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RESEARCH ARTICLE

ESTIMATION OF WATER QUALITY INDEX IN BARNA STREAM NETWORK OF NARMADA RIVER BASIN

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ABSTRACT

During the present study, water quality index (WQI) was calculated to assess the water quality of Barna stream network of Narmada River basin in Madhya Pradesh. A total of eight physicochemical parameters *viz.,* pH, conductivity, dissolved oxygen, total hardness, nitrate etc. were considered to estimate the water quality index. The methodology for physicochemical analysis was followed from APHA (1998) and Adoni (1985). The results obtained during the survey showed that the WQI score at six stations in Barna stream network were within the range of scale 26-50 exhibited 'Good' water quality at each station, reflecting the healthy ecological conditions within the watershed of the Barna stream network.

INTRODUCTION

Water is the most important chemical compound for the persistence of life on this planet (Prasad and Patil, 2008) and the freshwater must be recognized as the blood of society (Wetzel, 2000) as men uses this water for domestic, industrial and agricultural purposes. But, these days water is misused as urbanization increases and also anthropogenic activities have deteriorated the quality of water to a greater extent (Akoteyon *et al.,* 2011). Agricultural practices, grazing, washing, sewage disposal are the main anthropogenic activities prevailing within the watershed of Barna stream network. Hence, an attempt was made to assess the impact of such activities on water quality by calculating water quality index (WQI) for the Barna stream network. Water quality index assemble different physicochemical parameters of a water body into one single number that leads an easy interpretation of its quality, thus providing an important tool for its management purposes (Bordalo *et al.,* 2001; Kumar and Dua, 2009). Moreover, WQI is one of the most effective ways to communicate information on water quality status to policy makers and to execute the water quality improvement programmes more efficiently (Samantray *et al.,* 2009; Kalavathy *et al.,* 2011; Kumar *et al.,* 2011b). Also, in India a lot of work has been done on WQI of various river basins *viz.,* Mahanadi and Atharabanki Rivers (Samantray *et al.,* 2009); River Cauvery in Tiruchirappalli district, Tamil nadu (Kalavathy *et al.,* 2011); Sabarmati River at Ahmedabad, Gujarat (Kumar *et al.,* 2011b). But no such work has been done over this stream network of Narmada River basin, which forms the main basis of the present study. In the present research work, the water quality status of the Barna stream network is assessed through its physicochemical components. The study is supposed to help in designing strategies required for the conservation and management of the streams of Barna stream network.

MATERIALS AND METHODS

Study area

The present study was conducted on the Barna stream network (or Barna basin), a sub basin of Narmada River basin, located at latitude $22^0$50'-23.5^0 N and longitude $77^0$5'-78.2^0 E. Barna is one of the major tributaries of Narmada in addition to Dudhi, Ganjal, Kolar, Hallon, Banjar and Tawa while Satdhar, Jamner, Palakmati, Chamarsil and Narheri are the tributaries of Barna which forms the Barna stream network or Barna basin. These streams feed an irrigation reservoir which was built across the Barna stream, located at $23^0$5' N and $78^0$7' E near Bari village of Raisen district in Madhya Pradesh and called as Barna reservoir. Barna reservoir is identified under National Wetland Conservation Program by Ministry of Environment and Forests (Govt. of India). Hence, the present research work is of great importance for the ecology of this reservoir also.

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The geographical locations and map of the study area is given below in Table: 1 and Figure 1.

Table 1. Geographical locations of different stations in Barna stream network

Station	Stream	Geographical Location
Station-1	Barna	Lat23^{0}04’24.2”N,Long77^0 47’2” E
Station-2	Satdhar	Lat23^0 6’ 11.3”N,Long77^{0}55’27.2”E
Station-3	Jamner	Lat23^{0}4’21.1N,Long77^{0}56’59.8”E
Station-4	Palakmati	Lat23^{0}2’02.1”N,Long77^{0}56’11.7”E
Station-5	Chamarsil	Lat23^0 9’ 57.7” N,Long77^{0}57’48.5”E
Station-6	Narheri	Lat23^0 11’ 38.6” N,Long78^{0}02’23.2”E

WQI was computed using the following formula:

$$\mathbf{WQI} = \sum q_i W_i / \sum W_i$$

where,

W_i, is a unit factor, given by the formula, $W_i=K/S_i$

S_i is the standard value of i^{th} parameter and K is proportionality constant

The unit weights W_i for all the chosen parameters with standard values are given in Table 3.

q_i is the quality rating for nth water quality parameter which is determined by the formula given below,

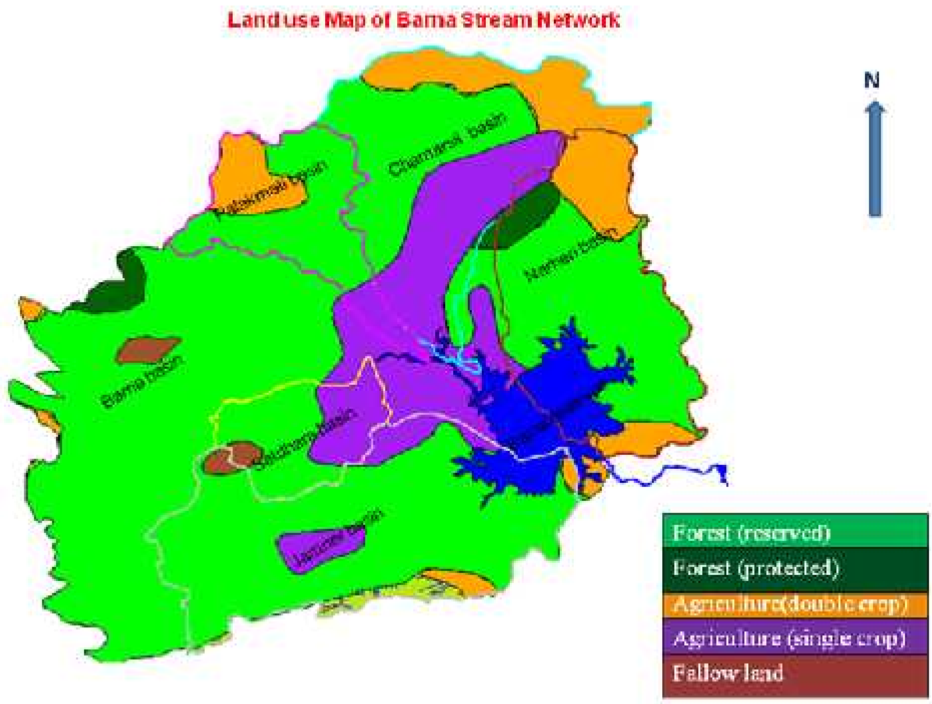

Figure 1. Map of Barna stream network

Sampling methods

The six streams of Barna basin which were under taken during the study include Barna, Satdhar, Jamner, Palakmati, Chamarsil and Narheri. In order to assess the water quality of Barna stream network, water samples were collected from each stream in different seasons for one year. Some of the physicochemical parameters *viz.,* pH, TDS, conductivity were measured on field whereas other parameters were performed afterwards in the laboratory. The methods for the physicochemical analysis were followed from Workbook on Limnology (Adoni *et al.,* 1985) and American Public Health Association (APHA, 1998)

Estimation of water quality index (WQI)

Water Quality Index is a very useful and efficient method for assessing quality of water (Asadi, 2007). In the present study, calculation of water quality index was followed from Srivastava *et al.,* 2007.

$$q_i = 100 \, x(V_i-V_{10})/(S_i-V_{10})$$

where,

V_i=estimated value of the nth parameters at a given sampling station

S_i=standard permissible value of nth parameter

V_{10}=ideal value of the nth parameter in pure water

All the ideal values (V_{10}) are taken as zero for the drinking water except for pH=7.0 and for DO=14.6mgl^{-1}. The quality ratings for all the chosen parameters are given in Table 4.

The calculated value of water quality index was compared with the WQI scale given in Table 6.

RESULTS AND DISCUSSION

During the present investigation, significant variation was observed in physicochemical components of the Barna stream network. Detailed structure of physicochemical variation is given in Table 2.

During the present investigation, the overall nature of waters of Barna stream network was found alkaline with a range of pH between 7.3-8.3. The higher mean value of pH was recorded in Chamarsil (8.3) while the lower mean value in Satdhar (7.9). Similar findings with pH ranged from 7.6-8.9 in Narmada River, Madhya Pradesh (Sharma *et al.*, 2011) and 6.43-9.13 in Yamuna River, Uttar Pradesh (Kumar *et al.*, 2011a) were also recorded.In the present study, the mean value

Table 2. Mean (X±SD) of physicochemical components at different stations in Barna stream network

Parameters	Barna	Satdhar	Jamner	Palakmati	Chamarsil	Narheri
pH	8.06±0.15	7.9±0.26	8.27±0.3	7.93±0.4	8.3±0.1	7.9±4.7
Conductivity(μ scm^{-1})	356.67±94.5	303.33±176.2	340±192.8	546.67±124.2	350±70	256.67±225
TDS (ppm)	246.67±75.7	226.67±105.3	223.33±80.8	416.67±110.6	253.33±100.6	223.33±220
DO (mgl^{-1})	7.8±3.02	7.6±13.5	7.4±4.9	6±4.4	7.2±3.2	6±4.8
Total alkalinity (mgl^{-1})	171.33±100.4	180±85.34	170.67±97.8	196.66±94.5	173.33±90.1	117.33±102
Total hardness (mgl^{-1})	182±31.4	160.67±80	182±75.6	236±13.11	188±30	148.66±129
Chloride (mgl^{-1})	30.68±5.9	29.61±10.1	33.26±12.5	53.46±42	66.68±50.4	66.24±62.8
Nitrate (mgl^{-1})	0.345±0.1	0.405±0.25	0.495±0.3	0.375±0.1	0.511±0.3	0.475±0.4

Table 3. Showing parameters, drinking water standards and unit weight (W_i)

Parameters	BIS (S_i)	Unit Weigth (W_i)
pH	6.5-8.5	0.2181
Conductivity	300	0.00618
TDS	500	0.003708
DO	5	0.3708
Total alkalinity	200	0.00927
Total hardness	300	0.00618
Chloride	250	0.007416
Nitrate	45	0.007416

Table 4. Showing quality rating (q_i) for physicochemical components at different stations

Parameters	Barna	Satdhar	Jamner	Palakmati	Chamarsil	Narheri
pH	70.66	60	80	60	86.67	60
Conductivity	118.89	101.11	101.11	182.23	116.67	85.56
TDS	49.33	45.34	45.34	63.34	50.66	46.66
DO	70.83	72.91	75	89.58	77.08	89.58
Total alkalinity	85.66	90	90	98.33	86.65	58.65
Total hardness	60.67	53.57	53.56	78.67	62.67	49.55
Chloride	12.27	11.84	11.84	21.384	26.67	26.49
Nitrate	0.77	0.9	0.9	0.83	1.13	1.05

Table 5. Showing calculated Water quality index (W_i) at different stations in Barna stream network

Parameters	Barna	Satdhar	Jamner	Palakmati	Chamarsil	Narheri
pH	15.41	13.08	17.44	13.08	18.9	13.08
Conductivity	0.734	0.624	0.624	1.126	0.721	0.528
TDS	0.182	0.168	0.168	0.234	0.187	0.165
DO	26.26	27.03	27.81	33.21	28.58	33.21
Total alkalinity	0.794	0.834	0.834	0.911	0.803	0.543
Total hardness	0.374	0.330	0.330	0.486	0.387	0.306
Chloride	0.091	0.087	0.087	0.158	0.197	0.196
Nitrate	0.005	0.006	0.006	0.006	0.008	0.007
WQI Score	43.85	42.16	47.30	49.21	49.78	48.03
Scale	25-50	25-50	25-50	25-50	25-50	25-50
Rating	Good	Good	Good	Good	Good	Good

Table 6. Showing status of water quality based on WQI

S. No	WQI Scale	Status
1	0-25	Excellent
2	25-50	Good
3	51-75	Poor
4	76-100	Very Poor
5	>100	Unsuitable for Drinking

of total dissolved solids was observed higher in Palakmati (416.67 ppm) whereas lower value in Narheri (223.33 ppm) and the value of conductivity was found to follow the same pattern as that of total dissolved solids throughout the study with higher value in Palakmati (546.67 µscm^{-1}) whereas lower value in Narheri (256.67 µscm^{-1}). Similar results were recorded with 30-320 ppm in Krishna River,Western Maharashtra (Prasad and Patil, 2008); 256-500 ppm in Ganga River, Kanpur (Trivedi *et al.,* 2009) and 255-540 ppm in Ganga River, Kanpur (Thareja *et al.,* 2011) supports the present findings. An important indicator of the condition of an aquatic ecosystem is the concentration of dissolved oxygen in water. DO is considered as the factor which reflects physical and biological processes taking place in the water body (Wetzel, 1983; APHA, 1998; Kumar *et al.,* 2011a). In the present survey, the mean value for dissolved oxygen was recorded higher in Barna (7.8 mgl^{-1}) due to forested land near the sampling station while the lower in Palakmati and Narheri (6 mgl^{-1}) due to anthropogenic activities at these stations as also reasoned by Chattopadhyay *et al.* (2005) during their work in Chalakudy river basin, Kerala. Dissolved oxygen values 6-9.27 mgl^{-1} in Venkatapura catchment, Karnataka (Karthick and Ramchandra, 2007) and 4.2-4.6 mgl^{-1} in Narmada River (Sharma *et al.,* 2011) were also reported by some workers. Total alkalinity is the measure of weak acid present in the water and of the cations balanced against them (APHA, 1998; Singh *et al.,* 2010; Kumar *et al.,* 2011a). In the present study, the higher mean value of total alkalinity was recorded in Palakmati (196.66 mgl^{-1}) and the lower value in Narheri (117.3 mgl^{-1}). Some workers have recorded similar range of total alkalinity with 123-240 mgl^{-1} in Yamuna River, Uttar Pradesh (Kumar *et al.,* 2011a); 79.3-107.8 mgl^{-1} in Ram Ganga River, Uttar Pradesh (Chandra *et al.,* 2011) which favors the present values. Also the higher input of nutrients *via* human activities in Palakmati causes high values of total alkalinity here as also explained by Chattopadhyay *et al.* (2005) while studying the Chalakudy River basin, India.

Total hardness is an important parameter from water quality perspective as it determines the suitability of water for domestic, industrial and drinking purposes and attributed to the presence of bicarbonates, sulphates, chloride and nitrates of calcium and magnesium in the water (Singh *et al.,* 2010 and Kumar *et al.,* 2011a). In the present work, mean value of total hardness was recorded higher in Palakmati (236 mgl^{-1}) and the lower value in Narheri (148.66 mgl^{-1}). The value for total hardness was recorded 106-246 mgl^{-1} in Ganga River, Kanpur (Thareja *et al.,* 2011) and 182.1-300 mgl^{-1} in Ram Ganga River, Uttar Pradesh (Chandra *et al.,* 2011) which favors the present findings. During the present survey, higher values of total hardness in Palakmati was due to reduced inflow, discharge of sewage, use of soaps and detergents for washing, bathing by local inhabitants as also observed by Kumar *et al.* (2011b) during their study in Sabarmati River and Singh *et al.* (2010) in Manipur river system.

Chlorides are salts resulting from the combination of the chlorine with a metal and in combination with a metal such as sodium it becomes essential for life (Golterman, 1975; Dikio, 2010; Singh *et al.,* 2010). In the present investigation, the higher mean value for chloride was recorded in Chamarsil (66.68 mgl^{-1}) and lower value in Satdhar (29.61 mgl^{-1}). Similar range of chloride was recorded with a value of 46.1-121 mgl^{-1} in Cauvery River, Tamil nadu (Kalavathy *et al.*, 2011) and 18-32 mgl^{-1} in Yamuna River, Uttar Pradesh (Kumar *et al.,* 2011a) supporting the present findings. The source of nitrate is the biological oxidation of organic nitrogenous substances in water and nitrate is important in evaluating the potential biological productivity of water (Venkatesharaju *et al.,* 2010). In the present study, the mean concentration of nitrate was observed higher in Chamarsil (0.511 mgl^{-1}) whereas, lower mean value was recorded in Barna (0.345 mgl^{-1}). Some workers have recorded value for nitrate ranged between 0.008-0.024 mgl^{-1} in Chambal River (Saksena *et al.,* 2008) and 1.38-2.6 mgl^{-1} in Ganga River, Varanasi (Mishra *et al.,* 2009). It was observed during the present study that the value of nitrate was recorded higher in Chamarsil due to agricultural practices and lower value in Barna because of forested land near the sampling stations as also observed by Chattopadhyay *et al.* (2005) in Chalakudy river basin.

In addition, during the present investigation water quality index based on eight variables showed that the water quality at all the stations in Barna stream network comes under ‘Good’ water quality rating. But, the score calculated at each station differs which reflects that the disturbance causing factors varies at each station. The WQI values ranged from 42.16-49.78 at all the stations during the present investigation. The higher value was calculated in Chamarsil (49.78) while the lower value in Satdhar (42.16). All the calculated values for water quality index at different stations are given in Table 5. The WQI values showed that the water is much healthier at stations having lower values than at the stations having higher values of calculated WQI. It is inferred from the results that the overall quality of water is good at all the sampling stations in Barna stream network. Similar WQI values ranged from 26-50 in two streams of Assam while Akoteyon (2011) observed WQI value 19.62 for urban streams, Lagos-Nigeria has been reported by Laskar and Kumar (2011). Water quality index in Mahanadi and Atharabanki Rivers and Taldanda Canal in Paradip area were assessed and found water quality of streams were of medium to good quality (Samantray *et al.,* 2009). Kalavathy *et al.* (2011) have reported WQI value ranged from 73.96-141.88 for River Cauvery and attributed reason for higher values of WQI to the anthropogenic activities such as agricultural practices, bathing, cleaning, open defecation, leachates from solid wastes and moreover to municipal sewage. Likewise, in the present investigation the variation in water quality were attributed to above mentioned factors prevailing near the sampling stations in Barna stream network. Furthermore, the calculated WQI revealed that the water quality at Barna stream network is suitable for various purposes, however, there is need for routine monitoring of the various anthropogenic activities within the watershed of Barna stream network especially at the stations which were under the influence of human activities and distressing water quality.

Conclusion

During the present survey, the calculated WQI revealed that the waters in Barna stream network is suitable for various purposes as no major effect of human interferences was observed on its water quality. However, there is need for routine monitoring of the various anthropogenic activities at the streams which were under the influence of human interference so that it may not deteriorate the health of water in future as well.

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