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Discussion and evaluation of water quality in river systems of West Bengal, India: An assessment of physicochemical and biological parameters as markers of water quality

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Abstract

The process of declination of water quality (WQ) in several natural sources of water is now an immense problem for mankind. Rivers are naturally flowing water bodies that have now become sewage carriers in most cases. Several workers monitored the deterioration of the WQ in rivers. This article reviews the WQ parameters of the river flow in the state of West Bengal (WB) in India. It also analyses and compares the WQ between the rivers of the northern and southern ranges of WB, emphasizing the complex interplay of geographies and anthropogenic influences. The rivers of northern WB, generally thought to be non-polluted, benefited from a slower pace of industrialization due to their hilly terrain. But recent evidence suggests a concerning decline in WQ, particularly in rivers like Torsha, attributed to factors like the initiation of industrialization, urban runoff, and agricultural practices. Conversely, rivers in southern WB face pronounced pollution from industrial effluents and untreated sewage, exacerbating contamination levels in rivers like Hooghly, Haldi, and Damodar. The direct discharge of pollutants into water bodies significantly impacts aquatic ecosystems, leading to nutrient enrichment, loss of biodiversity, and potential health hazards for both wildlife and human populations. The period of lockdown due to COVID-19 provided a distinct chance to observe the beneficial impacts of reduced anthropogenic activities on WQ, highlighting the potential for rejuvenation with proactive interventions. Comprehensive monitoring and treatment measures are urgently needed to address pollution from industrial, urban, and agricultural runoff. Effective policies and management strategies should be put in place. Thoughtful human activities can help alleviate the negative effects of water pollution and protect the sustainability of water sources for generations to come.

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Introduction

Water is a vital resource for all living beings, and its quality and quantity play a crucial role in human and animal health, industries, and the overall well-being of the population. Therefore, it is important to monitor water quality and address any issues promptly and regularly. However, with the population explosion, industrial development, frequent agricultural activities, and urbanization, water contamination and a significant decline in water quality have become major concerns in recent times (Tirkey *et al.*, 2013; Roy and Paramanik, 2022). In recent times, many rivers have become the ultimate destination for industrial effluents and untreated or partially treated wastewater from urban and industrial sewage. This often leads to nutrient enrichment, which causes a decline in water quality and harms aquatic life. The use of polluted water can also pose several health hazards to humans and other land animals and create breeding grounds for vector mosquitoes (Paramanik *et al.*, 2012, 2023; Mitra *et al.*, 2018; WHO, 2019). Faunal diversities associated with water bodies are also declining (Mukherjee *et al.*, 2022). In India, including West Bengal (WB), untreated wastewater disposal into rivers is a significant challenge for managing water quality.

WB, a state situated in the eastern part of India, covers a vast range of 88,752 sq. km. between the Himalayas to the Bay of Bengal, boasting diverse geographical features. The rivers in the state's northern region are distinct from those in the southern region. The catchment areas of the rivers in the northern region of WB, which are located in hilly regions, generally have higher water flow rates than those in the southern region of WB, which are in flatter areas. Apart from the Ganges, the other rivers in the southern region primarily rely on rainfall during the monsoon. Because of variations in geographical factors, the water quality parameters (WQPs) of the two regions are expected to vary to some extent. Consequently, the WQPs will also reflect the variation in pollution scenarios.

In WB, specifically in the southern part, most of the industry and industrial areas are situated close to the rivers. For instance, the river Hooghly has a large number of jute mills situated on both sides of it. The Haldia petrochemical industry is also located near the river Haldi, while SAIL-ISP in Burnpur and Durgapur is located near the river Damodar. On the other hand, while there are several small-scale industries in the northern region, the dominant pollutant there is urban runoff.

River system of West Bengal

WB stands out among Indian states for its geographical diversity, extending from the towering Himalayas to the serene Bay of Bengal, encompassing segments of the Chhotanagpur Plateau in the western region and the expansive Ganga-Brahmaputra Delta in the east. The state is home to the widest mangrove forest, located in the lower Ganga tidal region. The intricate network of rivers in WB (Fig. 1) has played a vital role in nourishing the lives and economy of the region since ancient times.

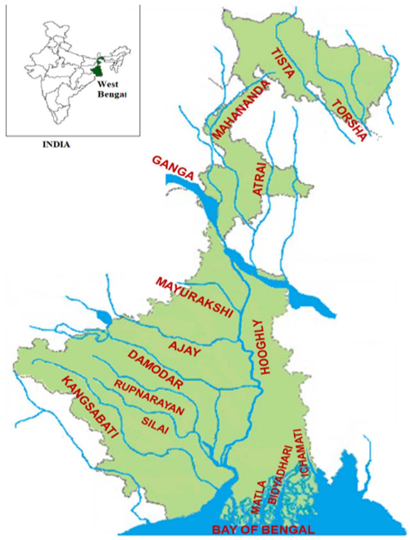

Fig. 1. Major rivers assessed for water quality in West Bengal, India (not to scale)

The river system of WB is diverse, reflecting the state's varied geography. The rivers differ in terms of flow patterns, water availability, and other factors. Broadly, the rivers in WB are classified into different categories.

Rivers originated in the northern region

The rivers that originate in the Himalayas and other northern fan rivers get water throughout the year.

These rivers receive water throughout the year, and the overall flow increases significantly during monsoons due to the high rate of precipitation in the catchment areas. Tista, Torsha, and Mahananda are the main rivers in that region. There are a few tributaries that originate from Tista and carry the water of Tista to the Ganga, e.g., Atrai, etc. Along with these rivers, there are many small streams and water bodies.

Rivers originated in the Chhotanagpur Plateau

Rivers originating from the Chhotanagpur Plateau, such as Damodar, Kangsabati, Ajay, etc., tend to dry up during the summer season. However, when the monsoon season arrives, the water flow in these rivers increases, and sometimes they may cause flooding in nearby areas (Bandyopadhyay *et al.*, 2015).

The Ganga, with its tributaries and branches

The Ganga is the most significant river in WB, providing water to several districts such as Hooghly, Howrah, Murshidabad, Purba Bardhaman, Malda, and Nadia through its tributaries. However, due to the river's vast stretch, the water flow pattern varies significantly across different regions. The tributaries can be broadly categorized into two groups - Upper Ganga Delta Rivers and Lower Ganga Delta Rivers. The upper Ganga Delta rivers include Churni, Jalangi, Mathabhanga, and others, whereas the lower Ganga Delta rivers comprise Ichamati, Kultigang, Hooghly, and others. The lower Ganga Delta rivers are particularly susceptible to flooding, as embankments fail to contain tidal water (Bandyopadhyay *et al.*, 2015).

River pollution in West Bengal

The primary contributors to river pollution in WB are urban and industrial wastewater, with agricultural water outflow also playing a role, although data on this is limited. Many of the rivers in the region have total coliform and biological oxygen demand (BOD) levels that exceed acceptable limits and are not suitable for bathing (Das, 2018).

Data collection

To conduct this review article, different bibliographic databases were utilized, like Web of Science, ResearchGate, PubMed, and Google Scholar. The gathered data from almost 25 previous studies was subsequently used to create tables, figures, and textual content for this article. This paper presents an assessment, discussion, and future research outlook for this field based on these findings.

WQPS of different river bodies of West Bengal

To assess the general quality of waterbodies, it is essential to measure various WQPs, including pH, temperature, total dissolved solids (TDS), alkalinity, the concentration of different ions, dissolved oxygen (DO), carbonates, hardness, and others. Each of these provides vital information about the water quality in a particular region. For example, pH indicates the level of acidity or basicity in the water, and by analyzing the responsible ions for acidity or basicity, it is feasible to pinpoint the origins of water pollution and take necessary actions to mitigate it. Additionally, certain WQPs, such as BOD, can indicate whether the water is apt for aquatic life or not. Therefore, monitoring these parameters can help in identifying potential water quality issues and implementing appropriate measures to maintain or improve water quality.

Different parameters of the water quality in rivers of WB are discussed according to available literature:

pH

The pH of a water sample indicates the concentration of hydrogen ions and is a crucial factor in determining its appropriateness for household and farming purposes. Any changes in pH can be harmful to living organisms (Goswami *et al.*, 2018). The optimal pH value for river water is around 7.4 (Mondal *et al.*, 2016). However, the pH values can vary seasonally and spatially in a single river. For example, the maximum pH was observed in Jalpaiguri of Murti River (8.78), while the lowest was found in the Hooghly River, near Rani Rashmoni Ghat (6.328±0.15) (Nath *et al.*, 2017).

The pH value fluctuates seasonally. and the value of pH in a single river may vary spatially. In the Tista River, the pH was 7.56 at the Gazoledoba barrage in Jalpaiguri, 8.372 at Paharpur in Jalpaiguri, and 8.377 near the Tista-Karola meeting point (Das, 2017). Das (2017) reported a similar kind of variation in the Karola, a small tributary of Tista too. Here the pH values were 8.073, 7.784, and 8.52 at Gourighat - just before entering Jalpaiguri, near Jalpaiguri Sadar Hospital, and just before meeting Tista, respectively. Considering the pH of other important rivers of the northern region of WB, it has been reported that the highest pH was in the Torsa River, observed at Balarampur, where the value was 7.64±0.41, whereas the lowest value of this river was at Ghugumari, where the value was 5.87±0.12 (Goswami *et al.*, 2018). In the Atrai River, the peak pH level (8.10±0.29) was recorded during December, while the lowermost value (6.75±0.22) was detected in March (Chaki *et al.*, 2014). The pH of the Mahananda River lies in the range of 6.9 - 7.9 (Mozumder *et al.,* 2015).

The mean pH value of the Hooghly River has been reported to be 6.49±0.06, where the maximum and minimum values were found in the Ghatakpara Ghat, near Barrackpore (6.642±0.08) and Rani Rashmoni Ghat of Barrackpore (6.328±0.15), respectively (Nath *et al.,* 2017). Among the rivers originating from the Chhotanagpur Plateau, the Damodar River shows a maximum pH of 8.50 at Birbhanpur, Paschim Bardhaman, whereas the minimum pH (7.50) was observed in Shyampur, Purbasthali, Purba Bardhaman (Haldar *et al.,* 2016). The pH of the Ajay River was reported to be low near the origin (Deoghar, Jharkhand), but it was maximum (7.70) near Natunhat, Purba Bardhaman, WB (Kumar *et al.,* 2014). The average pH of the river Mayurakshi was 7.36±0.25 (Ghosh *et al.,* 2017). The pH value of the Kangsabati River at Kangsabati Reservoir was reported to be in the range of 7.32 - 7.72 during the summer season, 7.38 - 7.98 during the rainy season, and 7.42 – 8.45 during the winter (Bera *et al.,* 2014). Amongst the rivers of the Gangetic estuary region and Sundarban, the pH of the Ichamati River in pre-monsoon, monsoon, and post-monsoon ranges from 6.9 to 8.9 (Mondal *et al.,* 2016). The pH of the Piyali River in this area was in the range of 7.0 - 9.5 in 2009, but in 2013, the range was observed as 7.5 - 8.5 (Das *et al.,* 2014). Bose *et al.* (2012) conveyed that the pH range of the Matla River was 7.6 - 8.2, and the range for Saptamukhi was 7.9 - 8.2 (the study was conducted in the years 1990-1999).

Acid rain has the potential to increase water acidity, which can negatively impact rivers. pH levels that are too high or too low can create an inhospitable environment for aquatic organisms. Young fish and insects, particularly vulnerable to low pH, face an additional danger from acidic water, which can accelerate the release of harmful heavy metals into their environment (Mondal *et al.,* 2016).

Electrical Conductivity (EC)

The electricity carrying ability of waterbodies is assessed through its EC. This property is influenced by the ions present in the water, which allow a flow of electric current (Rahmanian *et al.,* 2015). The EC levels for the Tista and Karola rivers range between 87.32 - 110 µmho/cm and 81.83 - 104.83 µmho/cm, respectively (Das, 2017). The EC value in the Murti River was reported to be 57.76 µmho/cm (Das, 2020). The range of the aforementioned parameter in the case of the Torsa River ranges between 502±6.9 µS/cm to 1105±1.8 µS/cm; the maximum value was observed at Takagachhi in Coachbehar (Goswami *et al.,* 2018). According to a study on the Kaljani River, the mean value of EC was reported to be in the range of 157.17 - 160.614 mho/cm (Mandal *et al.,* 2011).

The EC range in the Ajay River was 207.31 - 270.99 µS/cm, while the maximum value was observed at Bolpur (Kumar *et al.,* 2014). In River Damodar, the mean value of conductivity varies between 180 - 610 µS/cm (Banerjee and Gupta 2012). The mean conductance value for the Kangsabati River was reported to be 217.7 µS/cm (Mohanta and Goel, 2014). The Ichamati River exhibited seasonal variations in conductivity, with measurements of 6.5 mS/cm during the pre-monsoon and monsoon seasons, and 8 mS/cm during the post-monsoon season (Mondal *et al.,* 2016). According to a study on the Piyali River in 2009, the values of EC were between 4000 to 6000 µS/cm, and the maximum value was upstream of the sluice gate. In January 2013, the range of EC downstream of the river showed a huge difference from the previous years; the value was then 14000 - 18000 µS/cm, whereas, near the upstream of the Sluice Gate, it was recorded as only 1650 µS/cm (Das *et al.,* 2014).

Total Dissolved Solids (TDS)

The TDS value is indicative of the cumulative concentration of organic and inorganic minerals dissolved in the water (Mitra *et al.,* 2018). The inorganic ions are represented by sodium, potassium, bicarbonate, magnesium, calcium, chloride, sulfate, etc. For any purpose, the suitability of the water in the sample can be determined by the TDS value. The TDS value also indicates the salinity in water. As per Suthar *et al.* (2010), the mean TDS value in river water generally remains between 222.2 - 2426.3 mg/L.

During a study, it was observed that the TDS of the Tista River ranges between 51.32 - 56.21 ppm (maximum TDS is observed after the Tista and Karola River meeting point) and the TDS of the Karola River ranges between 39.3 - 49.44 ppm (Das, 2017). In the Mahananda River, the range of TDS was reported to be between 78.8 - 114 ppm according to Mozumder *et al.* (2015), while in the Murti River, the TDS value was recorded at 31.78 ppm as per Das (2020).

In the Hooghly River, the range of TDS is very wide; the lowest value (150±100 mg/L) was observed at Budge Budge, Hooghly, at monsoon time, while the highest value (6250±1250 mg/L) was observed at Gangasagar, at post-monsoon time (Mitra *et al.,* 2018b). The range of TDS in the Damodar River lies between 135 - 257 ppm (Haldar *et al.,* 2016) and in the Ajay River between 115.29 - 180 mg/L (Kumar *et al.,* 2014). In another study by Chatterjee *et al.* (2009), the mean TDS value of the Damodar River near an industrial site, Kalajharia, was estimated as 472.25±31.58 mg/L. The mean TDS value of the Mayurakshi River is reported to be 195.08±25.69 mg/L (Ghosh *et al.,* 2017). In the Piyali River of Sundarban, in January 2013, the range of TDS downstream of the sluice gate was reported to be 7800-9200 mg/L, whereas that value, at the upstream of the sluice gate, was between 550 - 900 mg/L (Das *et al.,* 2014).

Dissolved Oxygen (DO)

DO represent the overall quantity of free oxygen dissolved in water. Oxygen becomes incorporated into the water through the photosynthesis of hydrophytes and the aerating effect of winds (via simple diffusion). The critical threshold value of DO for aquatic life is 5 ppm, as indicated by Das (2020). Reduced DO levels can induce stress in aquatic organisms.

Among different rivers of WB, the maximum DO was reported by Bera *et al.* (2014) from Kangsabati reservoir in the winter season (10.40 - 12.00 ppm), while the minimum value (2.00 ppm) was observed in Damodar River at Tetul Bagan Gas Canal (Paschim Bardhaman). As reported by Das (2017), in the Tista River, the value of DO was in the range of 3.5 - 5.6 ppm in 2014, but the amount of DO was much higher in the year 2004 (9.93 - 7.9 ppm). The maximum DO value in the Tista River was near the Tista-Karola meeting point in the year 2004. The DO value in the Karola River lies in the range of 4.2 - 7.6 ppm. The DO values in the Murti River and Atrai River were reported to be 8.7 ppm (Das, 2020) and 7.25±1.39 ppm (Chaki *et al.,* 2014). In the Mahananda River, the aforesaid parameter lies in the range of 3.4 - 7.7 ppm during the pre-monsoon time, in the Siliguri Municipal Corporation area in the years 2011-2014 (Mozumder *et al.,* 2015).

In the Mayurakshi River, the value of DO was 5.94±0.96 ppm (Ghosh *et al.,* 2017). In Ajay River, the value of this parameter lies in a range of 4.4 - 5.8 ppm, the maximum value was observed in Natunhat, Purba Bardhaman (Kumar *et al.,* 2014). In the Damodar River, the values have a wide range of 2.0 - 8.8 ppm, the maximum value was observed in

Shilampur, Paschim Bardhaman (Haldar *et al.,* 2016). In the Hooghly River, the value of DO was very low compared to the other rivers of WB, the pooled data of DO in the Hooghly River is 2.87± 0.14 ppm, which may be due to the heavy industrial pollution (Nath *et al.,* 2017). Another water quality assessment of that river by Mitra *et al.* (2018b) suggests that the maximum DO level was observed in Gangasagar, during monsoon time and the value was 5.95±0.84 ppm. In the river, Kangsabati, the scenario of DO is quite better, where the range lies in 7.20 – 12.0 ppm (Bera *et al.,* 2014). In Ichamati River, the DO value lies in the wide range of 3.83 - 9.52 ppm, where the minimum and maximum values were observed in Old Bongaon Kalitala and Bongaon Bridge of North 24-Pargana respectively in the pre-monsoon time, April 2014 (Mondal *et al.,* 2016). The DO value in Saptamukhi and Matla rivers lies in the range of 4.4 - 4.6 mg/L and 4.2 - 4.4 mg/L respectively in the year 1998-1999, but the range increases in both rivers up to 4.8 - 5.00 mg/L in the year 1990-1991 (Bose *et al.,* 2012).

Carbon Dioxide

The level of free carbon dioxide can serve as an important indicator of the quality of water in an aquatic environment. Elevated carbon dioxide concentrations can lower the pH of seawater, resulting in adverse effects on fish populations inhabiting shallow waters (Ishimatsu *et al.,* 2007). The mean carbon dioxide concentration in the Atrai River was recorded at 14.87±0.84 mg/L. The highest value of 16.30±1.82 mg/L was noted in May 2012, whereas the lowermost value of 13.10±0.98 mg/L was observed in August 2011 (Chaki *et al.,* 2014). In Kangsabati reservoir, the values were different in different seasons. Bera *et al.* (2014) reported that in the summer season (March-June, 2010) the free carbon dioxide range was 3.66 - 4.00 ppm, in monsoon (July-October, 2010) the range was 3.33 - 7.00 ppm, and in winter (November 2010 - February 2011) the range was 3.66 - 9.66 ppm.

Alkalinity

The alkalinity of water measures how much acid it can neutralize. The alkalinity range of the Tista River was 32.55 - 34.55 ppm in the year 2004, but the range has been changed to 14 - 56 ppm in 2014 (Das, 2017). The range of alkalinity for the Karola River has also changed likewise, from 37.78 - 42.2 ppm in 2004 it has been changed to 48 - 62 ppm in 2014 (Das, 2017). The maximum value of alkalinity in the Karola River was observed at Gourighat, whereas in the case of Tista, the maximum value was observed after the meeting of Tista with the Karola River. Das (2020) reported the value of alkalinity in the Murti River was 20 ppm. In the case of the Atrai River, the alkalinity was measured at 114.37±20.41 mg/L. (Chaki *et al.,* 2014). In the Mahananda River, the range of $CaCO_3$ alkalinity was 40.08 - 57.37 mg/L (Mozumder *et al.,* 2015).

The alkalinity levels of Damodar vary between 100 - 136 mEq/L (Haldar *et al.,* 2016). The minimum value (100 mEq/L) was observed in Dhobanghata, Paschim Bardhaman District, while the maximum was observed near the Tentulbagan gas canal. The seasonal variation of alkalinity in Kangsabati reservoir was reported to be 54.33 – 94.00 mg/L in summer, 40.67 – 79.66 mg/L in monsoon, and 60.33 – 80.34 mg/L in winter (Bera *et al.,* 2014).

Hardness

The water hardness primarily reflects the bivalent metallic cations (++ charged) concentration in a water sample. It is typically quantified as the combined sum of calcium and magnesium concentrations, expressed in terms of calcium carbonate equivalents (Das, 2020). In the Tista River, the magnesium hardness ranged from 38.45 to 128.71 mg/L, while the calcium hardness ranged from 10.467 to 31.64 mg/L. The highest values for both magnesium and calcium hardness were recorded after the convergence of the Tista and Karola rivers. The total hardness range of the Tista River was reported to be 71.15 to 156 mg/L according to Das (2017). The calcium and magnesium hardness range of the Karola River was 14.7 - 20.58 mg/L and 44.43 - 49.01 mg/L respectively and the total hardness was 59.13 - 66.65 mg/L (Das, 2017). The value of total hardness in the Murti River in Jalpaiguri was reported to be 22.4 mg/L, whereas the value of calcium and magnesium hardness was 20.8 mg/L and 1.6 mg/L respectively (Das, 2020). In a study on the Kaljani River, the average total hardness ranges from 76.7 - 82.0 mg/L, the maximum average value was detected near Babupara, and the minimum average value was at Birpara under Alipurduar municipality (Mandal *et al.,* 2011). The total hardness of the Mahananda River water ranges between 53 mg/L to 70 mg/L expressed in terms of calcium carbonate (Mozumder *et al.,* 2015).

Total hardness in the Damodar River water ranges from 115 - 155 mg/L in pre-monsoon time, 60 - 170 mg/L in monsoon, and 112 - 180 mg/L in post-monsoon season (Haldar *et al.,* 2016). The total hardness level in the Kangsabati reservoir ranges from 115.18 - 178.6 ppm in summer, 137.00 - 195.36 ppm in the rainy season, and 112.60 - 170.60 ppm in winter (Bera *et al.,* 2014). The total hardness in the Hooghly River averaged 203.69±8.35 ppm (Nath *et al.,* 2017).

Biological Oxygen demand (BOD) and Chemical Oxygen Demand (COD)

BOD and COD are vital indicators of water quality, revealing the quantity of organic compounds within a water body. Regarding the Tista River, the BOD value was between 0.92 – 1.9 ppm, while the range in the Karola River was between 1.47 – 1.55 ppm (Das, 2017). For the Murti River, the value measured was 2.5 ppm (Das, 2020). The range of BOD values in the Mahananda River lies between 0.3 – 2.7 mg/L (Mozumder *et al.,* 2015) whereas the value for the Mayurakshi River was reported to be 1.4 – 3.7 mg/L (Ghosh *et al.,* 2017). The seasonal variation of BOD levels in the Damodar River fluctuates between 0.67 – 5.30 mg/L during the pre-monsoon period, 0.67 – 4.03 mg/L during the monsoon, and 2.81 – 5.64 mg/L post-monsoon (Haldar *et al.,* 2016). In the case of Hooghly River, the range of BOD was 0.96±0.58 – 1.70±0.73 mg/L, while the maximum value was reported at Triveni, Hoogly (in monsoon) (Mitra *et al.,* 2018b). The value of BOD in the case of the Bidyadhari River was reported to be 1.6 – 4.824 mg/L, the highest value detected at Kulti and Malancha of South 24-Pargana (Das and Datta, 2004).

The COD of Murti River was reported to be 18.4 mg/L (Das, 2020) and the range in Mahananda was 19.2 – 76.5 mg/L (Mozumder *et al.,* 2015). The seasonal disparity in COD values in the Damodar River was documented to be 32 – 128 mg/L during both the pre-monsoon and monsoon periods, and 32 – 96 mg/L during the post-monsoon season (Haldar *et al.*, 2016). In the Bidyadhari River, the COD value range was 20 – 92 mg/L, the minimum value was reported at Haroa and the maximum value was at Kulti (Das and Datta, 2004).

Major Ions

Major ions that are available in river water samples include Fluoride, Chloride, and Nitrate. Nitrites, Sodium, Potassium, etc., and also the heavy metals ions. Each of these ions indicates water quality status as well as pollution type.

Fluoride

Fluoride is not soluble in water, so it mainly remains as an ion in the water. It comes in contact with ground and surface water only by the process of leaching. In a study it was found that the fluoride ion content in the Tista River was very much lower at 0.05 mg/L, only after the confluence of Tista with Karola, the value has been increased to 0.77 mg/L (Das, 2017). But in the case of the Karola River, the maximum range of fluoride ions is quite high at 1.3 mg/L at the spot just before meeting the Tista River (Das, 2017). In the Murti River, the fluoride level was estimated at 0.4 mg/L (Das, 2020).

In the Hooghly River, the fluoride ion concentration is also very low, not detectable in some places to 0.238 mg/L (Mohanta and Goel, 2014). In Damodar River water, seasonal variation in fluoride content was noticed. The peak concentration of fluoride ions was noted during the pre-monsoon season, with a range of 0.54 - 1.82 mg/L, followed by the monsoon season with a range of 0.33 - 0.89 mg/L, and the post-monsoon season with a range of 0.276 - 1.12 mg/L. In all seasons, the Tentulbagan gas canal in WB registered the maximum fluoride content (Haldar *et al.,* 2016).

Chloride

Chloride ion is commonly found in sewage water. As the sewage water of urban areas ultimately gets mixed with the river, the chloride ions in river water samples are expected to be in the detectable range. The amount of dissolved chloride ions in the Tista River was between 0.736 - 1.684 mg/L in the year 2004 and the range has been changed to 3.67 - 28.39 mg/L in 2014, in both studies the maximum chloride ions were found after the confluence of Tista and Karola river (Das, 2017). Similarly, the Karola River has shown a chloride ion concentration range of 0.967 - 1.742 mg/L in 2004 and 6.2 - 13.2 mg/L in 2014 (Das, 2017). In the Murti River, the concentration of chloride ions was 8.6794 mg/L (Das, 2020) and in the Mahananda River, the range was 0.9 - 1.8 mg/L (Mozumder *et al.,* 2015). The value of chloride ions in the Kaljani River ranges between 0.4644 - 0.774 mg/L (Mandal *et al.,* 2011).

Ghosh *et al.* (2017) reported the chloride ion concentration in the Mayurakshi River water as 26.84±12.84 mg/L. In Damodar River water, a clear seasonal variation in chloride ion concentration was evident, ranging from 13.97 to 67.88 mg/L during the pre-monsoon period, 15.39 to 48.76 mg/L during the monsoon, and 13.99 to 101.96 mg/L during the post-monsoon season (Haldar *et al.,* 2016). In another study on the Damodar River, the mean chloride ion concentration in the industrial stretch was 84.55 ±3.28 mg/L (Chatterjee *et al.,* 2009). Likewise, in the Kangsabati River, the seasonal ranges were 132.91 – 305.30 mg/L, 127.40 - 160.93 mg/L, and 110.9 - 160.40 mg/L in pre-monsoon, monsoon, and post-monsoon, respectively (Bera *et al.,* 2014). In the Piyali River of Sundarban, the peak concentration of chloride ions was documented at 5537 mg/L during the pre-monsoon season of 2009 (Das *et al*., 2014).

Nitrate and Nitrite Ions

Nitrate and nitrite ions are commonly found in river water and are important indicators of water quality. These ions are naturally occurring in soil and are additionally discharged into the environment through a range of human activities, including agriculture and industrial processes. Nitrate ions represent the most stable and commonly found form of nitrogen in river water. While they are not typically considered toxic to aquatic life or human health at low levels, excessive levels of nitrate ions boost the growth of harmful algae and aquatic plants. This can lead to a decline in DO levels in the water, which can be harmful to aquatic organisms. On the other hand, nitrite ions are more toxic than nitrate ions and can harm both humans and aquatic life at high levels. Nitrite ions can also contribute to the growth of harmful bacteria and algae in river water, leading to a decrease in water quality.

Nitrate levels in river water tend to rise as a result of excessive application of inorganic fertilizers and animal fertilizers (Ward *et al.,* 2018). In the Kaljani River, the range of nitrate ion concentration was reported to be 13.8333 - 24.1666 mg/L (Mandal *et al.,* 2011). Nitrate ion detected in Murti River water was 4.5 mg/L (Das, 2020).

The nitrate and nitrite ion concentrations found during the study in the Mayurakshi River were 34.71 ± 1.16 mg/L and 32.83 ± 36mg/L respectively (Ghosh *et al.,* 2017). In Hooghly River, the concentration range of nitrate and nitrite were 0.964 - 6.905 mg/L and 0.153 - 3.064 mg/L respectively (Mohanta and Goel, 2014). In the case of the Damodar River, seasonal variations in nitrate ion concentration have been documented. During the pre-monsoon season, the range typically falls between 0.17 - 0.45 mg/L, while in the monsoon and post-monsoon seasons, the range shifts to 0.15 - 0.23 mg/L and 0.021 - 0.292 mg/L, respectively (Haldar *et al.,* 2016). In the Kangsabati reservoir, the seasonal variations of the range of nitrate ions were 0.50 - 1.08 mg/L (pre-monsoon), 1.06 -1.96 mg/L (monsoon), and 0.74 - 1.02 mg/L (post-monsoon) (Bera *et al.,* 2014). A long-term study (1990-1999) on the Matla River reveals that the range of the nitrate ion in this river fluctuates between 11.4 - 173 mg/L, the minimum value was observed during 1993-1994, and the maximum value was observed during 1991-1992 (Bose *et al.,* 2012). In a similar kind long-term study on the Saptmukhi

River, it was found that the range of nitrate ion varies between 49 - 221 mg/L, here the maximum value was observed in 1995-1996, and the minimum value was noticed in 1996-1997 (Bose *et al.,* 2012).

Sodium

The sodium ion is one of the abundant cations that remain present in river water samples. The seasonal variation in the levels of sodium ions in river Hooghly is evident. A study revealed that sodium ion was the second most abundant cation present in the Hooghly River. The concentration of ions ranges between 8.278 - 11.640 mg/L, 3.177 - 14.613 mg/L, and 3.560 - 6.010 mg/L in rainy, winter, and summer seasons respectively (Mohanta and Goel, 2014). In the case of the Mayurakshi River, the value of sodium ion concentration ranges from 26.14 -26.67 mg/L, with a mean value of 26.35 ± 0.16 mg/L (Ghosh *et al.,* 2017). In the Ajay River, the maximum value of sodium ion concentration was reported to be 29.686 mg/L at Bolpur, Birbhum (Kumar *et al.,* 2014). In the case of the Kangsabati River, the sodium ion concentration ranges between 6.196 - 7.435 mg/L (Mohanta and Goel, 2014).

Potassium

Another monovalent cation present in river water samples is potassium. In river Mayurakshi, the range of Potassium ion concentration ranges between 10.67 - 19.24 mg/L, with an average concentration of 14.77 ± 2.55 mg/L (Ghosh *et al.,* 2017). In the case of the Ajay River, the concentration ranges between 0.411 - 5.912 mg/L, with the highest concentration reported in Bolpur, Birbhum (Kumar *et al.,* 2014). In the Hooghly River, the potassium ion concentration is not in the detectable range, and in the Kangsabati River, the concentration was found in the range of 1.023 - 1.367 mg/L (Mohanta and Goel, 2014).

Sulfate

Sulfate ion concentration is a good indicator of water pollution. The sulfate-reducing bacterial (SRB) population is known to reduce sulfate ions and produce toxic sulfide, which hurts the aquatic biota and also can hamper the biogeochemical cycles (Sinha and Banerjee, 1995). Sulfides are toxic to many organisms because they combine with the cytochromes and other iron compounds inside the cell (Brock *et al.,* 1994). In 2004, in the rivers, Tista and Karola the sulfate ion concentrations were reported to be in the range of 5.288 - 8.4 mg/L and 0.541 - 0.752 mg/L respectively (Das, 2017). In the Tista River, the maximum value was observed after the meeting point of the Tista and Karola Rivers. Similarly, in the Kaljani river, the range was 3.88 - 4.78 mg/L (Mandal *et al.,* 2011).

The sulfate ion concentrations were also reported to be varying in different seasons. In the Damodar River, it was reported that the concentration of sulfate ion ranges from 22.4 - 36.8 mg/L, 14 - 30 mg/L, and 30.4 - 43.2 mg/L in pre-monsoon, monsoon, and post-monsoon seasons respectively (Haldar *et al.,* 2016). In the Mayurakshi River, the range of this parameter was 15.4 -15.94 mg/L, with a mean value of 15.63 ± 0.16 mg/L (Ghosh *et al.,* 2017). The range of sulfate ions in the Hooghly River is reported to be 3.658 - 42.295 mg/L (Mohanta and Goel, 2014).

Phosphate

Phosphate ions are also indicators of the health of any water body, excessive phosphate ions cause the growth of aquatic plants and algal bloom which causes the deterioration in oxygen levels (Singh, 2013). The concentration of phosphate ion in Damodar River ranges from 0.01 - 0.99 mg/L, 0.01 - 0.32 mg/L, and 0.003 - 0.502 mg/L in pre-monsoon, monsoon, and post-monsoon seasons respectively (Haldar *et al.,* 2016). In the case of the Mayurakshi River, the phosphate ion concentration ranges between 0.32 - 1.32 mg/L (Ghosh *et al.,* 2017), and in Kaljani River the range was 801.372-1570.658 ppm (Mandal *et al.,* 2011). In a study on Hooghly, it was reported that the range of phosphate ions was 0.125 - 5.278 mg/L (Mohanta and Goel, 2014). The amount of orthophosphate present in the Tista River and Karola River ranges between 65.21 - 105.03 mole/L and 90.03 - 149.07 mole/L respectively (Das, 2017). In the case of the Murti River, the value of phosphate ion was 0.1684 x 10-6 mol/L (Das, 2020). A study

(1990-1999) on the Matla and Saptamukhi rivers of Sundarban reveals that the range of inorganic phosphate remains in the range of 13 - 41 mg/L and 15 - 50 mg/L respectively (Bose *et al.,* 2012).

Calcium

Calcium ions mainly come to river water by the erosion of bedrock. The bedrock is rich in calcium carbonate after erosion with river water flow causes relatively high calcium content in that river water. The concentration of calcium ions contributes to the hardness of the river water. The amount of Calcium ions in the Hooghly and Kangsabati rivers ranges from 7.872 - 36.638 mg/L and 21.539 - 23.572 mg/L respectively (Mohanta and Goel, 2014). The range of calcium ion concentration in the Mayurakshi River ranges from 17.83 - 18.35 mg/L with an average value of 18.04 ± 0.17 mg/L (Ghosh *et al.,* 2017). In the case of the Ajay River, the range was 5.355 - 35.605 mg/L (Kumar *et al.,* 2014). In the Damodar River, seasonal variation of calcium ion concentration was reported as 22.4 - 36.4 mg//L, 14 - 30 mg/L, and 30.4 - 43mg/L in pre-monsoon, monsoon, and post-monsoon respectively (Haldar *et al.,* 2016).

Magnesium

Magnesium is a naturally occurring element and is among the most abundant elements found in the Earth's crust. It is an essential nutrient for both humans and aquatic life, and its ions are commonly found in river water. Magnesium ions in river water play an important role in several biological processes. For instance, magnesium ions are necessary for the proper functioning of enzymes involved in the metabolism of carbohydrates and fats. In aquatic ecosystems, magnesium ions also help maintain the pH levels and stabilize the electrical charge of cells. Magnesium is generally considered to be a beneficial element in river water and is not typically considered to be harmful at normal levels. However, excessively high levels of magnesium ions can make the river water hard and can cause scaling in water pipes and other industrial equipment. Conversely, low levels of magnesium ions can also negatively affect the growth and survival of aquatic life. Just like the calcium ions, the Magnesium content of river water is also dependent on the geological features of the catchment areas of that particular river. The amount of dissolved magnesium ion present in the Hooghly River was reported as 50 mg/L. The aforesaid ion is also present in the Kangsabati River, but the amount is low, compared to the Hooghly River, the value ranges between 12.469 - 14.207 mg/L (Mohanta and Goel, 2014). In Damodar, the range of magnesium ion concentrations was 11.6 - 36.4 mg/L, 6 - 52 mg/L, and 1.44 - 10.1 mg/L in pre-monsoon, monsoon, and post-monsoon seasons as estimated by Haldar *et al.* (2016). In Ajay River, the range was between 1.48 - 9.162 mg/L 14], which was 9.27 - 19.88 mg/L in Mayurakshi river water, with a mean of 12.37 ± 3.64 mg/L (Ghosh *et al.,* 2017).

Heavy Metals and their Ions

Heavy metals and their ions can be found in river water as a result of diverse human activities, including mining, industrial effluents, and agricultural practices. These metals and ions pose substantial risks to both aquatic ecosystems and human health. Arsenic (As), Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Mercury (Hg), Copper (Cu), Manganese (Mn), and Zinc (Zn) are the most abundant heavy metals in river water nowadays. According to a report, the concentration of As in the Tista and Karola rivers was more than 0.01 mg/L whereas the concentration of Mn in the Tista and Karola rivers was more than 0.25 mg/L (Das, 2017). In the case of the Murti River, the concentration was less than 0.01 mg/L, which was below the threshold value for wildlife (Das, 2020). In the case of the Torsha River, the value of Pb has been studied and an alarming result was found. In Torsha the range of Pb lies between 0.49±0.14 - 2.69±0.82 mg/L, the highest value was observed at Ghughumari, Coochbehar (Goswami *et al.,* 2018).

Regarding the Damodar River, a wide range of heavy metals has been encountered (Pb, Mn, Cd, etc.). The maximum concentration of Pb (188.75 μg/L) and Cd

(3.25 µg/L) was found at Chinakuri (Paschim Bardhaman), nearby the release point of the thermal power plant (Banerjee and Gupta, 2012). The Mn concentration of the Damodar River and Barakar tributary ranges between 0.0 - 65.09 µg/L (Banerjee and Gupta, 2012). The concentration of heavy metals in Kalajharia spot, an industrial site reported to be 0.03±0.01 mg/L for As, 0.3±0.05 mg/L for Cd,11.55±0.78mg/L for Cr (Chatterjee *et al.,* 2008). In the case of Hooghly River, the range of Cd is mostly not detectable to 3 µg/L, whereas the maximum range of Cr was observed at Uluberia (13 - 24 µg/L) (Paul, 2017). The maximum ranges of Cu (1 - 49 µg/L), Fe (13 - 5490 µg/L), and Hg (160-950 µg/L) were found at Kolkata, whereas maximum Mn (181 - 712 µg/L), Ni (35 - 53 µg/L), Pb (5 - 97 µg/L) and Zn (150 - 710 µg/L) ranges were reported at Berhampur (Murshidabad), Palta (North 24-Pargana), Dakshineswar (North 24-Pargana) and Diamond Harbour (South 24-Pargana) respectively (Paul, 2017).

Fecal Coliform and Total Coliform

Fecal coliform bacteria are microscopic organisms found in guts and excrement (feces) of vertebrates, including humans. Its presence in river water serves as a robust indicator of contamination by fecal materials, often stemming from untreated sewage or runoff from animal waste. The existence of fecal coliform in river water poses notable health hazards to both humans and aquatic life, as it signals the possible presence of pathogenic bacteria capable of causing illnesses like diarrhea, dysentery, and hepatitis A. Therefore, monitoring fecal coliform levels in river water is essential in assessing the water quality and potential health hazards associated with its use. In the Mahananda River, the range of fecal coliform remains within a range of 4000 - 15000 MPN/100ml, whereas the range of total coliform was reported to be in a wide range of 9000 - 93000 MPN/100ml (Mozumder *et al.,* 2015). In the Kaljani River case, the total coliform and fecal coliform ranges between 15640 - 43500 /100ml and 13400 - 24320 /100ml respectively (Mandal *et al.,* 2011).

In a study on the Damodar River, it was reported that the range of coliform in different seasons varies between 4 - 33 MPN/ml (pre-monsoon), 2 - 50 MPN/ml (monsoon), and 0.09 - 0.20 MPN/ml (post-monsoon) (Haldar *et al.,* 2016). The highest values for all the seasons were reported from a spot at the Tentulbagan gas canal, Bardhaman (Haldar *et al.,* 2016). In the case of Hooghly River, the seasonal variation in fecal coliform number was also evident, in monsoon the range of fecal coliform was reported to be 2093 ± 1006 MPN/100ml (Barrackpore, North 24-Pargana) to 4569 ± 1410 MPN/100ml (Lot 8, South 24-Pargana), in post-monsoon season 2766 ± 1590 MPN/100ml (Triveni, Hoogly) to 5615 ± 584 MPN/100ml (Babughat, Kolkata) and in the pre-monsoon season the range was between 1959 ± 719 MPN/100ml (Barrackpore, North 24-Pargana) to 4072 ±1 340 MPN/100ml (Lot 8, South 24- Pargana) (Mitra *et al.,* 2018b).

Discussion

WB's geography is so diversified that the state's rivers have a remarkable diversity in both physical qualities and chemical makeup. The varying bedrock composition of different rivers is caused by topographical diversity, which is also responsible for the varied dissolved ion composition of the rivers. The lower course (slowest part of a river) of India's greatest river, the Ganga, has been traveling through the state of WB, and parameters such as TDS and EC show greater values here, as the river performs deposition. Rivers that flow through hilly valleys generally exhibit lower levels of TDS. On the other hand, rivers situated near the sea typically exhibit notably higher TDS and EC values compared to those in northern regions (Table 1). Additionally, weather patterns can also affect certain physical parameters. For example, TDS values tend to increase in arid climates, which is prevalent in the southern part of WB and could be a contributing factor to the higher TDS levels observed in the southern part of WB. It's important to acknowledge that human activities exert a greater influence on the quality of river water compared to natural factors.

Table 1. Basic water quality parameters in rivers of West Bengal, India

Name of the River	pH	EC	TDS	Dissolved O_2	CO_2	Alkalinity	Hardness
Tista (Das, 2017)	8.372-8.377	87.32 - 110 µmho/cm	51.32 - 56.21 ppm	3.5 - 6.5 ppm	-	14 - 56 ppm	71.15 - 156 mg/L
Karola (Das, 2017)	7.784-8.52	81.83 - 104.83 µmho/cm	39.3 - 49.44 ppm	4.2-7.6 ppm	-	48 - 62 ppm	59.13 - 66.65 mg/L
Torsha (Goswami *et al.*, 2018)	5.87-7.64	502 - 1105 µS/cm	-	-	-	-	-
Murti (Das, 2020)	-	57.76 µmho/cm	-	8.75 ppm	-	20 ppm	22.4 mg/L
Kaljani (Mondal *et al.*, 2011)	-	157.17 - 160.614 mho/cm	-		-	-	76.7 - 82.0 mg/L
Atrai (Chaki *et al.*, 2014)	6.75-8.70	-	-	7.25 ppm	14.87 mg/L	114.37 ± 20.41 mg/L	
Mahananda (Mozumdar *et al.*, 2015)	6.9- 7.9	-	78.8 - 114 ppm	3.4 - 7.7 ppm	-	40.08 - 57.37 mg/L	53 mg/L - 70 mg/L
Mayurakshi (Ghosh *et al.*, 2017)	7.36	-	195.08 mg/L	5.94 ppm	-	-	-
Ajay (Kumar *et al.*, 2014)	7.70	207.31 - 270.99 µS/cm	-	4.4 - 5.8 ppm	-	-	-
Damodar (Haldar *et al.*, 2016)	7.5-8.5	180 - 610 µS/cm	135 - 257 ppm	2.0 - 8.8 ppm	-	100 - 136 mEq/L	60 - 180 mg/L
Kangsabati (Kasai) (Bera *et al.*, 2014)	7.32-8.45	217.7 µS/cm	-	7.20 - 12 ppm	33.66 - 9.66 ppm.	54.33 - 94.00 mg/L	115.18 - 195.36 ppm
Hooghly (Nath *et al.*, 2017)	6.328-6.342	-	150 - 6250 mg/L	2.87 ppm	-	-	203.69 ppm
Ichamati (Mondal *et al.*, 2016)	6.9-8.9	6.5 - 8 mS/cm	-	3.83 - 9.52 ppm	-	-	-
Piyali (Das *et al.*, 2014)	7.5 - 8.5	4000 - 6000 µS/cm	550 - 9200 mg/L	-	-	-	-
Matla (Bose *et al.*, 2012)	7.6 - 8.2	-	-	4.8 – 5.0 mg/L	-	-	-
Saptamukhi (Bose *et al.*, 2012)	7.9-8.2	-	-	4.8-5 mg/L	-	-	-

Table 2. Concentration of different ions in the river water of West Bengal, India

Name of the River	Calcium	Magnesium	Chloride	Fluoride	Sodium	Potassium	Sulphate
Tista (Das, 2017)	-	-	3.67-28.39 mg/L	0.05-0.77 mg/L	-	-	5.288-8.4 mg/L
Karola (Da,s 2017)	-	-	6.2-13.2 mg/L	1.3 mg/L	-	-	0.541-0.752 mg/L
Murti (Das, 2020)	-	-	8.6794 mg/L	0.4 mg/L	-	-	
Kaljani (Mandal *et al.*, 2011)	-	-	0.4644-0.774 mg/L	-	-	-	3.88-4.78 mg/L
Mahananda (Mozumder *et al.*, 2015)	-	-	0.9-1.8 mg/L	-	-	-	-
Mayurakshi (Ghosh *et al.*, 2017)	17.83-18.35 mg/L	9.27-19.88 mg/L	26.84 mg/L	-	26.35 mg/L	14.77 mg/L	15.63 mg/L
Hooghly (Mohanta and Goel, 2014)	7.872-36.638 mg/L	50 mg/L	-	0.233 mg/L	3.177-11.30 mg/L	-	3.658-42.295 mg/L
Damodar (Haldar *et al.*, 2016)	14-43 mg/L	6-36.4 mg/L	13.97-101.96 mg/L	0.33-1.82 mg/L	-	-	14-43.2 mg/L
Ajay (Kumar *et al.*, 2014)	5.355 - 35.605 mg/L	1.48-9.162 mg/L	-	-	3.808-37.473 mg/L	0.411-5.912 mg/L	-
Kangsabati (aka Kasai) (Mohanta and Goel, 2014)	21.539-23.572 mg/L	12.469-14.207 mg/L	110.9-305.3 mg/L	-	-	1.023-1.367 mg/L	-
Piyali (Das *et al.*, 2014)	-	-	5537 mg/L	-	-	-	-

WQPs can vary throughout the year, and some parameters may even fluctuate within a single day. For instance, the pH levels of a river may vary daily due to changes in temperature and photosynthesis within the water body. Additionally, the composition of the riverbed has a key role in influencing the water pH. Bedrock that is rich in calcium carbonate typically results in higher pH levels of the river water. TDS measures both organic and inorganic matter present in water, while EC indicates the concentration of conductive ions in the water. Industrial and agricultural effluents often contain pollutants that significantly affect both TDS and EC levels. Based on the data collected on various rivers in WB, it is evident that most rivers have a neutral to slightly alkaline pH, while TDS values are substantially higher in southern WB's rivers (Table 1). As previously discussed, this result could be due to urbanization and industrial development, but it is not solely responsible. Geographical factors also play a critical role.

Polluted water typically has a lower level of DO than unpolluted water. Although most rivers in WB have sufficient DO levels to support aquatic life, a few rivers in both the north and south regions have significantly low DO levels due to extensive industrial wastewater contamination.

Limited data is available on the concentration of different ions in many rivers of WB (Table 2), making it difficult to draw any conclusive observations. However, there is a general trend of increasing fluoride and chloride ion concentrations in rivers from the northern to southern regions of WB. Urban sewage effluents are usually responsible for the increase of different ions in river water (Khatri and Tyagi, 2014). Since most rivers in the state are contaminated with urban and agrochemical wastewater, there is no clear trend in nitrate, nitrite, and phosphate ion concentrations. Several cities and towns in close proximity to the rivers, such as Kaljani (Alipurduar), Murti (Malbajar), Mayurakshi (Suri), and Damodar (Asansol, Durgapur, Burdwan), are experiencing rapid urban growth. Even the water quality of some small tributaries passing through the cities are deteriorated drastically (Mukherjee and Paramanik, 2023). The concentration of ions varies from river to river depending on the amount of urban wastewater production in each city.

Heavy metals are not naturally occurring components of river water, but are primarily indicators of industrial wastewater pollution. In the northern region of WB, heavy metal contamination in most rivers is below the threshold value, except for the Torsha River, which has an alarming concentration of lead. This contamination may be due to industrial effluents from the nearby Coochbehar industrial park (Goswami *et al.,* 2018). The Damodar River and its tributary, Barakar, also have heavy metal contamination, and since the mouth of the Damodar River is at Hooghly, the contamination is evident there as well. Additionally, a large number of industries, like chemical, dairy, food and beverage, textile manufacturing, bleaching, dyeing, and tannery, are set on the banks of the Hooghly, contributing to the maximum heavy metal contamination observed in that area (Panigrahi and Pattnaik, 2019). The immersion of idols during festivals, along with the accompanying materials, is also a source of various pollutants, including heavy metals (Mukherjee and Paramanik, 2022).

Although there are some gaps in the data, the available information provides a clear depiction of the aquatic pollution of WB's rivers. Certain parameters exhibit seasonal fluctuations, reaching their minimum values at the monsoon time, possibly due to the dilution effect of rainfall. In the Sundarban rivers, few parameters, such as TDS and certain ions, show higher levels than those in other rivers in the northern region of WB and the Chhotanagpur Plateau, probably influenced by marine water influx during high tide (Table 2). Rivers that regularly come into contact with tidal water and have sluice gates also exhibit significant variations in several parameters before and after the sluice gate. Rivers located near industrial areas have higher concentrations of metal ions in their water samples, indicating that untreated industrial waste is causing ecological stress to the river. This stress poses a threat to the survival of living organisms, including humans, who depend directly or indirectly on these rivers.

Conclusion

Upon close examination, it is apparent that the majority of WQPs deteriorate due to direct or indirect human activities. The discussion above highlights that, in comparison to the southern region of WB, the pollution level of rivers in the northern region of WB is relatively better. This is likely because the northern region of WB is mostly surrounded by hills and mountains, and thus, the industrialization process has been slower there. However, the quality of water in some northern regions of WB rivers, such as Torsha, is also deteriorating, suggesting that the situation may be changing even in that region. In the case of the southern region of WB, industry, followed by unplanned urbanization, was a major contributor to the decline of river water quality. Aquatic life richness in the southern region of WB rivers has already been greatly reduced by careless anthropogenic activity and pollution. All through the COVID-19 pandemic lockdown time, with reduced human activities, there was an improvement in the pollution scenario of several rivers. (Chakraborty *et al.,* 2021; Muduli *et al.,* 2021), indicating that water quality rejuvenation is possible. However, close monitoring and proper policy are essential. Every source of polluted industrial, urban, and agricultural water must be monitored and treated before it enters rivers.

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