Evaluation of Physicochemical and Biological Parameters on the Water Quality of ShilabatiRiver, West Bengal, India

Misha Roya,b, Farzana Shamima and Saibal Chatterjeeb

aCentre for Environmental Studies, Vidyasagar University, Midnapur, West Bengal, India; bDirectorate of Distance Education, Vidyasagar University, West Bengal, India

ABSTRACT
Anthropogenic activities affect the rivers and the entire basin in different dimensions. All the river basins including Ganga and Damodar are polluted from unplanned anthropogenic activities. This study is an attempt to access the quality of Shilabati River by computing water quality and pollution index using eleven parameters, pH, COD, BOD, DO, TDS, Total Hardness, Total Alkalinity, Phosphate, Chloride, Nitrate, and Turbidity measured at eighteen different sites. The BOD and TC counts are found to be 2.45 mg/l and 9334 MPN/100 ml which reveal that the river water falls under the moderately polluted category of Central Pollution Control Board. The high phosphate concentration suggests a heavy load of anthropogenic and industrial wastes and contributes to the rise in COD and BOD. The high phosphate concentrations also account for the eutrophic water. The physicochemical parameters fall mostly under the E category of Central Pollution Control Board. The Water Quality Index, Comprehensive Pollution Index, and Eutrophication index values show that the river water quality is poor and seriously polluted indicating that the water is not suitable for drinking, domestic purpose, and also for healthy survival of aquatic life and needs urgent management.

INTRODUCTION

Water is a vital resource for the survival of all kinds of life on this planet. It is an essential and most precious commodity of life. Freshwater river systems are vital and essential for the sustenance of life (Suthar, Sharma, Chabukdhara, & Nema, 2010). Rivers are our natural heritage but are continuously exploited, mistreated, and contaminated by extreme pollution and are affecting the water quality and aquatic life therein. It is important to systematically study the status of pollution of the river concerning various anthropogenic activities as river water has been used for drinking and other domestic use and also for the healthy sustenance of the aquatic ecosystem. The water quality of most of the river water is contaminated due to heavy pollutant loads in India (Jindal & Sharma, 2010; Ramakrishnaiah, Sadashivaiah, & Ranganna, 2009). Urbanization is found to be the root cause of this contamination (Roy, 2019). Immersion of idols during festivals is also accounted to be one of the reasons for river pollution (Kamal, Malmgren-Hansen, & Badruzzaman, 1999). Direct disposal of industrial waste including detergents, heavy metals, acids, dyes, alkalis, and other chemicals affects water quality (Roy and Shamim, 2020a; Roy & Shamim, 2020b).

Water quality is based on the different components which should be present at the optimum level for the proper growth of aquatic life. Several studies conducted on different rivers all over India have portrayed the same picture of poor water quality and deteriorating aquatic life (Bhor et al., 2013; Gupta, et.al, 2017; Muniyan & Ambedkar, 2011; Rao & Vaidyanadhan, 1979; Roy & Shamim, 2020a; Sadia et al., 2013; Santosh and Shrihari, 2008; Shah & Geeta, 2017). There cannot be accounted a single reason for such pitiful condition of the rivers but the scenario has arrived at these levels because of the combined effect of various intertwined factors.

Shilabati River is a very important river situated in the West Midnapore district of West Bengal, India. It passes from Ghalat town in West Midnapore and is mainly part of the Damodar basin. It originates from Purulia district and flows from Bankura to Paschim Medinipur and finally joins the Hooghly River which ultimately drains into the Bay of Bengal. Various kinds of anthropogenic activities such as the unplanned market are seen on both sides of the Shilabati River. In addition, various anthropogenic wastes are continuously directly dumped into the river without any treatment. As a result, it deteriorates the river water quality and shoreline basin and pollutes the river badly. Very little work has been reported on the quality of Shilabati River, which is a very important riverine system for the people of West Midnapore district.
In the present investigation, the effect of the various physicochemical and biological parameters on the quality of water of the Shilabati River has been assessed to discuss the suitability of the water for human consumption and aquatic life based on values of water quality index (WQI) comprehensive pollution index (CPI) and eutrophication index (EI).

**Study methodology**

**Study area**

The river Shilabati originates from Chak Gopalpur village of Hura block in the Purulia district of West Bengal. The length of the river is 350 km, catchment area 4086 Sq km and it joins with the Dwarakeswar near Ghatal and is known as the Rupnarayan River in Purulia, Bankura, and Medinipur. Shilabati River is the main cause of flood in the Banka, Khirpai, and Ghatal area. There are many tributaries of the river on both sides. From the left side Joypanda, Purandar, Champakhali, Sasra and Donai, Kubai, Buriganga, Tamal, Parang originate from the right side (Figures 1a and 1b).

The present study is focused to investigate the status of the water quality of the Shilabati River. The direct discharging drains are not found in the main stem of river Shilabati from Dwarakeswar to upward Ghatal Zone (10 km stretch). The main drain of the municipality area is found nearby the Panchayet municipal area, which is approximately 6 km away from the river. This stretch of river has been identified as most polluted, and it passes through the Ghatal town. The sampling locations in this study are hence focused near this zone. The total study was carried out

![Image of Shilabati River](https://example.com/image1)

**Figure 1.** (a) Map showing the study area and the drainage pattern of the Shilabati river (Latitude: 23° 14’ 51.56” N; Longitude: 86° 28’ 34.09” E). (b) Study area: Shilabati River.
in different existing sites of the river where people used the water as domestic and drinking purposes in Ghatal subdivision, West Medinipur, West Bengal.

**Sampling location**

The entire study is conducted in different sites of the Shilabati River. The water samples are collected three-times a year pre-monsoon, monsoon, and post-monsoon both during high tide and low tide. The details of the sampling locations are given in Table 1.

**Collection and preservation of samples**

The water sample is collected from different depths of the Shilabati river to investigate to quality of water which is used by Ghatal people for domestic and drinking purpose. Before collecting the water sample all the plastic bottles are first washed with soap and tap water and then washed with the river water. One bottle was acidified with sulfuric acid to a pH <2 and maintained at 4 ± 2°C until analysis for COD measurement. After that water sample was poured in a plastic bottle with a plastic cap and respectively labeled with name and carefully transported to the lab and store in a cool dark place and is subjected to laboratory analysis (APHA, 2017).

**Materials and methods of analysis**

**Water quality parameters**

The parameters are selected to analyze the quality of river water for drinking and domestic purpose only. The parameters are pH, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, Total Alkalinity, Total Hardness, Phosphate, Chloride, Nitrate, TDS, Turbidity and Total Coliform (TC) was analyzed as per the standard guidelines and procedures (APHA (American Public Health Association), 2017).

**Water Quality Index**

To understand the comprehensive picture of the overall quality of water of the Shilabati River, Water Quality Index (WQI) is performed. WQI is a rating reflecting the composite influence of different physicochemical parameters on the overall quality of river water. Eleven water parameters are used in the study for checking the calculation of water quality index. The calculation of the water quality index was done using the weighted arithmetic index method (Abbasi, 2002; Brown, McCleland, Deininger, & O’Connor, 1972). The calculation of WQI is based on several physicochemical parameters which are then multiplied by a weighting factor and the final aggregate is obtained using the arithmetic mean. The weight assigned reflected a parameter’s significance; this index is based on the comparison of the water quality parameters to regulatory standards. The calculation of the WQI is explained below and the same formula is applied to calculate the WQI in the present study.

**Calculation of Water Quality Index**

The WQI was computed through three steps. First

Step: 1 – Calculate the Unit weight (Wn) factors for each parameter by using formula

\[ Wn = \frac{k}{sn} \]

Where, Where \( w_n \) = unit weight for nth parameter.

The unit weight \((Wn)\) of each parameter is proportional to the weightage of each parameter;

\( n \) is the number of water quality parameters.

\( sn \) = standard permissible value for nth parameter

\( k \) = proportionality constant.

Step: 2 – Calculate the Sub-index (Qn) value using formula

\[ Qn = \frac{[(Vn-Vi) \times (Vs-Vi)]}{100} \]

Where,

\( Vn \) – Observed value

\( Vi \)– Ideal value (Generally \( Vo = 0 \) for most parameters except pH and DO is 7 and 14.6)

\( Vs \) – Standard value

Step: 3 – Combining Step 1 and Step 2, WQI is calculate as follows.

\[ WQI = \sum_{n=1}^{w} q_n w_n \sum_{n=1}^{w} w_n \]  

(1)

**Comprehensive Pollution Index (CPI)**

CPI is a used to access the overall pollution load of water bodies. It is calculated according to the

| SL No | Location               | Sample No | Period                |
|-------|------------------------|-----------|-----------------------|
| 1     | Balarampur             | A1        | Pre monsoon Low tide  |
| 2     | Old post office Ghat   | A2        | Pre monsoon Low tide  |
| 3     | Katan Ghat             | A3        | Pre monsoon Low tide  |
| 4     | Balarampur             | A4        | Pre monsoon High tide |
| 5     | Old post office Ghat   | A5        | Pre monsoon High tide |
| 6     | Katan Ghat             | A6        | Pre monsoon High tide |
| 7     | Nimtala Ghat           | A7        | Monsoon High tide     |
| 8     | Konanagra Ward no 13   | A8        | Monsoon High tide     |
| 9     | Near pumping Station   | A9        | Monsoon High tide     |
| 10    | Nimtala Ghat           | A10       | Monsoon Low tide      |
| 11    | Konanagra Ward no 13   | A11       | Monsoon Low tide      |
| 12    | Near pumping Station   | A12       | Monsoon Low tide      |
| 13    | Nimtala Ghat           | A13       | Post monsoon Low tide |
| 14    | Konanagra Ward no 13   | A14       | Post monsoon Low tide |
| 15    | Near pumping Station   | A15       | Post monsoon Low tide |
| 16    | Nimtala Ghat           | A16       | Post monsoon High tide|
| 17    | Konanagra Ward no 13   | A17       | Post monsoon High tide|
| 18    | Near Pumping Station   | A18       | Post monsoon High tide|
following equation (Barnwal, Mishra, & Singhal, 2015; Mishra, Sharma, & Kumar, 2016):

\[ CPI = \frac{1}{N} \sum_{i=1}^{n} Pli \]  
\[ Pli = \frac{Ci}{Si} \]

where, Pli = pollution index of the \( i^{th} \) parameter,
Ci = measured concentration of the \( i^{th} \) parameter
Si = standard concentration of the \( i^{th} \) parameter

**Eutrophication Index (EI)**

Eutrophication is defined as the process through which the water bodies get enriched in nutrient loads which in turn promotes the growth of algae, aquatic species, and various fauna. The water bodies with very low nutrients are known as oligotrophic and moderate nutrients are known as mesotrophic. The deposition of anthropogenic and industrial wastes can result in eutrophication. It is calculated using the following equation (Barnwal et al., 2015; Mishra et al., 2016):

\[ EI = \frac{COD \times DIP \times D IN}{4500} \times 10^6 \]  

where, COD = chemical oxygen demand,
DIN = dissolved nitrite and nitrate (mg/L)
DIP = dissolved phosphate (mg/L).
EI < 1 = implies no eutrophication;
EI > 1 = implies eutrophication

Further, EL < 1 = oligotrophic;
1 ≤ EI ≤ 3 = mesotrophic; 3 < EI ≤ 9 = eutrophic
EI > 9 = hypereutrophic (Jiang and Christakos, 2018)

**Correlation study**

Correlation analysis among physicochemical parameters is calculated focusing on seasonal influences. Pearson’s correlation coefficient (r) is conducted among the physicochemical parameters, to determine seasonal parameter similarity and influence upon each other. The interrelationship between different water quality parameters is useful in understanding the overall impact of different parameters on each other. The correlation coefficient “r” is calculated using the equation as follows (Roy, 2017).

\[ r = \frac{n \sum(xy) - \sum(x) \sum(y)}{\sqrt{(n \sum x^2 - (\sum x)^2)(n \sum y^2 - (\sum y)^2)}} \]  

where n = number of data

**Results and discussions**

The thrust of the present case study has been on investigating pollutant load on the physicochemical parameters on the water quality of Shilabati River. The results of the physicochemical parameters are summarized in Table 2. The values are then compared with CPCB standards, mentioned in Table 3. The highest recorded values are highlighted in orange color code and lowest in green color code respectively.

pH is defined as the negative logarithm of hydrogen ion concentration. There are many factors that affect the pH of the water such as presence of dissolved gases, salts, bases, acids. In the present study the pH was found to be highest value 7.63 for location A5 and lowest value 6.96 for A1. All the values were under permissible limit according to CPCB. The COD values are found to be in the range of B to E of CPCB, predicting that the water is not suitable for drinking purpose without proper disinfection. The BOD value reveals the water is also unsuitable for drinking, bathing, and aquatic life. It can be only used for irrigation purpose after suitable treatment. However optimum amount of DO is still reported from the river water. The DO value ranges between 6.2 to 7.4 mg/L indicating that the water of the river is useable but after proper treatment. The phosphate values are again very high, but chloride and nitrate values are well within the limit. The major source of phosphate in river water can be attributed to the anthropogenic and municipal wastes. BOD and COD values depend on the oxygen consumption to break down organic and inorganic mater. Hence high BOD and COD values can be attributed to the rise in phosphate limits which in turn increases the eutrophication load of the river due to the increase in algal blooms as a result of nutrient enrichment (Adeola Fashae et.al, 2019; Isiku & Enyoh, 2020). The high phosphate values could be attributed to the direct dumping of municipality and shops wastes into the river water. Hardness is an important property of water that prevents lathering of water with the soap solution and if exceeds the tolerance limit may lead to serious illness. Highest hardness value was reported at A14 (82 mg/l) and lowest value found in A7 (68.5 mg/l). Hardness of water indicates that water of Shilabati river can used after treatment followed by disinfection. The turbidity values are also very high making it unsuitable for drinking, bathing and healthy survival of aquatic life. Turbidity is the condition resulting from suspended solids in the water, including wastes, sewage and planktons. The high turbidity values in the present analysis can be attributed to sediments and sewage loads from the nearby areas (Gupta, et.al, 2017). The analysis shows that the water quality of Shilabati River is not suitable for direct consumption; it needs some pre-treatment and disinfection. The water quality data
Table 2. Summary of the water quality data (year 2019) of the river Shilabati at different sites.

| Parameters                  | A1  | A2  | A3  | A4  | A5  | A6  | A7  | A8  | A9  | A10 | A11 | A12 | A13 | A14 | A15 | A16 | A17 | A18 | CPCB |
|-----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| pH                          | 6.96| 7.2 | 7.43| 7.55| 7.63| 7.43| 7.31| 7.49| 7.61| 7.52| 7.56| 7.58| 7.59| 7.42| 7.46| 7.46| A-E |
| COD (mg/l)                  | 30.0| 25.0| 8.0 | 15.0| 26.0| 16.0| 22.0| 26.0| 23.0| 26.0| 29.0| 26.0| 29.0| 26.0| 29.0| 26.0| B-E |
| BOD (mg/l)                  | 7.5 | 6.4 | <2  | 2.9 | 6.4 | 3.0 | 3.4 | 6.5 | 3.6 | 6.2 | 6.8 | 6.4 | 6.6 | 7.2 | 6.8 | 6.5 | 7.0 | E   |
| DO (mg/l)                   | 6.6 | 6.8 | 7.4 | 7.2 | 7.2 | 7.1 | 6.6 | 6.95| 6.8 | 6.8 | 6.5 | 6.5 | 6.2 | 6.6 | 6.7 | 6.4 | 6.4 | A   |
| Phosphate (PO₄³⁻) (mg/l)    | 9.2 | 8.2 | 7.5 | 7.8 | 8.5 | 7.9 | 8.2 | 8.4 | 8.5 | 7.3 | 8.4 | 8.5 | 7.8 | 8.0 | 8.0 | 7.6 | 8.0 | E   |
| Chloride (Cl) (mg/l)        | 32.28| 27.76| 21.13| 25.44| 23.13| 21.97| 25.28| 24.25| 26.26| 29.29| 30.30| 28.28| 29.29| A   |
| Nitrate NO₃-N (mg/l)        | 6.8 | 6.4 | 6.5 | 5.7 | 6.8 | 6.2 | 7.3 | 6.8 | 7.5 | 7.7 | 6.6 | 7.5 | 7.3 | 7.5 | 7.7 | 7.1 | 7.2 | 7.2 | A   |
| TH                          | 71.05| 72  | 74.25| 76.5 | 74.25| 74.25| 68.5 | 75  | 72  | 71  | 77  | 74  | 79  | 82  | 80  | 72  | 78  | 74  | C-E |
| TA (mg/l)                   | 74  | 74  | 81  | 81  | 77  | 81  | 79  | 78  | 81  | 84  | 82  | 85  | 86  | 84  | 85  | 84  | 79  | 88  | C-E |
| TDS (mg/l)                  | 179.4| 191.7| 203 | 248.5 | 231 | 214.4| 225 | 199 | 235 | 240 | 235 | 244 | 248 | 252 | 252 | 240 | 244 | 244 | A-E |
| Turbidity (NTU)             | 280 | 261 | 188 | 220 | 268 | 215 | 189 | 272 | 192 | 218 | 280 | 261 | 222 | 256 | 225 | 198 | 248 | 205 | E   |

BOD = Bio-chemical Oxygen Demand; COD = Chemical Oxygen demand; DO = Dissolved Oxygen; TH = Total Hardness; TDS = Total Dissolved Solids.
Table 3. Surface water quality standards (CPCB).

| SL No | Parameters | A | B | C | D | E |
|-------|------------|---|---|---|---|---|
| 1     | pH         | 6.85–8.5 | 6.85–8.5 | 6.85–8.5 | 6.85–8.5 | 6.85–8.5 |
| 2     | COD (mg/l) | 4   | 200 | 400 | -  | -  |
| 3     | BOD (mg/l) | 2   | 3   | 3   | -  | -  |
| 4     | DO (mg/l)  | 6   | 5   | 4   | 4  | -  |
| 5     | Phosphate (mg/l) | 6 | -  | -  | -  | -  |
| 6     | Chloride (mg/l) | 250 | -  | 600 | -  | 600 |
| 7     | Nitrate (mg/l) | 20 | -  | 50  | -  | -  |
| 8     | Total Hardness (mg/l) | - | -  | 200 | -  | 500 |
| 9     | Total Alkalinity(mg/l) | - | -  | 300 | -  | 600 |
| 10    | TDS (mg/l) | 500 | -  | -  | 1000 | - |
| 11    | Turbidity (NTU) | 5 | 10 | -  | -  | -  |

A- Drinking water source without conventional treatment but after disinfection;  
B- Outdoor batching  
C- Drinking water Source with conventional treatment followed by disinfection;  
D- Propagation of Wild life  
E- Irrigation, Industrial Cooling, Controlled water Disposer

Table 4. Biological Oxygen demand and Total Coliform count of the river (Year 2017 and 2018).

| Month, Year | BOD mg/l | TC(MPN/100 ml) | Month, Year | BOD mg/l | TC(MPN/100 ml) |
|-------------|----------|----------------|-------------|----------|----------------|
| January, 2017 | 3.45 | 17,000 | January, 2018 | 3.9 | 8000 |
| February, 2017 | 2.8 | 5000 | February, 2018 | 2.4 | 8000 |
| March, 2017 | 3.8 | 3000 | March, 2018 | 2.5 | 3000 |
| April, 2017 | 3.05 | 8000 | April, 2018 | 3.5 | 17,000 |
| May, 2017 | 1.9 | 11,000 | May, 2018 | 1.7 | 1700 |
| June, 2017 | 2.4 | 7000 | June, 2018 | 2.25 | 9400 |
| July, 2017 | 2.85 | 22,000 | July, 2018 | 2.6 | 17,000 |
| August, 2017 | 3 | 5000 | August, 2018 | 2.55 | 4900 |
| September, 2017 | 1.55 | 11,000 | September, 2018 | 0.85 | 11,000 |
| October, 2017 | 1.4 | 11,000 | October, 2018 | 1.45 | 7000 |
| November, 2017 | 3.2 | 7000 | November, 2018 | 1.05 | 14,000 |
| December, 2017 | 3 | 5000 | December, 2018 | 1.6 | 11,000 |

Source: Criteria for prioritization of polluted river location, CPCB

with respect of BOD and Total Coliform (TC) count of this stretch of river is analyzed for the last 2 years (Table 4). The average TC and BOD counts are found to be 2.45 mg/l and 9334MPN/100 ml; which reveal that the river water falls under moderately polluted category of CPCB.

Water Quality Index (WQI) is calculated to get a comprehensive picture of the overall water quality.

Table 5. Unit weights of chemical parameters.

| SL No | Chemical Parameters | Weight (Wn) |
|-------|---------------------|-------------|
| 1     | pH                  | 4           |
| 2     | COD (mg/l)          | 3           |
| 3     | BOD (mg/l)          | 3           |
| 4     | DO (mg/l)           | 3           |
| 5     | Phosphate (mg/l)    | 3           |
| 6     | Chloride (mg/l)     | 3           |
| 7     | Nitrate (mg/l)      | 5           |
| 8     | Hardness (mg/l)     | 2           |
| 9     | Alkalinity (mg/l)   | 3           |
| 10    | TDS (mg/l)          | 4           |
| 11    | Turbidity (mg/l)    | 2           |

Table 6. Water quality index grading.

| Water Level | Quality Index | Status   | Grading |
|-------------|---------------|----------|---------|
| 0–25        | Excellent water quality | A        |
| 26–50       | Good water quality    | B        |
| 51–75       | Poor water quality    | C        |
| 76–100      | Very poor water quality | D       |
| Above 100   | Unsuitable for drinking and fish culture | E       |

The unit weights are assigned to the parameters based on the subjective opinion, the weights reflect the significance of the parameter and its impact on the water quality (Table 5). The WQI is calculated in accordance with the CPCB standards A, B, C, and E, to understand the river water quality from the respect of drinking and domestic usage to overall healthy survival of aquatic life.

The water quality grading is summarized in Table 6 (Brown et al., 1972). With respect to drinking water quality, the river water from all locations falls under category E, that is not suitable for drinking, except location A3 (Katan Ghat) which falls in poor water quality. Based on the B, C, and E standards, the river waterfalls in poor water quality (C). The higher values of WQI are contributed due to very high turbidity and phosphate values. Hence the WQI index reveals that river water is not suitable for drinking and domestic activities without proper treatment and disinfection (Figure 2).

The comprehensive pollution index (CPI) is calculated to understand the overall pollution load in the river. The CPI values reveal that the water quality is severely polluted in most locations except, A2 (Old post office ghat) and A18 (Figure 3). The A18 location which is near Pumping Station falls under the sub clean category. The standard CPI values and their respective category and uses are shown in Table 7.
The high values of CPI can be accounted to high values of turbidity, BOD, COD and phosphate.

The Eutrophication index (EI) also reveals the eutrophic nature of the river which can be accounted for the high phosphate loads (Figure 4). Summarizing the average values of all the physicochemical parameters, WQI, CPI, and EI of all locations reveal that the water is moderately polluted and eutrophic (Table 8).

The correlation matrix shows a positive correlation between COD and BOD with Phosphate. Hence, the high values of COD and BOD can be accounted to the high phosphate values. The positive correlation is also observed between DO and Total Alkalinity (TA) in the pre-monsoon season. However, in monsoon season interesting correlations are found between pH with COD, BOD, turbidity, and BOD with Turbidity. In post-monsoon season strong relation is observed between turbidity with COD and BOD; Total dissolved solid with chloride, nitrate, and total hardness. A significant negative correlation is found between Chlorine and DO in both pre and monsoon seasons (Tables 9–11).

The pollution status of the Shilabati River is getting worse day by day. The main physicochemical parameters which are contributing to the rise in pollution, as revealed from the study, are phosphate and turbidity. Gangani, a tourist place located on the bank of Shilabati River, is accounted to be another reason for the river water pollution. Gangani is a natural canyon almost 70 feet deep formed due to natural erosion of the Shilabati River, due to its scenic beauty; the place has become a very famous tourist spot. The tourist activities results in dumping of wastes into the river and raises pollution. Total municipal (domestic) sewage of the Ghatal area, are also directly dumped in
river water via pipelines connected to every village (Figure 5). The pipelines are found in the Ghatal area, which comes from public toilets, which are directly connected to the Shilabati River. Apart from that, there are also few small scale industries and factories situated at the riverbank such as battery factories, incense stick factories, which also dump their total wastes directly into the river without proper treatment. Also besides the Shilabati River, there are varieties of shops; the waste and unused products of the shops and the ashes from the burning of the incense stick, used flowers are all thrown in the river water (Figure 6).

**Conclusions**

River pollution is an enormous problem in developing countries like India. The main cause attributed could be a lack of proper planning and ignorance of local and common people. The purpose of the study is to identify the present quality of Shibali river water and its implication toward public health. Different physicochemical and biological parameters are considered for the water quality determination of Shilabati River at eighteen

![Figure 4. Eutrophication Index of the studied sites of the river Shilabati.](image)

**Table 8. Summary of WQI, CPI and EI of the Shilabati River.**

| WQI                  | CPI          | EI          |
|---------------------|--------------|-------------|
| Unsuitable for drinking and Fish culture | Seriously Polluted | Eutrophic |

**Table 9. Correlation coefficient matrix of physicochemical parameters of pre-monsoon water samples.**

|         | pH    | COD  | BOD  | DO   | P    | Cl   | Nitrate | TH    | TA   | TDS  | Turbidity |
|---------|-------|------|------|------|------|------|---------|-------|------|------|-----------|
| pH      | 1     | 0.99 | 0.78 | 0.85 | 0.85 | 0.85 | 0.85    | 0.88  | 0.85 | 0.85 | 0.88      |
| COD     | 0.98  | 1    | 0.95 | 0.94 | 0.94 | 0.94 | 0.94    | 0.94  | 0.94 | 0.94 | 0.94      |
| BOD     | 0.97  | 0.95 | 1    | 0.95 | 0.95 | 0.95 | 0.95    | 0.95  | 0.95 | 0.95 | 0.95      |
| DO      | 0.85  | 0.85 | 0.85 | 1    | 0.85 | 0.85 | 0.85    | 0.85  | 0.85 | 0.85 | 0.85      |
| P       | 0.84  | 0.84 | 0.84 | 0.84 | 1    | 0.84 | 0.84    | 0.84  | 0.84 | 0.84 | 0.84      |
| Cl      | 0.83  | 0.83 | 0.83 | 0.83 | 0.83 | 1    | 0.83    | 0.83  | 0.83 | 0.83 | 0.83      |
| Nitrate | 0.83  | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 1       | 0.83  | 0.83 | 0.83 | 0.83      |
| TH      | 0.83  | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83    | 1    | 0.83 | 0.83 | 0.83      |
| TA      | 0.83  | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83    | 0.83  | 1    | 0.83 | 0.83      |
| TDS     | 0.83  | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83    | 0.83  | 0.83 | 1    | 0.83      |
| Turbidity | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83    | 0.83  | 0.83 | 0.83 | 1         |

**Table 10. Correlation coefficient matrix of physicochemical parameters of monsoon water samples.**

|         | pH    | COD  | BOD  | DO   | P    | Cl   | Nitrate | TH    | TA   | TDS  | Turbidity |
|---------|-------|------|------|------|------|------|---------|-------|------|------|-----------|
| pH      | 1     | 0.99 | 0.78 | 0.85 | 0.85 | 0.85 | 0.85    | 0.88  | 0.85 | 0.85 | 0.88      |
| COD     | 0.97  | 0.95 | 1    | 0.95 | 0.95 | 0.95 | 0.95    | 0.95  | 0.95 | 0.95 | 0.95      |
| BOD     | 0.85  | 0.85 | 0.85 | 1    | 0.85 | 0.85 | 0.85    | 0.85  | 0.85 | 0.85 | 0.85      |
| DO      | 0.84  | 0.84 | 0.84 | 0.84 | 1    | 0.84 | 0.84    | 0.84  | 0.84 | 0.84 | 0.84      |
| P       | 0.83  | 0.83 | 0.83 | 0.83 | 0.83 | 1    | 0.83    | 0.83  | 0.83 | 0.83 | 0.83      |
| Cl      | 0.82  | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 1       | 0.82  | 0.82 | 0.82 | 0.82      |
| Nitrate | 0.82  | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82    | 1    | 0.82 | 0.82 | 0.82      |
| TH      | 0.82  | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82    | 0.82  | 1    | 0.82 | 0.82      |
| TA      | 0.82  | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82    | 0.82  | 0.82 | 1    | 0.82      |
| TDS     | 0.82  | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82    | 0.82  | 0.82 | 1    | 0.82      |
| Turbidity | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82    | 0.82  | 0.82 | 1    | 0.82      |

**Correlation is significant at P = 0.01 level *; Correlation is significant at P = 0.05 level (2 tailed)**

BOD = Bio-chemical Oxygen Demand; COD = Chemical Oxygen demand; DO = Dissolved Oxygen; TH = Total Hardness; TDS = Total Dissolved Solids.
Table 11. Correlation coefficient matrix of physicochemical parameters of post monsoon water samples.

|       | pH  | COD  | BOD   | DO  | P  | Cl  | Nitrate | TH  | TA  | TDS | Turbidity |
|-------|-----|------|-------|-----|----|-----|---------|-----|-----|-----|-----------|
| pH    | 1   |      |       |     |    |     |         |     |     |     |           |
| COD   | 0.47* | 1   |       |     |    |     |         |     |     |     |           |
| BOD   | 0.42 | 0.96** | 1   |     |    |     |         |     |     |     |           |
| DO    | −0.32 | −0.92** | −0.83** | 1 |    |     |         |     |     |     |           |
| P     | 0.62** | 0.79** | 0.85** | −0.61** | 1 |     |         |     |     |     |           |
| Cl    | 0.88** | 0.43 | 0.46* | −0.38 | 0.55* | 1 |         |     |     |     |           |
| Nitrate | 0.89** | 0.37 | 0.44 | −0.17 | 0.69** | 0.89** | 1 |     |     |     |           |
| TH    | 0.89** | 0.77** | 0.73** | −0.57* | 0.84** | 0.71** | 0.77** | 1 |     |     |           |
| TA    | 0.20 | −0.36 | −0.46 | 0.11 | −0.38 | 0.44 | 0.13 | −0.19 | 1 |     |           |
| TDS   | 0.97** | 0.59** | 0.59** | −0.44 | 0.74** | 0.92** | 0.93** | 0.92** | 0.15 | 1 |           |
| Turbidity | 0.51 | 0.94** | 0.93* | −0.74** | 0.85** | 0.34 | 0.43 | 0.84* | −0.58* | 0.60** | 1 |

**Correlation is significant at P = 0.01 level; *Correlation is significant at P = 0.05 level (2 tailed)

BOD = Bio-chemical Oxygen Demand; COD = Chemical Oxygen demand; DO = Dissolved Oxygen; TH = Total Hardness; TDS = Total Dissolved Solids.

Figure 5. Direct discharge of municipal wastes into the river.

Figure 6. Local shops surrounding the river dumps the daily wastes into the river.
locations. Eleven water quality parameters were considered to assess the quality of river water. For further assessment of the water quality, Water Quality Index (WQI); Comprehensive Pollution index (CPI); Eutrophication Index (EI) is calculated in the study. The summary of the physicochemical characteristics of river water shows that the water quality is not suitable for human consumption and highly polluted and eutrophic in nature due to huge anthropogenic waste discharge. As far as public health is much concerned, there are several indicators of the adverse effect of inorganic pollutants, municipal solid wastes, and industrial waste on the river water observed in a major part of the Ghatal municipal area. During monsoon season Shilabati River face natural hazard like flood and which is also a serious problem.

The principal cause of the deterioration of the river water can be accounted to discharge of untreated industrial and municipal wastewater and pollution from nonpoint sources. The following recommendations can be made to prevent further deterioration of the river water quality:

- The direct drainage and discharge system of public toilets into the river must be stopped.
- The municipal waste must be treated before discharging into the river.
- The dead bodies of cattle must not be thrown into the river.
- There are many small-scale factories surrounding the river, whose waste must be treated before discharging in the river.
- For flood control, the sedimentation load due to erosion should be stopped by plantation surrounding the riverbank, which will in turn increase the depth of the river water and loading capacity can be increased.
- The floodwater reservoir can be made at the lower valley of the river for using the reserved water for agricultural practices.

Every natural body has a limited capacity for self-restoration, when the amount of pollutant loads is more than the capacity of the river to degrade the wastes, pollution results. The same is found in the case of the Shilabati River. Being a major river of the area, the focus should be given to prevent further decline of the river water quality. From the study, it can be said that the water quality of the Shilabati River is very poor it needed proper treatment before use. Besides ensuring government measures to combat pollution; local people of the Ghatal area and Daspur block have to be active and concerned about the pollution crisis.

Acknowledgments
The authors are thankful to the anonymous reviewers for their valuable suggestions in improving the article.

Disclosure of potential conflicts of interest
No potential conflict of interest was reported by the author(s).

References
Abbasi, S. A. (2002). Water quality indices, state of the art report, National Institute of Hydrology, scientific contribution no. INCOH/SAR-25/2002, Roorkee: INCOH, pp: 73. Adeola Fashae, O., Abiola Ayorinde, H., Oludapo Olusola, A. et al. (2019), Landuse and surface water quality in an emerging urban city. Applied Water Science, 9(2), 25
APHA (American Public Health Association). (2017). Standard methods for the examination of water and wastewater (23rd ed.). Washington, DC: American Public Health Association.
Barmwal, P., Mishra, S., & Singhal, S. K. (2015). Risk assessment and analysis of water quality in Ramgarh Lake, India. Journal of Integrated Science and Technology, 3 (1), 22–27.
Bhor, M., Kadave, P., Bhor, A., Bhor, S., Bhosale, M., & Bholay, A. D. (2013). Water quality assessment of the River Godavari, at Ramkund, Nashik, (Maharashtra), India. Research Invetory: International Journal of Engineering and Science, 2(2), 64–68.
Brown, R. M., McCleland, N. J., Deininger, R. A., & O’Connor, M. F. (1972). A water quality index- crossing the psychological barrier, Jenkis, S.H.[Ed]. Proc Int Conf On Water Pollution Res, Jerusalem, 6, 787–797.
Gupta, N., Pandey, P., & Hussain, J. (2017). Effect of physicochemical and biological parameters on the quality of river water of Narmada, Madhya Pradesh, India. Water Science, 31(1), 11–23.
Isuuku, G. O., & Enyoh, C. E. (2020). Pollution and health risks assessment of nitrate and phosphate concentrations in water bodies in South Eastern, Nigeria. Environmental Advances, 2, 100018.
Jiang, Q., He, J., Wu, J., Hu, X., Ye, G., & Christakos, G. (2018). Assessing the severe eutrophication status and spatial trend in the coastal waters of Zhejiang Province (China). Limnol. Oceanogr, 9999, 1–15.
Jindal, R., & Sharma, C. (2010). Studies on water quality of Surlej River around Ludhiana with reference to physico-chemical parameters. Environmental Monitoring and Assessment, 174(1–4), 417–425.
Kamal, M. M., Malmgren-Hansen, A., & Badruzzaman, A. B. (1999). Assessment of pollution of the River Buriganga, Bangladesh, using a water quality model. Water Science and Technology, 40(2), 129–136.
Mishra, S., Sharma, M. P., & Kumar, A. (2016). Assessment of surface water quality in surth lake using pollution index India. Journal of Material and Environmental Science, 7, 713–719.
Muniyan, M., & Ambedkar, G. (2011). Seasonal variations in physicochemical parameters of water collected from Kedilam River, at Visoor Cuddalore District, Tamil Nadu, India. International Journal of Environmental Biology, 1(2), 15–18.
Pramanik, A. K., Majumdar, D., & Chatterjee, A. (2020). Factors affecting lean, wet season water quality of Tilaiya reservoir in Koderma district, India during 2013-2017. Water Science, 34(1), 85–97.
Ramakrishnaiah, C. R., Sadashivaiah, C., & Ranganna, G. (2009). Assessment of water quality Index for the
groundwater in Tumkur Taluk, Karnataka State, India. *Electron. J. Chem.*, 6(2), 523–530.

Rao, K. N., & Vaidyanadhan, R. (1979). Evolution of coastal land forms in the Krishna delta, front, India. *Transaction. Indian Institute of Geographers*, 1, 25–32.

Roy, M. (2017). Hydrochemical analysis and evaluation on municipal supplied water and groundwater quality for drinking purpose in Asansol, W.B., India. *Asian Journal of Biochemical and Pharmaceutical Research*, 7(4), 47–57.

Roy, M. (2019). Arsenic contamination of groundwater in West Bengal: A Human Health Threat. *Journal of Multidisciplinary Research*, 1(1), 38–46.

Roy, M., & Shamim, F. (2020a). Assessment of anthropogenically induced pollution in the surface water of River Ganga: A study in the Dhakhineswar Ghat, W.B., India. *Journal of Water Pollution & Purification Research*, 7(1), 15–19.

Roy, M., & Shamim, F. (2020b). Research on the impact of industrial pollution on River Ganga: A Review. *International Journal of Prevention and Control of Industrial Pollution*, 6(1), 43–51.

Sadia, A., Feroza, H. W., Imran, Q., Muhammad Hamid, S. W., Tirmizi, S. A., & Muhammad, A. Q. (2013). Monitoring of anthropogenic influences on underground and surface water quality of Indus River at district Mianwali-Pakistan. *Turkish Journal of Biochemistry*, 38(1), 25–30.

Santosh, M., & Avvannavar, S. S. (2008). Evaluation of water quality index for drinking purposes for river Netravathi, Mangalore, South India. *Environmental Monitoring and Assessment*, 143(1–3), 279–290.

Shah, A. K., & Geeta, J. S. (2017). Evaluation of water quality index for River Sabarmati, Gujarat, India. *Applied Water Science*, 7(3), 1349–1358.

Suthar, S., Sharma, J., Chabukdhara, M., & Nema, A. K. (2010). Water quality assessment of river Hindon at Ghaziabad, India: Impact of industrial and urban waste water. *Environmental Monitoring and Assessment*, 165(1), 103–112.