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Statistical Assessment of Water Quality Index (WQI) of Narmada River Water Parameters in Narmadapuram City, Madhya Pradesh, India

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Abstract: ***Water is an essential need of human being and industrial development. Water should be safe for drinking purpose. Various national and International agencies have prescribed Standards for various uses of water in term of water quality parameters. Water Quality Index (WQI) provides meaningful information about water quality to general public and policy makers also. Present work deals with the various physico -chemical parameters of Narmada River water in Narmadapuram (M.P.). The results obtained will compare with the guidelines provided by World Health Organization (WHO) and Bureau of Indian standards (BIS). All these results would be helpful to indicate the suitability of water for domestic industrial and irrigation purposes and to improve the quality of river water in future.***

Keywords: Water Quality Index (WQI), Physico-Chemical Parameters, Water Quality Standards, Word Health Organization (WHO), Bureau of Indian Standard (BIS).

1. Introduction

Rivers are the important sources of water that plays an important role in development of nation and sustenance of life. These sources are being polluted due to rapid industrialization, urbanization and other developmental activities. River water quality deterioration has become a serious concern worldwide due to increased pollution and climate change. The degradation of water quality in a water body creates adverse condition so that it cannot be used for intended beneficial uses including domestic, recreation and as a source of raw water supply. WQI is an effective tool to assess the quality of water obtained by aggregating several water quality measurements into one number. It is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers. The aim of present study is to assess the water quality of Narmada River for its domestic and irrigation purposes.

2. Study Area

Narmadapuram, previously known as Hoshangabad is a city in the Indian state of Madhya Pradesh. It is located in central India, on the South bank of The Narmada River. Narmadapuram is 76.7 Km from the state capital Bhopal. Narmadapuram is located at 22.750 N to 77.720 E and has an average elevation of 278m from sea level. Northern boundary of the district is river Narmada. Across this, the district of Raisen and Sehore lies. The district of Betul lies in the South, whereas the Harda District faces with the Western and South-Western boundaries. Chhindwara and Narsingpur Districts, close to the North-Eastern and South-Eastern sides of the district respectively. As per official census 2011, Narmadapuram District with a population of 12,40,976 and population density of 185 inhabitants per square kilometer. The sex ratio is 912 females per 1000 males with the literacy rate of 76.52%. The Narmada River, also called the "Reva" is the fifth (5^{th}) longest river and overall longest West-flowing River in India. It is also the largest flowing river in the state of Madhya Pradesh. This river flows through the states of Madhya Pradesh and Gujrat in India. It is also known as "the life line of Madhya Pradesh and Gujrat. The Narmada River rises from the Amarkantak Plateau in Anuppur District Madhya Pradesh. It forms the traditional boundary between North India and South India and flows Westwards over a length of 1,312 km before draining through the Gulf of Khambhat into the Arabian Sea, 30 km west of Bharuch city of Gujarat.

3. Material and Methods

The Narmada River water samples were collected from five (05) different pollution prone sampling stations named as S1 (Sethani Ghat), S2 (Paryatan Ghat), S3 (Vivekanand Ghat), S4 (Midghat) and S5 (Budhni Ghat), located at the bank of Narmada River in Narmadapuram city, Madhya Pradesh. Water samples were collected in previously cleaned with 1:3 HNO_3 fresh three liters plastic bottles during the period of four (04) months of season from Jul. 2022 to Oct. 2022 on monthly basis. Samples were collected during the first week of every month in the early hours of the day in between 6.00 AM to 8.00 AM and were analyzed as per methods prescribed by APHA.

Determination of Water Quality Index (WQI) :
The WQI is the one of the most widely used and the simplified way of representing water quality information. It is expressed as a single number to describe overall water quality conditions using multiple water quality variables. The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO), Bureau of Indian standards (BIS) and Indian Council of Medical Research (ICMR).
Further, Quality Rating (Qn) was calculated using the following expression:

$$Qn = 100(Vn\text{-}Vio) / (Sn\text{-}Vio)$$

Where, Qn= Quality Rating for the nth water quality parameter.

Vn= Estimated value of the nth parameter at a given sampling station.
Sn = Standard permissible value of the nth parameter.
Vio= Ideal value of the nth parameter in pure water.

Unit Weight was calculated by a value inversely proportional to the recommended standard value Sn of the corresponding parameter.

Wn = K / Sn,
Where: Wn = unit weight of the nth parameter.
Sn = standard Value for nth parameters.
K = Constant for proportionality.

The overall Water Quality Index calculated by aggregating the quality rating with unit weight linearly.

WQI = ΣQnWn / ΣWn

4. Results and Discussion

The summary of observations for all the studied physico-chemical parameters and their corresponding calculated WQI values are presented in tabular form in the Table No.1, 2, 3, 4, 5, 6 and 7.

Table 1: Summary of Water Quality Index (WQI) and Corresponding Water Quality Status (WQS)

S.No.	WQI	WQS	Possible Uses
1.	0-25	Excellent	Drinking, Irrigation and Industrial
2.	26-50	Good	Domestic, Irrigation and Industrial
3.	51-75	Fair	Irrigation and Industrial
4.	76-100	Poor	Irrigation
5.	101-150	Very Poor	Restricted use for Irrigation
6.	>150	Unfit for Consumption	Proper Treatment Essential before use

Table 2: Statistical Analysis of Physico-Chemical Parameters Studied During Jul.2022 to Oct.2022

S. No.	Month	Parameter	Unit	Average Values of Sampling Stations					Min	Max	AV	SD	SE	AV±CL
				S1	S2	S3	S4	S5						
1	Jul.	pH		7.4	7.3	7.4	7.5	7.3	7.3	7.5	7.38	0.08	0.04	7.38±0.07
		EC	µmhos/cm	188.5	191.3	192.1	193.5	193.2	188.5	193.5	191.7	2.00	0.90	191.7±1.76
		Tur.	NTU	5.5	5.4	5.6	5.7	5.6	5.4	5.7	5.56	0.11	0.05	5.56±0.10
		TH	mg/l	124.5	132.1	130.5	131.6	132.7	124.5	132.7	130.3	3.33	1.49	130.3±2.92
		TDS	mg/l	185.6	190.1	192.3	191.4	193.3	185.6	193.3	190.5	3.00	1.34	190.5±1.34
		Ca^{++}	mg/l	92.4	93.1	93.5	94.1	94.3	92.4	94.3	93.48	0.77	0.34	93.48±0.67
		Mg^{++}	mg/l	32.4	32.6	32.7	32.8	32.8	32.4	32.8	32.66	0.17	0.07	32.66±0.15
2.	Aug.	pH		7.7	7.4	7.5	7.7	7.6	7.4	7.7	7.58	0.13	0.06	7.58±0.11
		EC	µmhos/cm	212.5	219.5	221.4	223.3	222.9	212.5	223.3	219.9	4.41	1.97	219.9±3.86
		Tur.	NTU	5.9	6.1	6.1	6.2	6.3	5.9	6.3	6.12	0.15	0.07	6.12±0.13
		TH	mg/l	128.4	133.3	132.5	132.1	134.4	128.4	134.4	132.1	2.27	1.01	132.1±1.99
		TDS	mg/l	190.7	193.8	196.5	194.7	197.1	190.7	197.1	194.6	2.54	1.13	1.13±2.22
		Ca^{++}	mg/l	93.4	93.5	93.7	94.6	94.8	93.4	94.8	94	0.65	0.29	94±0.57
		Mg^{++}	mg/l	32.5	32.7	32.8	32.9	32.9	32.5	32.9	32.76	0.17	0.07	32.76±0.15
3.	Sep.	pH		7.9	7.6	7.8	7.9	7.9	7.6	7.9	7.82	0.13	0.06	7.82±0.11
		EC	µmhos/cm	225.6	230.4	232.1	232.5	232.1	225.6	232.5	230.5	2.88	1.29	230.5±2.52
		Tur.	NTU	6.5	6.6	6.4	6.5	6.5	6.4	6.6	6.5	0.07	0.03	6.5±0.06
		TH	mg/l	130.2	133.8	133.4	135.1	135.8	130.2	135.8	133.7	2.16	0.97	133.7±1.90
		TDS	mg/l	!92.4	194.4	198.3	195.1	198.5	194.4	198.5	196.6	2.13	0.95	196.6±1.87
		Ca^{++}	mg/l	93.8	93.7	93.8	94.7	94.9	93.7	94.9	94.18	0.57	0.26	94.18±0.50
		Mg^{++}	mg/l	32.6	32.8	32.8	33.1	33.2	32.6	33.2	32.9	0.24	0.11	32.9±0.21
4.	Oct.	pH		8	7.9	8.1	8.2	8.3	7.9	8.3	8.1	0.16	0.07	8.1±0.14
		EC	µmhos/cm	237.7	240.5	241.3	241.1	242.8	237.7	242.8	240.7	1.87	0.84	240.7±1.64
		Tur.	NTU	6.8	6.7	6.8	6.9	6.8	6.7	6.9	6.8	0.07	0.03	6.8±0.06
		TH	mg/l	131.7	133.8	133.9	135.9	136.3	131.7	136.3	134.3	1.85	0.83	134.3±1.62
		TDS	mg/l	193.1	194.9	199.6	196.4	199.2	193.1	199.6	196.6	2.78	1.24	196.6±2.44
		Ca^{++}	mg/l	93.9	93.8	93.9	94.8	94.9	93.8	94.9	94.26	0.54	0.24	94.26±0.47
		Mg^{++}	mg/l	33.1	32.9	33.2	33.3	33.4	32.9	33.4	33.18	0.19	0.09	33.18±0.17

Table 3: Calculation of WQI Value of Water Samples of Narmada River during Jul. 2022 to Sep. 2022 (Month: Jul 2022)

S. No.	Month	Parameters	Average Test values	Standard permissible limit	Relative Weight (Wn)	Quality Rating (Qn)	Quality Weight
1	Jul.	pH	7.38	8.5	0.205	25.333	2.738
		EC	191.72	300	0.006	60.573	0.352
		Tur.	5.56	5	0.349	60.000	20.943
		TH	130.28	300	0.006	44.093	0.257
		TDS	190.54	500	0.003	34.508	0.120
		Ca^{++}	93.48	75	0.023	97.973	2.280
		Mg^{++}	32.66	30	0.058	95.533	5.558
					ΣWn=0.651		ΣWnQn=0.651
						WQI =49.540	

Table 4: Calculation of WQI Value of Water Samples of Narmada River During Jul. 2022 to Sep. 2022 (Month: Aug 2022)

S. No.	Month	Parameters	Average Test values	Standard permissible limit	Relative Weight (Wn)	Quality Rating (Qn)	Quality Weight
1	**Aug.**	pH	7.5	8.5	0.205	33.333	6.844
		EC	189.1	300	0.006	63.033	0.367
		Tur.	3.1	5	0.349	62.000	21.641
		TH	141.4	300	0.006	47.133	0.274
		TDS	161.2	500	0.003	32.240	0.113
		Ca++	78.3	75	0.023	104.400	2.429
		Mg++	25.6	30	0.058	85.333	4.964
					ΣWn=0.651		**ΣWnQn=36.632**
							WQI = 56.276

Table 5: Calculation of WQI Value of Water Samples of Narmada River during Jul. 2022 to Sep. 2022 (Month: Sep. 2022)

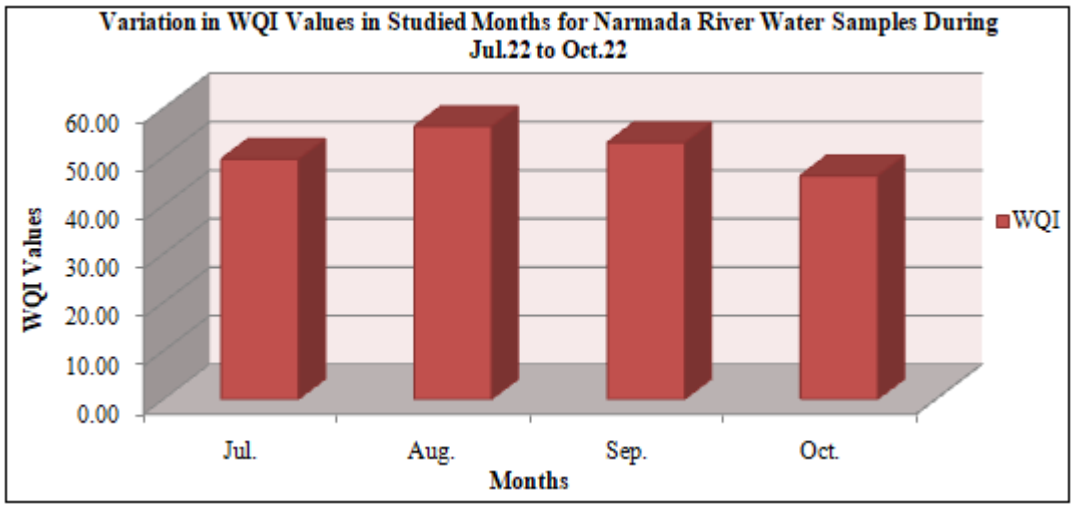
S. No.	Month	Parameters	Average Test values	Standard permissible limit	Relative Weight (Wn)	Quality Rating (Qn)	Quality Weight
1	**Sep.**	pH	7.3	8.5	0.205	20	4.106
		EC	190.1	300	0.006	63.367	0.369
		Tur.	3.2	5	0.349	64	22.339
		TH	144.3	300	0.006	48.1	0.280
		TDS	165.2	500	0.003	33.04	0.115
		Ca++	76.8	75	0.023	102.4	2.383
		Mg++	25.1	30	0.058	83.667	4.867
					ΣWn=0.651		**ΣWnQn=34.460**
							WQI = 52.94

Table 6: Calculation of WQI Value of Water Samples of Narmada River during Jul. 2022 to Sep. 2022 (Month: Oct. 2022)

S. No.	Month	Parameters	Average Test values	Standard Permissible limit	Relative Weight (Wn)	Quality Rating (Qn)	Quality Weight
1	**Oct.**	pH	7.1	8.5	0.205	6.667	1.369
		EC	184.5	300	0.006	61.500	0.358
		Tur.	2.9	5	0.349	58.000	20.245
		TH	136.1	300	0.006	45.367	0.264
		TDS	167.8	500	0.003	33.560	0.117
		Ca++	75.6	75	0.023	100.800	2.346
		Mg++	27.5	30	0.058	91.667	5.333
					ΣWn=0.651		**ΣWnQn=30.031**
							WQI = 46.13

Table 7: Calculated Values of WQI and their Corresponding Categories for Narmada River Water Quality Status during Study Period (Months From Jul. 2022 to Oct.2022)

S.No.	Month	WQI	Category
1	Jul.22	49.54	Good
2	Aug.22	56.28	Fair
3	Sep.22	52.94	Fair
4	Oct.22	46.13	Good



5. Conclusion

The Physico-Chemical Parameters for the quality of Narmada River at Narmadapuram were analyzed and compared with the prescribed drinking water standards of WHO and BIS (IS:10500) and have been considered for the calculation of WQI. On the basis of analysis of data obtained, it is found that the during the study period the water quality of Narmada River falls mainly under in "Good" category. Some variations in good quality may be mainly due to rainy season and it is concluded that the overall quality of water is suitable and safe for domestic and irrigation purposes.

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