

## Quality Assessment of Groundwater in Rampachodavaram Division of East Godavari District, Andhra Pradesh

T Giri Shashank Reddy, P Mohana Rao, Y Sudha Rani and Ch Pulla Rao

Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla.

### ABSTRACT

Quality of ground water resources in the Rampachodavaram division of East Godavari district in Andhra Pradesh assessed for its suitability for irrigation. For this, one hundred and two (102) ground water samples were collected from study area in pre and post-monsoon seasons of 2017-2018). The ground water samples were analyzed for pH, EC, cations and anions viz.,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{HCO}_3^-$ ,  $\text{CO}_3^{2-}$ ,  $\text{Cl}^-$  and  $\text{SO}_4^{2-}$ , SAR and RSC were also calculated. Eighty six per cent (86%) ground water samples were neutral (pH 6.5-7.5) in reaction in both pre and post- monsoon seasons while EC values of majority of water samples were under  $\text{C}_3$  class (EC 0.75-2.25  $\text{dS m}^{-1}$ ) in both pre and post-monsoon seasons. The SAR and RSC values of majority samples were under  $\text{S}_1$  (0-10) and  $\text{A}_1$  ( $< 1.25 \text{ me L}^{-1}$ ) classes in pre and post-monsoon seasons, respectively,

**Key words:** *Quality assessment, Groundwater quality, Irrigation.*

About 97.2 per cent of world's water is found in oceans and seas and the remaining 2.8 per cent of water is found as ground water and surface water, of which ground water (0.59 %) is 30 times greater than surface water (0.02 %). Ground water quality is one of the most important aspects in water resource studies, which is largely controlled by discharge and recharges pattern, nature of host and associated rocks and contaminated activities. In recent years, an increasing threat to ground water quality as well as quantity due to human activities has become of great importance. With the advent of the tube wells along with the rapid growth of demand for agricultural and municipal water, annual global groundwater extraction has increased in recent decades from 100 cubic km/year in 1950 to a current estimated use of about 800 cubic km/year. Currently about 43 per cent of global irrigation, with 45 per cent in India as well as more than 50 per cent of the world's drinking water supply and a large share of global industrial activity depend on groundwater. Quality of water is assuming great importance with the rising pressure on agriculture and rise in standard of living. (Wani *et al.*, 2014).

In India unfortunately, salinity hazards are extensive and different crops require different irrigation water qualities. Therefore, testing the irrigation water quality is highly essential for effective management and utilization of the groundwater resources, by clarifying relations among many hydro-ecological considerations. In the present study, the quality of groundwater was assessed through estimation of pH, EC, SAR and RSC with reference to their suitability for irrigation.

### MATERIAL AND METHODS

East Godavari district is one of the nine coastal districts of Andhra Pradesh and is known for its historical importance. The district enjoys a unique place and is known as "rice bowl" of Andhra Pradesh. The district forms part of the Godavari delta region and is endowed by a vast potential of surface water resources. The district lies between North latitude  $16^\circ 30'$  and  $18^\circ 20'$  and East longitude  $81^\circ 30'$  and  $82^\circ 36'$  spreading over an area of 10,807 Sq.km. In East Godavari. The total net area irrigated is 2,83,592 ha. The net area irrigated through canals and tanks is 1,81,165 and 23,871 ha. respectively, and irrigation through lift and other sources is 644 ha. The net area irrigated through tube wells and filter point wells is 62540 ha. and thus constituting 12.70 percent through ground water irrigation in the district (Groundwater Brochure, East Godavari district, Andhra Pradesh, Central Groundwater Board, 2013). Mismanagement of land at all levels, particularly in agriculture, has led to the problem of rising water table, soil salinization and pollution of surface and groundwater resources (Manjunatha *et al.*, 2011). The sampling was carried out during the pre-monsoon (July, 2017) and post-monsoon seasons and collected 106 groundwater samples from Rampachodavaram division of East Godavari district. In both the seasons representative water samples were collected from different sources like bore wells, open wells and hand pumps.

The following water analysis techniques were used to assess the quality of water by measuring *viz.*, water reaction (pH) by digital pH meter, Electrical Conductivity by EC meter, SAR and RSC by using following formula.

**Table 1. Criteria for classification of irrigation water**

i) Salinity (EC dS m <sup>-1</sup> )		
Class	EC range	USSL, 1954
C-1 – low salinity	0.0-0.25	
C-2 – medium salinity	0.25-0.75	
C-3 – high salinity	0.75-2.25	
C-4 – very high salinity	>2.25	
ii) SAR (Sodium Adsorption Ratio)		
Class	SAR	
S-1 – low sodium water	< 10	
S-2 – medium sodium water	18-Oct	
S-3 – high sodium water	18-26	
S-4 – very high sodium water	> 26	
iii) RSC (Residual Sodium Carbonate)		
Class	RSC (me L <sup>-1</sup> )	
A-1 – Water can be used safely	<1.25	
A-2 – Water can be used with certain management	1.25-2.5	
A-3 – Not suitable for irrigation	>2.5	
iv) Water Reaction (pH)		
Acidic	< 6.5	Anonymous, 1984
Neutral	6.5-7.5	
Alkaline	>7.5	

**Table 2. Classification of groundwater samples based on pH basis during pre and post -monsoon periods in Rampachodavaram division of East Godavari district at mandal level.**

S. No.	Mandal	No. of samples	Pre-monsoon				Post-monsoon			
			Neutral (6.5-7.5)		Alkaline (>7.5)		Neutral (6.5-7.5)		Alkaline (>7.5)	
			No.	%	No.	%	No.	%	No.	%
1	Devipatnam	9	9	100	0	0	9	100	0	0
2	Rampachodavaram	10	8	80	2	20	7	70	3	30
3	Maredumilli	5	5	100	0	0	5	100	0	0
4	Gangavaram	4	4	100	0	0	4	100	0	0
5	Addateegala	12	9	75	3	25	9	75	3	25
6	Y. Ramavaram	5	5	100	0	0	5	100	0	0
7	Rajavommangi	6	4	66.7	2	33.3	5	83.3	1	16.7
	Total	51	44	86.3	7	13.7	44	86.3	7	13.7

**Table 3. Classification of groundwater samples based on EC during pre-monsoon period in Rampachodavaram division of East Godavari district at mandal level.**

S. No.	Mandal	No. of samples	EC (dS m <sup>-1</sup> )							
			C <sub>1</sub>		C <sub>2</sub>		C <sub>3</sub>		C <sub>4</sub>	
			(0-0.25)		(0.25-0.75)		(0.75-2.25)		(2.25-5.00)	
			No.	%	No.	%	No.	%	No.	%
1	Devipatnam	9	0	0.0	2	22.0	7	78.0	0	0.0
2	Rampachodavaram	10	0	0.0	7	70.0	2	20.0	1	10.0
3	Maredumilli	5	2	40.0	2	40.0	1	20.0	0	0.0
4	Gangavaram	4	0	0.0	1	25.0	3	75.0	0	0.0
5	Addateegala	12	0	0.0	4	33.0	7	58.0	1	8.0
6	Y. Ramavaram	5	1	20.0	1	20.0	3	60.0	0	0.0
7	Rajavommangi	6	0	0.0	2	33.0	3	50.0	1	17.0
	Total	51	3	5.9	19	37.3	26	51.0	3	5.9

**Table 4. Classification of groundwater samples based on EC during post-monsoon period in Rampachodavaram division of East Godavari district at mandal level.**

S. No.	Mandal	No. of samples	EC (dS m <sup>-1</sup> )							
			C <sub>1</sub>		C <sub>2</sub>		C <sub>3</sub>		C <sub>4</sub> (2.25-5.00)	
			(0-0.25)		(0.25-0.75)		(0.75-2.25)			
			No.	%	No.	%	No.	%	No.	%
1	Devipatnam	9	0	0.0	3	33.3	6	66.7	0	0.0
2	Rampachodavaram	10	0	0.0	6	60.0	4	40.0	0	0.0
3	Maredumilli	5	2	40.0	2	40.0	1	20.0	0	0.0
4	Gangavaram	4	0	0.0	3	75.0	1	25.0	0	0.0
5	Addateegala	12	0	0.0	6	50.0	6	50.0	0	0.0
6	Y. Ramavaram	5	1	20.0	3	60.0	1	20.0	0	0.0
7	Rajavommangi	6	0	0.0	2	33.3	3	50.0	1	16.7
	Total	51	3	5.9	25	49.0	22	43.1	1	2.0

**Table 5. Classification of groundwater samples based on SAR during pre-monsoon period in Rampachodavaram division of East Godavari district at mandal level.**

S. No.	Mandal	No. of samples	SAR							
			S <sub>1</sub>		S <sub>2</sub>		S <sub>3</sub>		S <sub>4</sub>	
			(0-10)		(10-18)		(18-26)		(>26)	
			No.	%	No.	%	No.	%	No.	%
1	Devipatnam	9	9	100.0	0	0.0	0	0.0	0	0.0
2	Rampachodavaram	10	10	100.0	0	0.0	0	0.0	0	0.0
3	Maredumilli	5	5	100.0	0	0.0	0	0.0	0	0.0
4	Gangavaram	4	4	100.0	0	0.0	0	0.0	0	0.0
5	Addateegala	12	11	91.7	1	8.3	0	0.0	0	0.0
6	Y. Ramavaram	5	5	100.0	0	0.0	0	0.0	0	0.0
7	Rajavommangi	6	6	100.0	0	0.0	0	0.0	0	0.0
	Total	51	50	98.0	1	2.0	0	0.0	0	0.0

**Table 6. Classification of groundwater samples based on SAR during post-monsoon period in Rampachodavaram division of East Godavari district at mandal level.**

S. No.	Mandal	No. of samples	SAR							
			S <sub>1</sub> (0-10)		S <sub>2</sub> (10-18)		S <sub>3</sub> (18-26)		S <sub>4</sub> (>26)	
			No.	%	No.	%	No.	%	No.	%
1	Devipatnam	9	9	100.0	0	0.0	0	0.0	0	0.0
2	Rampachodavaram	10	10	100.0	0	0.0	0	0.0	0	0.0
3	Maredumilli	5	5	100.0	0	0.0	0	0.0	0	0.0
4	Gangavaram	4	4	100.0	0	0.0	0	0.0	0	0.0
5	Addateegala	12	12	100.0	0	0.0	0	0.0	0	0.0
6	Y. Ramavaram	5	5	100.0	0	0.0	0	0.0	0	0.0
7	Rajavommangi	6	6	100.0	0	0.0	0	0.0	0	0.0
	Total	51	51	100.0	0	0.0	0	0.0	0	0.0

**Table 7. Classification of groundwater samples based on RSC during pre-monsoon period in Rampachodavaram division of East Godavari district at mandal level.**

S. No.	Mandal	No. of samples	RSC (me L <sup>-1</sup> )					
			<1.25		1.25-2.5		>2.5	
			No.	%	No.	%	No.	%
1	Devipatnam	9	9	100.0	0	0.0	0	0.0
2	Rampachodavaram	10	9	90.0	0	0.0	1	10.0
3	Maredumilli	5	5	100.0	0	0.0	0	0.0
4	Gangavaram	4	3	75.0	1	25.0	0	0.0
5	Addateegala	12	9	75.0	1	8.3	2	16.7
6	Y. Ramavaram	5	5	100.0	0	0.0	0	0.0
7	Rajavommangi	6	6	100.0	0	0.0	0	0.0
	Total	51	46	90.2	2	3.9	3	5.9

**Table 8. Classification of groundwater samples based on RSC during post-monsoon period in Rampachodavaram division of East Godavari district at mandal level.**

S. No.	Mandal	No. of samples	RSC (me L <sup>-1</sup> )					
			<1.25		1.25-2.5		>2.5	
			No	%	No	%	No	%
1	Devipatnam	9	9	100.0	0	0.0	0	0.0
2	Rampachodavaram	10	9	90.0	0	0.0	1	10.0
3	Maredumilli	5	5	100.0	0	0.0	0	0.0
4	Gangavaram	4	3	75.0	1	25.0	0	0.0
5	Addateegala	12	8	66.7	2	16.7	2	16.7
6	Y. Ramavaram	5	5	100.0	0	0.0	0	0.0
7	Rajavommangi	6	5	83.3	1	16.7	0	0.0
	Total	51	44	86.3	4	7.8	3	5.9

### Sodium Adsorption Ratio (SAR)

$$\text{SAR} = \frac{\text{Na}^+}{\sqrt{\frac{\text{Ca}^{2+} + \text{Mg}^{2+}}{2}}} \quad (\text{Richards, 1954})$$

### Residual Sodium Carbonate (RSC)

$$\text{RSC (me L}^{-1}\text{)} = (\text{CO}_3^{2-} + \text{HCO}_3^-) - (\text{Ca}^{2+} + \text{Mg}^{2+}) \quad (\text{Raghunath, 1987}).$$

## RESULTS AND DISCUSSION

### pH

According to the classification of groundwater based on pH values during the pre-monsoon season 86 per cent samples were found to be neutral (pH 6.5-7.5) and 14 per cent found to be alkali (>7.5) in Rampachodavaram division. In the post-monsoon season, 86 per cent samples were found to be neutral (pH 6.5-7.5) and 14 per cent found to be alkali (>7.5) in Rampachodavaram division (Table 2). Nature of groundwater samples gets diluted from moderately alkaline to low alkalinity due to the monotonic effect in post-monsoon season as a result of increase in level of water table (Prakash and Somashekar, 2006). Similar results were earlier reported by Khodapanah *et al.* (2009).

### Electrical conductivity

Based on classification of EC values during pre-monsoon season, about 6 per cent come under C<sub>1</sub> class, 37 per cent samples come under C<sub>2</sub> class, 51 per cent under C<sub>3</sub> class and 6 per cent samples come under C<sub>4</sub> class in Rampachodavaram division. During post-monsoon season, about 6 per cent fall under C<sub>1</sub> class, 49 per cent samples fall under C<sub>2</sub> class, 43 per cent fall under C<sub>3</sub> class and 2 per cent samples comes under C<sub>4</sub> class in Rampachodavaram division (Tables 3 and 4). During post-monsoon season water samples had lower EC values as compared to pre-monsoon season water samples. This might be due to precipitation during monsoon season which resulted in flushing of salts and rain water diluted the salt content (Satyanarayana *et al.*, 2016).

### Sodium adsorption ratio (SAR)

Based on SAR classification, during pre-monsoon season, in Rampachodavaram division about 98 per cent of samples recorded under S<sub>1</sub> class and 2 per cent S<sub>2</sub> class. During the post-monsoon season, about 100 per cent of samples during post-monsoon season comes under S<sub>1</sub> class in Rampachodavaram division (Table 5 and 6).

High SAR values in pre-monsoon season indicated that the relative adsorption of Ca<sup>+2</sup> + Mg<sup>+2</sup> was low in summer and reverse was true in post-monsoon season (Venkateswarlu, 2001). Similar results were reported earlier by Hussian and Rao (2013).

### Residual sodium carbonate (RSC)

Water samples were classified based on RSC and the results revealed that about 90 per cent of samples during pre-monsoon season comes under A<sub>1</sub> class, 4 per cent samples comes under A<sub>2</sub> class, 6 per cent samples comes under A<sub>3</sub> class in Rampachodavaram division. During post-monsoon season, about 86 per cent of recorded under A<sub>1</sub> class, 8 per cent A<sub>2</sub> class and 6 per cent samples under A<sub>3</sub> class in Rampachodavaram division (Table 7 and 8).

Pre-monsoon season water samples had high RSC values as compared to post-monsoon season, due to water samples containing bicarbonates in excess over calcium and magnesium ions influences unsuitability for irrigation (Jeyaseelan *et al.*, 2013).

## CONCLUSION

Based on pH values, majority of water samples were under neutral in nature in both pre and post-monsoon seasons of Rampachodavaram division and based on EC values, majority of water samples were under C<sub>3</sub> class (EC 0.75-2.25 dS m<sup>-1</sup>) in both pre and post-monsoon seasons. Based on SAR classification, about 98 and 100 per cent water samples were under S<sub>1</sub> class *i.e.*, low salinity (S<sub>1</sub> <10) in pre and post-monsoon seasons, respectively. However, based on RSC classification, about 90 and 87 per cent of water samples were under A<sub>1</sub> class (RSC <1.25 me L<sup>-1</sup>). *i.e.*, water can be used safely for irrigation in both pre- and post-monsoon seasons, respectively. As per the USSL (1954) classification majority of the samples were recorded under C<sub>3</sub>-S<sub>1</sub> category *i.e.* high salinity-low sodium hazard class in both pre- and post-monsoon seasons, respectively and indicated that majority of groundwater samples in Rampachodavaram division were slightly suitable for irrigation purpose in crop production.

## LITERATURE CITED

- Anonymous 1984** Draft recommendations of soil correlator, Department of Agriculture, Andhra Pradesh, Hyderabad.
- Ground Water Brochure** East Godavari district, Andhra Pradesh, Central Ground water Board, Ministry of Water Resources, Government of India. Southern Region, Hyderabad September, 2013.
- Jeyaseelan A, Narmatha T, Mohan S P, Mahalingam S and Natchimuthu S 2013** Assessment of

- groundwater quality and its suitability for agricultural use in Nishabanathi and Kalingalar sub-basins of Vaippar river basin, Tamil Nadu, India. *Journal of Academia and Industrial Research*. 1(11): 720 – 725.
- Khodapanah L, Sulaiman W N A and Khodapanah N 2009** Groundwater quality assessment for different purposes in Eshtehard district, Tehran, Iran. *European Journal of Scientific Research*. 36(4): 543 – 553.
- Manjunatha M V, Oosterbaan R J, Boonstra J and Hebbara M 2011** Salt and water balance studies using SALTMOD for Tungabhadra command, Penninsular India. *Journal of Indian Society of Soil Science*. 59(1): 321-328.
- Prakash K L and Somashekar R K 2006** Groundwater quality assessment on Ankel taluk, Bangalore urban district. India. *Journal of Environmental Biology*, 27(4), 633–637.
- Raghunath H M 1987** Groundwater. ISBN-10: 0470206985, New Age International (P) Ltd. Publishers.
- Richards L A 1954** Diagnosis and Improvement of Saline and Alkali Soils, U.S. Department of Agriculture Handbook, 60 Washington DC, USA. 160.
- Satyanarayana E, Ratnakar D and Muralidhar M 2016** Major Ion Chemistry of Groundwater and Surface Water in Parts of Mulugu-Venkatapur Mandal, Warangal District, Telangana State, India. *Hydrology Current Research*. 7(3): 1 – 17.
- US Salinity Laboratory 1954** Diagnosis and improvement of saline and alkaline soils. *Agriculture Handbook No. 60. USDA*.160.
- Venkateswarlu J 2001** Management of soils of Andhra Pradesh printed at ANGRAU Press, Rajendranagar, Hyderabad. 43 – 45.
- Wani R A, Aabid H M, Tanveer A, Jehangir A and Yousuf, A R 2014** Preliminary study on irrigational quality of some ground water sources of Kashmir, India. *International Journal of Scientific and Engineering Research*. 5(2): 318 – 323.

Received on 27.07.2018 and Revised on 25.09.2018