structure of rock formations. Ground water in the study area occurs under water table conditions in the weathered and fractured granite, Gneisses in Grater Hyderabad. Major ion chemistry of groundwater of Hyderabad and Ranga Reddy District areas is not well reported in literature, and hence the study helps in assuming at suitability of ground water to drinking and irrigation. The assessment of ground water quality will be useful in identifying the sources of pollution. Ground water is suitable for drinking and irrigation .The study area location is shown in fig.1

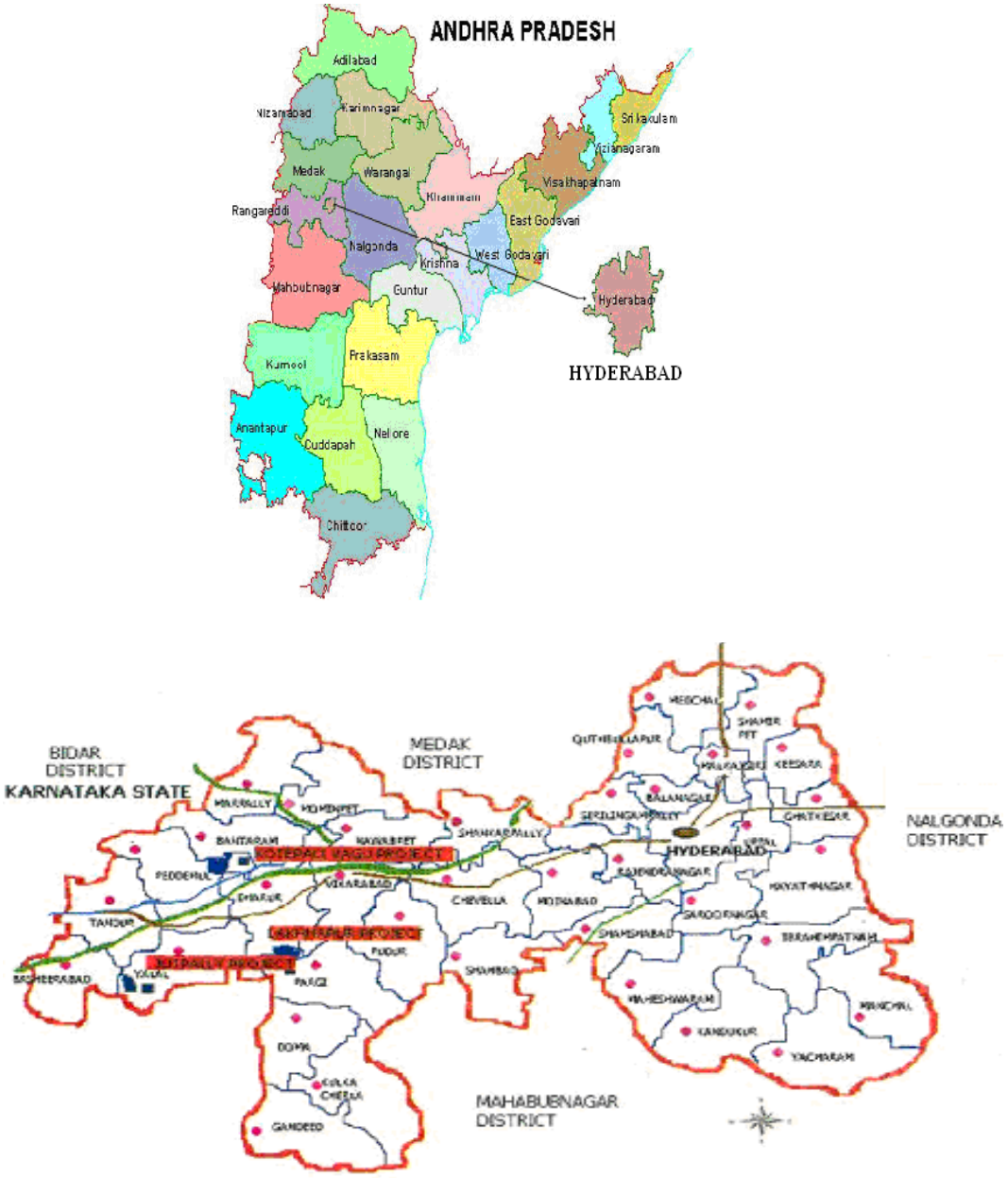

Figure 2: Groundwater sampling locations in Hyderabad and Ranga Reddy

Methodology

Groundwater samples were collected from various locations of Hyderabad and Ranga Reddy District areas during the pre-monsoon period (May 2008), Post-monsoon period (November 2008) (Fig. 2). 117 water samples during the Pre-monsoon period and 122 samples during the Post-monsoon period were collected and transferred into pre cleaned polythene container for analysis of chemical characters. Major ion concentrations of the water samples were analised using the standard procedures recommended by APHA, 1994. The analytical data can be used for the classification of water for utilitarian purposes and for ascertaining various factors on which the chemical characteristics of water depend.

Results and Discussion

Maximum and minimum concentration of major ions present in the groundwater from the study area are presented in Table 1. The Piper-Hill diagram . is used to infer hydro-geochemical facies. These plots include two triangles, one for plotting cations and the other for anions. The cations and anions fields are combined to show a single point in a diamond-shaped field, from which inference is drawn on the basis of hydro-geochemical facies concept. These tri-linear diagrams are useful in bringing out the chemical relationships among groundwater samples in more definite terms rather than with other possible plotting methods. Chemical data of representative samples from the study area presented by plotting them on a Piper-tri-linear diagram for pre and post-monsoon (figures 3 and 4). These diagrams reveal the analogies, dissimilarities and type of water in the study area, which are identified and listed in Table 2. The concept of hydro chemical facies was developed in order to understand and identify the water composition in different classes.

Table 1: Maximum and minimum concentration of major ions in groundwater Samples

Ions	Pre-Monsoon Samples (mg/l)		Post-monsoon Samples (mg/l)	
	Min	Max	Min	Max
Ca^{+2}	08	256	08	232
Mg^{+2}	00	146	05	156
Na^{+}	05	369	02	316
K^{+}	02	278	01	242
Co_3^{-2}	00	60	00	80
HCo_3^{-1}	10	300	16	269
Cl^{-1}	10	630	10	610
So_4^{-2}	22	315	23	470
Total Hardness	80	1140	70	1080

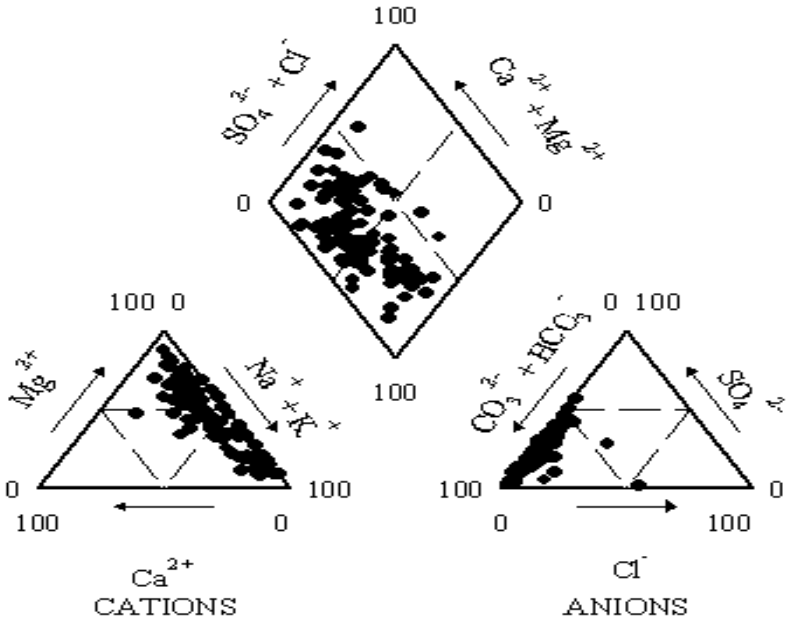

Figure 3Pre-monsoon groundwater Samples plotted in piper-Tri-linear diagram

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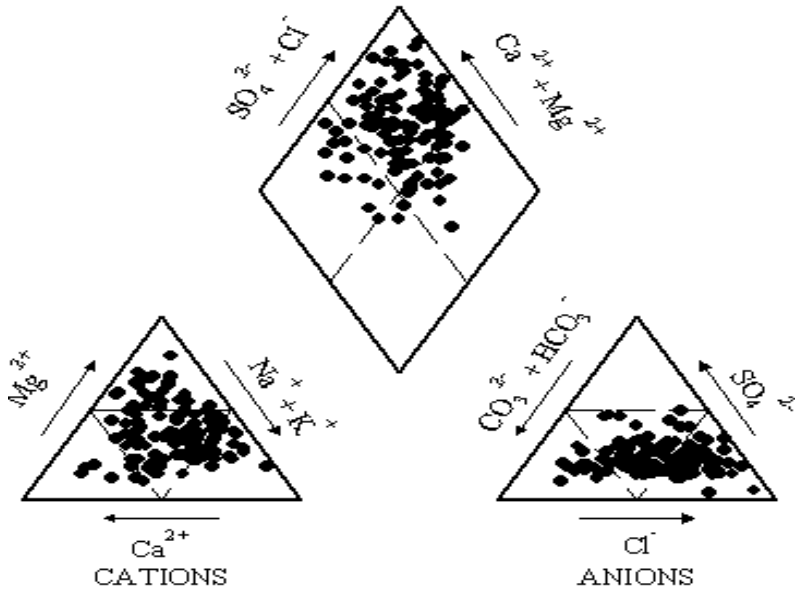

Figure 4 :Post-monsoon groundwater Samples plotted in piper-Tri-linear diagram

Table 2: Characterization of groundwater on the basis of Piper tri-linear diagram

Subdivision Diamond	Characteristics of Corresponding Subdivision of Diamond shaped field	Percentage of sample in this Category	
		Pre Monsoon	Post Monsoon
1	Alkaline earth (Ca+ Mg) Exceed alkalis (Na+ K)	72	80
2	Alkalis exceeds Alkaline earths	28	20
3	Weak acids ($C0_3$+HCO_3) exceed Strong acids (SO_4+Cl)	95	14.5
4	Strong acids exceeds Weak acids	05	85.5
5	Magnesium Bicarbonate type	61	11.5
6	Calcium-chloride type	01	29
7	Sodium-chloride type	02	16
8	Sodium-Bicarbonate type	06	00
9	Mixed type (cations-anion exceed 50%)	30	33.5

Facies are recognizable parts of different characters belonging to any genetically related system. Hydro chemical facies are distinct zones that possess cation and anion concentration categories. To define composition class, Back and co-workers , suggested subdivisions of the tri-linear diagram (figure 5). The interpretation of distinct facies from 0 to 10% and 90 to 100% domains on the diamond shaped cation to anion graph is more helpful than using equal 25% increments.

It clearly explains the variations or domination of cation and anion concentrations during pre-monsoon and post-monsoon. Ca – Mg type of water predominated during post-monsoon and the water samples falling under Ca – Mg type were 72% and 80% during pre-monsoon and post-monsoon seasons respectively. For anions concentration, HCO_3^- type of water during pre-monsoon with 95%

samples and during post monsoon with 14.5% samples. There is no significant change in the hydro-chemical facies noticed during the study period (pre and post-monsoon), which indicates that most of the major ions are natural in origin. The reason is that the groundwater passing through igneous rocks dissolves only small quantities of mineral matters because of the relative insolubility of the rock composition and complex molecular structure.

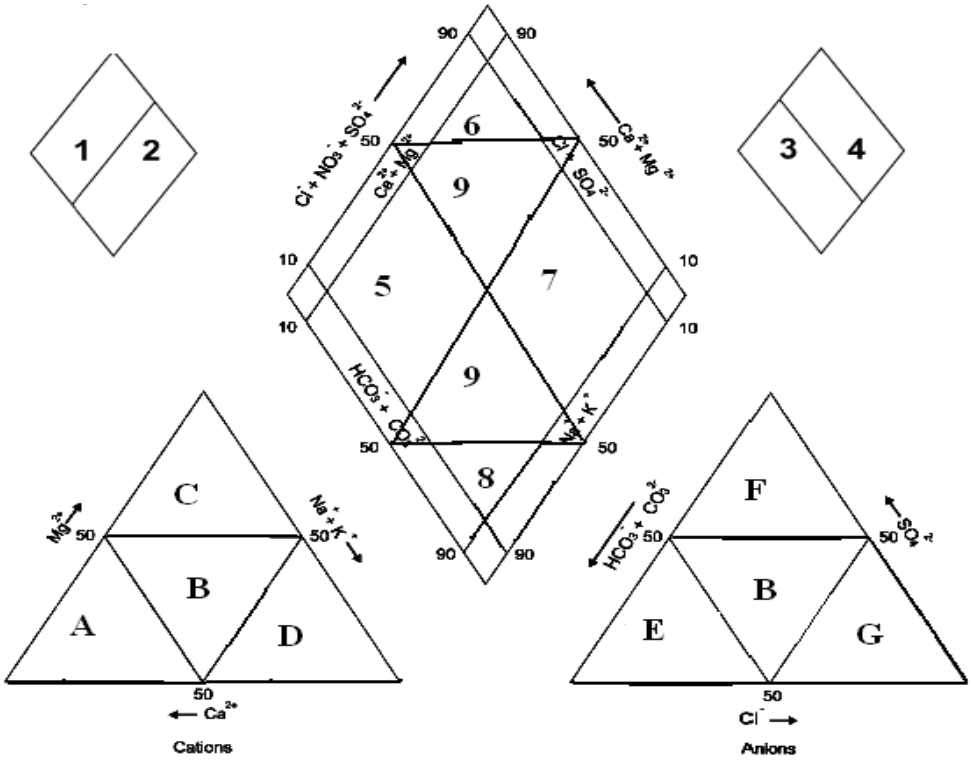

Figure 5 : Hydro chemical facies of ground water

Legend
A- Calcium type
B- No Dominant type
C- Magnesium type
D- Sodium and Potassium type
E- Bicarbonate type
F- Sulphate type
G- Chloride type

Hardness is caused primarily by the presence of cations such as Calcium and Magnesium and anions such as Carbonate, Bicarbonate, Chloride and Sulfate in water. Water hardness has no known adverse effects, however, some evidence indicates its role in heart disease.

In Hyderabad region, the total hardness varies between 80 to 1140 ppm for the pre-monsoon (May-2008) and 76 to 1420 ppm during the post monsoon period (Nov 2008) period. According to Sawyer and McCarty's , classification for hardness, 18 samples fall under moderately hard class and 60 samples under hard and 39 samples are very hard class for pre-monsoon. During post monsoon 1 sample fall under soft 15 samples fall under moderately hard class and 59 samples under hard and

47 samples are very hard class. Hard water is unsuitable fordrinking and domestic use. The hardness classification is given in Table 3.

The suitability of groundwater for irrigation purposes depends upon its mineral constituents. The general criteria for judging the water quality are: (i) total salt concentration as measured by Electrical conductivity (EC) (ii) Relative proportion of Sodium to other principal cations as expressed by SAR and (iii) Bicarbonate (HCO_3^-)

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Table 3: Classification of water based on hardness by Sawyer and McCarthy

Hardness as $CaCO_3$ (ppm)	Water class	Pre-monsoon samples	Post monsoon Samples
0-75	Soft	Nil	70 (01 samples)
75-150	Moderate Hard	80-140 (18 samples)	80 - 140 (15 samples)
150-300	Hard	160-300 (60 samples)	160 -300 (59 samples)
>300	Very hard	300-1240 (39 samples)	320-1420 (47 samples)

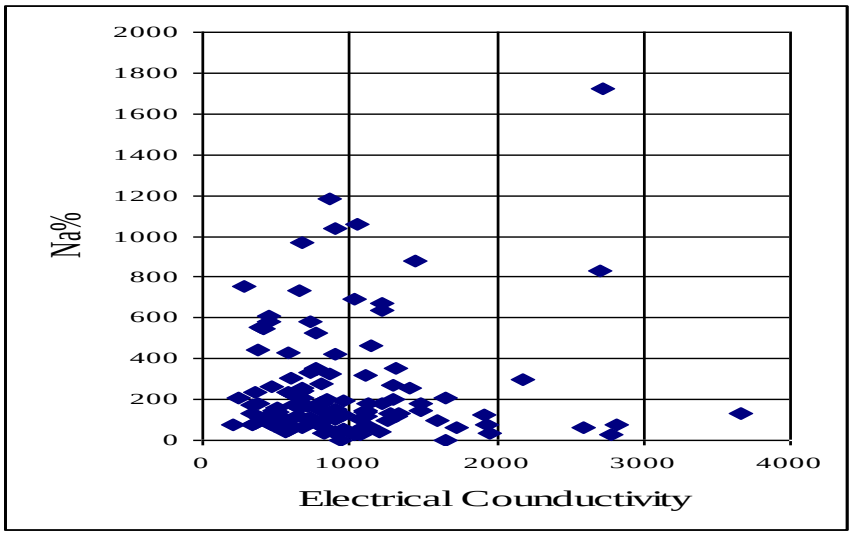

Figure 6: Wilcox diagram of ground water in Hyderabad Pre-monsoon

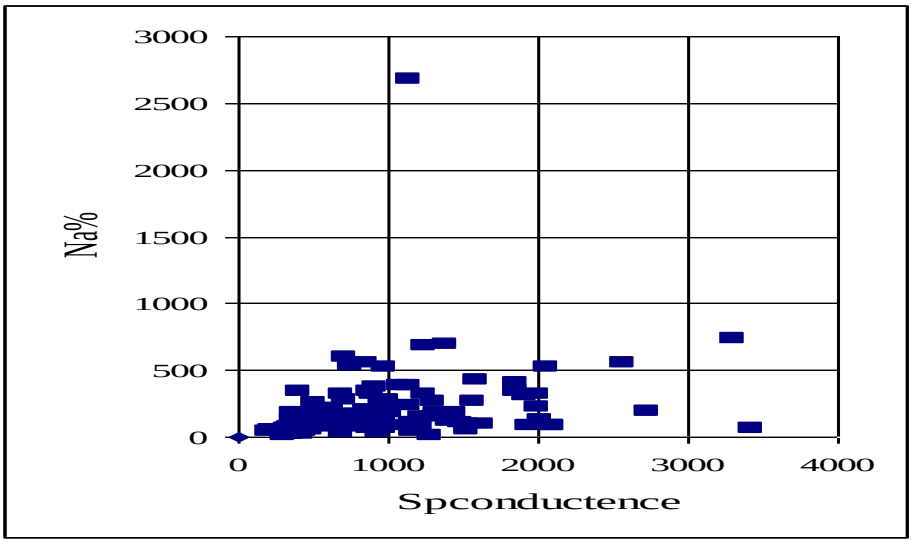

Figure-7: Wilcox diagram of ground water in Hyderabad Post- monsoon

Wilcox classified groundwater for irrigation purposes based on percent sodium and Electrical conductivity. Eaton recommended the concentration of Residual Sodium Carbonate to determine the suitability of water for irrigation purposes. Wilcox diagram develped for the study area are presented in fig 6 and 7.

The US Salinity Laboratory of the Department of Agriculture adopted certain techniques based on which the suitability of water for agriculture is explained. The sodium in irrigation waters is usually denoted as percent sodium and can be determined using the following formula , where the quantities of Ca^{+2}, Mg^{+2}, Na^{+1} and K^{+1} are expressed in milli equivalents per litre (epm).

$$\% Na = (Na^{+}) X 100/ (Ca^{+2} + Mg^{+2} + Na^{+1} + K^{+1})$$

Table 4: Sodium percent water class

Sodium (%)	Water Class	Pre-Monsoon Sample	Post-Monsoon Sample
<20	Excellent	9.58 – 18.7 (45 Samples)	9.87 - 18.2 (4 Samples)
20-40	Good	21 – 39.5 (15 Samples)	21.7 – 36.3 (6 Samples)
40-60	Permissible	40.6 – 58.5 (12 Samples)	40.3 - 60 (16 Samples)
60-80	Doubtful	60.5 - 78.3 (11 Samples)	60.2 – 72.7 (13 Samples)
>80	Unsuitable	81.58 - 1721 (76 Samples)	80.41 – 2682 (83 Samples)

The classification of groundwater samples with respect to percent sodium is shown in Table 4. It is observed that about 60samples and 10 samples are excellent to good during pre and post monsoon seasons respectively. In water having high concentration of bicarbonate, there is a tendency for calcium

and magnesium to precipitate as the water in the soil becomes more concentrated. As a result, the relative proportion of sodium in the water is increased in the form of sodium carbonate. RSC is calculated using the following equation, where all ionic concentrations are expressed in epm.

$$RSC = (HCO_3^- + CO_3^{-2}) - (Ca^{+2} + Mg^{+2})$$

Table 5: Groundwater quality based on RSC (Residual sodium carbonate)

RSC (epm)	Remark on Quality	Pre monsoon Samples	Post monsoon Samples
<1.25	Good	0.014 - 1.22 (35 samples)	0.02 -1.23 (18 samples)
1.25-2.5	Doubtful	1.25 - 2.48 (29 samples)	1.28 - 2.42 (32 samples)
>2.5	Unsuitable	2.8 – 12.37 (53 samples)	2.52 – 12.2 (72 samples)

According to the US Department of Agriculture, water having more than 2.5 epm of RSC is not suitable for irrigation purposes. Groundwater of the study area is classified on the basis of RSC and the results are presented in Table 5 for both pre and post-monsoon seasons. Based on RSC values, over 35 samples have less than 1.25 and are safe for irrigation during pre-monsoon. During post-monsoon 18 samples were safe for irrigation. Only 29 samples in the pre-monsoon and 32 samples in the post-monsoon are doubtful and 53 samples in the pre-monsoon and 72 samples in the post-monsoon unsuitable.

The most important characteristics of irrigation water in determining its quality are: (i) Total concentration of soluble salts; ii) Relative proportion of sodium to other principal cations; (iii) Concentration of boron or other element that may be toxic and (iv) Bicarbonate concentration as related to the concentration of Calcium and magnesium. These have been termed as the salinity hazard (Wilcox, 1995) sodium hazard, boron hazard and bicarbonate hazard. In the past, the sodium hazard has been expressed as percent sodium of total cations. A better measure of the sodium hazard for irrigation is the SAR, which is used to express reactions with the soil. SAR is computed as, where all ionic concentrations are expressed in epm

$$SAR = Na^+ / \sqrt{[(Ca^{+2} + Mg^{+2})/2]}$$

The further classification of groundwater samples from the study area with respect to SAR is represented in Table 6. During Pre and post-monsoon, the SAR value of all the samples are found to be less than 10, and are classified as excellent for irrigation When the SAR and specific conductance of water are known, the classification of water for irrigation can be determined by graphically plotting these values on the US salinity (USSL) diagram (figure 6 & 7).

The ground water of Hyderabad and Ranga reddy district area is in general Ca-Mg-HCO_3 type during both pre and post monsoon seasons for the year 2008. The anlalysis reveal that about 2, 56, 55 and 4 samples are grouped with in C1S1, C2S1, C3S1 and C4S1classes during pre-monsoon respectively. Further, 3, 54, 60 and 6 samples are grouped with in C1S1, C2S1, C3S1 and C4S1 classes during post monsoon season respectively, as shown in figure 6 & 7.

Table 6: Sodium hazard classes based on USSL classification

Sodium Hazard Class (Alkalinity)	SAR in Equivalents per mole	Remark on quality	Pre monsoon samples	Post monsoon samples
S_1	10	Excellent	0.17 – 1.64 (117 Samples)	0.08 - 3.31 (122 Samples)
S_2	10 – 18	Good	Nil	Nil
S_3	18-26	Doubtful	Nil	Nil
S_4 and S_5	>26	Unsuitable	Nil	Nil

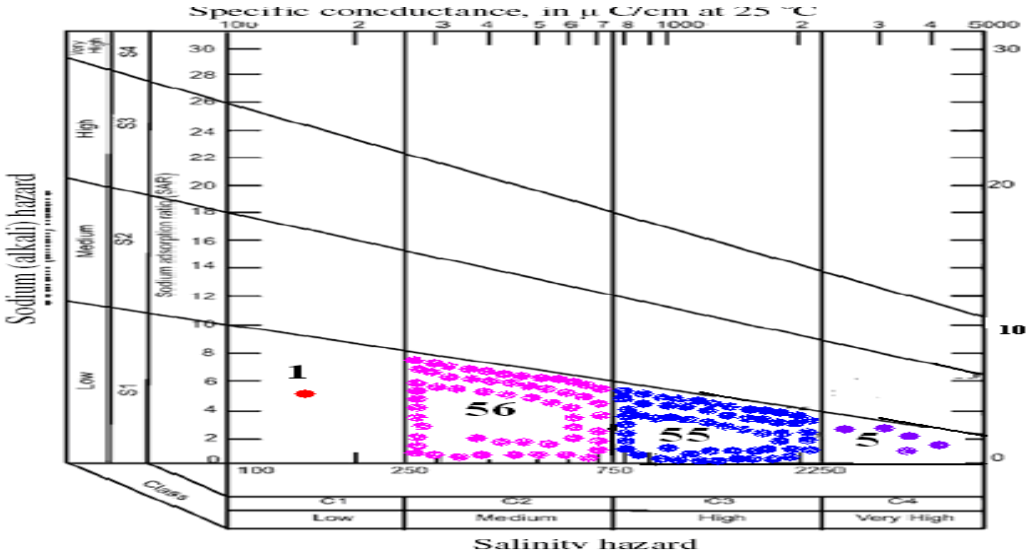

Figure 8 USSL classification of groundwater during pre-monsoon

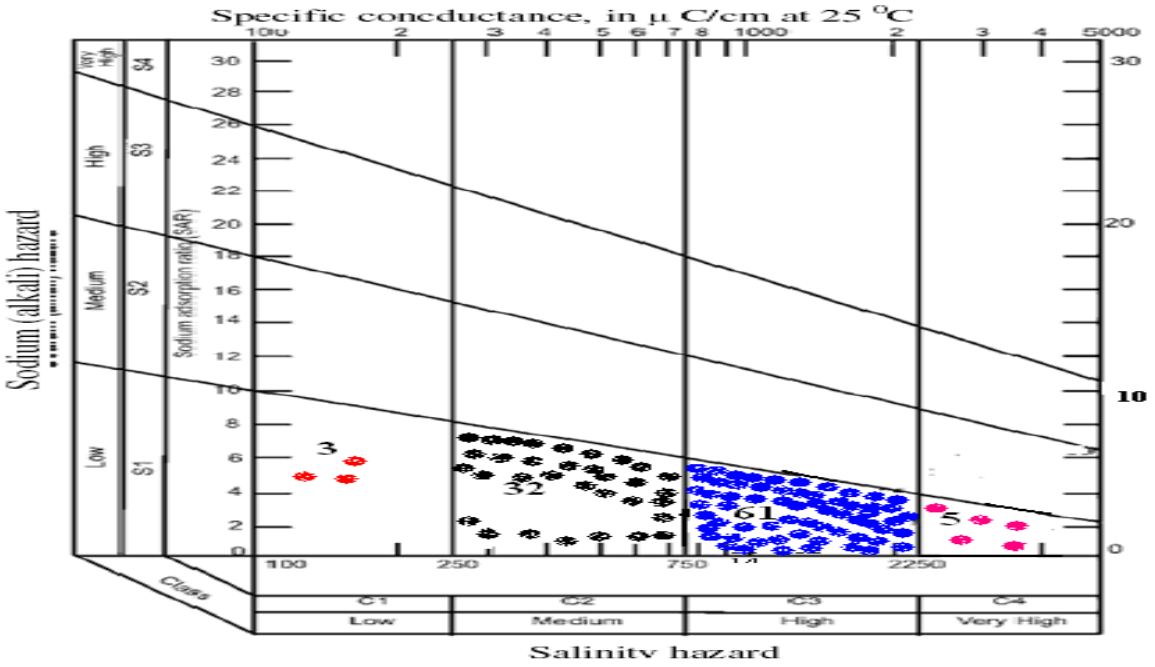

Figure 9 : USSL classification of groundwater during post-monsoon

For the purpose of diagnosis and classification, the total concentration of soluble salts (salinity hazard) in irrigation water can be expressed in terms of specific conductance. Classification of groundwater based on salinity hazard is presented in table 7. It is found from the EC value that only 6 samples during pre-monsoon and 4 samples during post-monsoon were found to be unsuitable for irrigation purposes.

Table7: Salinity hazard class

Salinity Hazard Class	EC in (micro-mohs/ cm)	Remark on quality	Pre monsoon Samples	Post monsoon Samples
C1	100-250	Excellent	192-242 (02 samples)	193-241 (03 samples)
C2	250-750	Good	268-750 (56 samples)	276 -750 (54 samples)
C3	750-2,250	Doubtful	751- 2230 (55 samples)	752 -2111 (60 samples)
C4 & C5	>2,250	Unsuitable	2390-3340 (04 samples)	2260 – 3490 (06 samples)

In Hyderabad and Ranga Reddy districts of Andhra Pradsh, India, the groundwater is generally Ca-Mg-HCO_3 type, which is mainly due to the geology of the area which comprises igneous rocks of crystalline nature.

Conclusions

1.The type of water that predominates in the study area is Ca-Mg-HCO_3 type during both Pre and Post monsoon seasons for the year 2008 based on hydro chemical facies.

2.Though the suitability of water for irrigation is determined based on SAR, % Na, RSC and Salinity Hazard, it is only an empirical conclusion. In addition to water quality, other factors like soil type, crop type, crop pattern, frequency and recharge (rainfall), climate, etc. have an important role to play in determining the suitability of water.

3.Water that is not suitable based on the above classification may be suitable in well-drained Soils.The suitability of water for irrigation is evaluated based on SAR, % Na, RSC and salinity Hazards. Most of the samples in Hyderabad and Ranga Reddy districts of Andhra Pradesh, India fall in the suitable range for irrigation purpose either from SAR, % Na or RSC values

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4.About 95% of the samples are grouped within C2S1 and C3S1 classes in both pre and Post- monsoon season.

5.Most of the samples in Hyderabad and Ranga Reddy Districts of Andhra Pradesh, India fall in the suitable Range for irrigation purpose from USSL diagram and not for other uses.

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