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Assessment of Irrigation Water Quality Status of Cuddapah Block in YSR District, Andhra Pradesh, India

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ABSTRACT

The present investigation has been carried out to evaluate the quality status of ground water used for irrigation purpose in Cuddapah block by collecting forty ground water samples from ten different villages and analyzed for various chemical parameters to check its suitability for irrigation use.Quality of irrigation water is determined by the amount of concentration ofdissolved constituents in water and key consideration in the irrigated area because it plays an important role for crop cultivation. In order to understand the irrigation water quality index the water samples were analyzed for primary parameters and secondary parameters. The analysis revealed that pH of the water samples ranged 7.0-8.3, EC was ranged 0.279- 3.642 dSm^{-1}. Sodium and potassium concentration in water was ranged from 0.56-3.87 $MeqL^{-1}$ and 0.025 – 0.793 $MeqL^{-1}$ respectively. Chloride and bicarbonate content was ranged from 1.6 - 28.4 $MeqL^{-1}$ and 1.6-5.2 $MeqL^{-1}$ whereas calcium + magnesium concentration ranged from 8.4 to 46.2 $MeqL^{-1}$.

Keywords Irrigation water quality, Status of Cuddapah block, Quality of ground water, Dissolved constituents, Primary.

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INTRODUCTION

Groundwater is the most important source of water which is used for industrial, domestic and agricultural sectors of many countries in the world. Water quality for agricultural purposes is determined on the basis of effect of water on the quality and yield of the crops and also the effect on characteristics changes in the soil (FAO 1985).The quality of irrigation water is determined by the concentration and state of organic and inorganic materials that are suspended in water.

The measurement of water quality has to be done through *in-situ* and by examining the samples in laboratory by following standard methods. Irrigated lands contribute significantly global agriculture output as well as food supply (Kawy *et al*. 2013). The quality of irrigation water should be within the permissible limit otherwise it could adversely affects the crop growth. Water quality assessment is a process of determination of true nature of water by evaluating the presence of different parameters and their limits through various experiments available. Hence, it is important to test the water quality as it plays a vital role in monitoring plant life and environment.Water used for irrigation can vary greatly depending on its type and the quantity of dissolved salts. In this context, study aims to analyze for various quality parameters of groundwater collected from different villages of Cuddapah block in YSR district, Andhra Pradesh.

MATERIALS AND METHODS

Analysis of water quality parameters

The total collected water samples were analyzed for various chemical water quality parameters by following standard analytical methods (APHA 1992) in the laboratory. The pH of the water samples was determined by using pH meter and Electrical conductivity was measured by using pocket EC meter and expressed in dSm-1.

Sodium and potassium were determined by using flame photometer after calibrating with standards of 100 ppm potassium chloride (KCl) and 50 ppm sodium chloride solution (NaCl). Alkalinity was measured by using Acidometric titration method with 0.05N sulphuric acid solution and phenolphthalein indicator.Calcium+magnesium concentration in the water samples were determined by using complexometric titration method with 0.01N EDTA solution and Erichrome Black-T as an indicator. Chloride was determined volumetrically by following silver nitrate titrametric method using potassium chromate as an indicator.The secondary water quality parameters such as SAR, SSP, RSC, KR and PI were analyzed by calculating the values obtained from primary water parameters.

$$\text{Sodium Adsorption Ratio (SAR)} = \frac{Na}{\sqrt{Ca + Mg/2}}$$

$$\text{Residual sodium carbonate (RSC)} = (CO_3^{2-} + HCO^{3-}) - (Ca^{2+} + Mg^{2+})$$

$$\text{Soluble sodium percentage (SSP)} = \frac{Na \times 100}{Ca+Mg+Na}$$

$$\text{Permeability Index (PI)} = \frac{Na + \sqrt{HCO^3}}{Ca+Mg+Na} \times 100$$

$$\text{Kelly's Ratio (KR)} = \frac{Na^+}{Ca^{2+} + Mg^{2+}}$$

Irrigation water quality index (IWQI)

The various water quality indices were derived from primary parameters which refers to its suitability for use in agriculture. The requirements for irrigation water quality could differ from one field to the other depending on the cultivated crop pattern as well as the regional soil and climatological conditions (Babiker *et al.* 2007).

IWQI model was developed by (Meireles *et al.* 2010) and this model was applied on the data.

Computation of WQI : The WQI is computed by the following three steps

Step 1: Weight has been assigned (wi) to each of the selected water parameters (e.g. pH, HCO_3, Cl, EC, Na, K…..etc) according to its relative importance in the overall quality of water.

Step 2: Computed the relative weight (Wi) of the chemical parameter from the following equation :

$Wi = w_i / \Sigma w_i$ (i =1 to n), Where, Wi = is the relative weight, W_i = Weight of each parameter n = Number of parameters

Step 3: Quality rating scale (q_i) for each parameter has been assigned as below:

$q_i = (C_i / S_i) \times 100$, Where, q_i = quality rating
C_i = Concentration of each chemical parameter in each water sample in mg/L

Table 1. Calculated values of water quality parameters to assess the suitability for irrigation use. NOTE: SAR= Sodium adsorption ratio, RSC= Residual sodium carbonate, KR= Kelly's ratio, SSP = Soluble sodium percentage, PI = Permeability index, IWQI= Irrigation water quality index.

Sample No.	pH	EC dSm^{-1}	Ca $MeqL^{-1}$	Ca+Mg $MeqL^{-1}$	Na $MeqL^{-1}$	K $MeqL^{-1}$	CO_3^{2-} $MeqL^{-1}$	HCO^{3-} $MeqL^{-1}$	Cl^- $MeqL^{-1}$	SAR	PI	KR	SSP	RSC	IWQI
W_1	7.5	1.642	17.8	25.6	1.30	0.128	0	4.2	6.8	0.36	12.45	0.05	27.88	-21.4	250.9
W_2	7.2	0.279	6.2	9.0	1.56	0.076	0	3.8	1.6	0.73	33.23	0.17	68.18	-5.2	86.70
W_3	7.4	0.466	9.0	16.4	1.00	0.076	0	3.6	2.0	0.34	16.65	0.06	42.52	-12.8	134.1
W_4	7.7	0.398	5.4	11.0	3.39	0.128	0	2.8	2.4	1.44	35.18	0.30	53.50	-8.2	107.2
W_5	7.6	0.785	6.8	26.8	0.73	0.102	0	2.8	3.2	0.19	8.72	0.02	27.60	-24.0	215.4
W_6	7.3	1.416	15.0	18.6	2.08	0.102	0	2.0	6.0	0.68	16.89	0.11	35.29	-16.6	196.0
W_7	7.9	0.779	5.8	24.0	0.73	0.102	0	3.8	3.2	0.21	10.83	0.03	31.94	-20.2	205.0
W_8	8.0	0.949	8.2	17.4	1.74	0.793	0	3.2	9.6	0.58	18.43	0.10	41.79	-14.2	185.7
W_9	7.8	0.876	6.4	20.7	2.13	0.025	0	4.0	6.4	0.66	18.09	0.10	34.16	-16.7	198.6
W_{10}	7.7	1.271	20.4	33.0	2.08	0.102	0	3.4	4.0	0.51	11.18	0.06	21.94	-29.6	256.1
W_{11}	7.7	1.128	14.2	21.2	0.56	0.307	0	4.4	4.0	0.17	12.21	0.02	35.38	-16.8	197.6
W_{12}	7.8	1.277	8.2	28.8	0.91	0.025	0	4.2	2.8	0.23	9.96	0.03	26.25	-24.6	257.3
W_{13}	7.5	1.666	5.6	29.6	1.52	0.128	0	2.0	8.0	0.39	9.42	0.05	24.10	-27.6	293.7
W_{14}	7.4	2.587	9.8	17.4	3.87	0.102	0	2.0	13.6	1.31	24.84	0.22	34.79	-15.4	285.8
W_{15}	7.7	1.143	7.4	13.0	1.13	0.102	0	2.4	5.2	0.44	18.96	0.08	54.49	-10.6	163.0
W_{16}	7.6	0.490	6.0	13.4	2.31	0.435	0	4.6	3.2	0.89	28.35	0.17	48.37	-8.8	130.7
W_{17}	7.6	0.844	6.8	13.0	1.26	0.153	0	4.0	4.4	0.49	22.86	0.09	53.29	-9.0	148.7
W_{18}	8.3	0.961	16.4	34.2	0.95	0.102	0	3.8	5.2	0.22	8.24	0.02	23.61	-30.4	257.4
W_{19}	7.8	1.187	11.4	20.8	1.43	0.076	0	2.2	4.8	0.44	13.10	0.06	35.08	-18.6	200.2
W_{20}	7.1	0.786	6.6	8.4	2.43	0.102	0	2.8	4.4	1.18	37.88	0.28	65.55	-5.6	116.1
W_{21}	7.5	1.810	9.8	18.0	2.74	0.128	0	2.6	9.2	0.91	20.98	0.15	36.16	-15.4	235.0
W_{22}	7.5	1.972	19.6	35.8	1.82	0.281	0	3.4	3.6	0.43	9.73	0.05	19.93	-32.4	315.7
W_{23}	7.2	1.629	14.8	34.6	3.17	0.153	0	3.2	28.4	0.76	13.12	0.09	19.06	-31.4	344.5
W_{24}	7.7	2.625	29.2	44.5	2.34	0.128	0	3.2	21.6	0.49	8.81	0.05	16.43	-41.3	420.2
W_{25}	7.3	1.230	7.6	24.6	1.08	0.588	0	4.0	4.0	0.30	11.99	0.04	28.42	-20.6	233.1
W_{26}	7.2	0.989	9.2	19.0	1.08	0.435	0	4.8	4.8	0.35	16.28	0.05	35.85	-14.2	188.0
W_{27}	7.0	3.178	27.6	44.2	2.82	0.435	0	4.4	21.6	0.59	10.45	0.06	14.88	-39.8	504.6
W_{28}	7.2	0.837	18.4	33.2	1.39	0.512	0	1.8	5.6	0.34	7.89	0.04	20.81	-31.4	243.9
W_{29}	8.2	1.970	12.2	14.6	1.95	0.051	0	1.8	7.6	0.72	19.88	0.13	49.54	-12.8	233.5
W_{30}	8.2	0.975	11.4	15.8	0.91	0.128	0	2.4	4.4	0.32	14.71	0.05	49.07	-13.4	165.9
W_{31}	7.6	1.586	30.0	46.2	2.69	0.512	0	2.2	6.8	0.55	8.53	0.05	15.54	-44.0	346.4
W_{32}	7.8	0.618	24.0	40.6	1.79	0.512	0	2.0	5.8	0.39	7.55	0.04	18.40	-38.6	263.5
W_{33}	7.5	3.642	13.9	24.9	1.65	0.184	0	3.0	5.0	0.46	12.73	0.06	28.24	-21.9	374.5
W_{34}	8.3	2.164	24.2	36.0	1.73	0.235	0	4.0	5.6	0.40	9.88	0.04	21.99	-32.0	331.7
W_{35}	8.2	3.322	13.6	16.8	2.39	0.316	0	5.2	9.8	0.82	24.33	0.14	42.73	-11.6	335.5
W_{36}	8.2	0.996	7.0	10.6	2.65	0.512	0	3.8	6.4	1.15	34.71	0.25	61.88	-6.80	156.8
W_{37}	7.1	1.564	10.0	12.4	1.82	0.512	0	3.8	3.8	0.73	26.50	0.14	49.92	-8.60	180.3
W_{38}	7.2	1.134	16.6	19.8	2.78	0.128	0	1.6	7.8	0.88	17.91	0.14	31.88	-18.2	202.2
W_{39}	7.8	2.767	18.0	22.4	1.67	0.490	0	1.8	10.2	0.49	12.51	0.07	32.40	-20.6	325.2
W_{40}	7.4	1.092	14.8	17.2	1.97	0.180	0	2.0	6.2	0.67	17.65	0.11	38.60	-15.2	181.3
Mean	7.6	1.425	13.1	23.3	1.83	0.239	0	3.17	6.97	0.58	16.84	0.09	35.44	-20.16	236.7
Range	7.0-8.3	0.279-3.642	5.4-30.0	8.4-46.2	0.56-3.87	0.025-0.793	0	1.6-5.2	1.6-28.4	0.17-1.44	7.55-37.88	0.02-0.30	14.88-68.18	-44-5.2	86.7-504.6
SD±	0.35	0.81	6.89	10.3	0.78	0.193	0	0.98	5.53	0.30	8.27	0.07	14.11	10.4	88.9
CV%	4.66	57.5	52.4	44.2	42.6	80.6	0	30.9	79.2	52.6	49.10	72.2	39.81	-51.5	37.5

S_i = Guide line value given in BIS 1991

For computating the WQI, the sub-index (SI) is first determined for each chemical parameter and then used to determine WQI as given below:

$SI_i = W_i \times q_i$, $WQI = \Sigma SI_i$, Where, SI_i = sub index of i^{th} parameter, W_i = Relative weight of i^{th} parameter, q_i = Rating based on concentration of i^{th} parameter,

Table 2. Classification of water samples under different IWQI range.

WQI	Water quality status	No. of samples	% of samples	Sustainable use
<50	Excellent	0	0%	Sustainable
50-100	Good	1	2.5%	Sustainable
100-200	Poor	15	37.5%	Slightly unsustainable
200-300	Very poor	15	37.5%	Unsustainable
>300	Unsuitable	9	22.5%	Highly unsustainable

n = Number of chemical parameters

RESULTS AND DISCUSSION

The results of chemical properties of irrigation water samples from different villages of Cuddapah block in YSR district are given in the Table 1. The pH of the ground water samples of Cuddapah block are in neutral to slightly alkaline in nature ranged from 7.0 to 8.3 with 7.61 as a mean value. This finding is in conformity with the observations made by (Gummadi *et al.* 2015).

The EC range varied from 0.279 to 3.642 dS/m with 1.425 dS/m as a mean value and found that only 10% of the samples are suitable for irrigation, 82.5% samplesare moderately suitable whereas 12.5 % of the water samples are not suitable. Higher concentration of EC indicates that high amount of total dissolved salts which causes water to lose its portability and bring down the solubility of oxygen in water (Kumar *et al.*2011). The chloride concentration range varied from 1.6 to 28.4 Meq/L with 6.97 Meq/L as a mean value where 22.5% of the samples were under suitable range, 65% of the samples in moderately suitable range whereas 12.5 % of the samples recognized as not suitable for irrigation.

The bicarbonate concentration varied from1 6 to 5.2 Meq/L with 3.17 Meq/L as the mean value and all the water samples were found to be moderately suitable for the irrigation use. Identical results were reported by (Acharya 2010) Gujarat. The potassium content varied from 0.025 to 0.793 Meq/L with 0.239 Meq/L as the mean value. The sodium concentration range in the water samples were varied from 0.56 to 3.87 Meq/L with 1.83 as a mean value. Out of total collected samples 92.5% of the samples have reported suitable for irrigation and 7.5% of the samples showed moderately suitable for irrigation.

The calcium plus magnesium content were varied from 8.4 to 46.2 Meq/L with 23.3 Meq/L as the mean value. According to the guidelines prescribed by (ICMR 1975) 6.0 $MeqL^{-1}$ is the highest desirable limit of total hardness and is not suitable for irrigation.

The irrigation water quality index (IWQI) range in the water samples were varied from 86.7 to 504.6 with 236.7 as mean value and out of total number of water samples collected 37.5% of the water samples are in poor rage for irrigation, 37.5% of the samples were found under very poor range for irrigation, 22.5% of the samples were found to be unsuitable for the irrigation use and 2.5 % of the samples were found in suitable range for its usage in irrigation purpose. Classification of water quality status based on WQI value is given in the Table 2.

CONCLUSION

As per the results obtained from the analysis it is concluded that the water from different villages of Cuddapah block are neutral to alkaline in nature. Only 2.5% of the samples have shown sustainable and good for its use in irrigation, 72.5% of the water samples indicated poor to very poor water quality index and 22.5% of the samples were reported as unsuitable for the irrigation use due to high calcium and magnesium concentration, moderate range of soluble salts in water samples.

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