



An assessment of water quality index of Godavari river water in Nashik city, Maharashtra

Ashali Chandrakant Kharake¹ · Vaishali Sanjay Raut²

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Abstract

Water resource is most essential basic resource for human being. Today water resource management has become an important issue (Kharake, Pathare, Deshmukh, Arabian J Geosci 14(10):1–10, 2021) for all developing countries. Rapid growth of population and its repetitive activities along the river pose a concerned impact on the river system. The water quality and quantity are under constant pressure by the presence of different human activities like removal of vegetation, industrial activities, and encroachment, domestic and religious activities. These all activities resulted in degradation of water quality. These all problems are largely concentrated in and around urban areas. Keeping this view in the account systematic study has been carried out the water quality of Godavari river in Nashik city. Water samples from 10 sampling stations have been collected during 1st week of June 2019. Physico-chemical parameters have been analyzed by standard method. The Karl Pearson correlation matrix has been established for examining relationship between the water quality parameters, and the study is conducted to analyze the water quality status of Godavari river in terms of water quality index (WQI). The overall values showed good water quality status (WQI 133.44) at upper stream in the study area, but as it enters in urban area water quality becomes deteriorate (WQI 35.01). The field observations reveal that water quality is declining due to many human activities mainly industrial, domestic and religious waste. To analyze the water quality index (WQI) is the main aim of the research with remedial measures to mitigate the deterioration and related consequences in future.

Keywords Water quality · Water quality index · Godavari river · Physico-chemical analysis · The Karl Pearson correlation matrix

Introduction

Hydrosphere is an important segment of environment including 0.3% of the fresh water on Earth, and it is easily accessible from lakes, reservoirs and river systems (UNESCO 1998). Water plays an important role in various life processes of living organisms, in which river water is a precious natural resource for human being. Many human activities like agriculture, industrial, tourism and domestic, etc., depend upon the river. River has great potential of economic change (Patil et al. 2013). Many villages which are situated along river experienced rapid economic changes;

many of them were converted into important towns and cities (Kharke 2008). It has been observed that from past few decades population growth, urbanization (Muhammad et al. 2018), industrialization (Isai et al. 2015) and encroachments have put immense pressure on the river system (Bora and Goswami 2017). Many human activities related to economic development (Unde and Turkunde 2008) are responsible for water quality deterioration (Zhaoshi et al. 2017). It leads to degradation of water quality (Das 2013). Rivers have capacity to detoxify a certain quantity of pollutants discharged into them (Koichi and Hong-Ying 2010), but if the discharge of pollutants exceeds (Wu et al. 2017), water quality deteriorates (Govorushko 2010). Unpleasant taste of drinking water (Marle 2011), disgusting odor from lakes, river and beaches unmonitored growth of aquatic weeds and decrease in number of fishes are some of indications of water pollution; to understand chemical phenomenon occurring in water body, certain general criteria of water quality are applied such as pH, DO, BOD, TDS. pH is indicator of concentration

✉ Ashali Chandrakant Kharake
ashali.kharake.27@gmail.com

¹ Department of Geography, K.V.N.Naik College, Nashik, Maharashtra, India

² Department of Chemistry, K.V.N.Naik College, Nashik, Maharashtra, India

H⁺ ions (Nag et al. 2018) in water natural water containing HCO₃⁻, CO₃⁻² and OH⁻. These are main contributors of pH of water. pH of natural water is in the range of 3–10. Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates), and some small amounts of organic matter are dissolved in water. TDS in water originates from natural sources, sewage, urban run-off, industrial waste water and chemicals used in the water treatment process (Patel et al. 2019a, b; Tyagi et al. 2013). Change in TDS is an indicator of water pollution (Duan et al. 2018). One more important parameter is dissolved oxygen (DO), which is a measure of how much oxygen is dissolved in the water. DO can tell us a lot about water quality (Popovic et al. 2016). Bacteria in the water consume oxygen when organic matter decays. Thus, excess organic material in rivers can cause eutrophic conditions, in which there is a deficiency of oxygen, which can cause a water body to "die." Measurement of many other parameters like BOD, Fecal coli also can help us to understand pollution of water body. Together they are summarized in the form of WQI (Sehnaz et al. 2017).

Nashik is an important industrial town in Maharashtra that has 125 large-, 350 medium- and 2500 small-scale units (Chavan et al. 2009) presently working in the upper part of the city. Godavari river is a major source of water for drinking, agriculture, domestic and industrial purposes. Nashik is also well known for religious tourism because the city is home of hundreds of temples. To understand inappropriate human activities and its impact on water quality is the main objective of the paper.

Water quality index is used to understand a general water quality status of water resource (Nadikatla et al. 2020); hence, it has been used to determine the water quality of surface and ground water quality (Akumtoshi et al. 2020; Phadatare et al. 2016). Number of studies are carried out related to water quality index (WQI) (Khound and Bhattacharya 2018; Horton 1965) used WQI for first time as an indicator of water pollution. Brown et al. (1970) also calculated WQI by basic arithmetic weighting, but without multiplicative variables these efforts were supported by National Sanitation Foundation (NSF) in which water quality variables were calculated using the Delphi method (Dalkey 1968). Bhargava (1983) also suggested water quality index for river Ganga. Ichwana and Nelly (2016), Shah and Joshi (2017), Bora and Goswami (2017), Verma et al. (2019) and Akukumtoshi et al. (2020) have calculated WQI for different rivers.

The main objective of the present study is to develop simplified WQI in order to examine the effects of anthropogenic activities on water quality of Godavari river in Nashik city. Further research will helpful to minimize activities which are responsible for water contamination and for creating

awareness among local people, farmers and entrepreneur, etc.

Study area

For the present study Nashik city has been selected. It located in the north-west direction of Maharashtra, at a height of 700 m. It is situated at 19°33' to 20°53' north latitude and 73°16' to 75°6' east longitude and on the bank of the Godavari river. The average annual temperature of Nashik city is 24 °C, and about 812 mm of precipitation falls annually. According to the 2011 census Nashik city has 1,486,973 populations. For the investigation of Godavari river water quality the channel from the Gangapur dam to Dasak village is selected which has a length of 24 km. From above channel 10 sampling stations have been selected for water quality analysis (Fig. 1)..

Materials and methods

For further study 10 sampling stations within Nashik city have been selected. Selection of sampling stations is based on types of human activities and their intensity as well as area affected by urban waste. For water quality analysis water samples have been collected from the surface water along the river. Temperature and pH of samples have been measured in the field during collection. The water samples were analyzed at Water Quality Laboratory level-II, Nashik under Hydrology Project, water resources department, Government of Maharashtra. The analysis was carried out in the laboratory as per BIS standard methods. Various physico-chemical parameters like total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (B.O.D.) (Yogendra and Puttaiah 2008), total solids and turbidity were analyzed to evaluate the impact of urban waste on water quality. The Karl Pearson correlation matrix has been established to examine the relationship between the water quality parameters. The data were analyzed for water quality status, and water quality index was determined by the formula developed by NSF (National Sanitation Foundation) and modified by CPCB (Central Pollution Control Board) (Table 1) which depicts the water quality in simple and easy way. WQI as it gives a single number that expresses the overall water quality of a certain water sample (location and time specific) for several water quality parameters. It all information summarized and analyzed with the help of graphs (Tables 2, 3).

$$WQI = \sum_{i=1}^P W_i I_i$$

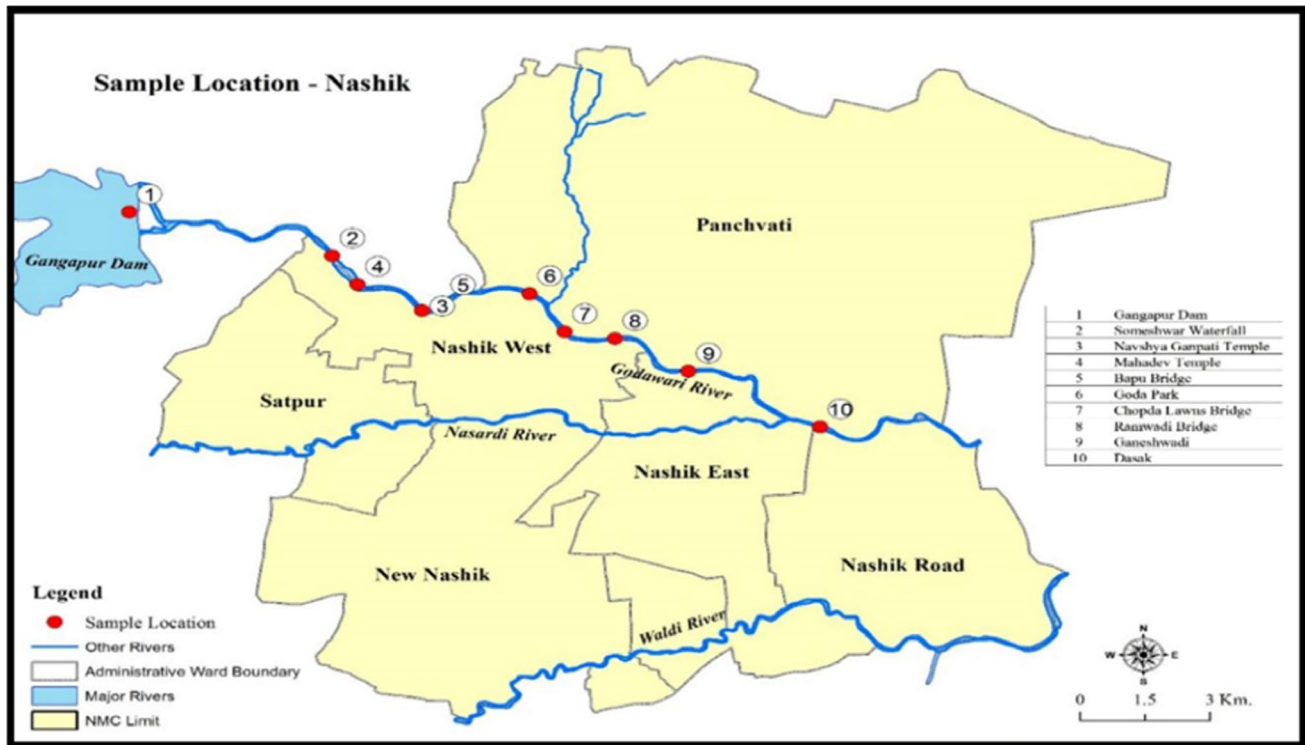


Fig. 1 Location map of study area

Table 1 Modified weights for computation of WQI based on DO, FC, pH and BOD

Sr. no	Parameters	Weight
1	Dissolved oxygen	0.31
2	pH	0.28
3	BOD	0.22
4	Fecal coli	0.19
	$\sum W_i$	1.00

Results and discussion

The analysis report of sample sites has been carried out as per BIS limits, which are given in Table 4.

We investigated the river behavior by measuring 8 parameters (Table 4) showing values of measured values of various parameters. Data show that water pollution increases as the river flows through the urban area in which pH values show alkaline or acidic behavior of water, TS and TDS affecting

Table 2 Subindex equation used to calculate NSF WQI for DO, FC, pH and BOD

Water quality parameters (Units)	Range applicable	Equation
Dissolved oxygen (DO) (% saturation)	0–40	$0.18 + 0.66 X \% \text{ saturation DO}$
	40–100	$(-13.55) + 1.17 X \% \text{ saturation DO}$
	100–140	$163.34 - 0.62 X \% \text{ saturation DO}$
Fecal Coliform (FC) (counts/100 ml)	$1 - 10^3$	$97.2 - 26.6 * \log FC$
	$10^3 - 10^5$	$42.33 - 7.75 * \log FC$
	$> 10^5$	2
pH	02–05	$16.1 + 7.35 * (\text{pH})$
	05–7.3	$(-142.67) + 33.5 * (\text{pH})$
	7.3–10	$316.96 - 29.85 * \text{pH}$
	10–12	$96.17 - 8 * \text{pH}$
BOD (mg/l)	< 2, > 12	0
	0–10	$96.67 - 7 * \text{BOD}$
	10–30	$38.9 - 1.23 * \text{BOD}$
	> 30	2

Table 3 Water quality classification and best designated use

Sr. No.	WQI	Class by CPCB	Remarks	Color Code
1	63-100	A	Non Polluted	
2	50-63	B	Non Polluted	
3	38-50	C	Polluted	
4	38 and less	D,E	Heavily Polluted	

Table 4 The parameters of the Godavari river at Nashik city (June 2019)

Station No	Location	Temperature (in °C)	PH	TS	DO	TDS	Turbidity	BOD	F-coli (MPN)
S1	Gangapur dam	23.4	8.7	66	7.5	60	4.6	2.5	2
S2	Someshwar water fall	23.9	8.2	80	7.3	70	5.0	3.0	2.5
S3	Navsya Ganpati	24.2	8.5	156	7.2	82	5.3	3.5	5.8
S4	Rameshwar Mahadev Temple	23.8	8.3	170	4.1	94	8.4	20	7.8
S5	Bapu Bridge	24	7.8	250	3.2	156	9.1	35	19
S6	Goda park	24.9	8.0	389	3.1	182	10.7	40	12
S7	Chopra Lawns Bridge	25.3	8.5	416	1.9	314	15.42	52	25
S8	Ramwadi Bridge	24.7	8.3	381	2.0	216	15.48	50	22
S9	Ganesh wadi	24.8	7.8	372	2.0	369	15.59	38	24
S10	Dasak Bridge	26	7.5	616	3.4	412	24.97	42	28

Required desirable limits—as per standards prescribed For Drinking Water by Bureau of Indian Standards, 2002 (BIS) limits, 2012

turbidity of water. The increased number of coliform germs indicates pollution, which comes from waste waters from households in the surrounding settlements. The increased values of BOD indicate the biological activity of the waste waters and are the main organic pollution indicator.

pH

pH is an indicator of the amount of hydrogen ion concentration value. It is used to indicate acidity or basicity of the water. Normal water has a pH value between 6.5 and 7.5. Sewage into water can change the hydrogen ion concentration (pH) in the water, and it became more alkaline depending on the types of waste and chemical substances contained in them (Ichwana et al. 2016). Change of pH can change the heart rate, curve spin and shape of the head (Shinde et al. 2019). The present study shows that water at various stations is alkaline. The pH value has been ranging between 7.5 and 8.7 at various sampling sites.

TS

Total solids are dissolved solids in the water, including suspended and settleable solids. Total solids ranged

between 66 and 616 mg/l at various sampling sites. TS has been suddenly increased from S₇ to S₁₀ (distance 11.5 km), and it may be due to the direct input of massive local discharge from city. It is all responsible to make water unpalatable.

DO

Dissolved oxygen in the water is an important index in determining the purity of water. It gives nature of organic matter present in water. DO is essential for healthy aquatic life. The DO values ranged between 1.9 and 7.5. It is observed that DO of river water between S₄ and S₁₀ (13.5 km) is less than 5 mg/l, and it may be due to contamination of urban waste during journey of the river. Godavari river deteriorates (Bawa and Gaikwad 2013).

TDS

TDS also shows similar trends due to contamination of sewage in the river. It has suddenly increased from S₇ to S₁₀ due to the high density of population which is responsible for emanation of large amount of solid waste, discharge of domestic wastewater, encroachment and sewages. As most of the major pathogenic diseases, hazards and dermatological

problems, are recognized due to consumption of polluted water (Koli et al. 2018), the river is supposed most suitable place to dump garbage waste and it is proved as a major load on the river, it increases TDS in water, and it causes unhygienic atmosphere and creating health problems like malaria, diarrhea, etc.

Turbidity

Turbidity is description of the optical properties of water which is calculated by amount of light emitted and absorbed by particles in the water (Ichwana et al. 2016).

It is observed that turbidity goes on increasing from S₃ to S₁₀ (14 km) and it is maximum at S₁₀ (24.97 NTU) again due to organic pollutant like cremate and discharge of ash of human dead bodies as well as to perform religious activities flower garlands and other solid waste directly added to the water.

BOD

BOD is the amount of oxygen consumed in biodegradation of organic matter during period of 5 days. It can be observed (Table 1) there is suddenly increase of BOD value from S₄,

Fig. 2 pH of selected sampling stations

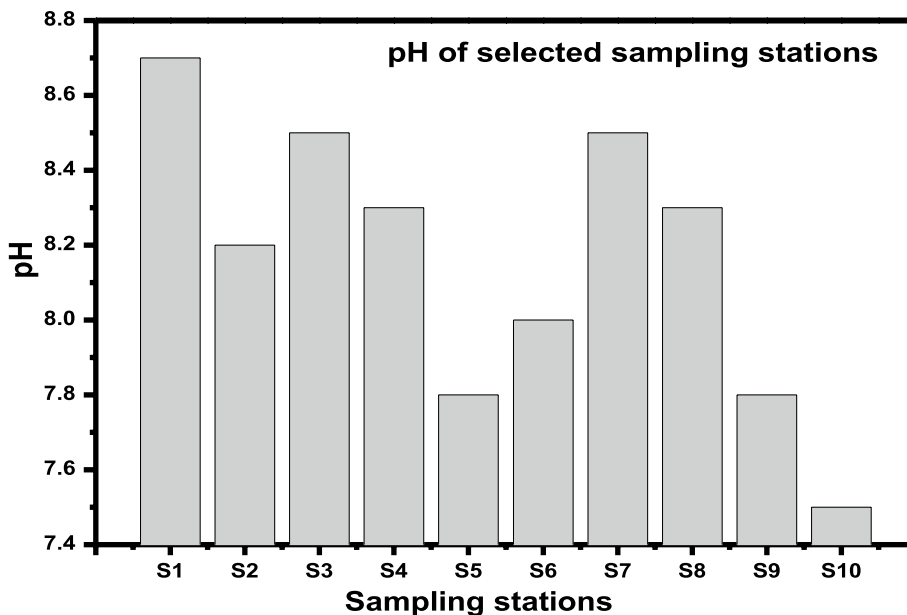


Fig. 3 TS of selected sampling stations

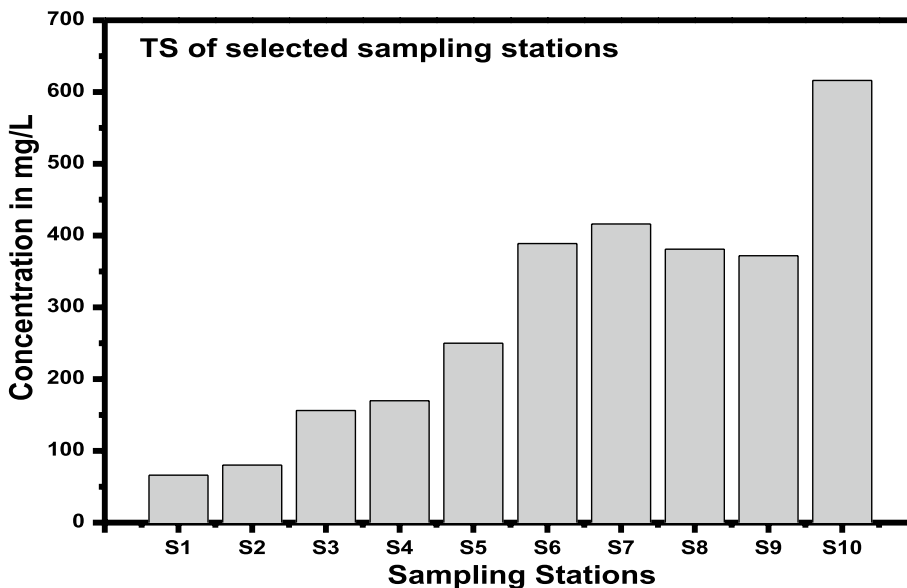


Fig. 4 DO of selected sampling stations

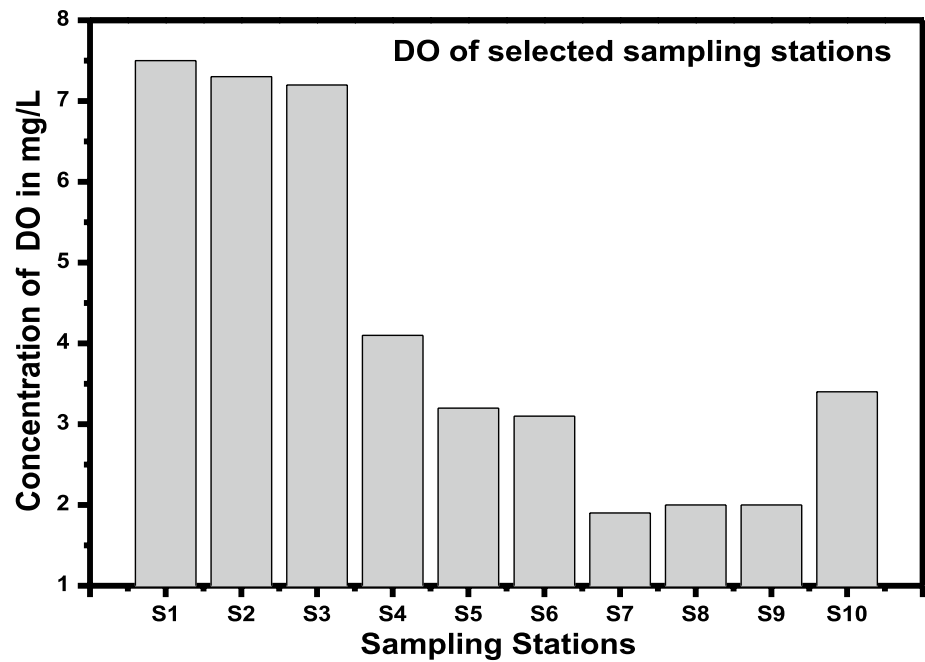
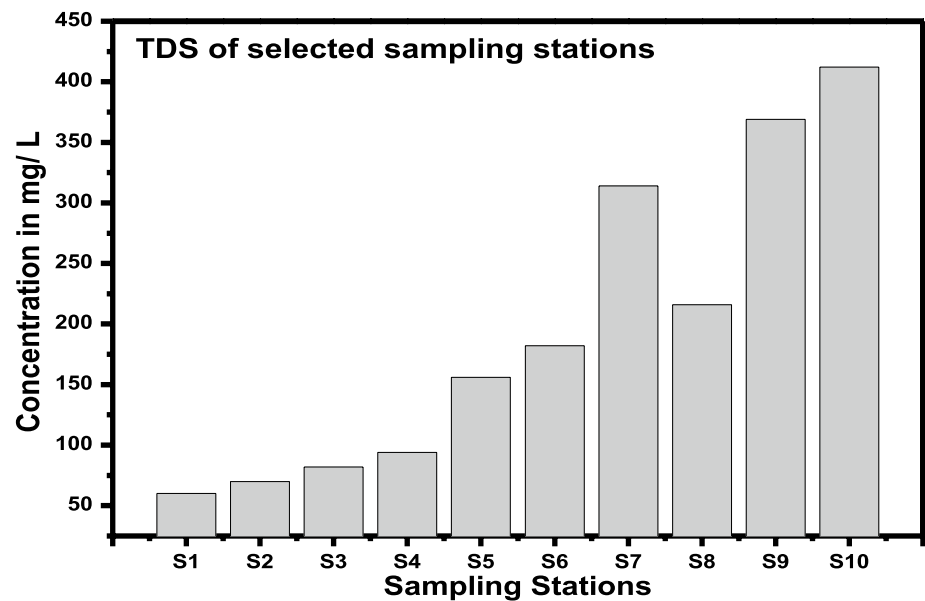
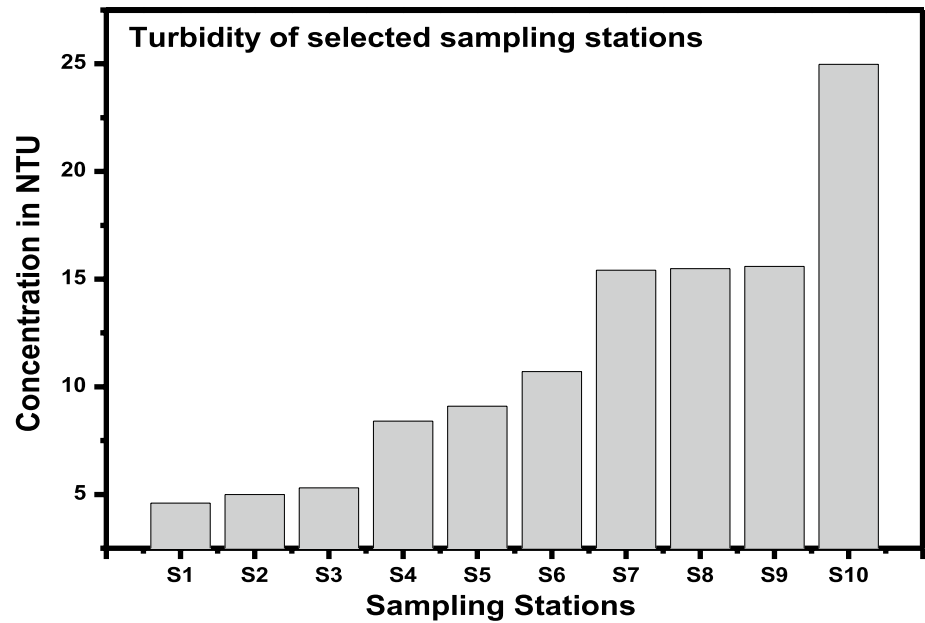
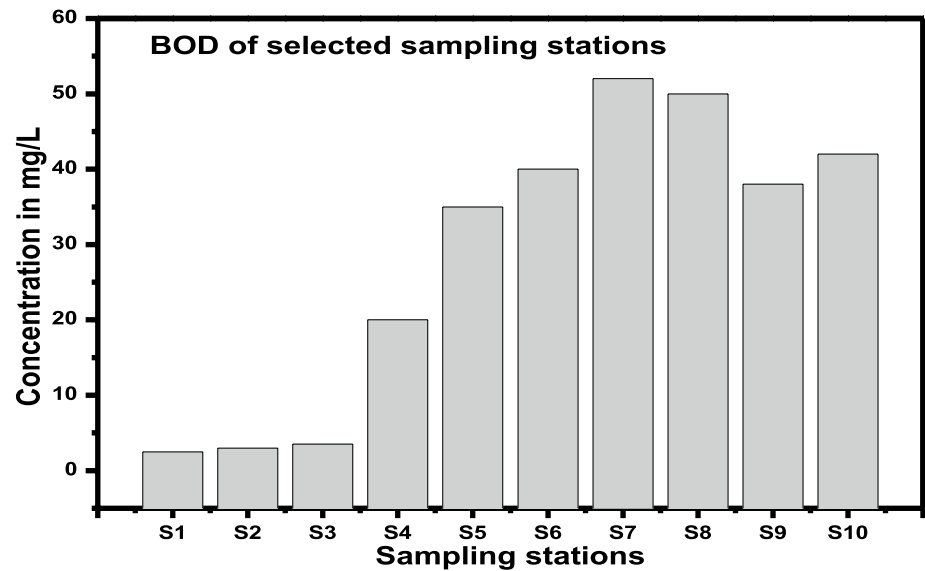


Fig. 5 TDS of selected sampling stations



and it may be due to sewage entering in the Godavari river by *nalas* coming out of industrial areas, hotels and slums nearby the river bank. BOD at S₇ and S₈ is found to be highest although no point source is observed here, lots of waste water from weekly market and vehicle washing which are responsible for contamination (Table 5, 6; Figs. 2, 3, 4, 5, 6, 7, 8, 9)).

The Karl Pearson correlation matrix has been established for examination of the relationship between two parameters of the samples. The value of correlation coefficient around 0.7 and above (Bawa and Gaikwad 2013) is considered to be a strong positive correlation. It has been found from analysis that positive correlation is found between turbidity and total dissolved solids. Positive correlation also found between turbidity and TDS (Table 6). This is due to fact as the number of particles in water (TDS) increases, so turbidity also has been increased. It can be seen that there is a positive

Fig. 6 Turbidity of selected sampling stations**Fig. 7** BOD of selected sampling stations

correlation between BOD and TS, higher the BOD values which arise TS presents in the water. There is positive correlation between BOD and turbidity as amount of suspended matter increases turbidity which in turn increases BOD value (Table 7, 8).

Conclusions

In this study water quality of Godavari river in Nashik city was evaluated, to evaluate water quality of Godavari river 10 sampling stations were determined, and 8 parameters were selected. The physico-chemical analysis of water samples indicates that the river water sample has alkaline properties. As pollutants are added in the river water at various stations, it has decreased dissolved oxygen value. Due to addition of pollutant at these stations BOD and

Fig. 8 F-coli of selected sampling stations

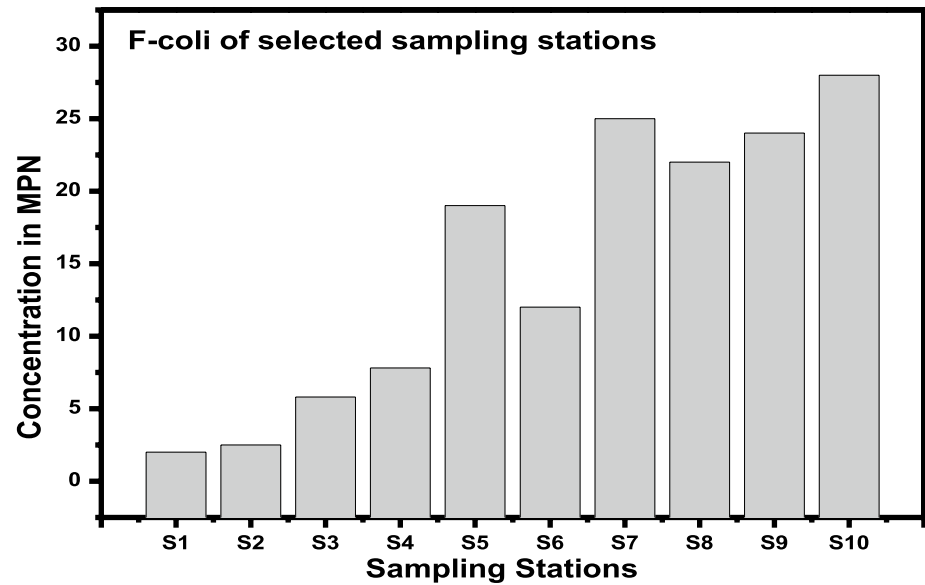


Fig. 9 WQI of collected water samples

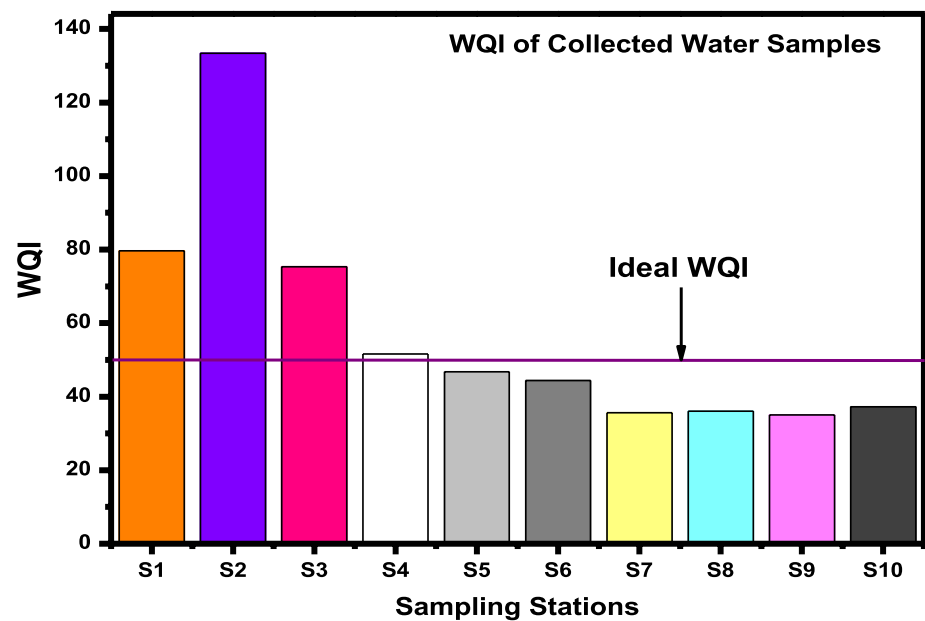


Table 5 Statistical summary of physico-chemical parameters

Parameters	Max	Min	Mean	Sum
pH	8.7	7.5	8.1	81.6
TS	616	66	341	2896
DO	7.5	1.9	4.7	41.7
TDS	412	120	266	1955
Turbidity	24.97	4.6	14.7	114.56
BOD	52	2.5	27.25	286

Max—maximum, Min—minimum

turbidity values have increased. TDS and F-coli parameters showed increased value at S₁₀ due to sewage and burial activities.

Water quality parameters pH, DO, BOD and F-coli were used to calculate water quality index (WQI) for evaluation of water quality. The water quality index values of Godavari river of about 24 km the stretch from Gangapur dam to Dasak Bridge show that due to urban slums, weekly markets and religious tourism lots of urban waste have been generated. It may be in liquid or solid forms responsible

Table 6 Karl Pearson correlation matrix for water samples of Godavari river water in Nashik city (June 2019)

Parameters	pH	TS	DO	TDS	Turbidity	BOD
pH	1.0					
TS	-0.6430	1.0				
DO	0.4718	-0.7704	1.0			
TDS	-0.6297	0.9137	-0.7437	1.0		
Turbidity	-0.6395	0.9578	-0.7181	0.9397	1.0	
BOD	-0.4523	0.8565	-0.9632	0.7776	0.7888	1.0

Computed by Researchers

Table 7 Godavari river water sampling stations and observed urban waste

Station no	Location	Distance from 1st sampling station (km)	Coordinates	Observed urban waste
S1	Gangapur dam	00	20°0; N 73°66"E	Tourism
S2	Someshwar water fall	7.7	20°0; N 73°66"E	Tourism, Bathing etc
S3	Navsya Ganpati	10	20°0' N 73°67E	Religious tourism
S4	Someshwar Mahadev Temple	10.5	20°0'N to 73°68'E	Religious tourism
S5	Bapu Bridge	11	20°0'N to 73°68'E	Sewage from Anandwalli slums
S6	Goda park	11.5	20°0'N to 73°69'E	Untreated sewage from hotels and local tourists
S7	Chopra Lawns Bridge	12.5	20°0'N to 73°70'E	Sewage from industries
S8	Ramwadi Bridge	15	20°0'N to 73°78'E	Religious tourism
S9	Ganesh wadi	16	20°0'N to 73°78'E	Waste from rituals and weekly market
S10	Dasak Bridge	24	20°0'N to 73°78'E	Sewage from different industries, domestic activities

Personal investigation

Table 8 WQI rating of various sampling sites of Godavari river

Sr. No.	Stations	WQI	Color Code
1	Gangapur Dam	79.67	
2	Someshwar Waterfall	133.44	
3	Navsya Ganpati	75.30	
4	Rameshwar Mahadev Temple	51.59	
5	Bapu Bridge	46.8	
6	Goda Park	44.34	
7	Chopra Bridge	35.6	
8	Ramwadi Bridge	36.01	
9	Ganesh wadi	35.01	
10	Dasak Bridge	37.24	

for water pollution. The computed WQI values are between 35.01 and 133.44 in the study area. The WQI classification shows that S₂ has good water quality status, but as

it enters in city considerable changes in WQI were observed at S₇, S₈ and S₉ sites due to burial activities, encroachment and contamination. In spite of all efforts made by

government authorities, local people and entrepreneur are not aware about river pollution. From the above analysis, it has been concluded that the acceleration of population increases the human interventions along the river which deteriorate the water quality. Hence, the suggested measures would help to minimize human interventions in and along the river Godavari. It is also helpful to minimize negative consequences of such impacts in the future and conserve the water resource.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Human Participants and/or Animals This article does not contain studies with human or animal subjects.

Informed consent We fully agree with the information provided in this article.

Authors Contribution Ashali Kharake helped in writing—original draft preparation, conceptualization, methodology, map—preparation. Vaishali Raut involved in writing—original draft preparation and data curation.

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