A study on Ground Water Quality Used for Irrigation in Prakasam District of A.P., India using Geographical Information Systems

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Abstract--- The ground water samples collected from different mandals of prakasam district are analyzed in the laboratory for electrical conductivity (EC), pH, cations (Na^+ , K^+ , Ca^{2+} and Mg^{2+}) and anions (CO_3^{2-} , HCO_3^- , Cl^- and SO_4^{2-}). The water samples are categorized as per criterion developed by Central Soil Salinity Research Institute, India. It has been found that, out of 55 Mandals, 35 Mandals have been found to be good in quality for irrigation at the district. Whereas 13 Mandals were found Saline (Marginally Saline (B1)-6, Saline (B2) - 2, High SAR Saline (B3) -5) and 7 Mandals are found as in Alkali category (Marginally Alkali (C1)-NIL, Alkali (C2)-3, Highly Alkali (C3)- 4). In general, these waters were of Ca-Na-Mg type with the dominance of HCO_3^- and CO_3^{2-} in case of good quality waters. The poor water quality belonged to categories of B1, B2, B3, C1, C2 and C3, which are either having accumulation of salts (high EC) or high Sodium adsorption ratio (SAR) or Residual Sodium Carbonate (RSC). Thematic maps are generated on the basis of different categories of ground water samples using ARC GIS 9.3 software depicting the places of saline and alkali water in the district.

Keywords--- Anions, Cations, CSSRI, EC, Image Processing, pH, RSC, SAR, Water Quality

I. INTRODUCTION

GROUND water is a good source of fresh water available on the Earth. Most of the water is being used for growing crops and vegetables. Due to urbanization and industrialization, the ground water is being polluted in several major cities of the country [16]. The ground water resources are often over exploited to meet the increasing demand by the people. Sometimes ground water contains various minerals and salts in solution at elevated concentrations posing danger to the human conception or utility. The well or tube well waters are expected to contain more dissolved salts of the

sodium, calcium and magnesium and their use in irrigation results in the increase of the salinity of the soil and thereby the loss of fertility [3]. Further, the presence of accumulated amounts of high concentration of carbonate and bi-carbonates of alkali or alkaline earth metals, turns to be responsible for the dispersion of soil particles that ultimately reduces porosity of the soil and thereby the loss of fertility [12, 13]. The endeavor of the present study is to assess the ground water suitability for irrigation pertains to 55 Mandals of Prakasam District Andhra Pradesh, India [6]. Figure 1 depicts the location map of Prakasam District, India.

Figure 1: Location Map of the Study Area – Prakasam District

II. MATERIALS AND METHODS

Prakasam District is situated in tropical region between 14057'00" to 16017'00" Northern Latitude and 78043'00" to 80025'00" Eastern Longitude. The agriculture activity in the district is deplorable owing to gambling of monsoons and unreliable rainfall and much dependence on tanks and wells for irrigation. The district receives rains from South-west and north east monsoons during the month of June to December. The average rainfall is 616 mm. Red loamy, Black cotton and Sandy Loams are the predominant soils in the district [7]. The central portion of the district contains large tracts of low shrubs and jungle diversified with rocky hills and stony plains which is a peculiar feature of the District. The samples were collected from open dug or tube wells. The open wells vary in depth from 5 to 25m, whereas the tube wells pump out water from 25-100m depth [4]. For the present study, 340 ground water samples were collected from 55 selected mandal stations

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of Prakasam District. The geographical position of sampling well station was recorded with the help of Global Positioning System (GPS). The water sample of about one liter from each well or tube well was collected in clean acid washed polythene bottles during April, June and October. The samples from open well had been collected using “sample thief” at bottom, middle and upper portions of the well and then, they were mixed to get homogenous solution as detailed in the literature [9, 11].

The samples collected were analyzed for pH using pH meter (systronic make) Electrical conductivity (EC) using Conductivity meter (Systronic make). The concentrations of Na⁺, K⁺, Ca²⁺, Mg²⁺, CO₃²⁻, HCO₃⁻, Cl⁻ and SO₄²⁻ were obtained through the standard laboratory methods available in Literature [1, 2]. Sodium Adsorption ratio (SAR) [5] and Residual Sodium Carbonate (RSC) [8] were calculated by the following equations 1 and 2.

$$SAR(mmL^{-1})^{1/2} = \frac{Na^{+}}{\sqrt{\frac{(Ca^{++} + Mg^{++})}{2}}} \quad (1)$$

$$RSC(meL^{-1}) = CO_3^{--} + HCO_3^{-} - Ca^{++} + Mg^{++} \quad (2)$$

(All values of cations and anions are in meL-1)

The collected ground water samples were classified representing salinity and alkalinity as per the criteria suggested by the Central Soil Salinity Research Institute (CSSRI), India [15] (Table 1). The spatial distribution maps were generated on the basis of different categories of ground water samples, using ARC GIS 9.3 software depicting the places of Saline and Alkali waters in the district.

Table1: Categorization of Ground Waters on the Basis of EC, SAR, and RSC, Standards Suggested by CSSRI, India

Water Quality	Electrical Conductivity (dSm ⁻¹)	SAR(mmL ⁻¹) ^{1/2}	RSC(me L ⁻¹)
A. Good	< 2	< 10	< 2.5
B. Saline waters B 1. Marginally saline	2-4	<10	<2.5

B 2. Saline	>4	<10	<2.5
B 3.High SAR Saline	>4	>10	<2.5
C. Alkali waters			
C 1. Marginally alkali	<4	<10	2.5-4.0
C 2. Alkali	<4	<10	>4.0
C 3. Highly alkali	Variable	>10	>4.0

III. RESULTS AND DISCUSSION

The suitability of well or tube well waters for irrigation depends upon the mineral constituents present in the water. The important factors that influence the irrigation water quality are salt concentration as represented by EC, SAR and RSC [8]. Excessive amount of salt in general and sodium in particular affect the soil permeability, soil structure and create toxic condition for plants. Sodium of the irrigation water was generally taken up by the clays in return of Calcium and Magnesium due to ion exchange. This happened in case of C1 and C2 irrigation water categories. It leads to the development of Alkali soil, which had un-favorable structure and restricts aeration. To quantify this effect an empirical parameter termed as SAR was used [10]. The analytical and calculated values were given in Table 2. The results of study revealed that EC of the samples varied from 0.41 to 7.86 dsm-1, SAR from 0.38 to 35.19 (mmolesL-1), pH from 7.90 to 9.05 and RSC from -32.16 to 7.97 meL-1. The salient features of ground water samples of Prakasam district is shown in Table 2. The dominant cat ion present in ground water samples of this region was Ca⁺⁺ and in some cases Na⁺ was the dominant one. The dominant anions were HCO₃⁻, Cl⁻ and SO₄²⁻. Most of the samples were of Ca-Na-Mg type with the dominance of Cl⁻ followed by bicarbonate and carbonate in case of good quality water.

Out of fifty five mandal stations, thirty five mandals were found to be good in quality for the purpose of irrigation. Under the category of Saline waters, six stations were come under Marginally Saline (B1) category. Two stations were in Saline (B2) category and five stations were in High SAR Saline (B3) category. While classify the water with respect to Alkali category, no station was identified under Marginally alkali (C1) category and three stations were in Alkali (C2) category. Four stations were observed in Highly Alkali (C3) category.

Table 2: Salient features of Ground Water samples of Prakasam District

Sl.No	Object ID Created in GIS map	Name of the Mandal Station	pH	SAR (mmolL ⁻¹) ^{1/2}	RSC (me L-1)	EC (dSm-1)	Classification
1	1	Giddalur	8.46	3.65	-10.6	2.27	B1
2	3	Komarolu	8.56	7.00	-5.58	2.10	B1
3	4	Bestavaripeta	8.61	3.95	-2.16	2.00	B1
4	5	Racherla	8.48	1.29	-5.61	1.01	A
5	6	Veligendla	8.66	1.35	-1.98	0.92	A
6	7	C.S.puram	8.51	1.63	-6.45	1.10	A

7	8	Pamuru	8.92	12.92	6.64	0.41	C3
8	9	Hanumantunipadu	8.93	7.94	4.40	1.42	C2
9	10	Cumbum	8.43	4.41	0.17	0.72	A
10	11	Tarlapadu	8.64	1.56	-1.17	0.96	A
11	12	K.K.Mitta	8.42	4.08	-6.04	1.10	A
12	13	Kanigiri	8.40	2.57	-7.97	1.57	A
13	14	P.C.Palli	8.71	13.37	1.16	4.41	B3
14	15	Lingasamudram	9.66	1.09	-2.63	0.97	A
15	16	V.V._Palem	8.20	5.24	-3.00	0.82	A
16	17	Ponnaluru	8.20	2.77	-0.18	0.78	A
17	18	Jarugumalli	8.40	7.98	-2.17	1.97	A
18	19	Marripudi	8.71	3.47	-1.43	1.63	A
19	20	Kondepi	8.58	2.78	-0.81	0.90	A
20	21	Podili	9.04	10.75	-2.43	4.63	B3
21	22	Darsi	8.51	0.73	4.22	0.67	C2
22	23	Kuruchedu	8.00	8.77	-	7.45	B2
23	24	Donakonda	8.59	2.59	-1.57	0.73	A
24	25	Markapuram	8.92	12.81	4.00	1.64	C3
25	26	Pullalacheruvu	8.36	1.22	-1.16	0.41	A
26	28	Yerragondapalem	8.48	2.14	-2.58	0.64	A
27	29	Dornala	8.27	10.00	-9.22	3.94	B1
28	30	Peddaraveedu	8.51	2.97	0.17	0.82	A
29	31	Gudluru	8.49	0.66	-7.78	1.09	A
30	32	Kandukuru	8.78	8.37	2.42	1.67	A
31	33	Ulavapadu	8.34	8.28	-1.03	0.68	A
32	34	singarayakonda	8.72	7.58	-1.96	1.72	A
33	35	Tanguturu	8.65	1.94	0.84	0.55	A
34	36	Kothapatnam	8.28	11.60	-9.77	6.13	B3
35	37	S.N.padu	8.69	5.77	0.03	1.20	A
36	38	Cheemakurthy	8.27	0.51	-5.56	0.72	A

37	39	Talluru	8.83	1.72	-2.61	0.79	A
38	40	Mundlamuru	8.48	0.38	-4.17	0.82	A
39	41	Addanki	8.88	4.74	1.84	0.90	A
40	42	Balikurava	8.76	4.89	-4.64	2.09	B1
41	43	S.Manguluru	8.63	8.85	7.97	2.22	C2
42	44	Marturu	8.90	1.63	-1.61	0.88	A
43	45	J. Panguluru	8.40	7.98	-2.17	1.97	A
44	46	Inkollu	8.01	2.70	-1.74	0.89	A
45	47	Karamchedu	7.90	2.80	-1.52	0.96	A
46	48	Vetapalem	8.80	0.66	-1.77	6.16	B2
47	49	Chinaganjam	8.56	1.77	-1.60	0.75	A
48	50	Naguluppalapadu	8.28	11.00	-2.80	6.13	B3
49	51	Maddipadu	8.69	35.19	-3.19	9.25	B3
50	52	Chirala	8.01	2.70	-1.74	0.89	A
51	53	Parchuru	7.90	2.80	-1.52	0.96	A
52	54	Yeddnapudi	8.94	18.80	7.38	7.86	C3
53	55	Tripuranthakam	8.79	2.08	-1.81	0.99	A
54	56	Arthaveedu	8.49	4.29	-8.78	2.55	B1
55	57	Ongole (West)	9.05	17.81	6.71	4.61	C3

IV. SPATIAL DISTRIBUTION MAPS FOR IRRIGATION SUITABILITY

The irrigation suitability was prepared for Prakasam District based on SAR, EC, and RSC values and mapping of SAR, EC, and RSC were prepared in GIS platform [14]. The spatial distribution pattern of SAR, EC, and RSC were shown in Figures 2, 3 and 4 respectively. It indicates that most of the waters were in good of quality for irrigation. A large area of thirteen mandal waters showed Saline ground water area. Only small patches of Mandals showed the area of Alkali water. Marginally Alkaline category (C1) was totally absent in the district. Hanumantunipadu, Darsi and S.Manguluru areas showed the area of alkali water (C2). Pamuru, Markapur, Yeddnapudi and Ongole areas showed highly alkali (C3) category in Prakasam district.

Figure 2: Spatial Distribution of SAR mapping

Figure 3: Spatial Distribution of Electrical Conductivity (EC) Mapping

Figure 4: Spatial Distribution of RSC Mapping

V. CONCLUSIONS

The study reveals that, thirty five stations namely Racherla, Veligendla, C.S. Puram, Cumbum, Tarlapadu, K.K.Mitta, Kanigiri, Lingasamudram, V.V.Palem, Ponnaluru, Jarugumalli, Marripudi, Kondepi, Donakonda, Pullalacheruvu, Yerragondapalem, Peddaraveedu, Gudluru, Kandukuru, Ulavapadu, Singarayakonda, Tanguturu, S.N.Padu, Cheemakurthy, Talluru, Mundlamuru, Addanki, Marturu, J.Panguluru, Inkollu, Karamchedu, Chinaganjam, Chirala, Parchuru, Tripuranthakam mandal stations were found as good in quality for irrigation suitability comes as category A. Giddaluru, Komarolu, Bestavaripeta, Dornala, Ballikurva and Arthaveedu mandal stations were marginally under saline zone (B1) and two stations namely Kuruchedu and Vetapalem stations were identified as Saline (B2) category. The stations P.C.Palli, Podili, Kothapatnam, Naguluppalapadu, Maddipadu

were come under High SAR Saline (B3) category. In Alkali zone, No station area was come under Marginally Alkali (C1) category. Three mandal stations namely Hanumantunipadu, Darsi and S.Manguluru were come under the category of Alkali (C2). The four stations namely Pamuru, Markapuram, Yeddapanudi and Ongole (West) were come beneath Highly Alkali (C3) category.

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