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GROUND WATER QUALITY ASSESSMENT FOR DRINKING AND IRRIGATION IN YERPEDU AREA CHITTOOR DISTRICT, ANDHRAPRADESH, SOUTH INDIA

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Abstract: The aim of present investigation is to determine the ground water resource has useful for drinking and irrigation purpose of Yerpedu area, Chittoor district. From that 25 water samples have been collected with different intervals. The physico chemical parameters were analyzed with help of ICP-OES instrument, determine the physicochemical parameters like cations and anions. Based on that, Evaluation of the irrigation parameters like such as the residual sodium carbonate, percent sodium, potential salinity, Kelly's ratio, chloro-alakaine indices, magnesium ratio, SAR and permeability index. The Gibbs diagramme was represented the rock-water interaction. The Prominent water type was Ca-Mg-Cl facies.

keywords: Physico chemical parameters, USSL diagram, Wilcox diagram, Chada's diagram and Gibb's diagram

1.0 Introduction

water is one of the most important commodity to survival of living organism on the Earth surface . Survival of human beings for various need such as agriculture, drinking and irrigation where the developing without water there is no life on the earth and it is a elixir for all living organisms(1-2). The quality of water play vital importance for survive countries in all over the globe(3). The increasing of the urban population may leads to the pollution and increase in chloride in ground water and 20% percent of sample s may leads to exceeding of the dirking water for the Yerpedu area(4). This work is helpful for better understanding the Ground water quality and upcoming for management of ground water resource in the study area.

2.0 Study Area

Yerpedu mandal lies between latitude 13° 40′ 59.88″ N and longitude of 79° 36′ 0″ E. It is a important Mandal in Chittoor District of Andhra Pradesh and Head Quarters is Yerpedu town and belongs to Rayalaseema region. It is encircled by Renigunta Mandal towards west, Srikalahasti Mandal towards NorthVadamalapeta Mandal towards South, Tirupati (Urban) Mandal towards west. It is consist of 97 Villages and 40 Panchayats. Among All, the smallest Village is Vedulla Cheruvu and the biggest Village is Vikruthamala. It receives the rainfall from the north east and south east monsoons and the highest temperature is 30º to 39º, average temperature lies 25ºc. The study area map is shown Figure-1.0.

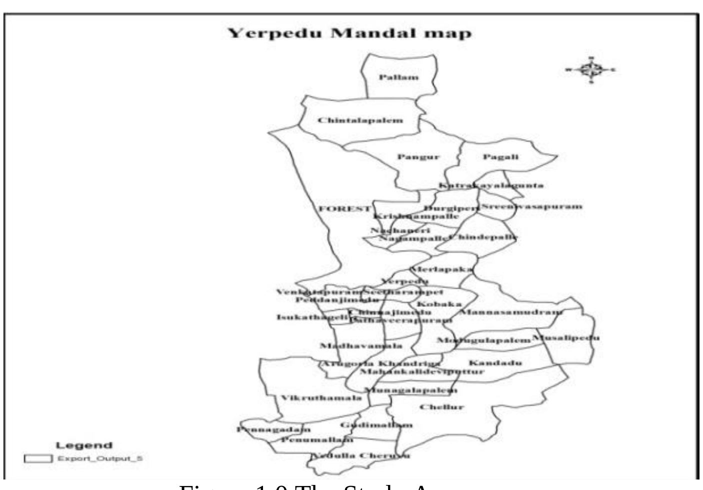

Figure 1.0 The Study Area map

3.0 Materials and methods

In the concentrated area, 25 groundwater samples have been collected in a 1000 ml de-ionized polythene bottles and analyzed the physico- chemical parameters such as cations and anions with a standard laboratory methods (5-6). The analytical results are existing in Tables 1.0 and 1.1.

TABLE -1.1 Minimum and Maximum Values of Physico Chemical Properties of Water

Parameters	Min	Max	Average	SD	Median	SE
EC	790.00	3270.0	1524.40	592.66	1400.00	83.82
PH	7.20	8.3	7.65	0.36	7.60	0.05
TDS	505.60	2092.8	975.62	379.30	896.00	53.64
Ca (mg/l)	105.61	428.1	240.48	93.91	225.45	13.28
Mg (mg/l)	93.27	408.0	217.78	73.87	209.85	10.45
Na (mg/l)	8.00	35.0	18.67	6.33	17.99	0.90
K (mg/l)	3.53	33.3	11.72	6.55	10.20	0.93
HCO3 (mg/l)	368.10	705.5	511.74	87.96	493.00	12.44
F (mg/l)	0.30	1.3	0.88	0.25	1.00	0.04
CO3 (mg/l)	0.00	0.0	0.00	0.00	0.00	0.00
Cl (mg/l)	132.98	319.1	212.06	55.54	212.77	7.85
SO4 (mg/l)	230.77	822.1	466.73	160.22	413.46	22.66
Hardness as CaCO3 (mg/l)	266.85	649.6	458.26	106.97	449.37	15.13
Percent Sodium	3.56	4.5	3.60	0.59	3.69	0.08
Potential Salinity	10.40	16.3	10.83	2.55	10.40	0.36
Residual Sodium Carbonate	-17.86	-7.2	-21.56	6.83	-20.58	0.97
Non-carbonate Hardness	893.00	1704.1	1078.01	341.49	1029.00	48.29
CaI 1	0.78	0.9	0.81	0.06	0.82	0.01
CaI 2	0.16	0.4	0.25	0.08	0.25	0.01
GR I	0.40	0.5	0.41	0.07	0.41	0.01
GR II	0.07	0.2	0.10	0.04	0.08	0.01
Kell's Ratio	0.02	0.0	0.03	0.01	0.03	0.00
Mg Ratio	48.20	82.6	59.53	12.53	59.15	1.77
SAR	0.15	0.3	0.21	0.05	0.21	0.01
PI	12.19	20.3	12.54	2.69	12.19	0.38

Table -1 Minimum and Maximum Values of Physico Chemical Properties of Water

4.0 Evaluation of water quality for drinking

The groundwater suitability for drinking in the concentrated area have been discussed below and the minimum and maximum values were shown in the Table1.0.

(pH)

pH is a determine the relative amount of free H^+ ions and OH^- ions in the water. In the current study, the values are ranging from 7.2 to 8.3, with a mean value of 7.65. The desirable limit for pH in drinking water is 6.5 to 8.5, according to the BIS (2012) and WHO (1993)(7-8). All the groundwater samples of the study area are falling within the desirable limits.

Electrical conductivity

EC values are ranging from 790 to 3270 µ mhos/cm with a mean value of 1520 µ mhos/cm. The groundwater with EC less than 750 µ mhos/cm is desirable for drinking. In the present study area, all the ground water samples fall in not fit for drinking(Table-1.0).

Total dissolved solids (TDS)

In the present study, TDS ranged from 505.60to 2092.8 mg/l in all groundwater samples with a mean value of 975.62 mg/l. The majority of the samples were fall in brackish nature.

Total Hardness

The hardness of groundwater in the study area ranges from 266.85 to 649.6 mg/l with an average value of 458.26 mg/l(10). Four water samples in the study area are shown very hard in nature (Table1.0).

Major cations

The concentrations of calcium and magnesium ranged from 105.4 to 428.1mg/l and 93.27 to 408.0 mg/l (Table1.0). The calcium is derived from calcium rich minerals like feldspars, pyroxenes and amphiboles from granitic rocks. majority of the samples in the study area are exceeding the maximum permissible limit of 200 mg/l (BIS 2012). The major source of magnesium (Mg2+) in the groundwater is due to ion exchange of minerals in rocks and soils by water. Most of the samples in the study area are within the maximum permissible limit of 150 mg/l (BIS 2012). The Na^+ and K^+ concentrations in groundwater range from 8 to 35 and 3.53 to 33.3 mg/l, respectively. The weathering of feldspar and clay is a source of sodium and potassium in groundwater. The maximum permissible limit for Na^+ in drinking water is 200 mg/l, according to WHO (2011). All the groundwater samples are falling in suitable for drinking .

Major anions

The concentration of bicarbonates ranged from 366.10 to 701.69 mg/l with a mean of 508.51 mg/l (Table 1.0). It is suggested that bicarbonate levels less than 200 mg/l is suitable for drinking purpose.The water didn't fit for the drinking due to exceeding the bicarbonate limits. The concentration of Chloride ranges from 132.75. to 318.59 mg/l. A total of 7 samples in the study area exceeded the maximum permissible limit of 250 mg/l (WHO 2011).The Fluoride content varies from 0.30 to 1.3 ppm. all the samples fall in desirable limit. In the present study, the sulphate ranges from 230.77 to 822.1mg/l with a mean value of 466.73 mg/l. The main cause of sulphate increase in groundwater due to dissolution of pyrite, gypsum, barite, and Celestine minerals and agriculture activity. 30 percent of the groundwater samples exceeds the maximum permissible limit of 250 mg/l. The abundance of the major ions in groundwater is in following order :$Ca^{2+} > Mg^{2+} > Na^+ > K^+$ and $HCO_3^- > Cl^- > SO_4^{2-} > F^- > CO_3^{2-}$

5.0 Evaluation of water quality for irrigation

The evaluation of irrigation water quality is important for planning, design and operation of irrigation (11).

Sodium Adsorption Ratio (SAR)

This parameter is used to estimate the sodicity hazard of the water. The sodium adsorption ratio (SAR) is used to predict the danger of sodium accumulation in soil. Excess sodium in water produces the undesirable effects of changing soil properties and reducing soil permeability and soil structure (12).The SAR value calculated from the following equation (13):

$$SAR = \frac{Na^+}{[(Ca^{2+} + Mg^{2+})/2]^{1/2}}$$

(Where the concentrations of all ions are in meq/l.)

It dealings the potential dangers posed by excessive sodium in irrigation water and shown in table 1.0 In the concentrated area, the SAR values of the groundwater samples are varying from 0.15 to 0.3 with a mean value of 0.21.All samples were falling in excellent and suitable for irrigation(14). The USSL diagram shows that about 60 % of water samples in the Concentrated area falling in C3S1 (EC<2250 µ mhos/cm) with high salinity and low sodium, about 20% of the samples are falling in the C4S1 zone (EC>2250 µmhos/cm) with Very high salinity and low sodium. (Figure 1.1).

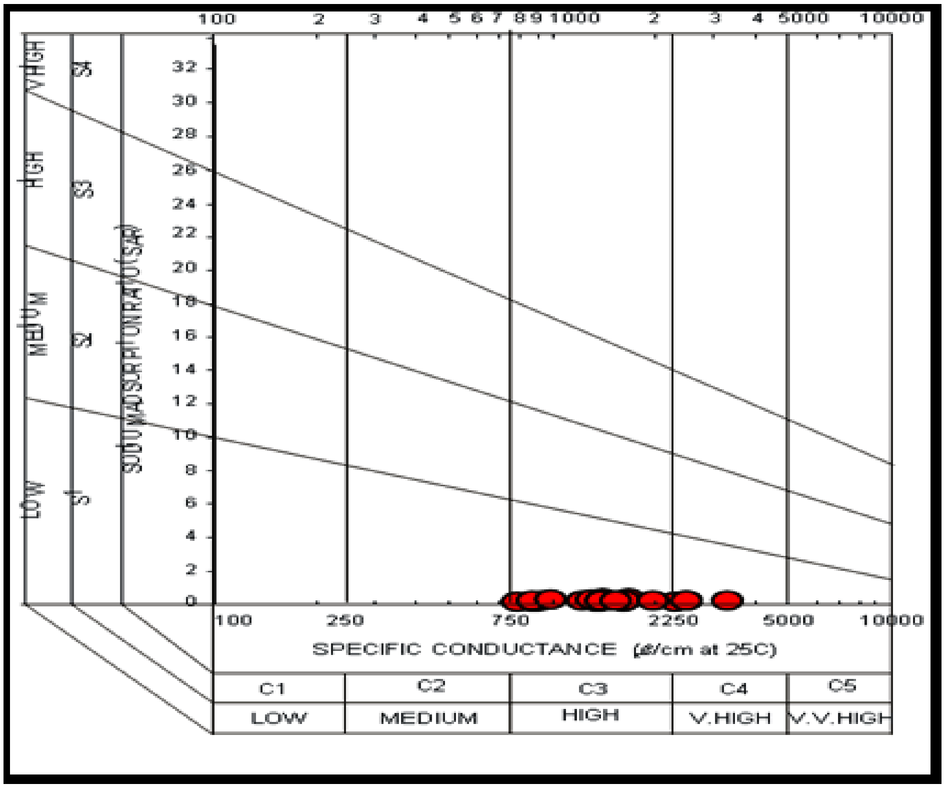

Figure 1.1 The quality of water in relation to salinity and sodium hazard (after U.S. Salinity Laboratory 1854

Non-carbonate Hardness (NCH)

NCH values ranged from 893.60 to 1704.1. According to ICMR, the maximum permissible limits <600(15). The majority of the samples exceeding the permissible limit in the groundwater.

Permeability Index

The suitability of groundwater for irrigation based on the permeability index (PI).

Doneen (1964) defined permeability index (PI) as:

$$PI = \frac{(Na^{+} + \sqrt{HCO_{3^-}})}{(Ca^{2+} + Mg^{2+} + Na^{+})} X 100$$

(Where the concentrations of all ions are in meq/l.)

The PI values varied from 12.19 to 20.3. All the samples fall under suitable for irrigation.

Kelly's

Kelley's ratio is calculated as follows (Kelly, 1963) described:

$$KR = \frac{Na^{+}}{(Ca^{2+} + Mg^{2+})}$$

Kelly's ratios for all the groundwater samples are calculated and it lies between 0.02 to 0.04 and with a mean value of 0.03 mg/l (Table 1.0). In the concentrated area all the samples fall value less than one. It is suitable for irrigation.

Magnesium hazard

Generally, calcium and magnesium maintain a state of equilibrium in most waters. More Mg^{2+} present in waters affects the soil quality, converting it to alkaline and decrease crop yield. Szabolcs and Darab (1964) proposed magnesium hazard (MH) value of irrigation water as given below:

$$MH = Mg^{2+}/ (Ca^{2+} + Mg^{2+)} x 100$$

Where the concentrations are in meq/l

The magnesium ratio has varied from 48.20 to 82.6 with an average value of 59.53. In this study, all the water samples fall in the permissible limit for growth of the plant and agriculture field .

Sodium percentage (%Na)

Percent sodium in water is a parameter computed to evaluate the suitability of water quality for irrigation (Wilcox, 1948) (16,17,18).

Todd (1980) defined soluble sodium percentage (SP) as

$$\%Na = \frac{(Na+ + K+)}{\quad} X 100$$

$(Ca^{2+} + Mg^{2+} + Na^{+} + K+)$

Where all the ionic concentrations are in meq/l

The determined value of sodium percentage lies between 3.56 and 4.5 a mean value of 3.60. In this study nearly all the groundwater samples are within the permissible limit. From Figure 1.2, it is clear that about84% of samples are good to permissible followed by doubtful to unsuitable (12%) and doubtful (4%) categories respectively. The agricultural yields are observed to be generally low in lands irrigated with water belonging to doubtful to unsuitable and doubtful. This is probably due to the presence of sodium salts, which cause osmotic effects in the soil-plant system.

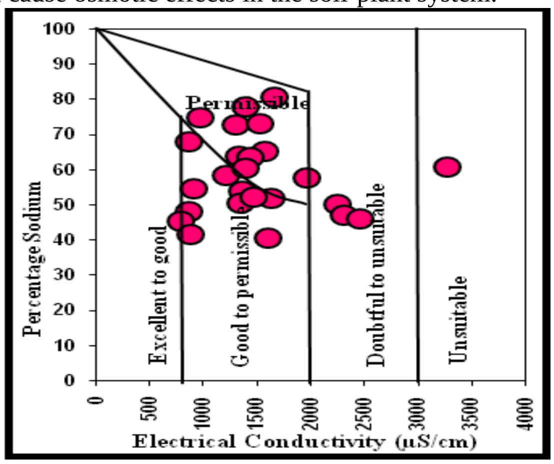

Figure 1.2 The quality of water in relation to electrical conductivity and percent sodium (Wilcox diagram)

Potential Salinity

The potential salinity of water samples ranges from 10.40 to 16.30 with a mean of 10.83 (Table 1.0). It suggests that the potential salinity of majority of the groundwater samples of the studied area nearly is high (>10), thus, making the water unsuitable for irrigation usage.

Hydrochemical facies of groundwater

The general purpose of a Hydrochemical facies study is to relate the chemical character of groundwater to the geological and hydrological environment. Graphical depiction of groundwater major dissolved constituents (major cations and major anions) assists in understanding its Hydrochemical evolution, grouping and areal distribution. In the present study, Chadha's plot was constructed to evaluate variation in hydrochemical facies.

Chadha's diagram

In the present study, the groundwater of the study area has been classified as per Chadha's diagram to identify the Hydrochemical processes. It is evident from the results that about all samples fall in Ca-Mg-Cl Water type(19,20,21). It shows alkaline earths exceed alkali metals and strong acidic anions exceed weak acidic anions; such water has permanent hardness (Figure 1.3)

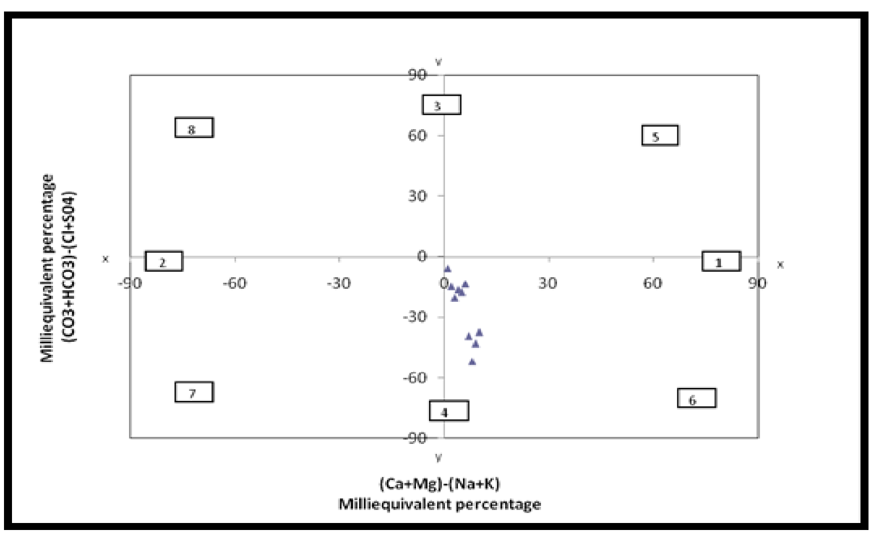

Figure 1.3 Chada's Diagram For Representing The Analysis Of Groundwater (Modified Piper Diagram)

Gibb's diagram: This diagram used to helpful for an interpretation of the effect of hydro geochemical processes such as precipitation, rock-water interaction mechanism and evaporation on groundwater geochemistry. The reaction between groundwater and aquifer minerals has a considerable role in groundwater quality which is useful to assume the genesis of water. Gibbs ratio is calculated by using the following equation (22).

Gibbs ratio I = $(Cl^-/Cl^- + HCO_3^-)$

$$\text{Gibbs ratio II} = (Na^+ + K^+)/(Na^+ + K^+ + Ca^{2+})$$

In the present study, Gibbs ratio I values varied from 0.4 to 0.5 and Gibbs ratio II values varied from 0.07 to 0.2 (Table 1). From (Figure 1.4), it is clear that 99% of samples are falling under rock dominance category. This indicates that the rock dominance plays an important role in controlling the groundwater chemistry of this area.

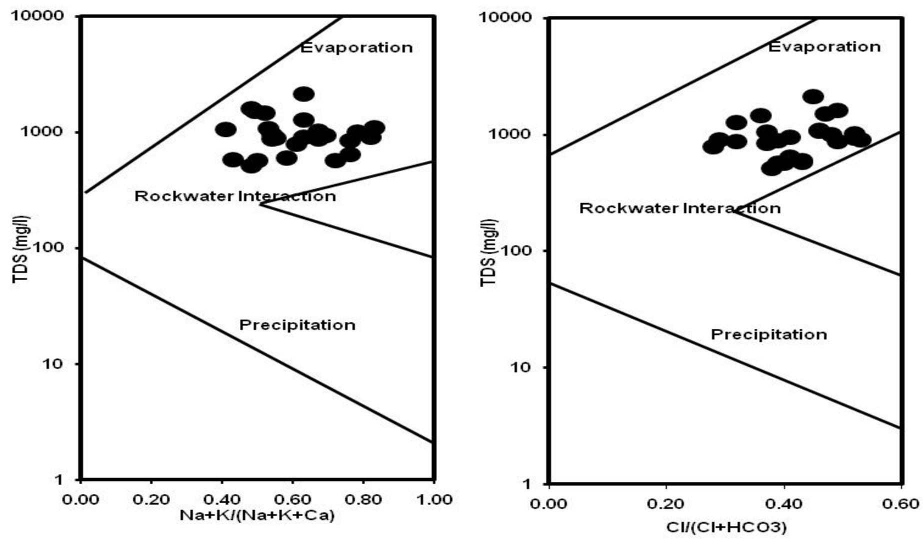

Figure 1.4 Shows the Gibbs diagram of the study area

Conclusion:

In overall, the present study area lies Further, the groundwater can be classified with few exceptions as suitable for irrigation under certain conditions such as a good management and good drainage system. The results obtained from these studies indicated that the parameters responsible for groundwater chemistry are weathering of silicate minerals, dissolution of chloride salts, ion exchange, rock water interaction and anthropogenic activities, agricultural activities such as irrigation practices and fertilization.

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