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Research Article

Studies on Water Pollution of River Bicchiya: Physicochemical Characteristics

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Abstract: Pollution studies of river Bicchiya, Rewa, India have been made with an emphasis on the physio-chemical assessment of water quality. The widen of Bicchiya river contained in the Maoganj is extending up to 12 km downstream to the confluence of Redwa river and again joining together with Beehar river near Rewa city. The river flow spans up to approximately 55-60 km in Rewa district. Three sampling stations viz., Station A-near confluence of Redwa river (Khaira village), Station B-near Kasthar Nath temple (Gurh township) and Station C-near Rewa city were established for the collection of water samples during may 2011 to June, 2012. The water quality parameters namely transparency, colour, turbidity, electrical conductivity, total dissolved solids, pH, dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, chloride, sulphate, phosphate, silicate, biochemical oxygen demand, chemical oxygen demand, ammonia, sodium and potassium reflects on the pristine nature of the river in Rewa city. The results on the basis of various parameters studied, Bicchiya River in this stretch can be positioned under the sort of oligosaprobic. The water quality analysis indicated that the river water in the area is pollution free but can become polluted if appropriate measures are not taken in right way.

Keywords: Bicchiya River, Water quality, Pollution status, Rewa city.

INTRODUCTION

"Holy rivers" has rather becomes a myth today. According to the report of National Environment Engineering Research Institute all the fourteen big rivers of India are badly polluted. River pollution in India has now reached to a point of crisis due to unplanned urbanization and rapid growth of industrialization. The entire array of life in water is affected due to pollution in water. The problem of water quality deterioration is principally due to human activities such as discharge of industrial and sewage wastes and agricultural runoff which are major cause of ecological spoil and pose severe health hazards.[1]. The degree of pollution is generally assessed by studying physical and chemical characteristics of the water bodies[2]. Studies related to water pollution of rivers like Godavari, Krishna and Tungbhdra[3] Cauvery[4, 5], Jhelum[6], Kosi[7, 8], Alaknanda[9], Brahamani[10-12], Ganga[13,14], Godavari[15,16], Yamuna[17,18], Pachin[19], Irai,[20], Tansa[21] and Purna[22] have received greater attention during recent years. The objective of this study was to evaluate the water pollution in river Bicchiya in Rewa district.

MATERIALS AND METHODS

The river flows through the areas of deeply eroded alluvium. There are many steeps banks and bends where the depth of water exceeds 4-6 m. Three sampling stations were established on the stretch of Bicchiya River flowing in the Rewa district. Station-A was established at Khaira village (Maoganj tehsil), Station-B was established at Kasthar Nath temple (Gurh Tehsil) and Station-C was established at Rewa city (Huzoor Tehsil). The water samples were collected from all the three sampling stations established on Bicchiya River from May, 2011 to June, 2012.

The monthly samples of subsurface water were collected during first fifteen days of each month in the early hours of the day i.e. between 8 am to 10 am. Utmost care was taken to avoid spilling of water and air bubbling at the time of sample collection. Iodine treated polyethylene double Stoppard bottles were used for collection of sample. Some of the physico-chemical characteristics of water including water temperature, depth, colour, transparency, flow rate, pH, dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, chloride, calcium and magnesium were determined at the sampling stations, while other parameters including turbidity, electrical conductivity, total dissolved solids, nitrate, nitrite, sulphate, phosphate, silicate, biochemical oxygen demand, chemical oxygen demand, ammonia, sulphide, sodium and potassium were analyzed in the laboratory within 5 to 6 hr of collection. The physico-chemical characteristics of water were analyzed according to the methods of APHA[23] and Trivedy and Goel[24].

RESULTS AND DISCUSSION

Study of physico-chemical characteristics provides an initial idea of the water quality of water body. The results of the physicochemical characteristics of Bicchiya river water are summarized in **Table 1**. Temperature is important parameter for physico-chemical study of water system because it can effects the chemical and biological reactions taking place within water and aquatic organisms[25]. Its effect varies with season to season, time of sampling and the temperature of effluents which is being added in to the river. Mean water temperature of Bicchiya River was given in **Table-1**. The low water temperature was recorded in winter, while highest temperature was recorded in summer season. Alike seasonal variation in water temperature was recorded by Shrivastava and Patil[25] in river Tapti.

Table-1: Analysis of physico-chemical parameters of Bicchiya River

Sl.No.	Parameters	Units	Station A (Khaira Village)			Station B (Kasthar Nath Temple)			Station C (Near Rewa City)		
			Min	Max	Mean &Standard Deviation	Min	Max	Mean &Standard Deviation	Min	Max	Mean &Standard Deviation
1	Temperature	^0C	16.50	32.00	26.37±4.06	16.90	33.00	26.65±4.43	17.10	33.10	25.67±4.30
2	Transparency	Cm	12.50	100.00	66.66±33.83	15.12	96.20	76.13±33.50	18.00	90.00	72.38±32.36
3	Flow rate	$cmsec^{-1}$	5.50	26.00	15.70±6.58	6.00	42.00	18.80±11.09	6.12	44.00	23.48±10.73
4	Colour		V.T	Transp	-	V.T.	Transp	-	V.T	Transp	-
5	Depth	M	1.32	3.26	3.20±1.25	2.20	4.08	3.79±0.75	2.47	4.38	2.27±1.42
6	Turbidity	NTU	1.20	82.10	19.14±22.86	1.63	90.00	30.72±51.37	11.00	110.00	21.70±27.81
7	EC	$GScm^{-1}$	135.40	378.10	283.00±91.98	140.00	606.40	360.50±168.89	168.00	884.00	418.32±236.67
8	TDS	mgl^{-1}	220.00	410.00	305.48±60.13	250.00	440.00	318.59±58.91	365.00	650.00	312.23±68.54
9	pH	-	7.80	8.63	8.22±0.36	7.80	8.72	8.30±0.23	8.10	8.98	8.46±0.46
10	DO	mgl^{-1}	4.86	9.23	6.63±1.54	5.06	11.73	7.86± 2.02	3.27	5.49	8.12±2.70
11	Free CO_2	mgl^{-1}	Nil	2.40	1.53±0.55	Nil	5.60	2.02±1.70	Nil	17.50	3.61±5.45
12	Total alkalinity	mgl^{-1}	70.50	265.00	142.82±63.88	72.00	271.00	152.30±61.31	85.00	370.00	174.14±66.97
13	Total Hardness	mgl^{-1}	41.00	90.00	73.96±14.85	42.00	114.00	94.31±22.35	82.00	160.00	112.54±28.13
14	Chloride	mgl^{-1}	11.22	49.64	24.42±13.12	14.32	34.73	24.57±7.19	28.46	90.94	44.14±24.69
15	Calcium	mgl^{-1}	8.62	33.28	24.51±5.84	18.73	45.18	31.88±7.82	29.23	54.46	32.85±5.37
16	Sulphates	mgl^{-1}	7.40	41.54	28.10±8.94	13.00	44.00	32.21±9.44	14.50	55.00	28.65±14.09
17	Phosphates	mgl^{-1}	0.006	0.040	0.019±0.007	0.006	0.050	0.024±0.013	0.04	0.09	0.02±0.01
18	Silicates	mgl^{-1}	1.80	3.80	2.03±0.95	2.00	4.50	4.36±2.23	3.80	6.60	3.00±1.88
19	BOD	mgl^{-1}	0.41	3.24	1.72±0.82	1.10	3.27	2.02±1.27	4.32	5.24	2.27±0.88
20	COD	mgl^{-1}	10.2	14.60	11.43±5.42	11.00	16.30	12.20±6.30	20.00	30.60	21.23±8.71
21	Ammonia	mgl^{-1}	Nil	0.32	0.02±0.11	Nil	0.36	0.10±0.12	0.23	0.84	0.45±0.28
22	Sulphides	mgl^{-1}	Nil	0.02	0.006±0.01	Nil	0.18	0.051±0.030	0.12	0.38	0.05±0.02
23	Magnissium	mgl^{-1}	1.21	7.23	3.10±1.62	1.40	18.10	8.31±5.26	1.88	21.10	11.82±5.2
24	Soadium	mgl^{-1}	10.10	42.70	14.56±9.75	21.70	48.20	33.01±6.41	26.32	84.30	48.02±10.45
25	Potassium	mgl^{-1}	1.12	5.31	3.20±1.01	3.21	6.15	4.43±0.92	4.14	16.10	5.51±1.41

Transparency depends on the intensity of sunlight, suspended soil particles, turbid water received from catchment area and density of plankton etc[26]. Transparency of river water is also affected due to total solids partly or fully decomposed organic matters, silts and turbulence caused by the current, human and cattle activities[27]. The transparency values were found less (12.50 cm) in Sampling Station A in monsoon season due to high current of water which erodes the bank of the river as well as due to turbid flood water and dissolved solid particles in water current. High value (90.00 cm) of transparency was recorded in winter season in Sampling Station C. Similar trends has also been observed by Shaikh and Yeragi[28].

Flow rate of rivers depends upon the amount of water available and on its depth[29]. Mean annual flow rate in Bicchiya river was found to be minimum (5.50 cm sec^{-1}) at Khaira village and maximum (44.00 cm sec-1) at Rewa city in the month of July-August. The colour of river water was found much turbid in monsoon where as in other seasons river water was transparent. But because of anthropogenic release of water effluents from city drainage into the river at sampling station C it seems to be somehow coloured. The minimum depth 1.32 m of river water was recorded at sampling station A in the summer season while maximum depth 4.38 m was recorded in rainy season at sampling station C. Electrical conductivity of water is the measure of capacity of flow of electric current through it. The lowest conductivity value 135.40 GS cm-1 was observed at sampling station A in the month of October while highest value of conductivity 884.00 GS cm^{-1} was observed at sampling station C in the month of May-June. The minimum value of turbidity 1.20 NTU was found at sampling station A in the January and maximum 110.00 NTU was recorded at Station A in July-August.

Total dissolved solids are composed of carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of Ca, Mg, Na, K, and Mn and organic matter, salts and others particles[8]. Minimum total dissolved solids 220.00 mgl^{-1} were recorded at sampling station B while maximum TDS 650.00 mgl^{-1} was recorded near Rewa city in the month of August. The suitable pH range for growth of aquatic biota is 6.7 to 8.4[30]. The water in Bicchiya River was almost always alkaline in nature throughout the year because the nature of soil and rocks in this region is alkaline due to the present of lime stone. Minimum pH value 7.80 was observed at sampling station A in the rainy season and maximum pH 8.98 was recorded at sampling station C near Rewa city in the month of May - June. The higher value of pH at sampling station C is possibly because of anthropogenic discharge of drainage directly to the river. Dissolved oxygen is the important parameter of assessment of suitability of water quality because it is essential to sustain different variety of biological life in the water system. Waste discharge effects on water system are determined by the oxygen balance in the aquatic body.

DO is regulator of metabolic activities of living organisms and thus governs metabolism of the biological community as a whole and also acts as an indicator of trophic status of the water body[31]. Oxygen is generally reduced in the water due to respiration of biota, decomposition of organic matter, rise in temperature, oxygen demanding wastes and inorganic reductant such as hydrogen sulphide, ammonia, nitrites, ferrous iron etc[13]. Minimum of 3 mgl^{-1} dissolved oxygen is necessary for healthy fish and other aquatic life[32]. The minimum value of dissolved oxygen were recorded as 3.27 mgl^{-1} at sampling station C in the rainy season and maximum recorded as 11.73 mgl-1 at sampling station B in the month of November-December. Most of the free carbon dioxide in water comes from the decomposition of organic matter and from respiration of organisms[33].

In Bicchiya river, free carbon dioxide ranged from non traceable amount to the maximum value of 17.50 mgl^{-1} at sampling station C in the month of June. Ganapati[34] attributed that the changes in the values of bicarbonates are associated with the rate of photosynthetic activity. Klein[35] suggested that the alkalinity is directly related to the abundance of phytoplankton which dissociate bicarbonate into carbonates and carbon dioxide.[35] The carbon dioxide, thus, released is used in photosynthesis.

Table-2: Comparison of physico-chemical parameters of Bicchiya River with Indian standards IS-2296: 1974

S.No	Parameters	Units	Present Study	Public Water Supply	Fish Culture	Irrigation
1	Turbidity	NTU	1.20-110.00	10 (IS:10500:1991)		
2	EC	$GScm^{-1}$	135.40-884.00		1000.00	
3	TDS	mg^{-1}	220.00-650.00	500		2100.00
4	pH	mg^{-1}	7.80-8.98	6.00-9.00	6.00-9.00	5.50-9.00
5	DO	mg^{-1}	3.27-11.73	>4.00	>3.00	
6	Free CO_2	mg^{-1}	2.40-17.50		6.00	
7	Total Alkalinity	mg^{-1}	70.50-370.00	200-600(IS:10500:1991)		
8	Total Hardness	mg^{-1}	41.00-160.00	300-600(IS:10500:1991)		
9	Chloride	mg^{-1}	11.22-90.94	600.00		600.00
10	Calcium	mg^{-1}	8.62-54.46	74-200(IS:10500:1991)		
11	Sulphate	mg^{-1}	7.40-55.00	200-400(IS:10500:1991)		1000.00
12	BOD	mg^{-1}	0.41-5.24	3.00		
13	Ammonia	mg^{-1}	0.32-0.84		1.20	
14	Sodium	mg^{-1}	10.10-84.30	200.00		

[36]George et al. have opined that with a pH range of 7.0 to 9.0 in water bodies, the bicarbonates concentration remains high.[36] The lowest level of total alkalinity in the Bicchiya river was 70.50 mgl^{-1} at sampling station A in the month of September and highest level was 370.00 mgl^{-1} at sampling station C in the month of May-June. Cation of calcium, magnesium, iron and manganese contribute to the hardness of water[25] .The minimum value of total hardness in the river was 41.00 mgl^{-1} at sampling station A in the month of September and maximum 160.00 mgl^{-1} were observed at sampling station C in the month of February. Chloride concentration in water indicates the presence of organic waste in water, primarily of animal origin[37]. It increases with ammonical nitrogen which is because of mostly to human and animal excretion. Concentration of Chloride in Bicchiya River is found 11.22 mgl^{-1} at sampling station A in the month of August while 90.94 mgl^{-1} at sampling station C in the month of June. According to Indian standards IS-2296: 1974 the chloride concentration for irrigation purpose should be 600.00 mgl^{-1}.

In comparison to Indian standard the chloride concentration was quite low which reflects that there is very less amount of organic waste of animal origin and practically no discharge of municipal and industrial wastes. The calcium is the most abundant substances in natural water being present in high quantities. The calcium level in the river water was observed in the range of 8.62-54.46 mgl^{-1} during April to March. Sulphate in the river varies from minimum of 7.40 mgl^{-1} at sampling station A to maximum of 55.00 mgl^{-1} at sampling station C in the month of April. Major source of phosphate in water are domestic sewage, agriculture effluents and industrial waste waters. In Bicchiya River, phosphate was recorded in the range of 0.006 mgl^{-1} at sampling station A in the month of September to 0.09 mgl^{-1} at sampling station C in the month of October.

Sinha *et al.* have reported higher phosphate content in lower stretch of Ganga River during monsoon season.[38] Silica is quite abundant on the earth but silicates remain small in water. The major source of dissolved silica in river is the weathering of rocks and mineral in the catchments area. Silicate is an essential nutrient for growth of diatoms that are important food to fishes[39]. In Bicchiya silicates were observed from 1.80 mgl^{-1} to 6.60 mgl^{-1}. Biochemical oxygen demand is a pollution indicator which showed its level in river in the range of 0.41 mgl^{-1} at sampling station A to 5.24 mgl^{-1} near Rewa city (sampling station C). Fokmare and Musaddiq[40] recorded high value of biochemical oxygen demand (BOD) as 20.00 mgl-1 in river Purna and said that this river is highly polluted due to organic enrichment, decay of plants and animal matter in the river.[40] Chemical oxygen demand is a reliable parameter for judging the extent of pollution in water[25]. COD is the measure of the oxygen required for chemical oxidation of organic matter. In present study, maximum value of COD (30.60 mgl^{-1}) at sampling station C during May and minimum value (10.20 mgl^{-1}) at sampling station A in August have been recorded. This also provides a direct measure of state of pollution in water bodies[26]. The presence of ammonia is an evidence of sewage inflow to a water system.

However, free ammonia serves as an indicator of aquatic pollution was generally absent or found in traces during most occasions in Narmada river[41]. Bicchiya river had almost nil at sampling stations A and B while reported in sampling station C in the range of 0.23-0.84 mgl^{-1} in month of April. Presence of ammonia in sampling station C reflects towards higher limits. Sulphide indicates the amount of organic matter present in water, degradable by sulphur bacteria. Bicchiya river water showed a range of sulphide at sampling station C in between 0.12-0.38 mgl^{-1} while at Station A and B found in trace amount in the month of May. Sodium, Potassium and magnesium are very important cations occurring naturally. But this concentration in water and soil is of great interest as high sodium contents make soil hard and unsuitable for seedling emergence. Bicchiya water had sodium concentration range 10.10 mgl^{-1} to 84.30 mgl^{-1}. Potassium level were observed minimum 1.12 mgl^{-1} at sampling station A in the month of July whereas maximum in sampling station C 16.10 mgl^{-1} . Magnesium in Bicchiya River varies from 1.21 to 21.10 mgl^{-1} during the period of study.

CONCLUSION

On the basis of various parameters studied, Bicchiya River in this stretch can be placed under oligosaprobic. When various parameters of our study are compared with that of Indian standards (IS, 1974, 1991) for public water supply, fish culture and irrigation, it was revealed that all such parameters are well within the tolerance range (**Table 2**). Alarming condition were found in sampling station C which reflects that quantity of dissolved oxygen is quite low compared to other stations. Apart from this, present study also indicate that station C is growing to create pollution problem compared to rest A and B sampling station. Therefore need to establish some new institutional approach, which deals with current and other associated emerging problems in the management of its water quality.

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