International Journal of Environmental and Ecology Research
www.environmentaljournal.in
Online ISSN: 2664-7117, Print ISSN: 2664-7109
Received: 10-05-2021, Accepted: 25-05-2021, Published: 09-06-2021
Volume 3, Issue 2, 2021, Page No. 14-19

Water quality assessment of Vashi creek (Maharashtra) of India by Nemerow pollution index

Sandip Chordiya[1], Prasad Bankar[2], Mayur Shitole[3*]
[1] Head and Assistant Professor, Department of Zoology, Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati, Dist. Pune, Maharashtra, India
[2] Assistant Professor, Department of Botany, Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati, Dist. Pune, Maharashtra, India
[3] Research Scholar, Department of Zoology, Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati, Dist. Pune, Maharashtra, India

Abstract
Water is the basic need of every living form including plants, animals, human, and microorganisms. Recent unplanned industrialization, rapid urbanization, and destruction of water resources, including the use of them as waste dumping grounds, deforestation, and depletion of water resources, have all played a role in the deterioration of aquatic environment on the earth. The Water Quality Index makes it easier to communicate knowledge about water quality patterns to the general public, policymakers, and water quality managers by simplifying the understanding of various physicochemical parameters. In the present study, Nemerow's Pollution Index (NPI) was used to assess the water quality of Vashi Creek using Indian Council of Medical Research and BIS standards. Data from 2008 to 2019 of Vashi Creek was extracted from the publically available database of the "ENVIS Centre on Control of Pollution Water, Air, and Noise". The extracted data was analyzed for water physicochemical parameters as well as NPI water quality analysis. NPI water quality analysis revealed that conductivity and BOD both exceeded the acceptable limit.

Keywords: water quality, physicochemical parameters, nemerow pollution index, vashi creek

Introduction
The fundamental necessity of human physiology is to drink high-quality water. Overuse of natural resources has occurred since the beginning of human civilization as a result of unbridled greed, resulting in unprecedented destruction. Recent unplanned industrialization, rapid urbanization and destruction of water resources, including the use of them as waste dumping grounds, deforestation and depletion of water resources are some challenges in monitoring water quality. Wastewater is the sewage that has been used. It comes from sinks, baths and toilets as well as commercial, manufacturing and agricultural operations that bring solvents, metals and toxic sludge. Rainfall brings road salts, chemicals, tar, grease and debris from impermeable surfaces into aquatic sources like rivers, streams, lakes and other aquatic sources (Alrumman *et al.*, 2016) [3]. When hazardous substances, such as chemicals or microorganisms, contaminate a stream, aquifer, lake, river, ocean or other sources of water, the water quality degrades and becomes harmful to humans or the ecosystem. Water is particularly susceptible to pollution. Water, also known as a "universal solvent", can dissolve more substances than any other liquid on the earth. It's also the reason why water is so easily contaminated. Toxic compounds from fields, towns and factories easily dissolve and combine with it, polluting the water. Most of the solid waste, such as plastic bags and soda cans, is washed into sewers and storm drains before being dumped into water sources, turning them into trash soup and forming floating garbage patches. Waterways are also contaminated by chemicals and heavy metals from industrial and urban wastewater (Kumari & Chaurasia, 2015) [13]. These toxins are toxic to aquatic life and find their way up the food chain as predators eat prey, limiting an organism's life span and ability to reproduce. This is how tuna and other large fish accumulate large amounts of pollutants like mercury. Waterborne diseases, such as disease-causing bacteria and viruses from human and animal waste, are a significant source of illness caused by polluted drinking water. Cholera, giardia, and typhoid are some of the diseases caused by contaminated water. Coliforms are bacteria that are found in the waste of animals, including humans, and are often present in their digestive tracts (Seo *et al.*, 2019) [17]. Total coliform bacteria are the most basic measure for bacterial contamination of a water source which provides a general indicator of a water supply's sanitary state. Fecal coliforms are a subset of total coliforms found in the gut and feces of warm-blooded animals and are considered a more reliable indicator of animal or human waste than total coliforms because their sources are more precise. *E. coli* is regarded as the best predictor of faecal contamination and the potential presence of pathogens in the coliform bacteria (Divya & Solomon, 2016) [8]. According to Samlafo & Ofoe, (2018) [16], Monitoring water physicochemical parameters provides scientific evidence that can be used to help in public health and environmental decisions. Monitoring water quality in the twenty-first century is becoming more complex due to the large number of contaminants used in our daily lives and in commerce that can end up in bodies of water. A variety of water quality targets must now be met by governments, towns,

and industries. Data from monitoring can be used to determine whether or not pollution regulations are being followed.

Water quality analysis is used extensively in environmental monitoring. When water quality is poor, it has ramifications for both marine life and the climate. Water quality is determined by numerous factors. Based on the desired water parameters, physicochemical and biological water quality parameters can be calculated and monitored. Some of the most significant water quality parameters are temperature, pH, dissolved oxygen, turbidity, and conductivity (Al-Othman, 2015; Singh & Shrivastava, 2015) [2, 18]. Additional parameters such as total algae, ammonia, nitrate, chloride, or laboratory parameters such as BOD, COD, as well as elemental analysis of Heavy metal ions and other metal ions such as Mg, Zn, Cu, and Fe (Zhong *et al.*, 2015; Wang *et al.*, 2019) [23, 22] can be determined during water quality monitoring. The present study was conducted to assess the water physicochemical parameters of Vashi Creek obtained from Vashi Creek using Indian Council of Medical Research standards. A Water Quality Index (WQI) is a method for summarizing water quality data in a consistent manner for public reporting (Boah *et al.*, 2015) [4]. It's close to the UV index or an air quality index, and it informs us what the quality of drinking water from a given source is in simple terms. There are numerous indices for evaluating water quality that has already been established (Srinivas *et al.*, 2012; Effendi *et al.*, 2015) [11, 9]. The Nemerow Pollution Index (NPI) was established by Nemerow and Sumitomo and is a very important pollution index that provides information about the parameters that induce changes in the water quality status of any water body. Thus NPI analysis is useful for determining pollutant parameters in water quality and is beneficial in terms of obtaining fast and easy water quality assessment results (Dawood, 2017) [6]. The current study evaluated the physicochemical parameters that can cause water pollution and also assessed the water quality status of Vashi Creek by Nemerow's Pollution Index (NPI) using water quality standards of Indian Council of Medical Research and BIS standards [11, 13].

Methodology

Data Collection

The data of water quality of Vashi Creek was extracted from the "ENVIS Centre on Control of Pollution Water, Air, and Noise" database (http://www.cpcbenvis.nic.in/)[1], which is hosted by the Central Pollution Control Board and sponsored by the Ministry of Environment and Forests of India. Vashi Creek is a tributary of Thane Creek. Thane Creek connects to the Ulhas River in the north through a small link, which connects it to the Mumbai harbor. The creek, however, runs from the river to the Vashi Bridge. Recognizing the importance of environmental data, the Government of India established an 'Envis Centre on Control of Pollution Water, Air, and Noise' in December 1982. ENVIS has focused on delivering environmental information to decision makers, scientists and engineers, policy planners, researchers and others around the country since its inception. The database consists of information on air, water and noise pollution. Water quality data for Vashi Creek was extracted from the publicly available "ENVIS Centre on Control of Pollution Water, Air, and Noise" database[1] and analyzed for seven physico-chemical parameters including temperature, pH, dissolved oxygen (DO), Biological Oxygen Demand (BOD), conductivity, Fecal coliforms and Total coliforms over a 12-years period from 2008 to 2019. The data was from two sites namely Airoli Bridge & Vashi Bridge of Vashi Creek. Also analysis of NPI water quality index of Vashi Creek was done.

Nemerow's Pollution Index (NPI) analysis

The Nemerow index is a water quality metric (Swati & Umesh, 2015) [19]. The pollution-causing parameters were determined by averaging the minimum and maximum values of water physicochemical parameters in Vashi Creek over a 12-years period, as shown in Table-1. The NPI for all parameters in each value is calculated, allowing the pollution-causing parameters to be specified.

NPI was calculated by using following formula-

$$\mathrm{NPI} = \frac{\mathrm{Cn}}{\mathrm{Ln}}$$

Where, C_n represents observed concentration of n^{th} parameter and L_n represents acceptable limit of n^{th} parameter.

The unit for C_n and L_n in the above equation should be same. Each NPI value reflects the contribution of each single parameter to causes pollution. NPI is unitless measurement. The L_n values for different water quality parameters are shown in Table-2. An NPI value greater than 1.0 denotes the presence of impurity in water. Using Nemerow's Pollution Index (NPI), the pollution parameters at each station were calculated.

Statistical analysis

The NPI water quality index method was used to analyze the extracted data from the "ENVIS Centre on Control of Pollution Water, Air and Noise" database to assess the responsible parameters affecting Vashi Creek water quality over a 12-years period from 2008 to 2019.

Result & Discussion

The pH is an important chemical factor concerning water quality (Madan *et al.*, 2018)[14] and it is directly impacts on productivity of lake (Desai, 2014)[7]. It is the negative logarithm of hydrogen ion (H^+) concentration that measures the relative amount of free hydrogen and hydroxyl ions in the water. The pH scale runs from 0 to 14, with 7 serving as a neutral pH, whereas pH less than 7 indicates acidic pH and greater than 7 indicates alkaline (basic) pH. In present study, from 2008 to 2019, pH was recorded slightly alkaline ranging between 7.1 to 8.1 at Airoli Bridge with a mean of 7.6 ± 0.3 and 7.2 to 8.1 at Vashi Bridge with a mean of 7.5 ± 0.3. For all 12 years, pH was reported within acceptable limit with NPI value ranging from 0.84 to 0.95 at both Airoli Bridge and Vashi Bridge (Figure-1; Table-1 & 3).

The temperature is a significant physicochemical parameter due to its effect on water chemistry. At higher temperature, the rate of chemical reactions tends to increase. The higher temperature allows water, especially groundwater, to dissolve more minerals from the surrounding rock, resulting in increased electrical conductivity. Ptak *et al.* (2019) [15] also reported that temperature has an impact on dissolved oxygen concentration since the oxygen holding ability of warmer water is lower than that of colder water. In present study, from 2008 to 2019, the temperature was ranging between 20 ^{0}C to 30 ^{0}C at Airoli Bridge with a mean of 26.1 ± 2.6 ^{0}C and 24.5 ^{0}C to 32.5 ^{0}C at Vashi Bridge with a mean of 28.3 ± 3.0 ^{0}C. The temperature was excluded from NPI analysis as there is no standard has been given by ICMR or BIS for temperature (Figure-1; Table-1 & 3). Dissolved oxygen (DO) is a key indicator of water quality and it's concentration varies due to biological processes such as photosynthesis by aquatic plants releases oxygen into the water as a byproduct (Desai, 2014) [7]. Thakor *et al.* (2011) [21] noticed that fish and other aquatic life cannot survive when dissolved oxygen levels fall too low. The high level of dissolved oxygen in drinking water contributes to the better test of water. But these high levels can damage the components and systems of water treatment plants. To understand water quality and what treatments may be needed, dissolved oxygen must be assessed. In present study, from 2008 to 2019, DO was ranging between 4.3 to 5.5 mg/L at Airoli Bridge with a mean of 4.8 ± 0.4 mg/L and 4.6 to 5.3 mg/L at Vashi Bridge with a mean of 4.9 ± 0.4 mg/L. At Airoli Bridge, DO was reported within the acceptable limit for years- 2010 to 2011 & 2013 to 2017 with NPI values ranging between 0.85 to 0.95. At Vashi Bridge, DO was reported within the acceptable limit for years- 2008 to 2010, 2013 & 2016 to 2019 with NPI values ranging between 0.77 to 1.0. For some time point, DO was found to exceed the acceptable limit slightly at both Airoli Bridge and Vashi Bridge (Figure-1; Table-1 & 3).

The potential of an aqueous solution to conduct an electrical current is measured by its conductivity. An ion is a negative or positive state generated by an atom of an element that has gained or lost an electron. Micromhos per centimeter (µmhos/cm) and microsiemens per centimeter (µS/cm) are the units of conductivity. Specific conductance, also known as conductivity, is a calculation of ionic strength that does not reveal the presence of specific ions (Bora and Goswami, 2016) [5]. In a study on water quality index of Kolong River by Bora & Goswami, (2016) [5], it was found that the significant changes in conductivity indicates the contamination has reached the water body from a discharge or another source. In present study, from 2008 to 2019, conductivity was ranging between 21772.0 to 30476.0 µmhos/cm at Airoli Bridge with a mean of 26984.8 ± 2294.9 µmhos/cm and 20841.5 to 41310.0 µmhos/cm at Vashi Bridge with a mean of 29274.0 ± 5600.6 µmhos/cm. For all 12 years, conductivity was reported to exceed the acceptable limit with NPI values ranging from 72.57 to 101.59 at Airoli Bridge and 69.47 to 137.70 at Vashi Bridge (Figure-1; Table-1 & 3). The amount of oxygen consumed by aquatic life and microorganisms is measured by biochemical oxygen demand (BOD). Thakor *et al.* (2011) [21] reported that certain environmental stresses such as high temperature and human-induced factors includes the addition of excessive fertilizers, domestic wastewater release to a water body reduces the amount of dissolved oxygen in a water body, putting local aquatic life under stress. The calculation of biochemical oxygen demand is used to understand the impact of aquatic life and microorganisms on the amount of oxygen they consume (BOD). In present study, from 2008 to 2019, BOD was ranging between 7.9 to 42.9 mg/L at Airoli Bridge with a mean of 20.3 ± 24.7 mg/L and 7.5 to 38.8 mg/L at Vashi Bridge with a mean of 12.9 ± 8.3 mg/L. For all 12 years, BOD was reported to exceed the acceptable limit with NPI values ranging from 1.58 to 18.50 at Airoli Bridge and 1.50 to 7.76 at Vashi Bridge (Figure-1; Table-1 & 3). Total coliform bacteria are harmless and commonly found in the environment. The presence of fecal coliform bacteria in the water body indicates that water has been polluted by human or animal feces. Source of coliform considered environmental if only total coliform bacteria are present in water (Divya & Solomon, 2016; Seo *et al.*, 2019) [8, 17]. In present study, from 2008 to 2019, Fecal coliforms were ranging between 65.0 to 935.0 MPN/100ml at Airoli Bridge with a mean of 492.3 ± 311.5 MPN/100ml and 66.0 to 965.0 MPN/100ml at Vashi Bridge with a mean of 407.3 ± 279.4 MPN/100ml. Whereas Total coliforms were ranging between 300.0 to 1075.0 MPN/100ml at Airoli Bridge with a mean of 764.1 ± 251.9 MPN/100ml and 237.0 to 965.0 MPN/100ml at Vashi Bridge with a mean of 703.6 ± 273.9 MPN/100ml (Figure-1; Table-1 & 3). Divya and Solomon, (2016) [8] found that the presence of E. coli in the water of the Chalakudy River points toward the existence of domestic pollution. In the same study, the total coliforms and fecal coliforms were found in a range between 100 MPN/100ml to 840 MPN/100ml and 10 CFU/100ml to 220CFU/100ml, respectively. Here CFU is stands for "Colony Forming Units". According to a study by Tambe and Gotmare (2017) [20], physicochemical analysis of water of Vashi Creek from July-2016 to August-2016 reported that the water of Vashi creek was unfit for drinking due to the high level of BOD. Also, pH was found within the standard limit. The present study also reported the same results. But the study by Tambe & Gotmare (2017) [20] was carried out for a limited time period of two months. Therefore, the current study has covered the time period of 12 years which can be helpful to make long-lasting decisions and actions to maintain the water quality of Vashi Creek.

Conclusion

The "Nemerow pollution index (NPI)" method for water quality assessment of extremely human-impacted aquatic systems currently has limited information. The normal composition of the water is most likely to be altered as a result of anthropogenic activities. Based on the NPI findings, it can be concluded that successful treatment steps are urgently needed to improve water quality by establishing an adequate water quality management plan, which will then help any possible plan for sustainable creek restoration. Water quality must be monitored on a regular basis in order to determine the extent of contamination and take the necessary corrective and preventative actions.

Figure

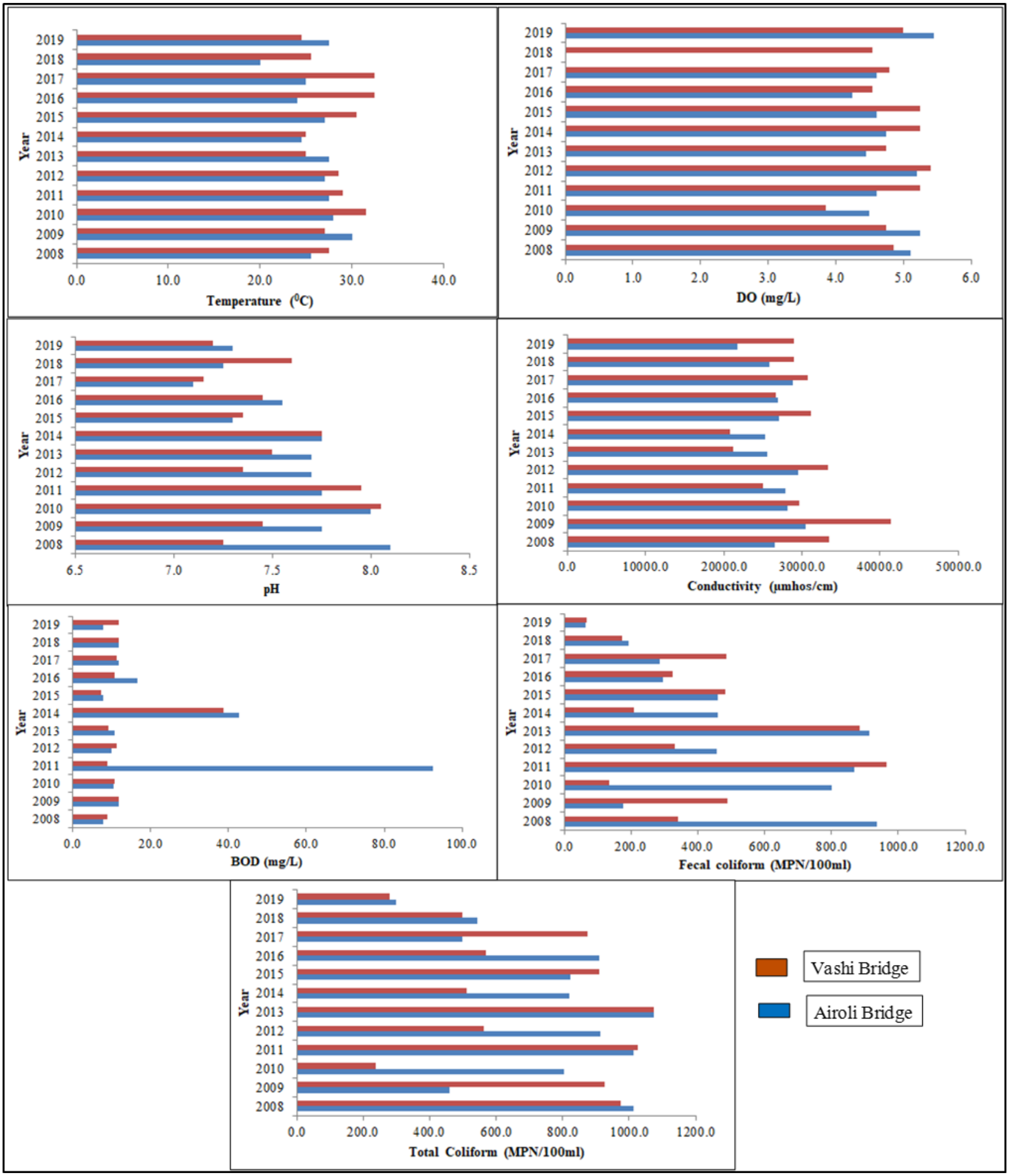

Fig 1: Values of water physico-chemical parameters of Vashi Creek.

Table:

Table 1: Values of Water physico-chemical parameters of Vashi Creek (Values given in table are mean values of maximum and minimum).

Year	Name of site of Vashi Creek													
	Airoli Bridge							Vashi Bridge						
	Temperature (^{0}C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	BOD (mg/L)	Fecal coliform (MPN/100ml)	Total Coliform (MPN/100ml)	Temperature (^{0}C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	BOD (mg/L)	Fecal coliform (MPN/100ml)	Total Coliform (MPN/100ml)
2008	25.5	5.1	8.1	26507.0	8.0	935.0	1012.0	27.5	4.9	7.3	33460.0	9.0	340.0	975.0
2009	30.0	5.3	7.8	30476.0	12.0	178.0	458.0	27.0	4.8	7.5	41310.0	12.0	490.0	925.0
2010	28.0	4.5	8.0	28100.5	10.5	801.0	803.0	31.5	3.9	8.1	29593.0	11.0	135.0	237.0
2011	27.5	4.6	7.8	27833.0	92.5	870.0	1012.0	29.0	5.3	8.0	25071.5	9.0	965.0	1025.0
2012	27.0	5.2	7.7	29580.0	10.2	456.0	912.0	28.5	5.4	7.4	33369.5	11.4	330.0	562.0
2013	27.5	4.5	7.7	25592.0	11.0	912.0	1075.0	25.0	4.8	7.5	21238.0	9.3	885.0	1075.0
2014	24.5	4.8	7.8	25336.5	42.9	460.0	819.0	25.0	5.3	7.8	20841.5	38.8	210.0	510.0
2015	27.0	4.6	7.3	27041.5	7.9	460.0	824.0	30.5	5.3	7.4	31150.0	7.5	483.0	910.0
2016	24.0	4.3	7.6	26919.5	16.7	294.0	910.0	32.5	4.6	7.5	26679.5	11.0	325.0	570.0
2017	25.0	4.6	7.1	28869.0	11.9	286.0	499.0	32.5	4.8	7.2	30676.5	11.5	484.0	875.0
2018	20.0	-	7.3	25790.5	12.0	191.0	545.0	25.5	4.6	7.6	28990.0	12.0	174.0	499.0
2019	27.5	5.5	7.3	21772.0	8.0	65.0	300.0	24.5	5.0	7.2	28909.0	12.0	66.0	280.0

Table 2: Water Quality Standard of physicochemical parameters for NPI analysis [11, 13].

Sr. No.	Parameter	Acceptable standard limit	Recommending Agency
1	pH	8.5	ICMR/ BIS (IS 10500: 2012)
2	D.O.	5 (mg/L)	ICMR/ BIS (IS 10500: 2012)
3	B.O. D.	5 (mg/L)	ICMR/ BIS (IS 10500: 2012)
4	Conductivity	300 (µmhos /cm)	ICMR/ BIS (IS 10500: 2012)

Table 3: NPI water quality index of Vashi Creek (values more than 1.0 indicates exceeded limit and '-' indicates data is unavailable in database).

Year		Name of site of Vashi Creek							
		Airoli Bridge				Vashi Bridge			
		DO (mg/L)	pH	Conductivity (µmhos/cm)	BOD (mg/L)	DO (mg/L)	pH	Conductivity (µmhos/cm)	BOD (mg/L)
	Water Quality Standard value (ICMR)	5	8.5	300	5	5	8.5	300	5
2008	NPI values	1.02	0.95	88.36	1.60	0.97	0.85	111.53	1.80
2009		1.05	0.91	101.59	2.40	0.95	0.88	137.70	2.40
2010		0.90	0.94	93.67	2.10	0.77	0.95	98.64	2.20
2011		0.92	0.91	92.78	18.50	1.05	0.94	83.57	1.80
2012		1.04	0.91	98.60	2.04	1.08	0.86	111.23	2.28
2013		0.89	0.91	85.31	2.20	0.95	0.88	70.79	1.86
2014		0.95	0.91	84.46	8.58	1.05	0.91	69.47	7.76
2015		0.92	0.86	90.14	1.58	1.05	0.86	103.83	1.50
2016		0.85	0.89	89.73	3.34	0.91	0.88	88.93	2.20
2017		0.92	0.84	96.23	2.38	0.96	0.84	102.26	2.30
2018		-	0.85	85.97	2.40	0.91	0.89	96.63	2.40
2019		1.10	0.86	72.57	1.60	1.00	0.85	96.36	2.40

Acknowledgment

Authors are sincerely thankful to Dr. Chandrashekhar Murumkar, Principal, Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati, Dist. Pune. Also sincerely thankful to Department of Zoology and Dr. S.J. Chavan (Head, Department of Botany), Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati, Pune. Central Pollution Control Board is also to be thanked for making the database accessible to the public.

References

1. "ENVIS Centre on Control of Pollution Water, Air, and Noise" database: http://www.cpcbenvis.nic.in/
2. Al-Othman A. Evaluation of the suitability of surface water from Riyadh Mainstream Saudi Arabia for a variety of uses. Arabian Journal of Chemistry,2015:12:2104-2110.
3. Alrumman S, El-kott A, Keshk S. Water Pollution: Source & Treatment. American Journal of Environmental Engineering, 2016:6:88-98.
4. Boah DK, Twum S, Pelig-Ba K. Mathematical Computation of Water Quality Index of Vea Dam in Upper East Region of Ghana. Environmental Sciences,2015:3:11-16.
5. Bora M, Goswami D. Water quality assessment in terms of water quality index (WQI): case study of the Kolong River, Assam, India. Applied Water Science,2016:7:3125-3135.
6. Dawood A. Using of Nemerow's Pollution Index (NPI) for Water Quality Assessment of Some Basrah Marshes, South

of Iraq. Journal of Babylon University/Engineering Sciences,2017:25:1708-1720.
7. Desai P. Water Quality Assessment of Lakes in Vashi, Navi Mumbai, Maharashtra, India. International Journal of Scientific Engineering and Research (IJSER),2015:3(7):66-69.
8. Divya AH, Solomon PA. Effects of Some Water Quality Parameters Especially Total Coliform and Fecal Coliform in Surface Water of Chalakudy River. Procedia Technology, 2016:24:631-638.
9. Effendi H, Romanto, Wardiatno Y. Water Quality Status of Ciambulawung River, Banten Province, Based on Pollution Index and NSF-WQI. Procedia environmental sciences, 2015:24:228-237.
10. Indian Standard DRINKING WATER — SPECIFICATION (Second Revision) IS 10500, 2012.
11. Srinivas J, Lokesh P, Purushotham AV, Purushotham AV. Determination of Water Quality Index in Residential Area of Ferozabad Village, Gulbarga Taluk & District, Karnataka, India. International Journal of Scientific Research, 2012:2:186-188. 10.15373/22778179/JUNE2013/59.
12. Jena V, Dixit S, Gupta S. Assessment of water quality index of industrial area surface water samples. International Journal of ChemTech Research,2013:5:278-283.
13. Kumari V, Chaurasia GL. Study of Water Quality Status of Sai River in Uttar-Pradesh With Reference to Water Quality Index Assessment. International Journal of Innovative Research in Science, Engineering and Technology, 2015:4(1):18614-18623.
14. Madan R, Chaudhry S, Madan S, Sharma M. Determination of water quality index of Indraprastha estate region and the vicinity area in Delhi, India. ESSENCE International Journal for Environmental Rehabilitation and Conservation, 2018:9:89-100.
15. Ptak M, Sojka M, Kozłowski M. The increasing of maximum lake water temperature in lowland lakes of central Europe: case study of the Polish Lakeland. Annales de Limnologie - International Journal of Limnology,2019:55:6.
16. Samlafo VB, Ofoe EO. Water Quality Analysis of Bobobo Stream, in Tarkwa, Ghana. World environment,2018:8:15-19.
17. Seo M, Lee H, Kim Y. Relationship between Coliform Bacteria and Water Quality Factors at Weir Stations in the Nakdong River, South Korea. Water,2019:11:1171.
18. Singh PK, Shrivastava P. analysis of water Quality of river narmada. International Journal of Current Research,2 015:7(12):24073-24076.
19. Swati S, Umesh S. Nemerow's Pollution Index: For Ground Water Quality Assessment. Journal of Environmental Science and Pollution Research,2015:1(1):24-31.
20. Tambe E, Gotmare S. Pollution Monitoring Study of Water Samples Collected from Vashi Creek by Determining Water Quality Index. International Journal of Innovative Research in Science, Engineering and Technology,2017:6(4):6501-6508.
21. Thakor FJ, Bhoi DK, Dabhi HR, Pandya SN, Nikitaraj BC. Water Quality Index (W.Q.I.) of Pariyej Lake Dist. Kheda - Gujarat. Curr World Environ,2011:6:225-231.
22. Wang X, Sun Y, Li S, Wang H. Spatial distribution and ecological risk assessment of heavy metals in soil from the Raoyanghe Wetland, China. PLoS ONE, 2019:14(8):e0220409.
23. Zhong S, Geng H, Zhang F, Liu Z, Wang T, Song B. Risk Assessment and Prediction of Heavy Metal Pollution in Groundwater and River Sediment: A Case Study of a Typical Agricultural Irrigation Area in Northeast China. International Journal of Analytical Chemistry, 2015:2015:921539.