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Environmental quality assessment of Bhavani river water for drinking and irrigation purpose

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ABSTRACT
Maintaining the quality of water is very essential in order to utilize the resource effectively. This study emphasizes on Bhavani River Basin, Tamil Nadu, India. People on globe are under tremendous threat due to undesired changes in the physical, chemical and biological characteristics of air, water and soil. Due to increased human population, industrialization, use of fertilizers and other man-made activity, water is highly polluted with different harmful contaminants. It is necessary that the quality of drinking water should be checked at regular time interval, for safe use. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Human population are suffers from various water borne diseases by consuming polluted water. The present study was conducted to assess the water quality status of river Bhavani from upstream to downstream to know its suitability for drinking and irrigation. Water samples were collected from Vanabhatharakali Amman temple (11⁰ 7' 40" N) (76⁰ 53' 33" E) to Bhavanisagar dam (11⁰ 18' 41.65" N) (76⁰ 55' 52.92" E) at 14 locations over four months from June 2017 to September 2017. The sampling points were fixed at every 2 to 3 km intervals. The collected samples were analyzed for 14 water quality parameters such as pH, EC, Dissolved Oxygen, BOD, Calcium, Magnesium, Sodium, Potassium, Total Hardness, Total Dissolved Solids, Acidity, Alkalinity, Chlorides and E. coli. The water samples collected from all the 14 locations were loaded with high amount of coliforms. In all the location EC, BOD and TDS values were high. Few water quality parameters are within the limit at few locations. On an overall, our study indicates that the water of the entire Bhavani river stretch is not fit for drinking, bathing but it can be used for irrigation.
Key words: *River Bhavani, Water Quality Parameters, Drinking purpose*

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INTRODUCTION

Water is the precious gift of nature for human beings, is being polluted day by day with increasing urbanization. Although three-fourth of the earth is being surrounded by water, a little portion of it can be used for drinking purpose. Water pollution is a phenomenon that is characterized by the deterioration of its quality as result of various human activities. Virtually almost all the surface water in India is unfit for direct consumption. In spite of the fact that the municipal water supply in most of the cities is through treated surface water, due to over contamination, more stringent treatments would be required to make the surface water potable. All living organisms on the earth need water for their survival and growth. Good quality of water is essential for living organisms. Water is most indispensable requirement for all living organisms and any alterations

According to the latest estimates, more than half of Indian rivers and other surface water bodies are now significantly polluted. River pollution is a growing problem and cause of concern in India. In developing countries, as much as 70 percent of industrial waste and 80 percent of domestic waste is said to flow untreated into rivers. In a number of industrialized countries, as well as some countries in transition, it has become common practice to base limits for discharges of hazardous substances on the best available technology. In order to reduce inputs of phosphorus, nitrogen and pesticides from non-point sources (particularly agricultural sources) to water bodies, environmental and agricultural authorities in an increasing number of countries are stipulating the need to use best environmental practices. The quality

of river water is indispensable for yield of crop, maintenance of soil productivity, and protection of the environment [3], Irrigation water usually contains some dissolved salts. They originate from dissolution or weathering of the rocks and soil, including dissolution of lime, gypsum and other soil minerals [5], In irrigated agriculture, the hazard of excessive dissolved salts is a constant threat with respect to water availability to plant, water infiltration, specific ion toxicity, etc. [4, 2], So, evaluation of water used for irrigation is a prime need for sustainable crop production as well as food security. In view of the fact, the present study was undertaken to evaluate the suitability of Bhavani river water for drinking and irrigation purpose.

Bhavani is a 217 km long perennial river fed mostly by the northeast monsoon. Its watershed drains an area of 0.62 million ha spread over Tamil Nadu (87%), Kerala (9%), and Karnataka (4%) mostly the river water is used for agriculture irrigation. Twelve major rivers including west and east Varagar river join Bhavani draining the southern Nilgiri slopes. At Mukkali, Bhavani takes an abrupt 120 degree turn towards the northeastern and flows for another 25 km Attapaddy plateau. It gets reinforced by the Kunda river coming from the north. Siruvani river, a perennial stream and the Kodungarapallam river, flowing from the south and southeast respectively join the Bhavani at Kerala-Tamil Nadu border. The river then flows east along the base of Nilgiris and enters the plains near Vanabathrakali Amman temple at Mettupalayam after joining with Conoor river coming from northwest. In plains it flows through Mettupalayam and reaches Bhavanisagar dam covers a distance of 30 km approximately. Then Bhavani reaches Kodiveri dam 160 km from Bhavanisagar dam. Finally this river joins Kaveri at Kooduthurai.

In between Vanabathrakali Amman Temple to Bhavanisagar dam many textiles, paper, aromatics and tannery units are functioning and they continue to dump thousands of gallons of untreated toxic effluent in the river. According to recent report by TNPCB, 77 illegal dyeing units are now functioning on both sides of the river mainly in Bhavani, Kadayampatti, Sengadu and Servarayanpalayam. The colour of the water flowing in the river has turned black due to the continuous dumping of untreated effluents from industry and domestic sewage. Both side of the river bank, farmers cultivate banana crops. They pump water from the river, the river water contains toxic substances, and it causes toxicity to human through banana. The river is also polluted by number of tea and coffee estate in Nilgiri, as they dump their waste into river. The people of Mettupalayam also discharge the domestic sewage along the river bank. People are bathing and washing their clothes in Bhavani rivers which is also a cause of concern.

Photograph showing the status of River Bhavani (2017)

MATERIALS AND METHODS

Water samples were collected from Vanabhatharakali Amman temple (11^0 7' 40" N) (76^0 53' 33" E) to Bhavanisagar dam (11^0 18' 41.65" N) (76^0 55' 52.92" E) at 14 locations over four months from June 2017 to September 2017. The sampling points were fixed at every 2 to 3 km intervals. The sampling locations are L1 - Vanabathrakali Amman temple, L2 - Samayapuram, L3 - Nanthavanam, L4 - Mettupalayam, L5 - Santhakadai, L6 - Karattumedu, L7 - Karuparayankovil, L8 - Vellipalayam, L9 - Kutharipalayam, L10 - Moolaiyur, L11 - Puthukadu, L12 - Sithankuttai, L13 - Kottakovilpalayam, L14 - Bhavanisagar dam. The water samples were collected in dry and clean polythene container. The collected samples were preserved at 4°C for testing of various water quality parameters throughout the period of analysis. Standard methods were employed during the collection, preservation and analysis of water samples [1].

Table: 1 Water quality standards [6]

S.No.	Parameter	Prescribed Limit by WHO/BIS (Drinking)	Prescribed BIS (Irrigation)
1	pH	6.5 to 9.0	6.99 to 9.05
2	EC	<1.0 dS m^{-1}	0.13 to 1.59 dS m^{-1}
3	Dissolved Oxygen	<4 mg L^{-1}	2.65 to 8.87 mg L^{-1}
4	Biological Oxygen Demand	6 mg L^{-1}	0.08 to 4.52 mg L^{-1}
5	Calcium	75 mg L^{-1}	0.56 to 1.85 mg L^{-1}
6	Magnesium	30 mg L^{-1}	2 to 14 mg L^{-1}
7	Sodium	100 mg L^{-1}	1.20 to 36.60 mg L^{-1}
8	Potassium	200 mg L^{-1}	0.14 to 5.00 mg L^{-1}
9	Hardness	200 mg L^{-1}	35 to 225 mg L^{-1}
10	Total Dissolved Solids	500 mg L^{-1}	52 to 1200 mg L^{-1}
11	Alkalinity	200 to 600 mg L^{-1}	25 to 250 mg L^{-1}
12	Chloride	250 mg L^{-1}	12.76 to 198.0
13	*E.coli*	100 ml	11 to 150 ml

BIS - Bureau of Indian standards, WHO – World Health Organization

RESULT AND DISCUSSION

pH is an indicator of the existence of biological life as most of them thrive in a quite narrow and critical pH range. The water samples collected from Kottakovilpalayam during September 2017 recorded the highest pH about 9.05. The permissible limit of pH of drinking water is 5.5 to 9.0. Except Kottakovilpalayam (9.05) the pH value of Bhavani river is within the prescribed limit (Table 1). In September 2017, Mettupalayam region recorded heavy rainfall. Even though, the pH of the river Bhavani was very high in this particular location. Increase in pH of water may be due to the mixing or discharge of any waste water with alkaline pH.

Electrical conductivity is used as basic index in judging the suitability of water for potable properties. For irrigation water having electrical conductance below 1.0 is normal, 1.0 - 3.0 is critical and above 3.0 is injurious. The EC values of river Bhavani was about 0.13 dS m^{-1} to 1.59dS m^{-1} in the entire study period (Table 2). The investigation shows that the EC value of most of the water samples are under critical value. The EC values of water samples collected at Vanaphathrakali Amman temple, Moolaiyur and Karuparayankovil during the month of June to July 2017 was reportedly high. The reason for the increase in river water may be due to the mixing of domestic waste water/industrial effluent in this region. There is no systematic flow control across the river Bhavani, which needs more attention to arrest the movement of effluent/domestic sewage to the river Bhavani.

Dissolved oxygen (DO) is one of the most important parameters of water quality assessment and reflects the physical and biological processes prevailing in the water and show metabolic balance. For diverse fish population, The DO above 4.0 is good and below 4.0 is not good. For better survival of fish, the DO level must range from 4-6 mg L^{-1} (Table 3). In some of the locations (Samayapuram, Nandhavanam, Karuparayankovil, Kutharipalayam, Moolaiyur, Puthukadu and Sithankuttai) of river Bhavani, the DO value was pretty low and recorded below 4.0 mg L^{-1} during June and August 2017. The DO values were ranged from 2.65 to 8.87mg L^{-1} during the entire study period. The reason for the decrease in DO may be due to the mixing of industrial effluent and domestic sewage in these region and frequent access of human beings in Bhavani River for bathing, washing of cattle's and cloths.

Biological oxygen demand is the amount of oxygen required by the bacteria to decompose the organic matter present in the water. The maximum permissible value of BOD for drinking water is 6 mg L^{-1} and 30 mg L^{-1} for irrigation water. The BOD values of the water samples collected from all the 14 locations were in the range of 0.08 to 4.52 mg L^{-1} and it is below 6 mg L^{-1}, it is a indication that there is much scope to use the water effectively for drinking and irrigation purpose (Table 4). However, the quality of water is not confined to a particular parameter and thus we need to consider other water quality parameters also.

The concentration of Calcium in the river water was varied from 0.56 mg L^{-1} to 1.85 mg L^{-1} and Magnesium varied from 2 to 14 mg L^{-1}. The permissible limit of calcium is 75 mg L^{-1} and 30 mg L^{-1} for Magnesium. According to European Economic Community the limit for sodium is 200 mg L^{-1} and for potassium is 10 mg L^{-1} for drinking water. The value of sodium ranged from 1.20 mg L^{-1} to 36.60 mg L^{-1} (Table 5). The value of potassium ranged from 0.14 mg L^{-1} to 5.00 mg L^{-1}. The present study reveals that the value of sodium and potassium content in the water samples are below the maximum permissible limit.

Hardness refers to the bicarbonates, chlorides and sulphate of Ca, Mg and Na. According to World Health Organization, the permissible limit of hardness as calcium carbonate is 300 mg L^{-1}. The total hardness value ranged from 35 mg L^{-1} to 225 mg L^{-1}. Hence our investigation shows, all the water samples are much below the permissible limit as for as hardness is concern (Table 6).

Total dissolved solid at a given temperature is the material residue left in the vessel after evaporation of a filtered sample and subsequent drying in an oven. Water containing more than 500 mg L^{-1} of TDS is not considered as desirable for drinking water supply and normally less palatable and may induce an unfavorable physiological reaction in the transient consumer. The locations namely Vanaphathrakali Amman temple, Samayapuram, Puthukadu, Sithankuttai during June 2017, Vanaphathrakali Amman temple, Samayapuram, Mettupalayam, Karattumedu, Karuparayankovil, Vellipalayam and Sithankuttai during July 2017 and all the location during August 2017 recorded TDS value above 500 mg L^{-1}. Whereas in the month of September 2017, all the locations were recorded TDS value below 500 mg L^{-1}. In the present investigation, it is seen that TDS value ranged from 52 mg L^{-1} to 1200 mg L^{-1} (Table 7). In June to August 2017, the TDS were exceed the permissible limit, but it was in the safer level during September 2017.

The prescribed limit of chlorides for drinking water is 250 mg L^{-1} (IS 10500). In present investigation, chloride concentration ranged from 12.76 mg L^{-1} to 198.0 mg L^{-1}. Hence all the Chlorides values of river water samples were within the permissible limit (Table 8).

Domestic sewage disposal carries to spread of enteric diseases and the coliforms are the indicators of water pollution. The coliforms are *E. coli*, *Enterobacter aerogenus, Salmonella, Shigella, Streptococci* and *Aeromonas*. The presence of these organisms in water system indicates the contamination of human and animal wastes. The water sample collected across Bhavani river had *E. coli* present for the entire study period. The water samples collected from 14 locations along the river Bhavani over months (June 2017 to September 2017) recorded high level of coliforms ranging from 11 to 150 MPN / 100 ml (Table 9) which are above the limit prescribed by WHO for safe drinking water. In general, the coliform count was high during July 2017 and August 2017. In few locations, namely, Vanabhathrakali Amman temple, Samayapuram, Nandhavanam and Mettupalayam were recorded high amount of coliforms in the month of July and August, 2017. The reason for the high amount of coliform may be due to the mixing of domestic waste water in these region and frequent access of human beings in Bhavani River.

Table 1. Changes in pH of river Bhavani during June 2017 to September 2017

Month	Changes in pH													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
June 2017	7.32	7.31	7.90	7.14	7.22	7.19	7.01	7.17	7.29	7.17	7.08	7.09	7.27	7.29
July 2017	7.36	7.16	7.58	7.35	7.26	7.45	6.99	7.23	7.16	7.56	7.25	7.31	7.42	7.53
August 2017	8.11	8.53	8.61	8.15	8.89	8.42	8.85	8.86	8.32	8.15	8.35	8.25	8.15	8.01
September2017	8.61	8.80	8.70	8.60	9.01	8.98	8.81	8.76	8.94	8.72	8.66	8.36	9.05	8.80

L denote Location; Values are mean of three replications

Table 2. Changes in Electrical Conductivity of river Bhavani during June 2017 to September 2017

Month	Changes in EC (dS m^{-1})													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
June 2017	1.53	0.98	0.38	0.97	0.95	0.53	1.59	0.69	0.42	1.32	0.65	0.38	0.40	0.39
July 2017	1.12	0.53	0.65	0.58	0.65	0.54	1.32	0.53	0.42	0.46	0.23	0.38	0.65	0.45
August 2017	0.98	0.65	0.45	0.45	0.67	0.42	0.98	0.54	0.57	0.65	0.35	0.39	0.55	0.56
September 2017	0.21	0.21	0.21	0.12	0.06	0.13	0.13	0.13	0.16	0.29	0.32	0.31	0.31	0.30

L denote Location; Values are mean of three replications

Table 3. Changes in Dissolved Oxygen of river Bhavani during June 2017 to September 2017

Month	DO (mg L^{-1})													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
June 2017	5.32	2.65	3.75	4.32	5.60	6.20	2.30	5.97	2.52	3.33	2.36	2.68	6.50	4.51
July 2017	6.21	6.55	5.50	6.80	6.56	6.98	5.62	5.50	5.56	6.38	5.58	6.00	6.76	6.57
August 2017	3.35	3.63	3.85	3.52	3.85	3.86	3.72	3.42	3.41	3.33	3.75	3.41	3.26	3.33
September 2017	4.65	5.45	5.85	6.54	7.95	5.90	5.14	5.54	6.65	6.24	7.45	8.87	4.32	4.24

L denote Location; Values are mean of three replications

Table 4. Changes in Biological oxygen demand of river Bhavani during June 2017 to September 2017

Month	BOD (mg L^{-1})													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
June 2017	0.08	2.21	0.56	2.35	0.52	0.08	1.56	0.16	0.24	1.56	2.33	1.53	0.08	0.28
July 2017	0.30	0.35	0.31	0.56	0.38	0.22	0.26	0.38	0.38	0.40	0.45	0.65	0.25	0.15
August 2017	2.35	4.52	3.65	4.51	2.12	3.21	2.26	1.15	3.35	1.25	3.56	2.26	1.15	2.15
September 2017	0.38	0.39	0.42	0.55	0.63	0.22	0.35	0.36	0.65	0.31	0.33	0.38	0.36	0.35

L denote Location; Values are mean of three replications

Table 5. Changes in sodium concentration of river Bhavani during June 2017 to September 2017

Month	Sodium (mg L^{-1})													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
June 2017	3.60	14.21	3.64	17.45	32.00	18.68	13.84	8.45	25.50	18.40	11.20	4.90	14.08	14.24
July 2017	3.60	6.45	7.54	10.23	11.69	13.41	11.24	14.92	2.96	18.25	36.60	14.25	17.70	12.20
August 2017	3.50	4.23	2.48	4.36	8.90	4.21	6.24	7.30	10.4	2.65	4.28	5.60	6.21	6.70
September 2017	3.20	7.10	5.50	8.40	1.20	4.90	4.08	4.24	3.05	1.21	4.80	1.85	2.45	3.65

L denote Location; Values are mean of three replications

Table 6. Changes in Total hardness of river Bhavani during June 2017 to September 2017

Month	Total Hardness (mg L^{-1})													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
June 2017	55	52	68	98	88	52	60	78	56	78	45	60	57	59
July 2017	45	76	86	85	75	68	85	42	87	65	35	86	45	38
August 2017	54	65	75	68	87	53	85	36	85	86	53	75	62	55
September 2017	155	135	135	115	225	115	75	50	80	145	105	70	105	70

L denote Location; Values are mean of three replications

Table 7. Changes in Total Dissolved Solids of river Bhavani during June 2017 to September 2017

Month	Changes in TDS (mg L^{-1})													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
June 2017	800	550	450	230	240	210	340	220	360	110	950	890	230	260
July 2017	900	850	450	620	400	550	750	630	440	365	456	580	490	465
August 2017	800	780	900	750	890	650	1200	605	625	645	680	625	650	654
September 2017	98	120	85	92	52	96	102	97	120	190	230	202	198	194

L denote Location; Values are mean of three replications

Table 8. Changes in Chloride concentration of river Bhavani during June 2017 to September 2017

Month	Chloride (mg L^{-1})													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
June 2017	185.2	139.2	89.5	125.2	122.0	132.5	135.6	185.0	120.3	156.6	198.0	166.3	185.9	157.3
July 2017	125.0	45.0	29.0	40.0	65.0	87.0	42.0	56.0	45.0	25.0	85.0	110.0	24.0	28.0
August 2017	40.0	56.0	85.0	98.0	45.0	68.0	75.0	46.0	45.0	36.0	78.0	49.0	98.0	63.0
September 2017	16.3	14.9	14.9	15.6	13.5	14.9	15.6	14.9	12.8	21.9	23.4	19.1	21.9	21.9

L denote Location; Values are mean of three replications

Table 9. Changes in *E. coli* count of river Bhavani during June 2017 to September 2017

Month	*E. Coli*													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
June 2017	23	45	53	26	26	28	31	65	32	15	22	11	19	35
July 2017	150	123	132	85	92	115	62	85	98	85	68	74	95	65
August 2017	110	135	140	136	117	98	75	65	53	45	42	58	65	62
September 2017	22	19	21	58	52	19	35	26	15	12	15	11	20	42

L denote Location; Values are mean of three replications

CONCLUSION

The water samples collected from all the 14 locations across the river Bhavani does not match the water quality standards prescribed by WHO, moreover the water is loaded with high number of *E. coli* which make the water unfavorable for drinking purpose. The water can be used for irrigation purpose, as the water quality is well within the irrigation water quality parameter prescribed by BIS. From this study it is clearly evident that the quality of Bhavani river water is deteriorating day by day, hence at most care is needed to arrest the movement of domestic sewage and untreated effluent discharge to the river. Focus should be given to establish green belt along the river banks by planting native trees like banyan, ficus, palmera and Jamun for ecosystem stability. Removal of encroachments and closure of illegal industries would protect the water. On an overall, our study indicates that the water of the entire Bhavani river stretch is not fit for drinking, bathing but it can be used for irrigation. If the water is treated properly, it can be used for drinking.

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