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Geochemical variations of groundwater quality during Pre and Post monsoon seasons in the Jagityal district, Telangana State, India

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Abstract:*A total no of 107 groundwater samples, collected during pre and post monsoon seasons in 2014-15 from southern western part of Godavari river basin in Jagityal district, Telangana State, India is located in the lies between the North latitudes 18^0 30' N and 19^0 5'N and east longitudes between 78^0 30' E and 79^0 35' E. The samples collected from the boreholes were analyzed for varied parameters like hydrogen ion concentration (pH), Total dissolved solids (TDS) , Total Hardness (TH), Electrical conductivity (EC) and constituents such as Potassium (K^+), Chloride (Cl), Nitrates (NO3), Sulfate (SO_4), Sodium (Na) and Calcium (Ca) are computed, contoured and analyzed to work out the realm of groundwater quality. Analytical results ascertained from numerous indices revealed that the ground water quality is good in some place. The ascertained chemical variations in Pre-monsoon and Post-monsoon seasons is additionally effect of rock , water interactions, ion-exchange reactions, and runoff of fertilizers from the encompassing agricultural fields.*
Key words*: Ground water Samples, Total dissolved solids (TDS), Total Hardness (TH), Groundwater Quality*

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I. Introduction

Groundwater quality is a vital concern for human beings since it's directly linked with the human welfare and it's needed to conserve water resources, once groundwater is contaminated, it's terribly tough to revive its quality. Therefore, there is a desire and concern for the protection and management of groundwater quality. Water quality analysis of groundwater contains determination of its physical, chemical and organic characteristics, from that its suitability for drinking, irrigational, industrial and different purposes (Subramaniam et al., 2005; Srinivasamoorthy et al., 2013; Udayalaxmi and Ramadass 2013; Abraham Ponsingh and Maharani, 2015) evaluated. Water quality parameters like pH, Electrical Conductivity (EC), Total dissolved solids (TDS), Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca), Chloride (Cl), Nitrate (NO_3), Sulfate (SO_4), Total Hardness (TH) were analyzed within the Jagityal district, T.S study region.

II. Study area

The study area falls in the Jagityal district, Telangana State, India is located in the south western part of Godavari river basin lies between the North latitudes 18^0 30' N and 19^0 5'N and east longitudes between 78^0 30' E and 79^0 35' E, which covers the total area of almost 141934 (ha), locate in the Indian peninsular shield and consist of the northern parts of erstwhile Karimnagar district, presently Jagtial district in Telangana State, India (Figure.1). Physiographically, the area under study is moderately undulating with sporadic exposures with a gradual relief towards the northeast i.e., towards the river Godavari the highest elevation is 300m and lowest elevation is below 160m with respect to the mean sea level.

Groundwater quality assessment is made possible by collecting 107 samples from the study area (Figure .1) from Pre-monsoon and Post-monsoon period during the year 2014-15. The well locations from where the water samples gathered marked through (geographic coordinates- longitude and latitude) of the sampling points were GPS (Global Positioning System).

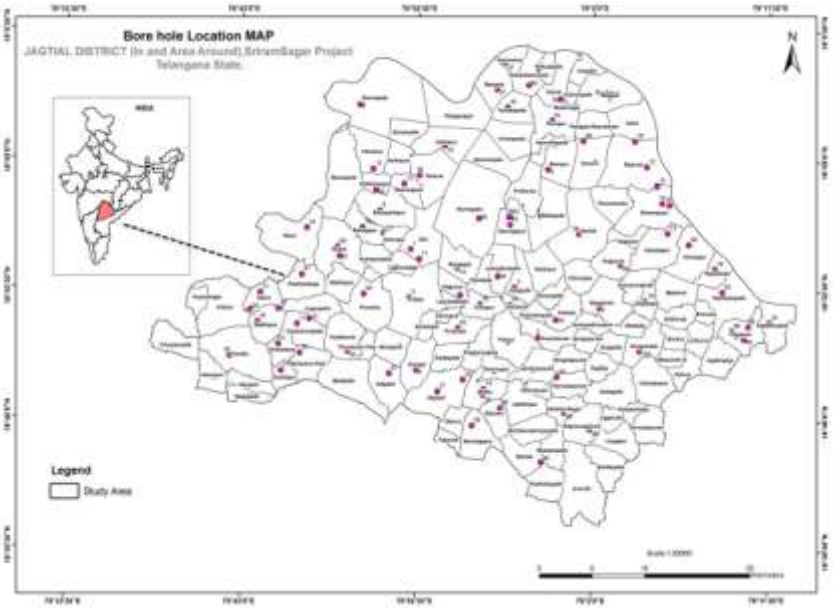

Figure .1 Groundwater sample (Boreholes) location map of the study area.

Geochemical Analysis

The groundwater samples collected from the study areas were analyzed for the parameters like pH, TDS, TH, EC and constituents such as K^+, Na^+, Mg^{++}, Ca^{++}, F^-, Cl^-, SO_4^{--}, NO_3^-, HCO_3^- by standard methods in the geochemical laboratory of the National Geophysical Research Institute (NGRI), as per the standard procedure for American Public Health Association (Browen et al., 1974; APHA 1985 & 1998).

In the following table-1 summarized the evaluated statistical parameters namely minimum(min), maximum (max), mean and standard deviation (S.D) values for each of the measured constituents, for pre-monsoon and post-monsoon of the ground water samples from study area are discussed with reference to international quality parameters in detail. Ground water quality data processed for the spatial distribution to understand the Surplus and deficit conditions and their suitability for various applications.

Table-1: Statistical Analyses of Groundwater Samples in Study Area

Pre monsoon: 2014-15

Parameter	Minimum	Maximum	Average	Standard Deviation	Permissible limit (BIS1983)
pH	6.56	9.03	7.96	0.4	6.5 - 8.5
E C	427	3249	1105.97	435.36	1000-1500
HCO_3	60	600	245.45	87.1	
TDS	273.28	2079.4	707.82	278.63	500-1000
T. H	139.96	1092.5	324.07	132.51	300-600
Na	32	511	103.15	59.81	200
K	0	208	21.62	36.69	---
Ca	8	192	52.53	23.23	75
Mg	0	145.86	44.68	24.94	<30
Cl	30	390	126.77	79.41	250
NO_3	0.27	46.59	10.89	8.41	45
SO_4	25	370	74.03	48.53	150- 250
F	0.16	1.87	0.43	0.683	0.6-1.2
SAR	0.83	10.5	2.51	1.23	
RSC	-9.29	1.9	-2.33	1.96	
P.I	12.42	34.5	24.92	4.36	
GWQI	42	345.2	127.54	66.68	

Post-Monsoon:2014-15

Parameter	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	2007.7	718.62	297.85	500-1000
T. H	139.98	959.8	365.68	137.89	300-600
Na	2	582	112.03	71.78	200
K	1	294	15.8	38.15	---
Ca	24	176	59.46	28.23	75
Mg	4.86	141	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	41.6	150- 250
F	0.03	2.78	0.8	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	75.8	

i) Hydrogen Ion Concentration (pH)

The Hydrogen Ion concentration (pH) can demarcate the acidity and alkaline state of water and is an important parameter for determining the geochemical conditions and equilibrium (Hem, 1991; Satish Kumar et al., 2007). It influences many chemical and biological processes within a water body. The pH values of groundwater in the study area for Pre- monsoon period (Fig .2 (a)) range from 6.56 to 9.03 with an average

of 7.96 and the standard deviation of 0.40 and for Post-monsoon (Fig. 2 (b)) it varying 6.9 to 8.92 with an average of an 8.05 and standard deviation is of 0.36 against permissible limits of 6.5 to 8.5 (BIS, 1983).
The pH value is less than <7 in Jainal, Ibrahimpatnam, above the area of Bornapalli, west side Katlakunta in pre-monsoon and Jainal, Kalleda, Buggaram, Velgatoor, jagtial and ibrahimpatnam villages in Post- monsoon season. Thus, the groundwater samples are at places slightly more basic than acceptable limits, Values of over 7.7 are noticed 75% study area, low values occurred with a narrow zone in the central part of the area in pre-monsoon and post monsoon seasons.

(a) Pre-Monsoon (b) Post-Monsoon

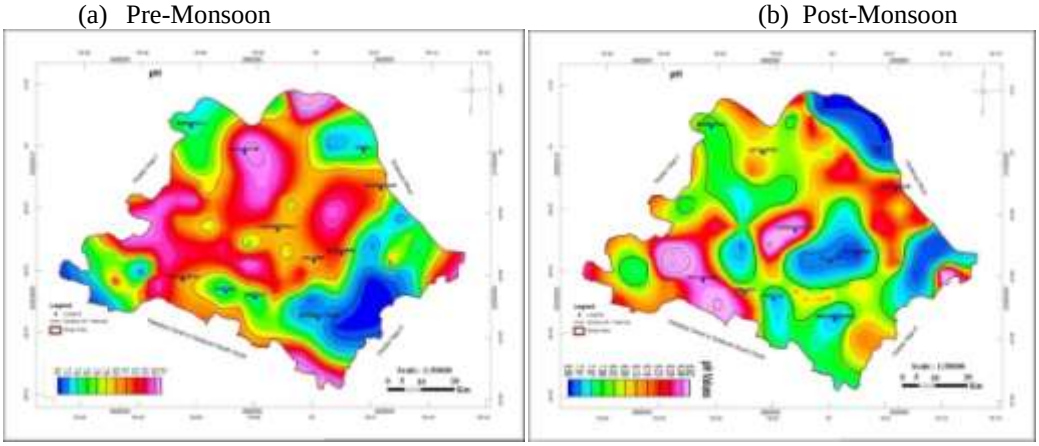

Figure 2 (a & b) Contour map of pH (Pre &Post-monsoon)

ii) Electrical Conductivity (EC)

The electrical conductivity (EC) is a measure of ionic concentrations in water and thus reflects the quality of groundwater. The electrical conductivity (EC) in the study area Figure 3 (a) varies from to 427-3249 µS/cm, average is of 1105.97 µS/cm, with a standard deviation of 435.36 µS/cm for (in pre -monsoon), and the EC values range from 269 to 3137µS/cm (Figure .3 b) (in post- monsoon) with an average of 1122.85 µS/cm with a standard deviation of 465.39 µS/cm at 25^0 C .

In the figure 3 (a) & (b) blue to green colour indicate low conductivity at Bornapalli, Jainal, Jagtial, Kalleda villages during pre-monsoon and Ibrahimpatnam, Jagtial, Chelgal, Bornapalli, Katkapur villages are with low values of EC during the post monsoon seasons. The pink to red colour regions exhibiting higher values of EC that exceed permissible limits. There is no significant variation in the distribution of EC in both pre-monsoon and post monsoon periods.

(a) Pre-Monsoon (b) Post-Monsoon

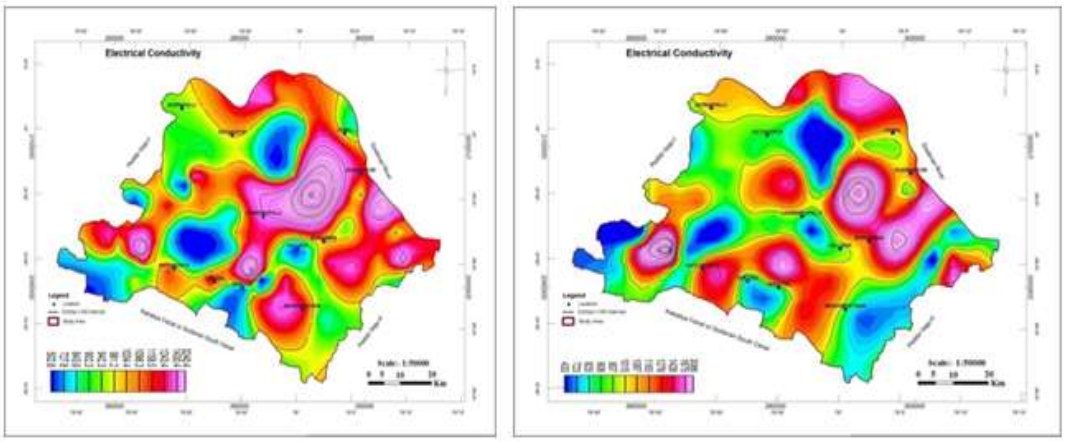

Figure. 3 (a & b) Contour map of electrical conductivity (EC) - (Pre&post-monsoon)

Total dissolved solids (TDS)

The TDS gives the general nature of groundwater quality and the extent of contamination if any (with high TDS) (Annon, 1946; Robinnove et.al., 1958; AWWA, 1998). In general, if TDS is found < 1000 mg/l are considered as fresh water and > 1000 mg/l are considered saline. TDS in the study area (Fig.4(a) in pre-monsoon) varies from to 273.28-2079.4 mg/l, average of 707.82 mg/l, with a standard deviation of 278.63 and ranging from 172.16 to 2007.7mg/l with an average of 718.62mg/l with a standard deviation of 297.85mg/l (Figure 4. (b) post- monsoon).

The measured TDS values in the study area contoured with an interval of 100 mg/l are shown in Figure 4 (a) & (b). As seen from the figure it is noticed that the values with min to max below 1000 mg/l are indicated with blue to red colour both in pre-monsoon and post-monsoon. Low TDS values i.e., 300-600 mg/l are noticed in the Bornapalli, Jainal, Katkapur, Kalleda, Jagtial in pre-monsoon and Laxmidevipalli, Kalleda, Jagtial, Chelgal in the post-monsoon.

The TDS values are almost having same average values both in pre-monsoon (707.82 mg/l) and post-monsoon (718.62 mg/l). It implies that in pre-monsoon except in few locations the ground water is potable and safe for drinking and other domestic uses.

The concentration of elements that increase the TDS of groundwater are HCO_3^-, SO_4^{--}, NO_3^- and chlorides of Ca^{2+}, Mg^{2+}, Na^+ K^+ and silica. These ions comprise about 90% of the total dissolved solids in naturally occurring water and groundwater. The concentration of TDS is found to increase in the downstream, possibly due to topography gradient, deposition of silt due to erosion and transportation (Freeze and Cherry, 1979) and floods along drainage channels and tanks, as also due to industrial and municipal waste disposal.

(a) Pre-Monsoon (b) Post-Monsoon

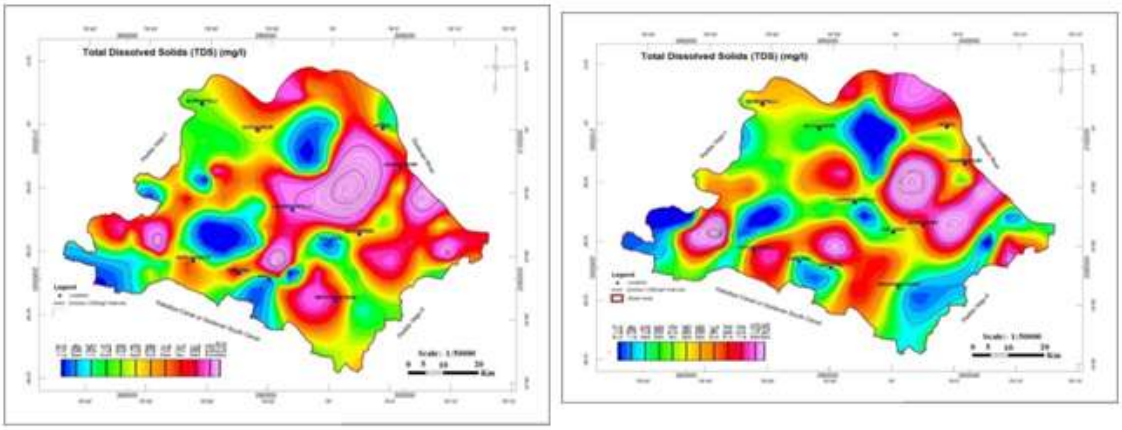

Figure 4 (a&b)Contour map of TDS (Pre&postmonsoon)

iv) Chloride

The source of chloride in groundwater is mainly from the weathering of crystalline rocks (Sunitha et al., 2002, Satish Kumar et al., 2007, Nagaraju et al.,2016) and domestic sewage or industrial effluents (Karanth, 1987). The anion is derived from minerals like sodalite, apatite, micas and hornblende in a rock matrix. Acceptable limit of chloride in drinking water is 250mg/L (1000 mg/L in case of no other alternative source (BIS, 2012). Surprisingly, concentration of chlorides are high in Laxmidevipalli, Buggaram, Ibrahimpatnam, Jainal (Fig. 5(a)) during Pre-monsoon and Bornapalli, Jainal, Buggaram villages having high chloride values in post-monsoon in figure 5(b). Chloride concentrations in the groundwater samples in the study area range from 30 to 390.mg/L and 10 to 470mg/L in Pre and post-monsoon respectively with an average of 126.77 mg/l ,with standard deviation of 79.41(in pre-monsoon) and an average of 148.35 mg/l with a standard deviation of 91.86mg/l (in post-monsoon). Northeastern parts of the study area are marked with higher than permissible limits, where the lithology is limestone and other Sullavais and stones.

(a) Pre-Monsoon (b) Post-Monsoon

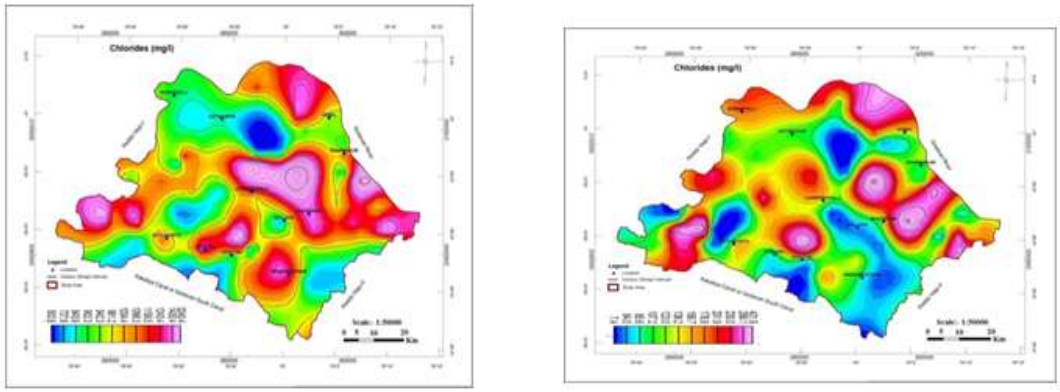

Figure .5 (a&b) Contour map of Chloride (Pre&Post monsoon).

v) Sulfate

Sulfates occur naturally in water as a result of leaching from surrounding rocks. Sulfates in the ground water are primarily due to the presence of sulfate minerals in the soil (gypsum and other common minerals), acid rain precipitation and application of fertilizer. Excess sulfate consumption through water might lead to occurrence of diarrhea in humans. Excess Sulfates in groundwater to the WHO limit of 150 mg/l are seen at several places in the study area. Sulfate concentration in the study area (Figure 6(a) and 6(b)) ranging from 25 to 370mg/l (Fig. 6 a) (in pre- monsoon) with an average of 74.03mg/l with a standard deviation of 48.53mg/l, varies from to 29-235 mg/l, average of 106.93mg/l ,with standard deviation of 41.60(in post monsoon).

The higher concentrations of Sulfates observed (Fig. 6 (a)) in Ibrahimpatnam, Bornapalli, west of the Katlakuntaand Dharmapuri. Low Sulfate concentration is noticed in Katkapur, Jagtial and northwest of Katlakunta areas. In post monsoon the villages in and around Katkapur, Jainal, Jagtial are observed with high values in the study area and the low values observed in the parts of Kalleda, beside Katlakunta and Dharmapuri (Fig. 6 (b)). Higher concentration peaks of red colour occur during pre-monsoon season and many red spots found in the eastern region, lower concentrations with green colour occur in the post monsoon are evident in the study area.

(a) Pre-Monsoon (b) Post-Monsoon

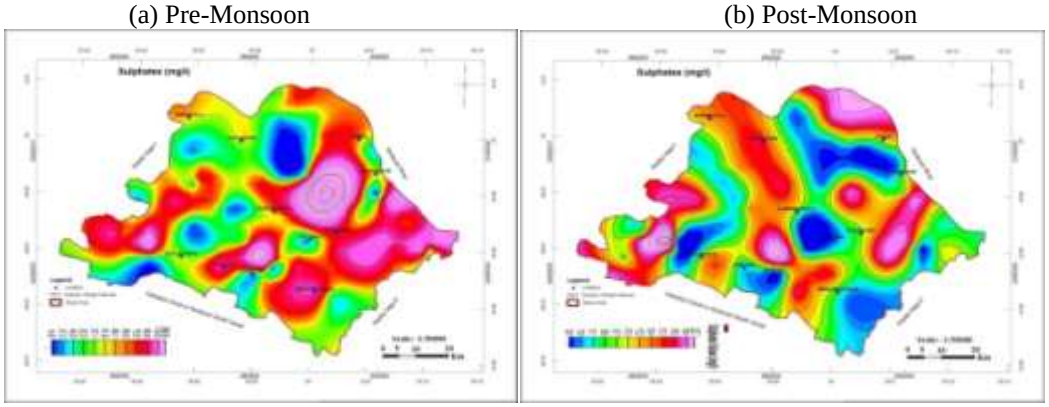

Figure.6 (a&b) Contour map of Sulfate (Pre&Post-monsoon).

vi) Nitrate

Nitrate in natural water is from the organic sources or from industrial and agricultural discharges (Feth, 1966). Nitrogen is an essential constituent of protein to all living organisms, nitrate concentrations of greater than 45 mg/l become toxic and can cause Cyanosis (Vigil et al., 1965 and Young et al., 1976) or the 'blue baby syndrome' (metheloglobenemia) where bottle feeding is practiced. It may also lead to development of cancer in adults (Gass, 1978WHO, 1984). Nitrates in the study area (Fig.7 (a)) varies from to 0.32-57.27mg/l, average of 11.78 mg/l, with a standard deviation of 9.92 (in post-monsoon), ranging from 0.27 to 46.59 mg/l (Fig .7 (b)) (in pre monsoon) with an average of 10.89 Mg/l with a standard deviation of 8.41mg/l (pre-monsoon).

During pre-monsoon the high values are seen in Katkapur, Laxmidevipalli, Katlakunta, Chelgal, Ibrahimpatnam and low values are found in Kalleda, Jagtial, andKatlakunta. In Post monsoon high nitrates accumulation is seen in Bornapalli, Jainal, Buggaram, Katlakunta, Ibrahimpatnam and the low values shows in

Chelgal, Jagtial and dharmapuri areas. The concentration of nitrate in groundwater in the study area is greater than 45 mg/l are marked with red to pink color in post and pre monsoon seasons (Fig .7 (a) & (b)). High nitrate values noticed in the vicinity of water bodies indicates lake water seepage into the groundwater regime.

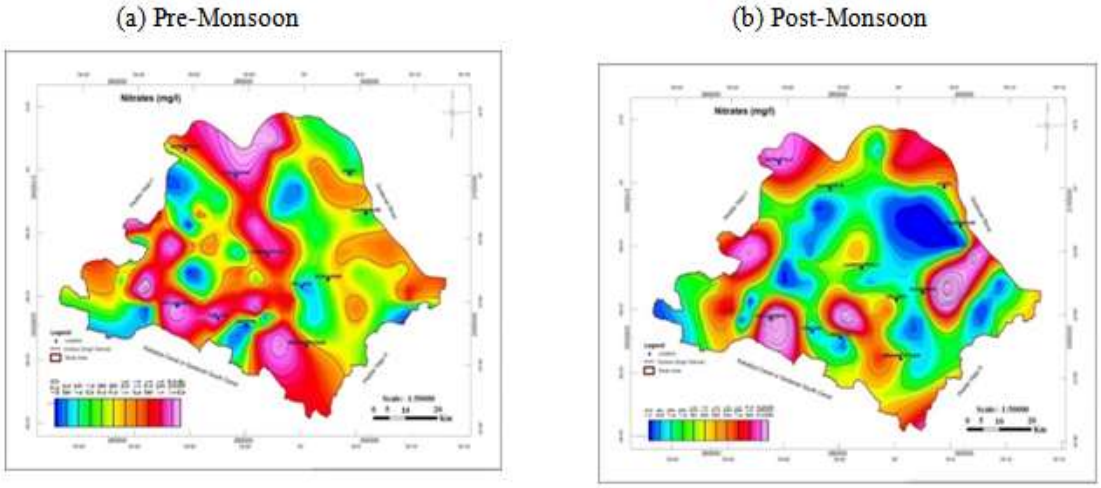

Figure 7 (a&b) Contour map of Nitrates (Pre& Post-monsoon).

vii) Fluoride

Fluoride is also a common element in the earth's crust and is present in groundwater naturally as trace concentrations to 0.5 mg/l. Enrichment in groundwater may also take place through leaching and weathering of fluoride bearing minerals present in rocks (Handa, 1975). According to UNESCO specifications, water containing more than 1.5 mg/l of fluoride can cause mottled tooth enamel in children, also lead to dental and skeleton fluorosis.

Fluoride concentrations in the study area (Fig .8 (a)) ranges from 0.16 to 1.87mg/l with an average of 0.43 mg/l and standard deviation of 0.683mg/l (pre monsoon). The concentration of fluoride in the study area ranges between and from0.03 to 2.78 Mg/l, in post monsoon with an average of 0.80 and standard deviation 0.53.

During pre-monsoon period the areas Chelgal, Ibrahimpatnam, Bornapalli villages shows low values in the study area. Buggaram, Katkapur, Katlakunta, Laxmidevipalli and Jainal villages exhibited high fluorides values indicates with red to pink colour in the study area.

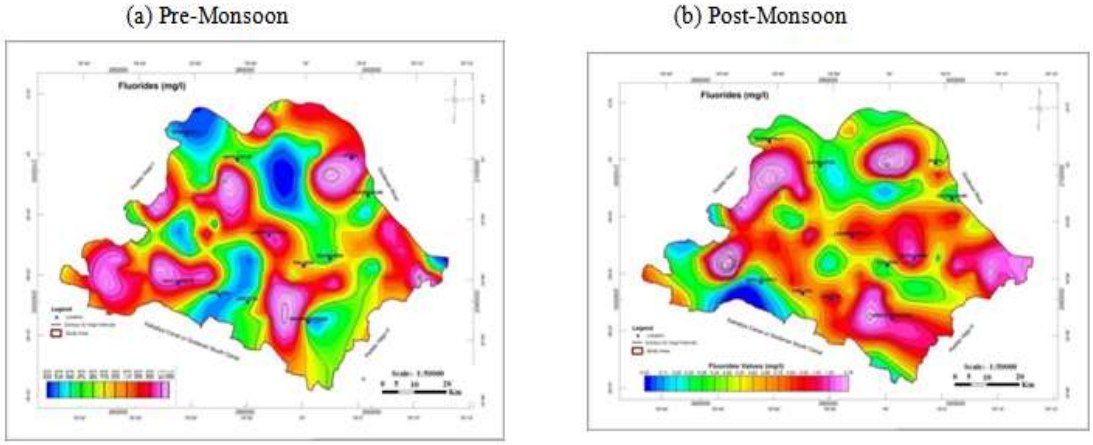

Figure.8 (a&b) Contour map of Fluoride (Pre&Post-monsoon)

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In post monsoon the high flouride values in the study area (Fig.8(b), which shows pink to red colour are Jagtial, Ibrahimpatnam, Chelgal, Laxmidevipalli, Buggaram, and the moderate fluoride values (green colour) are seen the villages such as Kalleda, Katkapur, Dharmapuri, Jainal. The village Katlakunta and some of the small patches are shown in the study area with low values which shows in blue colour. Fluorides values are high in post-monsoon compared to pre-monsoon in the study area.

viii) Potassium

Ionic potassium (K^+) occurs at fairly low concentrations in groundwater (Sravanthi and Sudarshan, 1998) and is derived from weathering of the mostly stable orthoclase, microcline feldspars and biotite minerals present in the granites of the area (Satish Kumar et al., 2007). However, excessive fertilizer additions can increase its concentration in surface water as well as groundwater. Potassium in the study area (Figure .9 (a)) varies from to 0-208 mg/l, average of 21.62 mg/l, with standard deviation of 36.69 (in pre-monsoon), ranging from 1-294 mg/l (Fig .9 (b)) (in post-monsoon) with an average of 15.80mg/l with standard deviation of38.15mg/l.

During pre-monsoon period Potassium concentration is high and shown in pink to red colour at Katlakunta and around Katkapur, Laxmidevipalli, Jainal, and the low values shows light blue colour to thick blue colour shows Ibrahimpatnam, Buggaram, Chelgal areas. In post monsoon Katlakunta, Chelgal Jagtial, Laxmidevipalli, jagtial shows high potassium values in the study area. The low potassium context shows with blue colour and covers in the areas like Ibrahimpatnam, Katkapur, Bornapalli and Kalleda areas.

(a) Pre-Monsoon (b) Post-Monsoon

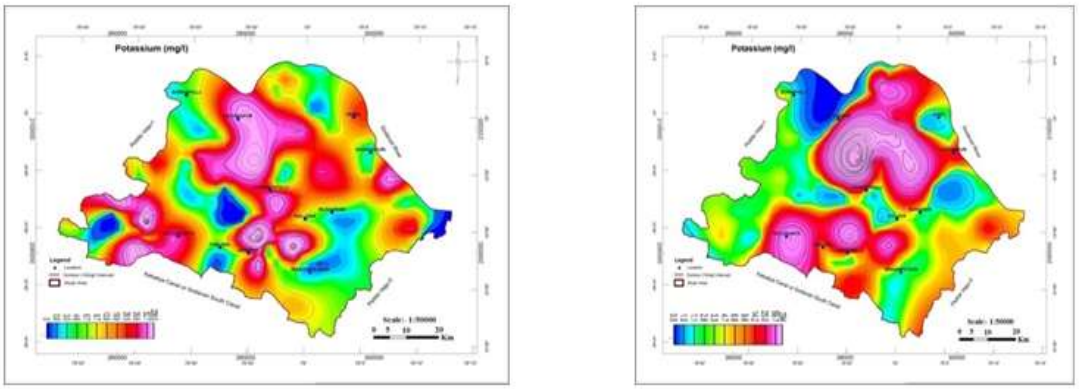

Figure .9 (a&b) Contour map of Potassium (Pre&Post-monsoon).

In general most of the study area is represented with low/below average concentration of potassium in the entire year. The Potassium values are high in post-monsoon (Fig.9(b) compared to pre-monsoon in the study area. Excessive fertilizer usage can increase its concentration in surface as well as groundwater, anomalously high potassium concentrations are indicative of sewage contamination.

ix) Sodium (Na)

The primary source of sodium in natural water is from the release of soluble products during the weathering of plagioclase feldspars minerals associated with gravities. Sodium concentration in groundwater (Fig. 10a) was found and vary from 2 to 582 mg/l, with a mean value of 112.12 mg/l, standard deviation of 72.15 in post monsoon and 32 to 511 Mg/l with an average value of 103.15mg/l, with a standard deviation of 59.81 mg/l during the pre-monsoon. The permissible limit is 200ppm in the study area, 50% of the area is having more than permissible limit of sodium.

In pre-monsoon, high sodium concentrations are observed at Laxmidevipalli, Buggaram, Dharmapuri, Ibrahimpatnam and low concentrations shows at Jainal, katkapur, Jagtial, Katlakunta regions (Figure 10(a). Figure. 10 (b) drawn for high sodium concentrations for post-monsoon at Bornapalli, Katkapur, Laxmidevipalli, Jagtialare. The low values cover areas like Katlakunta beside Ibrahimpatnam area Jainal. The high values of Sodium are approximately equal in both pre-monsoon & post monsoon.

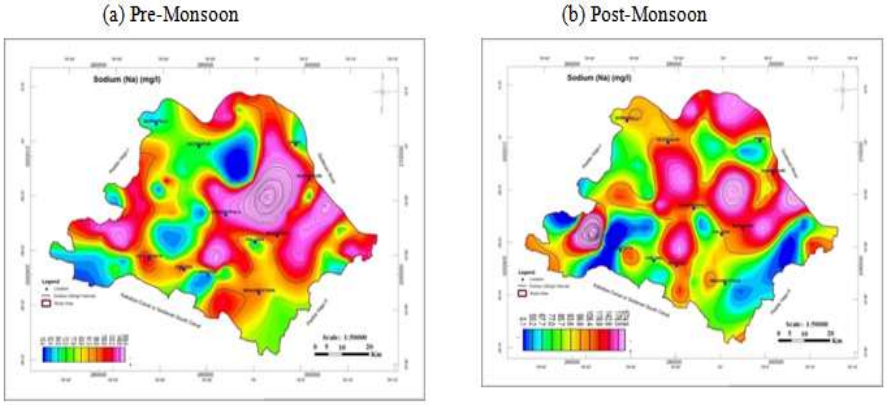

Figure .10 (a&b) Contour map of Sodium (Pre&Post-monsoon)

x) Calcium

Calcium concentration found in the study area ranging from 8 to 192 with an average 52.53 and a standard deviation is of 23.23 in the Pre monsoon (Fig.11(a)). In post monsoon (Fig 5.11 (b)) varies from to 24-176mg/l, average of 59.46mg/l, with standard deviation of 28.23ppm.

During the Pre-monsoon high Calcium content in the area shows Pink to red colour and covering the villages like Bornapalli, Buggaram, Ibrahimpatnam, Katkapur, and surrounding areas. The colour light blue to dark blue indicates low calcium values in the villages Jagtial, Katlakunta and surrounding places, Dharmapuri, Chelgal, Jagtial and Laxmidevipalli.

In Post-monsoon (Fig.11(b))Pink to red colour over the villages Bornapalli, Jainal, Jagtial are covered with high Calcium values. The colour light blue to dark blue indicates low Calcium values over the villages Kalleda, Laxmidevipalli, Katlakunta, Chelgal lower of the study area. Calcium ion is necessary for proper mineralization of bones and bone strength. Deficiency in intake of calcium leads to eventual demineralization for bones for complementing the inadequate amounts of calcium in the body. Calcium is high in pre-monsoon compared to post-monsoon in the study area.

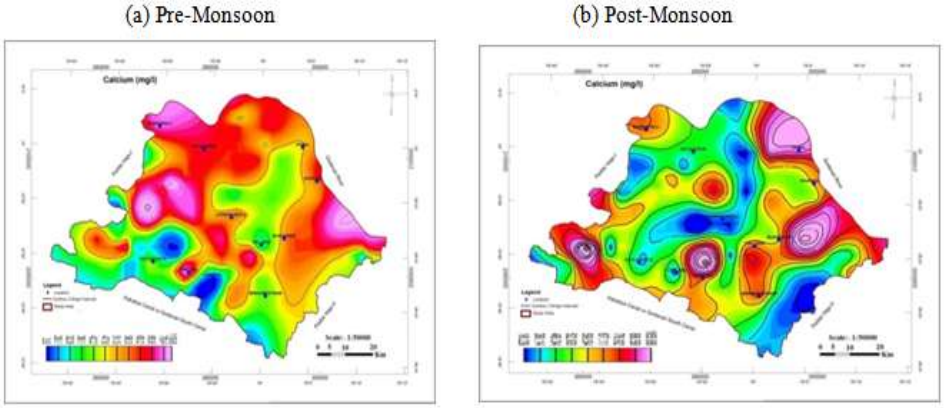

Figure 11(a&b) Contour map of Calcium (Pre&Post-monsoon)

xi) Magnesium

The permissible limits of Mg is < 30 mg/l, and is noticed with above average. The concentration of magnesium over the entire study area is between 0 to 145.86 with an average and 44.68 ppm and a standard deviation is of 24.94 ppm in pre-monsoon (Fig.12(a)) the values varies from 4.862 to 141 (Fig. 12(b) with an average of 52.7 ppm and standard deviation is of 28.68ppm in post monsoon.

High concentrations of Magnesium in the Figure 12(a) in pre-monsoon, shows high values at villages such as Ibrahimpatnam, Katkapur, Dharmapuri, Chelgal, Jagtial, Laxmidevipalli and moderate range values at areas of the Bornapalli, Chelgal, Katlakunta and some of the patches are found around the study area and low values at kalleda, chelgal, buggaram.

In Post-monsoon (Fig.5.12 (b)) high values of Mg observed in villages Bornapalli, Laxmidevipalli, Buggaram, Chelgal, Katkapur, Katlakunta, and low values in villages Jainal, Jagtial and Kalleda etc.

(a) Pre-Monsoon (b) Post-Monsoon

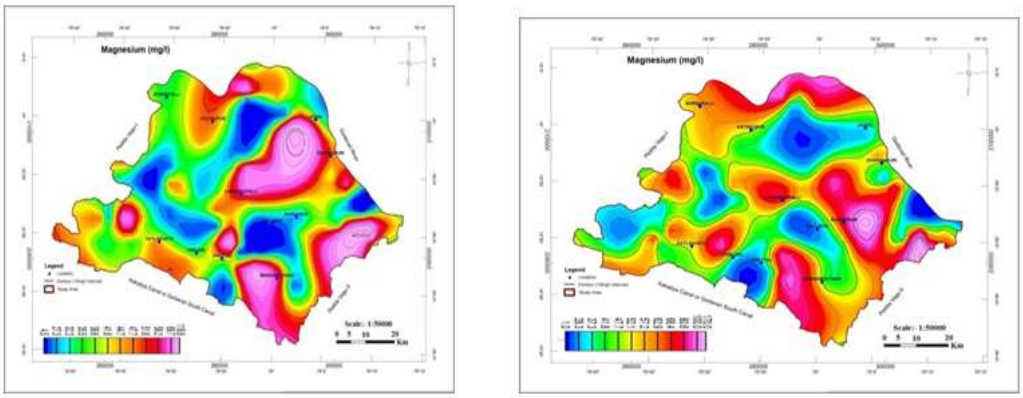

Figure 12(a&b) Contour map of Magnesium (Pre&Post-monsoon)

xii) Total Hardness (TH)

The total hardness (TH) of water is the combination of calcium carbonate and magnesium carbonate dissolved in ground water and is defined as the sum of their concentrations expressed in mg/l. basically, it is the soap-consuming property of water (Fletcher, 1986). The total hardness in the study area varies from 139.96 and 1092.5 mg/l in pre-monsoon with an average 324.06 and standard deviation 132.51 (Fig.13 (a)) and in post-monsoon ranges between 139.98 mg/l and 959.8mg/l in post-monsoon with an average of 365.38 and a standard deviation of 137.89(Fig.13 (b)).

In Pre-monsoon the high Total Hardness values observed in villages are Bornapalli, Katkapur, Dharmapuri, Chelgal, Jagtial, Laxmidevipalli and moderate range values at Katlakunta and some of the patches are found around the study area. The low values in the villages are Kalleda, Katlakunta and Jainal. In Post-monsoon the Total Hardness can be seen at Bornapalli, Jainal, Laxmidevipalli, Buggaram. the moderate range values at Dharmapuri, Katkapur, Katlakunta, Laxmidevipalli and low values at Chelgal, Jagtial and Kalleda etc. The Total Hardness is high in pre-monsoon compared to post-monsoon in the study area. More than 45% of the total study area has groundwater with TH values within desirable limits.

(a) Pre-Monsoon (b) Post-Monsoon

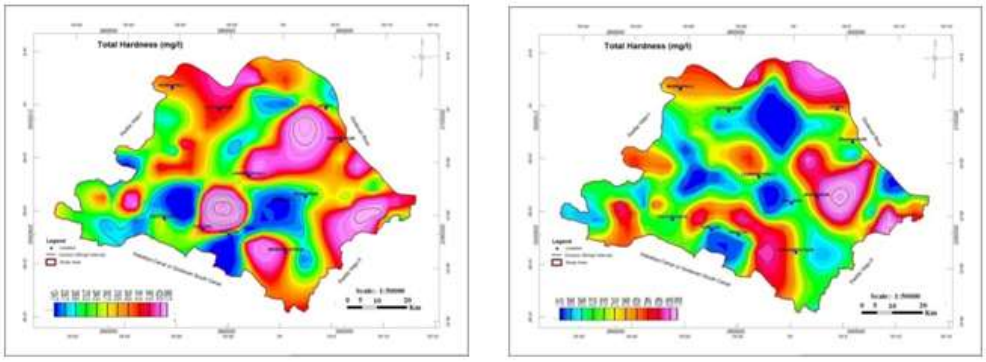

Figure 13(a&b) Contour map of Total Hardness (Pre&Post-monsoon)

III. Discussion

Chemical analysis of the 107 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 western part 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. While fluoride appears to be relatively above permissible limit in Ibrahimpatnam, Katlakunta, Jainal, Katkapur, Laxmidevipalli in both monsoons whereas in other parts of the study area is showing normal distribution and is under permissible limits.

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