

Water quality of Bakkhali River as major water source of Fish Landing Center, Cox's Bazar

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Abstract. The present study was carried out to analyze the water quality of Bakkhali river as a means of hygiene and sanitation aspects of BFDC Fish Landing Center at Cox's Bazar. Water samples were collected from 5 sampling sites seasonally near the landing center during monsoon (June to September), winter (October to January) and pre-monsoon (February to May) months. Water temperature, pH, DO, BOD and alkalinity was within the standard level in all seasons and sites under study. The TDS value was exceeded standard limit and water salinity was moderate in nature. The nitrite, nitrate and ammonia estimates of water were within standard limit and fluoride value was higher than standard limit except some sites in pre-monsoon period. Further study is needed to identify the microbiological aspects of water in fish landing center.

Keywords: Water quality, Bakkhali river, Cox's Bazar, Fish landing center

Introduction

Estuaries are transition area between sea and freshwater with various freshwater and marine fisheries. This area serves as different economic functions including transportation, industry and tourism, but also characterized by domestic, industrial and agriculture waste discharge (Rashed-Un-Nabi *et al.* 2011). This estuarine river is very productive and also serves as feeding, breeding and nursery grounds for a variety of aquatic organisms (Kamal and Khan 2009). However, pollution is one of the major factors affecting the estuary ecosystem (Hena *et al.* 2012). Bakkhali river water is being polluted through many ways such as, waste discharge from Cox's Bazar city, municipal and domestic wastes dumping, indigenous effluents from the city coming through the river and ending up in the river and boat repairing (Jahan *et al.* 2019). The presence and habitat of fisheries within estuaries depends on several biological and abiotic factors. These factors include physiochemical quality and nutrient quality of water (Rashed-Un-Nabi *et al.* 2011).

Since Cox's Bazar fish landing center located in the bank of Bakkhali estuarine river, various wastes generated in fish landing center directly dump into the river, drainage waste water goes directly into the river, which deteriorates water quality. Many engine boats comes to the fish landing center, so boat oil can also cause water pollution. It is very important to assess river water quality near any potential pollution source to identify the magnitude of pollution and take proper steps to mitigate or stop the pollution. There are number of studies conducted on water quality of Bakkhali river (Nabi *et al.* 2011, Siddique *et al.* 2012) in different locations but enough research has not been done near fish landing center to identify the pollution in Cox's Bazar fish landing center. Hence, the study was conducted to assess the physiochemical and nutrient quality of Bakkhali river water near Cox's Bazar fish landing center area.

Materials and Methods

Study area: The study was carried out in Bakkhali river near Cox's Bazar fish landing center for a period of 10 months from June 2016 to March 2017. Geographical location of the study area is between 21°26'01"N latitudes and 91°58'03"E longitudes along the Bay of Bengal at western part of Cox's Bazar Sadar Upazila and South-Eastern of Bangladesh.

Sample collection: The water samples were collected from 5 sampling locations denoted as St-1, St-2, St-3, St-4 and St-5 near the landing center during pre-monsoon (February to May), monsoon (June to September) and winter (October to January) season from June 2016 to March 2017. Samples were collected once in a season. At each sampling location, the sampling bottles rinsed at least three times before sampling done. Pre-prepared sampling bottles immersed about 10 cm below the surface water. After sampling, the bottles screwed carefully and marked with the respective identification number. The samples were acidified with 10% nitric acid (HNO₃), and placed in an ice bag and carried out to the laboratory.

Sample analysis: Water quality parameters such as temperature, pH, Total Dissolved Solids (TDS) and Salinity were determined by the Thermometer, digital pH meter (pH Scan-2, sensitivity 0.1±0.02), digital TDS meter (Jenway 4200 Conductivity Meter) and Refractometer (Atago), respectively. Buffer solution containing pH 7.0 was used to calibration the digital pH meter. Dissolved Oxygen (DO) was determined by the Winkler (or iodometric) test titrimetric method and alkalinity was determined by titration method with 0.1NHCl after addition 2-3 drops of methyl-orange indicator and was reported in terms of CaCO₃ equivalent. The Biochemical Oxygen Demand (BOD) was determined by measuring the difference between the oxygen concentration of sample just after sampling and the oxygen concentration after sample incubating for 5 days at 20°C.

Result and Discussion

Physiochemical parameters of water

Temperature: The study showed that water temperature in all five locations of adjacent river of fish landing center was almost same. Temperature ranged from 26.44°C in winter to 28.72°C in pre-monsoon season (Table 1) and which was found within the standard of surface water temperature 20 to 30°C (EQS 1997). Highest temperature increased from winter to pre-monsoon. A study on seasonal variation of physical-chemical parameters in Bakkhali river water found temperature in summer 22°C and in winter 21°C (Raknuzzaman *et al.* 2018). The lowest temperature study on assessment of water quality at Kalatoly at Cox's Bazar observed the lowest temperature of 24.5°C in January and the highest 28°C in May (Aftabuddin *et al.* 2009). Another study on coastal pollution showed that water temperatures of the Bakkhali river of Cox's Bazar coast were 21.3 to 27.5°C (Uddin 2010). Therefore, water temperature was optimum for aquatic life in the study area.

Total Dissolved Solids (TDS): Results showed the lowest TDS content of river water was 1647.6 mg/l during monsoon and the highest was 5539.0 mg/l during pre-monsoon season with coefficient ($R^2=0.9847$) of determination (Fig. 1). Result found remarkable difference in TDS value among different sampling locations in all three seasons among all three seasons. The TDS

ranges from 1320 to 1677 mg/l in monsoon, 2781 to 3790 mg/l in winter and 5386 to 5764 mg/l in pre-monsoon (Table I). The TDS was much higher in pre-monsoon season than any other seasons, which exceeded the standard limit 1000 mg/l (ADB 1994) and therefore, higher TDS content could be due to salinity or it indicates probable presence of pollution. During pre-monsoon pollution of the water could be higher which increased TDS level. The total dissolved solids depend on various factors such as geological character of the water shed, rainfall and amount of surface runoff (Parvez *et al.* 2018). Temperature and salinity can greatly affect TDS and also pollution can cause higher TDS concentrations (Phyllis and Duffy 2007). Low value of TDS recorded in winter might be due to sedimentation of suspended solids and slow decomposition rate during rainy season (Moharana and Patra 2014). TDS found from 21.28 to 24.20, 17.65 to 20.25 and 22.87 to 25.12 mg/l in Kolatoli, Cox's Bazar (Aftabuddin *et al.* 2009).

Table 1. Physicochemical parameters of Bakkhali river near BFDC fish landing center, Cox's Bazar during monsoon, winter and pre-monsoon season

Season	Temperature (°C)	TDS (mg/l)	Salinity (ppt)	pH	DO (mg/l)	BOD (mg/l)	Alkalinity (mg/l)
Monsoon	26.94±0.05	1647.6±247.40	18.0±0.0	6.516±0.10	9.958±1.29	4.42±1.97	156±5.48
Winter	26.44±0.11	3173.4±417.33	20.8±0.57	7.558±0.05	14.436±0.99	3.62±0.99	136±15.17
Pre-monsoon	28.72±0.04	5539±145.24	24.5±0.5	6.876±0.02	10.776±0.54	4.16±1.19	168±20.49

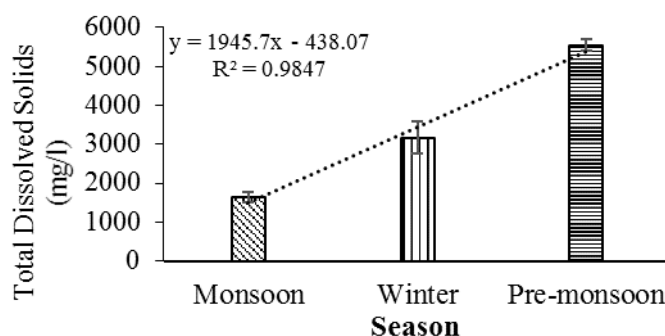


Fig. 1. TDS of Bakkhali river water near BFDC fish landing center during sampling seasons.

Salinity: Results showed that the salinity level increased from monsoon to pre-monsoon. Salinity was the highest in pre-monsoon season and lowest in monsoon (Table 1). The lowest salinity was 18ppt in monsoon and the highest was 24.5ppt in pre-monsoon with coefficient ($R^2=0.9937$) of determination (Fig. 2). Salinity can be affected by different factors. Evaporation increases salinity of the seawater and the addition of freshwater by rainfall or runoff which dilutes the seawater, reduces the salinity (Science Learning Hub 2010). One study on seasonal variation of physical-chemical parameters in Bakkhali river water found salinity level in summer 12 ppt and in winter 27 ppt (Raknuzzaman *et al.* 2018). A study on water quality investigation in Bakkhali River estuary found salinity level during monsoon 2.33 and

5.33 ppt, in winter 29.66 and 30.66 ppt, and in pre-monsoon 25.66 and 26.33 ppt in two stations of the estuarine area (Rashed-Un-Nabi *et al.* 2011).

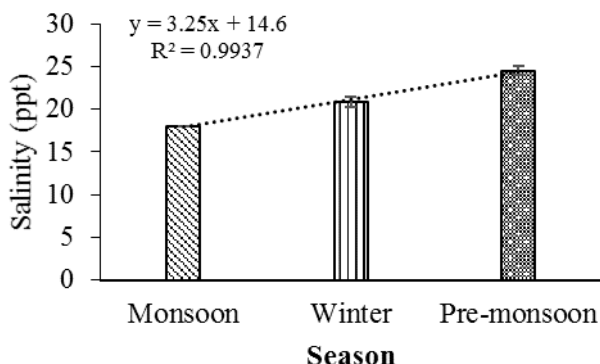


Fig. 2. Water salinity of Bakkhali river during the monsoon, winter and pre-monsoon season.

pH: The present study found that the pH value was the highest in winter and lowest in monsoon which ranged from 6.5 in monsoon to 7.6 in winter. The standard limit of pH is 6.5 to 8.5. (ECR 1997) and all of the recorded values were within the standard limit and therefore pH was suitable for aquatic life. Fluctuations of pH influenced by different factors such as, the dissolved minerals in the water, wastes dumping, photosynthesis, bacterial activity, water turbulence, chemical constituents in runoff flowing into the water body, sewage overflows and even aerosols and dust from the air (EPA 2006). Study on seasonal variation of physicochemical parameters in Bakkhali river water revealed pH level 6.0 in summer and 7.2 in winter (Raknuzzaman *et al.* 2018).

Dissolved Oxygen (DO): The lowest DO content of river water found 9.95 mg/l during monsoon and the highest 14.436 mg/l during winter (Table 1). The DO was much higher in winter than other seasons. The standard of minimum DO content is 5.0 mg/l (ECR 1997) and the study showed that all the recorded DO contents were higher than the standard, which explains the river water quality was satisfactory level and it was suitable for fisheries and aquatic organisms. A study to assess coastal water pollution found 9.20 mg/l DO concentration in Bakkhali river (Sarker *et al.* 2016).

Biological Oxygen Demand (BOD): The lowest BOD content of river water found 3.62 mg/l in winter season and the highest found 4.42 mg/l in monsoon with coefficient ($R^2=0.1015$) of determination (Fig. 3). The BOD content had low variation among seasons but among different locations BOD varies highly. In monsoon, BOD ranges from 1.6 to 6 mg/l, in winter 2.4 to 4.6 mg/l and in pre-monsoon 2.6 to 5.6 mg/l. The standard limit of BOD is below 6.0 mg/l (ECR 1997) and the study showed that all the recorded BOD contents were within the standard.

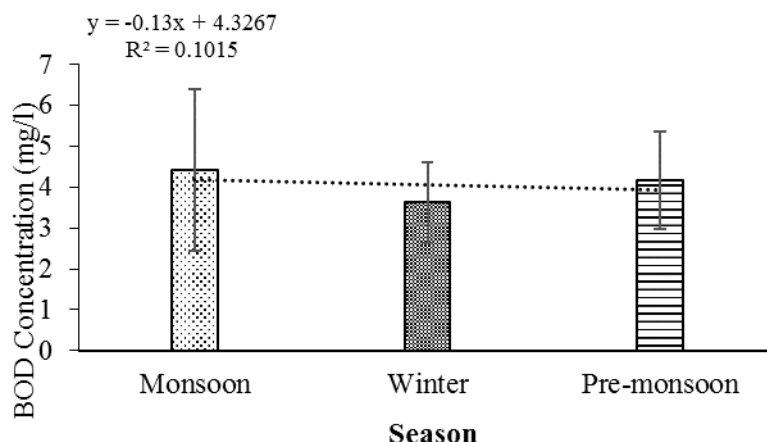


Fig. 3. BOD of Bakkhali river during the monsoon, winter and pre-monsoon season.

The BOD contents in monsoon and pre-monsoon season were slightly higher than the winter season might be due to natural water flow in the river. The other reason may be direct dumping of waste in the river, which can cause higher BOD concentration in water (EPA 1986). In monsoon and pre-monsoon period fish landing center functioned most since this time of the year fish caught much and comes to the fish landing center. And this time of the year waste dumping in the river is higher than winter season which can cause higher BOD concentration of water. Increase of BOD indicates decrease of DO in the water, that cause danger in certain stage where DO reaches in critical point which is harmful for aquatic organisms and even low higher BOD level can create lethal environment for aquatic organisms (EPA1993). Study on coastal pollution indicated that BOD of the Bakkhali river of Cox's Bazar coast was 4.42-7.35 mg/l (Uddin 2010).

Alkalinity: The lowest alkalinity of the river was found to be 136 mg/l in winter and the highest was 168 mg/l in pre-monsoon season (Table 1). Although alkalinity was low variation among seasons but among different locations in winter and pre-monsoon, alkalinity had higher variation. Alkalinity in winter ranges from 120 to 160 mg/l and in pre-monsoon 150 to 200 mg/l. The standard limit of alkalinity is more than 100 mg/l (EPA 1993) Moderate alkalinity expresses moderate salinity in the water (Shaik *et al.* 2015). Study on physicochemical assessment of surface and groundwater quality of the greater Chittagong region of Bangladesh indicated alkalinity of Bakkhali river was 146.85 mg/l (Ahmed *et al.* 2010).

Nutrient parameters

Nutrient concentrations in Bakkhali river water during monsoon, winter and pre-monsoon season are presented in Table II.

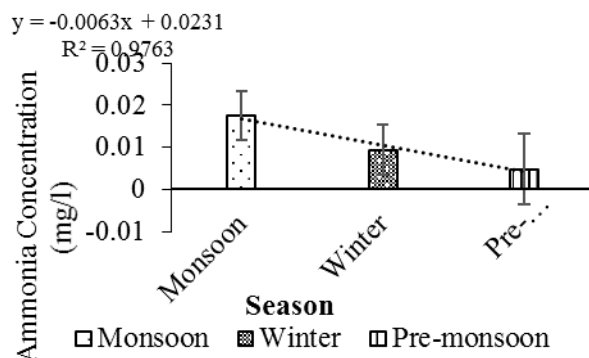
Table II. Nutrients (mg/l) in Bakkhali river water during monsoon, winter and pre-monsoon

Season	Nitrite (NO_2^-)	Nitrate (NO_3^-)	Ammonia (NH_3)	Fluoride (F^-)
Monsoon	0.0316 ± 0.03	4.02 ± 0.66	0.0174 ± 0.01	1.85 ± 0.51
Winter	0.011 ± 0.01	1.54 ± 0.61	0.0094 ± 0.01	1.732 ± 0.47
Pre-monsoon	0.0114 ± 0.01	0.14 ± 0.05	0.0048 ± 0.008	0.802 ± 0.32

Nitrite (NO_2^-): Study found that the lowest nitrite concentration in the river water was 0.011 mg/l in winter and highest 0.0316 mg/l in monsoon (Table II). Nitrite concentration had high variation among the locations in all the seasons under study and especially in monsoon. The standard of nitrite is less than 1 mg/l (ECR 1997) and all the recorded nitrite concentrations were within the standard levels. Level of nitrite in waters greater than 0.03 mg/l may indicate sewage pollution (EPA 1993). In two locations in monsoon (St-1 and St-2), nitrite concentration recorded higher than 0.03 mg/l which is a possibility of sewage pollution in the river water. Water quality study in Kolatoli, Cox's Bazar revealed nitrite from 0.006 to 0.12 ppm from the month of January to June during 2008 (Aftabuddin *et al.* 2009).

Nitrate (NO_3^-): Nitrate concentration was highest in monsoon season. The lowest nitrate concentration of the river water was 0.14 mg/l in pre-monsoon season and winter, whereas highest 4.02 mg/l was in monsoon (Table II). Nitrate concentration decreased from monsoon to winter and pre-monsoon respectively. The standard of nitrite is less than 10mg/l (ECR 1997). Study found 0.89 ppm nitrate concentration in Bakkhali river during winter (Islam *et al.* 2017).

Ammonia (NH_3): The lowest ammonia concentration of 0.0048 mg/l was recorded in pre-monsoon and the highest 0.0174 mg/l was in monsoon with coefficient ($R^2=0.9763$) of determination (Fig. 4). Higher variation of ammonia concentration observed among different locations in all studied seasons, remarkably in pre-monsoon season when standard deviation was higher than mean concentration of ammonia. Ammonia should be less than 0.5 mg/l according to the standard level (ECR 1997) and all the recorded ammonia concentrations within the standard levels. When ammonia present in levels above 0.1 mg/l N, sewage or industrial contamination may be indicated (EPA 1993). Therefore, the river is not polluted by sewage.

**Fig. 4.** Ammonia concentration in Bakkhali river water during monsoon, winter and pre-monsoon season.

Fluoride (F^-): Fluoride concentration was higher during monsoon and pre-monsoon season. The lowest fluoride concentration of the river water was found as 0.802 mg/l in pre-monsoon and the highest 1.85 mg/l was in monsoon with coefficient ($R^2=0.8333$) of determination (Fig. 5). Study indicated variations among different locations in all seasons and among seasons. The standard of fluoride is 1 mg/l (ECR 1997) and most of the recorded fluoride concentrations exceeded the standard levels except St-1, St-3 and St-5 in pre-monsoon season. Therefore, fluoride content in river water may not be suitable for aquatic organisms in sometimes of the year. Higher fluoride concentration occurs naturally in quite rare instance. It arises almost exclusively from fluoridation of public water supplies and from industrial discharges (EPA 1993).

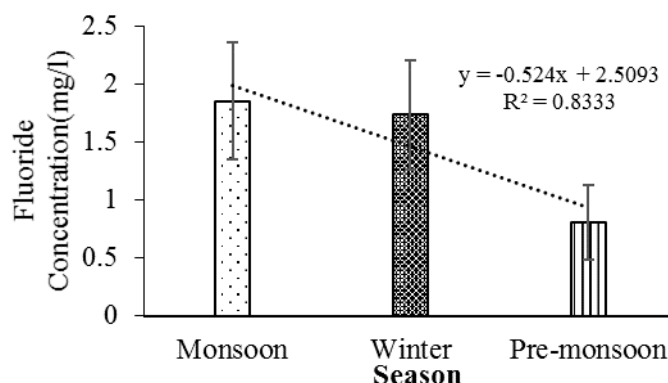


Fig. 5. Fluoride concentration in Bakkhali river water during monsoon, winter and pre-monsoon season.

Correlation between physiochemical and nutrient quality of Bakkhali river water: All the physiochemical and nutrient quality parameters measured in this study, several correlations were found between different parameters (Table III). Strong positive correlation was found between temperature and TDS ($r=0.812$), TDS and salinity ($r=0.983$), pH and DO ($r=0.931$) at 0.01 level of significance and moderate positive correlation was found between temperature and salinity ($r=0.784$), nitrate and ammonia ($r=0.664$), nitrate and fluoride ($r=0.688$) at 0.01 level of significance, and temperature and alkalinity ($r=0.630$) at 0.05 level of significance. Strong negative correlation found between salinity and nitrate ($r=-0.930$) at 0.01 level of significance, moderate negative correlation found between temperature and nitrate ($r=-0.606$) at 0.01 level of significance, and salinity and ammonia ($r=-0.642$), pH and alkalinity ($r=-0.530$), DO and alkalinity ($r=-0.582$) at 0.05 level of significance. Other than these correlations, negative correlations found between temperature and fluoride ($r=-0.731$), TDS and nitrite ($r=-0.913$), TDS and nitrate ($r=-0.644$), TDS and ammonia ($r=-0.684$), and salinity and fluoride ($r=-0.677$) statistically.

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Table III. The Pearson correlation coefficient (r) among the physiochemical parameters and nutrients concentrations in Bakkhali river near BFDC fish landing center

	Temp.	TDS	Sal.	pH	DO	BOD	Alkal.	NO ₂ ⁻	NO ₃ ⁻	NH ₃	F ⁻
Temp.	1										
TDS	.812**	1									
Salinity	.784**	.983**	1								
pH	-.374	.215	.257	1							
DO	-.485	.046	.082	.931**	1						
BOD	.099	-.028	-.104	-.185	-.001	1					
Alkalinity	.630*	-.359	.296	-.530*	-.582*	-.186	1				
NO ₂ ⁻	-.142	-.913**	-.347	-.437	-.486	-.464	.038	1			
NO ₃ ⁻	-.606*	-.644**	-.930**	-.448	-.257	.188	-.172	.274	1		
NH ₃	-.410	-.684**	-.642**	-.329	-.290	-.301	.347	.312	.664**	1	
F ⁻	-.731**	.297	-.677**	.092	.175	-.068	-.364	-.023	.688**	.493	1

Note: Temp= Temperature, Sal= Salinity, and Alkal= Alkalinity. **Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed).

Conclusions

The study conducted to identify potentiality and magnitude of pollution in Bakkhali river from Cox's Bazar to assess the hygienic and sanitation conditions of fish landing center. Temperature, pH, DO, BOD and alkalinity was within the standard level in all seasons and all locations. TDS exceeded standard limit probably due to increase the load of mud, surface runoff, erosion of seashore and slow decomposition rate during rainy season. Nitrite, nitrate and ammonia were within standard limit and fluoride was higher than standard limit except few locations in pre-monsoon season probably due to surface water run-off and release of municipal waste. Building waste dumping site, proper drainage system, ensure no sewage contamination and conducting more research needed to maintain good hygienic condition in fish landing center at Cox's Bazar.

Acknowledgements: Sincere appreciation to the University Grants Commission (UGC) of Bangladesh for financial support through the Research Cell of the Mawlana Bhashani Science and Technology University to carry out the research.

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