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Assessment of Ground Water Quality in Paddy-Sugarcane Areas of West Godavari District, Andhra Pradesh

Ch Kirankumar and G V Lakshmi
Deptarment of Soil Science and Agricultural Chemistry, Dr.Y.S.R Horticultural University, Krishi Vigyan Kendra, Pandirimamidi

ABSTRACT

An investigation was carried out during months of May, December and March, 2006–07 to assess the ground water quality in paddy and sugarcane growing areas of West Godavari district. Three hundred water samples i.e., 150 samples each in pre and post monsoon seasons were collected from tube wells, open wells and hand pumps and were analysed for various chemical properties . In pre-monsoon season 54.66 per cent samples were found to be marginally saline, while 16.33 per cent were good for irrigation. 8.66, 4.66, 9.33, 4.0 and 2.66 per cent of samples were categorized under saline, high SAR, marginally alkali, alkali and high alkali waters, respectively. The nitrate-nitrogen content in these waters was safe in 26 per cent, moderately safe in 55 per cent and unsafe in 19 per cent of water samples respectively. In post-monsoon season 57.50 per cent of samples were good and 42.50 were marginally saline for irrigation. The nitrate-nitrogen content in 4.37 per cent samples were safe, 41.87 percent of samples were moderately safe and 53.76 per cent samples were unsafe for irrigation/drinking.

Key words : Classification of Ground Waters, Paddy-Sugarcane growing areas, Water Quality.

Quality of irrigation water is essential to maintain the soil and crop productivity to higher level. The quality of irrigation water should be safe to use for achieving higher yields of crops without damaging the soils .In india, increasing trend of irrigated area has led to 3.58 M ha and 5.50 M ha of saline and alkali soils respectively (FAI,1998) .This contributes about 6.4 per cent of net sown area. For sound crop planning, knowledge of quality of irrigation water is essential. The magnitude of essentiality is more in multiple cropping programme where two or more crops are raised successively on the same patch of land in a year. The concentration and composition of dissolved constituents in water determine its water quality for irrigation use. Quality of water is an important consideration in any appraisal of salinity or alkali conditions in an irrigated area. The quality of water depends primarily on the total amount of salt present and proportion of sodium to other cations and certain other parameters. Based on the quality of water, the land use pattern changes as they have influence on the crops to be grown. Different parameters are used to assess the quality of water; depending on these parameters different land use pattern will be decided. Keeping this point in view a survey was carried out to characterize and classify the ground waters in West Godavari district.

MATERIAL AND METHODS

The ground water samples were collected from pre-selected sites during pre-monsoon and post-monsoon seasons. The first phase of sampling was carried out during the post-monsoon season (December, 2006) and 150 water samples were collected from paddy and sugarcane growing areas of West Godavari district (80 water samples from paddy and 70 samples from sugarcane cultivated areas). In pre-monsoon season (March, 2007) the representative 150 ground water samples were collected from the same point where the samples were collected during pre-monsoon season (2006). In both the seasons representative water samples were collected from different sources like bore wells, open wells and hand pumps in polythene bottles. Analytical grade H_2SO_4 (1-2 ml) was added to each polythene bottle to bring the samples pH down to 2 or less and stored it at 4^0C for determination of NO_3-N.The pH and EC values of the samples were measured *in-situ* immediately after collection. The analysis of these samples for various constituents

Table 1. Under ground waters of West Godavari district

S. No	Mandal	No. of samples	pH				EC (dS m^{-1})				SAR				RSC (me L^{-1})			
			Pre Monsoon		Post Monsoon		Pre Monsoon		Post Monsoon		Pre Monsoon		Post Monsoon		Pre Monsoon		Post Monsoon	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	Undrajavaram	20	7.35-9.61	7.62	6.78-8.56	8.15	1.51-3.76	2.21	1.51-2.55	1.95	2.65-11.90	6.75	1.97-6.32	4.68	0.70-2.41	1.50	0.10-1.94	0.77
2	Tadepalligudem	20	8.12-8.90	8.14	8.03-8.46	8.37	1.61-4.63	2.76	1.77-3.69	2.24	7.58-22.88	11.52	1.57-10.74	4.88	0.62-2.83	1.87	0.00-2.85	0.66
3	Ungaturu	20	6.64-9.20	7.04	6.70-7.40	7.85	1.94-4.35	2.49	1.07-2.93	1.89	4.01-12.89	8.72	2.99-6.33	4.65	0.80-3.24	2.16	0.38-2.44	1.15
4	Bhimadole	20	7.38-9.21	8.16	7.13-8.55	8.63	2.23-5.34	3.40	0.98-2.90	1.84	6.24-13.77	11.07	3.12-9.66	5.24	0.35-2.81	1.63	0.05-1.60	0.89
5	Poduru	20	7.81-9.41	8.41	7.66-9.27	8.41	1.77-5.07	3.03	1.31-2.90	1.92	6.24-20.78	11.60	3.12-10.20	5.40	1.01-2.86	1.93	0.05-1.90	0.73
6	Penugonda	20	8.14-9.50	8.23	7.70-8.76	8.75	1.50-2.88	2.02	0.94-2.39	1.44	6.25-11.07	8.87	2.91-6.39	4.45	1.20-2.45	2.13	0.07-2.73	1.12
7	Undi	20	8.25-9.34	7.89	6.64-8.36	8.79	2.09-5.53	3.46	1.28-2.15	1.74	4.32-14.86	9.74	2.64-9.78	6.15	0.90-2.50	1.82	0.15-1.60	0.70
8	Iragavaram	10	8.01-.9.25	8.55	7.57-8.85	8.94	1.69-3.72	2.94	0.66-3.08	1.73	8.51-18.59	14.50	3.43-9.71	5.56	1.20-3.80	2.71	0.25-2.86	1.74
	Average		6.64-9.61	8.01	6.64-9.27	8.49	1.50-5.53	2.79	0.66-3.69	1.84	2.65-22.88	10.35	1.57-10.74	5.13	0.35-3.80	1.97	0.00-2.86	0.97

was undertaken following methods outlined by Richards (1954).The water quality was judged depending upon the parameters like EC, RSC and SAR as followed by Ground water quality for irrigation in India (Technical Bulletin No.19, CSSRI, Karnal Gupta *et al.*1994). Ion sensitive electrode method was used for determination of nitrates in water sample by flow injection analyzer method (Goldman and Jacob 1961).

RESULTS AND DISCUSSION

pH of water samples

The pH values of pre and post-monsoon season water samples ranged from 6.64 to 9.61 and 6.64 to 9.27 with mean values of 8.01 and 8.49 respectively. The highest mean pH value was found in paddy grown area in Iragavaram (8.94) mandal during post-monsoon season and the lowest was found in sugarcane grown area in Ungaturu (7.04) mandal during pre-monsoon season.

During post-monsoon season water samples showed slight increase in pH values as compared to pre-monsoon season water samples. The reason for this might be due to dilution effect of rain water with higher OH^- ions and exchangeable position of soils were occupied by Na^+ causing higher pH values. Similar results of low pH values in pre-monsoon season compared to post-monsoon season in Ahmadabad region were reported by Shah et al (1962).

Electrical Conductivity (dSm^{-1})

The electrical conductivity of pre and post-monsoon season water samples ranged from 1.50 to 5.53 dSm^{-1} and 0.66 to 3.69 dSm^{-1} with mean values of 2.79 and 1.84 dSm^{-1}. During post-monsoon season water samples have lower EC values when compared to pre-monsoon season water samples. This might be due to high precipitation (1000 mm) due to which flushing of salts occurs, rain dilutes the salt content. The results of present investigation were in accordance with the findings reported by Satyanarayana *et al.* (1967. Further, decrease in ECw of ground waters during post-monsoon season in Krishna River, Vogeru Eru and Pendlipaka tank areas was reported by Venkateswarulu (2001)

Sodium Adsorption Ratio (SAR)

SAR identifies category of irrigation water. If it is less than 10, it is best for irrigation purpose. SAR values of pre and post monsoon season water samples ranged from 2.65 to 22.88 and 1.57 to 10.74 with mean values of 10.35 and 5.13 respectively. The highest mean SAR value was found during pre-monsoon season in paddy grown area of Iragavaram mandal (mean 14.50) and the lowest value was found during post-monsoon season in paddy grown area in Penugonda mandal (4.45).

Higher SAR values in pre-monsoon season indicates that relative adsorption of Ca and Mg was low in summer and reverse was true in post-monsoon season. Similar trend was reported by Venkateswarlulu (2001). Irrigation waters with S_2 class (10-18) will produce appreciable sodium hazard in fine textured soils. Proper soil management practices have to be adopted while irrigating to fine textured soils. Chemical amendments like gypsum have to be applied to soils while irrigating with S_3 (18-26) class water.

Residual Sodium Carbonate (RSC)

The RSC values of water samples during pre and post-monsoon season ranged from 0.35 to 3.80 me L^{-1} and nil to 2.86 me L^{-1} with mean value of 1.97 and 0.97 me L^{-1} respectively. The Highest mean RSC value was found in paddy grown area of Iragavaram mandal (2.71 me L^{-1}) during pre-monsoon season and lowest was found in sugarcane grown area of Tadepalligudem mandal (0.66 me L^{-1}) during post-monsoon season. Pre-monsoon season water samples have high RSC values as compared to post-monsoon season water samples. This might be due to fact that the water samples contain carbonates and bicarbonates in excess of calcium and magnesium ions. Carbonates and bicarbonates aggrevate the sodium hazard by precipitating calcium and magnesium ions. Similar trend was reported by Venkateswarlu (2001) for Krishna river, Pendlipaka tank and Vogeru Eru.

Based on RSC classification of pre-monsoon season 86 per cent samples were found in A_1 (2.5 me L^{-1}) class and 14 per cent were

Table 2 . Ionic composition of irrigation water in pre and post monsoon seasons .

S. No	Location of mandal	Soluable Anoins (me L^{-1})										Soluable Cations (me L^{-1})							
		CO_3^{2-}		HCO_3^-		Cl^-		SO_4^-		NO_3^-		Ca^{++}		Mg^{++}		Na^+		K^+	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
								Sugarcane growing areas											
1	Undrajavaram	0.00	0.00	8.65	9.60	13.16	10.23	0.47	0.66	3.03	10.98	3.29	3.83	3.78	4.58	14.93	11.22	0.59	0.46
2	Tadepalligudem	0.00	0.00	7.02	11.26	19.72	12.61	1.15	1.46	3.90	5.09	2.39	6.64	2.78	3.97	22.4	13.69	0.31	0.52
3	Ungaturu	0.00	0.00	8.82	11.92	15.02	6.20	1.16	1.71	2.86	4.75	3.80	4.44	3.61	3.35	18.9	10.88	0.23	0.29
4	Bhimadole	0.00	0.00	9.59	7.34	23.69	10.58	0.93	0.48	4.22	9.45	4.37	3.28	3.59	3.18	25.15	11.51	0.94	0.43
								Paddy growing areas											
5	Poduru	3.36	2.22	6.10	6.38	21.64	10.95	0.91	1.31	3.14	6.91	1.92	2.72	3.83	4.05	21.49	11.23	3.02	1.80
6	Penugonda	2.24	1.93	4.29	4.42	13.44	7.65	0.49	0.56	1.49	4.06	1.91	2.32	2.24	2.87	15.1	8.46	0.97	0.81
7	Undi	0.00	0.00	12.17	6.39	20.95	10.52	1.60	0.55	5.41	10.67	5.57	3.06	4.94	2.65	23.5	11.55	1.11	0.45
8	Iragavaram	2.36	1.82	3.83	4.18	20.88	9.36	2.39	1.98	3.06	6.66	2.09	2.59	1.36	1.66	24.0	9.98	1.99	3.10
	Mean	1.00	0.75	7.56	7.69	18.56	9.76	1.14	1.09	3.38	7.94	3.17	3.61	3.27	3.29	20.68	11.07	1.15	0.98

under A_2 (2.5 to 5.0 me L^{-1}) class .In post-monsoon season 95 per cent samples were found in A_1 class and 5 per cent samples were in A_2 class. Pre-monsoon season water samples have lower RSC values as compared to post-monsoon season. Similar results were reported by Sellamuthu *et al.* (2004).

Cationic Composition

During pre and post-monsoon seasons, sodium was dominant among the cations (mean 20.68 mel^{-1}). High sodium values were recorded in pre-monsoon season and these values were lowered during post-monsoon season (Table.2). The order of cations in West Godavari district was $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ in both pre and post-monsoon samples. In post monsoon season sodium and potassium values decreased and calcium, magnesium values increased as compared to values of pre-monsoon season in all areas. Similar results were reported by Srinivasa Rao (1998) in Vamsadhara river basin, Srikakulam district, Andhra Pradesh.

Anionic Composition

During pre and post monsoon seasons, the dominant anion was chloride with mean values of 18.56 and 9.76 me L^{-1}, respectively. The higher mean chloride value was found in sugarcane grown area of Bhimadole mandal (23.69 me L^{-1}) during pre-monsoon season and the lowest was found in sugarcane grown area Ungaturu (6.20 me L^{-1}) mandal (Table.2). The order of dominance of anions in the ground waters of West Godavari district in both pre and post-monsoon season was $Cl^- > HCO_3^- > SO_4^{2-} > CO_3^{2}$. In post-monsoon season bicarbonate values increased as compared to pre-monsoon season. Verma *et al.* (2005) observed similar results in case of ground waters of Nagaur district of Rajasthan.

Nitrates

Nitrate is a beneficial element which may be considered as an important ion in water and become a pollutant in above area specific limit of 10 mg kg^{-1} from irrigation point of view. The effect of nitrate ion has been found spectacular than all other nutrients because irrigated soils are generally deficit in nitrogen (Paliwal and Yadav, 1976).

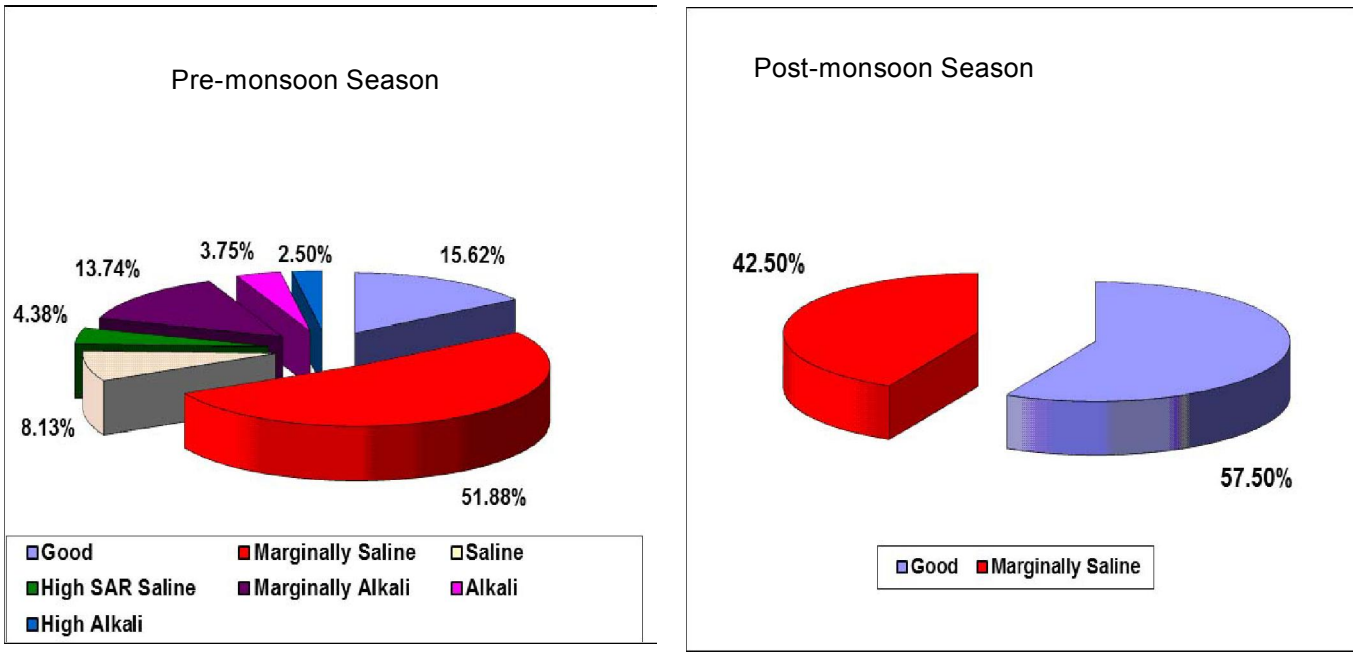

Figure 1. Quality ratings of ground water samples of West Godavari district

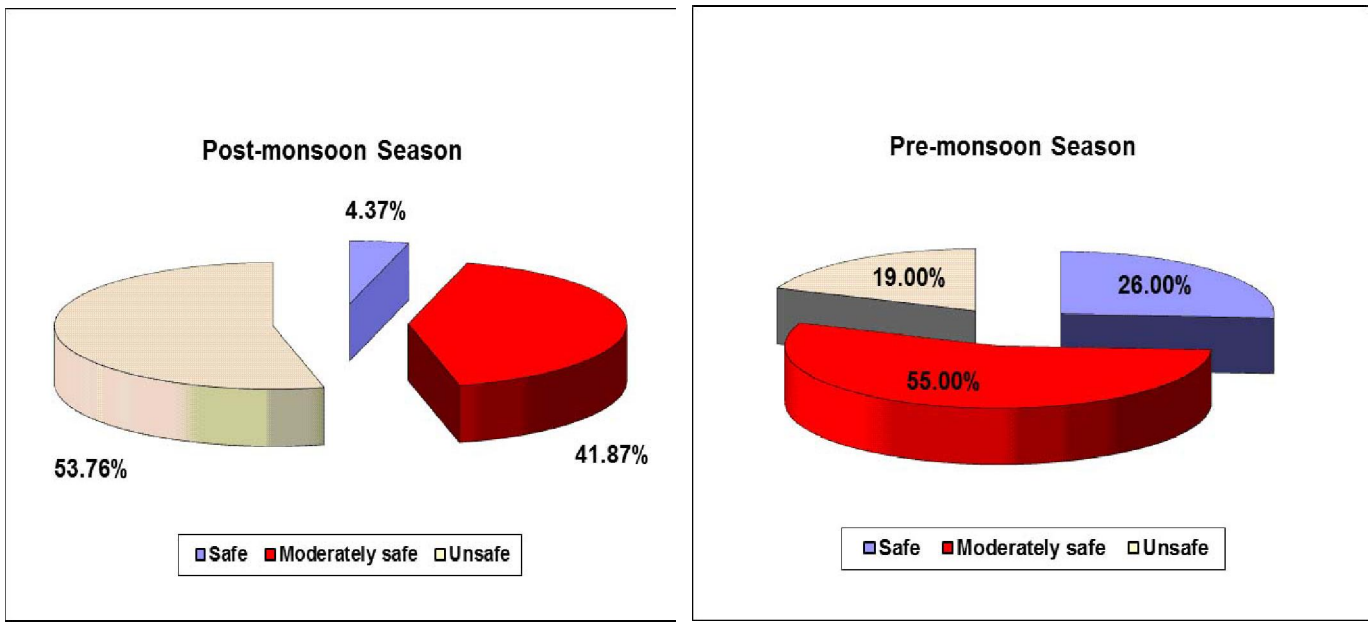

Fig. 2. Classification of ground water samples of West Godavari district based on nitrates (mg kg^{-1})

Table 3. Classification of ground water and their management.

	EC (dS m^{-1})	SAR	RSC (me L^{-1})	Percentage of samples		Recommended management practices
				Pre-monsoon	Post-monsoon	
Good	< 2	< 10	< 2.5	16.33	57.50	Can be used for all types of soils and crops.
Marginally saline	2 – 4	< 10	< 2.5	54.66	42.50	Can be used with slight salt tolerent crops and periodic monitoring salts.
Saline	> 4	< 10	< 2.5	8.66	—	Unsuitable for irrigation can be used with slight salt tolerant crops and periodic monitoring salts.
High SAR Saline	> 4	> 10	< 2.5	4.66	—	Unsuitable for irrigation.
Marginally alkaline	< 4	< 10	2.5 - 4.0	9.33	—	Can be used periodic monitoring of gypsum.
Alkaline	< 4	< 10	> 4	4.00	—	Can be used for periodic monitoring of gypsum.
Highly alkaline	< 4	> 10	> 4	2.66	—	Unsuitable for irrigation.

Nitrate content of pre-monsoon season samples ranged from nil to 13.2 mg $kg^{-1}$with mean value of 3.38 mg kg^{-1}. The highest mean value recorded in paddy growing Undi (5.41 mg kg^{-1}) mandal and the lowest was found in paddy grown in Penugonda (1.49 mg kg^{-1}) mandal. In post-monsoon season nitrate-nitrogen content in water samples ranged from 2.54 to 23.62 mg kg^{-1} with a mean value of 7.94 mg kg^{-1}.The highest and lowest mean values were found in sugarcane grown in Undrajavaram (10.98 mg kg^{-1}) and paddy growing Penugona (4.06 mg kg^{-1}) mandal, respectively.

Data showed that 26% of pre-monsoon and 4.37% of post-monsoon season samples were in safe (< 1 mg kg^{-1}) category while 55% of pre-monsoon and 41.87% post-monsoon season samples were moderately safe (1-5 mg kg^{-1}) and 19% pre monsoon season and 53.76% post monsoon season samples were unsafe(> 5 mg kg^{-1}) category. Nitrate-nitrogen content of pre-monsoon season samples have lower than post-monsoon season samples (Table.3). This might be due to sorption of ammonium on clay during dry periods and this sorbed ammonium creaks and releases nitrates into ground waters when it comes in contact with ground water.

Similar results were reported by Srinivasa Rao (1998) for ground waters of lower Vamsadhara river basin, Srikakulam district, Andhra Pradesh.

Classification of Ground Waters

During pre-monsoon season out of 150 water samples 24 samples were found to be good (16.33%), 82 samples were marginally saline (54.66%), 13 samples were saline (8.66%), 7 samples were high SAR (4.66%), 14 samples were marginally alkali (9.33%), 6 samples were alkali (4%) and 4 samples were alkali (2.66%) waters. In post-monsoon season out of 150 samples 87 samples were found to be good (57.50%) and 63 samples were marginally saline (42.50%) waters (Table 4 and 5). Management practices were suggested for saline and alkali waters presented in Table.6.

During post-monsoon season water quality increased when compared to pre-monsoon season water quality. This might be due to decrease in EC_{iw}, SAR and RSC values during post-monsoon season. Similar results were reported by Kadwe and Badhe (1977) for quality of well waters and their suitability for irrigation in deep black soils of Parbhani, Maharashtra.

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