Characterization of irrigation water quality of groundnut belt of erstwhile Mahabubnagar district of Telangana

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ABSTRACT
An investigation was performed to characterize the irrigation water quality of the groundnut belt in the erstwhile Mahabubnagar district, Telangana for which 35 irrigation water samples from both canal and groundwater sources from the study area were collected through a preliminary survey in the selected farmer’s fields. The samples which were analyzed for pH, EC, RSC, SAR, Mg/Ca ratio and Kelly’s ratio in the laboratory interpreted that the pH was slightly alkaline (pH: 7.58) with medium salinity (0.64 dS/m) and high Mg/Ca (1.15) ratio though the RSC (5.05) and SAR (2.68) fall in the safe ranges and were classified under C2S1 and C3S1 irrigation water classes. Considering the pH range in the irrigation water, proper management of the soil through incorporation of organic manures at regular intervals is suggested in all the regions of the groundnut belt (highly and marginally potential zones) having pH above 7.50 to prevent mounting up of soil pH when irrigated continuously over a period of time.

INTRODUCTION
In arid and semi-arid parts of India, groundwater is the primary source of irrigation for household, agricultural, and industrial needs. India has 2.2 percent of the world's territory, 4% of its water resources, and 16% of the world's people (Ramesh and Elango 2011; Bhutiani and Ahamad, 2019). So, development of irrigation in India has been driven by the paramount imperative of feeding a rapidly increasing population. Water quality is a major concern for humanity because it is directly linked to human welfare, particularly for drinking and agriculture (Tyagi et al., 2020; Ruhela et al., 2021; Bhutiani et al., 2021).

The irrigation water quality can be defined based on the concentration and kind of salts and solids dissolved in it (Etteieb et al., 2017). Irrigation water quality testing is necessary to ensure a safe supply of water to the crop. In recent years, there has been a growing concern over irrigation’s long-term prospects and the ramifications of continuing existing water management techniques on the system's long-term viability (Chintapalli et al., 2000). The information regarding irrigation water quality has critical importance in understanding the changes in the quality of the product, and the modifications that are required in the water management (Ramakrishnaiah et al., 2009). The quality of irrigation water is an essential element in the assessment of salinity or alkali conditions in irrigated regions, and it is largely determined by the overall quantity of salt present, the proportion of sodium (Na) to other cations, and a number of other factors (Tiwari, 2011). The efficiency of the product and the potential for emergence of hazardous conditions of the soil should be considered during the evaluation of water quality.
for irrigation for obtaining better yields in the crop production (Bhardwaj et al., 2020). Thus, evaluation of water quality is mandatory in planning, design and operation of irrigation systems (Mirabbasi et al., 2008). So, the present exploration was taken up aiming for irrigation water quality characterization during rabi 2019-20 in the erstwhile Mahabubnagar district of Telangana.

Material and Methods

Study area
Mahabubnagar district of Telangana lies between 15°55’ to 17°20’ latitudes and 77°15’ to 79°15’ Northern and Eastern longitudes where the climate is generally hot. The mean monthly maximum temperature ranges between 30.5˚C in August and 38.8˚C during April-May. The average monthly minimum temperature ranged from 16.3˚C during and to 26.4˚C during May. The mean annual rainfall is 604 mm which is mostly received during South-West monsoon. The annual rainfall was hardly 64.0 per cent of the state average (940 mm). The year-to-year variation in the actual rainfall showed that there were more dry spells during the cropping season (District census handbook-Mahabubnagar, 2011). The principal soil is the chalka dubba in about 70.0 per cent of the study area and has low water holding capacity (Statistical year book-Mahabubnagar, 2017). Krishna and Tungabhadra are the two principal rivers that flowed through the district. The total ayacut area under different irrigation projects is 5.37 lakh ha. The major irrigation projects occupy an area of 3.70 lakh ha. The medium irrigation projects occupy an area of 0.20 lakh ha, and an area of 1.30 lakh ha is under minor irrigation projects. There are about 1,87,216 minor irrigation sources in the district which include shallow tube wells, dug wells, deep tube wells, surface flow and lift irrigation projects (Statistical year book-Mahabubnagar, 2017). The average irrigation intensity of the state is 1.42 (average from 2011-12 to 2015-16). Net area irrigated under different sources of irrigation in the district was 2.50 lakh ha (2010-12), out of which the area irrigated by the groundwater resources was 2.10 lakh ha, which constitutes 83.2 per cent of the net area irrigated. Area irrigated by surface water was 0.30 lakh ha, which accounts for 13.7 per cent of the total irrigated area and remaining by other sources (Madhusudhana, 2013).

Water sample collection and analysis
The groundnut crop being an important rabi season crop of the erstwhile Mahabubnagar district is a crop colony of groundnut. The marginally potential zones of the crop colony have high crop spread but has low productivity. So, assessment of irrigation water could reveal the reason for low crop productivity in the study area. Thirty-five (35) irrigation water samples in total were collected from both borewell (24 samples) and canal (11 samples) (Table 1 & Figure 1) sources from the study area at the time of crop harvest i.e., from 28th November, 2019 to 6th February, 2020. The samples were analysed for pH, EC (Electrical Conductivity), carbonates, bicarbonates, calcium, magnesium and sodium following the standard procedures in the laboratory Jackson, 1967; Barnes (1964); Wood (1976); Hem (1970); Diehl (1950) from which sodium absorption ratio (SAR) residual sodium carbonate (RSC), magnesium/calcium ratio and Kelly’s ratio were computed and categorized them into suitable classes (Table 2). A detailed methodology followed for the assessment of quality of irrigation water samples was presented in Figure 2.

Results and Discussion
The irrigation water quality determines its suitability for the crop and its yield. So, a careful analysis was carried out for the assessment of pH, EC, RSC, SAR, Mg-Ca ratio and Kelly’s ratio in the samples of the groundnut belt in the erstwhile Mahabubnagar district, Telangana and the results were detailed here under (Table 3).

pH of Irrigation water:
The study area with regards to irrigation water pH was categorized in to three classes viz., acidic (< 6.50), neutral (6.50-7.50) and alkaline (> 7.50). The pH of the water samples in the research site stretched from 6.91 to 8.10 with the mean of 7.58. The pH of borewell samples stretched from 6.91 and 7.90 with a mean of 7.56. Similarly, pH of canal water samples stretched from 7.10 and 8.10 by mean value of 7.59. The overall assessment of both the sources showed that the irrigation water in the groundnut zone falls into alkaline range. Ranjit et al. (2017) at Kalwakurthy mandal of Mahabubnagar also reported pH of water samples ranging from 7.78 to 8.90 with a mean value of 8.12.
Table 1: Location and coordinates of the selected groundnut crop fields.

| SN | Village     | Mandal   | Division | Latitude  | Longitude |
|----|-------------|----------|----------|-----------|-----------|
| 1  | Shekupally  | Itikyal  | Gadwal   | 16.11833  | 77.92636  |
| 2  | Kothakota   | Kothakota| Wanaparthy| 16.36164  | 77.93672  |
| 3  | Putnapally  | Gadwal   | Gadwal   | 16.16716  | 77.84795  |
| 4  | Dattaipally | Wanaparthy| Wanaparthy| 16.31787  | 78.07460  |
| 5  | Maldakal    | Maldakal | Gadwal   | 16.10839  | 77.68590  |
| 6  | Basavapuram | Gattu    | Gadwal   | 16.15046  | 77.58418  |
| 7  | Mylagadda   | K.T.Doddi| Gadwal   | 16.23944  | 77.60169  |
| 8  | Nallahelli  | Dharoor  | Gadwal   | 16.28208  | 77.61575  |
| 9  | Pathapalem  | Dharoor  | Gadwal   | 16.28136  | 77.61658  |
| 10 | Mylaram     | Kodair   | Nagarkurnool | 16.17734 | 78.31488  |
| 11 | Buddharam   | Gopalpet | Wanaparthy| 16.41820  | 78.14000  |
| 12 | Velgonda    | Chinnambavi| Wanaparthy| 16.10885  | 78.09300  |
| 13 | Nallavelly  | Nagarkurnool| Nagarkurnool| 16.48328  | 78.24618  |
| 14 | Ankiravelly | Kollapur | Nagarkurnool | 16.10828  | 78.31293  |
| 15 | Kottapally  | Amrabad  | Nagarkurnool | 16.35644  | 78.81134  |
| 16 | Pentlavelly | Pentlavelly| Nagarkurnool| 16.07197  | 78.23838  |
| 17 | Veljal      | Talakondapally| Shadnagar| 16.65389  | 78.19442  |
| 18 | Gopaldinne  | Veepanagandla| Wanaparthy| 16.12852  | 78.06158  |
| 19 | Uppununtala | Uppununtala| Nagarkurnool| 16.52633  | 78.66717  |
| 20 | Lingala     | Lingala  | Nagarkurnool | 16.23610  | 78.08784  |
| 21 | Gattunellikuduru | Telkapally | Nagarkurnool| 16.40301  | 78.44006  |
| 22 | Chennaram   | Balmoor  | Nagarkurnool | 16.38845  | 78.55522  |
| 23 | Kakunooru   | Keshampet| Shadnagar | 16.91817  | 78.32250  |
| 24 | Kalvakolu   | Peddakottapally | Nagarkurnool| 16.17726  | 78.31484  |
| 25 | Waddeeman   | Bijinapally| Nagarkurnool| 16.48315  | 78.22762  |
| 26 | Gummakonda  | Timmajipet| Nagarkurnool | 16.65451  | 78.19461  |
| 27 | Lingotam    | Achampet | Nagarkurnool | 16.41383  | 78.62158  |
| 28 | Chinna Aadirala | Jachcherla | Mahabubnagar | 16.83731  | 78.31447  |
| 29 | Chinnamylaram | Kodangal | Kodangal | 17.09258  | 77.70106  |
| 30 | Dudhyal     | Kodangal | Kodangal | 17.04719  | 77.71156  |
| 31 | Pedda Aadirala | Jachcherla | Mahabubnagar | 16.09869  | 78.29169  |
| 32 | Papagal     | Tadoor   | Nagarkurnool | 16.65180  | 78.30635  |
| 33 | Rudrasamudram | Makhtal | Narayanpet | 16.49499  | 77.92636  |
| 34 | Rudrasamudram | Makhtal | Narayanpet | 16.46476  | 77.93672  |
| 35 | Mahabubnagar | Mahabubnagar | Mahabubnagar | 16.72500  | 77.84795  |
Figure 1: The study area map representing the coordinates of the groundnut fields

Table 2: Classes assigned for irrigation water parameters to assess the water quality in the study area (US Salinity Lab, 1954)

| SN | Water quality parameter          | No of classes assigned | Details of classes                             |
|----|----------------------------------|------------------------|------------------------------------------------|
| 1. | pH (1:2.5)                       | 03                     | • < 6.00: Acidic                                |
|    |                                  |                        | • 6.00-7.50: Neutral                            |
|    |                                  |                        | • > 7.50: Alkaline                              |
| 2. | EC (dS/m) (US Salinity Lab, 1954)| 04                     | • C1: < 0.25-Low saline                         |
|    |                                  |                        | • C2: 0.25-0.75-Medium                          |
|    |                                  |                        | • C3: 0.75-2.25-Highly saline                   |
|    |                                  |                        | • C4: > 2.25-Very highly saline                 |
| 3. | SAR                              | 04                     | • S1: 0-10.0- Low                               |
|    |                                  |                        | • S2: 10.0-18.0-Medium                          |
|    |                                  |                        | • S3: 18.0-26.0-High                            |
|    |                                  |                        | • S4: > 26.0-Very high                          |
| 4. | RSC (me 1^{-1})                  | 03                     | • < 1.25: Safe                                  |
|    |                                  |                        | • 1.25 -2.5 0: Moderate                        |
|    |                                  |                        | • > 2.5 0: Unsafe                               |
| 5. | Mg/ Ca ratio                     | 02                     | • < 1.00: Safe                                  |
|    |                                  |                        | • > 1.00: Unsafe                                |
| 6. | Kelly’s Ratio                    | 02                     | • < 1.0: Suitable                               |
|    |                                  |                        | • > 1.0: Unsuitable                             |
Assessment of groundwater quality in selected villages of Mahabubnagar by Srinivasulu et al. (2015) also showed that pH ranged from 7.09 to 8.19 which are slightly basic. The higher pH of the most of groundwater samples may be due to considerable Na\(^+\), Ca\(^{2+}\), Mg\(^{2+}\), CO\(_3^{2-}\) and HCO\(_3^-\). The samples from Nagarkurnool and Wanaparthy divisions of the research site in the groundnut belt showed that pH of irrigation water was mostly alkaline with exception of Timmajipet, Tadoor and parts of Bijinapally, Nagarkurnool, Telkapally, Balmoor, Uppununtala, Achampet, Kollapur, Veepangandla, Pebbair, Ghanpur mandals having neutral pH. Contrastingly, the irrigation water of entire Narayanpet and Gadwal divisions was characterized as alkaline with few exceptions in parts of Itikyal, Gadwal and Monopad mandals of Gadwal division with neutral irrigation samples. Considering the pH range, proper management of the soil through incorporation of organic manures at regular intervals is suggested in all the regions of the groundnut belt (highly and marginally potential zones) having pH above 7.50 to prevent mounting up of soil pH when irrigated continuously over a period of time.

**Electrical Conductivity of irrigation water:**
The irrigation water samples for electrical conductivity were classified into four classes viz., low saline (very good water: < 0.25 dS/m), medium saline (good water: 0.25-0.75 dS/m), highly saline (doubtful water: 0.75-2.25 dS/m) and very highly saline (not useful water: > 2.25 dS/m). The Electrical conductivity (EC) in the irrigation water samples (borewells and canals) in the study area ranged from 0.14 to 1.47 dS/m with a mean value of 0.64 dS/m. These values can be supported from EC values obtained at Kalwakurthy mandal which extend from 0.40 to 1.20 dS/m with a mean value of 0.71 dS/m in the irrigation water (Ranjit et al., 2017). The irrigation water from borewells had reported EC ranging from 0.14 to 0.98 dS/m with a mean of 0.47 dS/m. On the other hand, the EC of the water samples of canal irrigated regions ranged from 0.15 to 1.47 dS/m with an average value of 0.72 dS/m. The EC of the water samples (both borewells and canals) indicated that the irrigation water though was doubtful (highly saline) for crop growth in some regions it was mostly good for irrigating the crop. Disintegrated regions of (doubtful) highly saline water were seen in Kodangal, Kosgi, Bomraspet, Doultabad and parts

**Figure 2: Detailed methodology for sampling and analysis of irrigation water samples**

1. The groundnut crop colony of the Telangana region was selected for the present study.
2. The study area was delineated using the topographical maps of the Survey of India.
3. A survey was conducted in the groundnut fields in the study area.
4. The sampling locations were selected and the ground control points/coordinates were collected.
5. The irrigation water samples were collected from each mandal in the study area from 28th November, 2019 to 6th February, 2020.
6. The collected samples were analysed immediately within 24 hrs in the laboratory for carbonates and bicarbonates.
7. Then the samples were stored in the refrigerator for further analysis of pH, EC, Na, Ca and Mg.
8. The samples were analysed for the remaining parameters and the residual sodium carbonate (RSC) and Sodium Adsorption Ratio (SAR) were computed.
9. Then the results of each parameter was classified using the standard classification charts of USDA.
Table 3: Results of laboratory analysis of the irrigation water samples collected from the farmer’s fields in the study area.

| SN | District     | pH (1:2.5) | Rating       | EC (dS/m) | SAR Rating | Rating | Irrigation water class | Mg/Ca ratio | Rating | RSC | Rating | Kelly’s ratio | Rating |
|----|--------------|------------|--------------|-----------|------------|--------|------------------------|--------------|--------|-----|--------|----------------|--------|
| 1  | Gadwal       | 6.91       | Neutral      | 0.14      | Low (C1)   | 1.80   | Low Na (S1)            | C1S1         | 0.79   | Low | -6.70 | Safe           | 0.32   | Suitable |
| 2  | Wanaparthy   | 8.10       | Slightly alkaline | 0.79    | Highly saline (C3) | 1.99   | Low Na (S1)            | C3S1         | 1.07   | Low | -6.40 | Safe           | 0.34   | Suitable |
| 3  | Gadwal       | 7.40       | Neutral      | 0.17      | Low (C1)   | 1.83   | Low Na (S1)            | C1S1         | 0.84   | Low | -7.20 | Safe           | 0.32   | Suitable |
| 4  | Wanaparthy   | 7.70       | Slightly alkaline | 0.49    | Medium saline (C2) | 1.47   | Low Na (S1)            | C2S1         | 2.93   | Medium | -7.90 | Safe           | 0.23   | Suitable |
| 5  | Gadwal       | 7.90       | Slightly alkaline | 0.57    | Medium saline (C2) | 1.30   | Low Na (S1)            | C2S1         | 2.80   | Medium | -9.00 | Safe           | 0.20   | Suitable |
| 6  | Gadwal       | 8.05       | Slightly alkaline | 1.01    | Highly saline (C3) | 3.43   | Low Na (S1)            | C3S1         | 0.84   | Low | -7.20 | Safe           | 0.57   | Suitable |
| 7  | Gadwal       | 7.90       | Slightly alkaline | 0.64    | Medium saline (C2) | 1.90   | Low Na (S1)            | C2S1         | 0.51   | Low | -4.30 | Safe           | 0.40   | Suitable |
| 8  | Gadwal       | 8.10       | Slightly alkaline | 0.53    | Medium saline (C2) | 1.82   | Low Na (S1)            | C2S1         | 0.93   | Low | -3.10 | Safe           | 0.36   | Suitable |
| 9  | Gadwal       | 8.01       | Slightly alkaline | 0.24    | Low (C1)   | 1.33   | Low Na (S1)            | C1S1         | 1.95   | Medium | -9.00 | Safe           | 0.19   | Suitable |
| 10 | Nagarkurnool | 7.60       | Slightly alkaline | 1.43    | Low (C1)   | 10.3   | Medium Na (S2)         | C1S2         | 1.80   | Medium | -3.20 | Safe           | 2.00   | Unsuitable |
| 11 | Wanaparthy   | 7.90       | Slightly alkaline | 0.36    | Medium saline (C2) | 1.70   | Low Na (S1)            | C2S1         | 1.71   | Medium | -10.5 | Safe           | 0.24   | Suitable |
| 12 | Wanaparthy   | 7.72       | Slightly alkaline | 0.67    | Medium saline (C2) | 3.26   | Low Na (S1)            | C2S1         | 1.30   | Low | -6.00 | Safe           | 0.59   | Suitable |
| 13 | Nagarkurnool | 7.30       | Neutral      | 0.32      | Medium saline (C2) | 3.34   | Low Na (S1)            | C2S1         | 1.95   | Medium | -4.60 | Safe           | 0.64   | Suitable |
| 14 | Nagarkurnool | 7.80       | Slightly alkaline | 0.38    | Medium saline (C2) | 2.44   | Low Na (S1)            | C2S1         | 0.68   | Low | -1.70 | Safe           | 0.60   | Suitable |
| 15 | Nagarkurnool | 7.60       | Slightly alkaline | 0.15    | Low (C1)   | 2.00   | Low Na (S1)            | C1S1         | 1.86   | Medium | -7.10 | Safe           | 0.30   | Suitable |
| 16 | Nagarkurnool | 7.16       | Neutral      | 1.19      | Highly saline (C3) | 2.33   | Low Na (S1)            | C3S1         | 1.25   | Low | -5.70 | Safe           | 0.25   | Suitable |
| 17 | RangaReddy  | 7.15       | Neutral      | 0.62      | Medium saline (C2) | 1.33   | Low Na (S1)            | C2S1         | 0.60   | Low | -3.95 | Safe           | 0.29   | Suitable |
| 18 | Wanaparthy   | 8.05       | Slightly alkaline | 0.96    | Highly saline (C3) | 3.39   | Low Na (S1)            | C3S1         | 0.10   | Low | -6.95 | Safe           | 0.22   | Suitable |
| 19 | Nagarkurnool | 7.20       | Neutral      | 0.81      | Highly saline (C3) | 1.96   | Low Na (S1)            | C3S1         | 0.90   | Low | -4.10 | Safe           | 0.36   | Suitable |
| 20 | Nagarkurnool | 7.56       | Slightly alkaline | 0.44    | Highly saline (C3) | 2.07   | Low Na (S1)            | C3S1         | 0.60   | Low | -5.55 | Safe           | 0.08   | Suitable |
| Site          | pH       | Type      | EC (mS/cm) | Breakdown | Electrical Conductivity | Sodium | TDS (mg/L) | Classification |
|--------------|----------|-----------|------------|-----------|------------------------|-------|-------------|----------------|
| Nagarkurnool | 7.44     | Neutral   | 0.45       | Medium saline (C2) | 1.92 | Low Na (S1) | C2S1 1.07 | Low -4.50 Safe 0.04 Suitable |
| Nagarkurnool | 7.20     | Neutral   | 0.25       | Low (C1)   | 2.92 | Low Na (S1) | C1S1 0.04 | Low -3.75 Safe 0.23 Suitable |
| RangaReddy   | 7.20     | Neutral   | 0.85       | Highly saline (C3) | 2.18 | Low Na (S1) | C3S1 0.60 | Low -3.95 Safe 0.47 Suitable |
| Nagarkurnool | 7.72     | Slightly alkaline | 1.47 | Highly saline (C3) | 2.89 | Low Na (S1) | C3S1 0.27 | Low -1.80 Safe 0.61 Suitable |
| Nagarkurnool | 7.54     | Slightly alkaline | 0.98 | Highly saline (C3) | 4.47 | Low Na (S1) | C3S1 0.19 | Low 1.00 Safe 1.18 Unsuitable |
| Nagarkurnool | 7.52     | Slightly alkaline | 1.26 | Highly saline (C3) | 4.24 | Low Na (S1) | C3S1 2.40 | Medium -5.65 Safe 0.33 Suitable |
| Nagarkurnool | 7.79     | Slightly alkaline | 0.67 | Medium saline (C2) | 1.42 | Low Na (S1) | C2S1 2.43 | Medium -7.10 Safe 0.26 Suitable |
| Mahabubnagar | 7.10     | Neutral   | 0.31       | Medium saline (C2) | 1.06 | Low Na (S1) | C2S1 0.35 | Low -0.80 Safe 0.81 Suitable |
| Vikarabad    | 7.50     | Neutral   | 0.84       | Medium saline (C2) | 6.57 | Low Na (S1) | C2S1 0.74 | Low -2.15 Safe 0.60 Suitable |
| Vikarabad    | 7.60     | Slightly alkaline | 0.88 | Medium saline (C2) | 5.47 | Low Na (S1) | C2S1 0.84 | Low -5.85 Safe 0.36 Suitable |
| Mahabubnagar | 7.40     | Neutral   | 0.53       | Medium saline (C2) | 1.16 | Low Na (S1) | C2S1 1.33 | Low -2.90 Safe 0.48 Suitable |
| Nagarkurnool | 7.26     | Neutral   | 0.92       | Medium saline (C2) | 3.79 | Low Na (S1) | C2S1 1.41 | Low -4.70 Safe 1.57 Unsafe |
| Narayanpet   | 7.16     | Neutral   | 1.19       | Highly saline (C3) | 1.92 | Low Na (S1) | C3S1 1.08 | Low -5.34 Safe 0.66 Suitable |
| Narayanpet   | 7.15     | Neutral   | 0.62       | Medium saline (C2) | 1.34 | Low Na (S1) | C2S1 1.09 | Low -4.61 Safe 1.29 Unsafe |
| Mahabubnagar | 7.59     | Slightly alkaline | 0.32 | Medium saline (C2) | 1.42 | Low Na (S1) | C2S1 1.18 | Low -4.36 Safe 1.39 Unsafe |
of Bhootpur, Timmajipet, Jadcherla, Tadoor, Midjil, Bijinapally, Ghanpur, Keshampet, Kothur, Kundurg, Faroognagar, Uppununtala, Vangoor, Amrabad, Kothakota, Pebbair, Ghattu, Alampur, Monopadu, Veepanagandla, Pangal, Kodair, Peddakothapalli and Kollapur mandals. In these regions, while irrigating the crop precautions to be taken to manage the soil by adding organic matter once in two years to prevent build-up of soil EC due to long term irrigation with waters of high EC (0.75-2.25 dS/m). An overview of study area shows that the overall study (Nagarkurnool and Wanaparthy Narayanpet and Gadwal divisions) of groundnut cultivation receive medium saline water for irrigating the crop.

**Sodium Absorption Ratio (SAR)**

Corresponding to RSC contents, the SAR values were low for the irrigation water ranging from 1.06 to 10.3 with a mean value of 2.68 showing that the irrigation water was safe and sound for irrigating the crop. The sodium absorption ratio of the canal waters ranged from 1.30 to 4.48 with a mean of 2.47, while the SAR of borewell waters extended from 1.06 to 10.3 with an average value of 2.78. However, Ranjit et al. (2017) reported SAR values extending from 0.30 to 1.40 with a mean of 0.60 at Kalwakurthy mandal. The sodium absorption ratio was mapped with two rates viz., very low (-1.00 to -5.00) and low (-5.00 to -10.0). Entire district was portrayed as having very low SAR with few areas of low SAR in parts of Kodair, Kollapur, Kodangal, Kosgi, Bomraspet and Doulatbad mandals. A very low SAR in irrigation water was observed in the entire study area (Nagarkurnool, Wanaparthy, Narayanpet and Gadwal divisions) except in parts of Kodair, Kollapur and Kosgi mandals with low SAR values. Ayers and Westcot (1976) reported that irrigation water having SAR of 0-10, i.e., low Na\(^+\) water poses almost no risk of exchangeable Na\(^+\). Since calcium is the predominantly adsorbed cation in both seasons, soil tend to have a granular structure, which is easily worked and readily permeable (Laloo et al., 2020).

**Irrigation water class (EC x SAR):**

In accordance with the US Salinity Lab Classification System of irrigation water class, out of 35 water samples analysed, 18 samples fell into C2S1 category, 11 into C3S1, 5 into C1S1 and 1 sample into C3S2. Similar analysis was performed in Turkey by Yilmaz and Avci (2021), where the irrigation water samples were classified into C2S1 and C3S1.

**Residual Sodium Carbonate (RSC) content:**

The RSC content of irrigation water from both canals and borewells in the entire study area was very low ranging from -10.5 to 1.00 meq l\(^{-1}\) with mean of -5.05 showing that irrigation water was safe for attaining good groundnut yields. Sundaraiah et al. (2014) at Kalwakurthy mandal of Mahabubnagar district indicated similar RSC values of irrigation samples varied from -6.91 to 0.19 meq l\(^{-1}\). More precisely, the RSC content ranged from -10.5 to 1.00 meq l\(^{-1}\) in canal waters and -0.80 to -9.10 meq l\(^{-1}\) in borewell waters with a mean of 5.05 meq l\(^{-1}\) in both the cases. No large variations in either highly (Nagarkurnool and Wanaparthy divisions) and marginally (Narayanpet and Gadwal divisions) potential regions with respect to residual sodium carbonate was observed. Similar results were observed with Ranjitha et al. (2018) where the irrigation water was safe w.r.t SAR and RSC.

**Magnesium-Calcium ratio:**

The assessment of Mg/Ca ratio for irrigation water was carried out with two classes viz., safe (< 1.00) and not safe (> 1.00) for mapping. As per the classification given by U. S. Salinity Laboratory, Mg/Ca ratio < 1.50 is considered safe, 1.50 - 3.00 is moderately safe and >3.00 is unsafe (United States Salinity Laboratory, 1954). Though the irrigation water was safe in terms of sodium, the Mg/Ca ratio was higher in the study area ranging from 0.04 to 2.93 with an average of 1.15 which is not considered safe for irrigating the crops. Generally, Calcium and Magnesium maintains an equilibrium in water. But when Magnesium content increases, it promotes the increase in sodium concentration in water (Vasu et al., 2015; Ayers and Wescot, 1985). Considering different sources, the Mg/Ca ratio in canal water extending from 0.04 to 2.80 with a mean of 1.06, whereas in borewell waters, it stretched from 0.10 to 2.43 with an average value of 1.20. Most of the groundnut growing regions were classified as having Mg/Ca ratio in safe limits with few unsafe areas in Bomraspet, Kodangal, Doulatbad, Kosigi, Kothur, Keshampet and parts of Maddur, Kondurg, Faroognagar, Balnagar, Talakondapally, Amangal, Midjil, Bijinapally, Uppununtala, Balmoor, Lingal, Kollapur, Pebbair,
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Itikyal, Gadwal, Veepangandla, Monopadu, Alampur, Ghattu and Dharur mandals. Of the above mandals, unsafe regions were distributed in few clusters of Nagarkurnool, Wanaparthy, Narayanpet and Gadwal divisions) of groundnut belt.

Kelly’s ratio (KR): Sodium measured against calcium and magnesium was considered by Kelly (1940). The formula used in the estimation of Kelley’s ratio is expressed as KR = (Na+/Ca2++ Mg2+). If KI value is >1, then the water is unfit for irrigation. In the present study the values of KR ranged from 0.04 and 2.00 with a mean value of 0.54 which explains the suitability of water for irrigating the crop. Maximum KR value was found in Kodair mandal of Nagarkurnool district and minimum value was found in Telkapally mandal of Nagarkurnool district. All samples showed favourable KR values except in Kodair, Bijinapally and Tadoor mandals Nagarkurnool district, Makhtal mandal of Narayanpet and Mahabubnagar mandal.

Conclusion
Irrigation water quality assessment helps to sort out the reasons for reduced crop productivity in the marginally potential zones and this helps in providing better quality of resources to the crop. The overall quality of the irrigation water samples of both canal and groundwater was good for providing irrigation to the crop. However, the salt concentration and high magnesium-calcium ratio can be reduced with good crop management practices like application of organic manures to the crop and conjunctive use of irrigation water.

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Conflict of interest
The authors declare that they have no conflict of interest.

References
Ayers, R.S. & D.W. Westcot. (1976). Water Quality for Agriculture, FAO Irrigation and Drainage Paper, No. 29.

Ayers, R.S. & Westcot, D.W. (1985). Water Quality for Agriculture: FAO Irrigation and Drainage Paper, No. 29.

Barnes, Ivan. (1964). Field measurement of alkalinity and pH. U.S. Geological Survey Water Supply Paper, 1525-H (pp: 1-17).

Bhurian, S., Khanna, D. R., Ruhela, M., Bhatia, R., Bhardwaj, R., & Ahamad, F. (2020). Assessment of the soil quality of Haridwar Uttarakhand India: A comparative study. Environment Conservation Journal, 21(3), 155-164.

Bhutiani, R., & Ahamad, F. (2019). A case study on changing pattern of agriculture and related factors at Najibabad region of Bijnor, India. Contaminants in Agriculture and Environment: Health Risks and Remediation, 1, 236.

Bhutiani, R., Ahamad, F., & Ruhela, M. (2021). Effect of composition and depth of filter-bed on the efficiency of Sand-intermittent-filter treating the Industrial wastewater at Haridwar, India. Journal of Applied and Natural Science, 13(1), 88-94.

Chintapalli, S.M., Raju., P.V., Hakeem, K.A. & Jonna, S. (2000). Satellite remote sensing and GIS technologies to aid sustainable management of Indian irrigation systems. In Proceedings of ‘International Archives of Photogrammetry and Remote Sensing.” Amsterdam, The Netherlands, 16th to 23rd July, 2000, XXXIII (B7): 264-271.

Diehl, H., Goetz, C.A. & Hach, C.C. (1950). The versenate titration for total hardness. Journal of American Water Works Association, 42(1): 40-48.

District census handbook – Mahabubnagar. (2011): Directorate of Census Operations, Andhra Pradesh. Series-29, pp: 1-600.

Etteieb, S., Cherif, S. & Tarhouni, J. (2017). Hydro-chemical assessment of water quality for irrigation: A case study of the Medjerda River in Tunisia. Applied Water Science, 7(1), 469-480.

Hem, J.D. (1970). Study and interpretation of the chemical characteristics of natural water. United States Geological Survey, Water Supply, 2nd edition, (pp: 1-1473).

Jackson, M.L. (1967): Soil Chemical Analysis. (eds.) Prentice-Hall of India Pvt. Ltd., New Delhi.

Kelly, W.P. (1940). Permissible Composition and Concentration of Irrigated Waters. In Proceedings of ‘The American Society of Civil Engineers,” 66, 607-613.

Laloo, L., Chandrakanth, G., & Deshhbandari, P.G. (2020). Assessment of Groundwater Quality for Drinking and Irrigation use in Kumadvati watershed, Karnataka, India.
Madhusudhana, B.J. (2013): Ground water brochure, Mahabubnagar district, Andhra Pradesh. Central Groundwater Board, Ministry of Water Resources, Government of India, (pp: 1-29).

Mirabbasi, R., Mazloumzadeh, S. M. & Rahnama, M. B. (2008). Evaluation of irrigation water quality using fuzzy logic. Research Journal of Environmental Sciences, 2(5), 340–352.

Ramakrishnaiah, C.R., Adashiv, C. & Ranganna, G. (2009). Assessment of water quality index for the groundwater in Tumkur Taluk, Karnataka State, India. Egyptian Journal of Chemistry, 6, 523–530.

Ramesh, K. & Elango, K. (2011) Groundwater quality and its suitability for domestic and agricultural use in Tondiar river basin, Tamil Nadu, India. Environment Monitoring and Assessment, 11, 2231-2233.

Ranjit, M., Rao, K.J., Sridevi, S., Ramesh, S.T. & Bhave, M.H.V. (2017). Groundwater quality and fluoride contamination in Kalwakurthy Mandal of Mahabubnagar District, Telangana State, India. International Journal of Pure and applied Bioscience, 5(4), 1397-1405.

Ranjitha, A., Narasimha, A. & Saxena, P.R. (2018). Assessment of water quality for drinking and irrigation purpose in Alladurg mandal of Medak district, Telangana State, South India. In Proceedings of “5th National Conference on Water, Environment, and Society,” 399-404.

Ruhela, M., Singh, V. K., & Ahamad, F. (2021). Assessment of groundwater quality of two selected villages of Nawada district of Bihar using water quality index. Environment Conservation Journal, 22(3), 387-394.

Srinivasulu, D., Eshwar Chandra., Sateesh Kumar., Rahul., Santhosh & Gayathri. (2016). Assessment of ground water quality: selected villages of Mahabubnagar mandal & district, Telangana State (India). International Journal of Science and Research, 5(5), 2369-2374.

Sundaraiah, R., Laxman Kumar, D., Vishnu Bhoopathi, Sakram, G., Srinivas, E. & Sudarshan. (2014). Assessing groundwater quality and its suitability for drinking and irrigation purposes in Kalwakurthy area, Mahabubnagar district, Andhra Pradesh, India. International Journal of Scientific Research, 3(3), 30-33.

Tiwari, R.N. (2011) Assessment of ground water quality and pollution potential of Jawa block, Reva district, Madhya Pradesh, India. Proceedings of “International Academy of Ecology and Environmental Sciences,” 1, 202-212.

Tyagi, S., Dubey, R. C., Bhutiani, R., & Ahamad, F. (2020). Multivariate Statistical analysis of river ganga water at Rishikesh and Haridwar, India. Analytical Chemistry Letters, 10(2), 195-213.

United States Salinity Laboratory (eds.) (1954). Diagnosis and improvement of saline and alkaline soils. Soil and Water Conservation Research Branch, Agricultural Research Service. US Department of Agriculture Handbook, (pp: 60-160).

Vasu, D., Singh, S.K., Tiwary, P.P., Butte, S. & Duraisami, V.P. (2015). Evaluation of groundwater quality for irrigation suitability in Thimmapur Mandal, Mahabubnagar district. Andhra Pradesh Journal of Agricultural Sciences, 1(4), 1-6.

Wood, W. W. (1976). Guidelines for collection and field analysis of ground-water samples for selected unstable constituents. USGS Techniques of Water-Resource Investigation. U.S. Geological Survey, Reston, Virginia, 01-D2: 1-24.

Yilmaz, M. A. & Avci. (2021). Irrigation water quality assessment for water resources used in irrigation of agricultural fields in Mezitli town of Mersin Province. International Journal of Environmental and Agricultural Research, 7(9), 62-68.

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