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V Prasad
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

T Anjaiah
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

K Pavanchandra Reddy
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

TL Neelima
Water Technology Center, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

P Laxminarayana
Department of Agronomy, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

Corresponding Author:
V Prasad
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

Evaluation of seasonal groundwater quality variations and its suitability for irrigation purpose in Karimnagar district

V Prasad, T Anjaiah, K Pavanchandra Reddy, TL Neelima and P Laxminarayana

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Abstract
The ground water quality of Karimnagar district was carried out during pre and post-monsoon seasons of 2020 for irrigation purpose. Assessment of ground water quality in Karimnagar district was undertaken to study the physico-chemical and chemical characteristics of ground water and classified according to USSL (1954) classification for irrigation suitability. About 53 ground water samples were collected from different villages in Karimnagar district of Telangana state to study the physico-chemical and chemical parameters like pH, EC, cations, anions, SAR and RSC with the help of standard methods. Changes in water quality during study period was analysed and represented in terms of percent of samples in pie diagrams. The mean values of pH, EC, SAR and RSC are 7.25, 0.93 dS m^{-1}, 1.33 2.62 me L^{-1}during pre-monsoon and 7.47, 1.12 dS m^{-1}, 1.56, 4.45 me L^{-1} during post-monsoon respectively. 34%, 17% of samples fall under Medium salinity water (C_2) and 66%, 83% of samples under high salinity water (C_3) During pre and post-monsoon seasons respectively. 9.43%, 5.7% of samples under non- alkaline water (A_0), 7.55%, 5.7% samples under low alkalinity water, whereas 18.78%, 5.7% samples under medium alkalinity water (A_3), 64.20%, 83% of samples under high alkalinity water (A_4) during pre and post-monsoon seasons respectively. All the samples are low sodium hazardous and suitable for irrigation in both seasons.

Keywords: Groundwater quality, pre-monsoon, post-monsoon, seasonal variations, Karimnagar, Irrigation suitability, QGIS, thematic maps

1. Introduction
Groundwater is a important natural resources necessary for the human beings, irrigation, industrialization and urbanization. It is largest sources for available fresh water. Groundwater is a most precious and important resource on the earth of limited extent. No other resources on the earth, is more versatile, vital and abundant than groundwater. It is vital for the existence of all forms of life, for human consumption, for industrial and agricultural activities of civilization. Ground water contributes 0.58% of total water resources on earth. About 2.7% of water is fresh water out of total available water on earth, in that 30.1% is present as ground water. Due to the inadequacy of surface water, the ground water is becoming more and more important in India's agriculture and food security in the recent years. Most of Indian agriculture is depends on canal irrigation, bore wells, dug wells and village tanks. It is estimated that over 70% of India's food grain production comes from irrigated agriculture in which ground water plays a major role [1]. The estimated annual Replenishable ground water resources of country has been as 433 billion cubic meter (BCM). The irrigation sector is the major consumer of ground water, accounting for 92% of its annual withdrawal [2]. The State of Telangana holds 3.6% of national groundwater resources [3]. Ground water availability for future irrigation use in the country is 153.26 BCM.
Water used for irrigation can vary greatly in quality depending upon type and quantity of salts dissolved in it. Poor quality water can be responsible for slow growth, poor aesthetic quality of the crop and in some cases, can result in the gradual death of the plants. The use of ground water of marginal (saline or sodic) and poor (highly saline, highly sodic or both) quality for irrigation may degrade the soils especially at the tail end of the canal system. This practice may also give rise to some apparent and hidden soil problems directly or indirectly associated with tube well irrigation.

Telangana is under semi-arid environment, the accumulation of salts in the soil is faster under irrigation.

In order to address various issues related to ground water, keeping in view the climatic change, there is a need to prepare a road map with identified strategies for scientific and sustainable management practices for the available ground water resources in the state. The purpose of this paper is to carry out detailed assessment of groundwater quality with respect to suitability for irrigation purpose. This paper provides overview of groundwater quality of erstwhile Karimnagar district. The outcome paper is benefiting for professionals engaged in groundwater domain and local peoples to know the water quality status from their area.

2. Study Area

The Karimnagar district (erstwhile) is located under Northern Telangana zone lies approximately between the latitudes 17° 50' and 19° 05' N and longitudes 78° 29' and 80° 22' E. The general elevation is 280m MSL. The district forms part of the Godavari river basin. The entire district is mainly drained by Manair river, a tributary of river Godavari. 25% of the irrigated area is covered by surface water sources, 65% of the area is irrigated through groundwater sources and the remaining by other sources (Ground water Annual report 2016). Ground water occurs in all the geological formations in the district. The average annual rainfall received by this district was ~950mm of which 80% is contributed by SW monsoon and 11% is by NE monsoon and remaining from other seasons. The major rock types occurring in the district are granites, gneisses, sandstone, limestone, shale, quartzite's etc. are occupy about 2/3 of the area in the district. Rest of the area especially north corner is covered by sandstone, limestone, shale and quartzite [4].

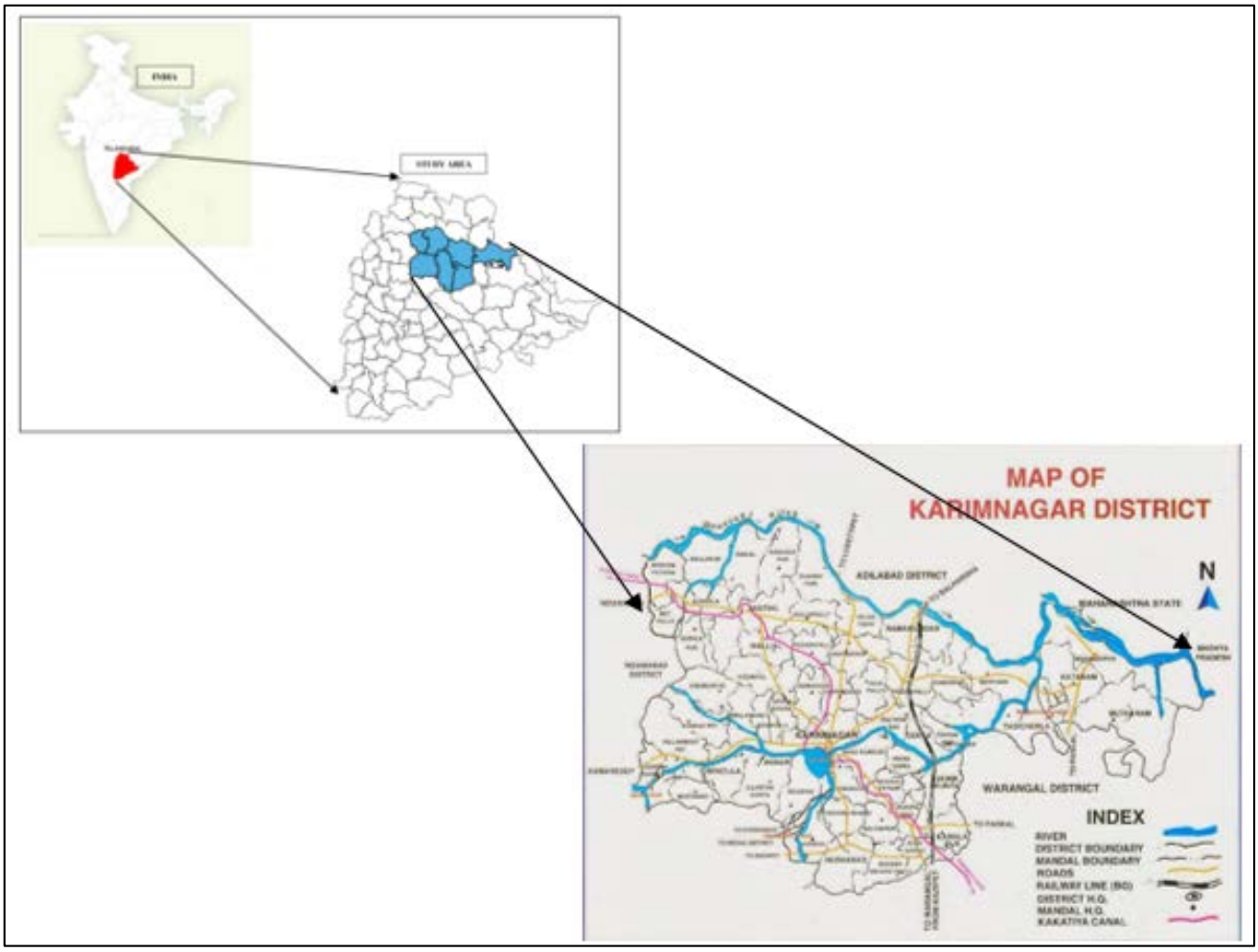

Fig 1: Study Area

3. Materials and methods

Total of 53 ground water samples were collected in various villages of Karimnagar district during pre-monsoon and post-monsoon season in 2020 and were stored in cleaned, rinsed and properly labelled polypropylean bottles. The physical and chemical parameters were analyzed for major ion chemistry employing the standard methods discussed below. Finally, thematic maps on water suitability for major crops were developed using QGIS (Quantum- GIS) software [5].

3.1 pH

The pH was determined by potentiometric method by means of glass electrode given by Richards (1954). 50ml of water sample was taken in clean 100 ml of glass beaker. Instrument was calibrated by using known buffer solutions of 4.0, 7 and 9.2. Later electrode was washed with distilled water then the electrode was immersed in water sample and pH was recorded.

3.2 Electrical conductivity (EC)

Electrical conductivity was measured by using conductivity meter as described in U.S.D.A. Hand Book No. 60 (1954). The water samples were taken to clean beaker. Then

conductivity cell immersed in to sample after adjustment of temperature to 27^0 C and calibration with 0.01N KCl solution.

3.3 Carbonates and bicarbonates
The CO^{3-}_2 and HCO^{3-} in irrigation water samples were determined by adding phenolphthalein indicator. It turned to pink colour if carbonates are present, then titrated against standard 0.01N H_2SO_4 till pink colour disappears. Then added methyl orange indicator and titrated against standard 0.01 N H2SO4 till colour changes to rose red. This method was given by Richards (1954).

3.4 Calcium and Magnesium
These were determined by versenate method as per the procedure outlined by Richards (1954). The calcium is determined by adding 4N NaOH and murexide (Ammonium purpurate) indicator and titrated against standard 0.01N EDTA solution and the magnesium was also determined by adding ammonia buffer and EBT indicator followed by titrating with same standard solution.

3.5 Sodium
Sodium was determined by flame photometry given by Richards (1954).

3.6 Chlorides
It was determined by titrating the sample against standard 0.01N AgNO3 solution after adding 5% K2CrO4 indicator method given by Richards (1954).

3.7 Sodium Adsorption Ratio (SAR)
United States Salinity Laboratory (USSL) Staff (1954) evolved this ratio as:

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

Where, all cations are expressed in me L^{-1}.

3.8 Residual Sodium Carbonate (RSC)
It was calculated by the following formula given by Richards (1954).

$RSC = (CO^3_2 + HCO^{3-}) - (Ca^{2+} + Mg^{2+})$

Where cations and anions are express in me L^{-1} [6].

3.9 Boron
It was estimated by Azomethine-H method as given by [7]. In this method yellow colour developed by adding ammonium acetate buffer and Azomethaine-H indicator to the 5ml of sample in boron free glassware and measured absorbance in colorimeter at 420 nm wave length.

3.10 Generation of thematic maps
The information on sensitivity of major or important crops for salinity, Sodicity and different cations and anions were Collected. The above information on crop specific critical limits were used in regrouping water samples of Karimnagar district for their suitability for major crops. Finally, thematic maps on land and water suitability for major crops were developed using QGIS (Quantum- GIS) software by fallowing procedure.

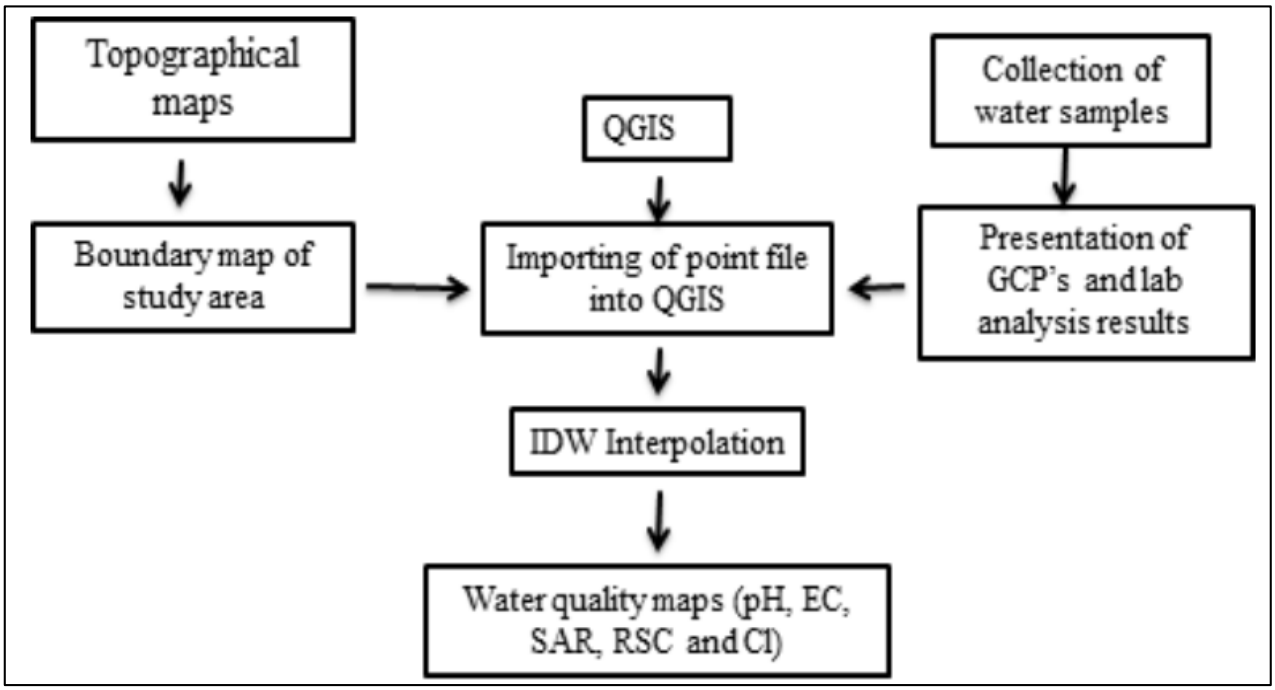

Fig 2: Flow chart showing the procedure for water quality mapping

4. Results and Discussion
The concentration and composition of dissolved constituents in a water determine its quality for irrigation use, several chemical constituents affect water suitability for irrigation from which the total concentration of the soluble salts and the relative proportion of sodium to calcium and magnesium. Moreover suitability of water for irrigation is depended on the effect of some mineral constituents in the water on both the soil and the plant (Wilcox, 1948 &1955). The following are the important characteristic properties of ground water of determine its suitability of irrigation proposes.

4.1 pH

The pH of ground water from Karimnagar district were ranged from 6.8 to 7.97 with a mean value of 7.25 [8, 9] during pre-monsoon and 7.03 to 8.42 with mean value of 7.47 [10-12] during post-monsoon season. Ground water from Karimnagar district are neutral to slightly alkaline in pre-monsoon were as neutral to alkaline in post-monsoon season [Fig 3]. Further data presented in table 3, revealed that pH of ground water from study area during post-monsoon season were slightly higher compared to pre-monsoon season due to increasing concentration of sodium dominated with carbonates and bicarbonates as compared to rainy season. The acidic pH in ground water may be due to shallow ground water from areas with acid rocks, intensive cultivation and ion exchange between sodium and hydrogen or aluminium in the ground and surface water.

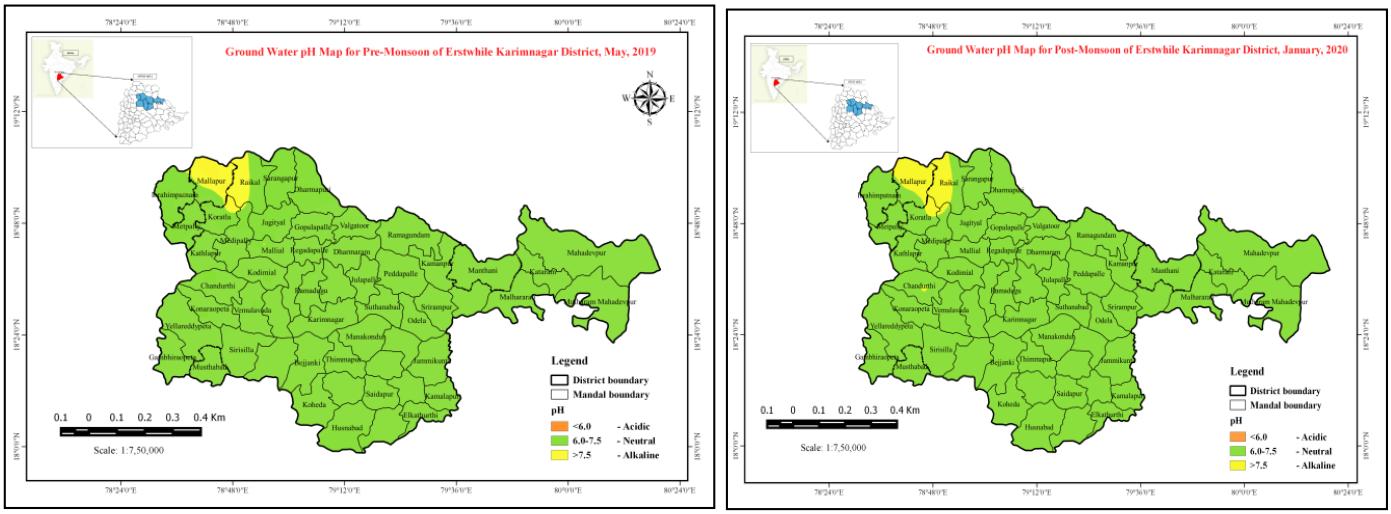

Fig 3: Ground water pH map for Pre and Post-monsoon of Karimnagar district

4.2 Electrical Conductivity (EC) of Water

The most influential water quality guideline on crop productivity is the salinity hazard as measured by electrical conductivity (EC). The primary effect of high EC water on crop productivity is the inability of the plant to compete with ions in the soil solution for water. The higher the EC, the less water is available to plants nearly all irrigation waters that have been used successfully for a considerable time have conductivity less than 2 dS m^{-1}. The EC of water samples from Karimnagar district lies between 0.5 to 1.91 dS $m^{-1}$with mean value of 0.93 dS m^{-1} during pre-monsoon. In post-monsoon EC varies from 0.64 to 2.23 dS m^{-1} with a mean value of 1.12 dS m^{-1} [11, 13]. In post-monsoon season the concentration of soluble salts are higher than the pre-monsoon [Fig 4] because in post-monsoon higher ground water table due to over exploitation of ground water and evaporation rate is higher hence decreases the dilution of water and concentration of salts increased. The water samples from Karimnagar district are medium to high salinity water during both seasons. It is evident from the results that most of the water samples show low to medium EC. This is mainly due to the presence of neutral salts of chlorides and sulphate in ground water samples.

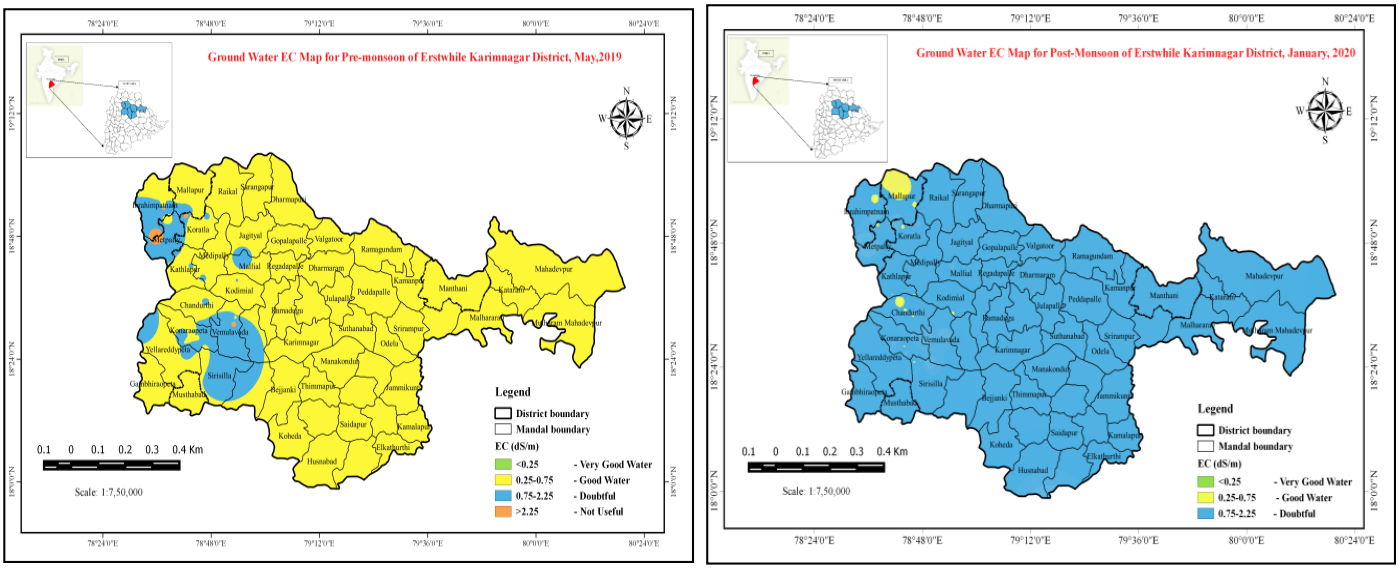

Fig 4: Ground water EC map for Pre and Post-monsoon of Karimnagar district

4.3 Calcium

The data concerned with Ca^{2+} in ground water of Karimnagar district were ranged between 2 to 8.7 me L^{-1} with mean value of 3.99 me L^{-1} during pre-monsoon and from 2.8 to 8.9 me L^{-1} with mean value of 4.53 me L^{-1} in post-monsoon. The presence of Ca^{2+} in groundwater might be attributed to

calcium-rich minerals such as amphiboles, pyroxenes and feldspars and the ion exchange of minerals in surrounding rocks and soils. The low and high Ca^{2+} in groundwater may be due to dissolution from solids and rocks, but especially from limestone, dolomite, and gypsum due to high rainfall leaching along with runoff water. The similar results were reported by [14, 15]

4.4 Magnesium

The Mg^{+2} content in ground water samples from Karimnagar district were ranged from 1.2 to 7.4 me L^{-1} with mean of 3.24 me L^{-1} during pre-monsoon season and between 1.6 to 12.7 me L^{-1} with mean value of 3.43 me L^{-1} In post-monsoon season. The Mg^{+2} in ground water might be due to olivine mineral and the ion exchange of minerals in surrounding rocks and soils. The similar results reported by [16].

4.5 Sodium

The data revealed that the soluble Na^{+} in irrigation water of Karimnagar district during pre-monsoon season varied from 1 to 4.65 me L^{-1} with the mean value of 2.47 me L^{-1} and from 1.53 to 5.72 me L^{-1} with the mean value of 3.05 me L^{-1} during post-monsoon. The presence of Na^{+} in ground water primarily results from the chemical decomposition of feldspars, feldspathoids and some iron, magnesium minerals. In post rainy season the concentration of cations are higher than pre-monsoon season because in post monsoon season the evaporation rate of water is higher than rainy season that caused in increase in concentration of cations in irrigation water as well as rainfall was high in pre-monsoon season that leads to decrease the concentration of cations in irrigation water. The similar results are reported [16-18].

4.6 Carbonates and Bicarbonates

The data concerned with CO_3^{2-} + HCO_3^{-} presented in table 3 revealed that CO_3^{2-} + HCO_3^{-} in ground of Karimnagar district during pre-monsoon season ranged from 6 to 14 me L^{-1} with mean value of 9.85 me L^{-1} and from 8.6 to 15.4 me L^{-1} with mean value of 12.4 me L^{-1} in post-monsoon season. The reason for carbonate (CO_3^{2-}) and bicarbonate (HCO_3^{-}) concentrations in groundwater can be ascribed to carbonate weathering as well as from the dissolution of carbonic acid in the aquifers. The similar results reported by [16, 18].

4.7 Chloride

In Karimnagar district the chloride ion concentration in ground water ranges from 1 to 6.4 me L^{-1} with mean value of 2.71 me L^{-1} during pre-monsoon season and from 2.1 to 6.5 me L^{-1} with mean value of 4.23 me L^{-1} in post-monsoon season. In post-monsoon season the concentration of anions is higher than pre-monsoon season [Figure 5] because in post-monsoon season the evaporation rate is higher than pre-monsoon season that caused in decrease the dilution of water. The increase in concentration of anions in irrigation water samples collected in post-monsoon season may be due to decrease in ground water volume and lower down of ground water table as well as no rainfall in post rainy season. In rainy season it was reverse because of rainfall in pre-monsoon. The similar results are reported by [19].

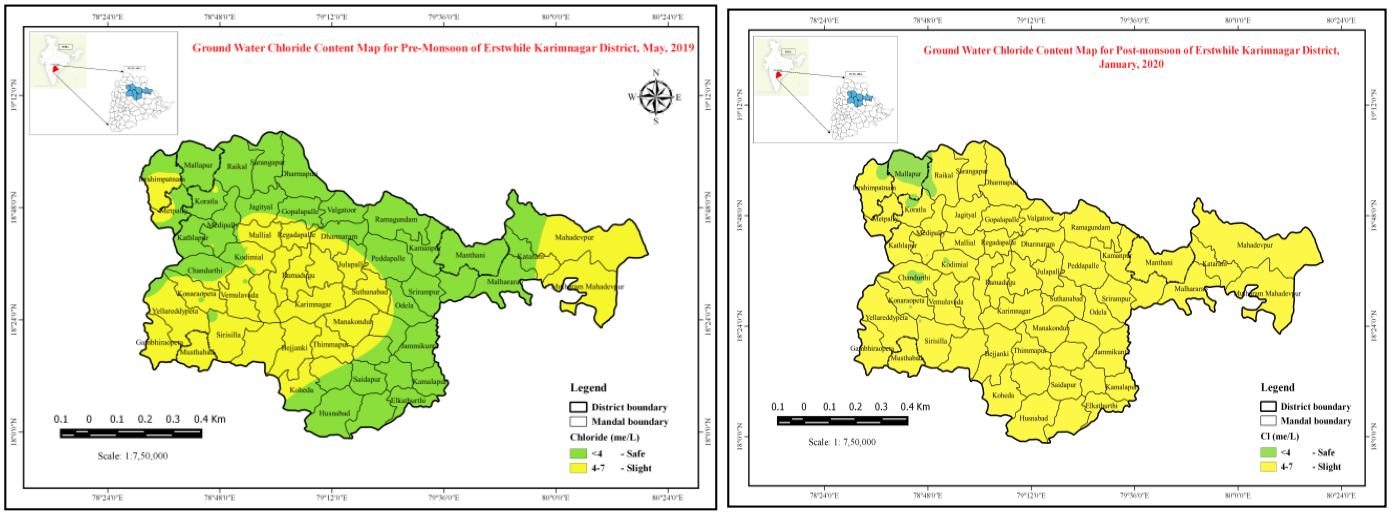

Fig 5: Ground water Chloride content (me L^{-1}) map for Pre and Post-monsoon of Karimnagar district

4.8 Boron

The data concerned with boron revealed that boron in ground of Karimnagar district during pre-monsoon season ranged from 0.06 to 1.32 ppm with mean value of 0.38 ppm and from 0.26 to 1.80 ppm with mean value of 0.61 ppm in post-monsoon season. Boron is present in groundwater primarily as a result of leaching from rocks and soils containing borates and borosilicates. The similar results were reported by [12].

4.9 Sodium Absorption Ratio (SAR)

There is a significant relationship between SAR values of irrigation water and the extent to which sodium is absorbed by the soil. If the water used for irrigation is high in Sodium and low in Calcium, the cation exchange complex may become saturated with Sodium. This can destroy the soil structure owing to dispersion of clay particles.

In Karimnagar district data presented in table 3 revealed that SAR of ground water samples ranges from 0.63 to 2.64 with mean value of 1.33 during pre-monsoon season while it ranges from 0.79 to 2.71 with mean value of 1.56 during post-monsoon season [21, 22]. From these results all water samples from three districts are low sodium water (SAR<10). Increased in SAR values of irrigation waters with the increase in pH and EC of irrigation water might be due to dominance of soluble Na^{+} over Ca^{2+}, Mg^{2+}. High SAR was recorded during post-monsoon because of evaporation and temperature was high due to decreased dilution of water.

4.10 Residual sodium Carbonates (RSC)

The results regarding RSC of ground water samples collected from Karimnagar district it varied from -8.10 to 7.80 me L^{-1} with the mean value of 2.62 me L^{-1} during pre-monsoon season and from -6.30 to 8.0 me L^{-1} with the mean value of 4.45 me L^{-1} during post-monsoon season [23, 24]. The excess of carbonates and bicarbonates in ground water over the sum of calcium and magnesium influence suitability of ground water for irrigation. Alkalinity of water is due the salts of carbonates, bicarbonates, borates, silicates and phosphates along with the hydroxyl ions in free state. The negative RSC indicates that Na^{+} build up is unlikely since sufficient Ca^{+2} and Mg^{+2} are in excess of what can be as precipitated. It is clear from the results that the most of the samples of ground water show grater than 1.25 RSC [Figure 6]. The continues and indiscriminate use of higher RSC (>1.25 me L^{-1}) underground water may be expected to build excessive sodium in soil solution and exchange complex and clog the soil pores which may lead to drainage problem. Similarly irrigation with high RSC water in the fine textured soil will result in the development of alkali soil [25]. On the other hand the continued usage of water with high RSC will results in burning of plant leaves and effect crop yield.

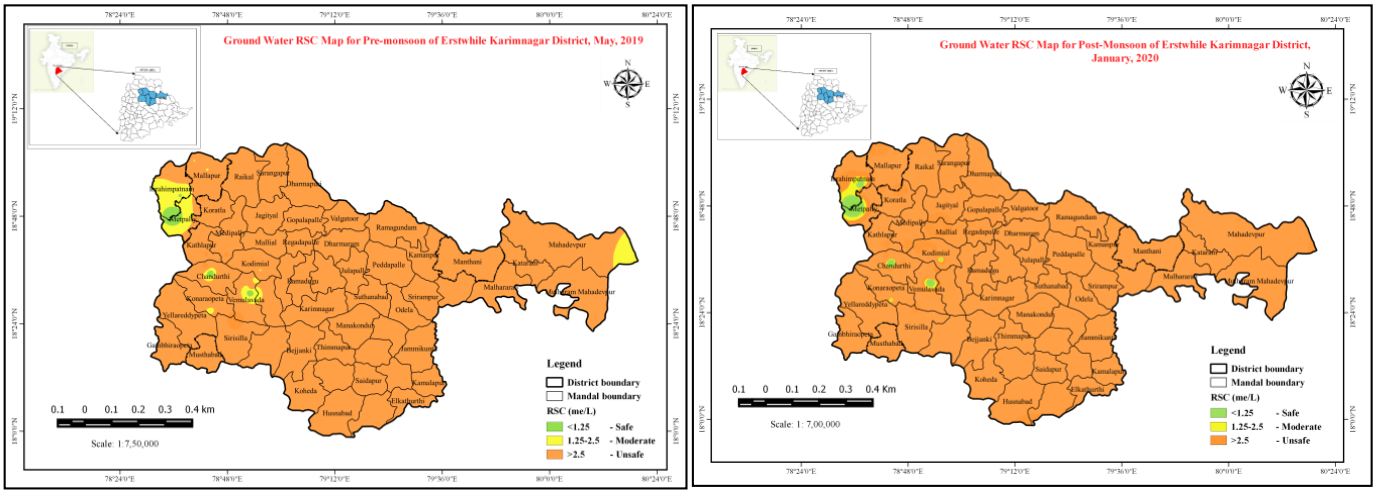

Fig 6: Ground water RSC (me L-1) map for Pre and Post-monsoon of Karimnagar district

4.11 Classification of irrigation water based on USSL (19540) for irrigation suitability

The water quality data of Karimnagar district was presented in Table 1. From this table it revealed that 34%, 17% of samples [figure 7a&7b] fall under Medium salinity water (C_2) and 66%, 83% of samples under high salinity water (C_3) during pre and post-monsoon seasons respectively (Figure 2a and 2b). All the water samples during both seasons are fall under low sodium water (S_1). According to alkalinity indices 9.43%, 5.7% of samples under non- alkaline water (A_0), 7.55%, 5.7% samples under low alkalinity water, 18.78%, 5.7% samples under medium alkalinity water (A_3), 64.20%, 83% of samples under high alkalinity water (A_4) during pre and post-monsoon seasons respectively represented by Figure 8a and 8b. All the water samples during both seasons are low sodium hazardous and suitable for irrigation.

Table 1: Classification of ground water From Karimnagar district for irrigation suitability based on EC, SAR and RSC (USDA, 1954)

S. No	Water class	No. of water samples		% of samples	
		Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon
	Based on Salinity(EC)				
1	C_1 - Low salinity waters	0	0	0	0
2	C_2 -Medium salinity water	18	9	34	17
3	C_3- High salinity water	35	44	66	83
4	C_4-Very high salinity water	0	0	0	0
B	**Based on SAR**				
1	S_1 -Low sodium water	53	53	100	100
2	S_2 -Medium sodium water	0	0	0	0
3	S_3-High sodium water	0	0	0	0
4	S_4 -Very high sodium water	0	0	0	0
	Based on RSC				
1	A_0- Non alkaline water	5	3	9.43	5.7
2	A_1-Normal water	0	0	0	0
3	A_2- Low alkalinity water	4	3	7.55	5.7
4	A_3- Medium alkalinity water	10	3	18.87	5.7
5	A_4- High alkalinity water	34	44	64.20	83

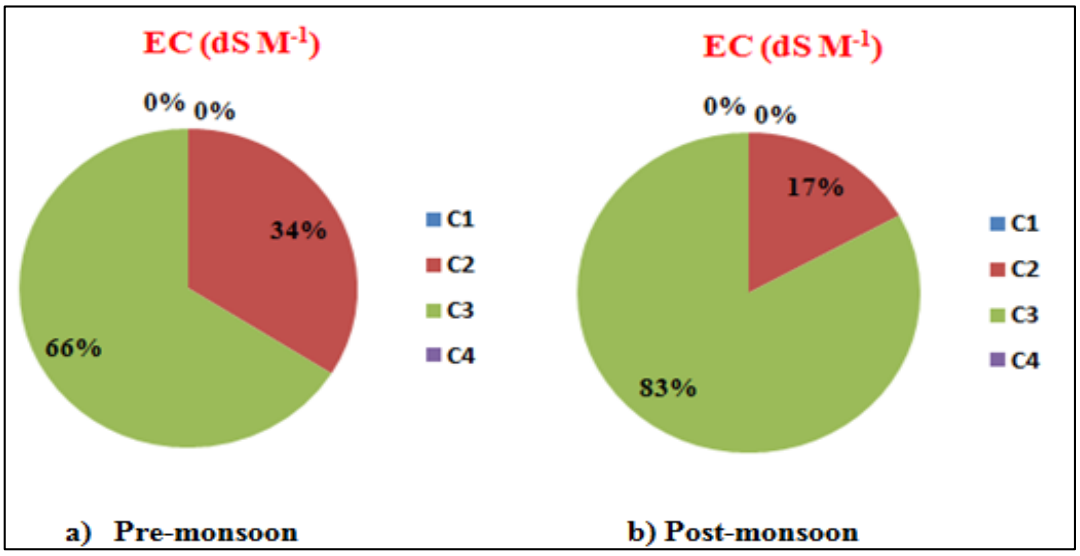

Fig 7: Percent distribution of water samples based on salinity during (a) pre-monsoon and (b) post-monsoon in Karimnagar district.

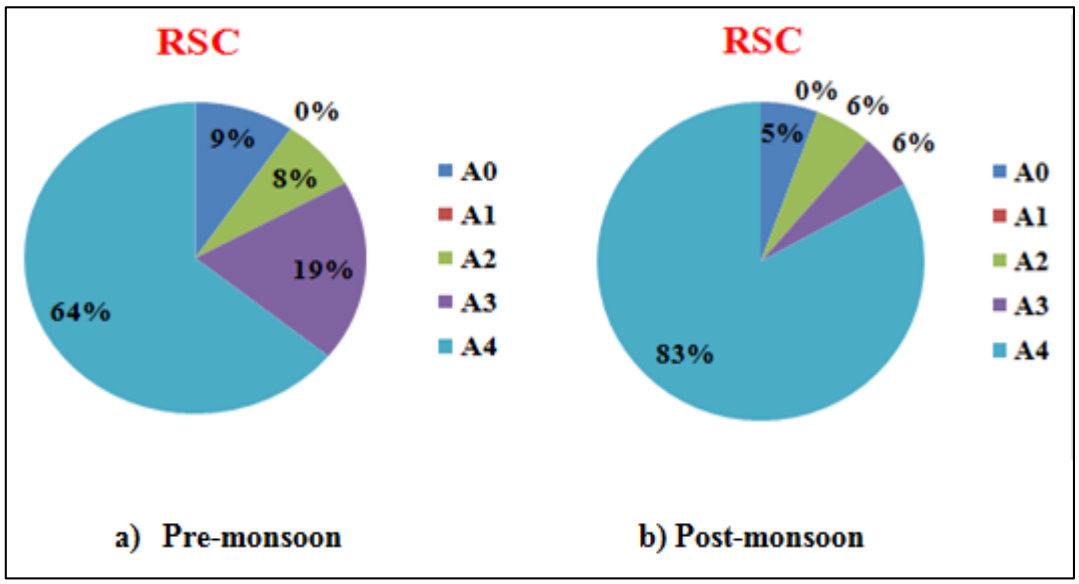

Fig 8: Percent distribution of water samples based on alkalinity during (a) pre-monsoon and (b) post-monsoon in Karimnagar district.

Table 2: Correlation study between different chemical properties of ground water during pre and post-monsoon seasons of Karimnagar district

	pH	EC	Ca^{+2}	Mg^{+2}	Na^{+}	$CO_3^{-2} + HCO_3^{-}$	Cl^{-}	RSC	SAR	B
pH	1.000	-0.238	-0.151	-0.055	-0.259	-0.299*	-0.283 *	-0.088	-0.207	-0.132
EC		1.000	0.498***	0.409 **	0.558 ***	0.187	0.650***	-0.339*	0.361**	0.182
Ca^{+2}			1.000	0.218	-0.123	-0.148	0.438**	-0.647***	-0.362**	0.084
Mg^{+2}				1.000	0.190	0.143	0.261	-0.598***	-0.029	-0.073
Na^{+}					1.000	0.514***	0.546***	0.257	0.946***	0.300*
$CO_3^{-2} + HCO_3^{-}$						1.000	0.037	0.596***	0.476***	0.213
Cl^{-}							1.000	-0.318*	0.362**	0.096
RSC								1.000	0.466***	0.139
SAR									1.000	0.292*
B										1.000

Table value at 5% level =0.270

From these water samples pH is positively correlated with $CO_3^{-2} + HCO_3^{-}$. Whereas EC is positively correlated with Ca^{+2}, Mg^{+2}, Na^{+}, Cl^{-} and SAR, while it negatively correlated with RSC. Ca^{+2} positively correlated with Cl^{-} and negatively correlated with RSC and SAR. Na^{+} positively correlated with $CO_3^{-2} + HCO_3^{-}$, Cl^{-} and SAR. $CO_3^{-2} + HCO_3^{-}$ are had positive correlation with RSC and SAR. Cl^{-} showed positive correlation with SAR and negatively correlated with RSC. SAR had positive correlation with Boron.

Table 3: Quality of ground water during pre-monsoon from Karimnagar district

Mandal	pH	EC (dS m^{-1})	Ca^{+2} (me L^{-1})	Mg^{+2} (me L^{-1})	Na^{+} (me L^{-1})	$CO_3^{-2} + HCO_3^{-}$ (me L^{-1})	Cl^{-} (me L^{-1})	RSC (me L^{-1})	SAR (mmol L^{-1})	B (ppm)
IBRAHIMPATNAM										
Range	7.08-7.6	0.68-1.69	3.2-6.3	2.4-4.4	1.43-3.43	7.00-10.00	1.3-5.5	-2.60 – 3.40	0.85-1.54	0.12-1.13
Mean	7.28	1.09	4.60	3.23	2.35	8.25	3.63	0.43	1.17	0.55
SD	0.23	0.49	1.42	0.95	0.89	1.50	1.79	2.47	0.29	0.42
Metpalli										
Range	7.13-7.5	0.66-1.91	3.3-87	1.8-7.4	1.69-2.13	5.00-8.00	1.7-3.6	-8.00 – (-0.10)	0.75-1.06	0.33-0.41
Mean	7.32	1.29	6.00	4.60	1.91	6.50	2.65	-4.10	0.90	0.37
SD	0.26	0.88	3.82	3.96	0.31	2.12	1.34	5.66	0.22	0.06
Mallapur										
Range	7.6-7.95	0.5-0.73	3.1-5.3	1.4-1.8	1.00-1.73	7.00-11.00	0.8-1.4	0.80-4.50	0.63-1.04	0.06-1.02
Mean	7.80	0.62	4.12	1.54	1.37	8.60	1.14	2.94	0.81	0.34
SD	0.17	0.10	0.93	0.17	0.27	2.07	0.24	1.83	0.15	0.39
Raikal										
Range	7.8-7.97	0.6-1.04	2.00-3.00	3.2-5.6	1.86-4.13	7.00-10.00	1.5-3.6	1.40-1.60	0.90-2.45	0.09-0.28
Mean	7.89	0.86	2.40	4.17	2.63	9.00	2.20	2.43	1.50	0.17
SD	0.09	0.23	0.53	1.27	1.30	1.73	1.21	1.62	0.83	0.10
Korutla										
Range	6.8-7.22	0.59-1.71	2.5-3.5	2.2-2.7	1.3-2.56	9.00-10.00	1.00-1.5	2.80-5.30	0.74-1.67	0.22-0.46
Mean	7.01	1.01	3.17	2.40	1.73	9.67	1.27	4.10	1.07	0.33
SD	0.21	0.61	0.58	0.26	0.72	0.58	0.25	1.25	0.52	0.12
Mallial										
Range	7.2-7.52	1.02-1.12	3.2-3.9	4.4-4.9	2.85-3.35	12.00	3.1-3.2	3.7-3.9	1.40-1.66	0.44-0.51
Mean	7.36	1.07	3.55	4.65	3.10	12.00	3.15	3.80	1.53	0.48
SD	0.23	0.07	0.49	0.35	0.35	0.00	0.07	0.14	0.19	0.05
Kodimial										
Range	7.05-7.07	0.74-1.04	2.5-4.9	1.3-4.5	1.65-3.17	9.00-12.00	1.5-3.8	1.50-6.00	0.85-1.73	0.07-0.21
Mean	7.17	0.83	3.57	2.67	2.50	9.86	2.71	3.61	1.43	0.82
SD	0.10	0.11	0.96	1.05	0.47	1.21	1.05	1.49	0.30	0.06
Medipalle										
Range	6.99-7.11	0.75-1.05	3.6-4.8	2.9-3.7	2.17-2.87	10.00-13.00	1.3-3.00	3.50-5.20	1.20-1.41	0.23-0.37
Mean	7.06	0.91	4.17	3.43	2.61	11.67	2.07	4.07	1.33	0.41
SD	0.06	0.15	0.60	0.46	0.38	1.53	0.86	0.98	0.11	0.08
Chandurthi										
Range	7.02-7.19	0.66-1.12	3.1-4.8	2.7-12.00	1.65-3.57	9.00-12.00	1.4-2.4	-6.00 – 4.90	0.58-1.83	0.13-1.03
Mean	7.10	0.86	3.93	5.28	2.65	10.75	1.90	1.55	1.34	0.41
SD	0.07	0.22	0.77	4.50	0.92	1.50	0.52	5.28	0.57	0.38
Rudrangi										
Range	6.85-7.25	0.56-0.98	1.8-4.6	1.6-4.2	1.57-4.3	9.00-11.00	1.6-2.8	3.00-5.90	0.98-2.48	0.18-0.82
Mean	7.05	0.77	3.30	2.70	2.72	10.33	2.10	4.33	1.57	0.78
SD	0.20	0.21	1.41	1.35	1.41	1.15	0.62	1.46	0.80	0.35
Kodimial										
Range	6.8-7.23	0.63-0.97	3.3-4.7	1.2-4.2	1.35-3.00	8.00-11.00	1.8-4.4	1.30-4.30	0.79-1.64	0.16-0.54
Mean	7.04	0.80	4.17	2.93	2.22	9.67	3.10	2.57	1.18	0.30
SD	0.22	0.17	0.76	1.55	0.83	1.53	1.30	1.55	0.43	0.20
Vemulawada										
Range	7.03-7.41	0.90-1.63	4.10-7.00	3.00-5.6	1.74-3.87	12.00-9.00	2.2-6.3	-4.60 – 3.90	0.85-1.16	0.10-0.82
Mean	7.16	1.20	5.16	4.10	2.80	10.40	4.22	1.14	1.31	0.30
SD	0.15	0.30	1.15	1.12	0.96	1.82	1.49	3.42	0.46	0.30
Dharmaram										
Range	7.01-7.37	0.74-1.22	3.8-5.5	2.00-4.3	1.39-3.87	8.00-12.00	1.40-6.40	-1.80 – 6.00	0.74-2.23	0.06-1.30
Mean	7.15	0.99	4.43	3.20	2.59	10.33	3.70	2.70	1.88	0.99
SD	0.19	0.24	0.93	1.15	1.24	2.08	2.52	4.04	0.77	0.64
Konaraopeta										
Range	6.96-7.26	0.6-1.12	2.6-5.1	1.90-3.7	1.78-3.87	9.00-11.00	1.5-4.7	1.80-5.40	1.07-2.18	0.13-0.62
Mean	7.09	0.90	3.80	2.54	2.93	9.80	3.36	3.46	1.64	0.35
SD	0.12	0.21	1.25	0.78	0.75	1.10	1.42	1.62	0.40	0.22

Table 4: Quality of ground water during Post-monsoon from Karimnagr district

Mandal	pH	EC (dS m^{-1})	Ca^{+2} (me L^{-1})	Mg^{+2} (me L^{-1})	Na^{+} (me L^{-1})	$CO_3^{-2} + HCO_3^{-}$ (me L^{-1})	Cl^{-} (me L^{-1})	RSC (me L^{-1})	SAR (mmol L^{-1})	B (ppm)
Ibrahimpatnam										
Range	7.12-7.42	0.72-2.10	4.10-7.10	2.60-4.60	2.18-3.64	8.6-11.5	2.50-6.70	-1.60 – 3.50	1.15-1.53	0.28-0.63
Mean	7.39	1.27	5.30	3.55	2.83	9.90	4.95	1.05	1.35	0.50
SD	0.25	0.66	1.36	1.00	0.73	1.25	1.76	2.22	0.18	0.16

Metpalli										
Range	7.32-7.72	0.76-2.00	3.80-8.90	2.10-7.70	2.28-2.75	10.30-11.20	3.4-4.8	-6.30 – 5.30	0.79-1.60	0.53-0.78
Mean	7.52	1.38	6.35	4.9	2.52	10.75	4.1	-0.50	1.06	0.66
SD	0.28	0.88	3.61	3.96	0.33	0.64	0.99	8.20	0.57	0.18
Mallapur										
Range	7.74-8.14	0.65-0.79	3.70-5.80	1.70-2.30	1.53-2.16	9.10-15.50	2.10-3.20	3.10-7.80	0.88-1.15	0.41-0.53
Mean	7.974	0.724	4.78	1.96	1.88	12.46	2.84	5.72	1.02	0.46
SD	0.18	0.05	0.84	0.24	0.27	2.35	0.44	1.83	0.10	0.06
Raikal										
Range	8.03-8.42	0.81-1.50	2.90-3.50	3.30-5.80	2.42-4.31	10.2-14.20	2.60-6.10	4.00-7.30	1.23-2.32	0.52-0.64
Mean	8.23	1.19	3.13	4.33	3.13	12.70	3.97	5.23	1.62	0.59
SD	0.20	0.35	0.32	1.31	1.03	2.18	1.87	1.80	0.59	0.06
Korutla										
Range	7.21-7.41	0.73-2.23	2.80-4.10	2.40-2.90	1.78-3.12	11.00-13.90	2.30-5.30	4.20-7.30	0.98-1.93	0.33-0.47
Mean	7.31	1.30	3.60	2.60	2.27	12.30	3.47	6.10	1.29	0.38
SD	0.10	0.81	0.70	0.26	0.74	1.47	1.61	1.66	0.53	0.08
Mallial										
Range	7.53-7.61	1.08-1.50	3.70-4.20	2.50-2.80	2.35-3.76	14.00-14.90	3.80-4.50	7.80-7.90	1.26-2.14	0.26-1.08
Mean	7.57	1.29	3.95	2.65	3.06	14.45	4.15	7.85	1.68	0.67
SD	0.06	0.30	0.35	0.21	1.00	0.64	0.49	0.07	0.62	0.58
Kodimial										
Range	7.21-7.62	0.85-1.29	2.90-5.30	1.60-3.60	2.51-3.85	11.40-13.50	3.10-6.20	3.50-8.00	1.26-2.22	0.37-0.82
Mean	7.44	0.98	4.03	2.51	3.13	12.64	4.17	6.10	1.73	0.55
SD	0.16	0.15	0.91	0.71	0.52	1.04	1.06	1.76	0.39	0.14
Medipalle										
Range	7.21-7.42	0.83-1.42	3.90-5.10	3.10-3.90	2.75-3.82	13.00-15.40	3.50-4.80	5.00-7.00	1.47-1.86	0.43-0.46
Mean	7.29	1.10	4.50	3.63	3.38	14.13	4.17	6.00	1.68	0.44
SD	0.12	0.30	0.60	0.46	0.56	1.21	0.65	1.00	0.20	0.02
Chandurthi										
Range	7.18-8.02	0.82-1.31	3.50-5.20	2.80-12.70	2.56-3.96	12.00-15.10	2.70-4.30	-4.70 – 6.90	0.87-1.91	0.32-0.38
Mean	7.43	1.00	4.25	5.70	3.20	13.55	3.35	3.60	1.43	0.35
SD	0.40	0.23	0.79	4.69	0.71	1.48	0.70	5.56	0.48	0.03
Rudrangi										
Range	7.03-7.53	0.64-0.92	3.90-5.10	2.00-4.10	2.78-4.56	11.50-13.00	3.80-5.20	2.90-7.10	1.43-2.20	0.29-0.68
Mean	7.26	0.80	4.50	2.97	3.40	12.43	4.30	4.97	1.76	0.55
SD	0.25	0.15	0.60	1.06	1.01	0.81	0.78	2.10	0.40	0.23
Kodimial										
Range	7.31-7.41	0.75-1.27	3.90-5.20	1.70-4.60	2.12-3.72	9.80-13.50	3.60-6.20	0.30-6.10	1.14-1.93	0.29-0.52
Mean	7.36	0.96	4.67	3.27	2.92	11.17	4.67	3.23	1.47	0.38
SD	0.05	0.28	0.68	1.46	0.80	2.03	1.36	2.90	0.41	0.12
Vemulawada										
Range	7.14-7.63	0.98-1.84	4.50-5.90	3.40-5.40	2.34-4.17	10.20-13.80	4.10-6.50	-2.80 - 5.10	1.07-1.40	0.67-1.27
Mean	7.37	1.49	5.60	4.32	3.34	12.34	5.08	2.42	1.51	0.85
SD	0.20	0.38	1.24	0.89	0.79	1.44	0.91	3.15	0.36	0.24
DHARMARAM										
Range	7.12-7.43	0.82-1.53	4.20-5.90	2.60-4.50	2.24-4.18	10.8-14.20	3.30-6.20	0.40-7.10	1.13-2.22	0.86-1.19
Mean	7.25	1.19	4.87	3.60	3.34	12.63	4.73	4.17	1.62	0.99
SD	0.16	0.36	0.91	0.95	1.00	1.72	1.45	3.43	0.55	0.17
Konaraopeta										
Range	7.15-7.42	0.81-1.47	2.80-5.60	2.30-4.20	2.26-4.28	10.70-13.10	2.80-6.20	2.70-6.50	1.29-2.24	0.50-1.80
Mean	7.25	1.15	4.14	3.02	3.49	11.82	5.04	4.66	1.84	1.03
SD	0.10	0.30	1.30	0.75	0.74	0.99	1.37	1.71	0.36	0.50

Conclusion

It concluded from the above results 35%, 66% and 44%, 83% sample exceeds the salinity limits for irrigation suitability during pre-monsoon and post-monsoon. On the other hand all the sampling station considered suitable for irrigation uses according to SAR value. Whereas 34%, 64.20% and 44%, 80% of samples exceeds the alkalinity limits for suitability for irrigation purpose. The dissolved salts contents increased from pre-monsoon to post-monsoon.

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