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Assessment of water quality index for Shivnath river in Durg, Chhattisgarh State, India

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ABSTRACT

The present work is aimed at assessing the water quality index (WQI) for Shivnath River, one of the major tributaries of Mahanadi River of Durg, Chhattisgarh. This enables us to assess whether the quality of water is fit for drinking, irrigation and industrial use or not. For this study samples were collected for 2017 and 2018 in all three seasons and subjecting the samples to a comprehensive physicochemical analysis. For calculating the WQI, the following parameters have been considered: pH, total hardness, calcium, magnesium, bicarbonate, chloride, nitrate, total dissolved solids. The WQI for these samples ranges from 29.12 to 91.62 in three seasons of two years. The high value of WQI has been found to be mainly for the Pre Monsoon season with deteriorating river water quality and this value decreases (good water quality) in Monsoon season where dilution and changing weather condition may be the reason. The results of analyses have been used to suggest models for predicting water quality. The analysis reveals that the river water of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination.

Key words : *River water, Water quality standards, Water quality index, Shivnath River, Durg, India*

Introduction

Rivers play important role in sustaining life in the environment. But natural water reservoirs are never chemically pure. Water quality index is one of the most effective tools (Mishra *et al.*, 2001; Naik *et al.*, 2001; Tiwari *et al.*, 1985) to communicate information on the quality of water to the concerned citizens and policy makers. It, thus, becomes an important parameter for the assessment and management of water quality. WQI is calculated from the point of view of the suitability of water for human consumption. The objective of the present work is to discuss the suitability of surface water for human consumption based on computed water quality index values. The objective of the present work is to discuss the suitability of Shivnath river water for human consumption based on WQI calculated by weighted index method.

Methodology

Study Area

Shivnath river is one of the longest tributary of the River Mahanadi. It has its join in Khargahni in Bilaspur District in Chhattisgarh India. It has a total course of 290 k.m. Shivnath flows through the District of Rajnandgaon, Durg, and Janjgir- Champa these are the main stations at the Bank of Shivnath River (Sharadha Vaishnav *et al.*, 2017). Several small and Big Cities including Rajnandgaon, twin city of

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Durg-Bhilai all depend on the Shivnath River water to satisfy the thirst of growth, industries, agriculture and potable water. The River water quality is getting deteriorated due to various human activities like discharge of industrial effluents (Islam *et al.,* 2015; Puttaiah *et al.,* 2008).

Sampling and Analysis

The sampling was conducted in two consecutive years i.e. 2017 and 2018. The samples were collected for all the three seasons (i.e. Pre Monsoon, Monsoon and Post Monsoon). Samples were collected in duplicate from Shivnath river as per standard procedures. Several Physiochemical parameters such as pH, electrical conductivity, and Alkalinity were monitored at the sampling site and other parameters like total dissolved solid, calcium, magnesium, total hardness were analyzed in the laboratory as per the standard procedures of APHA (1995). For the analysis of different parameters systronics conductometer and digital systronics pH meter were used for the determination of pH and conductivity. All the parameters were analyzed in duplicate.

Water Quality Index

TO design WQI method is one of the most effective tools to designate the quality of water that offer a simple, reproducible and effective means to express the quality of water. It is defined as a rating reflecting the composite influence of different water quality parameters (Ramkrishnah *et al.,* 2009). WQI is calculated from the point of view of to determine the suitability of ground water for drinking purpose. (Ramkrishnah *et al.,* 2009). In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a waterbody with number (Yogendra *et al.,* 2009).

Calculation of water quality index

In this study for the determining of Water Quality Index seven water quality parameters were chosen. Water quality index provides a single number that express the water quality status in determine the suitability for drinking purpose. For the calculation of WQI using the standards of drinking water quality recommended by the world health organization (WHO), Indian council of medical research (ICMR) and Bureau of Indian standard (BIS). The quality of water is obtained in terms of weighted arithmetic index has been used for the calculation of WQI of the water body. Quality Rating (qi) was calculated for each parameter by using the following expression:

$$Qi = \frac{(Vactual - Videal)}{(Vstandard - Videal)} \times 100$$

Where, Qi = Quality rating of ith parameter for a total of n water quality parameters. V_{actual} = Actual value of the water quality parameter obtained from laboratory analysis V_{ideal} = ideal value of that quality parameter can be obtained from the standard tables.

Videal for pH = 7 and for other parameters it is equating to zero $V_{standard}$ = Recommended WHO standard of the water quality parameter.

Calculation of Unit weight (Wi)

Unit weight was calculated by a value inversely proportional to the recommended standard (Si) for the corresponding parameter using the following expression

Results and Discussion

Water quality Index (WQI) of the Shivnath River water is calculated from different physicochemical parameters in three seasons of 2017 and 2018. The results were compared with the water quality index and status of water quality (Table 1). Table 2 shows the values of different parameters in all the three season and for two years. Season and Year wise calculation of WQI is presented in Table 3, 4, 5 and 6. It is clear from table 6 that with higher values of WQI in Pre Monsoon season in both the years supports the poor and very poor water quality which improves in Monsoon and post Monsoon season to good water quality status (Chatterji and Raziuddin, 2002).

Table 1. Water Quality Index (WQI) and status of Water Quality (Chatterji and Raziuddin, 2002)

Water Quality Index Level	Water Quality Status
0 – 25	Excellent water quality
26 -50	Good water quality
51 -75	Poor water quality
76 – 100	Very Poor water quality
> 100	Unsuitable for drinking

Table 2. Seasonal variation of the physiochemical parameter of the river (values are in ppm)

S. No.	Parameter	Standard Value	2017			2018		
			Pre Monsoon	Monsoon	Post Monsoon	Pre Monsoon	Monsoon	Post Monsoon
1.	pH	8.5	7.5	6.2	6	7.2	6.82	5.9
2.	EC µs/cm	300	1.23	52.8	23.2	2.82	0.729	0.932
3.	TDS	500	615	2640	1160	1410	365	466
4.	TH	300	160	140	120	130	125	225
5.	Ca	75	100	100	100	110	80	190
6.	Mg	30	60	40	20	20	45	35
7.	Alkalinity	120	150	100	110	180	150	220
8.	Nitrate	45	0.18	0.69	0.49	0.45	0.38	0.41
9.	Chloride	250	28	32	30	32	34	33
Water Quality Index		59.38	29.12	23.69	91.62	29.72	29.75	

Table 3. Calculation of Water Quality Index in Pre Monsoon Season

S. No.	Parameter	2017				2018			
		Obseved Value	WI	QI	WiQi	Obseved Value	WI	QI	WiQi
1.	pH	7.5	0.117647	88.235	10.380	7.2	0.117647	84.7059	9.9654
2.	EC	1.23	0.003333	0.41	0.001366	2.82	0.003333	0.94	0.0031
3.	TDS	615	0.002	123	0.246	1410	0.002	282.00	0.5640
4.	*Alkalanity*	160	0.003333	53.333	0.177758	130	0,003333	43.333	0.1444
5.	Ca	100	0.01333	133.33	1.77728	110	0.01333	46.66	1.9551
6.	Mg	60	0.03333	200	6.666	20	0,03333	66.666	2.2220
7.	Alkalinity	150	0.008333	125	1.0416	180	0.008333	150	1.2500
8.	Nitrate	0.18	0.0412	0.4	0.01648	0.45	0.0412	1.00	0.4120
9.	Chloride	28	0.0074	11,2	0.08288	32	0.0074	1.28	0.0947

Table 4. Calculation of Water Quality Index in Monsoon Season

S. No.	Parameter	2017				2018			
		Obseved Value	WI	QI	WiQi	Obseved Value	WI	QI	WiQi
1.	pH	6.2	0.117647	72.9412	8.5813	6.82	0.117647	80.24	9.439
2.	EC	52.8	0.003333	17.6000	0.0587	0.729	0.003333	0.24	0.00079
3.	TDS	2640	0.002	528.00	1.0560	365	0.002	73	0.1460
4.	*Alkalanity*	140	0,003333	46.667	0.1555	125	0,003333	41.67	1.1388
5.	Ca	100	0.01333	133.333	1.7773	80	0.01333	106.67	1.4218
6.	Mg	40	0,03333	133.33	4.4440	45	0,03333	150	4.9995
7.	Alkalinity	100	0.008333	83.333	0.6949	150	0.008333	125	1.0416
8.	Nitrate	0.69	0.0412	1.53	0.63173	0.38	0.0412	0.84	0.3479
9.	Chloride	32	0.0074	12.8	0.09472	34	0.0074	13.6	0.10064

Correlation study of the obtained data is also shown in Table 7, which shows the significant negative correlation of pH with Nitrate and Chloride concentration while both are significantly positively correlated with EC. The Regression analysis of the data is also shown in Table 8. The regression analysis is carried out between the WQI and the different parameters of water sample. In 2017 the pH and Nitrate values are showing higher values of R square while in 2018 Nitrate and EC having R Square value higher than 70%, which indicate that in these cases both (studied parameter and WQI) dependent and independent variables are in line. Hence change in one variable will definitely has impact on another variable.

Table 5. Calculation of Water Quality Index in Post Monsoon Season

S. No.	Parameter	2017				2018			
		Obseved Value	WI	QI	WiQi	Obseved Value	WI	QI	WiQi
1.	pH	6	0.117647	70.5882	8.30450	5.9	0.117647	69.4117	8.1661
2.	EC	23.2	0.003333	7.7333	0.02578	0.932	0.003333	0.310667	0.0010
3.	TDS	1160	0.002	2320,00	4.6400	466	0.002	93.2	0.1864
4.	*Alkalanity*	120	0,003333	40.00	0.1333	225	0,003333	75	0.2500
5.	Ca	100	0.01333	133.33	1.7777	190	0.01333	253.33	3.3778
6.	Mg	20	0,03333	66.6667	2.2222	35	0,03333	116.6667	3.8889
7.	Alkalinity	110	0.008333	91.667	0.76389	220	0.008333	183.33	1.5278
8.	Nitrate	0.49	0.0412	1.09	0.44862	0.41	0.0412	0.91	0.37538
9.	Chloride	30	0.0074	12	0.0888	33	0.0074	13.2	0.09768

Table 6. WQI of the River Shivnath

Year	Pre Monsoon	Monsoon	Post Monsoon	Mean
2017	59.38	29.12	23.69	37.40
2018	91.62	29.72	29.75	50.36
Mean	75.51	29.42	26.72	**43.88**

Table 7. Correlation study

	pH	EC	TDS	Alkalanity	Ca	Mg	Hardness	Nitrate	Chloride
PH	1								
EC	-0.7439	1							
TDS	-0.73167	0.088742	1						
Alkalanity	-0.82857	0.990541	0.22458	1					
Ca	0.599655	-0.98089	0.106757	-0.94491	1				
Mg	0.830589	-0.24572	-0.98732	-0.3764	0.052414	1			
Hardness	0.951347	-0.91362	-0.48604	-0.96077	0.817057	0.61859	1		
Nitrate	-0.86642	0.978217	0.293573	0.997448	-0.91913	-0.44158	-0.97812	1	
Chloride	-0.79808	0.996371	0.173196	0.998625	-0.96077	-0.32733	-0.94491	0.992336	1

Table 8. Regression analysis of some parameters, which have significant value of correlation with WQI of three seasons.

Multiple R	R Square	Adjusted R Square	*F*	*P-value*	
		2017			
pH	0.999827	0.999654	0.999309	2891.829	0.011837
Nitrate	0.85699	0.734432	0.468864	2.765514	0.344663
Chloride	0.786741	0.618961	0.237923	1.624406	0.423533
EC	0.731348	0.53487	0.069741	1.149939	0.477783
		2018			
pH	0.725252	0.525991	0.051982	1.109664	0.483446
Nitrate	0.904374	0.817892	0.635783	4.491239	0.280677
Chloride	0.866235	0.750363	0.500727	3.005824	0.333066
EC	0.996155	0.992325	0.984651	129.3014	0.055842

Conclusion

Nevertheless, WQI for Pre monsoon season for both the years indicates the deteriorating pattern of water quality of the river in this region. From the foregoing observation of physicochemical parameters and WQI calculations, it can be concluded that water quality of Shivnath River is deviating from good

quality to poor water quality status and care must be taken to control. Framing proper policies for maintaining the water quality status to good and very good level the assessment of WQI can be served as good tool.

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