Eco. Env. & Cons. 28 (August Suppl. Issue) : 2022; pp. (S272-S277)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i04s.041

Assessment of Drinking Water Quality of Bhavani River in Tamil Nadu, India

K. Ramah[1], R. Premchand[2], K. Sivakumar[3] and M. Tilak[1]

[1]Department of Agroforestry, Forest College and Research Institute, TNAU, Mettupalayam 641 301, Tamil Nadu, India
[2]GKVK, Bangalore
[3]Department of Remote sensing and GIS, TNAU, Coimbatore 641 004, T.N., India

(Received 4 December, 2021; Accepted 25 January, 2022)

ABSTRACT

Fresh water bodies, particularly rivers are getting polluted, thus decreasing the potability of water. A primary reason for this is that all three major sources of pollution *viz*., industry, agriculture and domestic, which are concentrated along the rivers. A study conducted to assess the physico-chemical properties of the Bhavani river water at three locations viz., Avalanche, Mettupalayam and Kooduthurai revealed that two parameters viz., dissolved oxygen and chemical oxygen demand at Mettupalayam and five parameters viz., EC, total dissolved solids, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand at Kooduthurai were beyond desirable limit. In these locations, water has to be treated with treatments such as distillation, reverse osmosis and deionization to make it potable. The river is highly polluted due to discharge of domestic and industrial waste particularly dyeing, textile industries through several drains.

Key words : *Water quality, Bhavani river, Total dissolved solids, Dissolved oxygen and biochemical oxygen demand*

Introduction

India is facing a serious problem of natural resource scarcity, especially that of water in view of population growth and economic development. Fresh water bodies, particularly rivers are getting polluted, thus decreasing the potability of water. A primary reason for this is that all three major sources of pollution *viz*., industry, agriculture and domestic, are concentrated along the rivers. Due to known and unknown urbanization, anthropogenic activities like industrial waste and agricultural waste, the concentration of heavy metal content increases (Karbassi *et al.,* 2008 and Dhanakumar *et al.,* 2015).

It is estimated that there are about 40 million organic compounds known in the environment, which cannot be defined individually with considerable analytical effort and in short time. These parameters reflect effect and material characteristics of one or more substances. The most popular sum parameter in water analysis is the BOD (biochemical oxygen demand), COD (chemical oxygen demand), TOD (total oxygen demand) and TOC (total organic carbon). The TOC reflects the organic pollution on the basis of a direct carbon determination. The other parameters are based on oxygen, which is required to reduce or to oxidise the samples' substances. The BOD indicates the content of oxygen needed to decompose organic compounds in waste water by bacteria. BOD and COD are found to be reliable and useful indicator to relate organic matter content in the river under tropical climate condition. Since

([1]Assistant Professor (Agronomy), [2]Assistant Professor (SS & AC),
[3]Assistant Professor (Agrl. Microbiology)

there are many organics which are rather hard or not possible to decompose biologically, a parameter has been defined indicating the amount of oxygen which would be needed when all organic ingredients would be oxidised completely. These changes make an unfavourable condition for living organisms as it decreases physicochemical parameters, nutrient level and water quality index. Finally the River water reaches the sea and the marine ecosystem gets polluted, which in turn creates a sub-lethal effect in human beings (Theofanis *et al.*, 2001; Jezierska and Witeska, 2006; Udhayakumar *et al.*, 2016).

Bhavani is the second largest and perennial river in Tamil Nadu, India which is a tributary of river Cauvery, which originates from Nilgiri hills of the Western Ghats, enters the Silent Valley National Park in Kerala and flows back towards Tamil Nadu through a total distance of 217 km. Its watershed drains an area of 6,200 sq. km area spread over Tamil Nadu (87%), Kerala (9%) and Karnataka (4%). It flows across three districts of Tamil Nadu, Nilgiris, Coimbatore and Erode. River Bhavani flows through Mettupalayam (Coimbatore District) and enters Erode District at Bhavanisagar Dam and finally reaches Kalingarayan Anaicut at Bhavani. The river confluences with Cauvery river at Kooduthurai, town of Bhavani, Erode district after it travels 185 km distance. About 90 per cent of the river water is used for agriculture. There are more than 100 textile units, 110 leather processing units, 2 sugar factories and 2 distillery units, which use Bhavani river water for their water requirements. Either directly or indirectly, all their effluents reach Bhavani river causing severe pollution, affecting agriculture and causing environmental damage (Kulandaivel *et al.*, 2009). In the study area, the agriculture and forest are the main landuse and land cover. The agriculture land is covering about 52 % of the total geographical area of the basin and forest is occupied by 30 % of the area.

According to recent report from Tamil Nadu Pollution Control Board, 77 illegal dyeing units are now functioning on both sides of river Bhavani (Sivakumar *et al.*, 2018). These dyeing units discharge toxic effluents directly into the river water continuously which have caused a serious threat to the environment and resulted in destroying Erode's agricultural sector. A study conducted by Sivakumar *et al.*, (2018) indicates that the water of the entire Bhavani river stretch is not fit for drinking, bathing but it can be used for irrigation. The Bhavani river water should be treated properly and disinfected before being supplied for industrial purposes and human consumption (Gopalswamy *et al.*, 2003). According to a report by Tamil Nadu Water Supply and Drainage Board, Bhavani river water, which is supplied to 1.5 lakh residents of Mettupalayam for potable purpose, is unfit for consumption (Times of India, Jan 16, 2017). Surface water, open wells and bore wells are often unsuitable for domestic, industrial, or agricultural use, due to high levels of pollution from urban and industrial processes.

With these background informations, the present study was conducted to assess the physico-chemical properties of the Bhavani river water at three locations and to give basic information on drinking water quality along the course of river by following standard procedures (Table 1).

Materials and Methods

Water samples were collected from three locations along the flow course of river Bhavani, Tamil Nadu, India during 2015-16 (Fig. 1). The first sample was taken at Avalanche (11°16′44.09"N, 76°34′3.31"E), Nilgiris district which is the source of Bhavani river. The second sample was taken from Mettupalayam

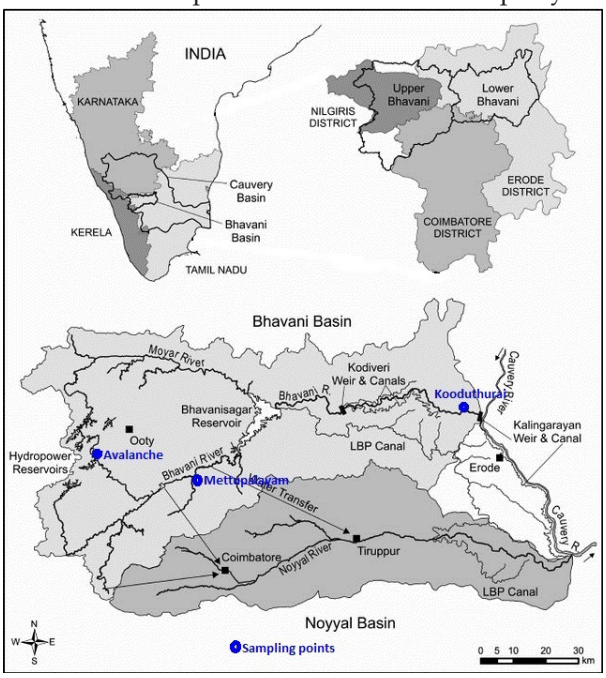

Fig. 1. Location map showing three sample points in Bhavani river basin

(11°18'41.69"N, 76°55'52.96"E), Coimbatore district, under the Bhavani bridge. The third sample was taken from Kooduthurai (11°26'19.67"N, 77°40'55.18"E), Bhavani, Erode district before the confluence point of Bhavani with Cauvery river. The physico-chemical properties of the water samples were analysed by following standard analytical procedures.

Parameters for assessing the water quality of the study areas: Quality of the water is the physical, chemical, and biological characteristics of water in association to the set of standards which has direct relation to the Water potability.

pH: pH is defined as the negative logarithm of hydrogen ion concentration or the log of the reciprocal of the hydrogen ion concentration. pH = -log (H^+). A glass electrode in contact with H^+ ions of the solution acquires an electric potential which depends on the concentration of H^+ ions. This is measured potentiometrically against some glass electrode which is usually a calomel electrode. The potential difference between glass electrode and calomel electrode is expressed in pH units (Jackson, 1973).

Electrical Conductivity (EC): The electrical conductivity (EC) measurement gives the total amount of soluble salts present in the water and is expressed as millimhos/cm or dSm^{-1} .The electrical conductivity is measured in terms of the resistance offered to the flow of current using a conductivity bridge (Jackson,1973).

Dissolved Oxygen (DO): DO is the dissolved gaseous form of oxygen. It is measured by following Winkler's method. The sample was collected in 300 ml bottle and DO was fixed on site by using 1 ml each of manganous sulphate and Alkaline-Iodide Azide. The precipitate formed was dissolved in laboratory by using Sulphuric acid and titrated with sodium thiosulphate using starch as an indicator. The end point of titration was blue to straw pale colour.

$$DO\ (mg/l) = \frac{\text{Volume of titrate (ml) x Normality x 8}}{(V2\ (V1 - V2)/V1)}$$

Biochemical Oxygen Demand (BOD): BOD is analysed by Modified Winkler method. The Azide modification of the Winkler method is the standard test for dissolved oxygen. In the analysis, manganous ion reacts with the dissolved oxygen in the alkaline solution to form a manganese (IV) oxide hydroxide flocculent. Then, Azide is added to suppress interference from nitrite, which would react with the iodide. Then, the solution is acidified and the manganese (IV) floc is decreased by iodide to make free iodine as I3– in proportion to the oxygen concentration. Then, the liberated iodine is titrated to the starchiodide end point (APHA, 1998).

Chemical Oxygen Demand (COD): COD is an important parameter in water-pollution control analysis. COD often is used as a measurement of pollutants in wastewater and natural waters. The COD is analysed by standard open reflux method (APHA, 1998). Here, the sample is added to Potassium dichromate (digestion solution) and sulphuric acid which is digested and refluxed for two hours. Then titrated with standard 0.10 M FAS. Ferroin indicator is added. This indicator is used to indicate change in oxidation-reduction potential of the solution and indicates the condition when all dichromate has been reduced by ferrous ion. The end point is a sharp color change from blue-green to reddish brown. A blank is also run simultaneously along with the samples. The excess Potassium dichromate left after the oxidation is back titrated against FAS and the COD is given as

COD (mg O_2/l) = [(A-B) × M×8000) / (V sample)

Where: A = volume of FAS used for blank (ml)

B = volume of FAS used for sample (ml)

M = molarity of FAS

8000 = milli equivalent weight of oxygen (8) ×1000 mL/l

Total Dissolved Solids (TDS): Gravimetric methods are the most accurate and involve evaporating the liquid solvent and measuring the mass of residues left. This method is generally the best, although it is time-consuming. If inorganic salts comprise the great majority of TDS, gravimetric methods are appropriate (Gupta, 2002).

Nitrates : Nitrates in drinking water are analysed by Nitrate Electrode Method which is useful for Nitrate concentration range of 0.14 to 1400 mg/L NO_3-N (APHA, 1998)

Chlorides: Chloride in the drinking water is determined by titration with standard silver nitrate, using potassium chromate as an indicator. Silver chloride is quantitatively precipitated before flesh red silver chromate is formed. This method is refered as Argentometric method (APHA, 1998).

Chloride mg/L = (A-B) x N x 35.45 x 1000 ml sample

Where,

A = ml of $AgNO_3$ required for sample
B = ml of $AgNO_3$ required for blank
N = Normality of $AgNO_3$ used

Results and Discussion

The analysed results of the physic-chemical properties of the study samples of Bhavani river are presented in Table 2.

pH is one of the most important factor that indicates the pollution level of the water. The pH values of all the sample locations were within the permissible limit (6.5-8.5). This finding of pH within permissible limit was in confirmity with the findings of Varunprasath and Nicholas Daniel (2010) and Sivakumar *et al.,* (2018). According to Bauder *et al.,* 2004, a proper biological treatment of wastewater is required for pH between 6.5 to 8.0. Hence, in study areas the pH values has not exceeded the standard limit however these were falling in basic or alkaline range.

The Electrical conductivity is a parameter used to evaluate the potability of drinking water. The EC values of the three samples ranged from 0.15 dS m^{-1} (Avalanche), 0.33 dS m^{-1} (Mettupalaym) and 0.85 dS m^{-1} (Kooduthurai). As per the BIS standard, the water sample taken from Kooduthurai was higher than the desirable limits. Pure water is not a good conductor of electric current rather a good insulator. These results clearly indicate that water in study areas was considerably ionized and has the higher level of ionic concentration activity due to excessive dissolved solids. Thus, it is a fine conductor of electric current.

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc. Total dissolved solids (TDS) in drinking water originates from sewage to urban industrial wastewater. Therefore, TDS test is considered a sign to determine the general quality of the water. Hence, it is advisable to lower down the TDS to determine its potability. The TDS value of Kooduthurai slightly exceeded the limit (500 mg $litre^{-1}$) which was recorded as 543 mg $litre^{-1}$, whereas the samples of Avalanche (98 mg $litre^{-1}$) and Mettupalayam (214 mg $litre^{-1}$) are in the desirable limits.

Dissolved oxygen plays an important role in water quality determination and also essential for aerobic metabolism of all aquatic organisms. Dissolved

Table 1. Methodologies followed for the assessment of drinking water quality

Properties	Methodology	Reference
pH	Potentiometry	Jackson (1973)
Electrical conductivity	Conductivity bridge	Jackson (1973)
Dissolved Oxygen	Modified Winkler method	APHA (1998)
Biological Oxygen Demand	Modified Winkler method	APHA (1998)
Chemical Oxygen Demand	Chromic acid Reflux method	APHA (1998)
Total Dissolved solids	Gravimetric method	Gupta (2002)
Nitrates	Nitrate Electrode method	APHA (1998)
Chlorides	Argentometric method	APHA (1998)

Table 2. Physico-chemical characteristics of river Bhavani at Avalanche, Mettupalayam and Bhavani

Sl. No.	Parameters	Locations			WHO Standards	BIS 10500 (2012)	
		Avalanche	Mettupalayam	Kooduthurai		Desirable limits	Permissible limits
1	pH	6.8	7.1	7.6	7.8	6.5-8.5	-
2	EC (dS/m)	0.15	0.33	0.85	-	0.05-0.5	-
3	TDS (mg/l)	98.0	214	543	500	500	2000
4	DO (mg/l)	6.3	3.8	2.4	>6	-	-
5	BOD (mg/l)	2.3	4.8	6.4	-	<5	-
6	COD (mg/l)	9.3	38.0	40.0	<10	-	-
7	Chlorides (mg/l)	20.5	36.8	38.2	200	250	1000
8	Nitrates (mg/l)	28.0	28.0	34.0	45	45	100

oxygen concentration values can be affected by the water temperature as the solubility of oxygen is a function of temperature and photosynthesis (Ahmad and Alam, 2003). Among the study samples, the dissolved oxygen level was found to be adequate in Avalanche sample (6.3 mg litre^{-1}), whereas the value was very low in the other two samples drawn from Mettupalayam and Kooduthurai, which might be due to the discharge of effluents from dyeing units surrounding Mettupalayam and Bhavani. The effluents of dyeing industries contain oxidizable organic matter resulting in bio-degrading and decay of vegetation. This finding was in conformity with the findings of Sivakumar *et al.,* (2018) and Varunprasath and Nicholas Daniel (2010). Kulandaivel *et al*., (2009) also confirmed that the DO value was greater in Nilgiri and decreased when the Bhavani river water reached the plains.

BOD and COD are used to determine the organic pollutant present in the river water, it is of paramount important to determine the correlation of BOD and COD for measurement of pollutants in the river water. Regarding the BOD levels, the water sample taken from Kooduthurai recorded 6.4 mg litre^{-1} which was higher than the desirable limit of 5 mg litre^{-1}, while, the BOD value of Avalanche and Mettupalayam was 2.3 mg litre^{-1} and 4.8 mg litre^{-1}, respectively indicating that the water from Avalanche and Mettupalyam may be used for domestic purpose with proper treatment, however, the water from Kooduthurai was polluted due to discharge of chemicals from dyeing and textile industries along the banks of the river Bhavani and hence it is unsafe to use for domestic purposes. Similar findings of higher BOD was reported in Bhavani River at Mettupalayam and Sirumugai by Varun Prasath and Daniel (2010). The meager presence of free oxygen in water is a clear indication of the inability of that water to support biological life present in water. This may be due to mixing of untreated industrial effluents and dumping of municipal solid waste into sewage water. The high value of BOD may be due to extensive use of organic nutrients (Charu *et al.,* 2006). Usually the microorganisms require more oxygen to reduce the high organic nutrients present in sewage.

The COD value of Mettupalayam and Kooduthurai samples were higher than the permissible limit of 10 mg litre^{-1}. Hence the water has to be purified by evolving suitable aerobic treatment by oxygen pumping and may be used for domestic purposes. Similar findings was revealed by Gaikwad and Sasane, 2013 in Lonar lake indicating the lake water should need some degree of treatment before consumption. The chlorides and nitrates of all the three locations were within the consumable limits as prescribed in Table 2.

Conclusion

The results from this study revealed that two parameters viz., DO and COD at Mettupalayam and five parameters viz., EC, TDS, DO, BOD and COD at Kooduthurai were beyond desirable limit. In these locations, water has to be treated with treatments such as distillation, reverse osmosis and deionization to make it potable. The river is highly polluted due to discharge of domestic and industrial waste particularly dyeing, textile industries through several drains. BOD:COD ratio can be used as crucial attribute for characterization of river and critical indicator for pollution measurement in the river water study. Further studies however are to be conducted for the correlation of BOD:COD base on other technical criteria and consideration. However, there could be gross differences in the test results of some samples at different laboratories, which could limit the use of these data for sensitive policy issues. The differences might be attributed to the approach adopted by laboratories in sample preservation, quality of chemicals used, testing method applied or qualification or expertise of the technicians or test performers

Acknowledgements

Authors wish to thank all the fellow scientists and students who have supported this work.

Conflict of Interest

We, authors' declare that there is no conflict of interest arising in publishing the article

References

APHA. 1998. *Standard Methods for the Examination of Water and Wastewater.* 20th ed. American Public Health Association, Washington, DC.Pp:5-13,5-18

Ahmad, A. and Alam, M. 2003. Physico-chemical and toxicological studies of industrial effluents in and around Delhi and groundwater quality of some ar-

eas in Delhi city. *Cheml Environ Res.* 12 (1& 2) : 5-13.

Bauder, T.A., Cardon, G.E., Waskom, R.M. and Davis, J.G. 2004. Water Quality Criteria, http://www.ext.colostate.edu/pubs/crops/00506.html.

BIS. 2012. Bureau of Indian Standards. *Indian Standard* drinking water — specification.

Bremner, J.M. 1965. *Total nitrogen*. Agronomy **9**: pp: 1149-78.

Charu, P., Savita, D. and Rajnish Shrivastava, 2006. Seasonal variations in Physico-chemical characteristics in upper lake of Bhopal. *Asian J. Exp. Sci.* 20 (2) : 297-302.

Dhanakumar, S., Solaraj, G. and Mohanraj, R. 2015. Heavy metal partitioning in sediments and bioaccumulation in commercial fish species of three major reservoirs of river Cauvery delta region, India. *Ecotoxicol. Environ. Saf*. 113 : 145-151.

Gaikwad, R.W.V. and Sasane, V. 2013. Assessment of ground water quality in and around Lonar lake and possible water treatment. *International Journal of Environmental Sciences.* 3(4).

Gopalaswami, P.M., Kumar, P.E. and Kulandivelu, A.R. 2003. Study on the quality of water in the Bhavani river. *Asian J. Chem.* 15(1) : 306-310.

Gupta, P.K. 2002. *Methods in Environmental Analysis: Water, Soil and Air.* Agrobios (India).

Jackson, M.L. 1973. *Soil Chemical Analysis.* Prentice Hall of India. Pvt. Ltd., New Delhi.

Jezierska, B. and Witeska, M. 2006. Soil and Water Monitoring, Protection and Remediation. In: *The metal uptake and accumulation in fish living in polluted waters* (ed. Irena Twardowska, *et al.*), Springer, Poland, PP.110.

Karbassi, A.R., Monavari, S.M., Bidhendi, G.R.N., Nouri, J. and Nematpour, K. 2008. Metal pollution assessment of sediment and water in the Shur River. *Environ. Monit. Assess.* 147(1-3) : 107.

Kulandaivel, A. R. K., Kumar, P. E., Perumal, V. and Magudeswaran, P. N. 2009. Water Quality Index of River Bhavani at Erode Region, Tamil Nadu, India. *Nature Environment and Pollution Technology*. 8(3) : 551–554.

Sivakumar, S. M. Prasanthrajan S. Shalini and J. Jaya Sri Balaji. 2018. Environmental quality assessment of Bhavani river water for drinking and irrigation purpose. *Bull. Env. Pharmacol. Life Sci*. 7(6) : 24-29.

Theofanis, Z.U., Astrid, S., Lidia, G. and Calmano, W.G. 2001. Contaminants in sediments: remobilisation and demobilization. *Sci. Total. Environ.* 266: 195-202.

Udhayakumar, R., Manivannan, P., Raghu, K. and Vaideki, S. 2016. Assessment of physico-chemical characteristics of water in Tamilnadu. *Ecotoxicol. Environ. Saf.* 134 : 474-477.

Varunprasath, K. and Nicholas A. Daniel. 2010. Physico-chemical parameters of River Bhavani in three stations, Tamil Nadu, India. *Iranica Journal of Energy and Environment.* 1(4) : 321-325.

WHO. 2012. "Standards for drinking water quality" – World Health Organization, Geneva.