Quality Status of Irrigation Water of Kaleshwaram Project Command Area of Nizamabad District in Telangana State

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Authors' contributions

This work was carried out in collaboration among all authors. Author VP designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors TA and KP managed the analyses of the study. Authors PL and TLN managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

The present study represents the quality of ground water from Kaleshwaram project command area of Nizamabad district of Telangana state, India during year 2019-2020. Total 72 ground water samples from bore wells were collected randomly from Nizamabad periodically in two seasons *i.e.* pre-monsoon season (May, 2019) and post-monsoon-season (January, 2020). The ground water samples were analyzed for quality parameters *viz.*, pH, EC, cations, anions, boron. The Sodium Adsorption Ratio and Residual Sodium Carbonate were also calculated for these ground water samples. The results found that all ground water samples from Nizamabad district were neutral to alkaline in reaction and having pH 7.02 during pre-monsoon and 7.48 during post-monsoon season respectively. EC of these water were 1.23dSm^{-1} and 1.53dS m^{-1} during pre-monsoon and post-

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monsoon seasons respectively. Among 72 water samples as per salinity classification 2.8, 23.61, 69.44 and 4.17 per cent water samples during pre-monsoon and 0, 1.4, 90.30 and 8.33 per cent water samples during post-monsoon were categorized in class C_1, C_2, C_3 and C_4, respectively. Among all the cations in ground water Calcium was dominant. Whereas anions CO_3^{-2} + HCO_3^- are dominant. The boron concentration of ground water was ranged from 0.48 to 0.67 ppm during pre and post-monsoon, respectively. According to sodicity classes, i.e. SAR and RSC of ground waters were 100 and 47.22 per cent during pre-monsoon, 100 and 26.40 per cent during post-monsoon are suitable for irrigation. The positive significant correlation was observed between EC, cations of ground water.

1. INTRODUCTION

Ground water is a precious source of fresh water excluding the polar ice caps and glaciers. Ground water studies are gaining more importance in the present day as it is used for almost all purposes such as domestic, industrial and agricultural activities in most parts of the world. Improper management of these replenishable resources may lead to ground water contamination and scarcity due to natural and anthropogenic causes, quantity of some ions and minerals increased beyond their permissible limit which make ground water unsuitable for drinking and irrigation purposes. Ground water quality has been given lot of importance and studied worldwide [1]. The lowering of ground water levels has resulted in reduction in individual well yield, growth in well population, failure of bore wells, drying up of dug wells and increase in power consumption [2]. Over the last two decades, 84 per cent of the total addition to net irrigated area came from ground water and only 16 per cent from the canals [3]. The estimated total replenishable ground water resource in India is 43.57 million hectare-meters per year. After allowing 14 per cent for domestic, industrial and other uses, the ground water available for irrigation is estimated to be about 86 percent of this i.e. 36.42 million hectare-meters. Out of this the utilizable ground water resources for irrigation are only 32.77 million hectare meters [4]. Telangana State is situated in the central stretch of the Indian Peninsula on the Deccan Plateau. The region is drained by two major rivers namely Godavari and Krishna.
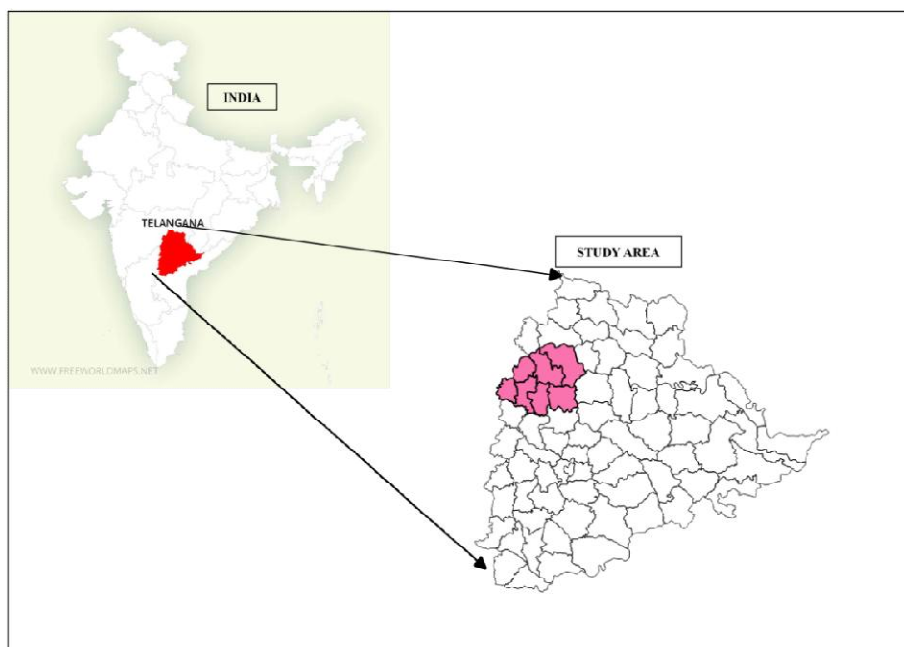

Fig. 1. Study area

Very little information is available in relation to irrigation water quality status of Nizamabad district. Therefore, the present study was planned to categorize the ground water of Nizamabad district and to illustrate the spatial variability of various parameters of ground water quality i.e. pH, EC (electrical conductivity), Cation, anions concentrations, RSC (residual sodium carbonate), SAR (sodium adsorption ratio) and Boron content.

1.1 Study Area

The Nizamabad district of Telangana, extending over an area of 7956 km^2 is bounded on the North by Godavari river, East by Karimnagar district, South by Medak district and West by Manjira river (Fig 1). It lies between north latitude 18°04′4.8"-19°00′54" and east longitude 77°31′41"-78°40′1.2". The district is situated at a considerable distance from the sea coast. The Normal mean minimum temperature is 13.7°C, and mean maximum is 39.9°C. The climate is semi-arid which is comparatively equitable and although it is very hot in May with temperature rising up to 47°C.The registered irrigated area is 117306 ha and out of this gross cropped area under surface water is under canals is 10900 ha only (9%). Irrigation water needs are covered through ground water.

2. MATERIALS AND METHODS

From Nizamabad district 72 villages are selected randomly to study water quality parameters. The ground water samples from bore wells were collected during pre-monsoon season and again during post-monsoon season. The total of 144 (72 during pre-monsoon season and 72 during post-monsoon season) collected by using standard procedure [5] in clean polypropylene bottles (500ml) and tightly screwed and brought to the laboratory on the next day for further analysis. The pH and EC of water samples were determined by using glass electrode pH and EC meter. The cations like calcium and magnesium were determined by versenate (EDTA) titration method given by Richards [5] and sodium was determined by using flame photometer [6]. The soluble anions like carbonates, bicarbonates, were determined by titrimetric method given by Richards [5] and chlorides and sulphates were determined by the Mohrs titration method [5]. The boron was estimated calorimetrically by using Azomethin-H at 420 nm [7]. The correlation between water quality parameters was worked

out as per the standard. The Residual Sodium Carbonate was calculated by formula given [8] as RSC (me L^{-1}) = (CO_3^{2-} + HCO_3^-) – (Ca^{2+} + Mg^{2+}) and Sodium Adsorption Ratio was computed by using following equation.

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

Finally, thematic maps on land and water suitability for major crops were developed using QGIS (Quantum- GIS) software [1].

3. RESULTS AND DISCUSSION

The data regarding pH, EC, RSC, SAR and Boron are presented in Table 1.

3.1 pH

The pH of ground water in Nizamabad district varied from 6.41 to 8.90 with a average value of 7.02 and 6.98 to 8.36 with average value of 7.48 during pre-monsoon and post-monsoon season respectively. Overall data revealed that the pH of this water sample is neutral to alkaline in reaction. The increase in pH of post-monsoon season water compare to pre-monsoon samples (Figs. 2&3) due to increase in concentration of sodium in post-monsoon samples due to more removal of ground water. Ground water samples of various locations which contained the higher amount of bicarbonate, Na, SAR and RSC recorded the higher pH [9,10,11,12,13].

3.2 Electrical Conductivity (EC) of Water

The salinity of the ground water of study area of Nizamabad district ranges between 0.2 to 1.72 dSm^{-1} with mean value of 1.23 dSm^{-1} during pre-monsoon and 0.8 to 4.1 dSm^{-1} (Table 1) with mean value of 1.53 dSm^{-1} during post-monsoon. The increased in EC of water samples in post-monsoon season (Figs. 4&5) 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.From the data (Table 5) it revealed that out of 72 water sample 23.61 percent of water samples are medium salinity (C_2), 4.17 percent of samples under very high salinity (C_4), 69.44 percent of samples under high salinity (C_3) and 2.8 percent of samples under low salinity (C_1) during pre-monsoon. While during post-monsoon 1.4, 90.30 and 8.33 percent of samples under medium (C_2), high salinity (C_3) and very high salinity (C_4) classes [14,11,15].
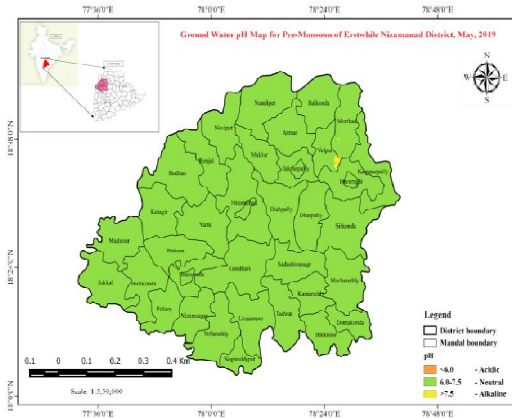
Fig. 2. Ground water pH map for Pre-monsoon of Nizamabad district
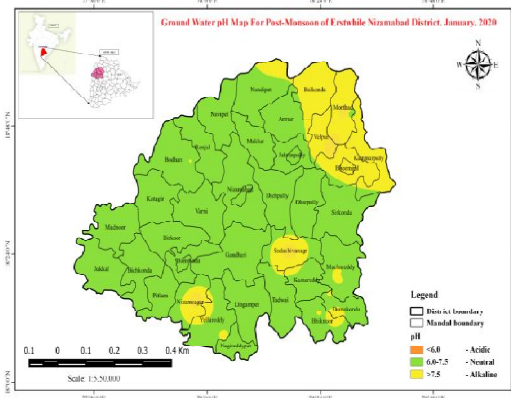

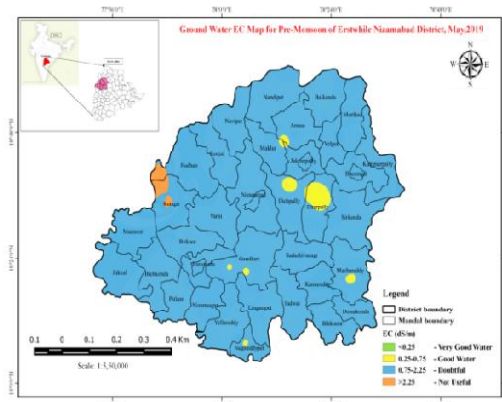**Fig. 3. Ground water pH map for Post-monsoon of Nizamabad district**

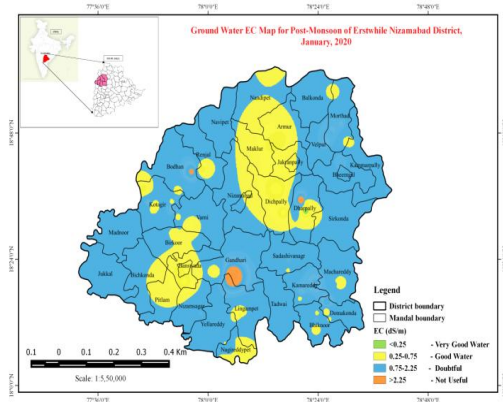**Fig. 4. Ground water EC map for Pre-monsoon of Nizamabad district**

Fig. 5. Ground water EC map for Post-monsoon of Nizamabad district

Table 1. Pre and post-mosoon physicochemical parameters of ground water samples

	Pre-monsoon					Post-monsoon				
	pH	EC (dS m^{-1})	SAR	RSC (meL^{-1})	Boron (ppm)	pH	EC (dS m^{-1})	SAR	RSC (meL^{-1})	Boron (ppm)
Maximum	8.90	1.72	2.72	6.90	1.12	8.36	4.10	4.51	70.40	1.38
Minimum	6.41	0.20	0.43	-16.60	0.08	6.98	0.80	0.55	-11.10	0.28
Mean	7.02	1.23	1.46	-0.54	0.48	7.48	1.53	1.85	4.29	0.67

Table 2. Pre and post-mosoon cation concentrations (me L^{-1}) of ground water samples

	Pre-monsoon			Post-monsoon		
	Ca^{+2} (me L^{-1})	Mg^{+2} (me L^{-1})	Na^{+} (me L^{-1})	Ca^{+2} (me L^{-1})	Mg^{+2} (me L^{-1})	Na^{+} (me L^{-1})
Maximum	12.90	15.50	7.69	12.50	10.50	7.91
Minimum	1.10	1.40	0.48	1.20	1.00	1.18
Mean	5.29	3.86	3.12	4.80	3.66	3.65

3.3 Total Cations Concentrations

The results on cation concentrations are presented in Table 2. The soluble cation Ca^{2+} in ground water of Nizamabad district during pre-monsoon varied from 1.10 to 12.90 me L^{-1} with mean value of 5.29 me L^{-1} and from 1.20 to 12.50 me L^{-1} with mean value of 4.80 me L^{-1} in post-monsoon. The concentration of Mg^{+2} in ground water samples of Nizamabad district varies from 1.40 to 15.50 me L^{-1} with mean of 3.86 me L^{-1} during pre-monsoon season and from 1.00 to 10.50 me L^{-1} with mean value of 3.66 me L^{-1} in post monsoon season. The soluble cation Na^+ in irrigation water of Nizamabad district during pre-monsoon seasonvaried from 0.48 to 7.69 meL^{-1} with the mean value of 3.12 meL^{-1} and from 1.18 to 7.91 meL^{-1} with the mean value of 3.65 meL^{-1} during post monsoon [9,16,15,17].

3.4 Total Anions Concentration

The $CO_3^{2-} + HCO_3^-$ in ground water samples from Nizamabad district lies between 3.80 to 12.20 me L^{-1} with mean value of 8.62 me L^{-1} during rainy season and between 4.80 to 76.00 me L^{-1} with mean value of 12.75 me L^{-1} during post rainy season. The Cl^- ion in ground water of Nizamabad district varies from 1.10 to 12.50 me L^{-1} with mean value of 4.48 me L^{-1} during pre-monsoon season and from 2.00 to 15.40 me L^{-1} with mean value of 5.51 me L^{-1} in post-monsoon season. The increase in concentration of anions in irrigation water samples collected in post-monsoon season (Figs. 6 & 7) 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 [16,1,17,6].

3.5 Sodium Adsorption Ratio (SAR)

The SAR in ground water samples varied from 0.43 to 2.72 with mean value of 1.46 during rainy season, while it ranges from 0.55 to 4.51 with mean value of 1.85 during post rainy season. According to sodicity all water samples during both seasons are fall under S_1 class (Low sodium water) and safe for irrigation. According to sodicity all water samples during both seasons are fall under S_1 class (Low sodium water) and safe for irrigation purpose according to USDA classification [18].

3.6 Residual Sodium Carbonate (RSC)

The RSC values of irrigation water varied from -16.60 to 6.90 me L^{-1} with the mean value of -0.54 me L^{-1} during rainy season and from -11.10 to 70.40 me L^{-1} with the mean value of 4.29 me L^{-1} during post rainy season (Figs. 8&9). The increase in RSC of post-monsoon season might be due to increase in concentration of CO_3^{-2} and HCO_3^- in post-monsoon. Out of 72 samples 47, 26.40% under non alkaline water (A_0), 1.40, 3.0% under normal water (A_1), 19.44,12.5% under Low alkaline water (A_2), 19.44, 9.72% medium alkaline water (A_3) and 12.5, 48.61% under high alkaline water (A_4) during pre and post-monsoon seasons respectively (Table 5).

3.7 Boron

The boron values of ground water samples collected in rainy season from Nizamabad were ranged from 0.08 to 1.12 ppm with an average value of 0.48 ppm. Water samples collected in post rainy season are ranged from 0.28 to 1.38 ppm with meanvalue of 0.67 ppm (Table 1). It was observed from the data that the boron of post-monsoon samples was higher as compare to pre-monsoon season samples [19,10,20,21& 22].

3.8 Correlation

The EC of irrigation water showed significant positive correlation with cations, anions and SAR while it negatively correlated with RSC. Ca^{+2} showed positive correlation with Na^+,$CO_3^{-2}+HCO_3^-$ and Cl^-, while it negatively correlated with RSC. Mg^{+2}, Na^+ showed positive correlation with $CO_3^{-2} + HCO_3^-$, Cl-, SAR and negatively correlated with RSC.$CO_3^{-2} + HCO_3^-$ showed positively correlation with SAR and Boron. Cl^- showed positive correlation with SAR and negative correlation with RSC.

Table 3. Pre and post-mosoon anion concentrations (me L^{-1}) of ground water samples

	Pre-monsoon		Post-monsoon	
	$CO_3^{-2} + HCO_3^-$ (me L^{-1})	Cl^-(me L^{-1})	$CO_3^{-2} + HCO_3^-$ (me L^{-1})	Cl^-(me L^{-1})
Maximum	12.20	12.50	76.00	15.40
Minimum	3.80	1.10	4.80	2.00
Mean	8.62	4.48	12.75	5.51

Table 4. Correlation study between different chemical properties of ground water during pre and post-monsoon seasons of Nizamabad district

	pH	EC	Ca^{+2}	Mg^{+2}	Na$^+$	CO$_3^{-2}$ + HCO$_3^-$	Cl$^-$	RSC	SAR	B
pH	1.000	-0.017	-0.140	0.036	0.097	0.059	-0.132	0.130	0.189	-0.015
EC		1.000	0.825***	0388***	0.694***	0.312**	0.734***	-0.689***	0.415***	0.106
Ca^{+2}			1.000	0.284	0.485***	0.270*	0.715***	-0.804***	0.134	0.111
Mg^{+2}				1.000	0.553	0.394***	0.363**	-0.505***	0.281*	0.118
Na$^+$					1.000	0.496***	0.609***	-0.389***	0.891***	0.062
CO$_3^{-2}$ + HCO$_3^-$						1.000	0.211	0.155	0.456***	0.356**
Cl$^-$							1.000	-0.645***	0.364**	-0.033
RSC								1.000	0.011	0.054
SAR									1.000	0.032
B										1.000

At table value 5% level = 0.367
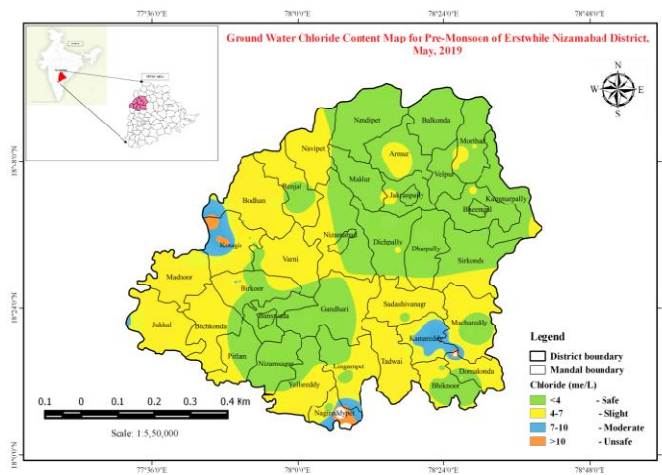
Fig. 6. Ground water Cl$^-$ content (me L^{-1}) map for pre-monsoon of Nizamabad district
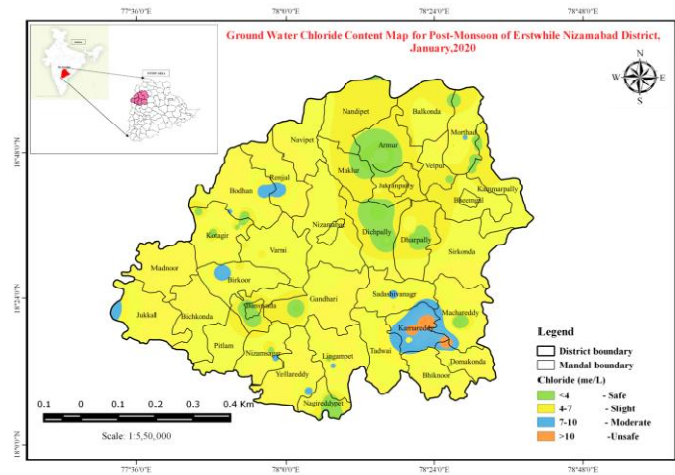

Fig. 7. Ground water Cl$^-$ content (me L^{-1}) map for post-monsoon of Nizamabad district
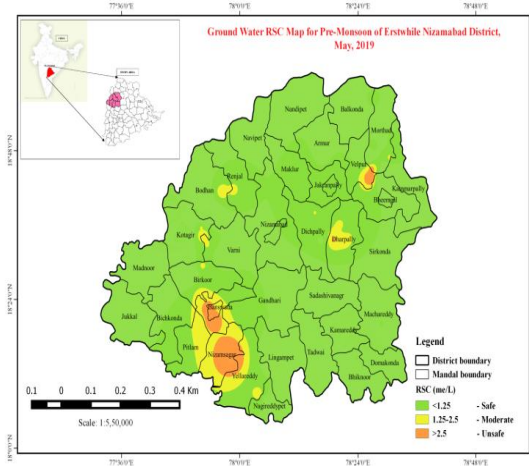
Fig. 8. Ground water RSC (me L^{-1}) map for pre-monsoon of Nizamabad district
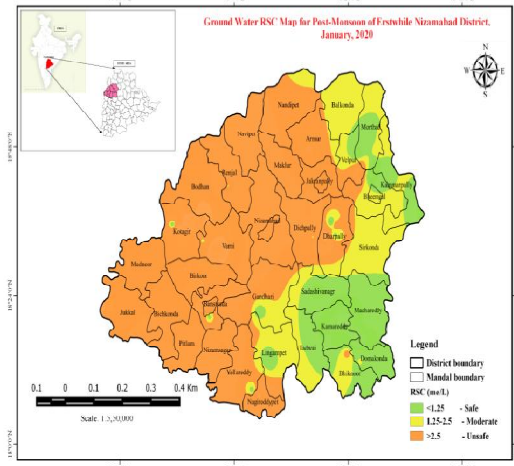

Fig. 9. Ground water RSC (me L^{-1}) map for post-monsoon of Nizamabad district

Table 5. Classification of ground water from Nizamabad district for irrigation suitability based on EC, SAR and RSC (USDA, 1954)

S.No	Water class	No of water samples		Percent of samples	
		Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon
	Based on Salinity(EC)				
1	C_1- Low salinity waters	2	0	2.8	0
2	C_2 -Medium salinity water	17	1	23.61	1.4
3	C_3- High salinity water	50	65	69.44	90.30
4	C_4-Very high salinity water	3	6	4.17	8.33
B	**Based on SAR**				
1	S_1 -Low sodium water	72	72	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	34	19	47.22	26.40
2	A_1-Normal water	1	2	1.40	3.0
3	A_2- Low alkalinity water	14	9	19.44	12.5
4	A_3- Medium alkalinity water	14	7	19.44	9.72
5	A_4- High alkalinity water	9	35	12.5	48.61
	Based on Chlorides (me L^{-1})				
1	Low chlorides content	39	30	54.2	42
2	Slight chlorides content	21	23	29.2	32
3	Moderatechlorides content	3	15	4.2	21
4	High chlorides content	9	4	12.5	6

4. CONCLUSION

Based on the results obtained it can be concluded that ground water from the study area is neutral to alkaline in reaction and fairly suitable for irrigation but some areas salinity or alkalinity measures are needed to be taken to improve crop productivity. Among the different cations and anions calcium and bicarbonates are predominant. Because of increase in ions concentrations during post-monsoon due to exploitation of ground water for irrigation leads decreasing the dilution of ground water. According to sodicity and RSC most of the ground water samples are safe and suitable for irrigation. Overall data indicated that most part of

ground water of Nizamabad district was suitable for irrigation purpose.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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