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Groundwater Quality and Fluoride Contamination in Kalwakurthy Mandal of Mahabubnagr District, Telangana State, India

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ABSTRACT

Assessment of ground water quality and fluoride contamination was carried out during rainy and post-rainy seasons of 2015-16 by collecting samples from different villages of Kalwakurthy mandal, Mahabubnagar district, Telangana state. The results revealed that, 18%, 10% and 8% of irrigation water samples had above normal level of pH, bicarbonates and magnesium contents during both seasons. Fluoride contamination is very much prevalent with 92% of irrigation water samples having fluoride above the permissible limit of 1 ppm. During rainy season, the fluoride content in water ranged from 0.79 to 4.20 ppm where as during rabi or post rainy season it varied from 1.0 to 4.31 ppm. Marcharla village of the mandal had recorded maximum fluoride content. Other quality parameters of irrigation water viz., EC, chlorides, carbonates, sulphates, calcium, sodium, potassium, RSC, SAR and micronutrients (Cu, Mn, Fe and Zn) were fit and safe for irrigation water use. The quality of irrigation water categorized into C_2S_1 and C_3S_1 classes in study area.

Key words: *Ground water quality, Fluoride, Kalwakurthy and Telangana state.*

INTRODUCTION

Water is very important to life and earth surface is covered by 3/4 of the water resources. Water quality is critical factor affecting human and soil health and also quality of agricultural products. Studies showed that approximately 1.7 million deaths and 1.9 million disabilities worldwide are attributable to unsafe water, poor sanitation and hygiene[11]. Ground water is an important resource for domestic and agriculture in both rural and urban areas of India. The chemical composition of ground water is very important criteria that determine the quality of water. Water quality is very important and often degraded due to agriculture, industrial, human activities and geogenic pollution. Even though the natural environmental processes provide by means of removing pollutants from water, there are definite limits.

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Major problems are being faced by the country due to the presence of excess fluoride, arsenic and nitrate in groundwater in certain parts of country. Nearly 12 million of the 85 million tons of fluoride deposits on the earth's crust are found in India. It is not surprising; therefore, the fluorosis is endemic in 17 states of India[18]. The most seriously affected areas are Andhra Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Tamil Nadu and Uttar Pradesh. Fluoride is a common constituent of groundwater. Natural sources are connected to various types of rocks and to volcanic activity. Agricultural (use of phosphatic fertilizers) and industrial activities (clays used in ceramic industries or burning of coals) also contribute to high fluoride concentrations in groundwater.

The fluoride content of groundwater varies greatly depending on the geological settings and type of rocks. The most common fluorine-bearing minerals are fluorite, apatite and micas. Therefore fluoride problems tend to occur in places where these minerals are most abundant in the host rocks. Arid regions are prone to high fluoride concentrations. Here, groundwater flow is slow and the reaction times with rocks are therefore long. The fluoride contents of water may increase during evaporation if solution remains in equilibrium with calcite and that alkalinity is greater than hardness. Dissolution of evaporative salts deposited in arid zone may be an important source of fluoride. Telangana is the youngest state in the country in terms of geographic spread. It has an area of 3,42,239 lakh Sq kms being largest state of the country having 10.41 % of the country's area and 5.5% of nation's population but has low water resources i.e. 1% of the country's resources. The state has extreme climatic and geographical condition and it suffers both the problems of quantity and quality of water.

At present, Telangana state is facing the problem of fluoride contamination because ground water is used as source of drinking and irrigation water which has natural occurrence of excessive amounts of fluoride levels. Nalgonda, Mahaboobnagar, Adilabad, Karimnagar, Khammam and Medak are some of the districts in the state that have the problem of fluoride comtamination. Hence the study was taken up to assess the extent of fluoride contamination and quality of groundwater by collecting samples during *kharif* or rainy and *rabi* seasons of 2015-16 in Kalwakurthy mandal of Mahabubnagar district, Telangana state.

MATERIAL AND METHODS

The study area Kalwakurthy is located in central-northern parts of Mahabubnagar district, lies in between North Latitudes 16° 34′ 30″ to 16° 42′ 00″ and East longitudes 78° 24′ 00″ to 78° 28′ 48″. The climate of the study area is generally hot. Average temperature in summer is 40.9^0C, in winter is 25^0C and rainfall is 604 mm.

In order to evaluate the fluoride contamination and groundwater quality, fifty groundwater samples were collected in two successive *kharif* (2015) and *rabi* seasons (2015-16) with twenty five samples during each season. The water samples were collected and stored in 1 liter capacity clean plastic bottles. Before collection of samples, the bottles were properly washed. Prior to collecting the samples, the containers were rinsed by the water to be sampled.

The collected water samples in study area were analyzed for quality parameters of water *viz.*, pH, electrical conductivity (EC), anions like chlorides, carbonates, bicarbonates, sulphate, major cations like calcium, magnesium, sodium, potassium, residual sodium carbonate, sodium adsorption ratio and micronutrients (Cu, Mn, Fe and Zn) in the laboratory using the standard methods given by the APHA[1]. Specific ion electrode method was used for anlysing the fluoride content in water samples[16]. Sampling was carried out using pre-cleaned polyethylene containers. The results were evaluated in accordance with the irrigation water quality standards given by the FAO[4] and US Salinity Laboratory Staff[18].

RESULTS AND DISCUSSION

The results pertaining to quality parameters of groundwater are presented in Table 1 and 2.

The statistical parameters of the variables viz., minimum, maximum, mean and standard deviation of different chemical parameters of groundwater are summarized in Table 3.

pH

In the groundwater regime, all chemical and biological reactions directly depend on the pH of the system. During *kharif* 2015, the pH of irrigation water samples ranged from 7.62-8.66 with mean value of 8.07. Maximum pH value was observed in the samples collected from Marcharla village (8.66) whereas the minimum pH in Lingasanapalle village (7.62). The pH of water samples collected during r*abi* season ranged from 7.78 (Gundur village) to 8.90 (Marcharla village) with a mean value of 8.12. pH is an indicator of the acidity or basicity of water, the normal pH range for irrigation water is from 6.50 to 8.40. Irrigation water with a pH outside the normal range may cause a nutritional imbalance or may contain a toxic ion[4]. In the study area, it was observed that, 82% of the water samples had shown pH within the recommended level (6.5 to 8.4) as given by FAO[4], while 18% of samples had shown the pH values above the permissible level. Sundaraiah *et al*.[13] reported a pH range of 7.42 to 8.80 for the groundwater samples collected from Kalwakuthy area of Mahaboobnagar district.

EC (dS m^{-1})

Concentration of water is generally measured with the help of Electrical Conductivity (EC) which is directly proportional to the salt concentration and vice versa. Conductivity is a good indicator to assess groundwater quality. The study revealed that the electrical conductivity of irrigation water widely varied from 0.40 to 1.20 dS m^{-1} with a mean of 0.71 dS m^{-1}. The maximum EC was observed in Lingasanapalle village (1.20 dS m^{-1}) and minimum in Marcharla village (0.40 dS m^{-1}) during *kharif* season. During *rabi* also the same Lingasanapalle (1.62 dS m^{-1}) and Marcharla (0.62 dS m^{-1}) villages had shown maximum and minimum EC with a mean of 0.94 dS m^{-1}. The classification of irrigation water based on EC *viz.*, low (C_1 - 0 to 0.25 dS m^{-1}), medium (C_2 – 0.25 to 0.75 dS m^{-1}), high (C_3 – 0.75 to 2.25 dS m^{-1}) and very high (C_4 - >2.25 dS m^{-1})[15]. The irrigation water samples collected from the study area during *kharif* and *rabi* seasons fall under C_2 and C_3 class whereas according to FAO[4], it was observed within the acceptable limit (0 to 3 dS m^{-1})

Chlorides (me L^{-1})

Presence of chlorides indicates the pollution by sewage. People accumulated to higher chloride in water are subjected to laxative effects. During *kharif* season**,** the content of chloride in irrigation water samples varied between 0.9 to 2.7 me L^{-1} with mean value of 1.5 me L^{-1}. Marcharla and Mukural villages had the minimum chloride content (0.9 me L^{-1}) and Lingasanapalle village (2.7 me L^{-1}) had maximum. The chloride content varied from 0.9 to 5.3 me L^{-1} with an average of 2.0 me L^{-1} in the samples collected during *rabi* season. The highest chloride content was recorded in Lingasanapalle (5.3 me L^{-1}) and lowest in Gundur village (0.9 me L^{-1}). Acoording to FAO[4], the acceptable limits for chloride concentrations in irrigation water is 0 to 30 me L^{-1}4 and all the water samples of the study area were found to be within the acceptable limits . These results are in conformation with the findings of Das and Muralidhar[3].

Carbonates (me L^{-1})

In the study area, during *kharif* season, the status of carbonates present in irrigation water samples was recorded to be in the range of 0 to 0.70 with mean value of 0.05 me L^{-1}. Panjugal village had shown the maximum content of carbonates (0.70 was me L^{-1}). During *rabi* season, the concentration of carbonates varied from 0 to 0.40 me L^{-1} with mean of 0.04 me L^{-1}. Highest carbonates were recorded at Aurpalle village (0.64 me L^{-1}). According to FAO[4], the maximum permissible limit of carbonates in irrigation water is from 0 to 1 me L^{-1}. During both the seasons, all the irrigation water samples were within permissible limits. Similar results were reported by Sundaraiah *et al*.[14] in Kalwakurthy area, Mahabubnagar district.

Bicarbonates (me L^{-1})

In the study area, the bicarbonates in irrigation water samples vary from 6.5 to 10.2 me L^{-1}

(mean 8.0 me L^{-1}) and 6.9 to 10.5 me L^{-1} (mean 8.7 me L^{-1}) during *kharif* and *rabi* seasons. During both seasons, the highest and lowest bicarbonates were present in Panjugal village (10.2, 10.5 me L^{-1}) and Lingasanapalle village (6.5, 6.9 me L^{-1}). The acceptable limit of bicarbonates in irrigation water samples were ranged from 0 to 10 me L^{-1} given by FAO[4]. In study area, 90% irrigation water samples were found to be within the recommended level of bicarbonates.

Sulphates (me L^{-1})

Sulphates may come into ground water by industrial or anthropogenic additions in the form of sulphate fertilizers or weathering. It can also be contaminated by sewage and other sources rich in sulphates. [4]The maximum permissible range of sulphate content in irrigation water is 0 to 20 me L^{-1}. In study area the sulphate content of irrigation water below the maximum permissible limit. The average value of sulphate content in irrigation water was 0.39 me L^{-1} with the lowest and highest values 0.09 and 0.84 me L^{-1} at Gundur and Lingasanapalle villages during *kharif* season. The range of sulphate content during *rabi* was 0.13 to 0.91 me L^{-1} with an average value of 0.38 me L^{-1}. Panjugal village (0.91 meL^{-1}) had the highest sulphate content whereas Gundur village (0.09 me L^{-1}) recorded the lowest during *rabi* season.

Calcium (me L^{-1})

The calcium ion concentration in irrigation water samples varied from 3.0 to 6.8 me L^{-1} and 5.1 to 7.6 me L^{-1} during *kharif* and *rabi* seasons with an average of 5.6 me L^{-1} and 6.6 me L^{-1} respectively. During *kharif* season, highest (6.8 me L^{-1}) and lowest calcium (3.0 me L^{-1}) was reported in Panjugal village while during *rabi* season highest calcium was found in Lingasanapalle village (7.6 me L^{-1}) and lowest in Marcharla village (5.1 me L^{-1}). The acceptable range of calcium in irrigation water is from 0 to 20 me L^{-1} given by FAO[4]. The irrigation water samples of the study area falls under maximum permissible range of calcium. Similar results were also reported by Rajitha *et al*.[9]

Magnesium (me L^{-1})

The concentration of magnesium ions in the irrigation water during the *kharif* season varied from 2.5 to 5.6 me L^{-1} with a mean of 3.8 me L^{-1} and in the *rabi* season from 2.5 to 5.9 me L^{-1} with a mean of 3.8 me L^{-1}. Lowest (2.5 me L^{-1}) magnesium ion concentration was in Marcharla and highest (5.6 me L^{-1}) in Lingasanapalle village during the *kharif* season. Maximum and minimum concentration of magnesium ions was reported in Panjugal (5.9 me L^{-1}) and Lingasanapalle village (2.5 me L^{-1}) during *rabi* season. The acceptable level of magnesium in irrigation water 0 to 5 me L^{-1} (FAO, 1994). In study area during both the seasons, 8% of water samples were found to have greater concentration of magnesium ions than permissible limits and 92% of irrigation of water samples were found to have the magnesium content within permissible limit**.** These results were in conformation with the findings of **Satyanarayana *et al*.[10] in Warangal district of Telangana state.**

Sodium (me L^{-1})

The sodium concentration of irrigation water ranged from 0.6 to 4.3 me L^{-1} with a mean of 2.0 me L^{-1} in *kharif* season, whereas 1.3 to 6.4 me L^{-1} with a mean of 3.2 me L^{-1} during *rabi* season. During *kharif* season, the highest and lowest sodium content was reported in Marcharla (4.3 me L^{-1}) and Lingasanapalle (0.6 me L^{-1}) villages. During *rabi* season, Mukural village showed maximum and minimum sodium values such as 1.3 me L^{-1} and 6.4 me L^{-1} respectively. According to FAO[4], the maximum permissible level of sodium content in irrigation water samples ranged 0 to 40 me L^{-1}. All the ground water samples collected during both *kharif* and *rabi* seasons were within acceptable level of sodium content.

Potassium (me L^{-1})

The potassium values in the irrigation water samples of study area varied from 0.06 to 0.18 during the *kharif* season and 0.07 to 0.43 me L^{-1} during the *rabi* season. During *kharif* season, highest potassium content (0.18 me L^{-1}) was observed in Panjugal and lowest in Gundur village (0.06 me L^{-1}) while in *rabi* season, the

highest and lowest potassium contents was observed in Chandradana (0.43 me L^{-1}) and Padakal (0.07 me L^{-1}) villages. The average potassium content was 0.10 and 0.13 me L^{-1} during *kharif* and *rabi* seasons respectively. Sudhakar and Narsimha[12] reported the potassium content of irrigation water samples ranged from 0.07 to 0.40 me L^{-1} in Kushaiguda area of Ranga Reddy district, Andhra Pradesh.

Residual sodium carbonate (RSC me L^{-1})

Residual sodium carbonate (RSC) is an index used to determine the bicarbonate hazard as well as to distinguish between the different water classes for irrigation purposes. In water having high concentration of bicarbonate there is tendency for calcium and magnesium to precipitate as carbonates. In the study area, the RSC of irrigation water samples ranged from -4.70 to 0.10 and 0.50 to -3.70 with mean of -1.39 me L^{-1} and -1.65 me L^{-1} during *kharif* and *rabi* seasons. Maximum and minimum RSC was recorded in Marcharla village [0.10 me L^{-1} (*kharif*), 0.50 me L^{-1} (*rabi*)] and minimum in Lingasanapalle village [-4.70 me L^{-1} (*kharif*), -3.70 me L^{-1} (*rabi)*] during both seasons. According to the U.S. Salinity Laboratory staff[15], an RSC value less than 1.25 me L^{-1} is safe for irrigation; a value between 1.25 and 2.5 me L^{-1} is marginal quality and a value greater than 2.5 me L^{-1} is unsuitable for irrigation. The irrigation water of RSC in study area is less than 1.25 me $L^{-1,}$ hence it is safe for irrigation usage.

Sodium adsorption ratio

Sodium hazard is also usually expressed in terms of the SAR. SAR is an important parameter for determination of suitability of irrigation water. SAR values varied from a minimum (Lingasanapalle village) of 0.3 to a maximum (Marcharla village) of 1.9 with a mean value of 0.9 in *kharif* season and from a minimum (Mukural village) of 0.3 to a maximum (Marcharla village) of 1.4 with a mean value of 0.6 in *rabi* season. The classification of SAR in irrigation water <10 (S_1 - low), 10 – 18 (S_2 - medium), 18 – 26 (S_3 - high) and >26 (S_4 - very high). The SAR values of the irrigation water samples of the study area are less than 10 and are classified as good for irrigation. Nagaraju *et al*.[6] reported the SAR of irrigation water ranged from 0.33 to 4.93 in Rapur area of Andhra Pradesh.

Micronutrients (Cu, Mn, Fe and Zn)

In *kharif* season, the Cu, Mn, Fe and Zn status of irrigation water samples collected from study area were ranged from 0 to 0.24, 0 to 0.18, 0 to 0.23 and 0 to 0.10 ppm with mean values of 0.06, 0.05, 0.06 and 0.03 ppm. During *rabi* season, the micronutrients (Cu, Mn, Fe and Zn) varied from 0 to 0.24, 0 to 0.18, 0 to 0.23 and 0 to 0.10 with mean values of 0.05, 0.05, 0.06 and 0.03 ppm was recorded. [7]The recommended level of Cu, Mn, Fe and Zn in irrigation water samples is 0.2, 0.2, 5.0 and 2.0 mg L^{-1}. In study area, during both the seasons, maximum irrigation water samples had micronutrients (Cu, Mn, Fe and Zn) within permissible limits hence all the water can be safely used for irrigation purpose.

All the collected irrigation water samples in study area during both seasons categorized into C_2 S_1 (48%) and C_3 S_1 (52%) classes. C_2 type of irrigation water can be used with moderate leaching whereas C_3 type cannot be used on soil with restricted drainage. Low Na water (S_1) can be used on all soils with little danger of development of normal level of exchangeable Na.

Fluoride (ppm)

Fluoride occurs as fluorspar (fluorite), rock phosphate, triphite, phosphorite crystals etc, in nature. Among factors which control the concentration of fluoride are the climate of the area and the presence of accessory minerals in the rock minerals assemblage through which the ground water is circulating. In the present investigation, fluoride content of groundwater varied from a minimum of 0.79 ppm (Lingasanapalle) to a maximum of 4.20 ppm (Marcharla) with a mean value of 2.06 ppm during *kharif* season. In *rabi* season the concentration of fluoride ranged between 1.0 to 4.31 ppm with a mean value of 2.56 ppm. Similar to *kharif* season, fluoride content was highest in Marcharla village (4.31 ppm) and lowest in Lingasanapalle village (1.0 ppm). The recommended maximum concentration of fluoride in irrigation water is 1.0 ppm[7,8]. In

study area, 92% of irrigation water samples had fluoride content greater than that of maximum permissible level *i.e*., 1.0 ppm. Similar findings were also reported by Arif *et al*.[2] in the samples collected from Ladnu block of Nagaur district in Rajasthan, Sundaraiah *et al*.[14] in Kalwakurthy area of Mahaboobnagar district and Lakshmi *et al*.[5] reported a range of fluoride content from 0.99 to 3.94 ppm in ground water samples of adjoining Nalgonda district, Telangana state.

Table 1: Physico-chemical characteristics of the water samples in different villages of Kalwakurthy Mandal (*Kharif* 2015)

S.no	Name of the village	pH	EC (dS m^{-1})	F mg L^{-1}	Cl	CO_3^{-2}	HCO^-_3	SO_4^{-2}	Ca^{+2}	Mg^{+2}	Na^+	K^+	RSC	SAR
					me L^{-1}									
1	Gundur	7.85	0.60	1.80	1.6	0.0	6.8	0.10	4.5	2.9	1.0	0.07	-0.60	0.5
2	Gundur	8.50	0.55	2.00	1.6	0.0	8.8	0.09	5.8	3.1	1.8	0.11	-0.10	0.9
3	Gundur	7.75	0.65	1.60	1.1	0.0	7.6	0.44	4.6	3.3	1.5	0.06	-0.30	0.8
4	Gundur	7.80	0.70	1.80	1.7	0.0	7.5	0.28	5.2	3.5	1.8	0.07	-1.20	0.9
5	Gundur	8.00	0.65	1.70	1.3	0.0	9.2	0.14	6.1	4.2	2.3	0.11	-1.10	1.0
6	Marcharla	8.66	0.40	4.20	2.1	0.5	8.5	0.53	5.9	3.0	4.1	0.09	0.10	1.9
7	Marcharla	7.96	0.45	3.30	1.1	0.0	8.8	0.41	5.7	3.2	2.8	0.07	-0.10	1.3
8	Marcharla	8.35	0.50	2.10	0.9	0.0	8.3	0.42	6.0	2.5	2.1	0.13	-0.20	1.0
9	Marcharla	8.60	0.65	3.70	1.8	0.0	7.8	0.17	5.1	3.6	2.6	0.10	-0.90	1.2
10	Marcharla	8.05	0.90	3.80	2.4	0.0	9.3	0.62	5.5	4.5	4.3	0.11	-0.70	1.9
11	Panjugal	8.42	0.92	3.95	2.0	0.0	7.1	0.58	3.0	4.5	2.7	0.18	-0.40	1.4
12	Panjugal	7.85	0.67	1.50	1.7	0.0	8.2	0.34	5.1	4.7	2.4	0.10	-1.60	1.1
13	Panjugal	8.15	0.66	2.90	1.3	0.0	10.2	0.50	6.8	5.0	2.1	0.07	-1.60	0.9
14	Panjugal	8.60	0.79	2.20	1.3	0.7	6.8	0.65	4.7	3.7	2.3	0.09	-0.90	1.1
15	Panjugal	8.33	0.72	2.50	1.3	0.0	9.5	0.32	6.8	4.6	1.2	0.13	-1.90	0.5
16	Lingasanapalle	7.62	0.85	0.82	2.0	0.0	7.0	0.25	6.1	5.6	2.0	0.09	-4.70	0.8
17	Lingasanapalle	7.95	0.82	0.85	1.3	0.0	6.9	0.43	5.4	3.4	1.9	0.15	-1.90	0.9
18	Lingasanapalle	7.95	1.20	0.95	2.7	0.0	6.5	0.72	5.3	4.1	2.4	0.10	-2.90	1.1
19	Lingasanapalle	7.91	0.60	0.79	1.1	0.0	7.2	0.09	5.9	5.4	0.6	0.18	-4.09	0.3
20	Lingasanapalle	7.98	0.71	1.10	1.1	0.0	7.5	0.84	6.1	5.3	1.1	0.10	-3.90	0.5
21	Mukural	7.80	0.45	1.30	1.1	0.0	8.1	0.53	5.6	2.6	1.0	0.11	-0.10	0.5
22	Mukural	8.03	1.12	1.70	0.9	0.0	7.9	0.25	6.0	3.6	2.1	0.10	-1.70	1.0
23	Mukural	7.77	0.71	1.50	1.3	0.0	7.1	0.37	5.8	2.6	0.9	0.09	-1.30	0.4
24	Mukural	7.75	0.68	1.80	1.6	0.0	7.6	0.22	6.2	3.7	1.0	0.07	-2.30	0.4
25	Mukural	8.00	0.87	1.70	1.0	0.0	8.8	0.40	6.1	3.1	1.0	0.08	-0.40	0.5

Table 2: Physico-chemical characteristics of the water samples in different villages of Kalwakurthy mandal (*Rabi* 2015-16)

S.no	Name of the Village	pH	EC (dS m^{-1})	F mg L^{-1}	Cl	CO_3^{-2}	HCO^-_3	SO_4^{-2}	Ca^{+2}	Mg^{+2}	Na^+	K^+	RSC	SAR
					me L^{-1}									
1	Gundur	7.86	0.72	2.30	1.1	0.0	8.1	0.21	6.5	3.3	2.2	0.16	-1.7	0.4
2	Gundur	8.15	0.86	2.50	1.5	0.0	8.3	0.18	6.2	3.6	2.8	0.11	-1.5	0.6
3	Gundur	7.78	0.97	2.10	0.9	0.0	7.6	0.47	6.1	4.5	3.2	0.08	-3.0	0.6
4	Gundur	8.20	0.76	2.40	2.1	0.0	8.0	0.25	6.7	3.9	2.7	0.12	-2.6	0.5
5	Gundur	7.91	0.68	1.85	1.5	0.0	9.6	0.13	7.2	4.8	2.6	0.11	-2.4	0.4
6	Marcharla	8.56	1.36	4.31	3.1	0.4	10.1	0.38	7.0	3.3	6.4	0.28	0.20	1.2
7	Marcharla	8.17	1.01	3.84	1.2	0.0	8.6	0.16	5.8	3.5	4.8	0.15	-0.7	1.0
8	Marcharla	8.90	0.82	2.24	1.0	0.0	8.7	0.47	6.7	3.3	3.1	0.13	-1.3	0.6
9	Marcharla	8.05	0.95	3.84	2.3	0.0	9.3	0.51	5.5	4.2	3.3	0.10	-0.4	0.7
10	Marcharla	8.43	1.26	4.15	3.0	0.0	9.1	0.48	5.1	3.5	5.9	0.15	0.5	1.4
11	Panjugal	8.21	0.98	4.31	4.3	0.0	10.2	0.50	6.5	3.8	5.5	0.18	-0.1	1.1
12	Panjugal	7.91	1.56	1.55	1.9	0.0	7.7	0.91	7.5	3.6	1.9	0.29	-3.4	0.3
13	Panjugal	8.45	0.76	3.22	1.7	0.0	9.7	0.58	6.1	5.9	3.6	0.17	-2.3	0.6
14	Panjugal	8.31	0.63	2.97	1.4	0.0	10.2	0.61	6.4	3.8	2.8	0.10	0.0	0.5
15	Panjugal	8.40	0.97	3.51	2.1	0.0	10.5	0.28	6.8	4.0	3.8	0.09	-0.3	0.7
16	Lingasanapalle	7.82	0.68	1.90	1.4	0.0	7.5	0.53	7.1	3.7	3.7	0.10	-3.3	0.7
17	Lingasanapalle	7.86	1.28	1.30	2.2	0.2	7.8	0.41	7.4	4.1	3.3	0.19	-3.5	0.6
18	Lingasanapalle	8.00	1.62	1.00	5.3	0.0	6.9	0.14	6.3	4.3	3.7	0.34	-3.7	0.7
19	Lingasanapalle	8.01	1.13	1.45	1.3	0.0	8.1	0.19	7.6	3.2	1.8	0.11	-2.7	0.3
20	Lingasanapalle	7.95	0.70	2.20	1.2	0.0	9.2	0.33	6.8	2.5	1.4	0.10	-0.1	0.3
21	Mukural	8.05	0.82	2.51	1.6	0.0	9.8	0.40	6.9	3.3	1.9	0.05	-0.4	0.4
22	Mukural	8.13	0.74	2.60	1.9	0.3	8.3	0.32	6.5	3.8	2.8	0.11	-1.7	0.5
23	Mukural	7.79	0.95	1.81	1.8	0.0	7.3	0.38	7.2	2.9	1.3	0.15	-2.8	0.3
24	Mukural	7.94	0.76	2.10	2.4	0.0	8.5	0.23	6.6	3.9	1.8	0.07	-2.0	0.3
25	Mukural	8.13	0.62	2.15	1.5	0.0	8.3	0.38	6.5	4.1	3.1	0.08	-2.3	0.6

Table 3: Range, mean and standard deviation of different quality parameters in study area

Parameters	*Kharif* (2015)			*Rabi* (2015-16)		
	Range	Mean	SD	Range	Mean	SD
pH	7.62-8.66	8.07	0.30	7.78-8.90	8.12	0.27
EC (dS m^{-1})	0.40-1.20	0.71	0.19	0.62-1.62	0.94	0.28
F (mg L^{-1})	0.79-4.20	2.06	1.02	1.0-4.31	2.56	0.96
Cl (me L^{-1})	0.9-2.7	1.5	0.47	0.9-5.3	2.0	1.03
CO_3^{-2} (me L^{-1})	0-0.70	0.05	0.17	0-0.40	0.04	0.10
HCO_3^- (me L^{-1})	6.5-10.2	8.0	0.98	6.9-10.5	8.7	1.02
SO_4^{-2} (me L^{-1})	0.09-0.84	0.39	0.20	0.13-0.91	0.38	0.18
Ca (me L^{-1})	3.0-6.8	5.6	0.80	5.1-7.6	6.6	0.60
Mg (me L^{-1})	2.5-5.6	3.8	0.92	2.5-5.9	3.8	0.67
Na (me L^{-1})	0.6-4.3	2.0	0.93	1.3-6.4	3.2	1.33
K (me L^{-1})	0.06-0.18	0.10	0.03	0.05-0.34	0.14	0.07
RSC (me L^{-1})	-4.70-0.10	-1.39	1.32	-3.70-0.50	-1.65	1.31
SAR	0.3-1.9	0.9	0.44	0.3-1.4	0.6	0.29
Cu (mg L^{-1})	0 - 0.24	0.04	0.06	0-0.24	0.05	0.07
Mn (mg L^{-1})	0 – 0.18	0.03	0.05	0-0.23	0.04	0.06
Fe (mg L^{-1})	0 – 0.23	0.04	0.06	0-0.34	0.08	0.12
Zn (mg L^{-1})	0 – 0.10	0.02	0.03	0-0.21	0.04	0.06

CONCLUSION

In the study area, 18%, 10% and 8% of irrigation water samples had above recommended level of pH, bicarbonates, magnesium during both the seasons. However, 92% of irrigation water samples had fluoride cocentration above the permissible limit of 1 ppm. Other quality parameters of irrigation water *viz.*, EC, chlorides, carbonates, sulphates, calcium, sodium, potassium, RSC, SAR and micronutrients (Cu, Mn, Fe and Zn) were fit in recommended levels of irrigation water. In study area, the collected irrigation water samples classified into C_2S_1 (48%) and C_3S_1 (48%) groups.

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