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Water Quality Assessment Using Overall Index of Pollution (OIP) in Upper Godavari River (Maharashtra, India)

Avaliação da Qualidade da Água Usando o Índice Geral de Poluição (OIP) no Alto Rio Godavari (Maharashtra, Índia)

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Abstract

This study on water quality assessment in Upper Godavari River basin (India) was conducted for a period of one year between 2018 and 2019. An Overall Index of Pollution (OIP) was applied to assess the water quality to determine the water quality. Water samples were collected for post Monsoon season June to September. Physical and chemical parameters such as pH, electrical conductivity, total dissolved solids, turbidity, dissolved oxygen, biological oxygen demand, sulphate, and chloride were investigated for three selected sites. As a result, the OIP values of different sites explains that water quality of Upper Godavari River basin was observed between 'slightly polluted' to 'polluted'. Therefore, surface water quality of upper Godavari basin within the urbanized area and industrial area had high OIP score, and it required urgent management for the mitigation for the ecological sustainability and protection of aquatic life.

Keywords: Water Pollution; Ecological Assessment; Sustainability

Resumo

Este estudo sobre avaliação da qualidade da água na bacia do rio Upper Godavari (Índia) foi realizado durante um período de um ano entre 2018 e 2019. Um Índice Global de Poluição (OIP) foi aplicado para avaliar a qualidade da água para determinar a qualidade da água. Amostras de água foram coletadas após a estação das monções, de junho a setembro. Parâmetros físicos e químicos como pH, condutividade elétrica, sólidos totais dissolvidos, turbidez, oxigênio dissolvido, demanda biológica de oxigênio, sulfato e cloreto foram investigados em três locais selecionados. Como resultado, os valores do OIP de diferentes locais explicam que a qualidade da água da bacia do Alto Rio Godavari foi observada entre 'ligeiramente poluída' e 'poluída'. Portanto, a qualidade da água superficial da bacia superior de Godavari dentro da área urbanizada e da área industrial teve uma pontuação elevada no OIP e exigiu uma gestão urgente para a mitigação para a sustentabilidade ecológica e protecção da vida aquática.

Palavras-chave: Poluição hídrica; Avaliação ecológica; Sustentabilidade

1 Introduction

From time immemorial, rivers are said to be the lifeline for living beings, as all types of developments, directly or indirectly relate to them, that is why civilizations settled in riverbanks, even the old cities considering river as lifeline (MPCB Report 2015). Rivers are the main source for fulfilling human requirements and also provides habitat for aquatic organisms (Katyal et al. 2012). But, with an increase in population and rapid urbanization, the water quality has been degraded globally (Sharda & Sharma 2013). So many anthropogenic and entire aquatic ecosystem have several problems in keeping the water free from pollution.

Rivers located in urban cities provide benefits, such as recreation, nature viewing, climate amelioration, water flow regulation, carbon sequestration etc (Chaudhary et al. 2013). However, rivers are becoming more polluted because of uncontrolled urbanization and discharge of untreated municipal waste and this leads to a serious reduction in water quality, damaging aquatic ecosystem.

Nasik city has municipal water management system, even though it has enormous discharge of untreated sewage waste into the rivers, contaminating its water. The population of Nasik city was consistently rising from 0.15 million in 1951 to 2 million in 2020. Due to famous pilgrimage, the city attracts a floating population of 1 Lakh people daily. In addition to it Nasik has two main industrial estates

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within the Nasik Municipal Corporation area, Ambad and Satpur with 314 and 204 industries respectively. Therefore, the assessment of river water quality is vital for further plans towards the mitigation and management of the river ecosystem.

The consistent and compressive monitoring system of water quality is important for public and decision makers. There are several approaches to assessing water quality at selected places. The Water Quality Index (WQI) was initiated by Horton in 1965 (Horton 1965). Consequently, numerous other indices were developed and water quality assessment were carried out in different countries of the world. There are different water quality indices, such as Brown WQI Oregon WQI (Cude 2001), British Columbia WQI (BCMOELP 1995), Canadian Council of Ministers of the Environment WQI (CCME 2001) etc. were developed. All these indices generate a single value for the assessment of water quality comparing various parameters as per the standards.

Godavari River is one of the most polluted rivers in India and in Nasik city. So, the aims of this study were to study the pollution level and to assess the water quality of Godavari River at Trambakeshwar, Kopargaon and Pravarasangam using Overall Index of Pollution (OIP). The OIP method is used because it is simple to appraisal and it is an open index that enables to the add and remove parameters of the index (Lalrindika, Zonunsanga & Rinawma 2020).

2 Study Area

Godavari River flows through mountainous region in western parts of Nasik city in the state of Maharashtra, India. It rises at an altitude of about 1465 m in the Trambakeshwar, 28 km away from Nasik city. The river flows in eastward direction covering a length of about 42 km till its confluence with Darana River. Since the river passes through the core part of Nasik city, it gathers huge amount of unprocessed domestic sewage and discharge of solid wastes, especially in the upper course. Three samples were collected from different sites: at source (Trambakeshwar), middle station (Kopargaon), and last station (Pravarasangam) of upper Godavari River basin in Maharashtra as seen in Figure 1.

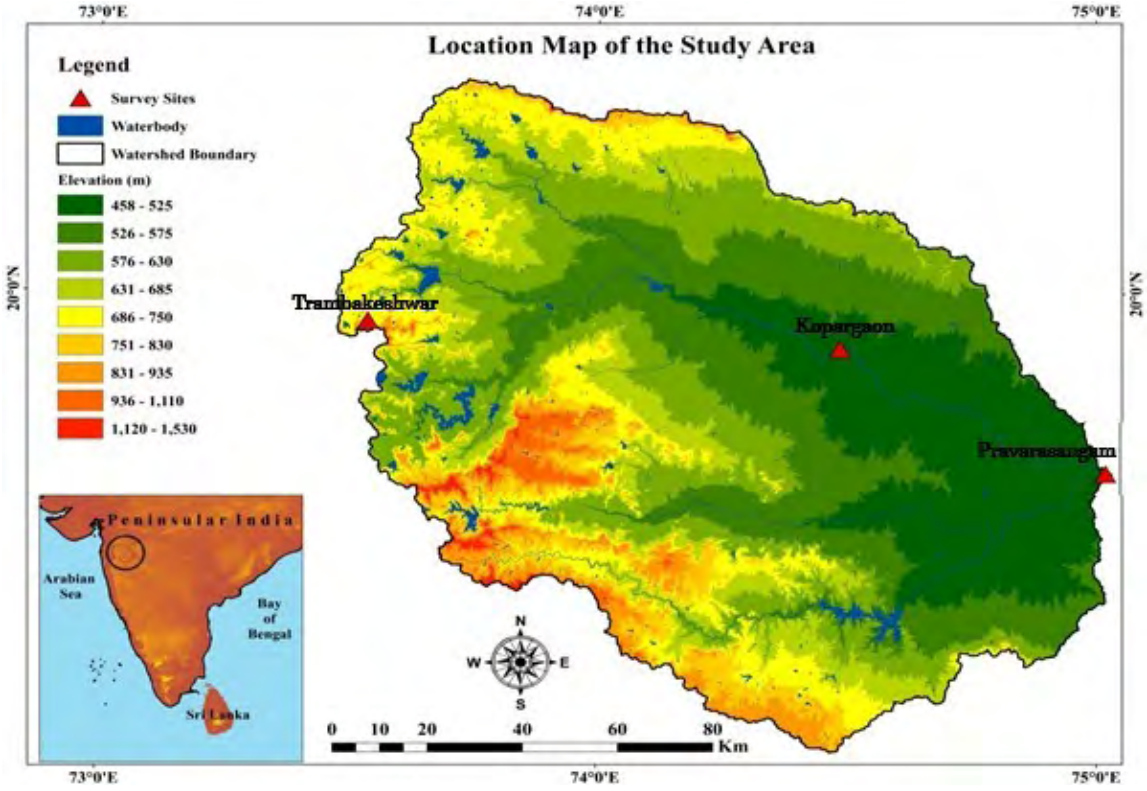

Figure 1 Location map of upper Godavari River basin.

3 Materials and Method

3.1 Water Data

The water samples of three different sites were collected in sterilized sample bottles during monsoon season on July 24, 2018. The sample containers needed for a sampling campaign were prepared by the laboratory and given to the person collecting samples. These seasons for the present study were taken in to experts advised. The physic-chemical properties of river water were collected from above said three sample sites on 24 July 2018 in monsoon season and are coordinates were demonstrated in Table 1.

Table 1 Sampling sites location in Godavari River (24 July 2018).

Sr. No.	Name of Sample Site	Location
1.	Trambakeshwar	19° 56' 26" N 73°32'19" E
2.	Kopargaon	19° 53' 6" N 74° 29' 10" E
3.	Pravarasangam	19° 37' 27" N 75°01'20" E

3.2 Geostatistical Analysis

This method of Overall Index of Pollution (OIP) was used for the calculation of Water Quality Index (Sargaonkar & Deshpande 2003). Sargaonkar and Deshpande (2003) suggested a classification scheme for surface water quality assessment in Indian scenario considering accepted standards such as Central Pollution Control Board (CPCB 2011) standards, as shown in Table 2. This is a comprehensive methodology, which can be useful to any particular index (Sargaonkar, Gupta & Devotta 2008). Salunke (2020a) suggested selected parameters from different water quality are used to obtain combined index for further recommendations. The pH, total dissolved solids (TDS) and turbidity were examined at location using portable Water Purity Tester and HM Digital COM-80. Other parameters, including dissolved oxygen (DO), nitrate (NO_3-), chloride (Cl^-) and sulphate (SO_4^{2-}), were analysed by using updated water testing equipment like EQ 826. Hydro chemical concentrations are shown in Table 3.

Class index score was set in geometric development (1, 2, 4, 8, 16), and were allotted to each of the classes C1, C2, C3, C4 and C5 respectively to determine level of contamination water, that varies from Excellent (C1), Acceptable (C2), Slightly Polluted (C3), and Polluted (C4) to Heavily Polluted (C5). Aggregate of all the pollution indices (Pi) for each factor and the concentration levels considered in this study and is given by Equation1.

$$OIP = \frac{\sum iPi}{n} (1)$$

where,
OIP = Overall Index of Pollution
Pi = pollution index for the ith parameter.
i = 1,2,3,4…, n and n = number of parameters.

Table 2 Parameters content at the sampling sites.

Parameters	Sampling Sites on Godavari River		
	Trambakeshwar	Kopargaon	Pravarasangam
Temp. (^{0}C)	21.92	21.81	28.5
pH	6.82	6.75	7.91
TDS (mg/L)	251.38	213.04	220.52
E. Conductivity(uS/cm)	209.29	311.71	336.5
Turbidity (NTU)	61.13	173.25	80
DO (%)	6.17	6.68	7.99
BOD(mg/L)	2.15	7.69	1.62
COD (mg/L)	6.72	34.13	39
Sodium (mg/L)	13.83	20.13	25.2
Potassium (mg/L)	1.55	2.25	2.8
Chlorides (mg/L)	9.80	24.74	9.90
Sulphate (mg/L)	6.45	15.34	7.29

Table 3 Water Quality classification in Overall Index of Pollution (OIP). pH: Potential of Hydrogen; TDS: Total Dissolved Solids; TUR: Turbidity; DO: Dissolved Oxygen; BOD: Biochemical Oxygen Demand; Cl: Chloride; SO_4^{2-}: Sulphate.

WQ– Status	Class	Class Index (Pi Score)	Parameters (Concentration Limits / Ranges)						
			pH	TDS (mg/L)	TUR (NTU)	DO (%)	BOD (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)
Excellent	C1	1	6.5 – 7.5	500	5	88 – 112	1.5	150	150
Acceptable	C2	2	6.0-6.5 and 7.5 -8.0	1500	10	75-125	3	250	250
Slightly Polluted	C3	4	5.0 – 6.0 and 8.0 – 9.0	2100	100	50 - 150	6	600	400
Polluted	C4	8	4.5 – 5 and 9 – 9.5	3000	250	20 – 200	12	800	1000
Heavily Polluted	C5	16	<4.5 and >9.5	> 3000	> 250	> 250	24	> 800	>1000

4 Results and Discussion

The outcome of physicochemical parameters for three various sites are publicised a broad data of water qualities in Godavari River (Table 3). From the obtained analysis, it is very clear that turbidity, dissolved oxygen and BOD have a prominent impact on water quality in the study area. The pH, total dissolved solids and chloride are found to have a minor impact for the present study (Figures 2 and 3). Higher values of turbidity were recorded because samples were taken during monsoon season as seen in Figure 4. In monsoon season river water is includes silt and clay particles generated by rain-splash in the watershed. The highest turbidity was found in Kopargaon with 173 NTU and the lowest value of 61 NTU was observed at Trambakeshwar. Most of the observed value exceeds the permissible limits of 5 NTU. Anthropogenic activities like agriculture, construction, mining and brick making near river basin increases turbidity of river water Salunke (2020b).

The obtained value of dissolved oxygen is low, and it ranges between 6.17-7.99 mg/L and it observed lower during the monsoon season. As most of the dissolved oxygen value in the study area lies near the desired limits, its relative Index score also have shown high impact towards the water quality.

Parameter, such as BOD, is most vital and it remains crucial in determining overall quality of water. Higher BOD levels concentration is caused by high consumption of DO by microorganisms (Gaikwad et al 2023). It indicates that the water is highly polluted with organic matter. Most pristine rivers will have BOD below 1 mg/L. Moderately polluted rivers may have a BOD value in the range of 2 to 8 mg/L (Figure 5). Rivers may be considered severely polluted when BOD values exceed 8 mg/L Parameters, such as pH, total dissolve solids, chloride, and sulphate are found adequate within the permissible limits of different standards developed by various agencies. Among them, the TDS value recorded ranges between 213.04 to 251.38 mg/L but is still within the limits. The higher value of TDS was recorded during monsoon season which could be attributed mainly to the presence of silt and clay particles in the river water (Katyal et al. 2012).

The acquired OIP score indicates that the water quality at sampling locations Trambakeshwar and Pravarasangam falls under Excellent to Acceptable. The water quality is slightly polluted in at Kopargaon site, where there is higher impact of human activities. The variation in the concentration of seven effective parameters is shown in and the trends of OIP score for the study area is given in Table 4.

The trends of Overall Index of Pollution on the basis of concentration of seven effective parameters are shown in the graph for the study area is given in Figure 6.

The Overall Index of Pollution on the basis of concentration of seven parameters are shown in it is very clear Kopargaon region shows the high overall pollution than Trambakeshwar and Pravarasangam. Area of Kopargaon shows high concentration of all pollutants so it is unsuitable for human consumption. Figure 7 shows the interpolation map for the parameter of study area.

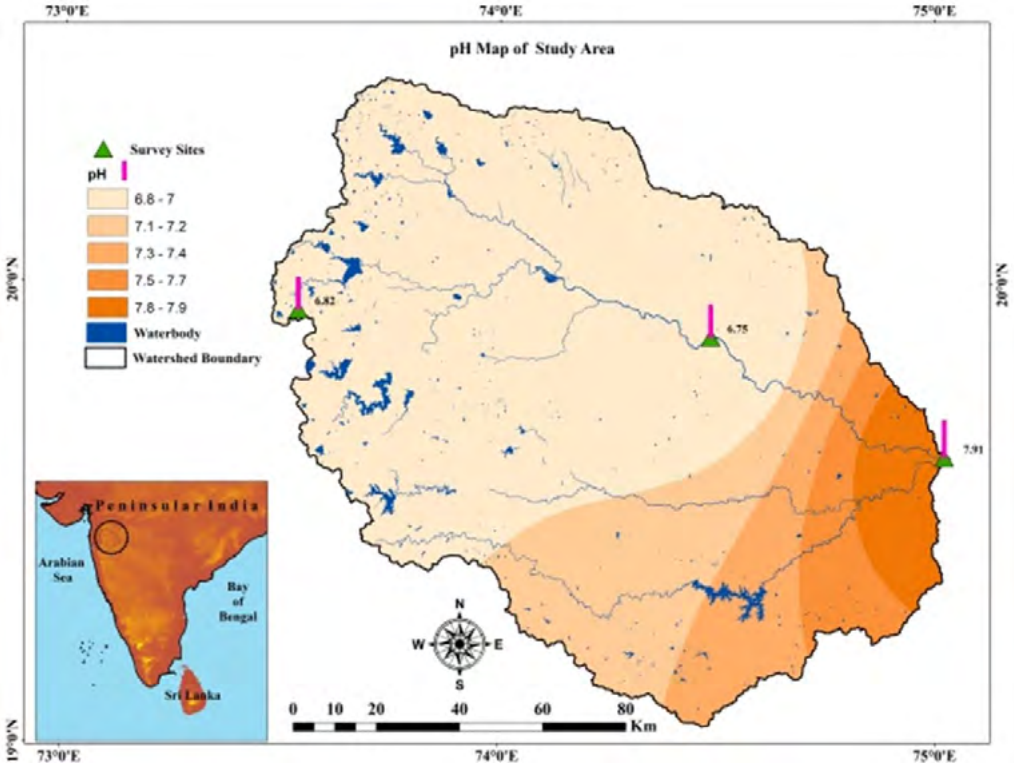

Figure 2 pH distribution map for the study area (24 July 2018).

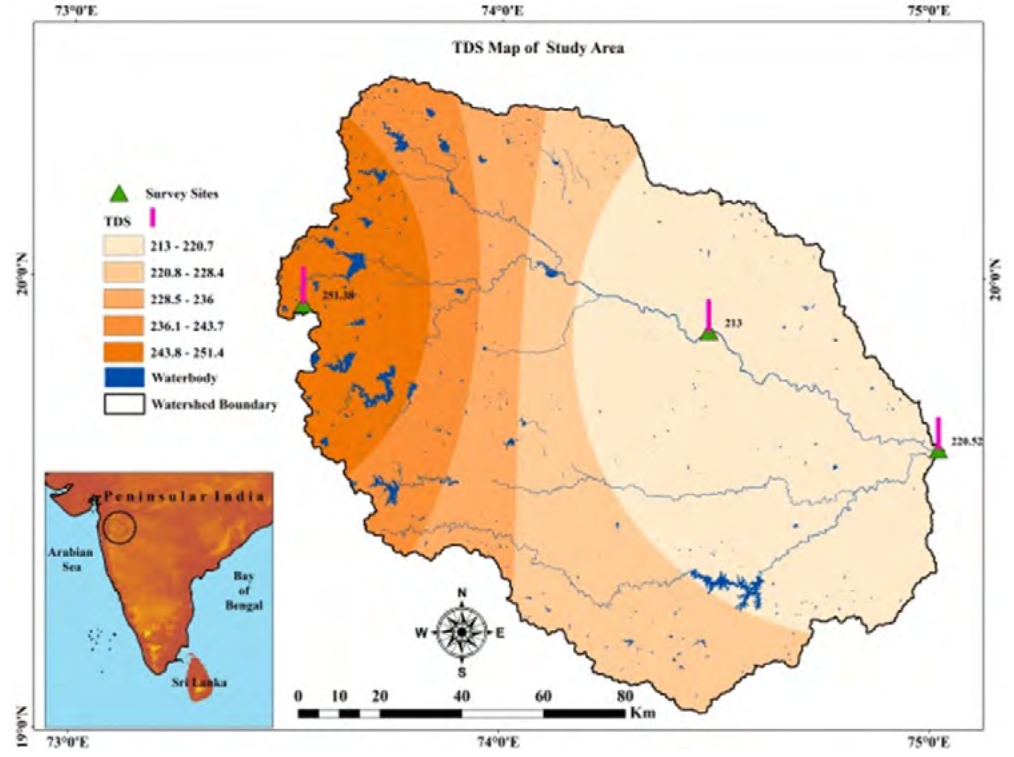

Figure 3 TDS distribution map for the study area (24 July 2018).

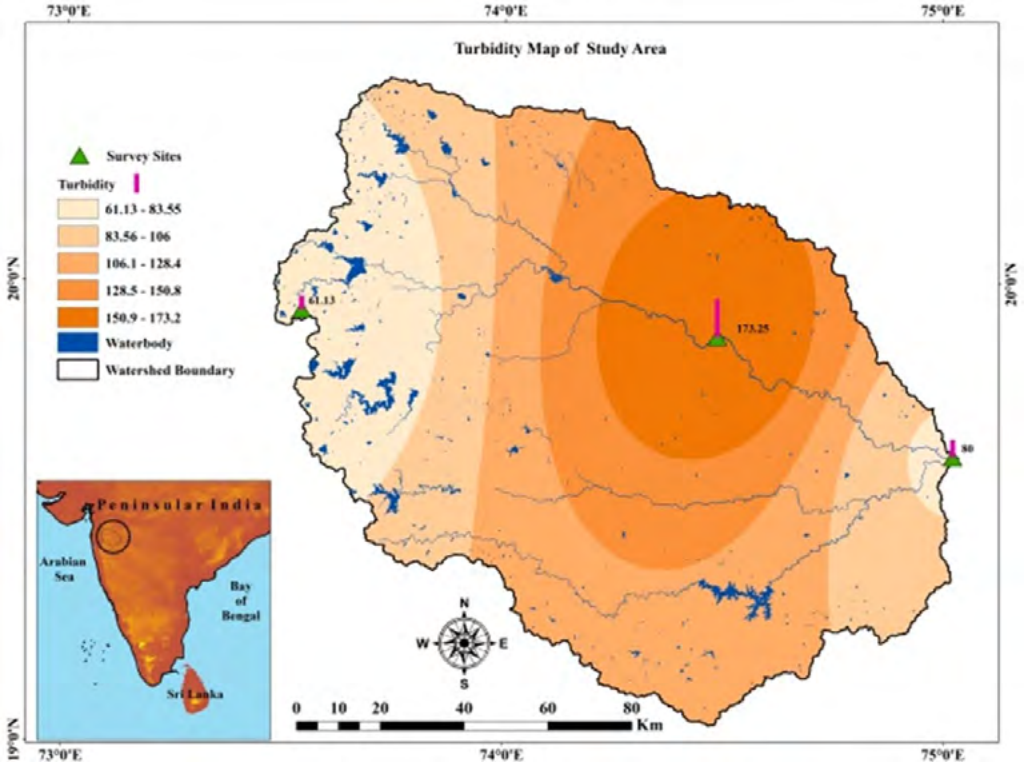

Figure 4 Turbidity distribution map for the study area (24 July 2018).

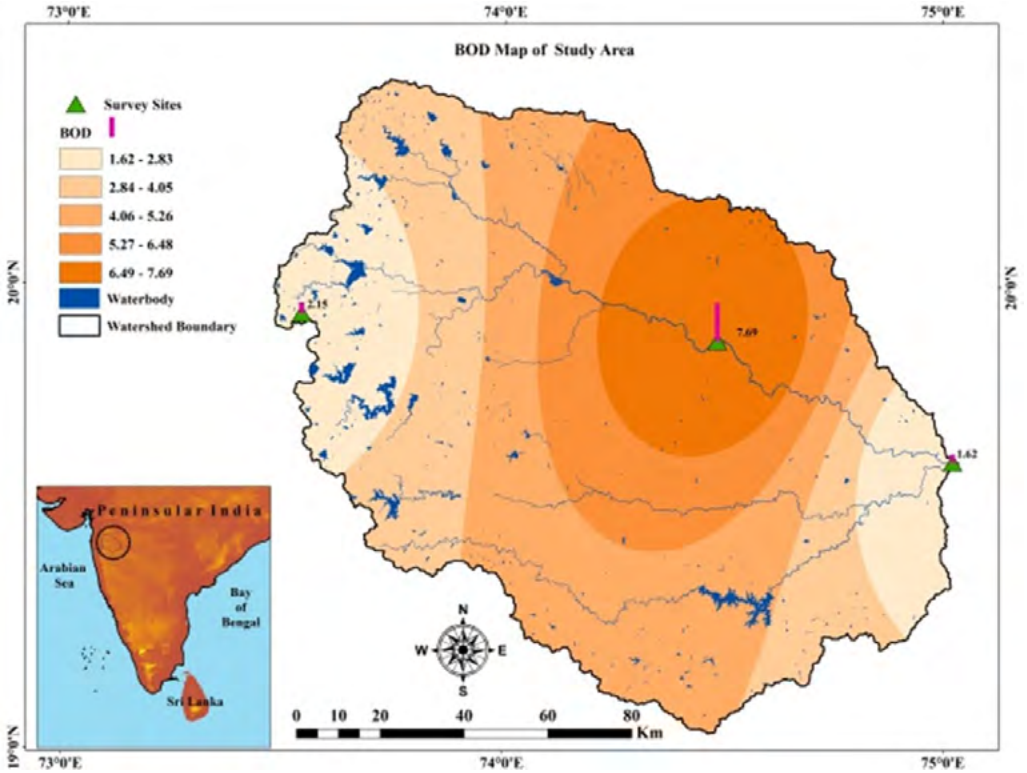

Figure 5 BOD distribution map for the study area (24 July 2018).

Table 4 Individual parameter indices and OIP score at various sampling sites (2018–2019)

Parameter	Sampling Sites on Godavari River		
	Trambakeshwar	**Kopargaon**	**Pravarasangam**
pH	6.82	6.75	7.91
Class Index Score (Pi)	**1**	**1**	**2**
TDS	251.38	213.04	220.52
Class Index Score (Pi)	**1**	**1**	**1**
Turbidity	61.13	173.25	80
Class Index Score (Pi)	**4**	**8**	**4**
DO	6.17	6.68	7.99
Class Index Score (Pi)	**1**	**1**	**1**
BOD	2.15	7.69	1.62
Class Index Score (Pi)	**2**	**4**	**1**
SO4	6.45	15.34	7.29
Class Index Score (Pi)	1	1	1
Cl	9.80	24.74	9.90
Class Index Score (Pi)	1	1	1
OIP	1.57	2.43	1.57
Pollution Category	C1 **(Acceptable -Excellent)**	C2 **(Acceptable-Slightly Polluted)**	C1 **(Excellent-Acceptable)**

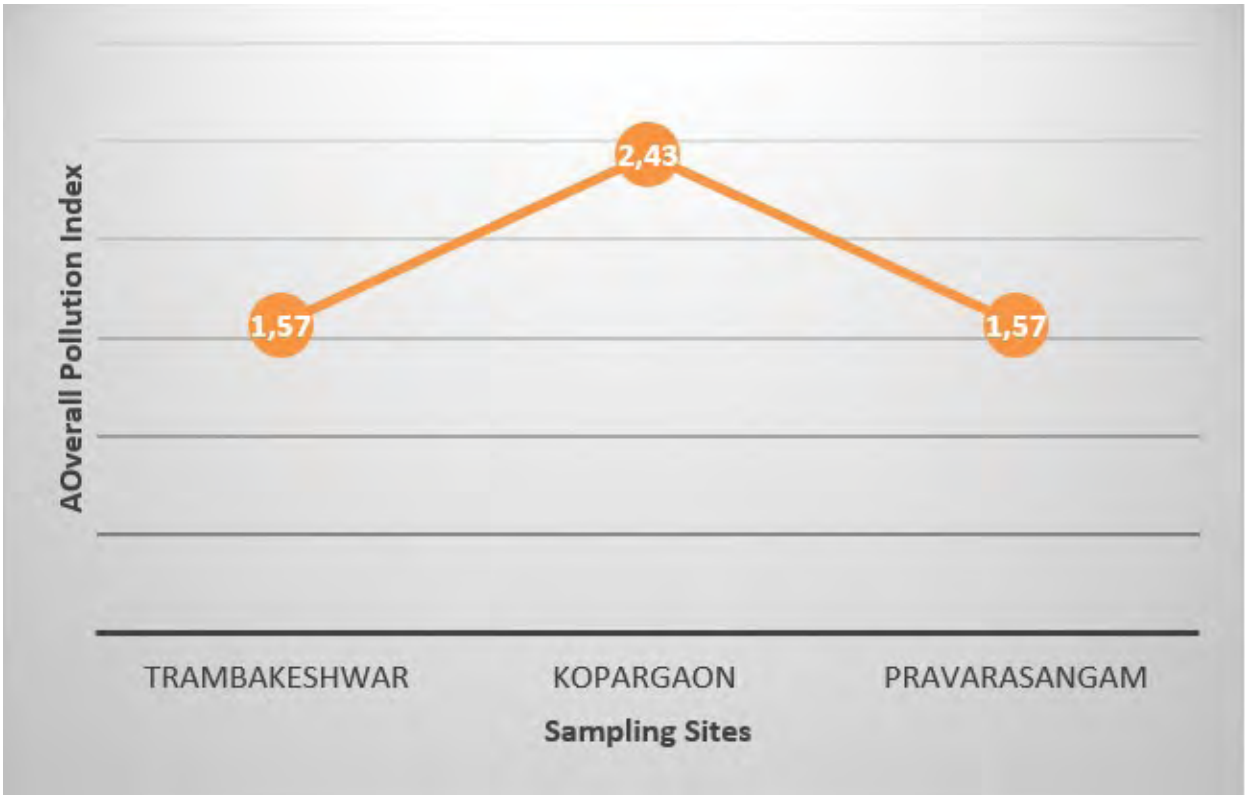

Figure 6 Trends of OIP Score for the study area (2018–2019).

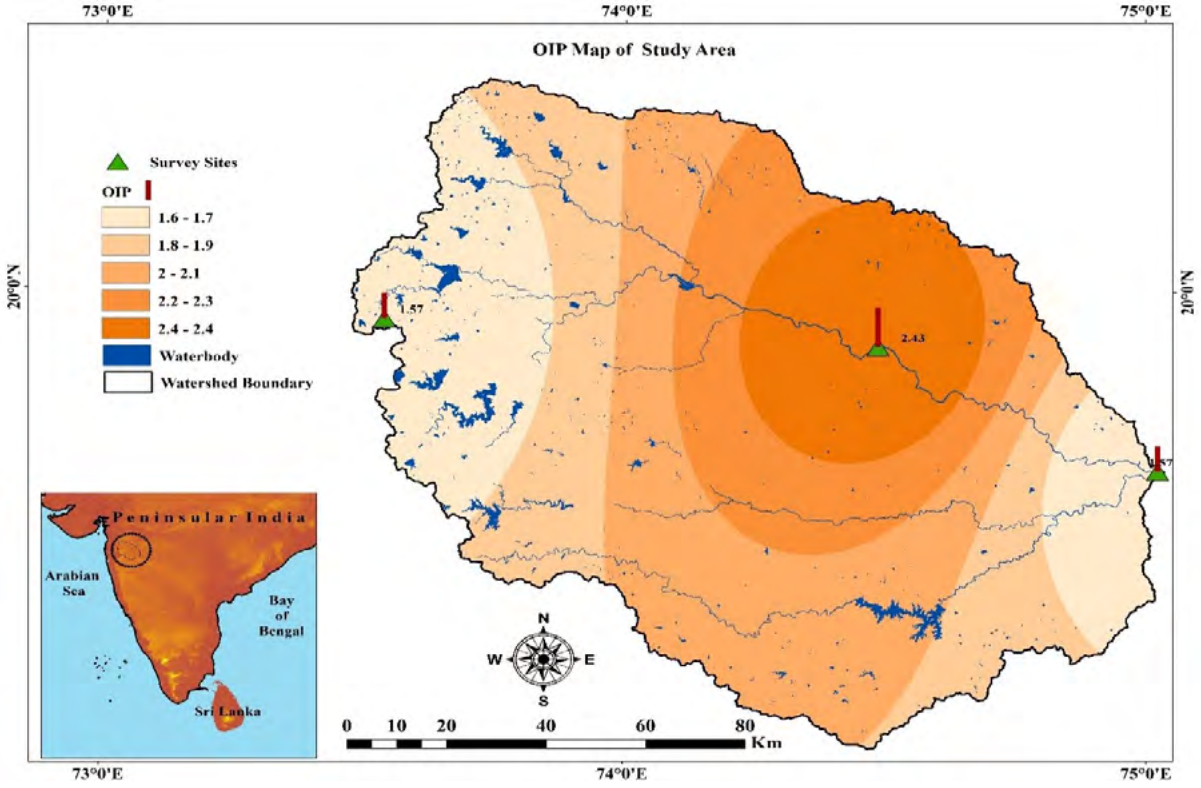

Figure 7 Overall Index of Pollution distribution map for the study area (24 July 2018).

5 Conclusion

WQI for a Godavari River was calculated at three different sites for understanding water suitability for human drinking purpose. In this paper, OIP score from the physicochemical analysis evidently explains that the water quality of Godavari River at Trambakeshwar and Pravarasangam is excellent and suitable for human consumption and survival of aquatic organisms. Water under category of Excellent means the water quality is clean. But in general water quality situation at Kopargaon is becoming worsen, as determined at a point in time in this article. Kopargaon water sample is under 'Acceptable' category, so water only needs disinfection. However, if it added more pollutants it can shifted to polluted category in future. So, it is alarming sign for policy makers, administrators and peoples who resides on the bank of river Godavari.

During the field investigation and site examination it is observed that human encroachment could be seen along the river bank in form of brick fields, slums and hutments, agricultural chemical effluents were traced in water. If societal negligence increases about water quality, there will not much time required to shift under 'slightly polluted' category. Hence it may be concluded that there is crucial time for prerequisite careful observation and supervision of the river. Attention of Government administrators, mass participation in cleaning, NGOs should work together for clear and pollution free Godavari River. It is currently crucial time for demands of time for assessment and conservation of the river ecosystem.

6 References

BCMOELP 1995, *The British Columbia Water Quality Index, Water Quality Branch*, Environmental Protection Department, British Columbia Ministry of Environment, Lands Parks.

CCME – Canadian Council of Ministers of the Environment 2001, *Canadian water quality guidelines for the protection of aquatic life: CCME Water Quality Index 1.0, User's Manual*, Canadian Environmental Quality Guidelines, Winnipeg.

CPCB – Central Pollution Control Board 2011, *Guide manual: Water and wastewater analysis*, New Delhi.

Chaudhary, P., Sharma, M.P., Bhargave, R., Kumar, S. & Dadhwal, P.J.S. 2013, 'Water Quality Assessment of Sukhna Lake of Chandigarh City of India', *Hydro Nepal Journal of Water Energy and Environment*, vol. 12, no. 12, pp. 26-30, DOI:10.3126/hn.v12i0.9028.

Cude, C., 2001, 'Oregon Water Quality Index: A tool for evaluating water quality management effectiveness', *Journal of American Water Resources Association*, vol. 37, no. 1, pp. 125-37, DOI:10.1111/j.1752-1688.2001.tb05480.x.

Gaikwad, V., Sing, K., Salunke, V.S. & Kudnar, N.S. 2023, 'GIS-based comparative analysis of lineament extraction by using different azimuth angles: A case study of Mula river basin, Maharashtra, India', *Arabian Journal of Geoscience*, vol. 16, no. 9, 538, DOI:10.1007/s12517-023-11636-2.

Horton, R. 1965, 'An index number system for rating water quality', *Journal of the Water Pollution Control Federation*, vol. 30, no. 3, pp. 300-6.

Katyal, D., Qader, A., Ismail, A.H. & Sarma, K., 2012, 'Water quality assessment of Yamuna River in Delhi region using index mapping', *Interdisciplinary Environmental Review*, vol. 13, no. 2/3, pp. 170-86, DOI:10.1504/IER.2012.047796.

Lalrindika, P.C., Zonunsanga, R. & Rinawma, P. 2020, 'Water Quality Assessment of Chite River using Overall Index of Pollution (OIP) in Aizawl, Mizoram', *A Journal of Geography Association of Mizoram Geographic*, vol. 15, pp. 56-62.

Maharashtra Pollution Control Board Report 2015, *Comprehensive study of polluted river stretches and preparation of action plan of River Godavari from Nasik to Paithan*, Aavanira Biotech, Chinchwad.

Salunke, V.S. 2020a, 'A comparative Study of Air pollution four pre and during lock down: A case study of four metropolitan city of Maharashtra', *Shodh –Sarita*, vol. 7, no. 27, pp 160-7.

Salunke, V.S. 2020b, 'Study of Talpona River Mouth by using Geospatial Technology', *Studies in Indian Place Names*, vol. 40., no. 50, pp. 791-800.

Sargaonkar, A.P., Gupta, A. & Devotta, S., 2008, 'Dynamic weighting system for water quality index', *Water Science & Technology*, vol. 58, no. 6, 1261, DOI:10.2166/wst.2008.468.

Sargaonkar, Aabha & Deshpande, Vijaya. (2003). Development of an Overall Index of Pollution for Surface Water Based on a General Classification Scheme in Indian Context. Environmental monitoring and assessment. 89. 43-67. 10.1023/A:1025886025137.

Sharda, A.K. & Sharma, M.P., 2013, 'Water quality assessment of Swan River in Himachal Pradesh, India', *International Journal of Environmental Sciences*, vol. 4, no. 3, pp. 402-14.

Author contributions
Vasudev Shivaji Salunke: conceptualization; formal analysis; writing-original draft; writing – review and editing; visualization. Pramila Salunke: methodology; validation; writing – original draft.

Conflict of interest
The authors declare no potential conflict of interest.

Data availability statement
Data and Reference datasets can be freely available on demand.

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