Ground Water Quality Assessment in Jagtial District, Telangana State - A Case Study

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Abstract

This paper examine the groundwater quality of various water quality parameters of a total 99 ground water samples collected during pre and post monsoon seasons in 2014-15 from south western part of Godavari river in Jagtial district, T.S. These 99 samples were analyzed for different parameters such as pH, Total dissolved solids (TDS), Total Hardness (TH),Nitrate(NO_3),Suphate(SO_4),Sodium(Na),Potassium (K),Calcium(Ca), Magnesium (Mg), Chloride (Cl). Sodium absorption ratio (SAR), Permeability index (PI), Residual carbonate (RC), Electrical conductance (EC) and Groundwater quality Index (GWQI) have evaluated.

Water quality parameters were studied through Wilcox and Pipertrillinear diagrams reveals their suitability for irrigation both in pre and post monsoon periods

Statistical data analysis suggests that there is strong positive correlation and relations ship is established between various elements and moderates its affinity to each other on the ground water quality for different uses. A strong affinity is found between the ions is a positive indication on quality of water.

The SAR, RSC and PI shows the groundwater with salinity can be considered moderately suitable for irrigation.

Keywords: *Hydro geochemical, Ground water, correlation, salinity,*

I. INTRODUCTION

Ground water is the most important component of the fresh water and more than 88% of the freshwater available to us (Venkateshwarlu and Narsi Reddy, 2017) Ground water is the main source for drinking water and irrigation in India and indispensible source of our life. Groundwater quality being a function of various natural and cultural factors is variable with respect to space and time. Water quality analysis of groundwater comprises determination of its physical, chemical and organic characteristics, from which its suitability for drinking, irrigational, industrial and other domestic purposes (Abraham Ponsingh and Maharani, 2015; Subramani et al., 2005, Srinivasamoorthy et al., 2013, Udayalaxmi and Ramadass 2013) evaluated. The general water quality parameters such as anions and cations along with Chloride (Cl), Nitrate (NO_3) and Sulphate (SO_4),were analyzed in the Jagtial district, T.S .These elements further processed statistically for groundwater quality parameters to assess the spatial distribution of various Hydro geochemical parameters for suitability of groundwater resources.

II. LOCATION

The area under investigation forms part of survey of India top sheets (1:50,000) No. 56J/13, 56N/1, 56I/16 and 56M/4 bounded by between latitude 18^o 30' N to 19^o5´ N to 78^o 30´ E and longitudes 79^o 35´E, which covers the major part of Jagtial district of Telangana State-India (Figure.1) of Karimnagar district (old) and presently newly formed Jagtial district. Geology of the present study area can be divided into two regions. The major part of area is part of the Peninsular shield of Archean era comprises granites, gneisses and lies in the south western flanks of this River Godavari.

A. Sample collection and Analysis

For the assessment of groundwater quality in the study area 99 water samples were collected at depths from bore wells in the regions during Premonsoon and Post monsoon in the year of 2014-15 covering all the villages falling in the study area. The precise location (geographic coordinates- longitude and latitude) of the sampling points was determined in the field using GPS (Global Positioning System).pH is determines in the field itself during the sample collection

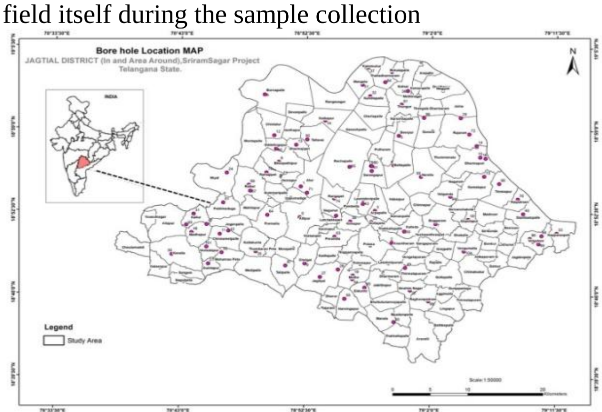


Figure 1 Study area and groundwater sampling Locations

All the water samples collected were analyzed for major ions using qualitative methods as per the standard procedures (Brown et al 1970 & 1974, and APHA,1985& 1998). From the analyzed data Sodium Absorption ratio (SAR), Residual carbonate (RC), Permeability Index (PI) and the groundwater quality index (GWQI) determined and presented in table 1(a) and 1(b). The data is processed statistically for mean and standard deviation to all the major ions analyzed for both pre and post monsoon periods (table 1a and 1b).The characteristic features and significance of data is discussed in detail in their respective paras.

Table - 1 (a) & (b) Statistical Analysis of Groundwater Samples in Study Area

1. Premonsoon

Parameters	Minimum	Maximum	Average	Standerd Deviation	Permissible limit (BIS1983)
pH	6.56	9.03	8.0	0.40	6.5 - 8.5
E C	427	3249	1106.0	435.36	1000-1500
HCO_3	60	600	245.5	87.10	
TDS	273.28	2079.36	707.8	278.63	500-1000
T. H	139.96	1092.5	324.1	132.51	300-600
Na	32	511	103.2	59.81	200
K	0	208	21.6	36.69	---
Ca	8	192	52.5	23.23	75
Mg	0	145.86	44.7	24.94	<30
Cl	30	390	126.8	79.41	250
NO_3	0.27	46.59	10.9	8.41	45
SO_4	25	370	74.0	48.53	150- 250
F	0.16	1.87	0.683	0.43	0.6-1.2
SAR	0.83	10.54	2.5	1.23	
RSC	-9.29	1.90	-2.3	1.96	
P.I	12.42	34.5	24.9	4.36	
GWQI	42.00	345.2	127.5	66.68	

2.Postmonsoon

Parameters	Minimum	Maximum	Average	Standard Deviation	Permissible limit (BIS1983)
pH	6.9	8.92	8.05	0.36	6.5 - 8.5
E C	269	3137	1122.85	465.39	1000-1500
HCO_3	90	1000	225.98	113.51	
TDS	172.16	2007.68	718.62	297.85	500-1000
T. H	140.0	959.8	365.68	137.89	300-600
Na	2	582	112.03	71.78	200
K	1	294	15.80	38.15	---
Ca	24	176	59.46	28.23	75
Mg	4.862	140.998	52.78	28.24	<30
Cl	10	470	148.35	91.86	250
NO_3	0.32	57.27	11.78	9.92	45
SO_4	29	235	106.93	41.60	150- 250
F	0.03	2.78	0.80	0.53	0.6-1.2
SAR	0.06	16.3	2.61	1.81	
P.I	13.77	34.9	21.71	4.67	
RSC	-16.56	5.1	-3.67	2.95	
GWQI	40.68	464.8	142.51	75.80	

III. RESULTS OF DISCUSSIONS

Water samples collected from Jagtial distinct, T.S are critically studied for various parameters for ground water assessment to for different applications and uses. The data obtained subjected to many exercises to categorize in to different applications .The pH and EC are primary constituents in water and influences many chemical and biological pesticides within in a water body**(** Hem.1971;Satish Kumar et al., 2007).

Water-soluble salts increase the conductivity of water. The electrical conductivity (EC) is a measure of ionic concentrations in water and thus reflects the quality of groundwater (Sujatha and Reddy, 2004).The weight of the residue consisting of pollutants (dissolved ions) left behind after all the water from a water sample is evaporated is a measure of the TDS and gives the general nature of groundwater quality and extent of contamination (Annon, 1946; AWWA, 1998).

Total dissolved solids and EC dependent on each other, that the TDS increases the EC also increases correspondingly (table 1a and 1 b).The EC and TDS are under permissible limits except in few cases, where the TDS is less than 1000mg/l is considered as pure water (AWWA,1971)

The source of chloride in groundwater is due to the weathering of crystalline rocks (Sunitha et al., 2002; Satish Kumar et al., 2007) and domestic sewage or industrial effluents (Karanth, 1987). The anion is derived from minerals like sodalite, apatite, micas and hornblende in the granitic rock. Greater than 250 mg/l (BIS,1983) in the water is always toxic to human health and is found higherconcentrations of chloride in the post monsoon periods (Table.1b).

Sulphates,Nitrates and Fluorides area derived the weathering granitic rocks and also from additions in the form of fertilizers and pesticides and leached in to ground water (Feth, 1966, Raghunath, 1987).These concentrations are under permissible limits in both the monsoons(Table1a &1b), and is not in marked differences. Fluoride in ground water is due leaching of fluorine rich minerals like apatite, gypsum and biotite which are common constituents in granites (Handa, 1975),fluoride always a complex with other elements.

The alkali elements of Na and K are found in the earth crust in their free state in nature.Thealkali metals due to the formation of hydroxides which are highly alkaline in nature when they react with water.These alkaline metals Na and K are occur abundantly in granites in the form of feldspar (Satishkumar et. al2007) and is fairly low concentrations in ground water(Sravanthi and Sudarshan, 1998). However, excessive fertilizer usage can increase its concentrations in surface as well as ground water. The recommended daily requirement is greater than 300 mg/l and 200mg/l in K and Na respectively, and is widely occurs in the environment including all natural water,Sodium compounds naturally end up in water., Na stainsfrom rocks and soils.Not only Seas, but also rivers and lakes contains high amount of Sodium concentrations,however are much lower (table 1a and 1b) depending on geological conditions and waste water contaminations.Drinkingwater usually about 50mg/l Na. This value is clearly higher for mineral water in soluble form sodium always occurs as Na^+ ions.

Calcium and Manganese are the principalcations that are widely distributed in the earth's crust and are important element in all waters. Ca and Mg mainly derived from weathering of the silicate minerals in plagioclase, pyroxenes and amphiboles, which are present in rocks. High concentration of calcium is not desirable for washing and other domestic uses.Ca and Mg dissolved in water are the two most common minerals that make water hard.The degree of hardness becomes greater as the Ca& Mg content increases and is related to the concentrations of multivalues cations dissolved in water.

The permissible limits of calcium and magnesium concentration is about 75 mg/l,130mg/l respectively, but higher concentration are noticed in few cases and making the water more harder (Fletcher,1986).Hard water is not a health issue,but a nuisance because of mineral bulling on fixtures and poor soap or detergent performance.

IV. SODIUM ABSORPTION RATIO (SAR)

The sodium Absorption ratio is an irrigation water quality parameters used in the management of Na affected soils. It is an indicatory of the suitability of water for use in agriculture, as determined form the concentration of the main alkaline an alkaline earth cations present in the water

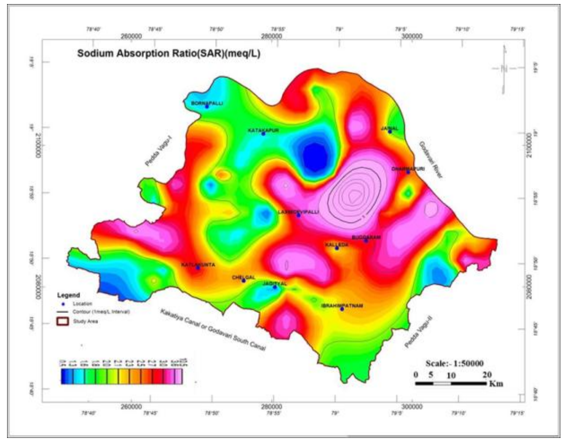
Sodium absorption ratio is a measure of the salinity of the soil determined through quantitative chemical analysis for water in contact with it. An excess of HCO_3^- and CO_3^{2-} ion in water react with Na^+ in soil, resulting in a sodium hazard. The US Salinity Laboratory (1954) gives the following expression

$$SAR = \frac{Na}{\sqrt{(Ca+Mg)/2}} \qquad (1)$$

Although SAR is only one factor in determine the suitability of water for irrigation,in general the higher the SAR,the less suitable for water for irrigation. When SAR is less than 3 there will not acceptable where in sandy soils, but fine textured soils will have severe problem of SAR is greater than 5

Based on the SAR values all samples have low sodium hazard and on plotting over the US salinity map Lab (Figure 2 a & b) the water samples fall in the C1-S2 and C2-S1 classes (post monsoon), C1-S1, C2-S1and C3-S1 classes (pre-monsoon) and hence can be considered moderately suitable for irrigation.

1. Premonsoon



2.Postmonsoon

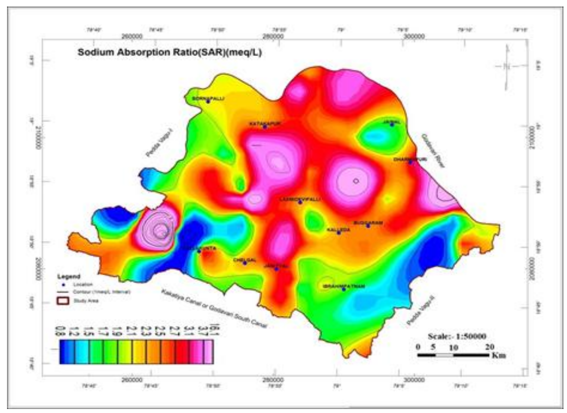


Figure 2 Contour map of Sodium Absorption Ratio (SAR)(a) premonsoon &(b) postmonsoon

The distribution of Sodium absorption in the resent area is shown in Figs 2a and 2b for pre and post monsoon periods respectively. High SAR is noticed Bornapalli, Jagtial, Laxmiidevepally, Kalleda and Buggram villages during premonsoon period with more than 6 and found suitable for irrigation, low ratios and found at Chelgaland Ibrahipatnam (Fig.2a).In the post monsoon period high SAR ratios are observed in Katlkunta, Jagtial and Chelgal regions (Fig.2b).The village Chelgal is moderately suitable for irrigation in Post monsoon and is suitable in premonsoon periods.

V. RESIDUAL SODIUM CARBONATE (RSC)

Residual sodium carbonate (RSC) index for irrigation/soil water is used to indicate the alkalinity hazard of soil. RSC index is used to find the suitability of water for irrigation in clay soils which has 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**.** Eaton (1950) indicated that if waters which are used for irrigation contain excess of CO_3^{--} + HCO_3^- than its equivalent Ca^{++}+Mg^{++}, there will be a residue of Na^+ + HCO_3^- When evaporation takes place the pH of the soil increases to alkanity. RSC is obtained by the following formula.

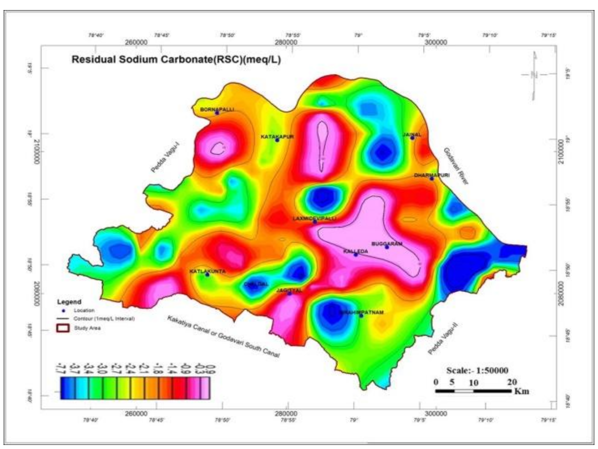
$$RSC = (CO_3^{--}+ HCO_3^-) – (Ca^{++}+ Mg^{++}) \quad (2)$$

Where all the ionic concentrations are expressed in mill equivalents per liter.

In the study area the RSC values range from -9.29 to 1.9 me/l with an average of -2.33 and a standard deviation is of 1.96 in pre-monsoon and during post-monsoon the values varies from -16.56 to 5.1 with an average -3.67 and standard deviation 2.95 (Figure 3(a) and(b). More than > 80% of the water samples contain greater than RSC > 2.5 and this phenomenon indicates that water in this area poses an alkaline hazard to the soil during post-monsoon period. In the pre-monsoon period, 76% of RSC values fall in the save category indicating nonhazardous.

In Pre-monsoon the high values of Residual Sodium Carbonate (RSC) are observed at Bornapalli, Jagtial, Laxmidevipalli, Kalleda, Buggaram and low values at Chelgal and Ibrahimpatnam. In Post-monsoon thehigh values of Residual Sodium Carbonate (RSC) are observed at Katlakunta, Jagtial, Chelgal and Ibrahimpatnam and low values at northeast of Ibrahimpatnam.

1. Premonsoon



2. Postmonsoon

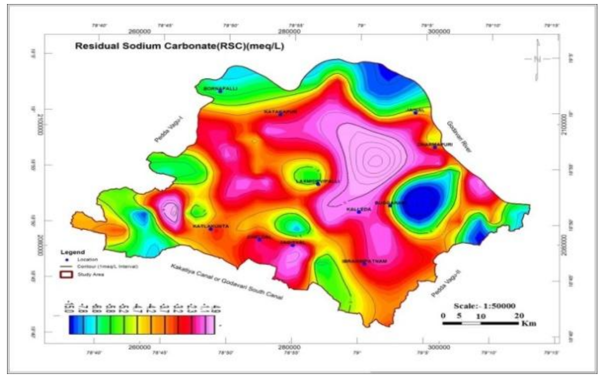


Figure3 Contour map of Residual Sodium Carbonate (RSC) (a) Pre-monsoon (b)Post-monsoon

VI. PERMEABILITY INDEX (PI)

Permeability Index (PI) is a parameter computed to evaluate irrigation water quality (Doneen, 1962) and is given by

$$PI = \frac{(Na+\sqrt{(HCO3)}\times 100}{(ca+Mg+Na)} \quad (3)$$

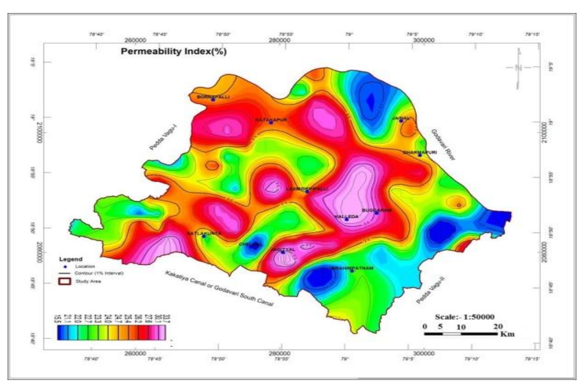
Whereall the ions are expressed in me/l.

From the environmental point of view, a high permeability index, in association with subsurface structural features would facilitate wide spread contamination of groundwater. In pre-monsoon, the PI values ranging from 12.42 to 34.45 with a mean value of 24.92 and with a standard deviation 4.36 (Figure 4(a)) and from 13.77 -34.9 with a mean value of 21.71 and with a standard deviation 4.67 in post monsoon (Figure 4 (b)). Low PI values of less than 20% are noticed and high PI values varying from 60-80% are observed.

In Pre-monsoons high Permeability Index can be seen at Bornapalli, Katkapur, Jagtial, Laxmidevipalli, Kalleda, Buggaram, and low values at Katlakunta, Chelgal and Ibrahimpatnam.

a)

In Post-monsoon the high Permeability Index are



observed at Katlakunta, ChelgalBornapalli, Katkapur, Jagtial, Kalleda, Buggaram and low values at Bornapalli, Jainal and Laxmidevipalli.

b)

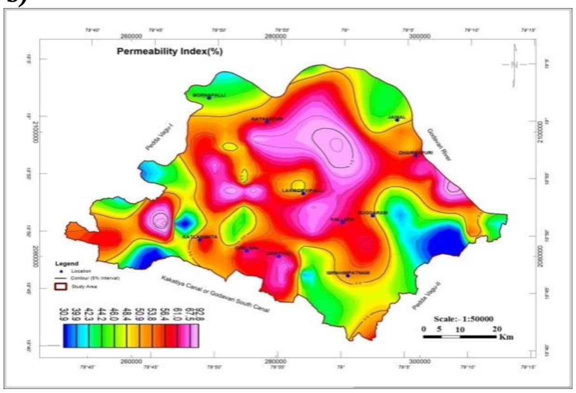


Figure 4(a&b) Contour map of Permeability Index Pre & postmonsoon

VII. GROUND WATER QUALITY INDEX (GWQI)

Groundwater quality normally reflects water-rock interaction. However, this resource is increasingly at risk of contamination from potentially polluting activities on the surface. While chemical analysis yields the physical and chemical composition of water, the water quality index gives an estimate of the quality of drinking water. The GWQI (Brown et al., 1970) was calculated using weighted arithmetic index method and the quality rating / sub index (Qi) corresponding to the i^{th} parameter Pi is a number reflecting the relative value of this parameter. Qi is calculated by using the following expression.

$$Qi = \frac{(Mi - li)}{(Si - li)} \times 100 \qquad (4)$$

Unit weight of the parameter Wi = K/Si

$$K = \frac{1}{(1/s1)+(1/s2)+(1/s3)+----------+(1/si)} \qquad (5)$$

s1, s2, s3,-----, si are standard values of various parameters from 1,2,3,---i.

Mi = Estimated value of the i^{th} parameter in the laboratory

li = Ideal value of the i^{th} parameter

li = 0 for all the parameters except pH , which is 7.0.

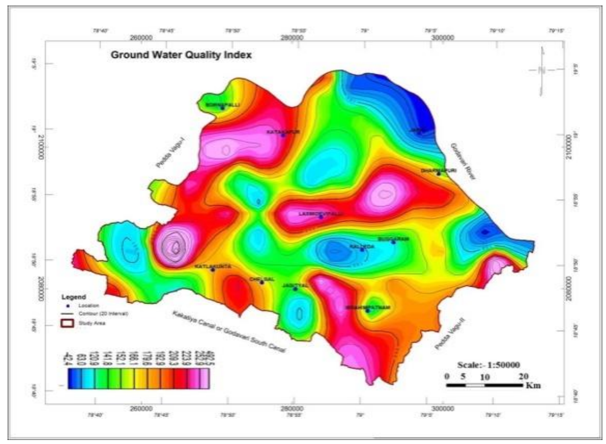
The overall GWQI was calculated by aggregating the quality rating (Qi) with the unit weight (Wi) linearly:

$$GWQI = \left[\frac{\sum_{i=1}^{n}(QiWi)}{\sum_{i=1}^{n}(Wi)} \right] \qquad (6)$$

It is to be noted that parameter selection in calculating WQI has great Importance and consideration of too many parameters might widen the quality index. In this study, the GWQI is considered for drinking purposes and the permissible value for the index is 100, and more than 100 indicates contamination of groundwater.

In the study area GWQI values range from 42.00-345.2with a mean value of 127.54 and standard deviation is of 66.68 in pre-monsoon (Figure 4(a)) and 40.68-464.8 with a mean value of 142.51 and standard deviation is of 75.80 in post-monsoon (Figure 4.(b).

1. Premonsoon



2. Postmonsoon

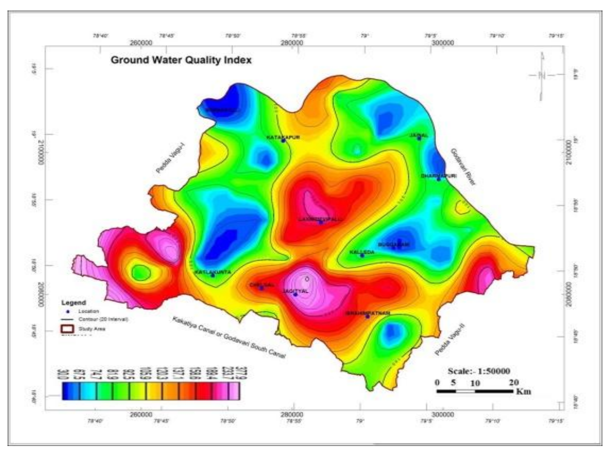
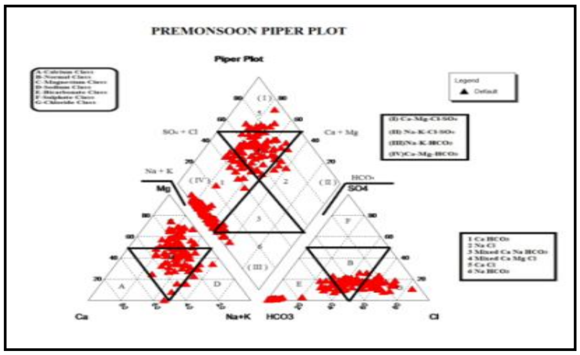


Figure 5 Contour map of Ground WaterQuality Index for (a) Premonsoon& (b) Post-monsoon

Pre-monsoon, the Ground Water Quality Index high values are observed at Jagtial, Ibrahimpatnam, Chelgal, Laxmidevipalli and low values at Buggaram, Dharmapuri, Bornapalli and katlakunta. In Post-monsoon the Ground Water Quality Index high values are observed at Chelgal, Laxmidevipalli, Katkapur and low values at Kalleda, Buggaram, Dharmapuri, Ibrahimpatnam and Jainal.

VIII. PIPER TRILLINEAR METHOD

The Piper Trilinear map (Piper, 1953) is one of the most useful graphical representations of groundwater quality. It helps in understanding the geochemistry of shallow groundwater by bringing out the chemical interrelationships in large sample groups in more definite terms than with the other plotting methods. Fig 5(a) & (b) are the Piper Trilinear maps for the data obtained from chemical analysis of 99 groundwater samples from the study area for the pre-monsoon & post-monsoon period.



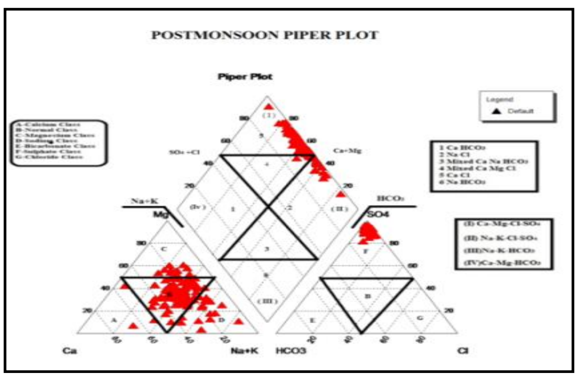


Figure 6(a)&(b) Piper trillinear diagrams for (Pre &Postmonsoon)

These plots include two triangles, one for plotting cations and another for plotting anions. The anions and cations are combined to show a single point in a diamond–shaped field from which inference is drawn on the basis of hydro-geo chemical facies concept. The clustering of data points indicates samples that have similar compositions.

In pre-monsoon most of the samples are fallen in mixed CaMgCl Type and 4 samples are in block II and 20% of samples in block IV and 3% of the samples are fallen in block III.

In post-monsoon most of the samples are fallen in block I and remaining are in block II. Thus we see that ground water in the region is significantly dominated by the alkalis(Na+K) as compared to the alkaline earths (Ca+Mg), likewise the strong acids (So_4 &Cl) exceed the week acids (HCO_3).

IX. WILCOX METHOD

To classify groundwater suitability for irrigation Wilcox (1955) gave a map with sodium content (expressed as % sodium) and electrical conductivity as determining parameters. The Wilcox plot is a simple scatter plot of sodium hazard (SAR) vs. salinity hazard (conductivity, plotted on a log scale).

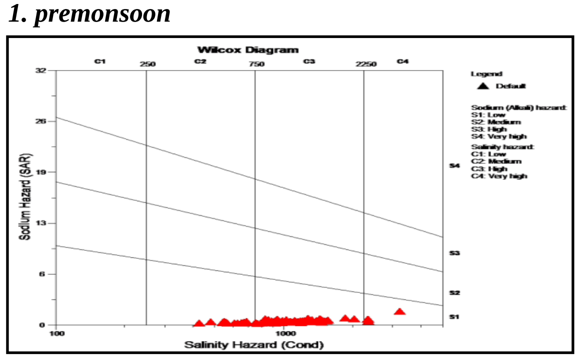
The Wilcox map (Figure 6) indicates that about 96 of the samples in the study area fall under the C2, C3 and 3 samples in C41 class, i.e., the low sodium and high salinity hazard.

The data plotted is of Wilcox map, shows the Sodium (alkali) hazard and salinity hazard during the pre-monsoon period 2014-15. The graph reveals that in the study area all (99) samples are falling in S1 i.e., low sodium alkali hazard in the area. Two samples are in the very high salinity hazard which indicates with a symbol C4 in the graph and 75% of the samples in high salinity hazard zone and remaining samples are in the medium salinity hazard zone.

The graph is the Wilcox map which shows the post monsoon 2014-15 season of the study area shown in Figure 6 (a & b) one sample is in very high sodium alkali hazard S4 block and four samples are in medium sodium alkali hazard zone (S2) and rest of the samples are in low sodium alkali hazard zone (S1).Regarding salinity hazard, three samples are in very high salinity hazard zone (C4) and 75% are in high salinity hazard zone (C3) and remaining samples are in medium salinity hazard zone (C2).

Comparative study of ground water at pre-monsoon and post-monsoon 2014-15 indicates the salinity and sodium alkali hazard from pre-monsoon and post-monsoon.

1. premonsoon



2. postmonsoon

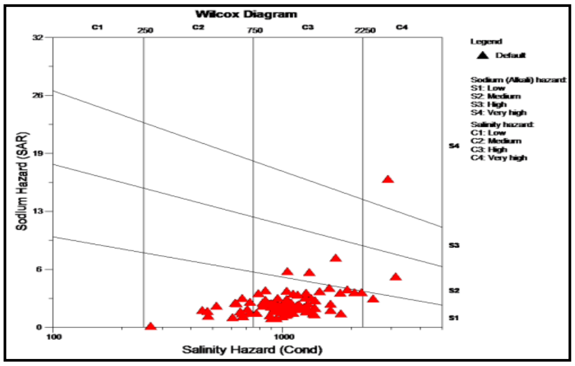


Figure 7(a&b) Wilcox plots for ground water sample (Pre&post monsoon).

X. CORRELATION MATRIX

To examine the degree of correlation (if any) between the different chemical parameters affecting the quality of groundwater, the correlation matrix between the different components was computed (Table 2. (a)& (b)).

A best correlation is observed between TDS and EC, which is equal to 1 and TH-Mg, TDS and Cl^-. Likewise, a strong correlation is also observed between TH and EC, Mg^{++} and EC, and Ca^{++} and EC as also between Ca^{++} and TH, Mg^{++} and TH, and Ca^{++} and Mg^{++}. However, the correlation of TDS with Ca^{++}, Mg^{++} and TH is only moderate.

A marginal negative correlation is seen between the pH and all other parameters, except potassium. The presence of certain cations appears to preclude to an extent the occurrence of other cations; a small negative correlation is observed between NO_3^- and alkalinity and NO_3^- and Cl^-, as also between Na^+ and TH and Na^+ and Mg^{++}. The wide variation in the correlation coefficients suggests an irregular pattern of groundwater contamination/pollution

Table 2 (a) & (b) Correlation Pair (Pre&Post-monsoon) of Geochemical in the study area.

(a)

	pH	*EC*	*TDS*	*HCO_3*	*Cl*	*NO_3*	*SO_4*	*Na*	*K*	*Ca*	*Mg*	*TH*
pH	1											
EC	0.16	1										
TDS	0.16	1	1									
HCO_3	-0.01	0.58	0.58	1								
Cl	0.12	0.85	0.85	0.24	1							
NO_3	0.09	0.48	0.48	-0.14	0.54	1						
SO_4	0.22	0.72	0.72	0.26	0.69	0.45	1					
Na	0.25	0.78	0.78	0.48	0.63	0.23	0.66	1				
K	0.02	0.31	0.31	0.30	0.20	0.09	0.18	0.22	1			
Ca	-0.14	0.44	0.44	-0.02	0.46	0.45	0.34	0.15	0.14	1		
Mg	0.07	0.53	0.53	0.29	0.52	0.36	0.39	0.17	0.04	0.03	1	
TH	-0.01	0.68	0.68	0.24	0.68	0.53	0.50	0.22	0.10	0.54	0.86	1

(b)

	pH	EC	TDS	HCO_3	Cl	NO_3	SO_4	Na	K	Ca	Mg	TH
pH	1											
EC	-0.07	1										
TDS	-0.073	1	1									
HCO_3	-0.099	0.59	0.59	1								
Cl	-0.090	0.83	0.83	0.21	1							
NO_3	-0.085	0.56	0.56	0.19	0.45	1						
SO_4	-0.076	0.89	0.89	0.46	0.76	0.44	1					
Na	-0.001	0.88	0.88	0.55	0.72	0.38	0.82	1				
K	0.090	0.50	0.50	0.25	0.32	0.40	0.45	0.33	1			
Ca	-0.128	0.33	0.33	0.18	0.26	0.54	0.29	0.24	0.09	1		
Mg	-0.171	0.57	0.57	0.39	0.47	0.25	0.44	0.35	0.18	-0.2	1	
TH	-0.074	0.55	0.55	0.30	0.47	0.43	0.45	0.37	0.15	0.3	0.6	1

Table 2 (c) & (d) Correlation Matrix Pair (Pre&Post-monsoon) of Geochemical in the study area.

(c)

Best Correlated	**Godd Correlated**	**Moderately Correlated**	**Negative Correlated**
r > 0.8	**r = 0.5 to 0.8**	**r = 0.3 to 0.5**	**r< 0**
TDS-EC=1	NO_3-TDS=0.56	Mg-So_4=0.44	pH - EC = -0.073
So_4-EC=0.89	Mg-TDS=0.57	K-So_4=0.45	pH -TDS = -0.073
So_4-TDS=0.89	TH-TDS=0.55	T.H-So_4=0.45	pH -HCO_3= -0.099
Na-EC=0.88	TH-Mg=0.6	K-na=0.33	pH -CL= -0.090
Na-TDS=0.88	Ca-NO_3=0.54	Mg-Na=0.35	pH -NO3 = -0.085
Cl-TDS=0.83	So_4-CL=0.77	T.H-Na=0.37	pH- So_4= -0.0764
Cl-EC=0.83	Na-cl=0.72	TH-Ca=0.3	pH -TH = -0.074
Na-So_4=0.82	Na-HCO_3=0.55	T.H-NO_3=0.43	
	SO_4-HCO_3=0.46	k-No3=0.40	
	K-TDS=0.5	Na-NO_3=0.38	
	HCO_3-TDS=0.59	So_4-NO_3=0.44	
	TH-EC=0.55	TH-CL=0.47	
	MG-EC=0.57	Mg-cl=0.47	
	K-EC=0.50	K-cl=0.32	
	NO3-EC=0.56	NO3-Cl=0.45	
	HCO_3-EC=0.59	TH-HCO_3=0.30	
		Mg-HCO_3=0.39	
		Ca-TDS=0.33	
		Ca-EC=0.33	

(d)

Best Correlated	Godd Correlated	Moderately Correlat	Negative Correlated
r > 0.8	r = 0.5 to 0.8	r = 0.3 to 0.5	r <0
TDS-EC=1	T.H-Ca=0.542	Mg-Ca=0.0336	pH -TDS =-0.073
TH-Mg=0.86	T.H-So_4=0.505	Mg-So_4=0.39	pH -HCO_3= -0.01
Cl-TDS=0.851	T.H-NO_3=0.533	Ca-So_4=0.34	pH -Cl= -0.090
Cl-EC=0.85	T.H-Cl=0.67	Mg-NO_3=0.36	pH -NO_3 = -0.085
	NO_3-Cl=0.545	Ca-NO_3=0.45	pH -So_4= -0.0764
	Mg-Ec=0.535	S04-NO_3=0.45	pH -NA= -0.001
	TH-EC=0.68	K-HCO_3=0.30	pH -Ca= -0.14
	So_4-EC=0.72	K-TDS=0.31	pH -Mg= -0.171
	Na-EC=0.78	NO_3-TDS=0.48	pH -TH=-0.01
	So_4-TDS=0.722	K-EC=0.31	Mg-Ca= -0.2
	Na-TDS=0.78	NO_3-EC=0.48	Ca-HCO_3= -0.02
	TH-TDS=0.68		

XI. DISCUSSION

Chemical analysis of the 99 groundwater samples collected from study area, it is seen that the entire region having high values of parameters both in pre-monsoon and post-monsoon. It is evident that the majority of the samples are influenced by domestic sewage that has led to deterioration in the quality of the resource and now poses a serious health hazard.

The Quality of groundwater in the central part of area appears to be contaminated in the areas Chelgal, Laxmidevipalli and Jagtial and in the westernpart near the Peddavgu and Kakatiya canal areas. All the areas more than EC, TDS, SO_4^{--}, NO_3^-, Na^+, Ca^{++}, Mg^{++} and TH in ground water. Excessive values of TDS and TH were found over the entire study area, other than lakes and surface water bodies. TH is within permissible limits, some parameters like high correlation, viz., TDS and EC &Cl^-; EC and TH; Ca^{++} and Mg^{++}. The hardness of the groundwater may be mainly from surface water, which shows that anthropogenic activities are also the reason for high calcium and magnesium concentrations.

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