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Urbanization and deterioration of River water Quality with Special Reference of Mahananda River of West Bengal, India

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Abstract:

Rapid urbanization and population growth leads to a numbers of ill effects on the various corner of the environment including the water resource of the earth. The river Mahananda is supplying the water to the large numbers of people inhabiting in its catchment area, to the agricultural field, and to a numbers of urban centres, but is polluting from its own beneficiaries.This study investigates the impact of urbanization on the water quality of the Mahananda River, based on the data derived from Central Pollution Control Board of India from two monitoring stations, Siliguri and Ramghat, over a period of ten years. The CCME-WQI method has been applied to determine the water quality. The study reveals that the water quality of the river Mahananda at Ramghat is even worse than that of Siliguri, primarily due to the impact of urban pollution. The study shows that a numbers of urban pollutants from the Siliguri Municipal Corporation, and English Bazar Municipality are deteriorating water quality of the river. The data shows that the impact of urban growth is visible and apparent, and a prominent negative relation has been established between urbanization and the water quality of the river. The study concludes that immediate actions are necessary to control and reduce urban pollution to prevent further deterioration of water quality in the Mahananda river, which directly affects the health and wellbeing of the local community.

Key Words: CCME-WQI Method; Pollutants; Untreated Sewage; Urbanisation; Water Quality

1. Introduction:

It is straightforward to understand that water is the most crucial element in our environment. It can maintain every kind of life on one hand, and on the other side, it plays a vital role in the circulation, movement, and cycling of the material having nutrients in the biosphere. Less than 3% of the water from the hydrosphere is available and usable to the biotic community, including human beings, to satisfy their needs. Water bodies have their self-purifying skill. However, the undesirable substances, which we call pollutants, when added and exceed the tolerant level, water become polluted. It is the human beings who are totally responsible for this. According to WHO (1966), Water pollution is the alteration of water

quality that makes it hazardous to human and animal health, industry, agriculture, fishing, or recreational activities. (Nigussie, 2008).

The world has experienced sharp population growth worldwide in the 20th century, along with a population explosion in the developing world. With the increase in the human population, urbanization has also accelerated. Census data (2011) says that West Bengal is one of India's most highly urbanized states, with 31.87% of the total population residing in urban areas ranking 4th in India. Census 2011 also indicates that the state saw a sharp rise in urban centers from 2001 to 2011. 'Census towns' has risen from 255 in 2001 to 780 in 2011. Counting of statutory towns increased from 375 in 2001 to 909 in 2011. However, high urban growth is very much related to the pollution of the surface water bodies of West Bengal. Urbanization has a paramount impact on water resources, particularly water supply, sanitation, and drainage. In urban areas, the number of water pollutants is long, including industrial effluent, which has warm and pollutant water, heavy metals, harmful chemicals, garbage from people's daily use, sewage disposal, etc. Misra (2010) highlights the importance of these elements within the urbanization process and their potential to increase pressure on urban hydrology. Unfortunately, urban freshwater resources such as rivers, lakes, and groundwater aquifers are continuously overexploited, leading to pollution and degradation (Mitra et al., 2018). Mozumder et al. (2015) conducted a physicochemical analysis and found that the pollution intensity increased significantly when the river was exposed to sewage and industrial waste.

The Mahananda is one of the essential rivers in West Bengal. Mondal et al. 2020 have highlighted the significant role of the Mahananda River in the daily lives of people residing in areas located along its banks in Malda Municipal Corporation (Mondal et al., 2020). Whereas Rangarajan et al., 2019 highlighted the importance of the Mahananda River to people residing in Siliguri Municipal Corporation located at the bank of the river Mahananda. However, towns like Siliguri, Old Malda, and English Bazar drain garbage and effluent daily into the river water without any treatment (Rangarajan et al., 2019). The River water of Mahananda near Siliguri is continuously deteriorating due to the random dumping of wastes from all over Siliguri town, which threatens residents' lives (Chowdhury, 2018). Every year, the Mahananda River is subjected to substantial amounts of untreated effluent water from various sources, including domestic, industrial, and inappropriate waste management practices associated with unplanned urbanization. These sources can significantly affect the water quality of the river (Mozumder et al., 2015; Shil & Singh, 2019; Parween et al., 2022).

Urban areas in developing countries like India often lack proper effluent disposal facilities and inadequate sewerage and garbage disposal systems (Singh & Sarkar, 2020). Wastewater from the urban center is a prevalent cause of alteration of physicochemical parameters, leading to water pollution. So, in India and the world, river water is being contaminated due to the lack of proper sanitation. Urbanization, inadequate treatment capacity, and disposal of untreated wastes cause severe pollution in urban and peri-urban areas (Shrivastava et al., 2018). Approximately one-third of industrial wastewater and 70% of household sewage are discharged directly into rivers and lakes without treatment (Guo et al., 2019). The growth of slum areas is a common scenario with the urbanization process. According to the Census of India (2011), West Bengal has 122 slum towns, among which Malda city is important. Jamal et al. (2020) reported that out % of the municipality's total population, 29.71% lived in slum households, which amounted to 12,337 households. It is seen that most of the slum areas tend to develop on the riverside, with the facility of vested land occupied by the dwellers of that slum. Moreover, the slums do not have proper sanitization or garbage disposal systems, and every pollutant produced from slums is directly thrown into the river water, causing deterioration of river water quality.

Evaluating water quality is crucial for ensuring safe drinking water, sustaining aquatic life, supporting recreational activities, and maintaining ecosystem health. Using the physical, chemical and biological indicators water quality evaluation can determined of any source of water (Tyagi, 2013). Utilizing index numbers to assess water quality, Horton (1965) first devised a system providing a valuable tool for managing water pollution (Horton, 1965). Building on this foundation, Brown et al. (1970) introduced a comprehensive Water Quality Index (WQI) incorporating nine key variables. Steinhart et al. in 1982 pioneered the Environmental Quality Index (EQI) tailored for the intricate ecosystem of the Great Lakes in North America. By the mid-1990s, British Columbia introduced a refined WQI, subsequently endorsed by the Water Quality Guidelines, Task Group of the Canadian Council of Ministers of the Environment (CCME) in 2001, becoming the CCME WQI. Later on Liou et al. in 2003 in Taiwan; Said et al. in 2004 in Florida, USA; in 2007, the Malaysian WQI (MWQI); West Java Water Quality Index (WJWQI) etc are developed to measure the water quality (Chidiac et al.,2023). There lies a branch of Water Quality Indices to measure the suitability of water for a specific purpose of use. Here the CCME Water Quality index is applied to measure the water quality of river Mahananda using the data of CPCB of India. The complex and technical data are simplified in this method and provides WQI value (Chidiac et al., 2023) ranging between 0 to 100 where the high value indicates better water quality and vice versa.

The present research aims to provide a clear understanding of the challenges faced by the Mahananda River due to urbanization and to propose practical solutions to improve and maintain its water quality. The specific objective is set for a detailed examination of the primary sources and locations of pollution along the Mahananda River and a scientific analysis of the river's current water quality status, with a proposal to offer some actionable solutions to mitigate the same.

Previous literature explores that the catchment area of the Mahananda River is highly populated, and pollutants from urban areas are the main cause of water quality deterioration. However, no work has been done to assess water quality using the CCME WQI method and to offer remedies for mitigating the severity of water pollution. The CCME WQI is a novel approach for evaluating river water quality, categorizing it into suitable classes for various uses. This study aspires to emphasize the negative impacts of urbanization on river water quality by applying the CCME WQI method, which has not been previously used in the study area.

2. Data and methods:

The ongoing study is based on the secondary data. A numbers of research papers related to the current tropic have been studied to extract information regarding the status of pollution of river causing for the urban area giving special citing of Mahananda river pollution. Secondary data from West Bengal Pollution Control Board (WBPCB) and Central Pollution Control Board (CPCB) has been considered. Census data of India have also been taken into consideration. Necessary charts and diagrams are prepared on the Microsoft excel platform. The evaluation of water quality in Mahananda River utilized the CCME-WQI method. It consists of three measures of variance from selected water quality objectives (Khan et al., 2005): scope (F_1), frequency (F_2), and amplitude (F_3). These elements gauge different aspects of water quality deviation from standards (Hu *et al.*,2022).

Scope (F_1) assesses the extent to which water quality parameters deviate from established standards. It is determined by the proportion of parameters that fail to meet their respective standard values at least once during the evaluation period. Equation (i) is showing the calculation of F_1.

$$F_1 = \frac{\text{Number of failed variables}}{\text{Total number of variables}} \times 100 \quad \ldots\ldots\ldots\ldots \text{(i)}$$

Frequency (F_2) measures how often water quality objectives are not achieved. It indicates the percentage of monitoring instances where water quality falls below the set standards. The calculation of F_2 is expressed by Equation (ii):

$$F_2 = \frac{\text{Number of failed tests}}{\text{Total number of tests}} \times 100 \quad \ldots\ldots\ldots\ldots \text{(ii)}$$

Amplitude (F_3) evaluates the degree to which water quality parameters exceed their objectives. It quantifies the extent by which failed test values surpass the guideline values. The determination of F_3 involves three distinct steps.

In the Step1 determination of the excursion for each individual concentration compared to the objective. If the test value exceeds the objective, Equation (iii) is used; if it does not fall below the objective, use Equation (iv).

$$\text{Excursion i} = \left[\frac{\text{Failed TestValue i}}{\text{Objective i}}\right] - 1 \quad \ldots\ldots\ldots\ldots \text{(iii), when objective is maximum.}$$

$$\text{Excursion i} = \left[\frac{\text{Objective i}}{\text{Failed TestValue i}}\right] - 1 \quad \ldots\ldots\ldots\ldots \text{(iv), when objective is minimum.}$$

Step 2 is associated with the calculation of the normalized sum of excursions in the following manner.

$$nse = \frac{\sum_{i=1}^{n} \text{excursion i}}{\text{Total number of tests}} \quad \ldots\ldots\ldots\ldots \text{(v)}$$

In the next step F_3 is determined by an asymptotic function that adjusts the normalized sum of excursions from objectives, resulting in a scale ranging from 0 to 100.

$$F_3 = \frac{\text{nse}}{0.01\text{nse} + 0.01} \quad \ldots\ldots\ldots\ldots \text{(vi)}$$

Ultimate CCME- WQI index is laid in equation (vii).

$$\text{WQI} = 100 - \left(\frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732}\right) \ldots\ldots\ldots\ldots \text{(vii).}$$

According to CCME-WQI model the value ranges within 0 to 100 and having five classes as laid in the table 1.

Table: 1 CCME-WQI value and Water Quality.

CCME-WQI value	Water Quality
95-100	Excellent
80-94	Good
65-79	Fair
45-64	Marginal
0-44	Poor

Source: CCME-WQI, Hu et al., 2022.

2.1 Study Area:

One of the prime rivers of west Bengal or especially of north Bengal is Mahananda (Fig.1). Warm tropical monsoon climate is prevailing on the Mahananda river basin located at the foothill of Darjeeling Himalaya and at the plain a temperate climate (Ghosh et al., 2017; Parween, et al., 2022). Its origin point is a spring in Dow Hills near Chimli in Darjeeling district and near Kurseang. It falls on Paglajhora and ultimately merges into the slopping plain of southern part of Darjeeling District. It has the flow path of 360 km of which 324 km in India and rest in Bangladesh. It touches Jalpaiguri district and enters into Bangladesh for few sort of length and returns India. Then it flows into the Uttar Dinajpur; three districts of Bihar and Malda district of West Bengal and finally merges to Padma in Bangladesh. It has a catchment area of 20000 square km. however the Mahananda, is perennial in nature has the huge life supporting capacity. From few decades a numbers of settlements have grown up on the bank of it with the

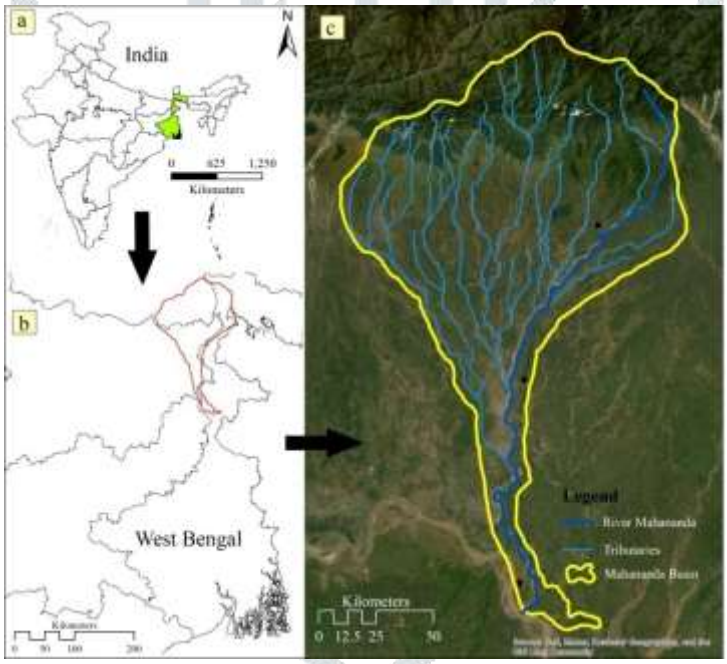

Fig 1 Study Area

increasing population. Among these settlements Siliguri in Darjeeling, Katihar and Kishanganj town of Bihar and English Bazar and Old Malda of Malda district are very significant.

3. Result and discussion:

The growth of urbanization in the last few decades in developed and developing countries is very significant. A projection by the United Nations says that 64.1% and 85.9% of the developing and developed world population will be urbanized by 2050 (Sharma.S, 2017). After the independence, there was a slow growth rate in the urban population. But since 1991, the rate has accelerated. The number of urban centres and share of the urban population in north Bengal is comparably less than in the southern part. But Siliguri and English Bazar (Malda) town have the capability of pulling people towards them and raising their number considerably high. Among the districts of West Bengal, Malda has the highest

growth of urban population of 129%, concentrating in the English Bazar and Old Malda municipal town located at the right and left bank of river Mahananda, respectively. As a result, the river Mahananda, carrying its effluents, is getting seriously polluted.

3.1 Pollution of Mahananda River:

West Bengal is drained by an intricate network of rivers that have nourished life and the economy since the dawn of civilization. However, many rivers have lost their pristine water quality due to the mixing of urban and industrial wastewater (State of Environment Report, West Bengal Pollution Control Board, 2016). Rising invulnerability, amplified runoff from urban land surfaces, and increased townships and industrial discharges result in an increased load of nutrients into the rivers (Singh & Gupta, 2016). Though the non-point source of pollutants like pesticide washes from agricultural fields plays a significant role in the pollution of water, the point sources from the urban centers, namely Siliguri, Old Malda, and English Bazar, play the most crucial role in the pollution of the river Mahananda.

According to experts Siliguri town is one of the major source areas of pollution of Mahananda River. In river Mahananda total coliform and fecal coliform are in such a level that raw water is entirely unsuitable to use (Mazumder et.al, 2015).The sources of river water pollution from Siliguri Municipal Corporation, affecting the river Mahananda in several ways. Untreated sewage and wastewater from households, industries, and commercial establishments can contain harmful chemicals, pathogens, and organic matter that pollute river water. According to West Bengal Pollution Control Board, 2019, with 94 municipal sewage discharge points on the left bank and 60 on the right bank of the Mahananda River, of Siliguri Municipal Corporation poses a significant threat. Discharge of untreated or inadequately treated industrial effluents having heavy metals, toxic chemicals, and other pollutants can significantly degrade water quality. Improper disposal of solid waste, including plastic, paper, metals, and other non-biodegradable materials from peri-urban area of Siliguri, lead to their accumulation in Mahananda, causing pollution and harming aquatic life. The garbage from the river attached slums is directly thrown into river water. Illegal dumping of waste, including hazardous materials, directly thrown into the river or its tributaries can pose a significant threat to water quality. Construction activities near the rivers often lead to the discharge of construction waste and debris into the rivers. Study shows that Siliguri Municipal Corporation (SMC) is the largest city of northern part of West Bengal having over one million populations, at present, generates a huge quantity of sewage. Unfortunately absence of sewage treatment plant all the untreated sewage water is drained to the river water causing serious damage of the water quality of the river water. After idol immersion activity of Durga Puja, Kali Puja, Jagaddhatri Puja etc the water quality degrade significantly. Observing the severity of water pollution of Mahananda a bench headed by NGT Chairperson Justice S. Kumar issued a notices to the West Bengal government, SPCB, Siliguri Municipal Corporation and its Deputy Commissioner and stated that there are serious environmental issues in relation to pollution of river Mahananda in Siliguri, District Darjeeling and indiscriminate dumping of municipal solid waste all over the city (Press Trust of India | New Delhi Last Updated at March 1, 2017 16:42 IS). As per the data of WBPCB, 2021 among the seven important river of north part of West Bengal Mahananda river water near Ramghat just after the Siliguri Municipal Corporation is the most polluted in respect of biochemical and bacteriological parameters.

There are two urban centres on both the Bank of Mahananda River (Old Malda at the east bank and English Bazar at the west bank) in the Malda district. It forms an urban agglomeration which comprises Old Malda Municipality and English Bazar town. The population growth in English Bazar is alarming, and it was 313,681 in 2011. Within this large population,

there lies a slump at the river's attached place. However, there is no treatment system for huge sewage water, which merges through a number of high drains from the town, causing severe water pollution in Mahananda. Some of the habitats of river site Wards of the municipality, especially those who are living immediately adjacent to the river, generally throw garbage and other liquid and solid waste directly into the river bed. As a result it, large-sized 'Garbage Lobes', comprising solid waste, plastic materials, and other biodegradable and non-biodegradable materials, are formed. Some portions of these garbage lobes are washed into the river in a time of monsoon with the rising of the water level and velocity. The river water gets polluted during the festival time, like 'Durga puja' and a number of other puja along with 'Chhat puja', the drowning of a large number of 'Murties' and other associated materials into the river of Mahananda. The handling of municipal waste in this township has reached a critical juncture, attributed to the lack of adequate facilities for treating and disposing of the substantial volume of solid waste produced daily in urban zones (Roy, 2018). Mandal and Sinha, 2019, have measured the lower level of DO and BOD but very higher count of Total Coliform and Fecal Coliform of Mahananda River at English Bazar and Old Malda Municipal area than the standard level. Situated to the east of the Mahananda and Kalindi rivers' confluence, the town of Old Malda is now a vital segment of the English Bazar urban agglomeration and is also responsible for the river water pollution.

Table: 2 Water Quality Data of Mahananda River at Siliguri (Upstream) and Ramghat (Downstream), Darjeeling district.

Parameters	Location	2012	2014	2016	2018	2021
Temperature	Siliguri (US)	26.0°C	24.1°C	22.0°C	23.5°C	25.0°C
	Ramghat (DS)	24.0°C	25.2°C	23.0°C	24.0°C	25.5°C
DO (mg/l)	Siliguri (US)	6.8	7.2	6.0	6.9	7.0
	Ramghat (DS)	7.1	6.0	3.9	5.5	5.45
P^H	Siliguri (US)	7.3	7.5	7.2	7.7	7.05
	Ramghat (DS)	7.7	7.5	7.3	7.2	7.15
Conductivity (µmho/Cm)	Siliguri (US)	166	160	150.5	166	94
	Ramghat (DS)	159	356	295.5	266.5	164
BOD (mg/l)	Siliguri (US)	3.0	2.3	3.65	3.1	1.95
	Ramghat (DS)	3.4	4.0	13.7	10.9	16.25
Nitrate (mg/l)	Siliguri (US)	0.42	0.7	0.4	0.35	0.395
	Ramghat (DS)	0.47	0.5	0.35	0.35	0.465
Faecal Coliform (MPN/100ml)	Siliguri (US)	21417	12542	20850	9500	5200
	Ramghat (DS)	173750	84167	725000	125000	130000
Total Coliform (MPN/100ml)	Siliguri (US)	75917	33583	56650	23000	15700
	Ramghat (DS)	494000	196667	1455000	260000	210000

Source: NWMP Data, Central Pollution Control Board, Ministry of Environment, Forest and Climate Change; Government of India, 2022.

However, the data in the Table 2 shows the impact of Siliguri urban area for the deterioration of various parameters for measuring water quality of Mahananda River. Data are taken by CPCB from two monitoring stations namely Siliguri, located at the upper reach before entering the town and the second one is at Ramghat, located at the lower reach just leaving the urban area. At water monitoring station siliguri, the impact of urban center on the river water is nil as it is at the upstream

location. The table shows that temperature and P^H of the river water are the two parameters not affected much by the urban processes but all other important parameter shows a high level of deterioration at the downstream data of Ramghat. The amount of Dissolved Oxygen (mg/l) reduces at an alarming level; before entering the city area at Siliguri, the river had the precise level of BOD which increases in every year and reaches extremely high at 16.25 in the year 2021at downstream. The bacteriological parameters like Faecal Coliform and Total Coliform count have reached to the extreme at the downstream. This is actually alarming situation of degradation of water quality.

Table: 3 Water Quality of Mahananda River and Designated Best Use Water Quality Criteria as prescribed by CPCB, 2022.

Class of water	DO (mg/l)			P^H			BOD (mg/l)			Total Coliform (MPN/100ml)		
	Standard Value	Actual Value		Standard Value	Actual Value		Standard Value	Actual Value		Standard Value	Actual Value	
		US	DS		US	DS		US	DS		US	DS
A	6			6.5-8.5			≤ 2			≤ 50		
B	5			6.5-8.5			≤ 3			≤ 500		
C	4			6-9			≤ 3			≤ 5000		
D	4			6.5-8.5			--			--		
E	--	7.0	5.45	6.0-8.5	7.05	7.15	--	1.95	16.25	--	15700	210000

Source: NWMP Data, Central Pollution Control Board, Ministry of Environment, Forest and Climate Change; Government of India, 2022.

Note: 'A'- Drinking Water Source without conventional treatment but after disinfection, 'B'- Outdoor bathing (organized), 'C' - Drinking water source after conventional treatment and disinfection 'D' - Propagation of Wild life and Fisheries 'E' - Irrigation, Industrial Cooling, and Controlled Waste disposal

The Central Pollution Control Board of India (2022) designated the criteria and assigned the standard value of few parameters to categorize the river water into A, B, C, D, and E as shown in Table 3. At the downstream the DO value fails to achieve the class 'A'water. Whereas the 'P^H'value stands within the standard level. Lower BOD levels and lower count of Total Coliform indicate better water quality. But both BOD and Total Coliform are the two criteria which are very much higher than the standard level and disqualified the water of Mahananda from each class and even are not suitable for bathing.

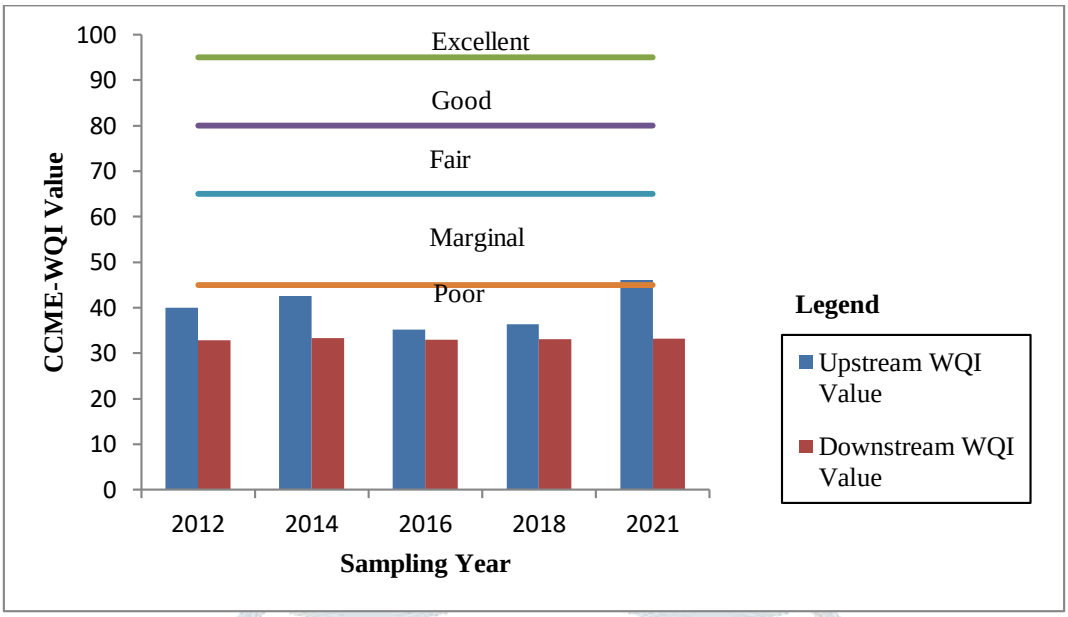

Fig: 2 Water Quality for Drinking water source without conventional treatment but after disinfection (A) by CCME WQI method.

Class 'A' water quality (Drinking water source without conventional treatment but after disinfection) as designated by CPCB of the river Mahananda is shown in Fig: 2. The CCME- WQI has been adopted to determine the water quality for the present study. A lower CCME-WQI value represents lower water quality and vice-versa. For this category overall, river water is actually unfit and has not reached the marginal category except for the upstream water in 2021. The downstream water quality values were lower than the upstream WQI value and exposed the substandard quality throughout the sampling years. Here, the impact of urban growth is visible and evident.

Fig.3 represents water quality for Drinking (class-B) of Mahananda River as designated by CPCB at Siliguri (upstream) and Ramghat (downstream) for the period of 2012 to 2021. It has been observed that the upstream water quality of the river achieved the marginal category in every sampling year with temporal variation.

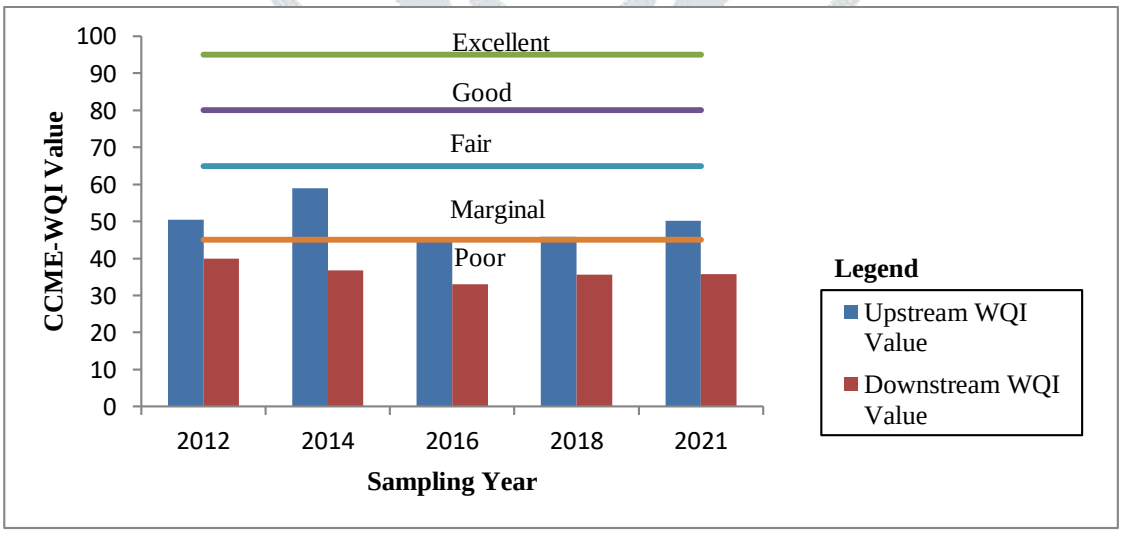

Fig. 3 Water Quality for Drinking water source after conventional treatment and disinfection (B) by CCME WQI method.

The reason is evident that the urban pollutants are not added at this point. All of the sampling year, water quality at downstream of Mahananda failed to achieve even the minimum marginal category and is limited to the poor category.

Untreated sewage water, dumping of garbage, medical waste, industrial effluent, etc., from the Siliguri Municipal Corporation, is added to the water of Mahananda, and the water is polluted as well as the quality deteriorates. So, a prominent negative relation has been established between urbanization and the water quality of the river.

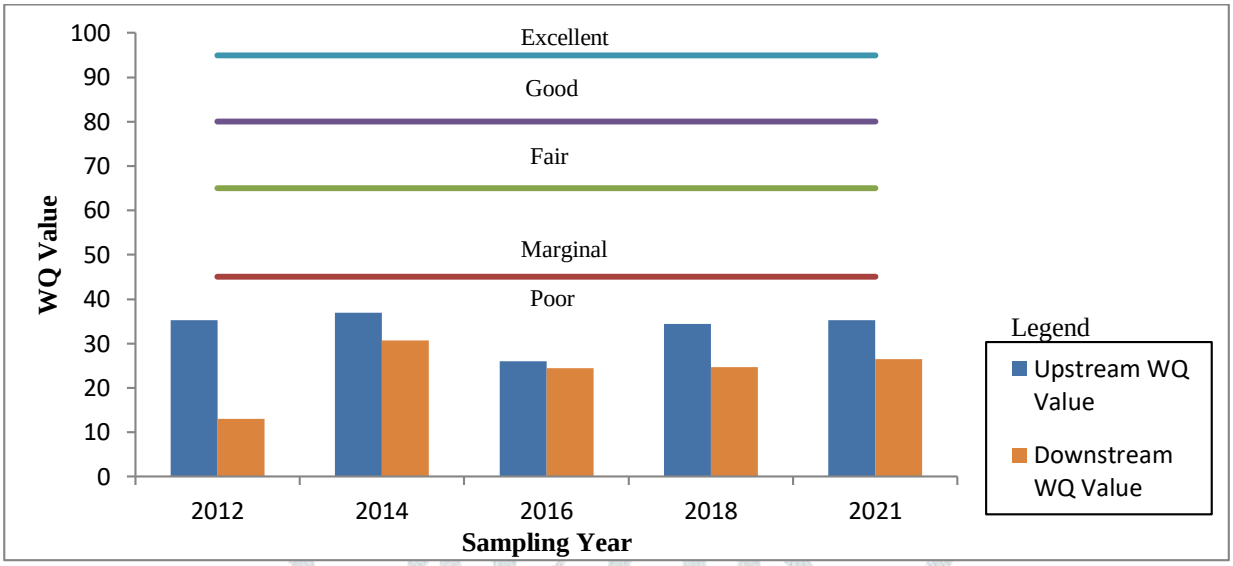

Fig. 4 Water Quality for Outdoor bathing (Organized) (C) by CCME WQI method.

The water quality for outdoor bathing, as shown in Fig: 4, is a matter that should deeply concern us all. Both the upstream and downstream water quality consistently shows poor results across all sample years. The water quality of the river at Ramghat is even worse than that of Siliguri, primarily due to the impact of urban pollution. The bacteriological parameters indicate that the water is unfit for human consumption and other uses, particularly bathing. This poses a direct threat to the health and well-being of our local community. The urban anthropogenic activities on both sides of these rivers are significant sources of pollution, leading to a severe degradation of the water quality.

3.2Major Findings:

Along with Siliguri, the English Bazar, Old Malda, and other urban areas significantly impact the deterioration of various parameters used to measure the water quality of the Mahananda River. The amount of Dissolved Oxygen (mg/l) has reduced at an alarming level, and bacteriological parameters like faecal coliform and Total Coliform count have reached extremes downstream. Both BOD and Total Coliform levels are alarmingly higher than the standard, rendering the water of Mahananda unsuitable for any use, including bathing. Urban growth has a visible and apparent impact, and a prominent negative relation has been established between urbanization and river water quality. The water quality of the river at Ramghat is still inferior to that of Siliguri, primarily due to the impact of urban Pollution.

4. Conclusion:

The study highlights the severe degradation of water quality in the Mahananda River due to the impact of urbanization. Therefore, it is essential to take immediate action to control and reduce urban pollution to prevent further decline of water quality of Mahananda, which immediately affects the human health and hygiene of its catchment. The present study recommends few remedial measures be taken to reduce the water pollution of Mahananda and restore the water

quality. Adoption of advanced waste treatment technologies, such as wastewater treatment plants, bioremediation techniques, and sustainable method like 'permeable pavements' are the urgent need of time for the Siliguri, Englishbazar and other urban centers. The municipality should have to take the initiative to stop throwing garbage into the river by the riverside dwellers. Side by side, the authorities of municipalities have to clear the 'garbage lobe' which already developed along the river bed. Authorities should encourage community participation in river conservation efforts through awareness campaigns and science projects. Authorities have to stop the illegal slump growth and make awareness programmes in the existing slump to stop the river water pollution. Industries in the urban centers must have proper permission from the State and Central Pollution Control Board. River bank restoration projects, forestation, etc, may be adopted by the government to protect the river from further pollution.

Limitation and Future Scope of the Study:

The present study encompasses only the secondary data as collected from Central and State Pollution Control Board and only two point of source. The study lacks the primary level data of the river throughout its course. So, a future scope of research lies in that inclusion of primary data from throughout the river course. It may provide more vivid scenario of the water quality of the river and the implication on the ecology of its surrounding.

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