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# HYDROGEOCHEMISTRY FOR THE ASSESSMENT OF GROUNDWATER QUALITY FOR IRRIGATION PURPOSE IN AND AROUND LAKKIREDDYPALLI, CUDDAPAH DIST, ANDHRA PRADESH

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**Abstract:** Hydrogeochemical characteristics and quality of groundwater in around Lakkireddypalli area of Cuddapah District, Andhra Pradesh have been evaluated based on different indices for assessing groundwater for irrigation purpose. Groundwater samples were collected and analyzed for physiochemical parameters and major ions. The suitability of groundwater of the study area for irrigation is determined using different factors like Sodium percentage, Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Kelley's Ratio (KR), and Magnesium Ratio (MR).The results revealed that the groundwater is alkaline in nature. Irrigation water quality indicators like SAR, Na%, SSP, KR, RAC and MR reveal that the groundwater is suitable for irrigation purposes with few exceptions. As per the SAR classification all groundwater samples fall under safe category. The interpretation on the basis of available data has shown that the groundwater of the study area is suitable for irrigation purpose.

**Keywords**: ***Groundwater, Irrigation water quality, Lakkireddypalli , Andhra Pradesh***

## 1. Introduction

Groundwater is the primary source of water for drinking, domestic, industrial and agricultural uses. The world wide rapid growth of population and increased industrial and agricultural activities led to the great demand for water from surface and ground. The quality of groundwater has major impact on human health. Slight change in water quality reflects improper functioning of water ecosystem (Thakkar and Gwalai, 1987). Indiscriminate disposal of anthropogenic, mining wastes, excess use of agrochemical and fertilizers caused excess accumulations of pollutants on the land and contamination of surface and subsurface water. Many of the research works on groundwater quality with respect to drinking and irrigation purposes have been carried out in different parts of India. Groundwater of this area is intensively used for irrigation purpose, an effort is made in the paper to discuss the hydrogeochemistry of groundwater to evaluate its suitability of agricultural use in and around Lakkireddypalli, Cuddapah District, Andhra Pradesh.

## 2. Study area

The study area, Lakkireddypalli (Lat.$14^0$ 18' N; Long $78^0$ 69'E) is located in Cuddapah District, Andhra Pradesh . The geological formations in this area quartzites, sand stones, dolomites, and limestones. The drainage pattern is dendritic to sub-dendritic. In this area the important soil types are black cotton, red soils, alluvial, and mixed soils. Agriculture is the major occupation in this area. The important crops of this area are sunflower, cotton, coconut, groundnut, and vegetables. Majority of the crops of this area are rain fed. The average annual rain fall of the study area is around 850 mm and the average temperature varies from 21ºC in the month of December and 37ºC in the month of May. The area also experiences the effect of S-W and N-E monsoons.

## 3. Methodology

15 Water Samples were collected in pre-cleaned polythene bottles of one liter capacity. The samples were collected for different seasons (pre-monsoon and post-monsoon seasons) of 1997 from borewells as well as from deep hand pumps of Lakkireddypalli area, Andhra Pradesh for assessing the groundwater quality. The physico-chemical analysis of groundwater samples were carried out by adopting standard methods given by APHA (1985, 1992). pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured immediately in the field. The chemical parameters such as sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), carbonates ($CO_3$), bicarbonates ($HCO_3$) and chloride (Cl) were analyzed by following the standard techniques (APHA, 1985, 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.

**Table 1.** Summary of hydrochemical data of Lakkireddypalli area, Andhra Pradesh

| Physical & Chemical parameters | Minimum | Maximum | Average of 15 samples |
|---|---|---|---|
| pH | 6.4 | 8.2 | 7.4 |
| EC (*u*S/cm) | 256 | 1260 | 690 |
| TDS (mg/l) | 35 | 610 | 380 |
| Ca (mg/l) | 18 | 89 | 53 |
| Mg (mg/l) | 10 | 52 | 32 |
| Na (mg/l) | 13 | 80 | 37 |
| K (mg/l) | 2 | 12 | 5.66 |
| Cl (mg/l) | 19 | 130 | 67 |
| $HCO_3$ (mg/l) | 40 | 440 | 170 |
| $CO_3$ (mg/l) | 10 | 72 | 36 |

## 4. Results and discussions

### 4.1 Hydrochemical Characterization

Based on the physicochemical analysis, irrigation quality parameters were studied.
The pH of the analyzed samples varies from 6.4-8.2 (Avg 7.4). Electrical conductivity (EC) is the measure of capacity of solution or substance to conduct electric current. The conductivity of water increases with rise in temperature and varies with the amount of dissolved minerals in it (Arthur, 1995). It is an important criterion for determining the suitability of groundwater for irrigation. EC values ranges from 256 to 1260 *u*S/cm

### 4.2 Major Ion Chemistry

The anion chemistry of the analyzed samples reveals that bicarbonates ($HCO_3$) and chlorides (Cl) are the dominant ions both in pre and post-monsoon seasons. The concentration of bicarbonate ($HCO_3$) ranges from 40-440 mg/l (Avg 170 mg/l). The concentration of carbonate ($CO_3$) ranges from 10-72 mg/l (Avg 36 mg/l). Chloride concentration varies from 19-130 mg/l (Avg 67 mg/l). Cationic chemistry is dominated by sodium (Na) and calcium (Ca).The concentration of sodium varies from 13-80 mg/l. The concentration of calcium (Ca) is in the range of 18-89 mg/l Magnesium (Mg) ranges 10-52 mg/l. The concentration of potassium ranges from 2-12 mg/l (average 5.66 mg/l).

## 5. Suitability of groundwater for irrigation purpose

Groundwater is commonly used for irrigation and its quality influences the growth of plant, and fertility of the soil. The suitability of groundwater for irrigation use depends upon several factors like water quality, soil structures, climate drainage characterization. The water used for irrigation is an important factor in productivity of crop. The quality of irrigation water depends mostly on the presence of dissolved salts and their concentrations. The salt present in the water affect in soil structure, permeability and aeration this affects the plant growth. The suitability of groundwater of the study area for irrigation is determined using different factors like Sodium percentage (Na%), Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Kelley's Ratio (KR), and Magnesium Ratio (MR), (Table 2).

### 5.1 Sodium Adsorption Ratio (SAR)

The sodium adsorption ratio is an important parameter for determination of suitability of irrigation water because it is responsible for the sodium hazard. The main problem with high sodium concentration is its effect on soil permeability. SAR of the groundwater has been estimated by using the following formula, and all the ions are expressed in epm.

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

The groundwater with SAR < 10 is considered as of excellent quality, between 10 to 18 is good, 18 to 26 is fair and above 26 to said to be unsuitable for irrigation (USSL, 1954; Ayers and Wescot, 1994).The

SAR values of the samples vary from 0.64 to 4.3 (Avg 2.13) (Table 2). All the fifteen water samples are <10 and therefore considered as excellent quality for irrigation.

**5.2 Kelley's Ratio (KR)**

Kelley's Ratio (KR) is determined for sodium hazard. It is the ratio of Na ions to Ca and Mg ions expressed in epm. It is expressed as KR= Na/ Ca + Mg. The Kelley's ratio has been calculated for the groundwater samples of the study area and presented in Table 2 and 3. The groundwater having KR <1 is considered to be good quality for irrigation, whereas KR >1 is considered to be unsuitable for irrigation and causes alkali hazard to the soil (Karnath, 1987). The Kelley's ratio was found in the range of 0.16-1.53 (Avg 0.53). Except one sample all the samples in the study are less than permissible rate of 1, indicating all the samples are of good quality for irrigation (Table 2).

**5.3 Magnesium Ratio (MR)**

Magnesium Ratio (MR) is calculated as MR = Mg x 100/ Ca + Mg

MR values of <50 are suitable for irrigation and MR values of >50 are unsuitable (Lloyd and Heathcoat, 1985). Excess amount of magnesium reduces the yield of crop. High magnesium contents in water can affect the quality of soil. The MR values of water samples show the range of 19.65 to 62.14 (Avg 35.96). Except one sample all the samples in the study are less than permissible rate of <50, indicating all the samples are of good quality for irrigation (Table 2).

**5.4 Soluble Sodium Percentage (SSP)**

Soluble Sodium Percentage (SSP) of groundwater samples of study area is determined by the following formula and all the ions are expressed in epm.

$$SSP = Na \times 100 / Ca + Mg + Na$$

In Base Exchange process, calcium is replaced by sodium, which in turns lowers soil permeability. The SSP values of <50 indicate good quality and if it is more than 50 it indicates the unsuitable for irrigation. The SSP values of water samples show the range of 12.54-50 (Avg 32.89). The SSP values of all the groundwater samples of the study area are less than 50, which indicate good quality for irrigation purpose.

**5.5 Sodium Percentage**

Sodium concentration in groundwater has an important role in classification of irrigation water quality, because by the process of base exchanges, sodium replaces calcium in the soil and which reduces the permeability of soil. The sodium percentage (Doneen, 1962) is calculated as, Percent Sodium = (Na+K /Ca+Mg+Na+K) x100, it is expressed in epm. Percentage sodium of groundwater in the study area varies from 12.76 to 62.15 (Avg 33.02) (Table 2). Based on Na% 3 samples (31.57%) are excellent category, 8 samples (53.33%) are good category and 2 samples (13.33%) is permissible category and 2 samples (13.33%) are in doubtful and unsuitable category. (Table 2).

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**Table 2:** Irrigational specification values of groundwater from the study area

| S.No | Na% | SAR | KR | MR | SSP |
|---|---|---|---|---|---|
| 1 | 14.00 | 3.76 | 0.16 | 23.80 | 21.238 |
| 2 | 12.76 | 4.30 | 0.18 | 20.00 | 39.130 |
| 3 | 28.84 | 2.65 | 0.17 | 19.65 | 48.648 |
| 4 | 17.50 | 1.56 | 0.42 | 30.34 | 15.036 |
| 5 | 37.00 | 0.65 | 0.25 | 24.70 | 48.543 |
| 6 | 21.00 | 2.15 | 0.60 | 46.71 | 43.820 |
| 7 | 37.75 | 0.82 | 0.28 | 38.50 | 34.666 |
| 8 | 40.72 | 1.70 | 0.65 | 24.10 | 50.00 |
| 9 | 30.16 | 2.46 | 0.62 | 37.18 | 18.518 |
| 10 | 42.10 | 1.78 | 0.52 | 42.00 | 49.500 |
| 11 | 33.42 | 1.36 | 0.74 | 35.25 | 18.478 |
| 12 | 22.48 | 2.10 | 0.60 | 45.10 | 30.120 |
| 13 | 26.18 | 0.64 | 0.30 | 42.70 | 34.751 |
| 14 | 62.15 | 1.77 | 0.39 | 37.40 | 12.541 |
| 15 | 60.40 | 3.72 | 1.53 | 62.14 | 31.603 |
| Min | 12.76 | 0.64 | 0.16 | 19.65 | 12.54 |
| Max | 62.15 | 4.3 | 1.53 | 62.14 | 50 |
| Avg | 33.02 | 2.13 | 0.53 | 35.96 | 32.89 |

**Table 3:** Classification of Water based on Na%

| Na% | Water Class | No and Percentage of |
|---|---|---|
| Upto 20 | Excellent | 3 (20%) |
| 20-40 | Good | 8 (53.33%) |
| 40-60 | Permissible | 2 (13.33%) |
| 60-80 | Doubtful | 2 (13.33%) |
| >80 | Unsuitable | - |

**Conclusions**

Groundwater in the study area is generally alkaline in nature. The water is excellent quality for irrigation in study area according to the SAR classification. The Kelley's ratio and magnesium ratio suggests that except one sample all the samples in the study are less of good quality for irrigation. The SSP values of all the groundwater samples of the study area are less than 50, which indicate good quality for irrigation purpose. Based on Na%, 3 samples are excellent category, 8 samples are good category and 2 samples are permissible category and 2 samples are in doubtful and unsuitable category. Overall majority of samples are showing their suitability for irrigation in the study area.

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