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Classification of River Water Quality Using Irrigation Indices – A Case Study of River Godavari

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***Abstract:** Rapid industrialization and growth of population put enormous pressure on water resources of the country. Because of inadequate surface water, the demand for ground water has increased. Eighteen ground water samples were collected in monsoon and post monsoon seasons respectively and were analysed for the various parameters like sodium, calcium, magnesium, carbonate and bicarbonate etc. The irrigation indices like sodium adsorption ratio (SAR), permeability index (PI), residual sodium carbonate (RSC), sodium percentage (Na %) were determined to assess the suitability of ground water for irrigation purpose. The water was found to exceed the permissible limits in some of the indices*
***Keywords:** Sodium adsorption ratio, Permeability index, Residual sodium carbonate, Sodium percentage*

I. INTRODUCTION

Water is a divine drink essential for sustaining life. Water is not only one of the most essential commodities of our day to day life but plays a crucial role in economic and social development processes. While the total amount of water available in the World is constant and is generally said to be adequate to meet all the demands of mankind, its quality and distribution over different regions of the World is uneven and causes problems of scarcity and suitability. It is therefore imperative that man uses and manages this scarce commodity rationally and efficiently. Unfortunately, more than one in six people lack reliable access to this precious resource in developing World.

India accounts for 2.45% of land area and 4% water resources of the World, but represent 16% of the World population. The trend of human civilization, urbanization exerted stress on civic authorities to provide safe drinking water. The inherent problem associated with this water supply schemes is lack of proper maintenance throughout and this leads to insufficient supply to serve the requirement of water for public. The water demand is increasing, while the availability is declining over the years. There is a rapid decline in surface water and the need for ground water has increased.

Quality of ground water is equally important to its quantity owing to the suitability of water for various purposes (Schiavo et al., 2006). Ground water chemistry, in turn, depends on a number of factors, such as general geology, degree of chemical weathering of the various rock types, quality of recharge water and inputs from sources other than water rock interaction. Such factors and other interactions result in a complex ground water quality (Guler et al., 2004).

All waters contain substantial amounts of dissolved salts such as chlorides, sulphates, carbonates, bicarbonates of calcium, magnesium, sodium and potassium. Soil sodicity refers to the amount of sodium present in irrigation water. Highly saline and sodic waters are big problems for irrigation (Michael et al., 1978). Salts and other substances begin to accumulate in water and water evaporates from the surface and crops withdraw water. Generally two types of salt problems exist in irrigation waters like salinity and sodicity. Soils may be affected by salinity or by a combination of both salinity and sodium (Talukder et al., 1998).

United Nations have predicted the global food requirement for future of about 40 – 45%. In addition to the problems of water logging, salinization and erosion etc affect irrigation potential enormously. The entire physical and biological systems involved in saline agriculture must be understood and carefully managed if increased production is to be achieved without exacerbating the existing problems. Soil water salinity is dependent on soil type, climate and water use. As the water is taken up by plants through transpiration or lost to the atmosphere by evaporation, salinity increases because salts become more concentrated in the remaining soil water. Thus evapotranspiration between irrigation periods can increase salinity further. Water with high salinity is toxic to

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plants and poses a salinity hazard (Biswas et al., 2002).

Salinity and sodicity are separate and unique descriptions of the impact of soluble salts in soil and water. Sodicity represents the relative predominance of exchangeable sodium compared to other exchangeable cations like calcium, magnesium, potassium, hydrogen and aluminium and is expressed as ESP (exchangeable sodium percentage) (Ibrahim et al., 2013).

II. MATERIALS AND METHODS

A. Study Area

West Godavari is one of the 13 districts of Andhra Pradesh, India. West Godavari district occupies an area approximately 7700 square kilometers. It has 46 mandals: out of which 20 are in Upland and the rest in Deltaic region. The delta region is abundant with water sources and so agriculture, aquaculture and industries are surviving with these abundant water resources. Irrigation in West Godavari is carried on through a network of streams, namely Eluru stream, Narasapur stream, Venkayya Vayyeru stream, Gostani Velpur stream, Attili stream etc.

Fig 1: Study area of six streams

Eluru stream is considered as a main source for the study. The study was carried out at 18 locations of Eluru stream. The sampling stations selected for the analysis were: S1-Nandamuru, S2 – Arulla, S3 – Navabpalem, S4 – Krishnayyapalem, S5 – Pathipadu, S6 – TP Gudem, S7 – Pentapadu, S8 – Badampudi, S9 – Unguteru, S10 – Narayanapuram, S11 – Chebrolu, S12 – Raikaram, S13 – Pulla, S14 – Bhimadolu, S15– Gundugolenu, S16 – Pothunuru, S17 – Kovali, S18 – Eluru.

All the samples collected were tested for pH, TDS, chlorides, sodium, calcium, magnesium, carbonates and bicarbonates.

B. Sodium Adsorption Ratio (SAR)

SAR is a significant parameter for the determination of suitability of irrigation water, excess sodium in water produces the undesirable effects of changing soil properties and reducing the permeability of soils. The soil becomes compact and impervious in nature due to excess SAR (Richards, 1954). SAR is the ratio of sodium concentration to the concentration of the square root of the average calcium plus magnesium concentration in either irrigation water or the soil solution (Miller and Gardiner, 2007). Numerous studies show that sodicity problems associated with irrigation water as permeability.

This was calculated employing the equation (Raghunath, 1987) as:

$$SAR = Na + Ca^{2+} + Mg^{2+} + 2$$

(Concentrations are in meq/L)

The concentration of both carbonate and bicarbonate influence the suitability of water for irrigation purpose. The relative abundance of sodium with respect to excess of carbonate ad bicarbonate over alkaline earth also affects the suitability of water for irrigation purpose and this excess is denoted by residual sodium carbonate (Richards, 1954).

This was calculated employing the equation (Eaton, 1950) as:

$$RSC = CO^{3}_{2-} + HCO^{3-} - Ca^{2+} + Mg^{2+} \qquad \text{(Concentrations are in meq/L)}$$

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C. Permeability Index (PI)

The suitability of water for irrigation was based on PI. The PI can be classified as class I, class II and class III orders. Class I and Class II water was categorized as good for irrigation with 75% maximum permeability. Class III was unsuitable with 25% of maximum permeability (Doneen, 1964).

This was calculated employing the equation (Domenico, 1990) as:

$$PI = (Na^{+} + HCO^{3-}) \div Ca^{2+} + Mg^{2+} + Na + 100$$

(Concentrations are in meq/L)

D. Sodium Percentage (Na %)

It is defined as the ratio of sodium in epm to the total cation epm multiplied by 100. Water with sodium percentage greater than 60% may result in sodium accumulations that will cause a breakdown in the soil's physical properties.

This was calculated employing the equation (Todd, 1995) as:

$$Na\% = Na^{+} + K^{+} \div Ca^{2+} + Mg^{2+} + Na^{+} + K + 100$$

(Concentrations are in meq/L).

Classification of water based on irrigation indices was presented in Table 1.

Table 1. Status of water quality of different irrigation indices

SAR	Class	RSC	Class	PI	Class	Na%	Class
<10	Excellent	<1.25	Safe	75%	Class I	< 20	Excellent
10 to 18	Good	1.25 to 2.5	Marginal	75%	Class II	20 - 40	Good
18 to 26	Fair	>2.5	Unsuitable	25%	Class III	40- 60	Permissible
>26	Poor					60 - 80	Doubtful
						>80	Unsuitable

III. RESULTS AND DISCUSSION

The results of different irrigation indices were presented for all the sampling stations in Table 2.

Table 2. Irrigation indices (All values are expressed in meq/L)

SNO	SAR		PI		RSC		Na %	
	Monsoon	Post Monsoon	Monsoon	Post Monsoon	Monsoon	Post Monsoon	Monsoon	Post Monsoon
S-1	8.47	7.03	62.29	67.46	43.85	72.64	50.58	50.58
S-2	8.88	7.03	66.04	69.09	57.13	69.71	52.27	51.64
S-3	11.29	6.98	71.34	71.35	41	76.35	59.72	52.37
S-4	9.25	6.87	66.2	67.45	56.27	68.49	52.98	50.46
S-5	10.38	7.55	70.2	70.83	50.28	61.28	57.37	54.14
S-6	10.26	8.65	64.64	73.01	41.55	65.92	53.92	57.06
S-7	9.13	8.78	67.96	74.17	77.13	85.07	52.96	51.97
S-8	10.71	10.71	66.94	70.34	51	68.92	55.5	55.5
S-9	13.13	8.03	74.61	74.71	50.7	77.14	63.75	54.31
S-10	10.83	8.28	65.84	71.43	57.41	60.5	54.98	56.75
S-11	10.18	8.29	63.62	64.96	74.7	60.3	52.46	55.86
S-12	13.57	7.27	73.11	74.79	33.11	73.49	61.76	50.25
S-13	10.69	10.71	58.37	73.76	74.71	74.71	50.05	60.73
S-14	9.28	9.23	73.76	71.93	48.27	84.49	61.62	58.5
S-15	14.67	10.24	70.34	63.36	45.84	72.06	59.17	54.21
S-16	13.62	7.15	67.94	64.78	72.69	65.28	58.25	48.51
S-17	13.57	7.00	67.9	64.59	67.96	67.96	55.15	55.15
S-18	12.55	12.55	64.59	67.79	70.69	69.76	55.45	50.45

The values of SAR were found within the permissible range. The highest SAR was 14.67 at S-15 in Monsoon.

All the sampling stations were found with the permeability index of Class I and Class II as shown in Table 1.

The values of RSC were found to exceed in all the sampling stations and water was found to be unsuitable as per standards of RSC from Table 1.

The values of sodium percentage were found to be higher and was categorized as doubtful in almost all the sampling stations.

The variations of four indices of all sampling stations for two seasons both Monsoon and Post monsoon were presented in Fig 2 and Fig 3.

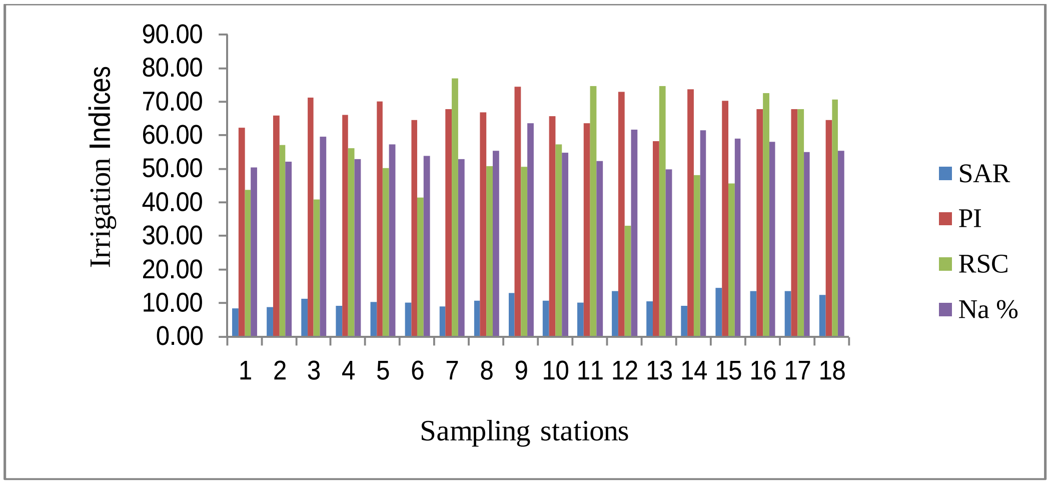

Fig 2. Variation of irrigation indices of sampling stations (Monsoon)

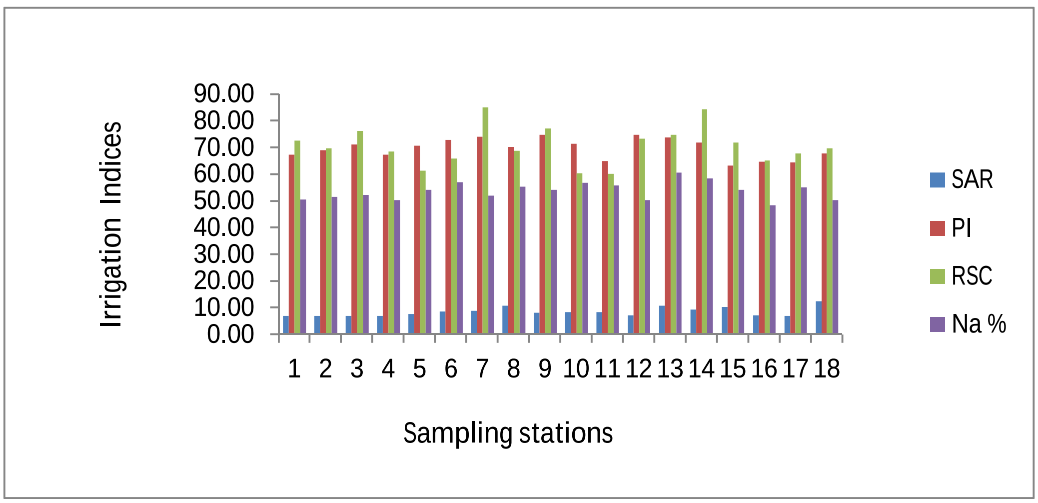

Fig 3. Variation of irrigation indices of sampling stations (Post Monsoon)

III. CONCLUSIONS

Evaluation of ground water quality for irrigation was carried out using four indices like SAR, PI, RSC and Na %. The values of SAR and PI were found to be within permissible range. The value of RSC was found to vary from 41 to 85.07 and was extremely unsuitable. The values of Na% were found to be unsuitable. Therefore the water quality was found to be suitable for irrigation purpose as per SAR and PI and unsuitable as per RSC and Na%. The water has to be checked further for other indices and has to be confirmed if the same could be used for irrigation purpose.

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