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Evaluation of Groundwater Quality for Irrigation in Eluru Division of West Godavari District, Andhra Pradesh

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ABSTRACT

Good quality water helps to maintain agricultural productivity and sustain soil fertility. Agricultural activities in West Godavari depend on surface water and also on groundwater. This study was done to evaluate the status of groundwater quality and its suitability for irrigated agriculture. To achieve this objective, 236 groundwater samples from each season *i.e.* during pre monsoon and post monsoon were collected from 16 mandals of Eluru division in July and December of 2016, respectively. The water quality in the study area was estimated from different water quality parameters such as EC, pH, sodium adsorption ratio, residual sodium carbonate, and classified based on CSSRI and USSL criteria. The results showed that the sodium hazard in the groundwater samples was low. High EC and low SAR in all the area showed that the water from these sources could be used for irrigation purposes with special management.

Key words*: Boron, Ground water, Irrigation, Quality, West Godavari.*

The quality of groundwater is determined by the physico-chemical and chemical characterization of groundwater, which is the major source of water for domestic, agricultural, and industrial purposes in many countries. Intensive agricultural activities have increased the demand on groundwater resources in many countries (Abdulla and Alsheik, 2015). To meet the growing demands of water for the agricultural sector, exploration of alternative sources of water, for use in agriculture, is important. Agriculture is a dominant sector in the economic development of India, as it is the source of sustenance for the majority of the population and contributes 46 per cent of the gross national product (Kumarasamy *et al*. 2011). Irrigated agriculture consumes 60–80 per cent of the total water usage and contributes nearly 38 per cent of the global food production (Shahinasi and Kashuta, 2008). The utilizable water resource in India is not enough to irrigate the cultivatable area. Hence, efforts are needed to maximize the chances of water for irrigation in agriculture (Sharma, 2005). Keeping in mind the importance of water quality assessment, a study regarding the "Evaluation of groundwater quality for irrigation in Eluru division of West Godavari district, Andhra Pradesh" was carried out to evaluate the quality of groundwater suitable for irrigation. In this study, many of the wells which are still in use the groundwater of the West Godavari area was evaluated for quality of irrigation water. The following were determined: pH, EC (dS m^{-1}) sodium adsorption ratio (SAR) and Residual sodium carbonate (RSC).

MATERIAL AND METHODS

Water sampling, processing, and analysis

A total of 236 groundwater samples were collected from sixteen mandals of Eluru division of West Godavari district during pre monsoon (July, 2016) and post monsoon (December, 2016) seasons. The samples were taken from the bore wells after pumping them about 5 minutes, and then the samples were collected in clean polyethylene bottles. Prior to collection, the sample bottles were rinsed three to four times using sampling water. The water samples were taken by pumping, so the sample was representative and contamination from the surface was avoided. After collecting the sample 2-3 drops of toulene was added to prevent the contamination. Collected samples were transported to the laboratory and stored at room temperature.

The water samples were analyzed as per the standard methods. Values of pH were measured by a pH meter with electrodes. The instrument was calibrated with buffer solutions having pH values

of 4.0, 7.0 and 9.2. The values of electrical conductivity (EC) were measured by EC meter with electrodes in the lab. The concentrations of Ca^{+2}, Mg^{+2}, HCO_3^- were determined by volumetric method. Ca^{+2} and Mg^{+2} were determined by EDTA titration. For HCO_3^- titration with a methyl orange was used. Flame emission photometry has been used for the determination of Na^+

RESULTS AND DISCUSSION

The analytical data of successive pre and post monsoon seasons for groundwater sample corresponding to July 2016 and December 2016 are given in me L^{-1} given in Table.3 and Table.5.

Electrical Conductivity (EC)

Water salinity hazards are measured by using EC. If EC is greater than 2.25 dS m^{-1}, then crop productivity is affected very much, and it is good if EC is less than 0.25 dS m^{-1} (Westcott and Ayers, 1984). If EC increases, water intake by the plant significantly decreases and, hence, the productivity is also considerably reduced. In the study area, Electrical Conductivity values ranged between 0.3-26.0 dS m^{-1} during pre monsoon, 2016 (Table 3). The EC values during post monsoon, 2016 ranged between 0.3-26.0 dS m^{-1} majority of the samples were fell under C_3 class *i.e.* high salinity (Table 1).

Hydrogen ion concentration (pH)

The ground water pH Values in Eluru division was ranged from 6.5 to 8.3 and 6.5 to 8.8 during pre and post monsoon seasons of 2016, respectively (Table 3). The groundwater is neutral to alkaline in nature and majority of the samples fell under neutral range in both pre and post monsoon seasons. Similar results were reported by Thomas (2016).

Residual Sodium Carbonate (RSC)

RSC was computed using the following formula

RSC (me L^{-1}) = $(CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$

RSC values were calculated to determine the hazardous effect of CO_3^{-2} and HCO_3^- on the water quality for agricultural purpose (Eaton, 1950; Richards, 1954). According to USSL diagram, an RSC value <1.25 me L^{-1} is probably safe for irrigation. If it is >2.5 me L^{-1}, it is not suitable for irrigation. In the study area, the RSC values ranged from -74.6 to 20.5 me L^{-1} with an average value of -0.3 during pre monsoon 2016 (Table 5). During post monsoon of 2016, the RSC values range from -68.1 to 20.8 me L^{-1} with an average value of- 0.3 me L^{-1} (Table 5). Majority of the samples have RSC <1.25 me L^{-1}. Therefore the quality of irrigation water is safe for irrigation in this study area (Table 4). Similar results were obtained by (Jafer, 2013).

Sodium Adsorption Ratio (SAR) Criterion

SAR is calculated from the ionic concentration (me L^{-1}) of sodium, calcium and magnesium according to following relationship. SAR was computed to indicate the sodicity or alkalinity hazard of irrigation waters.

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

The SAR value ranged from 0.1 to 63.1 with an average value of 4.7 in the samples, collected during pre monsoon 2016 (Table 5). During post monsoon, the SAR values were ranged from 0.1 to 29.2 with an average value of 4.3 (Table 5). Out of 236 samples 210 samples (89%) fell under the class of S-1 during pre monsoon period. During post monsoon period, 217 samples (91.9%) fell under the class of S-1 (Table 6).

USSL Classification

The interpretation of water quality suitable for the irrigation purposes are given by Richard (1954) in the form of EC versus SAR values. Electrical Conductivity (E.C.) has been treated as index of salinity hazards and Sodium adsorption ratio (SAR) as an index of sodium hazard. Irrigation water of Eluru division of West Godavari district was classified on the basis of SAR and EC. Classification revealed that most of the water samples about 41.5 per cent (98 out of 236) fell under C_3–S_1 (high-salinity hazard and low-sodium hazard) and 52 samples with 22 per cent were fallen in the class C_2–S_1 (medium-salinity hazard and low sodium hazard). Only 5.9 and 3.0 per cent samples were fallen in C_4–S_4 (very high salinity and

Table 1. Classification of water samples based on EC.

EC (dS m^{-})	Pre monsoon		Post monsoon	
	No. of samples	percent	No. of samples	percent
C_1<0.25	0	0.0	0	0.0
C_2 0.25-0.75	52	22.0	65	27.5
C_3 0.75-2.25	127	53.8	124	52.5
C_4 >2.25	57	24.2	47	19.9

Table 2. Classification of water samples based on p^H.

p^H Class	No.of samples	percent	No.of samples	percent
Neutral(6.5-7.5)	177	75	212	89.8
Alkaline(>7.5)	59	25	24	10.2

Table 3. Range and mean of pH and EC of groundwater samples of different mandals of West Godavari district during pre and post monsoon periods.

S. No.	Name of the mandal	Total samples	pH				EC (dSm^{-1})			
			Pre monsoon		Post monsoon		Pre monsoon		Post monsoon	
			Mean	Range	Mean	Range	Mean	Range	Mean	Range
1	Bheemadole	13	6.8-7.9	7.5	6.8-7.9	7.3	0.5-3.7	2.1	0.5-3.6	1.8
2	Chinthalapudi	17	6.9-7.9	7.4	6.5-7.6	7.1	0.3-12	1.5	0.3-11.5	1.4
3	Denduluru	18	7.3-7.7	7.5	7.1-8.8	7.4	0.8-5.8	2.4	0.8-4.4	2.0
4	Dwarakathirumala	35	6.7-8.1	7.3	6.7-7.9	7.1	0.4-1.3	0.8	0.4-1.2	0.8
5	Eluru	4	7.3-7.8	7.6	7.1-7.7	7.4	1.6-2.7	2.1	0.9-1.9	1.3
6	Ganapavaram	15	7.2-8.0	7.5	7.0-8.0	7.4	1.1-26	4.8	1.0-26	4.7
7	Kamavarapukota	9	6.5-7.7	7.3	6.9-7.4	7.3	0.4-0.9	0.7	0.4-0.7	0.7
8	Lingapalem	16	7.1-8.1	7.4	7.1-7.7	7.4	0.6-3.5	1.6	0.6-3.4	1.5
9	Nallajarla	11	6.7-7.5	7.1	6.7-7.4	7.1	0.5-1.4	0.8	0.5-1.3	0.8
10	Nidamarru	10	6.9-7.5	7.2	6.6-7.5	7.1	0.7-16	3.1	0.4-14	2.6
11	Pedapadu	12	7.2-7.8	7.5	6.6-7.7	7.4	0.7-4.9	2.3	0.6-3.9	2.0
12	Pedavegi	21	7.1-7.9	7.5	7.1-7.7	7.3	1.0-3.6	1.8	0.9-3.5	1.7
13	Pentapadu	15	7.1-7.7	7.4	7.1-7.4	7.3	0.6-12	3.5	0.6-12	3.2
14	T.Narasapuram	13	6.9-7.9	7.4	6.5-7.2	7.0	0.6-1.2	0.8	0.5-1.1	0.8
15	Thadepalligudem	13	7.1-8.3	7.4	6.9-8.2	7.2	0.6-9.7	2.6	0.6-9.6	2.3
16	Ungutur	14	7.1-7.7	7.3	6.9-7.3	7.1	0.8-2.4	1.5	0.7-3.5	1.4

Table 4. classification of water samples based on RSC (me L^{-1}).

RSC	Pre monsoon		Post monsoon	
	No. of samples	percent	No. of samples	Percent
<1.25	157	66.5	162	68.6
1.25-2.5	30	12.7	31	13.1
>2.5	49	20.8	43	18.2

Table 5. Range and mean of SAR and RSC of groundwater samples of different mandals of West Godavari district during pre and post monsoon periods.

S.No	Name of the mandal	Total samples	SAR				RSC (me L^{-1})			
			Pre monsoon		Post monsoon		Pre monsoon		Post monsoon	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	Bheemadole	13	1.3-12.2	6.2	1.0-10.1	5.0	-10 to 13.2	1.6	-11to 11.1	0.2
2	Chinthalapudi	17	0.4-9.0	3.0	0.5-5.6	2.6	-69 to 2.8	-4.2	-68.1to 1.6	-4.4
3	Denduluru	18	1.1-15.5	6.2	1.0-9.8	5.3	-11.6 to 10.4	0.4	-10.1 to 9.0	0.7
4	Dwarakathirumala	35	0.3-5.3	2.4	0.1-5.4	2.2	-3.2 to 3.0	0.4	-4.0 to 3.4	0.5
5	Eluru	4	4.0-10.2	6.4	0.5-5.7	4.9	-4.0 to 3.4	0.4	-1.3 to 3.1	-0.03
6	Ganapavaram	15	2.5-63.1	13.8	2.4-29.2	10.9	-23.6 to 11.2	0.01	-65 to 10.6	-3.8
7	Kamavarapukota	9	0.1-3.9	1.2	0.7-4.0	1.3	-5.0 to 3.3	-0.7	-1.6 to 3.1	0.2
8	Lingapalem	16	1.0-7.9	3.4	1.0-7.4	3.2	-25.6 to 5.6	-2.7	-13.6 to 2.8	-1.8
9	Nallajarla	11	0.3-3.5	1.6	0.3-3.5	1.2	-5.0 to 1.9	-1.5	-4.8to 1.9	-1.2
10	Nidamarru	10	1.6-13.6	5.4	1.2-11.2	5.4	-74.6 to 5.0	-5.5	-58.6to 6.9	-3.2
11	Pedapadu	12	1.8-12.8	7.4	1.8-12.6	5.7	-8.8 to 9.4	0.5	-8.4to 9.0	0.1
12	Pedavegi	21	1.0-15.0	5.8	0.5-11.8	5.1	-11.2 to 7.8	0.3	-5.5to 8.0	0.6
13	Pentapadu	15	0.7-19.9	9.7	0.8-20	9.2	-13.7 to 11.2	1.2	-13.4 to 6.9	0.1
14	T.Narasapuram	13	0.0-2.8	1.1	0.7-3.0	1.7	-5.0 to 1.0	-1.3	-2.5 to 1.8	-0.3
15	Thadepalligudem	13	0.8-13.7	6.1	0.6-13.3	5.5	-31.3 to 4.4	-4.5	-30 to 3.6	-4.4
16	Ungutur	14	0.5-6.8	3.0	0.5-5.1	2.8	-5.1 to 4.8	-0.7	-5.7 to 1.4	-1.3

Table 6. Classification of water samples based on SAR.

SAR Class	Pre monsoon		Post monsoon	
	No. of samples	percent	No. of samples	percent
S1 (<10)	210	89.0	217	91.9
S2 (10-16)	23	9.7	16	6.8
S3 (16-26)	2	0.8	2	0.8
S4 (>26)	1	0.4	1	0.4

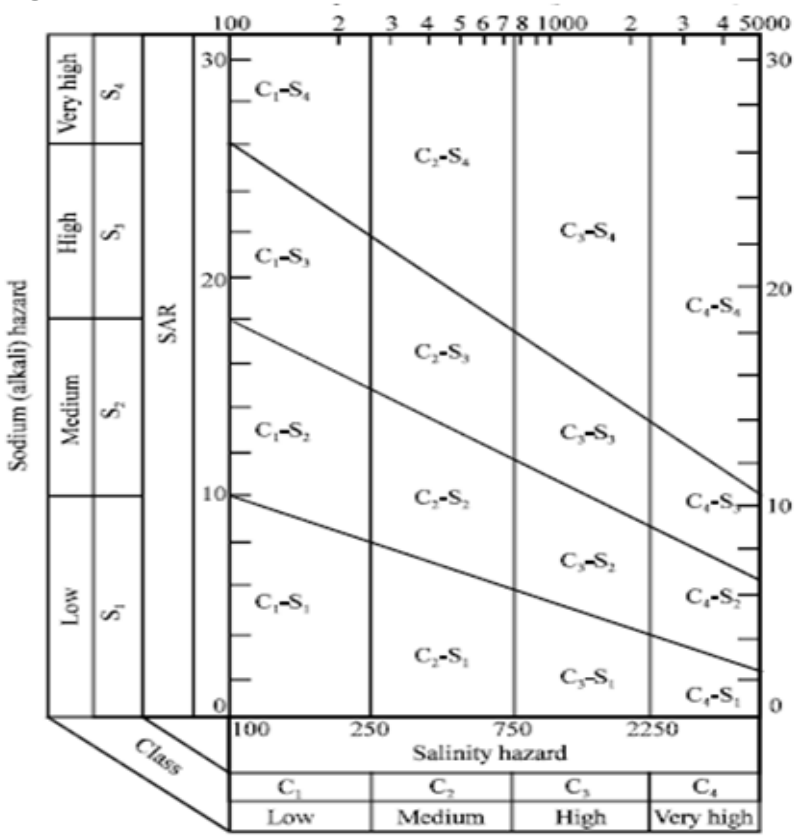
Table 7. Classification of water samples based on USSL diagram

Class	Pre monsoon		Post monsoon	
	No. of samples	percent	No. of samples	percent
C_{2}-S_{1}	52	22.0	61	25.8
C_{3}-S_{1}	98	41.5	105	44.5
C_{3}-S_{2}	25	10.6	26	11.0
C_{4}-S_{2}	30	12.7	28	11.9
C_{4}-S_{3}	17	7.2	9	3.8
C_{4}-S_{4}	14	5.9	7	3.0

Table 8. Classification of water samples based on CSSRI.

Class	Pre monsoon		Post monsoon	
	No. of samples	percent	No. of samples	percent
GOOD	148	62.7	155	65.7
Marginallly saline	20	8.5	22	9.3
Saline	9	3.8	9	3.8
High SAR saline	12	5.1	10	4.2
Marginally alkali	19	8.1	18	7.6
Alkali	15	6.4	12	5.1
High alkali	13	5.5	10	4.2

Fig 1. USSL diagram.



very high sodium hazard) in pre and post monsoons, respectively (Table 7).

Groundwater that is present in the medium-salinity hazard class (C_2) can be used in most cases without any special practices for salinity control. The groundwater observed from the zone C_3–S_1 and C_3–S_2 is considered to be of moderate quality to irrigate semi-tolerant crops. However, water samples those fell in the high-salinity (C_3) areas require careful management practices. Very high-salinity water (C_4) is not suitable for irrigation under ordinary condition, but it may be used for salt-tolerant plant on permeable soil with special management practice (Khodapanah *et al*. 2009). Similar results were obtained by (Jafer, 2013: Dhiman,2014)

CSSRI Classification

Eluru division of West Godavari district as a whole, out of 236 underground irrigation waters, 62.7 per cent of samples were good, 8.5 per cent

were marginally saline and 8.1 per cent were marginally alkali in nature. Almost similar results were observed in post monsoon season but good quality was raised to 65.7 per cent. Similar results were reported by Viswanath *et al*. (2015) in Prakasam district. The division having different qualities of underground water was presented in Table 6.

CONCLUSION

The ground water quality varied from place to place. The ground water extraction sources and their surroundings should be properly maintained to ensure hygienic conditions and no sewage or polluted water should be allowed to percolate directly to ground water aquifer. The analysis of the samples indicated that, based on pH, most of the samples fell in neutral class and based on EC majority of the samples fell in C_3 class *i.e*. high salinity, they cannot suitable for irrigation. Higher salt content in irrigation water causes an increase in soil solution osmotic pressure. Based on USSL criteria, about 45 % of the samples were found under $C_3 - S_1$ class. They cannot be used on the soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good tolerance should be selected. Based on CSSRI classification more than 60 per cent samples were good quality they can be safely used for irrigation without special management practices.

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