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Assessment of Seasonal Variation in Irrigation Water Quality of Indravati River in Bastar District of Chhattisgarh

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A B S T R A C T

The river Indravati is also known as the oxygen of the Bastar district of state of Chhattisgarh which was considered one of the greenest and eco-friendly districts found in the whole of India. This paper is an attempt to analyze the water quality of river Indravati in Bastar district for irrigation purpose. Water quality variables were measured from water samples collected from six check dams viz. Aasna, Indravati (Kumrawand), Karanji, Rotma, Narayanpal and Chitrakote in the river over a period of one year (June 2019 to March 2020) fortnightly. The samples were analyzed for pH, EC, TDS, Ca, Mg, Na, K, Cl, CO_3^{2-}, HCO_3^-, NO_3^-, SO_4^{2-}. Based on these parameters different irrigation water quality indices such as sodium percent (SP), SAR, RSC and WQI were estimated. Studies of all these characteristics indicate that Indravati river water can be safely used for irrigation round the year.

Introduction

Indravati River is a stream of the river Godavari. Its starting point is found to be the Ghats of Dandakaranya range, in the Kalahandi district of the state of Odisha rises at an elevation of 914 metres on the western slopes of the Eastern Ghats. It flows west-ward through the Kalahandi, Nabarangapur and Koraput districts for 164 km and after forming the boundary between Odisha and Chhattisgarh states for 9.5 km, enters the Bastar district of Chhattisgarh. After flowing 233 km in Chhattisgarh, it turns south and flows along the boundary of Chhattisgarh and Maharashtra for about 129 km and joins Godavari River at the junction of the boundaries of Maharashtra, Chhattisgarh and Telangana states. According to Interstate Agreement as per Godavari Water Disputes Tribunal (GWDT) Report, the State of Odisha has to ensure 1.3×10^9 cubic metres ($45{,}000\times10^6$ cu ft) (45 TMC) of water at the Odisha–Chhattisgarh border. Now the fall is worth viewing during the rainy seasons only. River Indravati is assigned a Red category on account of an existing Major Dam in Odisha and impending threat from the series of dams

planned on it as part of lower Indravati power projects in Chhattisgarh. Due to which river flow in *Rabi* season very limited and majority of the untreated sewage water from Jagdalpur city goes to it, causing water to pollute. Looking to the problem concern we have planned to investigate the "Assessment of seasonal variation in irrigation water quality of Indravati river in Bastar district of Chhattisgarh" with the following objectives to prepare index of irrigation water quality and to estimate the suitability of water for irrigation.

Materials and Methods

Water samples were collected from six check dams viz. Aasna, Indravati (Kumrawand), Karanji, Rotma, Narayanpal and Chitrakote in 40 km stretch of the river over a period of one year (June 2019 to March 2020) fortnightly (Fig. 1).

The samples were analyzed for pH, EC, TDS, Ca, Mg, Na, K, Cl, CO_3^{2-}, HCO_3^-, NO_3^-, SO_4^{2-} by standard procedures (Chopra and Kanwar, 2011). Based on these parameters (Table 2) different irrigation water quality indices such as sodium percent (SP), SAR and RSC were estimated and finally, WQI were estimated as follows-

Water Quality Index (WQI) Calculation

WQI is a single score derived by considering different important parameters of water quality. It is an integration of the individual effect of all the parameters in right proportion in deciding the quality of water. WQI is generally computed in three steps by several researchers (Water programme, 2007; Ramkrishnaiah *et al.* 2009). Here a different approach of assigning weightage (Raychaudhuri *et al.*, 2014) was considered to identify and highlight the location specific reasons for contamination of water.

At first each parameter was assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes based on per cent of samples within the permissible limit as per the standards. Weights of 5, 4, 3, 2, 1 are assigned to the quality parameters when 0-20, 21-40, 41-60, 61-80 and 81-100 % of samples are within the permissible limit respectively (Raychaudhuri *et al.*, 2014).

Secondly, the relative weight (Wi) is computed from using the following equation:

$$\mathbf{Wi} = \frac{\mathbf{wi}}{\sum_{i=1}^{n} \mathbf{wi}} \quad \ldots\ldots\ldots (1)$$

where, Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters. Third step involves assignment of a quality rating scale (qi) for each parameter by dividing its concentration in each water sample by its respective standard according to the guidelines laid down in the BIS followed by multiplication with 100:

$$\mathrm{qi} = (\mathrm{Ci}/\mathrm{Si}) \times 100 \quad \ldots\ldots\ldots(2)$$

where qi denotes the quality rating, Ci denotes the concentration of each chemical parameter in each water sample in mg/L, and Si is the Indian drinking water or irrigation water standard for each chemical parameter in mg/L according to the guidelines of the BIS 10500, 1991 or FAO respectively (Table 1). For computing the WQI, the SI is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation.

$$\mathrm{SIi} = \mathrm{Wi}\,.\mathrm{qi} \quad \ldots\ldots\ldots(3)$$

$$WQI = \sum_{i=1}^{n} \mathrm{SIi} \quad \ldots\ldots\ldots(4)$$

SIi is the sub-index of ith parameter; qi is the rating based on concentration of ith parameter

and n is the number of parameters. The computed WQI values are then categorised into four classes based on "none", "slight", "moderate" and "severe" restrictions for irrigation use (Table 3). The WQI identifies the causative element or group of parameters responsible for the deteriorated quality so that appropriate measures can be implemented for its restoration.

Results and Discussion

Water Quality Index (WQI)

Water of adequate quantity and acceptable quality is essential for the sustenance of life. In order to assess the suitability of water for irrigation in the study area of Bastar District, WQI is a single score derived by considering different important parameters of water quality. It is an integration of the individual effect of all the parameters in right proportion in deciding the quality of water.

WQI of water at all the six study sites showed a range of 44.57 to 89.82 with mean and SD of 66.26 and 9.11, respectively (Fig. 2) and was found excellent water in terms of WQI for irrigation. The 13.75 % variability found in WQI of river water at different sampling locations of Bastar district. The highest WQI was found in the Aasna checkdam (89.82) in the month of February followed by Karanji checkdam in the month of February (82.52), Indravati (80.16), Rotma checkdam (78.14) and lowest WQI (44.57) was found in the month of August in Karanji checkdam. The box plot showed that the distributions of WQI data are useful in visualizing skewness in the WQI of water (Fig 4). Mean values were taken into consideration as characteristic values to see the differences during three seasons (Fig 3). The average values of WQI recorded highest in summer (86.73) compare to rainy (68.22) and winter (59.55).

Table.1 FAO standard for individual parameters for irrigation use and weightage assigned

Parameters	Units	FAO standards	% Compliance	Weight	Relative weight
pH	-	6.0-8.5	67	2	0.13
EC	µS/cm	1000*	100	1	0.06
SAR	-	3	100	1	0.06
CO_3^{2-}	ppm	60	100	1	0.06
HCO_3^-	ppm	610	100	1	0.06
Cl	ppm	1065	100	1	0.06
NO_3^- -N	ppm	45**	100	1	0.06
SO_4^{2-} -S	ppm	1920	100	1	0.06
Total Hardness	ppm	1000	100	1	0.06
Ca	ppm	400	100	1	0.06
Mg	ppm	60	100	1	0.06
Na	ppm	920	100	1	0.06
K	ppm	2	67	3	0.19
			Total	16	

*Full yield potential is obtained for nearly all crops when using irrigation water less than 1.0 dSm-1

**Mostly Indian soils are low in N content so the permissible limit for drinking water quality parameter is considered

Table.2 Chemical parameters of Indravati river water in Bastar district during 2019-20

Parameter	Minimum	Maximum	Mean	SD	CV %
pH	6.99	9.09	7.74	0.64	8.25
EC (dS/m)	0.06	0.25	0.13	0.05	37.10
TDS(ppm)	254.2	381.2	302.75	30.89	10.20
HCO_3^-(meq/l)	0.745	6.66	2.69	1.41	52.24
Ca(meq/l)	0.9	4.2	2.11	0.83	39.30
Mg(meq/l)	0.4	1.45	0.84	0.32	38.45
Na(meq/l)	0.17	0.43	0.26	0.06	23.75
K(meq/l)	0.06	0.14	0.10	0.02	16.53
NO_3^-(ppm)	0.56	19.94	5.68	4.87	85.72
SO_4^{2-}(ppm)	0.3	3.25	0.93	0.65	69.92
Cl(ppm)	1.90	20.66	9.16	5.10	55.69
Na(%)	4.41	32.78	15.18	7.04	46.41
SAR	0.14	0.44	0.23	0.06	27.57
RSC(meq/l)	-2.05	3.70	-0.26	2.06	79.1

Table.3 Classification of surface water quality for irrigation use based on WQI

WQI	Class	Restrictions	% of water samples
<150	I	None	100%
150-300	II	Slight	-
300-450	III	Moderate	-
>450	IV	Severe	-

Fig.1 Map of River Indravati showing sampling sites

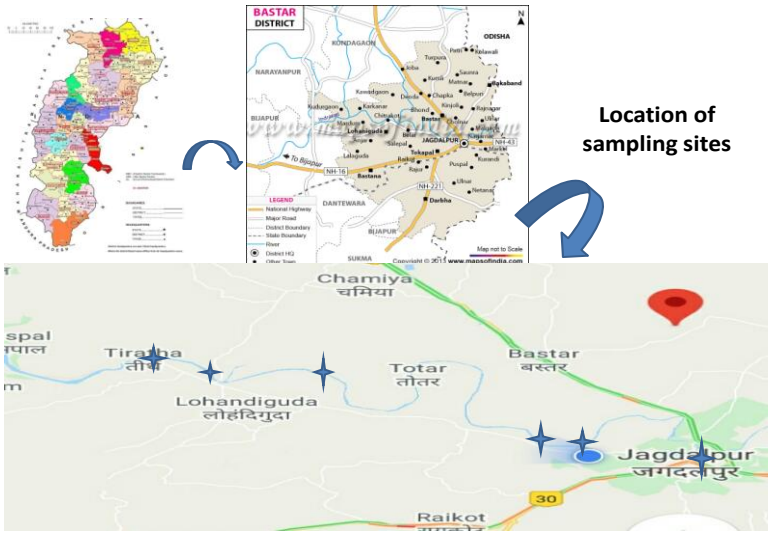


Fig.2 Site wise WQI variation in surface river water of Indravati during different months

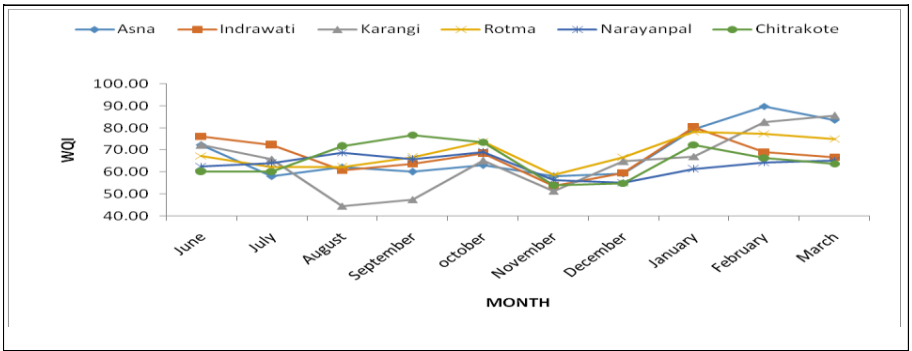


Fig 2. Site wise WQI variation in surface river water of Indravati during different months

Fig.3 Seasonal WQI variations in surface river water of Indravati in Bastar

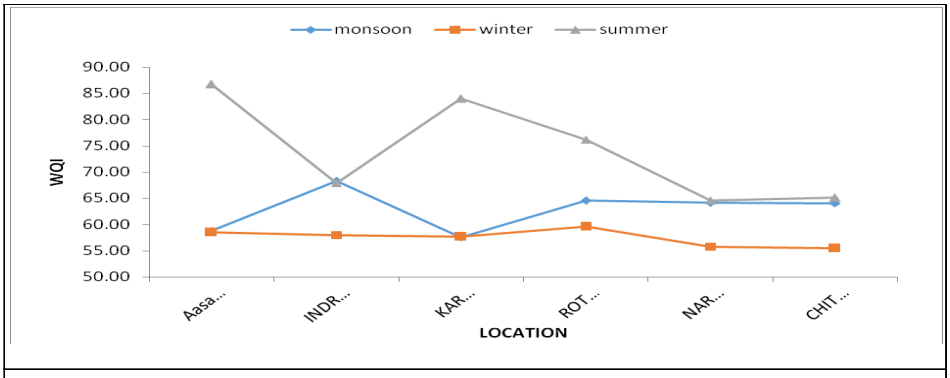
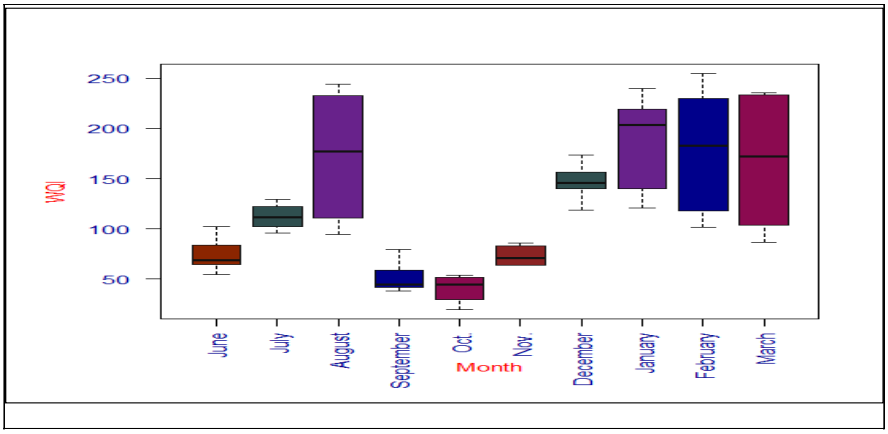


Fig. 3. Seasonal WQI variations in surface river water of Indravati in Bastar

Fig.4 Box plot of monthly WQI of river Indravati in Bastar District in Chhattisgarh



The higher WQI during summer was due to more Na and NO_3^- concentration and in rainy season, it may be due to soil erosion, mixing of domestic and agricultural discharges due to heavy rain and other anthropogenic activities as mentioned by Parmar and Parmar (2010). As per classification, the calculated values of WQI at all the six study sites was less than 150, the water can be safely used for irrigation with none restrictions round the year.

In conclusion the water quality status is assessed through Weighted Arithmetic Index method. WQI values of surface water samples analyzed for pre and post monsoon seasons depict that there exists a narrow change in the WQI values which is not vary significantly with reference to irrigation water quality. As per WQI scale, the river water at various stations was classified excellent to good for irrigation.

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