International Journal of Research
International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 08, August 2015
Available at http://internationaljournalofresearch.org

# Evaluation of Groundwater Quality and its Suitability for Agricultural Use in Lingala area of Kadapa District, Andhra Pradesh, South India

**L. Chandra Sekhar Reddy*[1]; K.V Ramana Reddy [2]; S. M. Deshpande [3]& K. R. Aher[4]**

[1] Department of Geology,[2] Department of Chemistry Loyola Degree College, Pulivendula- 516 390, Kadapa District, Andhra Pradesh, India,
*E-mail: chandrareddyloyola@gmail.com
[3,4] Post Graduate Department of Geology, Institute of Science, Caves Road, Aurangabad- 431 006, Maharashtra, India

**Abstract**

*Hydrochemical characteristics were carried out in and around Lingala area of Kadapa District, Andhra Pradesh to ascertain the suitability of groundwater for irrigation/agricultural purpose. 22 groundwater samples were collected and were analyzed for pH, EC, TDS, Ca, Mg, Na, K, $CO_3$ and $HCO_3$ by standard methods. The mean concentration of cations is in the order Na> Ca> Mg> K, while for anions it is $HCO_3$> $CO_3$.To ascertain the suitability of groundwater for irrigation purposes, hydrochemical parameters of the study area have been evaluated for their chemical composition. The suitability of groundwater for irrigation has been evaluated based on various chemical parameters such as Sodium adsorption ratio (SAR), Sodium percentage (%Na), Residual sodium carbonate (RSC), Kelley Ratio (KR), Residual sodium bicarbonate (RSBC), Permeability index (PI), and Magnesium adsorption ratio (MAR) and this study indicates that water of the study area is suitable for irrigation purposes but 8 samples restrict its utility with respect to KR only. From US salinity hazard diagram, it is evident that the water samples belongs to category of $C_2S_1$ and $C_3S_1$ indicating good to moderate quality. This groundwater source can be used to irrigate all types of soils. From Wilcox plot, it is observed that groundwater of the study area is excellent to good and good to permissible quality for irrigation utilizes. Based on Wilcox plot, out of 22 groundwater samples, six samples fall in the zone of excellent to good category and sixteen samples fall in good to permissible category. Overall the analytical data of the groundwater in the study area indicates that groundwater is suitable for irrigational purpose.*

***Keywords***: Groundwater quality; Irrigation; Hydrochemistry; SAR; %Na; RSC; KR; RSBC; PI; MAR; Lingala

## 1. Introduction

Groundwater is the primary source of water for domestic, drinking, agricultural and industrial uses in India. Water is the elixir of life but it is also cause of more than 80% of the diseases affecting mankind (Dev Burman et al., 1995; Subba Rao, 2003). In recent years rapid development has created an increase in demand for groundwater. The quality of groundwater within a region is governed by both natural process and soil erosion and anthropogenic effects such as urban, industrial and agricultural activities. The quality requirement of a groundwater supply depends on its purpose; thus quality criteria for drinking and irrigation water vary widely. To establish quality criteria, measures of physical and chemical constituents must be specified, as standard methods for reporting and comparing results of water analyses. The quality of groundwater is very important in evaluating its utility in various fields such as domestic, public water supply and agriculture. Water during course of its flow, acquires the properties of its surrounding conditions and becomes source of elements present in the areas through which it flows. It may also contain some harmful contaminants through the process of seepage from the surface water and biological activities. Technological advances in the field of agricultural and increased stress on the land to increase crop yield by irrational use of inorganic fertilizer has caused groundwater pollution. Water quality plays an important role in promoting agricultural production. Assessment of groundwater quality requires determination of ion concentration which decides the suitability for agricultural uses. Various workers has contributed their work in different areas especially related to the quality with reference to drinking and irrigation (Thakkar and Gwalani, 1987; Chandra Sekhar Reddy and Ramana Reddy, 2011 Deshpande and Aher, 2012; Reddy et al., 2012; Narasimha and Sudarshan, 2013)).In the present work, hydrochemical studies and quality of groundwater in and around Lingala area of Kadapa District, Andhra Pradesh are carried out in order to evaluate its suitability for irrigation purpose.

## 2. Study Area

The study area, Lingala is in Lingala Mandal of Kadapa District, Andhra Pradesh and lies between lattitude 14$^{o}$' 30' 00'' N and longitude 78$^{o}$ 07'00''E and is included in the Survey of India toposheet No. 57 J/2. This area is about 90 kms from the district headquarter, Kadapa and about 25 kms from Pulivendula, the Taluk headquarter.

### 2.1 Geology and Hydrogeological Setting

This study area comes under the Lower Cuddapah super group comprising Papagni and Chitravati groups. Geologically the area is mostly occupied by basalts, dolomites, quartzites, and shales. The climate of the area is of the hot steppe type characterized by hot summers and mild winters. Maximum temperature of 43$^{o}$C is recorded during summer. During winter minimum temperature is 24$^{o}$C. In this area groundwater occurs under semi-confined conditions. The fractures constitute the porosity and permeability of the rocks. The area receives an average annual rain fall of 625-700 mm from monsoon period. In the study area, rainfall is the main source of groundwater recharge and this water is the only source for drinking and irrigation purpose. Groundwater has been used for various purposes, such as drinking, agricultural and domestic needs. The important soil types are red sandy loam, clayey loam, black cotton soil and clayey. Cultivation is more common in this area. The main crops of this area are ground nuts, sunflower, lemon, orange, jowar, banana and vegetables.

## 3. Sampling and Analytical procedure

Twenty two groundwater samples were collected from bore wells of the study area in the year 2011. The water samples were collected in one liter pre-washed polyethylene bottles, adequately labeled and preserved. Chemical analysis of water samples were carried out following the standard analytical methods (APHA, 1992) for various parameters like pH, EC, TDS, calcium ($Ca^{++}$), magnesium ($Mg^{++}$), sodium ($Na^{+}$), potassium ($K^{+}$), bicarbonate ($HCO_3^{-}$), and carbonate ($CO_3$). The physical parameters include pH, electrical conductivity

International Journal of Research
International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 08, August 2015
Available at http://internationaljournalofresearch.org

(EC) and total dissolved solids (TDS) were measured immediately after obtaining the groundwater samples in the field. The chemical parameters such as sodium (Na) and potassium (K) were estimated by flame photometer; calcium (Ca), magnesium (Mg), carbonates ($CO_3$), and bicarbonates ($HCO_3$) were analyzed by titrimetric method following the standard techniques (APHA, 1992). Results of chemical analysis of groundwater samples along with physical parameters are represented in Table 1.The obtained results in mg/l were converted in equivalent per million (epm) to determine the groundwater quality for agricultural purpose.

## 4. Results and Discussions

The quality of groundwater is very important because it is the main factor which decides its suitability for domestic, industrial and agricultural purpose. Based on the physicochemical analysis, irrigation quality parameters were studied.

### 4.1 Hydrochemical Characterization

The pH of the groundwater samples in the study area varies from 6.4 to7.9 with mean of 7.2 (Table 1) indicating alkaline nature. The EC of the groundwater varies from 296 to 1900 μS/cm with a mean of 990.5 μS/cm (Table 1). The concentration of total dissolved solids (TDS) ranges from 400 to 1100 mg/l with an average 680.3 mg/l (Table 1).The major cations include Ca, Mg, Na and K. The cationic chemistry is dominated by sodium and calcium. The results (Table 1) revealed that the mean concentration of cations is in the order Na> Ca> Mg> K. The results revealed that the calcium and magnesium concentrations vary from 20 to 114 mg/l with mean 60.9 mg/l and 10 to 34 mg/l with mean 21.0 mg/l respectively. Sodium and potassium concentrations in the groundwater of the area are varying from 12 to 260 mg/l (mean, 92.0 mg/l) and 4 to35 mg/l (mean, 12.0 mg/l) respectively. The anion chemistry shows that bicarbonate is the dominant ion in the groundwater of the study area. The concentration of bicarbonate ($HCO_3^-$) varies from 40 to 200 mg/l (mean, 134.4 mg/l) followed by carbonate ($CO3^{--}$) in the range 2 to 25 mg/l (mean, 9.0 mg/l).

**Table 1. Summary of hydrochemical data of Lingala area, Andhra Pradesh**
[The values are in mg/l except pH and EC (μS/cm)]

| Constituents | Range of Concentration in the study area | Average Concentration in the study area |
|---|---|---|
| pH | 6.4-7.9 | 7.2 |
| TDS | 400-1100 | 680.3 |
| EC | 296-1900 | 990.5 |
| Ca | 20-114 | 60.9 |
| Mg | 10-34 | 21.0 |
| Na | 12-260 | 92.0 |
| K | 4-35 | 12.0 |
| $CO_3$ | 2-25 | 9.0 |
| $HCO_3$ | 40-200 | 134.4 |

### 4.2 Irrigational Quality of Water

Irrigation water quality refers to the kinds and amounts of salts present in the water and their effects on crop growth and development; high salt concentrations influence osmotic pressure of the soil solution and affect the ability of plants to absorb water through their roots (Glover, 1996). Groundwater is widely used for irrigation and its quality influences the growth of plant, fertility of soil. The suitability of groundwater for irrigation purpose depends upon various factors including the quality of water, soil structures, and climate drainage characterization. Groundwater utilized for irrigation is an essential aspect in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation groundwater depends mostly on the occurrence of dissolved salts and their concentrations. The salt present in the water affect in soil structure, permeability and aeration this affects the plant growth. Sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) are the mainly significant quality decisive factor, which persuade the groundwater quality moreover its fittingness for irrigation. The total salt concentration, sodium percentage (%Na), residual sodium carbonate (RSC), sodium adsorption ratio (SAR) Magnesium adsorption ratio (MAR), Residual sodium bi-carbonate (RSBC), Permeability index (PI) and Kelley index (KI) are the important parameters used for assessing the suitability of water for irrigation uses (Ayers, and Westcot 1985). The computed values of these parameters calculated by the following equations are furnished in Table 2.

- Sodium adsorption ratio (SAR) = $Na^+/(\sqrt{Ca^{2+}+Mg^{2+}})/2)$
- Sodium percentage (%Na) = $Na^{++} + K^+ / (Ca^{2+}+Mg^{2+}+Na^+ + K^+)$ X100 +
- Residual sodium carbonate (RSC) = $(CO_3^- + HCO_3^-) - (Ca^{2+} + Mg^{2+})$
- Kelley index (KI) = $Na^+/(Ca^{2+}+Mg^{2+})$
- Permeability index (PI) = $(Na^+ + \sqrt{HCO_3^-}) \times 100/ Ca^{2+}+Mg^{2+}+ Na^+$
- Magnesium adsorption ratio (MAR) = $Mg^{2+} X\ 100/ Ca^{2+}+Mg^{2+}$
- Residual sodium bi-carbonate (RSBC) = $HCO_3^- - Ca^{2+}$
  (All ionic concentrations used for calculation are expressed in epm)

### Sodium adsorption ratio (SAR)

The sodium or alkali hazard in the irrigation water are expressed in terms of sodium adsorption ratio (SAR) and classified into four categories as $S_1$ (SAR<10), $S_2$ (10-18), $S_3$ (18-26) and $S_4$ (>26). The sodium adsorption ratio values for each water sample were calculated by using equation (Richards, 1954), and all the samples fall in excellent ($S_1$) category (Table 2 & 3), indicating that these groundwater sources are suitable for irrigation purpose.

### Sodium percentage (%Na)

The % Na is one of the important parameter and widely used for the suitability of groundwater quality for irrigation. High % Na in irrigation groundwater causes barter of sodium in groundwater, and exchange of calcium and magnesium contents in soil having meager internal drainage. The % Na varies from 0.52 to 11.30.The % Na < 60 represents safe water while it is unsafe if > 60. As per these criteria the groundwater is safe for irrigation purpose (Table 2 & 3). All the samples fall in excellent category and fit for irrigation.

### Residual sodium carbonate (RSC)

The excess of carbonate and bicarbonate of water is denoted as residual sodium carbonate. When the sum of carbonates and bicarbonates is in excess of calcium and magnesium, there may

International Journal of Research
International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 08, August 2015
Available at http://internationaljournalofresearch.org

be possibility of complete precipitation of $Ca^{2+}$ and $Mg^{2+}$ (Raghunath, 1987). A high salt concentration in water leads to formation of saline soil and alkaline earth metal cations, expressed as residual sodium carbonate (RSC) are also influencing the water quality for irrigation purposes (Karanth,1989). The $HCO_3^-$ and $CO_3^-$ in the irrigation water tend to precipitate calcium and magnesium ions in the soil resulting in an increase in the proportion of the sodium ions. For this reason, RSC was considered as an indicative of the sodicity hazard of water. A high value of RSC in water leads to an increase in the adsorption of sodium on soil (Eaton, 1950). Table 2 and 3 shows that the groundwater is suitable for irrigation purposes. RSC values of groundwater ranges from -4.82 to 0.23 with an average -2.27. All the twenty two samples are in good category and fit for agriculture (Table 3).

**Kelley's Ratio (KR)**

Kelley's ratio is also used for the classification of water for irrigation. Water with >1.0 Kelley's ratio indicate an excess level of sodium and unsuitable for irrigation. Water with Kelley's ratio of <1.0 are only considered suitable for irrigation (Kelley, 1946; Paliwal, 1967). KR values in the groundwater varied from 0.08 to 4.15 with an average of 0.97. The analyzed samples suggest that 63% samples are suitable for irrigation and 37% samples shows their unsuitability for irrigation. (Table 2&3).

**Residual sodium bicarbonate (RSBC)**

Gupta and Gupta (1987) have proposed the equation for analyzing the residual sodium bicarbonate (RSBC). The RSBC values of groundwater samples varies from −2.99 to 1.71 and according to the norm all groundwater samples are found to be suitable (<5) (Table 2) for irrigation use.

**Permeability index (PI)**

The soil permeability is persuading by long term put into practice of groundwater for irrigation and supplementary reason. Calcium, magnesium, bicarbonate and sodium material of the groundwater are noteworthy donors which have an effect the soil permeability (Mohan et al, 2000; Aher, 2014, Aher et al, 2015). Doneen (1964) to be had water appropriateness classification for irrigation reason base on the permeability index (PI). The PI value of the groundwater ranges from 24.23 to 87.03 with an average values 58.95 imply that the groundwater samples are suitable for irrigational use (Table 2).

**Magnesium adsorption ratio (MAR)**

Szobolces and Darab **(1968)** had given the equation to calculate Magnesium adsorption ratio (MAR). MAR of the groundwater varied from 15.75 to 66.30 (Table 2). High MAR affects the soil unfavorably, a harmful effect on soils (Shirazil et al, 2011) appear when MAR exceeds 50. In the present study indicate that only three samples were above 50 which might cause harm to soil rest of the samples are having MAR less than 50 which would cause no harm to soil.

**Table 2 Computed values of irrigation water quality* parameters**

| S.No. | SAR | % Na | RSC | KR | RSBC | PI | MAR |
|---|---|---|---|---|---|---|---|
| 1 | 2.34 | 4.09 | -2.88 | 0.67 | -0.43 | 56.82 | 45.79 |
| 2 | 0.29 | 0.52 | -4.82 | 0.08 | -2.99 | 24.23 | 32.63 |
| 3 | 0.46 | 0.74 | -1.34 | 0.14 | -0.29 | 42.47 | 32.97 |
| 4 | 9.68 | 11.30 | -1.67 | 4.15 | -0.43 | 87.03 | 54.14 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 1.11 | 1.74 | -3.46 | 0.36 | -2.90 | 42.52 | 16.83 |
| 6 | 0.61 | 1.13 | -3.29 | 0.17 | -2.42 | 37.25 | 15.75 |
| 7 | 0.49 | 0.87 | -2.93 | 0.14 | -1.62 | 37.26 | 23.89 |
| 8 | 2.46 | 3.00 | -1.16 | 1.01 | 0.54 | 71.08 | 66.30 |
| 9 | 3.60 | 5.22 | -2.51 | 1.24 | -1.43 | 68.95 | 27.34 |
| 10 | 2.88 | 3.65 | 0.23 | 1.13 | 1.71 | 79.21 | 53.44 |
| 11 | 0.59 | 0.87 | -3.54 | 0.20 | -2.34 | 31.91 | 31.72 |
| 12 | 5.75 | 7.39 | -0.25 | 2.24 | 1.64 | 85.03 | 62.11 |
| 13 | 3.31 | 5.39 | -3.69 | 1.02 | -2.29 | 60.71 | 34.00 |
| 14 | 2.32 | 3.74 | -3.55 | 0.72 | -1.54 | 55.26 | 42.45 |
| 15 | 2.15 | 3.65 | -1.98 | 0.64 | -0.77 | 57.07 | 35.64 |
| 16 | 2.94 | 4.78 | -3.89 | 0.90 | -2.73 | 57.39 | 29.34 |
| 17 | 5.35 | 9.13 | -2.75 | 1.57 | -0.75 | 72.51 | 36.55 |
| 18 | 1.26 | 1.70 | -0.19 | 0.47 | 1.21 | 65.38 | 45.05 |
| 19 | 3.10 | 4.96 | -1.74 | 0.97 | -0.06 | 65.95 | 43.28 |
| 20 | 6.08 | 8.70 | -0.61 | 2.13 | 0.83 | 82.18 | 40.09 |
| 21 | 1.44 | 2.13 | -3.30 | 0.49 | -2.61 | 46.32 | 22.44 |
| 22 | 2.42 | 3.39 | -0.53 | 0.87 | 1.10 | 70.29 | 50.22 |
| Min | 0.29 | 0.52 | -4.82 | 0.08 | -2.99 | 24.23 | 15.75 |
| Max | 9.68 | 11.30 | 0.23 | 4.15 | 1.71 | 87.03 | 66.30 |
| Avg | 2.76 | 4.00 | -2.27 | 0.97 | -0.84 | 58.95 | 38.27 |

(*All ionic concentrations are expressed in epm)

## USSL and Wilcox Diagrams

The total concentration of soluble salts in irrigation water can be expressed as low (EC= <250 μS/cm), medium (250-750 μS/cm), high (750-2250 μS/cm) and very high (>2250 μS/cm) and classified as C-1, C2, C3 and C-4 salinity zone respectively (Richards, 1954). While high salt concentration (high EC) in water leads to formation of saline soil, a high sodium concentration leads to development of an alkaline soil. Salinization is one of the most prolific adverse environmental impacts associated with irrigation. The sodium or alkali hazard in the irrigation water are expressed in terms of sodium adsorption ratio (SAR) and classified into four categories as S-1 (SAR<10), S-2 (SAR10-18), S-3 (SAR18-26) and S-4 (SAR>26). (Tiwari and Singh, 2014).

**Table 3 Classification of groundwater for irrigation quality.**

| Parameter | Range | Water Class | No. of Samples | Samples in (%) |
|---|---|---|---|---|
| SAR | <10 | Excellent (S1) | 22 | 100 |
| | 10-18 | Good (S2) | - | - |
| | 18-26 | Doubtful (S3) | - | - |
| | >26 | Unsuitable (S4) | - | - |
| % Na | <60 | Excellent | 22 | 100 |
| | >60 | Unsuitable | - | - |
| RSC | <1.25 | Good | 22 | 100 |

| | | | | |
|---|---|---|---|---|
| | 1.25-2.50 | Doubtful | - | - |
| | >2.5 | Unsuitable | - | - |
| KR | <1 | Suitable | 14 | 63 |
| | >1 | Unsuitable | 8 | 37 |

The correlation between sodium adsorption ratio (SAR) and electrical conductivity (EC) was plotted on the US salinity diagram (Fig. 1) (USSL, 1954). The plots of groundwater chemistry of study area in USSL (1954) diagram are shown (Fig. 1). In which the EC is taken as salinity hazard and SAR as alkalinity hazard, shows that the water samples belongs to category of $C_2S_1$ and $C_3S_1$ indicating good to moderate quality. Out of 22 groundwater samples, seven samples fall in the zone of good category and fifteen samples fall in moderate category. (Fig. 1).This groundwater source can be used to irrigate all types of soils. The good water ($C_2S_1$) can be used for irrigation with little danger of harmful levels of exchangeable sodium and salinity. The moderate water ($C_3S_1$) may be used to irrigate salt tolerant and semi-tolerant crops under favorable drainage conditions (Karanth, 1989).

Electrical conductivity (EC) and sodium concentration are very important parameters in the classification of the irrigation water. Water used for irrigation always contains measurable quantities of dissolved substances as salts. The salts, besides affecting the growth of the plants directly, also affect soil structure, permeability and aeration, which indirectly affect plant growth. Irrigation with high sodium water causes exchange of Na in water for Ca and Mg in soil and reduces the permeability and eventually results in soil with poor internal drainage (Collins and Jenkins 1996). Sodium percent value in analyzed samples range between 0.52 and 11.30 % (avg. 4.00 %).

Wilcox (1955) classified groundwater for irrigation purpose by correlating percent sodium and Electrical conductivity (EC). The classification of groundwater samples with respect to percent sodium and EC is shown in Fig.2. Plot of analytical data on the Wilcox (1955) diagram reveals that groundwater of the area is excellent to good and good to permissible quality for irrigation utilizes. Out of 22 groundwater samples, six samples fall in the zone of excellent to good category and sixteen samples fall in good to permissible category (Fig.2)

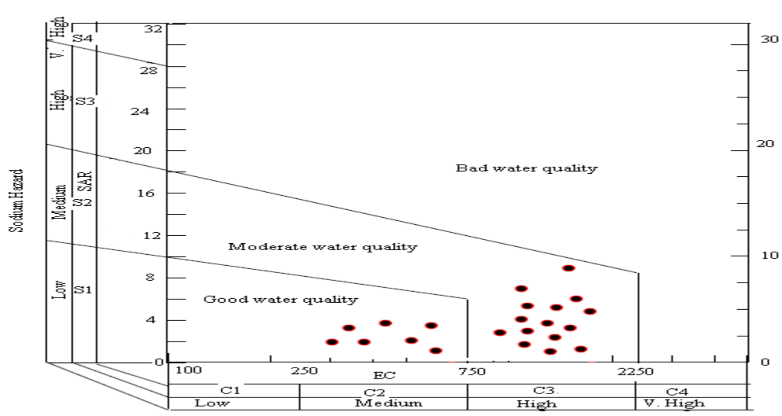


**Fig.1. US salinity diagram (USSL) for classification of irrigation**

International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 08, August 2015
Available at http://internationaljournalofresearch.org

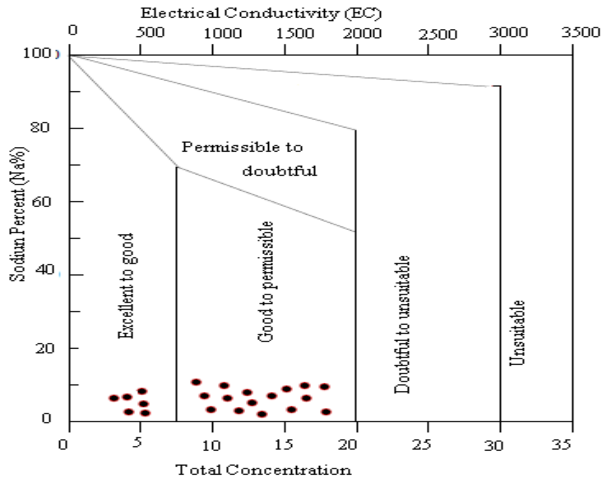


**Fig.2. Wilcox diagram for classification based on EC and %Na**

## 5. Conclusions

The groundwater quality evaluation in and around Lingala area of Kadapa District, Andhra Pradesh have been evaluated for their chemical composition and suitability for agricultural uses. The suitability of groundwater for irrigation has been evaluated based on various chemical parameters such as Sodium adsorption ratio (SAR), Sodium percentage (%Na), Residual sodium carbonate (RSC), Kelley Ratio (KR), Residual sodium bicarbonate (RSBC), Permeability index (PI), and Magnesium adsorption ratio (MAR). The pH in the groundwater samples of study area indicates alkaline nature. The mean concentration of cations is in the order of Na> Ca> Mg> K, while for anions it is $HCO_3$> $CO_3$. Based on various chemical parameters such as SAR, %Na, RSC, MAR, RSBC, and PI indicates that water of the study of area is suitable for irrigation purposes but eight samples (37%) show their unsuitability only with respect to KR. The plot of groundwater chemistry of study area in USSL diagram shows that most of the groundwater samples belong to category of $C_2S_1$ and $C_3S_1$ indicating good to moderate quality. This groundwater source can be used to irrigate all types of soils. Plot of analytical data on the Wilcox diagram reveals that groundwater of the study area is excellent to good and good to permissible quality for irrigation utility. Based on Wilcox plot, out of twenty two groundwater samples, six samples fall in the zone of excellent to good category, and sixteen samples fall in good to permissible category. Quality assessment for irrigation uses reveals that the groundwater of the study area is good for irrigation.

## References

[1.] Aher, K.R., Patil, Suryakant M. and Mane, V.P. (2015). Preliminary study in Irrigational quality of Groundwater sources in parts of Soygaon block, District Aurangabad, India, International Research Journal of Earth Sciences, Vol. 3(2), 7-12.

[2.] Aher,K.R. (2014). Geochemistry of Groundwater in Basaltic aquifer of Phulambri taluka, District Aurangabad, India, *Res. J. Chem. Sci.,* Volume 1, Special issue of NCCICR-2014, 1-124.

[3.] APHA (1992). Standard method for the examination of water and waste water. American Public Health Association. 18th ed.

[4.] Tiwari Ashwani Kumar And Singh Abhay Kumar (2014). Hydrogeochemical investigation and groundwater quality assessment of Pratapgarh District, Uttar Pradesh. Jour. Geol. Soc. India, V. 83, pp.329-343.

[5.] Ayers, R.S. and Westcot, D.W. (1985).Water quality for irrigation. *FAO Irrigation and Drainage Paper* No.20, Rev 1, FAO Rome.

[6.] Chandra Sekhar Reddy, L., and Ramana Reddy, K.V. (2011). Hydrochemistry and groundwater quality with special reference to nitrate: A case study from Ippatla, Kadapa district, Andhra Pradesh. Indian Streams Research Journal, V. 1(9), pp.149-151.

[7.] Collins, R. and Jenkins, A. (1996). The impact of agricultural land use on stream in the middle hills of the Himalayas, Nepal. Jour. Hydrol., V.185, pp.71-86.

[8.] Deshpande, S.M. and Aher, K.R. (2012) Evaluation of groundwater quality and its suitability for drinking and agriculture use in parts of Vaijapur, District Aurangabad, MS, India. Res.Jour. Che. Sci., Vol.2 (1), pp.25-31.

[9.] Dev Burman, G.K., Singh, B., and Khatri, P. (1955). Fluoride in environment: Hydrogeochemical studies groundwater having high fluoride contents in Chandrapur district. Gondwana Geol. Magz, V.9, pp.71-80.

[10.] Doneen L.D. (1964).Notes on water quality in agriculture. Published in *Water Science and Engineering*, Univ. California, Davis.

[11.] Eaton, F.M. (1950). Significance of carbonates in irrigation waters. *Soil Sci*., v.39, pp.123-133.

[12.] Glover, C.R. (1996). Irrigation water classification systems. Guide A-116. cooperative Extension Service, College of Agriculture and Home Economics, New Mexico State University.

[13.] Gupta SK and Gupta IC. (1987). Management of saline soils and water. *Oxford and IBM Publ. Co*., New Delhi, 399.

[14.] Karanth, K.R. (1989). Groundwater assessment development and management. *Tata McGraw-Hill Publ. Com. Ltd*. New Delhi, India.

[15.] Kelley, W.P. (1946) Permissible composition and concentration of irrigation waters. *In: Proc. Amer. Soc. Civil Engg.,* p. 607.

[16.] Mohan R., Singh A.K., Tripathi J.K. and Choudhry G.C. (2000). Hydrochemistry and quality assessment of groundwater in Naini industrial area Allahabad District, *Uttar Pradesh. Journal of the Geological Society of India*, 55, 77–89 .

[17.] Narasimha, A. and Sudarshan, V. (2013). Hydrogeochemistry of ground water in Basara area, Adilabad district, Andhra Pradesh, India. Journal of Applied Geochemistry, V. 15, pp.224-237.

[18.] Paliwal, K.V. (1967) Effects of gypsum application on the quality of irrigation water; *The Madras Agr. Jour.* v.59, pp.646-647.

[19.] Raghunath, H.M. (1987). Groundwater. Wiley Eastern Ltd. Delhi, India, 563p.

[20.] Reddy L. Chnadrasekhar., Deshpande, S.M., Reddy K.V.Ramana. and Aher, K.R., (2012).Characterization and quality assessment of groundwater with special emphasis on irrigation utility: A case study of Vemula area, Kadapa district, Andhra

Pradesh, India. Int.Jour.Env. and Earth Sciences, V. 2(1), pp.36-49.

[21.] Richards, L.A. (1954).Diagnosis and improvement of saline and alkali soils. Agri. Handbook 60, *U.S. Dept of Agriculture,* Washington. D.C., 160p.

[22.] Shirazi1 S. M., Islam, M. A., Ismail1, Z.., Mohammed Jameel1, Johnson Alengaram, U.,and Mahrez, A. (2011) Arsenic contamination of aquifers: A detailed investigation on irrigation and portability, *Scientific Research and Essays* Vol. 6(4), pp. 1089-1100.

[23.] Subba Rao, N., (2003). Groundwater quality: Focus on fluoride concentration in rural parts of Guntur district, Andhra Pradesh, India. Hydro. Sci. Jour. – des sciences Hydrologiques, V.48 (5), pp.835-847.

[24.] Szobolces I, Darab K. (1968). In Irrigation, Drainage and Salinity, Int. *Source Book*, Hutchinson & Co., London. p. 510.

[25.] Thakkar, B.O., and Gwalani, L.G., (1987). Environmental geological studies of the Chandrapur-Ballarshah industrial belt and chemical quality of water in the Wardha River Basin, Maharashtra State, India. The Role of geology in urban development. Geol.Soc. Hong Kong Bulletin No.3.

[26.] USSL (US Salinity Laboratory) (1954). Diagnosis and improvement of saline and alkali soils. *U.S. Department of Agriculture Hand Book*, No. 60, p.160,

[27.] Wilcox, L.V., (1955).Classification and use of irrigation waters, *US Dept of Agriculture* Cir 969, Washington DC.