Spatio-Temporal Assessment of Surface Water Quality of Torsa River in Cooch Behar Municipality, its Adjacent Areas, and Outskirts, West Bengal, India Using CCME-WQI

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ABSTRACT

Water is a vital resource for sustaining life, and its quality is of utmost importance for the well-being of both humans and ecosystems. Rivers serve as significant sources of freshwater, providing drinking water, irrigation, and supporting various aquatic habitats. An attempt has been made in this paper to show the spatio - temporal variation of water quality along the Torsa River at Cooch Behar Town, its adjacent areas and outskirts, West Bengal, India. The field work was conducted during Pre-Monsoon, Monsoon, Post-Monsoon and Winter in the year of 2022 and 2023. To carry out the study, water samples have been collected from 5 stations, one station from urban environment, two from adjacent to urban environment, and two from outskirts. The collected samples have been tested in the laboratory by titration, gravimetric and coloration method. CCMEWQI was applied using thirteen water quality parameters namely Temperature, pH, Conductivity, Turbidity, Total Hardness, Total Dissolved Solids, Total Soluble Solids, Dissolved oxygen, Biological Oxygen Demand, Chloride, Ferrous, Nitrate and Phosphate. Based on the results obtained from the index, the water quality of Torsa River ranged between 71.13 to 90.06 which indicate that the river has Fair to Good quality due to effect of various rural and urban pollutant sources. The temperature, turbidity, DO, BOD, Chloride and Phosphate do not meet the standards in different sampling stations especially in Monsoon. This makes the water unsuitable for drinking purposes without proper treatment. The work confirms the need to take an action for monitoring the river for proper management. Therefore, there is a need of intensive study leading to a contamination zone mapping to river water quality management.

Keywords: Water Quality Index, American Public Health Association, Bureau of Indian Standard, Indian Council of Medical Research, World Health Organization.

INTRODUCTION

Freshwater bodies around the world are getting increasingly contaminated day by day. Urbanization plays an important role to increase pollution, and decrease the potability of water, posing a severe concern for human life (Kumar et al., 2021; Bhatt et al., 2024). Most of the water bodies are moderately polluted by agricultural waste, sewage, industrial waste and by human intervention (Maji et al., 2020; Mukate et al., 2018) because of population growth and economic development. India is facing a problem of natural resource scarcity, especially that of water (Kumar & Ballabh, 2000). Water exists in nature in many forms like ocean, river, lake, clouds, rain, snow and fog etc and it is too much important as all life is dependent on it (Chakraborty & Chakraborty, 2021). Drinking water sources in India include rivers, streams, lakes, ponds, wells, underground aquifers, reservoirs, and springs. Rivers play a vital role by providing water, food resources, and supporting human livelihoods. However, chemically pure water is generally considered not to exist in nature for any appreciable length of time (Hem, 1970). It is important to monitor the measurement of physico-chemical water quality indicators to get a comprehensive appraisal in the spatio-temporal variation of surface water quality (Saha et al., 2022). Hence, river water quality is an important environmental concern that must be preserved and monitored (Yeleliere et al., 2018). Drinking water quality of surface water may be assessed using physico-chemical parameters, and their compliance to the water quality standards (Ugbaja& Ephraim, 2019). Physico-chemical water quality indicators don't give overall status of surface water. The Water Quality Index (WQI) is a useful model that converts complex datasets into a single, unitless numerical value representing the overall status of water quality and its suitability for various uses (Uddin et al., 2021; Katyal, 2011; Gupta & Gupta, 2021). It provides a single value, which makes it widely used for assessing river water quality in India and other countries as well (Kumar & Dua, 2009). Cooch Behar District located in WesternDooars Region, A part of India i.e., North of West Bengal abounds in freshwater systems especially the region is blessed with several rivers which are originates from Himalaya and Torsa River is the major river of the district and the river flows by the western side of the Cooch Behar Town (Biswas & Bhattacharya, 2017). Torsa is an international river traversing four countries – China (Tibet), Bhutan, India and Bangladesh and it is the second largest river of North Bengal as well as in Dooars Region of West Bengal (Sarkar & Pal, 2017; Mukherjee, 2020). Rising from Chumbi Valley in Tibet, China the river flows through Bhutan. She cuts across in a southeasterly direction and passes by the market town of the Phuntsholing on the Indo-Bhutan Border and finally merges with the River Brahmaputra i.e., Jamuna in Bangladesh. The river is named as 'Machu' in Tibet, China, 'Amo - Chu' in Bhutan and in the plains of North Bengal it is familiar as Torsa (Mukherjee, 2020). Once upon a time it is known that the rivers are free flowing with clean water but during the last few decades' water quality of different freshwater sources are deteriorated gradually (Mishra, 2023). There are a few studies on the status of river water especially Torsa River at Cooch Behar in India. With a total length of about 145 km in India, it travels through a Himalayan foothill terrain and a number of small villages. The villagers as well as the people of the outskirts and town of Cooch Behar are entirely dependent on this river for their livelihood, other domestic uses, and drinking water plants etc. Hence the evaluation of surface water quality of the river is imperative. Against this backdrop we have analyzed physico-chemical properties of surface water of the river in different stations and applied CCMEWQI for determining the quality of water of Torsa River. The objectives of the work are to assess the spatio-temporal variation of surface water quality at different stations of Torsa River in Cooch Behar Town, its adjacent areas and outskirts, West Bengal, India.

MATERIALS AND METHOD

Study Area

The total length of Torsa River is 358 kms and the area of the basin is about 4883 sq km. After travelling 113 km path Torsa entered Bhutan. About 50% of the total flow path of Torsa falls in Bhutan and Tibet. In India, it flows for 145 kms only through two districts of West Bengal i.e., Alipurduar and Cooch Behar districts (Sarkar and Pal, 2017; Gautam, 2023). The main tributaries of Torsa are Halong and Kaljani (Gautam, 2023). The present research covers only the Cooch Behar Municipality, its adjacent areas and outskirts, West Bengal, India.

Table No.1. Details of sampling locations.

Station Code	Station Name	Geographical Extension	Station Location	Station description
S1	Kamrangaguri, Cooch Behar, W.B.	Lat- 26° 21'08'' Long- 89°23'49''	Outskirt	Domestic waste, bathing
S2	Karishal, Cooch Behar, W.B.	Lat- 26°19'11''N Long- 89°25'39''E	Adjacent to Urban	Urban sewage, domestic sewage, bathing, fishing
S3	Bisarjan Ghat, Cooch Behar, W.B.	Lat- 26°18'20''N Long- 89°26'55''E	Urban	Urban sewage, domestic sewage
S4	Guriahati, Cooch Behar, W.B.	Lat- 26°18'17''N Long- 89°28'42''E	Adjacent to Urban	Municipal waste, urban sewage, domestic sewage

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S5	Kunidanga, Cooch Behar, W.B.	Lat- 26°17’56’’N Long-89°30’47’’E	Outskirt	Domestic waste, bathing

Source: Tabulated by Author.

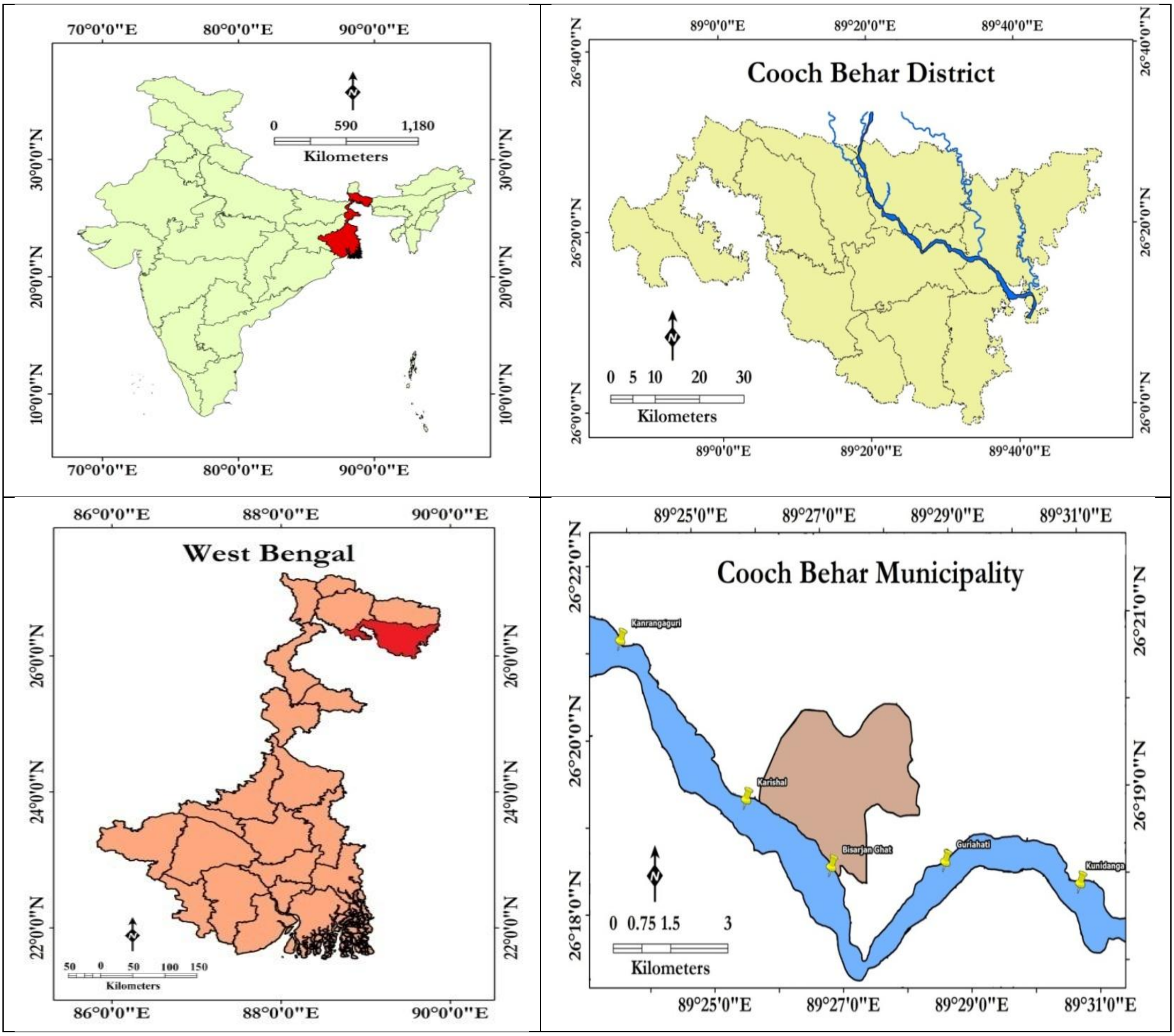

Fig. No. 1: Study area and sampling stations in Torsa River.

Water Sampling And Analysis

Four different seasons have been selected for the collection of samples namely Pre-Monsoon, Monsoon, Post-Monsoon and Winter in the year of 2022 and 2023 (Chakravarty and Gupta, 2021). Samples were collected from five predesignated stations, one station from Cooch Behar Municipality, two stations from adjacent areas of the town and two stations from outskirts based on equal interval of four kilometers along the river and convenience to the station (Plumb, 1981; Chatanga et al., 2019; Parweenet al., 2022). From each sampling site, three samples were collected by means of a 1.5-liter sterilized clean polyethylene bottles from left and right bank and middle of the river at the depth of 15 cm from the surface water through the grab and bucket sampling technique; all three samples were mixed and, were analyzed as single sample. The bottles were opened under water, rinsed thoroughly with the sample water even it was pre – cleaned (Ahsan et al., 2019; Parween et al., 2022; Saha, 2014). For the study, thirteen Physio-chemical water parameters were chosen based

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on both importance and availability of data. The analytical methods of the parameters of which 3 were physical and 10 were chemical parameters summarized in Table 2 (Parween et al., 2022). The parameters are Temperature, pH, Conductivity, Turbidity (Turb), Total Hardness (TH), Total Dissolved Solids (TDS), Total Soluble Solids (TSS), Dissolved oxygen (DO), Biological Oxygen Demand (BOD), Chloride, Ferrous, Nitrate and Phosphate. The samples were collected following the standard guidelines (APHA, 2012) and the detailed information of the sampling site has been shown in Table 1. Water temperature was measured on in-situ and other samples were stored at 4 °C and transported to the laboratory immediately after collection (Parween et al., 2022). The WQI was calculated by using the standards of the drinking water quality recommended by the BIS (IS 10500), EPA, CPCB, ICMR and WHO guidelines. CCMEWQI was computed based on Microsoft Excel frame to get the overall status of the river water quality.

Table -2. Physico-chemical parameters of river water and analytical methods

Water Quality Indicators	**Abbreviation**	**Analytical Instruments/Techniques/Method**
Temperature	Temp.	Thermometer
pH	-	pH Meter
Conductivity	Cond.	Conductometer
Turbidity	Turb.	Nephelometer
Total Hardness	TH	Titration
Total Dissolved Solids	TDS	Gravimetric Method
Total Suspended Solid	TSS	Gravimetric Method
Dissolved Oxygen	DO	Titration
Biological Oxygen Demand	BOD	Titration
Chloride	Cl	Coloration Method
Ferrous	Fe	Coloration Method
Nitrate	NO^{3-}	Coloration Method
Phosphate	$PO^3{}_4^-$	Coloration Method

Table No. 3: Standard of Different Water Quality Parameters

Sl. No.	**Parameters**	**Standard Value**	**Units**	**Source**
1	Temperature	25	℃	EPA, Ireland
2	pH	6.5 - 8.5		BIS & ICMR
3	Conductivity	300	µS/cm	ICMR
4	Turbidity	5	NTU	BIS
5	TH	300	mg/L	BIS & ICMR
6	T D S	500	ppm	BIS
7	T S S	500	ppm	WHO
8	D O	5	mg/L	ICMR
9	B O D	5	mg/L	ICMR
10	Chloride	250	mg/L	BIS & ICMR
11	Ferrous	0.3	mg/L	BIS
12	Nitrate	45	mg/L	BIS & ICMR
13	Phosphate	0.1 - 0.3	mg/L	EPA, Ireland

EPA: Environmental Protection Agency, Ireland; BIS: Bureau of Indian Standard; ICMR: Indian Council of Medical Research; WHO: World Health Organization.

Source: Tabulated by Author

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Conceptual Framework Of CCME Water Quality Index

The Canadian Council of Ministers of the Environment (CCME) introduced a methodology to determine water quality status in the form of an index by considering several water quality parameters (Hurley et al., 2012). The CCME Water Quality Index (CCMEWQI) was originally developed as the Canadian Water Quality Index (CWQI) by the British Columbia Ministry of Environment, Lands and Parks and was later modified by Alberta Environment. The index incorporates three factors—scope, frequency, and amplitude—to generate a single dimensionless number that represents the overall status of water quality (Haldar et al., 2016).

Factor 1: F1 (Scope) Scope assesses the extent of water quality guideline non-compliance over the time period of interest, which means the number of parameters whose objective limits are not met. It stands for the percentage by which the variables deviate from their objectives.

$$F_1 = \left(\frac{\textbf{Number of failed variables}}{\textbf{Total number of variables}}\right) \times \mathbf{100}$$

Factor 2: F2 (Frequency) It is the percentage of “failed” tests (tests not fulfilling their objectives)

$$F_2 = \left(\frac{\textbf{Number of failed tests}}{\textbf{Total number of tests}}\right) \times \mathbf{100}$$

Factor 3: F3 (Amplitude) it represents the amount by which failed tests do not meet their objectives. This is calculated in three steps:

Step 1- Calculation of Excursion. Excursion is the number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective.

When the test value must not exceed the objective:

$$\textbf{Excursion} = \left(\frac{\textbf{Failed Test Value}}{\textbf{Objective}}\right) - \mathbf{1}$$

When the test value exceeds the objective or must not fall below the objective:

$$\textbf{Excursion} = \left(\frac{\textbf{Objective}}{\textbf{Failed Test Value}}\right) - \mathbf{1}$$

Step 2- Calculation of the Normalized Sum of Excursions (nse): The normalized sum of excursions (nse) represents the collective amount by which individual tests fail to comply with their respective objectives. This is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives).

Normalized sum excursions (nse) is calculated as follows-

$$\textbf{nse} = \frac{\sum_{i=1}^{n} excursion}{Number\ of\ tests}$$

F3 ($Amplitude$) is calculated by an asymptotic function that scales the normalized sum of the excursions from objectives to get a range from 0 to 100. Amplitude is computed as follows-

$$\mathbf{F_3} = \left(\frac{nse}{0.01nse + 0.01}\right)$$

Finally, the CCME Water Quality Index is determined using the following equation.

$$\textbf{CCMEWQI} = \mathbf{100} - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}\right)$$

The range i.e., 0 - 100 of the CCMEWQI is categorized into five categories indicates overall status of water quality like 0 - 44 as Poor (Water quality is not suitable for using purposes at any level), 45 – 64 as Marginal (Water quality is frequently threatened or impaired; conditions often depart from natural or desirable level), 65 – 79 as Fair (Water quality conditions sometimes departs from natural or desirable levels), 80 – 94 as Good (Water quality is departed from natural or desirable limits) and 95 – 100 as Excellent (Natural water quality) (Uddin et al., 2021).

RESULT AND DISCUSSION

Temperature is very important parameter and as well as determinant as it plays an important role to manage water quality. Physico-chemical parameters of water changes because of the action of temperature (Bojarczuk et al., 2018). At higher temperature, the rate of chemical reactions generally increases (Alam et al., 2007; Uddin et al., 2016). The solubility of oxygen in waters decreases with the increase in temperature (Weiss, 1970). Temperature also affects the metabolism, growth, and reproduction of bacteria responsible for the biodegradation of organic matter in water (Arora & Kazmi, 2015). An increase in temperature enhances the rate of biodegradation and overall biological activity, which consequently increases the oxygen demand in water (Lipczynska-Kochany, 2018). The highest water temperature was recorded at station 2, 3 and 4 (32°C) during Monsoon and the same temperature (32°C) also recorded at station 5 in Pre-Monsoon and Monsoon seasons respectively and the lowest was recorded at station 1 (21°C) in Winter season. The concentration of hydrogen ion present in the solution is the measurement of pH of that solution (Clayton & Byrne, 1993). The standard range of pH of Drinking water is between 6.5 and 8.5 according to BIS and ICMR. It is considered to be Acidic water if the pH is below 6.5 which is corrosive to pipes and hand pumps while pH above 8.5 is Alkaline water which may tend to have a bitter or soda-like taste (Goon et al., 1968). pH is an important parameter that determines the suitability of water for various purposes and serves as an indicator of water pollution. Monitoring the pH of surface water is essential because changes in pH can increase the toxicity of many pollutants, thereby adversely affecting water quality (Bouslah et al., 2017). The result of pH varied from 7.4 - 8.0 in station 1, 8.0 - 8.4 in station 2, 7.9 - 8.4 in station 3, 7.6 – 8.4 in station 4 and 7.6 – 8.1 in station 5 indicating that the water samples are almost neutral to sub-alkaline in nature. The highest pH value was recorded at Station 2, 3 and 4 (8.4) in Monsoon and lowest at station 5 (7.4) during Winter. The recorded range of pH values in present study were general in accordance with the pH values of fresh waters and were in permissible level (Ismaiel, 2018).) recommended by the BIS and ICMR for drinking water. Electrical conductivity (EC) is an important parameter because it reflects the concentration of cations in water, which greatly influence its taste and, consequently, the acceptability of water for potable use (Pradeep, 1998; Bouslah et al., 2017). EC also serves as an indirect measure of total dissolved salts in water (Benjankar&Kafle, 2021). The presence of high conductivity in water may result from the natural weathering of sedimentary rocks or from anthropogenic sources such as industrial discharges and sewage effluents. In general, EC represents the ability of an ionic solution to conduct electric current (Haldar et al., 2016). The range of electrical conductivity in Torsa River extended from 120 – 180 μs/cm. The highest EC value recorded in station 4 (180μs/cm) but it remained higher at Station 3 and 5 (175 μs/cm and 176μs/cm) in winter. Highest EC value was recorded during the winter when the river flow was lowest. Minimum EC recorded during monsoon (120 μs/cm) probably due to the effects of monsoon precipitation (Mor et al.2006). EC values change according to the geological settings and amount of precipitation (Ustaoğlu et al., 2021). Turbidity indicates the cloudiness, murkiness, or clarity of water and is primarily caused by the presence of suspended particles such as clay, silt, organic matter, plankton, and other microscopic organisms (Bouslah et al., 2017). It is also considered an optical property of water that results in the absorption or scattering of light. Turbidity is widely recognized as a significant parameter in assessing drinking water quality (Kothari et al., 2021; Ghosh &Panigrahi, 2023). Additionally, turbidity influences the temperature of surface waters, as bottom temperatures in turbid waters are generally lower than those in clear waters (Paaijmans et al., 2008). However, the observed value was higher than the standard level recommended by BIS (IS 10500) for drinking water for all seasons in the Stations of 2, 3 and 4. The highest Turbidity (10.9 NTU) was recorded at station 2 in Monsoon and Post-Monsoon, and lowest Turbidity (4.3 NTU) at station 5 in Pre-Monsoon. In the present study, it is found that almost all the stations recorded higher Turbidity value than the standard limit recommended by BIS in Post-Monsoon and Monsoon and is not fit for drinking purposes. It is known that calcium and magnesium ions are the reason of causing hardness in water and all other divalent cations also contribute to the concentration (Saurina et al., 2002). The rocks surrounding the water body is largely the source of hardness, although some industrial wastes and irrigation drainage contribute (Bouslahet.al, 2017). The higher hardness value in summer season is mainly attributed to rising temperature thereby increasing the solubility of calcium and magnesium salts (Hujare& Mule, 2008). It is suggested that the increase of risks of calcification in arteries, urinary concretions, disease of kidney or bladder or stomach disorder may be the reason of high Total Hardness in drinking water (Garg et al, 2009). The value of total hardness is maximum in Pre-Monsoon recorded as 52 mg/L at station S4 and minimum in Winter recorded as 23 at station S1 and S5. Total dissolved solids (TDS) refer to the inorganic salts and small amounts of organic matter dissolved in water (WHO, 1996; Ndefo et al., 2011). TDS is considered an important parameter for assessing water quality, as increases in turbidity, hardness, alkalinity, and electrical conductivity directly influence TDS levels. Water containing high TDS concentrations, particularly above the permissible limit of 300 mg/L, is generally considered unsuitable for drinking purposes (Kothari et al., 2021; Patil et al., 2012). In the present study, the value of TDS in the analyzed water samples varied between 180 and 390 mg/l, as shown in Table 3. Highest value of TDS 390 mg/l was observed at station S4 in Pre-Monsoon and the lowest value (180 mg/l) was observed at station 1 in Post-Monsoon. The overall TDS values were found to be within the standard limit (500 mg/l) for all sampling stations recommended by BIS. Hence, the drinking water is safe in case of TDS. The other qualities of water i.e., taste, hardness, etc, are influenced by high TDS (World Health Organization, 2010). Fine clay or silt particles, plankton, organic compounds, inorganic compounds or other microorganisms typically consists TSS (Chapman et al., 2017; Adjovu, 2023). The formation of TSS is influenced by different physical processes like aggregation of dissolved organic materials, erosion of stream banks, and surface soils largely controlled by hydrology (Adjovu, 2023). The recorded TSS ranged between 250 – 490 mg/l. The maximum value of TSS (490 mg/l) was observed at Station S3 and S4 during Monsoon and the minimum value (250 mg/l) was recorded at station S2 during Winter. The both minimum and maximum values are within the WHO standards. It is considered that DO is a direct indicator of water quality and the concentration of DO depends on the physical, chemical and biological characteristics of the water body (Bouslahet.al, 2017). Any forms of life cannot sustain without oxygen (Clark, 1924). In order to maintain adequate oxygen level for survival of aerobic life, natural stream purification process is required (Lampert, & Sommer, 2007). It is well known that DO in water body has inverse relation with temperature and turbidity while BOD has direct relation. While the temperature or turbidity increases, the rate of DO decreases and BOD increases (Tao et al., 2019). Warm temperatures reduce the amount of DO a water body can store (Evans et al., 2005). Turbulence, photosynthesis and decrease in temperature increase the concentration of DO in the water (Demars& Manson, 2013). At S2, S3 and S4 high organic pollution with increased temperature caused a little bit low DO level than the standard limit recommended by ICMR. The maximum DO was observed at Station S5 in Pre-monsoon season (6 mg/l) whereas minimum was observed in the S4 in Monsoon (4.7 mg/l).

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Table no: 4. Physico – chemical parameters of water of Torsa River and their testing values of five sampled stations in four water seasons.

Parameters	Station No: S1				Station No:S2				Station No: S3				Station No: S4				Station No: S5			
	Post Monsoon*	Winter	Pre-Monsoon	Monsoon	Post Monsoon	Winter	Pre-Monsoon	Monsoon	Post Monsoon	Winter	Pre-Monsoon	Monsoon	Post Monsoon	Winter	Pre-Monsoon	Monsoon	Post Monsoon	Winter	Pre-Monsoon	Monsoon
Temperature	24	21	31	31	24	23	31	32	24	23	31	32	23	22	31	32	24	22	32	32
pH	7.6	7.4	7.5	8	8.3	8.2	8	8.4	8.2	8.1	7.9	8.4	8.2	8.1	7.6	8.4	8	7.8	7.6	8.1
Conductivity	152	158	145	120	167	170	165	143	160	175	`160	132	171	180	158	142	169	176	172	145
Turbidity	5.2	4.9	4.7	6.4	10.9	9.6	9.8	10.9	6.8	5.9	6.1	7.4	5.43	5.1	5.2	5.64	5.35	4.6	4.3	6.1
TH	35	23	48	32	36	31	46	45	45	34	49	41	40	37	52	41	36	23	43	40
TDS	180	200	290	190	180	190	210	190	190	280	320	305	280	300	390	318	219	230	324	257
TSS	315	310	290	380	410	250	290	420	470	390	380	490	410	420	390	490	418	380	376	487
DO	5.1	5	5.2	5.8	5.2	5.1	5	4.8	5.1	5	5.2	4.7	5.1	5.5	5.2	4.7	5.7	5.6	6	5.1
BOD	1.7	1.9	3.6	1.3	1.6	1.9	3.3	2.1	2.6	2.9	2.45	4.1	2.4	3.6	2.9	5.2	2.9	1.85	3.2	1.9
Chloride	160	190	180	195	160	140	140	180	280	150	180	260	170	180	150	270	150	145	140	185
Ferrous	0	0.1	0.1	0.15	0.1	0	0.1	0.2	0.1	0.1	0.15	0.325	0.1	0	0	0.1	0.1	0	0	0.1
Nitrate	0.5	0.25	0.5	1	0.25	0.2	0.3	0.5	0.5	0.25	0.5	0.5	0.5	0.5	0.5	1	0.2	0.2	0.1	2
Phosphate	0	0	0.1	0.2	0	0	0.2	0.2	0	0	0.15	0.2	0	0	0.2	0.35	0	0	0.2	0.3

*Post Monsoon (Oct. – Dec.), Winter (Jan. – Feb.), Pre-Monsoon (March - May), Monsoon (June – Sept.)
Source: Collected by author.

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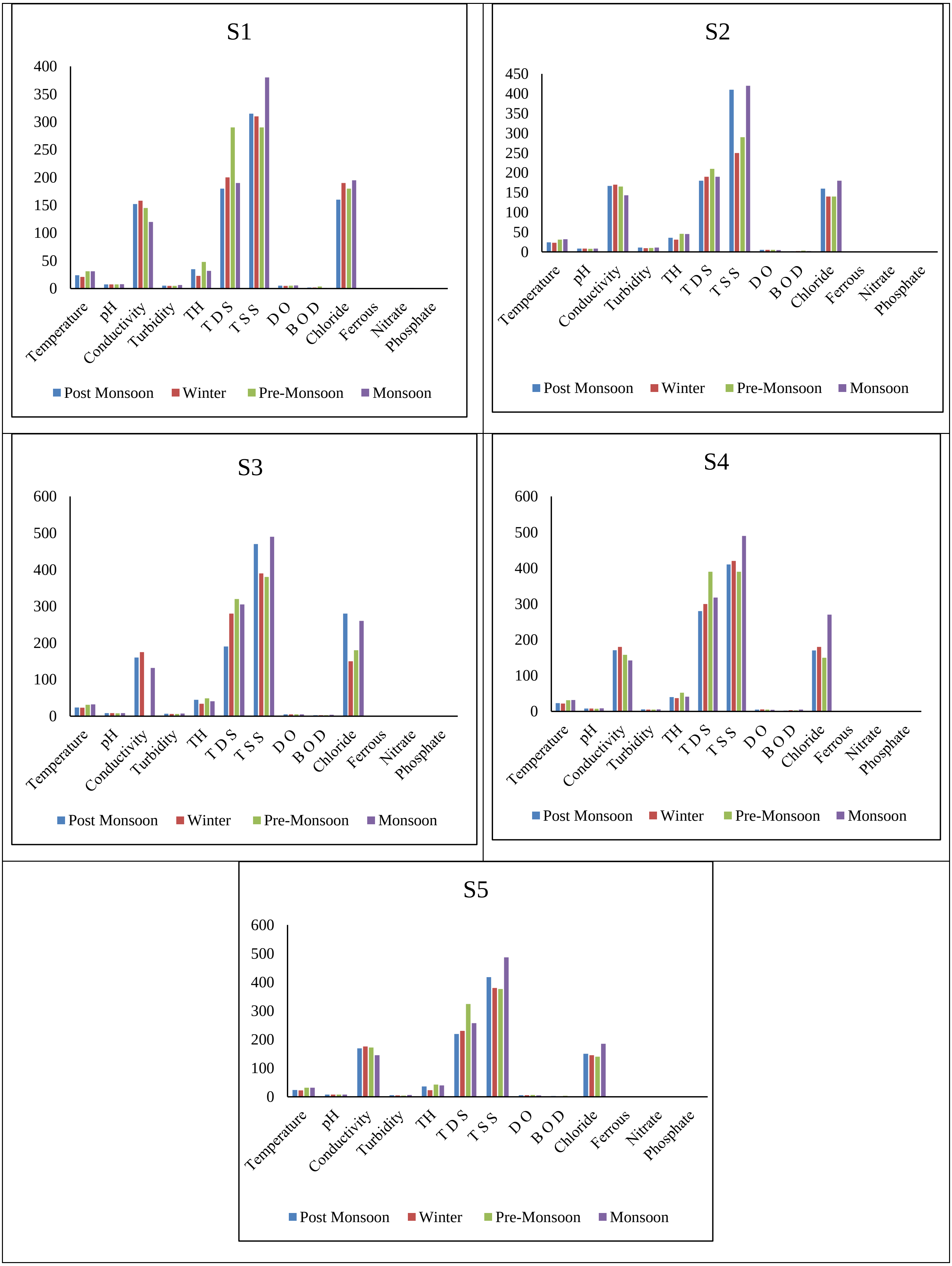

Fig. 2. Variation of water quality parameters using in different sampling stations of Torsa River.

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BOD measures the biodegradable portion of the organic pollutants (Jouanneau et al., 2014). At station S4, high variation was observed in BOD values (2.4 –5.2 mg/l). Highest value of BOD (5.2 mg/l) was reported in monsoon season at Station 4. The DO levels are 4.7 mg/l during this period because of increased oxygen demand at high temperatures in monsoon as reported earlier (Jaiswal et al., 2019). Except the Station S4, all the stations have standard level. During the period of monsoon, the sewage treatment plants receive a high amount of sewage which sometimes exceeds their treatment capacity (Shah & Joshi, 2017). So that, untreated or partially treated sewage is discharged into the river which is the reason of increasing BOD values observed at S4 in the monsoon periods (Kumar et al., 2026). The concentration of Iron (Fe) was in standard limit (0.3 mg/l) recommended by the BIS (IS 50100) for drinking water in all the stations except the station 3 (Bisarjan Ghat, 0.325 mg/L) and it was higher than the standard limit in the season of only monsoon. Nitrate was found on the Torsa River in very less quantity. All the stations have zero or below the standard limits (45 mg/l) recommended by BIS and ICMR. It varied between 0.2 to 2 mg/l. They are found in surface waters as a result of wastewater discharge, runoff from land application of fertilizers. The nitrate (NO3-N) contents were higher in monsoon and lower in winter (Hujare& Mule, 2008). The station S4 and S5 recorded the values 0.325mg/L and 0.3mg/L respectively only in the season of monsoon. Low level of Phosphates are not toxic to people or animals but they are toxic while present in very high levels (Nieder et al., 2018). Digestive problem could occur from extremely high level of phosphate (Komaba&Fukagawa, 2016). The presence of phosphate indicates the use of pesticides in the agricultural field (Jayasumana, 2015). The drinking water standard and surface water criterion for dissolved chloride is 250 mg/l recommended by BIS and ICMR. In the present study chloride ranged 140 - 270 mg/L among all the stations. During the monsoon period only, Station S4 has the highest value of chlorine amounting 270 mg/l and Station S3 has also high value of 260 mg/l than the standard limit (250 mg/l) of Cl- in drinking water. The high amount of Cl- in surface water could be associated with chloride rich minerals and it may origin from pollution sources, e.g., domestic effluents, fertilizers and septic tanks (Lang et al., 2006). It indicates that the water in these few stations, were unsuitable for drinking purposes.

Based on the results obtained from the CCMEWQI, the water quality of Torsa River for drinking purposes ranged between 71.13 to 90.06 which indicate that river water has Fair to Good quality. The station S1 and S5 are located beyond the town of Cooch Behar and the values of CCMEWQIs is 90.06 and 85.56 respectively and the value for the station S2 is 86.34 indicating that water quality for drinking uses can be rated as good for the mentioned three stations. A significant observation from the analysis is that the CCMEWQI values for the outskirts stations (S1 and S5) and the adjacent area station (S2) are nearly similar. This similarity in both the CCMEWQI values and water quality categories is expected, as these regions are relatively free from non-point source pollution and other human-induced influences. In contrast, stations S3 and S4 are located within the town and in areas adjacent to the town, where anthropogenic activities are comparatively higher. The water

Table No: 5. Water Quality of different stations along Torsa River based on CCMEWQI

Stations	Sample size (Total no of variable)	Total no of failed Variable	% of failed variable	Total no. of tests	Total no of failed test	% of failed tests	CCMEWQI Value	CCMEQWI Category
S 1	13	2	13.33	52	4	6.66	90.06	Good
S 2	13	3	20	52	7	11.66	86.34	Good
S 3	13	5	33.33	52	9	15	75.64	Fair
S 4	13	6	40	52	10	16.66	71.13	Fair
S 5	13	3	20	52	5	8.33	85.56	Good

Source: Calculated by Author

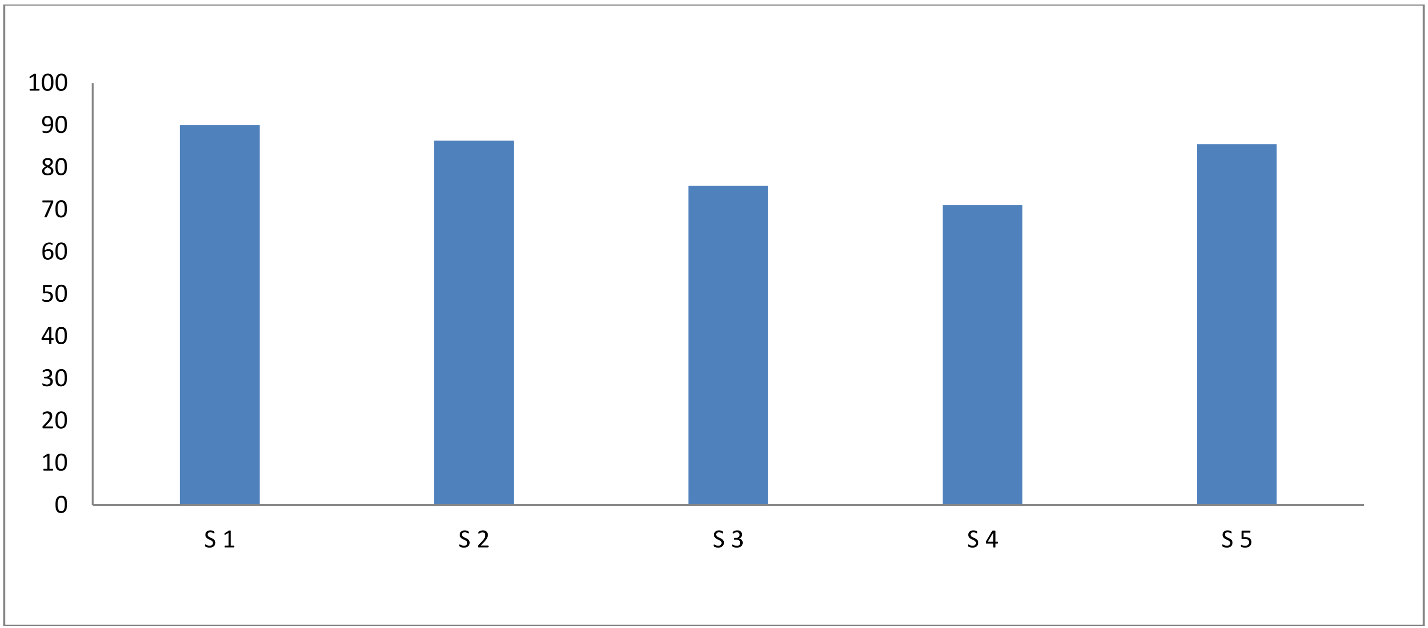

Fig No 3: Water Quality of sampled stations along Torsa River based on CCMEWQI.

Quality is mostly rated as Fair (CCMEWQI values range from 71.13 to 75.64) for drinking uses, when evaluated against BIS, ICMR, EPA, CPCB standards. This may reflect the discharge of pollutants to a water resource system from domestic sewers and other sources from the town as today Cooch Behar is experiencing urbanization and is a financial as well as a commercial hub having impact on water quality (Haque & Talukdar, 2021).

CONCLUSION

The aim of this research was to assess the spatio – temporal water quality of the Torsa River. The results of this study revealed that water quality generally changes along the Torsa River as it passes by Cooch Behar Town and the urban stresses influenced the river water quality. Cooch Behar town currently is rapidly urbanizing caused environmental issues (Haque and Talukdar, 2021). Water quality status at the outskirts (S1 and S5) and only in one adjacent area of Municipality (S2) was found relatively "good" whereas "Fair" water quality was investigated in Cooch Behar Municipality (S3) and one adjacent area (S4) during the study period. Anthropogenic activities play an important role to alters the water quality of the river while most of the physico – chemical water quality parameters of Torsa River are under the standard level recommended by BIS (IS 10500), EPA, CPCB, ICMR and WHO guidelines. The temperature, turbidity, DO, BOD, Chloride and Phosphate do not meet the standards in different sampling stations especially in the Monsoon season (June – Sept.) comparing to winter (Jan. – Feb.). Water qualities of dry seasons are better than rainy season i.e., Monsoon season because rainfall carries sediments, pollutants, and other contaminants into water bodies. In many areas, the sewage and stormwater drainage systems are interconnected; therefore, during heavy rainfall, untreated sewage is often discharged directly into water bodies without proper treatment, leading to deterioration in water quality (De Andrade Costa et al., 2020; Yu et al., 2016; Wu et al., 2017; Bae, 2013). This makes the water unsuitable for drinking purposes without proper treatment specifically in Monsoon season. This work confirms the need to take an effective action for monitoring the river for proper management. Therefore, there is a need of intensive study leading to a contamination zone mapping to river water quality management.

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