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Assessment of Water Quality Scenario of Karnaphuli River in Terms of Water Quality Index, South-Eastern Bangladesh

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Abstract River plays an important role to agribusiness, industry, and the necessities of people and natural life. A great many individuals rely upon the river water for irrigation and fish cultivation. Karnaphuli River is the largest and major watercourse of the Chattogram region, Bangladesh. But day by day the river is losing its quality due to several anthropogenic reasons. Several studies have been done considering water quality and sediment quality of Karnaphuli River. But no research conducted specially on the basis of WQI. The main objective of this study is to assess the water quality of Karnaphuli River from Kalurghat to Patenga in terms of water quality index (WQI). For the determination of WQI, the weighted arithmetic method is used in this study. The water quality of River Karnaphuli was monitored for a period of 8 Months (January - August, 2018). After the completion of collection process, the water samples were assessed by analyzing the various physico-chemical parameters, such as pH, EC, total dissolved solids (TDS), total hardness, total alkalinity, dissolved oxygen, biological oxygen demand (BOD), chemical oxygen demand (COD), chloride, nitrate and phosphate. The WQI reveals that the water quality of Karnaphuli river water from Sha- Amanat Bridge to Karnaphuli Halda estuary can be used for irrigation and fish cultivation purpose and from Sandwip channel to Chaktai Khal confluence point proper treatment required before use.

Keywords: *karnaphuli river, physico-chemical parameters, water quality index, weighted arithmetic method*

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1. Introduction

River plays an awfully necessary half within the water cycle, acting as drain channels for surface water. For individuals, they have invariably been very important, and to use water resources, cities and industrial furthermore as agricultural centers are established adjacent to them. In with the progress of time, development of communities, and multiplied use of water resources, pressures upon dominant water resources and detection of abnormal changes in water quality conditions have multiplied [1]. Now a days, for Population growth, environmental pollution from discharge of urban and industrial waste material, and runoff have accumulated pollution and restricted accessible water resources [2,3]. Monitoring and dominant surface waters are necessary and important to assure the supply of high-quality water for its several uses [4]. One of elementary strategies which will relate the qualitative conditions of water is that the use of water quality indexes [5,6,7]. The water quality index WQI is a numerical tool used to incorporate large amounts of water characterization data into a specific number representing the rate of water quality [3,8]. WQI use is a straightforward technique that allows ample water quality classification. WQI determination involves a standardization step in which each parameter is converted into a scale of 0–100 at which 100 is the maximum quality [9].The next stage is to pertain a weighting factor as an indicator of water quality in compliance with the significance of the parameter.

Karnaphuli River is the largest and most influential river in chittagong and the chittagong hill tracs from the Lushai hills of Mizoram State of India [10,11]. It is the swiftest river among the other river of Bangladesh. Principal tributaries include the Kawrpui River or Thega River, Tuichawng River and Phairuang River. But the river is garlanding the city of Chittagong because it acts as garbage for industrial, domestic, commercial and agricultural purposes. The area of Karnaphuli between Kalurghat and Patenga is the most polluted due to the presence of many chemical, fertilizers, iron and steel, leather, paint, garments, food, cosmetics, toiletries and pharmaceutical industries on its banks or in its hinterland

[11]. To solve this problem, we need to have reliable information on the present situation and study the degree of current Karnaphuli river pollution. Several studies have been done considering water quality [12,13,14] and sediment quality [15,16] of Karnaphuli River. But no research conducted specially on the basis of WQI. The main objective of this study is to assess the water quality of Karnaphuli River from Kalurghat to Patenga in terms of water quality index (WQI). For the determination of WQI, the weighted arithmetic method is used in this study.

2. Materials and Methods

To obtain the required information to investigate the water quality of the Karnaphuli River, water was sampled twice a month in five stations (Figure 1). To ensure the best results, it is important to properly collect the samples. In this study the water samples were collected manually from around 0.5 meter depth of water surface. Stations were selected based on accessibility and pollution sources along the Karnaphuli River and one of its tributary.

The field work was conducted during the period Jan 2018 to August 2018. The samples were collected by 1-liter capacity plastic bottle. Bottles were filled with water samples at every site in during Tide and Ebb. After collection of samples these bottles were labeled and possible efforts were made to transport them to the laboratory as earlier as possible. DO, BOD, COD determination started within 6 hours in the departmental laboratory of Southern University Bangladesh (SUB). The concentration of Phosphate and Nitrate was tested in the laboratory of Department of Public Health Engineering (DPHE).

Figure 1. Location of sampling point in Karnaphuli River

All the tests were done using the method described in Table 1.

Table 1. Methods of analysis of different parameters

Parameters	Method of analysis
Temperature	Thermometry
pH	pH Meter
Dissolved Oxygen (DO)	Potentiometry
Oxygen demand (Biochemical) BOD	Complexometric titration
TDS	Potentiometry
Alkalinity	Complexometric titration
EC	Potentiometry
Hardness	Complexometric titration
Chloride	Complexometric titration
COD	Complexometric titration
Phosphate	UVS
Nitrate	UVS

After getting the result of all selected water quality parameters, the water quality index (WQI), is calculated by using Weighted Arithmetic water quality index method. One of the main advantages of this method is particular use of water simplifies with less comparison as a smaller number of parameters required.

The water quality index, $WQI = \frac{\sum Q_i W_i}{\sum W_i}$.

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$Q_i = \left[\frac{(V_a - V_i)}{(V_s - V_i)}\right] \times 100$$

Where V_a = actual value of the water quality parameter obtained from laboratory analysis.
V_i = ideal value of the water quality parameter can be obtained from the standard tables.
(ideal for pH = 7 and for DO ideal =14.6mg/l and other parameters it is equal to zero)
V_s = recommended standard value of i^{th} parameter [17].

The unit weight for each water quality parameter is calculated by a value inversely proportional to recommended standard (Vs) for the corresponding parameter using the following expression.

$$W_i = \frac{K}{V_s}$$

Where, Wi is Unit weight of factor
K is proportionality constant.

Values of K were calculated as; $K = \frac{1}{\sum\left(\frac{1}{V_s}\right)}$.

The rating of water quality according to above calculated WQI is as follows:

Table 2. WQI range, status and possible usage of the water sample [18,19]

WQI	Water quality status (WQS)	Possible usage
0–25	Excellent	Drinking, irrigation and industrial
26–50	Good	Drinking, irrigation and industrial
51–75	Poor	Irrigation and industrial
76–100	Very Poor	Irrigation
>100	Unsuitable for drinking and fish culture	Proper treatment required before use

3. Result & Discussion

3.1. Water Quality Parameters

The mean value plus standard deviation of physicochemical parameters (during tide and ebb) of the water column such as dissolved oxygen (DO), pH, temperature etc. are presented in Table 3 and Table 4.

The physicochemical parameters are very important because they have a significant effect on the water quality. Further -more, aquatic life also suffers due to degradation of water quality. Among the all variables temperature is one of the most significant elements which influence the aquatic ecology [20]. The values of temperature were ranged from 22.1°C to 30.1°C and 22.2°C to 30.6°C during Tide and Ebb, respectively (Table 3 & Table 4). The mean value of water temperature was found within the permissible limits set by (WHO, 2004), which was between 25 and 30°C. pH is the indicator of acidic or alkaline condition of water status. The standard for any purpose in-terms of pH is 6.5- 8.5; in that respect the value of Karnaphuli River water lies in between 5.3 to 7.9 during the study period. The concentration of EC, TDS and Chloride was gradually decreased from S1 to S5 (S1>S2>S3>S4>S5) (Table 3 & Table 4). The concentration of chloride was found beyond the ECR' 1997 standards adjacent to the sea (S1, S2, and S3) and within the limit far from Bay of Bengal (S4 & S5).

Table 3. Mean + Standard deviation of physicochemical parameters during Tide

Station	Temp. (°C)	pH	EC (µS/cm)	DO (mg/L)	BOD (mg/L)	Chloride (mg/L)	TDS (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)	COD (mg/l)	Phosphate (mg/l)	Nitrate (mg/L)
S1	27.88 ± 2.87	7.22 ± 0.43	9140 ± 9253	3.74 ± 1.45	12.9 ± 9.48	4667 ± 4534	6292.6 ± 5933	60.92 ± 26.52	467.4 ± 89.52	16.36 ± 3.42	0.178 ± 0.02	0.675 ± 0.08
S2	27.94 ± 3.32	6.78 ± 0.54	3963 ± 5226	3.3 ± 1.31	12.2 ± 7.64	2006 ± 2862	2651 ± 3505	51.82 ± 31.75	248.4 ± 183.5	16.69 ± 2.34	0.145 ± 0.03	0.668 ± 0.18
S3	27.88 ± 3.17	6.6 ± 0.51	1206 ± 1102	3.36 ± 1.07	3.64 ± 1.5	800 ± 598	1204 ± 884	49.16 ± 25.7	190 ± 187	12.92 ± 3.4	0.225 ± 0.12	1.07 ± 0.72
S4	28.3 ± 3.4	6.48 ± 0.76	451 ± 498	2.98 ± 0.83	3.36 ± 0.54	127± 182	307 ± 335	44.54 ± 27	70 ± 34.5	9.74 ± 2.61	0.46 ± 0.04	1.29 ± 0.21
S5	28.16 ± 3.12	6.56 ± 0.61	213 ± 187.6	3.42 ± 1.07	3.14 ± 1.21	71.8 ± 68.6	143.6 ± 125	49.02 ± 33	67 ± 21.6	10.05 ± 3.13	0.528 ± 0.13	1.193 ± 0.04

Table 4. Mean + Standard deviation of physicochemical parameters during Ebb

Station	Temp. (°C)	pH	EC (µS/cm)	DO (mg/L)	BOD (mg/L)	Chloride (mg/L)	TDS (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)	COD (mg/l)	Phosphate (mg/l)	Nitrate (mg/L)
S1	27.9 ± 3.2	7.04 ± 0.4	6704 ± 4821	3.96 ± 1.40	5.44 ± 1.21	3255 ± 1785	4617 ± 3454	59.66 ± 29.7	421 ± 62	15.15 ± 1.98	0.125 ± 0.04	0.53 ± 0.05
S2	27.9 ± 3.26	6.58 ± 0.49	1564 ± 550	3 ± 0.68	4.1 ± 0.57	1606 ± 2255	1206 ± 398	55.68 ± 29.27	238 ± 207	12.68 ± 2.01	0.14 ± 0.03	0.85 ± 0.35
S3	28.1 ± 3.41	6.52 ± 0.54	1216 ± 1157	3.02 ± 1	3.24 ± 0.65	615 ± 689	802 ± 748	45.02 ± 25.75	121 ± 114	10.92 ± 1.98	0.235 ± 0.04	2.12 ± 1.22
S4	28.26 ± 3.4	6.52 ± 0.65	488 ± 751	3.54 ± 1.09	3.02 ± 1.4	187 ± 338	328 ± 504	39.88 ± 20.85	62 ± 38.62	10.72 ± 2.46	0.55 ± 0.06	1.3 ± 0.29
S5	28.02 ± 3.06	6.66 ± 0.55	310.2 ± 397	3.48 ± 0.89	2.4 ± 1.33	115 ± 166	206 ± 265	42.1 ± 23.07	57.5 ± 37.9	8.92 ± 3.28	0.65 ± 0.23	1.95 ± 0.70

The dissolved oxygen value in water is dependent on temperature, salinity, barometric pressure, and solids. Moreover, climatic conditions and chemical, biological, and microbial processes are effective in determining oxygen variation in water [21]. The dissolved oxygen (DO) was found 2.2 – 5.4 mg/L during Tide and 1.9–6.4 mg/L in winter. Except DO, the concentration of all parameters was found higher during Tide. The mean value of DO was found below the acceptable limit in all locations. During Tide the highest COD value was found 19.2 mg/l in S2 location in the month of April and lowest value found 7.2 mg/l in S4 location in the month of August. The corresponding highest and lowest value of COD during ebb was found 18 mg/l and 4.5 mg/l in S1 and S5 locations respectively in the month of April. Joseph et al. (1993) [22] reported that a suitable range of alkalinity is 20-300 mg/L for fish. In the present study the highest alkalinity range was (42.1 ± 23.07–60.92 ± 26.52mg/L), it indicates that the level of alkaline is a suitable condition. The concentration of phosphate and nitrate was found within the allowable range in all locations but the relatively higher concentration was found in between locations S4 and S5, it might be because the Kalurghat Industrial area is located around the locations.

3.2. Water Quality Index

The values of Weighted Arithmetic WQI are presented in Table 5, which shows that the water quality during study period was observed to vary between Unsuitable for drinking and fish culture and very poor. The mean of this index for Tide and Ebb is presented in Figure 2. It is observed that during Tide the calculated WQI value was higher than the Ebb. From upstream to downstream the value of WQI is being increased.

Table 5. Mean WQI during Tide and Ebb

Time	S1	S2	S3	S4	S5
During Tide	170.83	164.78	113.93	93.15	94.58
During Ebb	140.72	114.17	100.00	93.93	86.54

All the selected locations are classified according to the rating of WQI and also described the status of specific location during Tide and Ebb in Table 6 and Table 7.

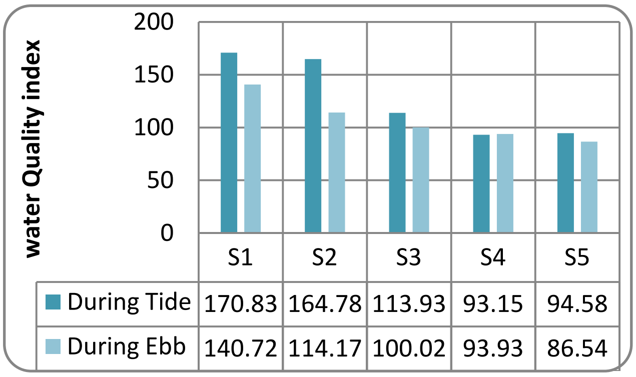

Figure 2. Graphical Representation of WQI During Tide and Ebb

From that observation, the river water from Sha Amanat bridge to Karnaphuli Halda estuary can be used for irrigation and fish cultivation purpose but the river water from Sandwip channel to Chaktai Khal mouth Proper treatment required before use.

Table 6. Status of water quality at different locations and their possible usages during Tide

Sample Locations	WQI value	Water quality status (WQS)	Possible usage
S1 (Near Sandwip Channel)	170.83	Unsuitable for drinking and fish culture	Proper treatment required before use
S2 (Chittagong port container terminal)	164.78	Unsuitable for drinking and fish culture	Proper treatment required before use
S3 (Near Shah Amanat bridge / Chaktai khal confluence point)	113.93	Unsuitable for drinking and fish culture	Proper treatment required before use
S4 (Near Kalurghat BSCIC Area)	93.93	Very Poor	Irrigation
S5 (Karnaphuli Halda Estuary)	86.54	Very Poor	Irrigation

Table 7. Status of water quality at different locations and their possible usages during Ebb

Sample Locations	WQI value	Water quality status (WQS)	Possible usage
S1 (Near Sandwip Channel)	140.72	Unsuitable for drinking and fish culture	Proper treatment required before use
S2 (Chittagong port container terminal)	114.17	Unsuitable for drinking and fish culture	Proper treatment required before use
S3 (Near Shah Amanat bridge / Chaktai khal confluence point)	100.00	Very Poor	Irrigation
S4 (Near Kalurghat BSCIC Area)	93.15	Very Poor	Irrigation
S5 (Karnaphuli Halda Estuary)	94.58	Very Poor	Irrigation

4. Conclusions

i. The results of this study show that according to water quality index standards, the quality of the Karnaphuli River observed to vary between Unsuitable for drinking and fish culture and very poor. However, pollution did increase from upstream to downstream.
ii. By conducting analyses and investigating the results, it can be concluded that with wastewater from industrial activities, port, construction activities, and waste and oil disposal from stagnant ship, the Karnaphuli River's water quality has declined.
iii. It is recommended that stringent pollution control activity shall be undertaken immediately to improve the WQI.

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