Proceedings of the 6th International Conference on Civil Engineering for Sustainable Development (ICCESD 2022), 10~12 February 2022, KUET, Khulna, Bangladesh (ISBN-978-984-35-1972-6)

SURFACE WATER QUALITY ASSESSMENT IN TERMS OF WATER QUALITY INDEX: A CASE STUDY OF PANGUNCHI RIVER, BAGERHAT

Sajid Shahriar*[1], S. M. Moniruzzaman[2]

[1] *Undergraduate Student, Department of Civil Engineering, Khulna University of Engineering and Technology, Bangladesh, e-mail: shahriar394@gmail.com*
[2] *Professor, Department of Civil Engineering, Khulna University of Engineering and Technology, Bangladesh, e-mail: moniruzzaman@ce.kuet.ac.bd*

***Corresponding Author**

ABSTRACT

Pangunchi river's water is used for different purposes such as bathing, irrigation, domestic, fisheries etc. Many small industries and poultry farms are going to be built. So, there remains a necessity to assess the quality of river water and its suitability of using for different purposes. It is to be noted that, water quality of this river has not been studied yet. In this research, assessment of the water quality has been carried out by collecting water samples from four sampling sites on November 5, 2021 and analyzed at the laboratory. Fifteen most important water quality parameters namely, pH, Dissolved oxygen (DO), Biochemical oxygen demand (BOD), Electrical conductivity (EC), Temperature, Turbidity, Chloride, Hardness, Total dissolved solids (TDS), Total suspended solids (TSS), Total solids (TS), Fecal coliform (FC), Sulphate, Phosphate, Nitrate were analyzed at the laboratory. Parameter values were compared with standard value (WHO and ECR'97 standard for drinking water). DO, BOD, EC, Turbidity, Fecal coliform, Alkalinity values crossed standard limits for some sampling stations. Finally, two water quality indices, namely: Weighted Arithmetic Index and National Sanitation Foundation Water Quality Index (NSF-WQI) were calculated for different sampling sites. Weighted Arithmetic Index value ranged from 59.5 to 62.95 and NSF-WQI value ranged from 53.43 to 55.87. Weighted Arithmetic Index value indicated "poor" water quality at every sampling stations. NSF-WQI indicated "medium" water quality at every sampling stations. Water can be used for irrigational and industrial purposes without any treatment.

Keywords: *Water quality index, Assessment, Pangunchi river, Post monsoon.*

1. INTRODUCTION

Water has great environmental significance. Rivers are vital and vulnerable freshwater ecosystems that are critical for the sustenance of all life (Zeb et al., 2011). Discharge from domestic sewers, storm water, industrial wastewaters, agricultural runoff to river can have short and long-term significant effects on the river water quality (Singh, 2007). Physical, chemical and biological interactions are responsible for certain water quality characteristic of a water body. A regular monitoring of water bodies with required number of parameters in relation to water quality prevents the outbreak of diseases and occurrence of hazard (Zeb et al., 2011). Rivers are most accessible to population and they are also most studied (Tereza et al., 2014). It is imparative to control river water pollution and obtain relaiable information on river water quality for effective management (Singh, 2007).

Pangunchi river passes through Morrelgonj upazilla, contributing much to the water demand of people living here (Bangladesh National Portal, 2021). This river starts it's journey from the estuary of Mongla and Dharatana river, passes Ghashiakhali, Baharbunia union, Morrelgonj union and ends her journey by joining with Baleshwar river near Sarankhola upazilla. Pangunchi is 25.6 km in length. Several canals branch out from this river and meet water demand to adjacent people and irrigable lands. River water is used for different purposes like bathing, washing etc. For irrigation, fisheries, poultry farms, feedstock in the adjacent area, river water is a must.

There is no institution responsible for management of solid wastes in rural areas of Bangladesh (Ahmed & Rahman, 2000). Solid waste management senerio in Morrelgonj upazilla exactly agree with that statement. Wastes are thrown away in low-lying areas, dumped directly in the river or in the canals which branch out from the river and possibly degrade river water quality. Many small and medium industries are being built at Morrelgonj and Saronkhola upazilla. So there remains a necessity to assess water quality of this river whether it's water is suitable for using different purposes like irrigation, industries, recreational activities etc. and whether widespread using of this river's water is deteriorating it's quality or not.

Water is essential component of all production system. Considering it's importance, Department of Environment (DoE) of Bangladesh has been monitoring surface water quality since 1973 (Department of Environment, 2014). Monitoring water quality of rivers and lakes provide empirical evidence, which helps in decision making on health and environmental issues (Myers, 2018). Water quality status of Pangunchi river has remained unstudied yet. Determining water quality status of this river will help the policy makers to take decision on health and environmental issues in future.

Thus, the overall objective of this present study is to assess overall water quality status of Pangunchi river with the help of two water quality indices, namely: Weighted Arithmetic Water Quality Index and National Sanitation Foundation Water Quality Index (NSF-WQI).

Water quality index (WQI) summarizes large amount of water quality data into a single term, which is easily understandable to general people (Sharma et al., 2014). By knowing water quality index, it's easy to know the suitability of using river water for different purposes (Brown et al., 1972). Water quality index provides an extensive interpretation on the water quality and suitability of using water for different purposes like drinking, fisheries, industrial uses, irrigation etc. (Abbasi, 2012). Water quality index method has been applied for assessing water quality for both surface and ground water by many researchers in the last few decades (Sharma & Kansal, 2011).

2. METHODOLOGY

2.1 Sample collection

Samples were collected from four different stations on post monsoon season (November, 2021). Weather was clear during sampling. Sampling stations were selected randomly. Details of these stations are shown at Table 1. Methods of water quality sampling and parameters which were analysed are presented in Table 2. From each station, water sample was collected with 1000 ml of plastic bottle. The pre-washed bottles were rinsed for three times with water samples on-site before collecting sample. After collecting, samples were stored in the cooler box. Collected samples were carried at the Environmental Engineering Laboratory, KUET in the next day and different parameters were analysed.

Table 1: Details of Sampling Stations

Sampling Location	North Latitude	East Longitude	Sampling Point Name
S1	22°29'19"	89°47'44"	Fulhata Mallick Bari
S2	22°27'15"	89°51'33"	Morrelgonj Central Mosque
S3	22°24'56"	89°51'51"	South Gabtala
S4	22°23'50"	89°52'17"	Sannyasi Launch Ghat

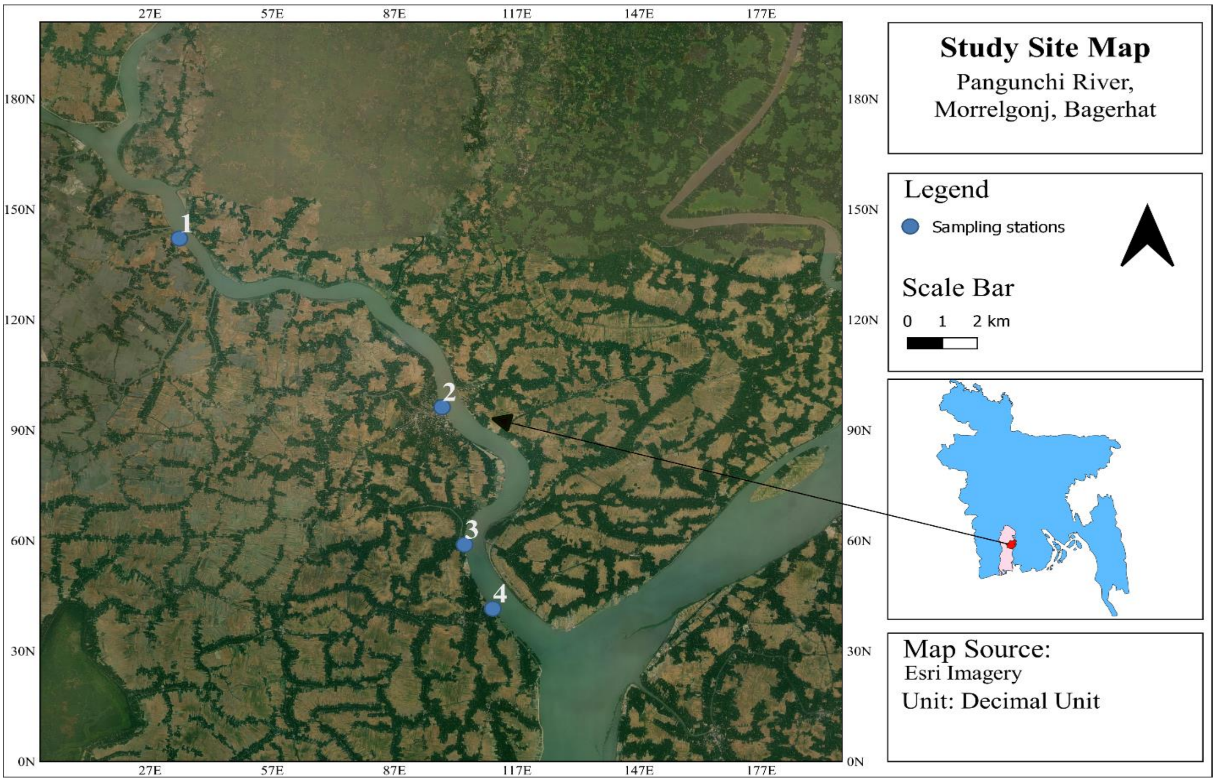
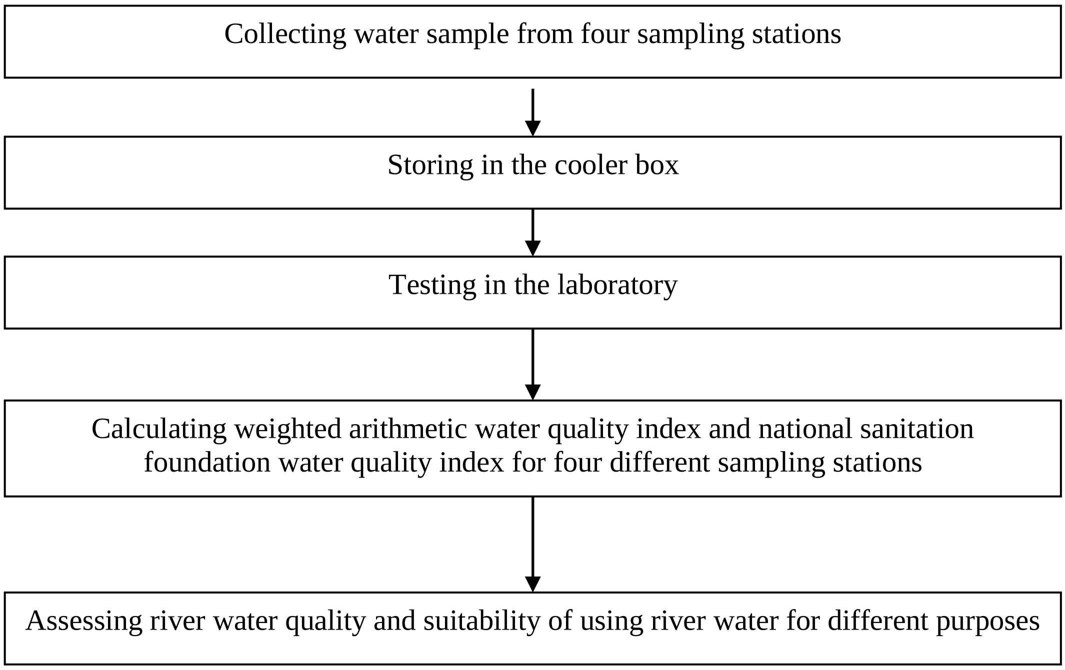


Figure 1: Sampling location at Pangunchi river

Table 2: Water quality parameters and measurement methods

No	Parameter	Unit	Method of analysis	Measurement Site
1	pH	-	pH meter/Potentiometric	On-site
2	DO	mg/l	DO meter	Laboratory
3	BOD	mg/l	Winkler and incubation	Laboratory
4	EC	µS/cm	Conductivity meter	On-site
5	Turbidity	NTU	Turbidimeter	Laboratory
6	Total Coliform	cfu/100ml	Membrane filter technique	Laboratory
7	Temperature	°C	TDS/Temperature meter	On-site
8	Chloride	mg/l	Titration	Laboratory
9	Nitrate	mg/l	Spectrophotometer/NitriVer 3 Nitrite reagent	Laboratory
10	Sulfate	mg/l	Spectrophotometer/Sulfaver 4 sulfate reagent	Laboratory
11	Phosphate	mg/l	Spectrophotometer/PhosVer 3 Phosphate reagent	Laboratory
12	Alkalinity	mg/l	Titration	Laboratory
13	Hardness	mg/l (as CaCO3)	Titration	Laboratory
14	TDS	mg/l	Gravimetric	Laboratory
15	TS	mg/l	Gravimetric	Laboratory

2.2 Methodological approach



2.3 Weighted Arithmetic Water Quality Index

Weighted arithmetic index method involves calculation of water quality index by multiplying water parameter's concentration value with 'unit weight factor', assigned for each parameter. Unit weight is calculated by taking account standard value assigned for each water quality parameters. Purpose of determining 'unit weight' is that, it transforms each water quality parameters into a common scale. A parameter will have more significance in water quality index, which has higher 'unit weight' value. In this calculation, pH, DO and BOD has higher unit weight (0.215, 0.365, 0.365 respectively) contributing much in overall water quality index value. As a result, a little variation of DO, BOD, pH from standard value, results a large variation on water quality index value. Total ten parameters are selected for determining weighted arithmetic water quality index. They are: pH, DO, BOD, EC, TDS, TSS, Total hardness, Chloride, Sulphate, Alkalinity (Bora & Goswami, 2017). By calculating water quality index, water quality status and its possible uses can be suggested.

Table 3: Unit Weightage (Wi) of the parameters used for determining water quality index

Parameter	Unit	ECR'97 Standard	WHO standard	Unit Weight (Wi)
pH	-	6.5-8.5	6.5-8.5	0.215
DO	mg/l	6	5	0.366
BOD	mg/l	0.2	5	0.366
EC	µS/cm	-	400	0.005
TDS	mg/l	1000	500-1000	0.004
TSS	mg/l	-	500	0.004
Hardness (as CaCO3)	mg/l	200-500	500	0.006
Chloride	mg/l	150-600	250	0.007
Sulphate	mg/l	400	250	0.012
Alkalinity	mg/l	-	120	0.015

Calculation of water quality index was calculated by using the following equation:

$$WQI = \frac{\Sigma WiQi}{\Sigma Wi} \quad (1)$$

$$Qi = 100\left[\frac{(Vi - Vo)}{(Si - Vo)}\right] \tag{2}$$

Where
W_i = Unit weight of i^{th} parameter.
Q_i = Sub-index value of i^{th} parameter.
V_i = Concentration of i^{th} parameter.
V_o = Ideal value of i^{th} parameter (V_o=7 for p^H and 14.6 mg/l for DO. For other parameters, V_o= 0).
S_i = Standard value for i^{th} parameter.

Unit weight can be calculated by the following formula:

$$Wi = \frac{K}{Si} \tag{3}$$

$$K = \frac{1}{\Sigma \frac{1}{Si}} \tag{4}$$

Table 4: Water quality status and possible uses with respect to water quality index range (After: Brown et al., 1972)

WQI	Water quality status	Possible usage
0-25	Excellent	Drinking, irrigation and industrial usage
26-50	Good	Drinking, irrigation and industrial usage
51-75	Poor	Irrigation and industrial usage
76-100	Very poor	Irrigation
Over 100	Unsuitable for drinking and fish culture	Proper treatment is necessary before any usage

2.4 National Sanitation Foundation Water Quality Index (NSF-WQI)

NSF-WQI was developed by considering 9 most important water quality parameters such as: pH, Dissolved oxygen (DO), Biochemical oxygen demand (BOD), Total solids (TS), Faecal coliform (FC), Temperature, Turbidity, Nitrate, Total phosphate. Unit weight factor was assigned for each parameter. Furthermore, unit weight of i^{th} parameter (Wi) was multiplied with sub-index value (Qi) of i^{th} parameter. There is total 9 rating curves for determining Qi value with respect to corresponding concentration of i^{th} parameter (Brown et al., 1970). In this paper, sub-index value was obtained by NSF-WQI calculator online (http://www.water-research.net/watrqualindex/index.htm). After getting Qi value, unit weight value (Wi) was multiplied with Qi and summed together with the following equation:

$$NSF - WQI = \Sigma WiQi \tag{5}$$

Where
W_i = Unit weight of i^{th} parameter
Q_i = Sub-index value of i^{th} parameter

Table 5: NSF-WQI Classification (After: Effendi & Wardinatno, 2015)

NSF-WQI Score	Criteria
0-25	Very Bad
26-50	Bad
51-70	Medium
71-90	Good
91-100	Excellent

3. RESULT AND DISCUSSION

Pangunchi river doesn't show much variation in water quality along four selected sampling stations, which is shown in Figure 2. For all the sampling stations, pH, Total dissolved solids (TDS), Total suspended solids (TSS), Chloride, Hardness, Sulphate, Phosphate, Nitrate, Temperature were in acceptable range.

Electrical conductivity ranging 466-1025 μS/cm crossed the acceptable limit for every sampling stations. Conductivity increases due to increased amount of dissolved solids entering in a water body (US-EPA, 2021).

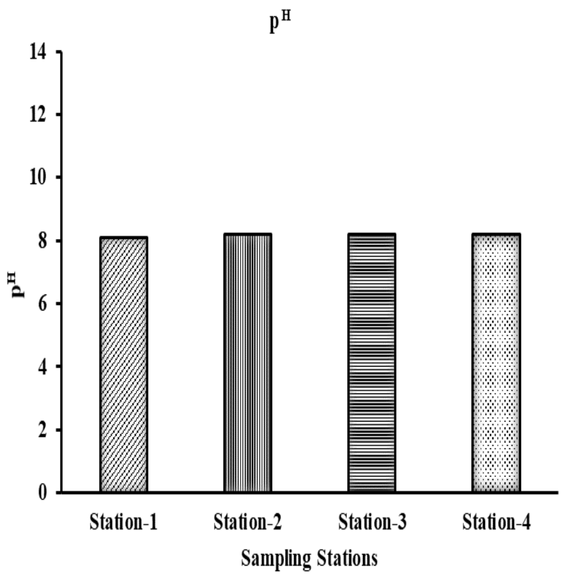
According to ECR'97, dissolved oxygen concentration should be more than 6 mg/l for drinking water. Every station showed less value than prescribed, ranging 5-5.5 mg/l.

Biochemical oxygen demand (BOD) value ranged 0.4-1 mg/l, which crossed ECR'97 standard (0.2 mg/l).

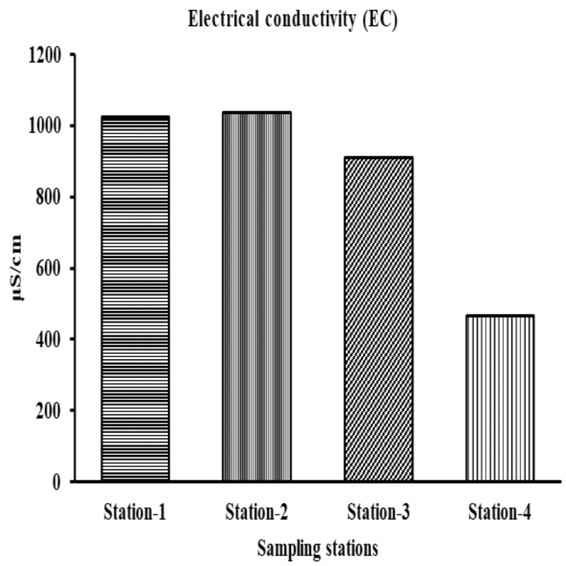
Turbidity value ranged 185.33-619 NTU, crossing ECR'97 standard value (10 NTU). Station 4 showed highest turbidity value (619 NTU).

Alkalinity value ranged 105-150 mg/l. Station 1 (Fulhata Mallick Bari) showed 150 mg/l alkalinity, which crossed ECR'97 standard value (120 mg/l).

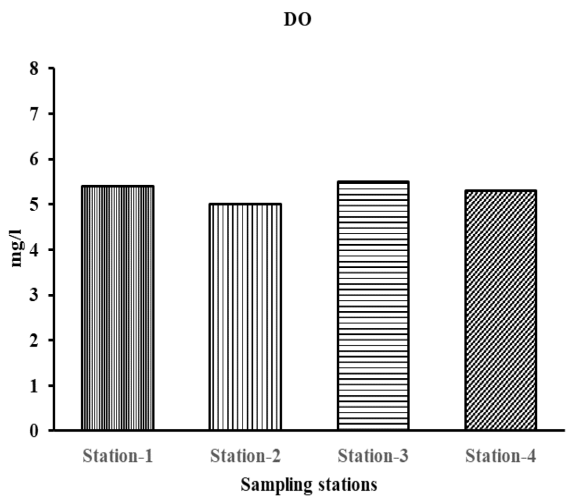
Fecal coliform value at every station crossed standard value for drinking water (0 cfu/100ml). Needless to say, different anthropogenic activities, waste dumping etc. caused coliform bacteria to grow. Station 1 (Fulhata Mallick Bari) showed 200 cfu/100 ml value which was highest among four.



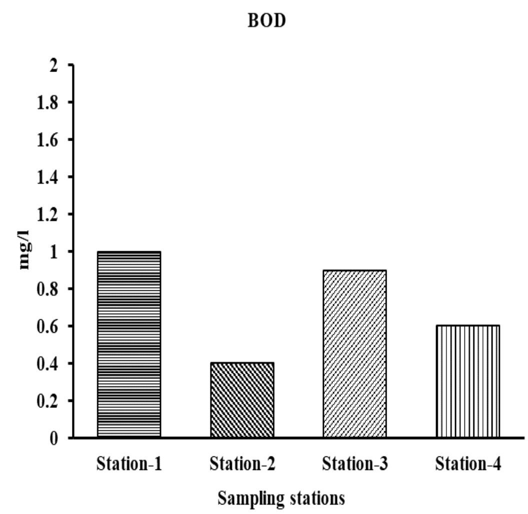
(a)



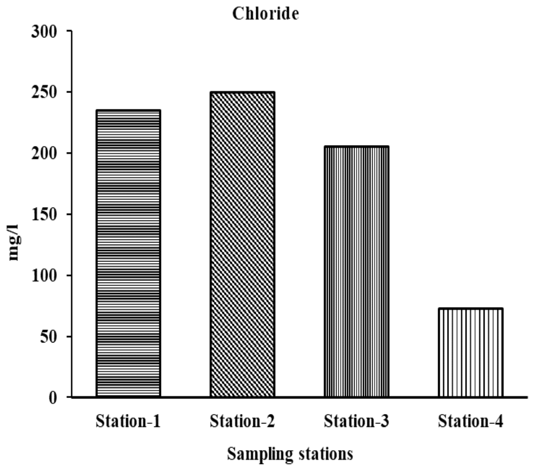
(b)


DO
mg/l
0
1
2
3
4
5
6
7
8
Station-1
Station-2
Station-3
Station-4
Sampling stations

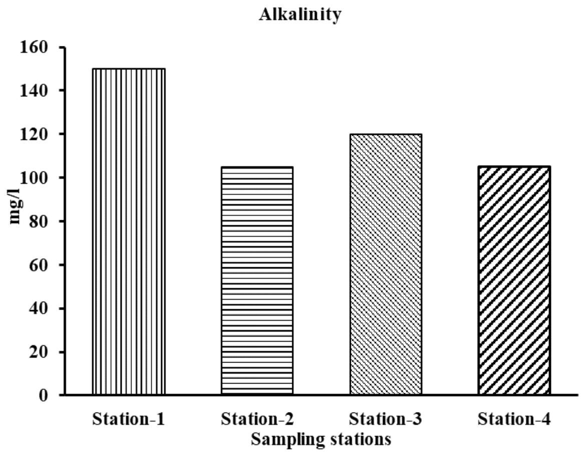
(c)


BOD
mg/l
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Station-1
Station-2
Station-3
Station-4
Sampling stations

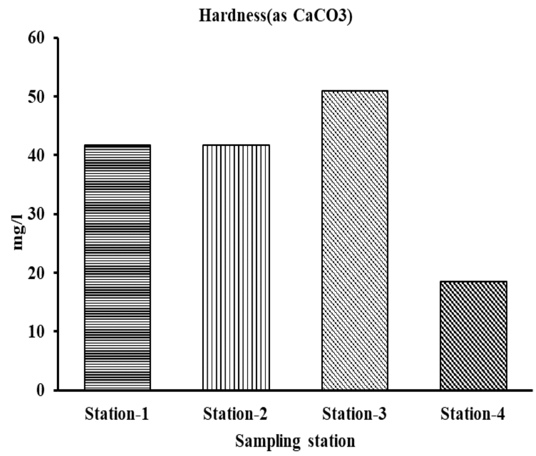
(d)


Chloride
mg/l
0
50
100
150
200
250
300
Station-1
Station-2
Station-3
Station-4
Sampling stations

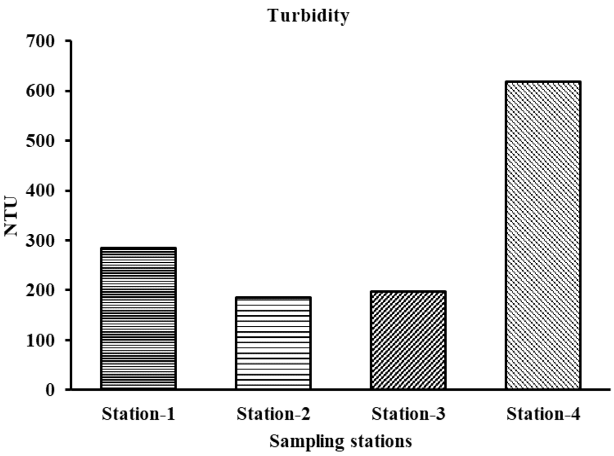
(e)


Alkalinity
mg/l
0
20
40
60
80
100
120
140
160
Station-1
Station-2
Station-3
Station-4
Sampling stations

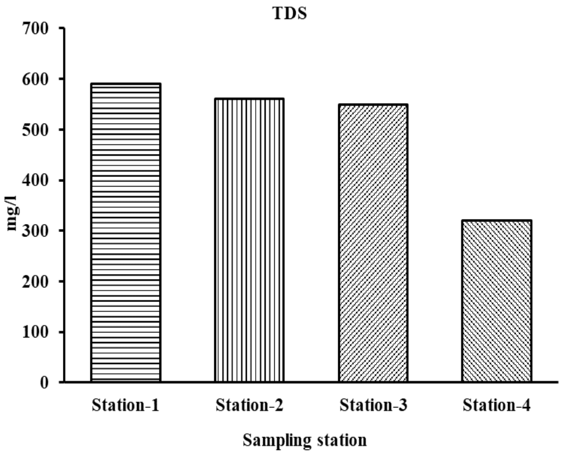
(f)


Hardness(as CaCO3)
mg/l
0
10
20
30
40
50
60
Station-1
Station-2
Station-3
Station-4
Sampling station

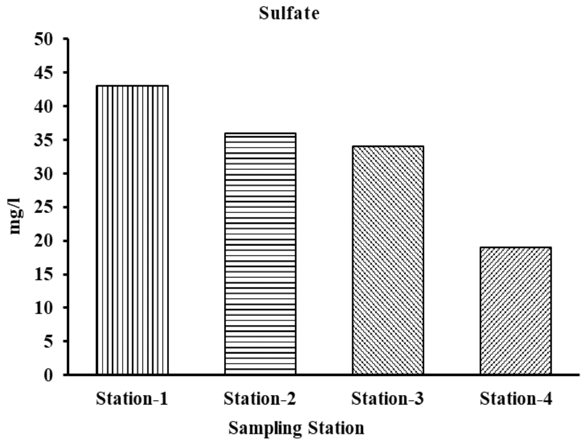
(g)


Turbidity
NTU
0
100
200
300
400
500
600
700
Station-1
Station-2
Station-3
Station-4
Sampling stations

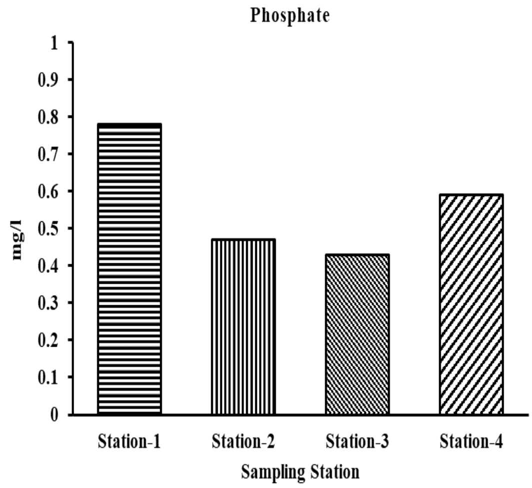
(h)



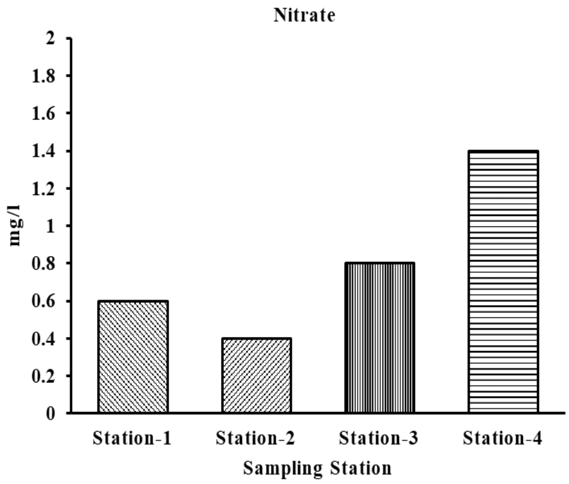
(i)



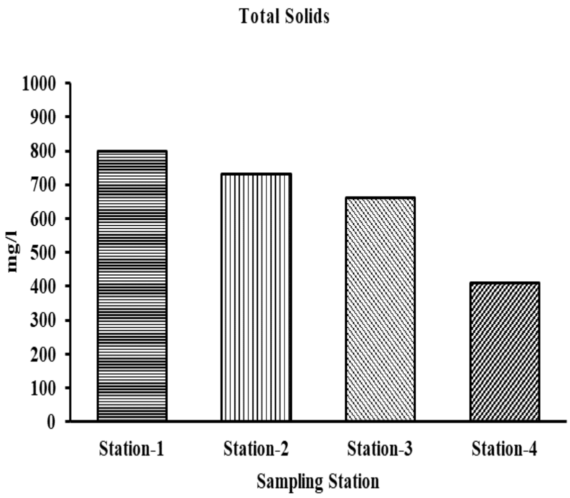
(j)



(k)



(l)



(m)

Figure 2: (a) pH (b) Electrical conductivity (EC) (c) Dissolved oxygen (DO) (d) Biochemical oxygen demand (BOD) (e) Chloride (f) Alkalinity (g) Hardness (h) Turbidity (i) Total dissolved solids (TDS) (j) Sulfate (k) Phosphate (l) Nitrate (m) Total solids of different sampling stations.

Table 6: Physiochemical characteristics of water samples collected from four sampling stations of Pangunchi river

Parameter	Unit	ECR'97 standard	WHO standard	S-1	S-2	S-3	S-4
pH	-	6.5-8.5	6.5-8.5	8.1	8.19	8.2	8.19
Electrical conductivity (EC)	μS/cm	-	400	1025	1035	910	466
Dissolved oxygen (DO)	mg/l	6	5	5.4	5	5.5	5.3
Biochemical oxygen demand (BOD)	mg/l	0.2	5	1	0.4	0.9	0.6
Turbidity	NTU	10	25	285	185.33	198	619
Total dissolved solids (TDS)	mg/l	1000	500-1000	590	560	550	320
Total suspended solids (TSS)	mg/l	-	500	210	170	110	90
Total solids (TS)	mg/l	-	-	800	730	660	410
Chloride	mg/l	150-600	250	235	250	205	72.5
Hardness (as CaCO3)	mg/l	200-500	500	41.67	41.67	50.93	18.52
Alkalinity	mg/l	-	120	150	105	120	105
Fecal coliform	cfu/100ml	0	0	200	180	140	156
Sulfate	mg/l	400	250	43	36	34	19
Phosphate	mg/l	6	5	0.78	0.47	0.43	0.59
Nitrate	mg/l	10	50	0.6	0.4	0.8	1.4
Temperature	^{0}C	20-30	20-30	24.6	24	23.7	23

3.1 Weighted Arithmetic Water Quality Index

Weighted arithmetic water quality index value for all the stations is almost same, which is considered as "poor".

Table 7: Weighted arithmetic water quality index value of Pangunchi river

Station	WQI score	Water quality status	Possible usage
1	62.95	Poor	Irrigation and industrial
2	60.77	Poor	Irrigation and industrial
3	61.49	Poor	Irrigation and industrial
4	59.50	Poor	Irrigation and industrial

3.2 National Sanitation Foundation Water Quality Index (NSF-WQI)

Water quality based on NSF-WQI is almost same for all the stations, which is considered as "medium".

Table 8: NSF water quality index value of Pangunchi river

Station	NSF-WQI Score	Water quality status
1	53.43	Medium
2	53.79	Medium
3	55.87	Medium
4	55.63	Medium

4. CONCLUSION

The major findings from this paper are:

1) Water quality status of Pangunchi river has been categorised as 'poor' by the weighted arithmetic water quality index method and 'medium' by the NSF-WQI method.
2) Water of this river is unsuitable for drinking. But no treatment is necessary for using in irrigational, industrial purposes.

ACKNOWLEGEMENT

The authors are grateful to Khulna University of Engineering & Technology for providing financial support.

REFERENCES

Abbasi, S., & Abbasi, T. (2012). *Water quality indices.* Amsterdam: Elsevier.

Ahmed, F., & Rahman, M. (2000). *Water supply and sanitation.* Dhaka: ITN-Bangladesh.

Bangladesh National Portal. (2021). Retrieved from Bangladesh National Portal: http://morrelganj.bagerhat.gov.bd/site/page/166072bd-1c4b-11e7-8f57-286ed488c766/%E0%A6%A8%E0%A6%A6-%E0%A6%A8%E0%A6%A6%E0%A7%80

Bora, M., & Goswami, D. C. (2017). Water quality assessment in terms of water quality index (WQI): case study of the Kolong River, Assam, IndiA. *Applid Water Science*, 3125-3135.

Brown, R. M., McClelland, N. I., Deininger, R. A., & O'Connor, M. F. (1972). A water quality index-crashing the psychological barrier. *W.A. Thomas (ed.), Indicators of Environmental Quality*, 173-182.

Brown, R. M., McClelland, N. I., Deininger, R. A., & Tozer, R. G. (1970). A water quality index-do we dare? *Water and sewage works*, 339-343.

Department of Environment. (2014). *River Water Quality Report.* Dhaka: National Resource Management Section, Department of Environment.

Effendi, H., & Wardinatno, Y. (2015). Water Quality Status of Ciambulawung River, Banten Province, Based on Pollution Index and NSF-WQI. *Procedia Environmental Sciences*, 228 – 237 .

Myers, D. N. (2018). *Why monitor water quality?* U.S.A: U.S. Geological Survey.

National Resources and Environmental Protection. (n.d.). *Sulfate and water quality*. Retrieved from Sulfate and water quality: http://www.state.ky.us/nrepc/water/ramp/rmso4.htm

Rusydi, A. F. (2017). Correlation between conductivity and total dissolved solid in various types of water: A review. *IOP Conference Series: Earth and Environmental Science* (p. 118). Canada: IOP Publishing.

Sharma, D., & Kansal, A. (2011). Water quality analysis of River Yamuna using water quality index in the national capital territory, India (2000–2009). *Applied Water Science*, 147-157.

Sharma, M., Jain, C., & Singh, O. (2014). Characterization of point and non point sources and water quality assessment of river hindon using water quality index. *Journal of Indian Water Resources Society*, 53-64.

Singh, L. (2007). *River Pollution.* New Delhi: APH Publishing.

Swenson, H., & Baldwin, H. (1965). *A primer on water quality.* USGS.

Tereza, M., Barreto, F., & Carlos, J. (2014). A global scientific literature of research on water quality indices. *Acta Limnologica Brasiliensia*, 245-253.

US-EPA. (2021, June 1). *US-EPA.* Retrieved from National Aquatic Resource Surveys: https://www.epa.gov/national-aquatic-resource-surveys/indicators-conductivity

Zeb, B. S., Malik, A. H., & Mahmood, Q. (2011). Water quality assessment of Siran river, Pakistan. *International Journal of the Physical Sciences*, 7789-7798.