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Environmental Degradation of River Tandula Physico Chemical Analysis and Water Quality Index of River Water and Measures to its Restoration

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Abstract- ***The ongoing challenges of water scarcity and river pollution are becoming increasingly critical in India. The Tandula River, an essential water source in Chhattisgarh, is crucial for the Durg and Balod districts. This study investigates the changes in the physicochemical properties and evaluates the water quality index of the Tandula River, which is impacted by urbanization and industrial activities such as rice and sugar mills, sponge iron production, cement manufacturing, brick production, and various human activities, alongside deforestation. Nine samples were collected from the Tandula River for comprehensive analysis. The physicochemical characteristics and water quality index were assessed and compared to the water quality standards for inland surface waters set by the Central Pollution Control Board in 1979. The Water Quality Index (WQI) was determined using the drinking water quality standards recommended by the World Health Organization (WHO), the Bureau of Indian Standards (BIS), and the Indian Council for Medical Research (ICMR). The assessment utilized the weighted arithmetic index method to evaluate the river's water quality. The results indicated that the water quality index varied from good to very poor, with values ranging from 47.89 to 85.62. The mean water quality index was approximately 64.91, reflecting poor water quality. These fluctuations are primarily due to pollution and the river's inherent self-purification capabilities. However, with the expected rise in industrial activities and anthropogenic pressures, along with surface and hydraulic loading, the water quality is likely to deteriorate further. Therefore, the assessment concludes that the water quality index is poor, indicating that the examined water sources are not suitable for human consumption without prior treatment. The analytical results highlight the urgent need for ongoing monitoring of water sources and further scientific research based on these findings.***

I. INTRODUCTION

The Tandula River is a significant tributary of the Mahanadi, playing a crucial role as a waterway in the state of Chhattisgarh. Its origin is located in the hills to the north of Bhanupratappur, within the Kanker district. The river flows for a distance of 34 kilometers before it converges with Sukhanala and subsequently joins the Sheonath River approximately 13 kilometers to the southwest of Durg. The overall length of the Tandula River measures 96.6 kilometers, flowing in a northeast direction from its source until it meets the Shivnath River near the village of Konari Bharda in the Durg District. Numerous projects have been developed along this river, most notably the Tandula Dam situated near Balod city, in addition to various anicuts. This river is crucial for providing water to a multitude of industries and for supplying drinking water to several districts within Chhattisgarh. Key projects along the river include the Tandula Major Dam, Admabad Tank, Heerapur Anicut, Nawagaon Anicut, Pairi Anicut, Iraguda Anicut, Sanaud Anicut, Chandanbirhi Anicut, Gunderdehi (Baghmara) Anicut, Bhardakhurd (Gureda) Anicut, Vinayakpur Anicut, and Aalbaras Anicut. Chhattisgarh is rich in natural resources such as coal, bauxite, iron, limestone, and various precious stones. The Durg and Balod districts have developed into industrial centers due to the presence of these valuable raw materials. Numerous brick manufacturing facilities and other industries are established along both banks of the river. However, the ongoing discharge of industrial and domestic sewage has resulted in considerable pollution of the river, making the water unsafe for consumption by both humans and animals. In response to this issue, I have commenced a study on environmental degradation, focusing on the physico-chemical analysis of the water in the Tandula River within the Durg and Balod districts. The combination of industrial activities, mining operations, and rapid urbanization has significantly contributed to the river's pollution, with both treated and untreated wastewater from these sources further intensifying the problem.

II. MATERIALS AND METHODS

2.1 Approach

The Tandula River extends for a total length of 96.6 kilometers, making it unfeasible to select sampling points at various intervals along its length. As a result, we have pinpointed critical sites where the river is expected to experience pollution due to anthropogenic activities. These sites encompass regions adjacent to power generation facilities, rice processing mills, industrial zones, and sponge iron production plants. Water samples were gathered from both upstream and downstream of the designated sampling stations, maintaining approximately equal distances.

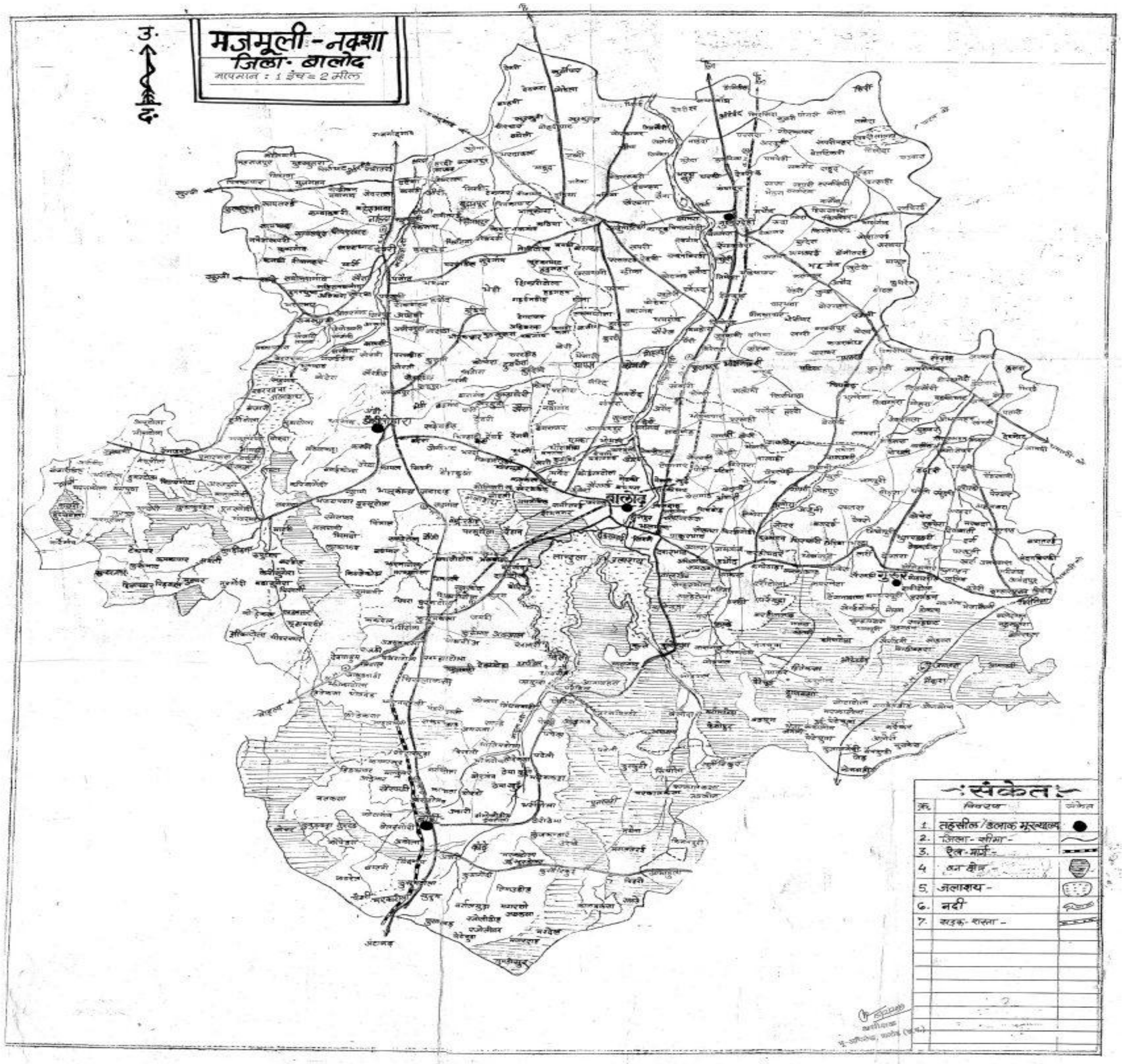

Fig. 1: Selection of Sampling Points

2.2 Methodological Approach to Sample Collection

The sample collection methodology follows the guidelines established in IS 3025-1987 (Part-I). The experimental approach consisted of collecting grab samples in clean 1-liter plastic containers from nine different sites. In March 2020, samples were collected from the surface water layer and from a depth of approximately 30 cm below the surface at the center of the main flow. This was achieved by orienting the mouth of the container in the direction of the water flow to ensure effective collection.

Filling the bottles: When collecting samples for the evaluation of physico-chemical parameters, it is essential to adhere to certain precautions. Although this approach may not be universally applicable, a recommended technique involves filling the bottle to its maximum capacity and sealing it in a way that prevents any air from remaining above the sample.

Sampling Locations: Samples should ideally be collected from the midstream region at mid-depths whenever possible. Sampling conducted near the riverbank may produce results that are not representative. It is recommended to choose sampling sites where notable changes in water quality are evident and where significant river activities take place, such as confluences, major discharges, or water abstractions. Furthermore, when feasible, samples can be obtained from boats in rivers and lakes, while ensuring that unsafe banks are avoided. In cases where the objective is to monitor the effects of a discharge, it is crucial to perform sampling both upstream and downstream of the discharge point, as the interaction between the discharge and the receiving water is a vital consideration. For longer rivers, it is important to establish three fixed sampling points across a cross-section (left, middle, and right), ensuring that the left and right points are adequately distanced from the bank. Sampling should extend downstream sufficiently to assess the impacts on the river. Ideally, samples should be collected from areas of turbulence where the flow is streamlined, promoting mixing. For biochemical oxygen demand (BOD) analysis, a sample volume of 300 ml was taken using a BOD bottle produced by Borosil. These bottles underwent cleaning with chromic acid and washing soda, followed by rinsing with tap water and then double-distilled water. The neck and stopper were secured with butter paper and a rubber band. The bottles were then sterilized in an autoclave at 15 lbs pressure (121°C) for a duration of 15 to 25 minutes. Various sizes of pipettes were also cleaned, fitted with a cotton plug at the top, wrapped in butter paper, and sterilized in an autoclave under the same conditions for 15 to 20 minutes. Petri dishes were washed and subsequently sterilized in an oven at temperatures between 160°C and 180°C for 1 to 2 minutes.

2.3 Study Area

This research investigation will concentrate on the analysis performed in the Durg and Balod districts. The chosen study regions host a diverse array of industries located along the riverbanks, such as steel manufacturing facilities, brick production units, rice processing mills, small-scale handicraft businesses, agro-industrial enterprises, soda water production, and cotton textile operations, among others. Some of these industries exert both direct and indirect effects on the river water quality. Therefore, these sites have been selected for the study.

1. SST-1 = Heerapur cross regulator
2. SST-22 = Pairi anicut
3. SST-3 =Sanaud tape
4. SST-4 = Chandanbirhi anicut
5. SST-5 = Chichalgondi joint
6. SST-6 = Baghmara anicut
7. SST-7 = Bharda bank
8. SST-8 = Gureda Anicut
9. SST-9 = Aalbaras bank

Table 1: Classification of Inland Surface Waters according to CPCS Standards and an Evaluation of Results Against Standard Values

S. No.	Characteristics	A*	B*	C*	D*	E*	SST-1	SST-2	SST-3	SST-4	SST-5	SST-6	SST-7	SST-8	SST-9
5.	Total suspended solids	500	-	1500	-	-	56	62	66	82	216	85	156	64	56
4.	Total hardness	200	-	-	-	-	68	72	78	76	52	70	75	68	60
1.	pH value	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	-	7.18	7.17	7.22	7.18	7.13	7.22	7.1	7.15	7.2
7.	Magnesium hardness	200	-	-	-	-	34	32	36	30	26	30	32	32	34
3.	Total alkalinity	200	-	-	-	-	76	80	86	82	60	68	82	70	76

S. No.	Characteristics	A*	B*	C*	D*	E*	SST-1	SST-2	SST-3	SST-4	SST-5	SST-6	SST-7	SST-8	SST-9
9.	Nitrates (as NO_3), mg/l, Max	20	-	50	-	-	0.8	1	0.9	1	0.8	1.1	0.9	0.8	0.8
2.	Total Dissolved Solids, mg/l, Max	500	-	1500	-	-	265	276	290	296	342	297	306	294	240
6.	Calcium hardness	200	-	-	-	-	32	36	38	40	30	34	40	38	32
10.	Sulphates (as SO_4), mg/l, Max	400	-	400	-	-	12	14	18	20	16	20	22	14	12
8.	Chlorides (as Cl), mg/l, Max	250	-	600	-	-	17	18	21	25	22	32	21	19	17
14.	Iron (as Fe), mg/l, Max	0.3	-	50	-	-	-	-	-	-	-	-	-	-	-
12.	Biochemical Oxygen Demand, mg/L, Max	2	3	3	-	-	2	4.8	2.4	2	3.5	5.2	2.4	4.6	2.4
11.	Dissolved Oxygen, mg/l, Min	6	5	4	4	-	6.6	6.2	5.8	6.6	6.2	5.2	5.8	5.4	6.7
13.	Copper (as Cu), mg/l, max.	1.5	-	1.5	-	-	-	-	-	-	-	-	-	-	-
17.	Manganese (as Mn), mg/l, max.	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
16.	Lead (as Pb), mg/l, Max	0.1	-	0.1	-	-	-	-	-	-	-	-	-	-	-
15.	Zinc (as Zn), mg/l, Max	15	-	15	-	-	-	-	-	-	-	-	-	-	-

Assessment of Water Quality Index: This study identified thirty critical parameters for evaluating the water quality index. The WQI was calculated in accordance with the drinking water quality standards established by the World Health Organization (WHO), the Bureau of Indian Standards (BIS), and the Indian Council for Medical Research (ICMR). The weighted arithmetic index method, as outlined by Brown et al., was utilized to determine the WQI for the water body. Furthermore, the quality rating or sub-index (qn) was obtained using the designated formula

$$.\, q_n = \frac{100[V_n - V_{io}]}{[S_n - V_{io}]}$$

Let there be n water quality parameters, with the quality rating or sub-index (qn) for the nth parameter representing a numerical value that indicates the relative status of this parameter in contaminated water compared to its acceptable standard value. qn = Quality rating for the nth water quality parameter Vn = Estimated value of the nth parameter at a specific sampling location Sn = Standard permissible value of the nth parameter Vio = Ideal value of the nth parameter in pristine water, which is 0 for all parameters except for pH and dissolved oxygen, where the ideal values are 7.0 and 14.6 mg/l, respectively.

The unit weight was determined based on a value that is inversely related to the recommended standard value Sn of the relevant parameter.

$$W_n = K / S_n.$$

Wn represents the unit weight associated with the nth parameter. Sn denotes the standard value corresponding to the nth parameter. K is the constant that establishes proportionality.

The Overall Water Quality Index was determined by linearly combining the quality ratings with their respective unit weights..

$$WQI = \frac{\Sigma W_n q_n}{\Sigma W_n}$$

Table 2: Comparison of water quality index to standard value

S. No.	Sampling Points	Water quality index of sample	Assessment of water quality conditions
1.	SST-1	47.90	Good
2	SST-2	70.88	Poor
3	SST-3	59.84	Poor

S. No.	Sampling Points	Water quality index of sample	Assessment of water quality conditions
4	SST-4	48.08	Good
5	SST-5	69.01	Poor
6	SST-6	85.65	Very Poor
7	SST-7	66.05	Poor
8	SST-8	79.33	Very Poor
9	SST-9	57.36	Poor
Average value		64.90	Poor

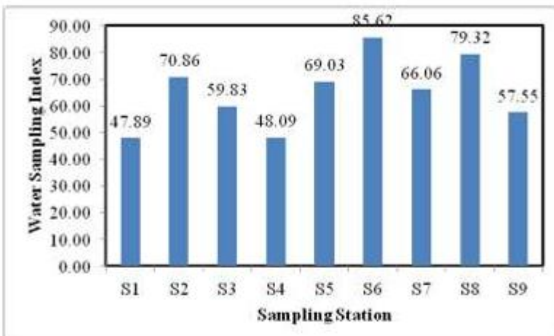

Fig. : A visual depiction illustrating the relationship between the Sampling Station and the Water Quality Index.

III. RESULTS AND DISCUSSION

1. The Central Pollution Control Board (CPCB) delineates that the permissible pH range for drinking water sources, which are disinfected without undergoing conventional treatment, as well as for organized outdoor bathing and drinking water sources that are subjected to conventional treatment followed by disinfection, is set between 6.5 and 8.5. In the area under investigation, the pH levels of the water samples ranged from 7.10 to 7.22. In general, the mean pH of all samples remained within the acceptable limits defined by CPCB standards.
2. The concentrations of total solids, total dissolved solids, and total suspended solids in this water body were found to be within the acceptable thresholds. The Central Pollution Control Board (CPCB) and the Indian Council of Medical Research (ICMR) / Bureau of Indian Standards (BIS) have established a maximum allowable limit for total dissolved solids (TDS) at 1500 mg/l and 500 mg/l, respectively.
3. The total alkalinity of the water, measured as CaCO3, varied between 60 and 86 mg/l, indicating a moderate range of alkalinity. Water designated for domestic consumption is deemed safe when its alkalinity remains below 100 mg/l. The minimum alkalinity was noted at sample station S5, whereas the maximum was found at sample station S3.
4. The hardness of the sampling locations was assessed, revealing values that ranged from 52 mg/l at S5 to 78 mg/l at S3.
5. The chloride concentrations measured at the sampling sites ranged from 17 mg/l at S1 to 32 mg/l at S6. It is important to highlight that the chloride levels in the water remain below the threshold of 250 mg/l.
6. The nitrate concentrations measured at the sampling locations were determined to be within permissible thresholds. However, it is important to note that even minimal quantities of nitrates can engage in reactions with different compounds within the body, potentially resulting in the production of carcinogenic agents.
7. The presence of sulphate in water can lead to a bitter taste when its concentration exceeds 250 mg/l. Current measurements reveal that the concentration of sulphate typically ranges from 12 mg/l to 22 mg/l.
8. The concentrations of dissolved oxygen at the sampling sites ranged from 5.2 mg/l at S6 to 6.7 mg/l at S9. As per the standards set forth by the Central Pollution Control Board (CPCB), the Indian Council of Medical Research (ICMR), the Bureau of Indian Standards (BIS), and the World Health Organization (WHO), it is advised that the solubility of atmospheric oxygen in freshwater should fall within the range of 4 mg/l to 5 mg/l.
9. Biological Oxygen Demand (BOD) is utilized as a measure of microbial contamination in aquatic environments. The results indicate a notable presence of microbial pollution within the analyzed water samples. The BOD measurements for the chosen samples vary from 2 mg/l (S1) to 5.2 mg/l (S6). Among these samples, the maximum BOD value is 5.2 mg/l (S6), whereas the minimum values are recorded at 2 mg/l (S1) and 2 mg/l (S4).

10. The results demonstrate that the river's contamination is predominantly attributed to organic loading, especially from domestic waste and the residential sectors of industrial activities, as indicated by the high biochemical oxygen demand (B.O.D.) recorded at sampling sites S2 and S6. Based on the classification of inland surface waters set forth by the Central Pollution Control Board (CPCB) standards, the river is classified as category E', suggesting that the water is appropriate for irrigation and industrial uses, thereby underscoring a significant level of pollution within the river.
11. Water Quality Index: The water quality index for the chosen water samples was assessed using defined water quality parameters. The results revealed values ranging from 47.89 at sampling site S1, which is classified as having good water quality, to 85.62 at sampling site S6, which is categorized as very poor water quality. The overall average water quality index was determined to be 64.91, placing it within the poor water quality category. These index values distinctly demonstrate that the water sources in the study area are compromised due to various discharges from multiple origins.

IV. CONCLUSION

1. The results of the physico-chemical analysis suggest that the water is not significantly contaminated, making it appropriate for domestic applications, although it is not safe for consumption.
2. The physico-chemical characteristics of the Tandula River have undergone significant changes from the initial sampling location to the final sampling location, attributable to industrial operations, human activities, sand extraction, and various environmental influences.
3. The results of the water quality analysis reveal that the water quality index at sampling locations S6 and S8 is categorized as very poor, whereas sampling points S2, S3, S5, S7, and S9 are classified as having poor water quality. This degradation is primarily attributed to high levels of biochemical oxygen demand, in accordance with the criteria established by the Central Pollution Control Board (CPCB), the Indian Council of Medical Research (ICMR), and the Bureau of Indian Standards (BIS). Conversely, sampling points S1 and S4 are rated as having good water quality. Considering the developmental prospects of Durg and Balod, which are bolstered by their abundant natural resources, it is expected that there will be an increase in industrialization, urbanization, mining, and other activities in the future, resulting in a greater pollution burden on the river. This scenario underscores the urgent need for the implementation of strategies aimed at mitigating both the intensity and volume of waste. As pollution from various sources continues to impact the river, it is advisable to formulate a comprehensive river action plan to enhance the quality of the river water, which should include measures such as the interception and diversion of drains discharging into the river.

i. The interception and redirection of drainage channels that flow into the river.
ii. The establishment of additional anicuts along the river.
iii. The implementation of a sewage treatment facility for the management of domestic wastewater.
iv. The optimization of the recovery and reuse of treated wastewater.
v. The initiation of tree planting initiatives along the riverbanks and in various urban areas, contingent upon land availability.
vi. The organization of public awareness campaigns focused on sanitation, water pollution, and its mitigation strategies.

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