

CHAPTER I

INTRODUCTION

1.1 Background of the study

The Teknaf Upazila located in the south-eastern edge of Bangladesh which linkage with many reservoir-like canals, feeder, creeks and stream corridors, forming crisscrossed coast. Warm tropical climate and sufficient rainfall make this land blessed for a wide range of biodiversity. Teknaf coast is characterized by unique physiography, bio-diversity and diverse socio-economic development opportunities. Teknaf Sea Beach is known as the longest sandy beach ecosystems in the world which is widespread till 80km. It represents an important habitat and transitional ground for the flora and fauna and also contribute to support a 'Mangrove Forest' as natural forest which is distributed in the inter-tidal zone with the habitat of 161 different fisheries species (Chowdhury et al., 2011).

Coastal ecosystem is the vibrant host for flora and fauna and provide a good platform for coastal life (Adebola et al., 2019). Coastal marine resources support greater biodiversity than open ocean regions and due to terrestrial adjacency most productive marine ecosystems are found within coastal ecosystem (Bierman et al., 2009). Moreover, coastal water is the vital factor for all life processes and this physico-chemical parameters make desirable to take water as an environment (Soundarapandian et al., 2009).

For the production of fisheries, the water quality plays an important role (Riedel et al., 2000). Monitoring the water quality does not only measure the environmental health on an ecosystem, but rapid assessment of aquatic ecosystem also provides environmental quality before using by living organisms (Connell, 2006). According to UNCED (1992), 80% diseases and over one third of deaths are caused by consumption of contaminated water. Furthermore, contamination of water quality, depletion of water resources, natural calamities, various types of pollution, anthropogenic activities and loss of aquatic biodiversity are prominent features in the coastal region (Upal, 2015). Hence, monitoring of water quality is important for vast resources of coastal area than others.

Natural disasters and increasing of human intervention are responsible for degrading of the environmental quality and ecological value of this coast. Due to increasing of visitors and solid wastes reduce water quality day by day in the coastal region. Also, future threat for the coral habitat might be apparent due to wastes throwing by tourists either on beach or in the water. Therefore, saving the coastal ecosystem needs careful protection to maintain the water quality and its standard.

Several authorities and researchers are tried to concern about the sustainable use of resources, management of waste, drainage system and water quality problems of the coast. Several anthropogenic causes of environmental deterioration and their adverse impacts upon water were also analyzed to reveal the biological state of the aquatic ecosystem at the Teknaf coast (Ahmad and Shamim, 2019). Estuarine fisheries depend on the biotic and abiotic factors which include with physio-chemical quality and nutrient quality of water (Nabi et al., 2011). In case of coastal aquatic ecosystem, physio-chemical factors are varied with tide and discharge of freshwater through the network of rivers (Zafar, 1992). It also depend on natural process like precipitation, erosion, weathering and evolution processes (Meena and Chandrakala, 2017). Therefore, effect of seasonal variation on coastal ecosystems is of serious concern to scientists and policy makers involved in climatic change, biodiversity and the marine environment. (Islam et al., 2019).

The interactive process operations like physical, chemical, and biological processes in the coastal ecosystems sustain higher result richness in diversity in the coastal region. Therefore, it's very important to assess water quality parameters with seasonal variability to maintain sustainability of environment and biodiversity in the coastal region of Bangladesh. However, these studies have been carried out in whole Cox's bazar but in the Teknaf coast in where scanty information is available on the water quality parameter. Therefore, the present investigation is undertaken to assess the hydro-logical parameters so as to find out the ecological status of the studied area as well as to outline the seasonal variation of each factor which will help to find out the healthy ecosystem in where fish activities are available.

❖ **Significance of the study**

- ✓ This study provides a complete understanding of the water quality parameters and also help to observe the variations among the whole season.

- ✓ This study also help to outline the convenient zonation of fishing and fish culture activity and also suggested for future researches to get comparable ideas about the water quality parameters in the Teknaf coast of Bangladesh.

❖ **Scopes of the study**

The findings might be used as favorable states for regular monitoring of the water quality parameter in the coastal region of Bangladesh.

1.2 Objectives of the study

The present study was undertaken by observing the following objectives:

- To determine the physico-chemical parameters of coastal water in the Teknaf coast.
- To determine the seasonal variability of physico-chemical parameters of coastal water.

CHAPTER II

REVIEW OF LITERATURE

Several studies on assessment of water quality parameter of the coastal region have been done in Bangladesh. However, in spite of the great necessity of studies on the Teknaf coast, only a few empirical studies have been done in Bangladesh so far. The available literatures relevant to the present investigation have been presented below:

Kashem et al. (2019) carried out an experiment on the physico-chemical parameters of Saint Martin Island. In their studies, the ranges of physico-chemical parameters of coastal seawater were 25 to 30°C for temperature, 30.8 to 33.4 ppt for salinity, 48966 to 55235 $\mu\text{S}/\text{cm}$ for conductivity, 5.08 to 6.87 mg/L for DO, 8.05 to 8.38 for pH and 29575 to 31980 mg/L for TDS.

Islam et al. (2019) stated that, salinity and water pH showed very strong changes between 9 psu to 33 psu and 7.5 to 8.24 due to heavy rainfall and fresh water discharge into the stations. He revealed that physico-chemical properties of the study have shown reasonable variation with the seasonal and spatial.

Mehedi et al. (2000) suggested that during the period of investigation, the values of DO showed inverse relationship with salinity and water temperature. Nutrient contents in the investigated areas were much higher. The maximum and minimum values of water Temperature, Salinity, DO, pH, Transparency, Phosphate-phosphorous ($\text{PO}_4\text{-P}$), $\text{NO}_3\text{-N}$, $\text{NO}_2\text{-N}$, $\text{NH}_3\text{-N}$ were noted as 27.9 and 25.6°C; 34.93 and 31.40 ppt.; 8.71 and 6.35 mg/l; pH 9.39 and 7.2; 74.86 and 52.40 cm; 18.02 and 7.28 mg/L; 3.61 & 0.72 mg/L; 1.88 and 0.07 mg/L; and 1.92 and 0.08 mg/L respectively.

Rashid et al. (2013) dealt with the adverse impacts of ocean acidification upon the environment of the Bay of Bengal which was related with physicochemical parameters of water where recorded average pH of water in seawater was around 7.75 and has fallen by 0.2 units and it inferred that reduced pH showed adverse effects on water quality and calcifying organisms.

Shamsuzzaman et al. (2018) discussed about both natural and anthropogenic factors as the causes of 'Coastal and Marine' ecosystem deterioration at Bangladesh coast.

Comprehending the severity of environmental deterioration, the Teknaf coast has been declared as an ‘Ecologically Critical Area’.

Miah et al. (2015) investigated the quality of water in the coastal belt region of Noakhali. Whereas all recorded water parameters were maintained standard limit but measured concentration of toxic metal ions (As, Cd, Pb, Hg, Cr) were below the standard permissible limit.

Ahmed and Shamim (2019) revealed that the environmental deterioration of the Teknaf coast through evaluate the physico-chemical parameters of water, whereas all anthropogenic activities, fishing boats and disposal of municipal wastes were responsible for deteriorating the coast.

Shammi et al. (2017) designed the study to understand the seasonal variation of the coastal rivers and estuaries contributing in the spatial trend in salinity. By ordinary kriging method the spatial analysis was confirmed approximately 77% and 34% sample in the dry-monsoon and wet-monsoon respectively that shown seawater intrusion (SWI).

Islam et al. (2018) conducted to evaluate the physicochemical parameters of the water in Rupsha River. Whereas, significant positive and negative correlations were found among different physicochemical parameters from ‘Pearson Correlation Program’ and stated that this area was highly polluted and special monitoring as well as protective measure of water quality were needed to reduce pollution.

Mallic et al. (2016) reported the water quality and sediment of Karnafully river in respect to the pollution index. The result indicates that these investigated parameters were changed due to changing the pattern of water chemistry and sediment characteristics with the effect of uprising pollution.

Islam et al. (2017) suggested that the parameters controlling the water quality in different seasons are related with the salinity and human activities in Pre-monsoon; precipitation induced surface runoff in Monsoon; and erosion, oxidation in post-monsoon.

Rashedul and Zafar (2018) reported that sediment salinity was showed inverse relationship with the water salinity and sediment pH was positively correlated with

water pH. This result focuses a baseline data for developing an index relationship with water and sediment of the coastal zone in Bangladesh territory.

Fatema et al. (2014) revealed that the water quality parameters in the Merbok estuary varied with temporal and spatial scales and also suggested a baseline information for the management of estuarine aquatic ecosystem.

Uddin et al. (2020) conducted to assess the of physico-chemical parameters of water of the Karnaphuli river. Whereas, conducted parameters were total hardness, phosphorus, sulfate, chloride, TDS, and free CO₂ were found 275.63mg/L, 19.75mg/L, 0.904mg/L, 778.83mg/L & 18.03mg/L, respectively

Panigrahy et al. (1999) stated that estuarine discharges which including remineralization of organically bound materials into its dissolved inorganic form and land drainage has significant influence on fluoride content in coastal water.

Lombardi et al. (2021) showed that biological activities and physico-chemical variables of the investigated shallow coastal site are influenced on each other. Dissolved Oxygen and pH were showed the lowest values between July and November and highest value in January. In fact, salinity shows the lowest and highest values during February and September respectively.

Shefat et al. (2020) stated that the Pasur River Estuarine (PRE) waters are nitrogen-limited during the dry season. This study showed that the significant positive correlation among the temperature, salinity and TDS and negative correlation with DO.

Alam (2021) recorded that no notable variations were occurred water quality parameters in Naf River are observed in monthly data assessment except April and July. Then founded water parameters were water temperature, transparency, turbidity, pH, DO, salinity, alkalinity and ranges from 27-34°C; 19-54 cm; 18-138 NTU; 7.2-8.2; 7-13 mg/L; 25-30 ppt and 86-336 mg/L respectively which were suitable for abundance of fish in the coastal water.

CHAPTER III

MATERIALS & METHODS

The methodology is a key and necessary piece of any exploration. In logical research, the worthiness of the outcomes relies upon an extraordinary expectation of a suitable approach. This part manages the strategies that are followed and materials that are utilized to accomplish the goals of the investigation.

The experiment was carried out from March, 2020 to February, 2021 in two sampling areas Moheshkhalia para and Naf estuary of Teknaf coast for the assessment of physico-chemical parameters of water from season to season.

3.1 Study Area

The Teknaf coast is surrounded by hilly area and Ukhia Upazila on the north and Naf River and Myanmar coast on the east and the south and west covered by the Bay of Bengal whereas about 55km longest Naf River flows towards the south and finally falls into the Bay of Bengal. This coast occupying an area of about 388.68 sq. km between latitude 21°10" N and 20°40" N and longitude 92°05" E and 92°25" E.

The study area consists of two different locations in the Teknaf coast.

(S1) Moheshkhalia para (Lat. 21°58'13" N and Lon. 91°98'79" E), and

(S2) Naf estuary (Lat. 20°54'44.94"N and Lon. 92°16'33.48"E).

The study area is shown in the Figure 1.

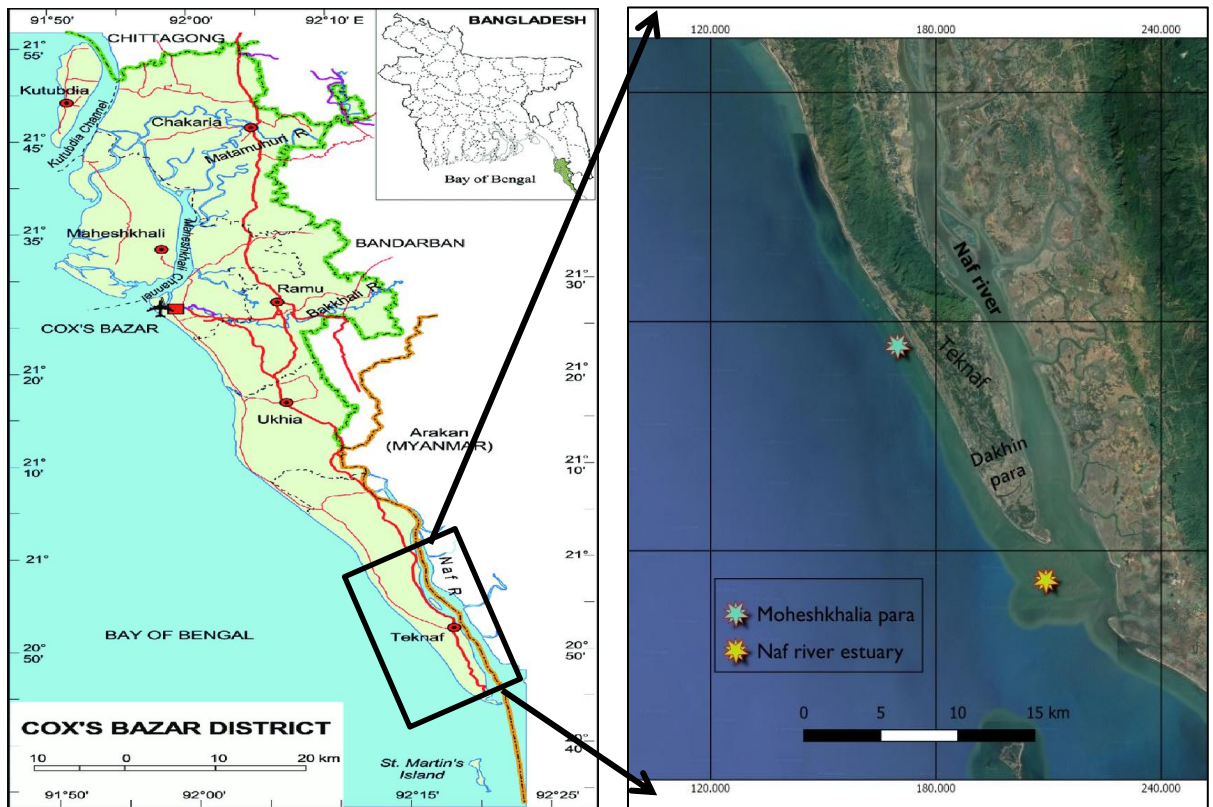


Figure 1. Study area Moheshkhali para and Naf River estuary of Teknaf coast

3.2 Sample Collection

The samples were collected for three times in each month from the two stations for a period of one year during March, 2020 to February, 2021. During the study period, the samples were collected in every month with a sterilized plastic bottle and immediately kept in an ice box and transported to the Aquatic Ecology lab, Faculty of Fisheries, CVASU; for determining the physico-chemical parameters. In every sample, water quality parameters such as Salinity, Dissolved Oxygen (DO), pH, Alkalinity, Total Dissolved solids (TDS), Transparency & Temperature were measured and recorded.

3.3 Procedure of Study

A table is given below to describe the methodology of this research work. The following outlines helps to achieve the research objectives and logical order of the study:

Table 1: Total research procedure

Steps	Description
1.Taking preparation for sampling	Necessary equipment were carried to collect sample such as pH, thermometer, DO meter, secchi disc, rope & sampling bottle.
2.Collection of samples	At first water samples were collected seasonally from two areas to measure the water quality and variability.
3.Assessing water quality in the lab	DO, Salinity, Alkalinity were measured in the lab by using renowned method which is practiced in lab. (Rahman, 1992)
4.Data collection	The data on water quality parameters of each month was recorded and analyzed.
5.Reporting	Final step for conducting this research was to make an overall report where all data were included sequentially and statistically

3.4 Determination of Water Quality Parameter

3.4.1 Physical Parameters

Temperature: Water temperature is important parameters and all other parameters depends on its balance. A Celsius thermometer was used during the study period to determine the temperature of water.

Transparency: Water transparency is the determination of productivity in water. A standard secchi disk was used for measuring of transparency.

pH: pH was measured by using a Hannah pen pH meter (HI2211 model). To determine it, at first pH meter was calibrated and submerged into water for recording data carefully.

Total Dissolved Solid (TDS): TDS is the measurement of solid particles like organic or inorganic materials which are all dissolved in water. TDS meter (HACH sensION+EC71) was used to determine the total dissolved solids in sampling water.

3.4.2 Chemical Parameters

Dissolved Oxygen (DO): DO is very crucial parameter for all life, in water DO act as a vital role for all aquatic life. So, DO parameter was measured by using DO meter (HANNA HI2004-01 edge^{DO})

Alkalinity

It was determined in laboratory by using following procedure:

- Alkalinity was measured through the Titration method.
- Collected sample about 50ml sample was taken in beaker.
- After that 2-4 drops of phenolphthalein indicator were added to the sample.
- The color not change: indicated the absent of phenolphthalein means Alkalinity in water.
- Further, 50ml of water sample was taken in beaker
- After that, 2-4 drops of Methyl Orange indicator were added to the sample and thus the color was turned into yellow
- Then burette was filled with Sulfuric acid
- The contents were titrated against Sulfuric acid (0.02N)
- Again, this was titrated with Sulfuric acid, it was continued until the color was changed to red
- At last, Alkalinity was calculated by following formula:

Alkalinity (mg/L) as CaCO₃ = (ml of titrant × N of acid used × 50 × 1000 / ml of sample)

Salinity:

- Salinity was measured by using refractometer (ATC COMINHKPR124469).
- At first refractometer was calibrated.
- After calibrating refract, two drops of samples were spreads across surface of the prism.
- Then aim the front end of the refractometer in the direction of the bright light and look through eyepiece.

3.5 Seasonal Discretion:

In present study, the study period was seasonally allocated in the following:

- ✓ **Pre-Monsoon:** March, April, May
- ✓ **Monsoon:** June, July, August
- ✓ **Post Monsoon:** September, October, November
- ✓ **Winter:** December, January, February

3.6 Analysis of Data:

The collected data were scrutinized and summarized carefully before the actual tabulation. All three times collected water samples were converted into mean value in each month for actual statistical analysis. The Microsoft Office Excel (2016) software, Statistical Package for Social Sciences (SPSS, 25 version) software was used to present and interpret the collected data and these results of the study were represented in charts and tabular forms.

Photos of Gallery

Photos of Measurement Meter



Plate 1: DO meter
(HANNA HI2004-01
edge^{DO})



Plate 2: TDS meter
(HACH sensION+EC71)



Plate 3: pH meter
(HI2211)



Plate 4: Refractometer
(ATCCOMINHKPR124469)



Plate 5: Titration of
Alkalinity

Photos of working in lab



Plate 6:
Assessing of DO



Plate 7:
Assessing of pH



Plate 8: Assessing
of TDS



Plate 9: Titrating
for Alkalinity



Plate 10: Assessing of Salinity



Plate 11: Lab
analysis

CHAPTER IV

RESULTS

4.1 Water Quality Parameters in Monthly

4.1.1 Salinity

The mean value of salinity was observed as (23.60 ± 5.08) mg/L with the maximum 32.4 mg/L and minimum 17.2 mg/L value was recorded in Moheshkhalia and Naf estuary during May and October respectively. The variations of Salinity of two stations have been shown in following figure (2):

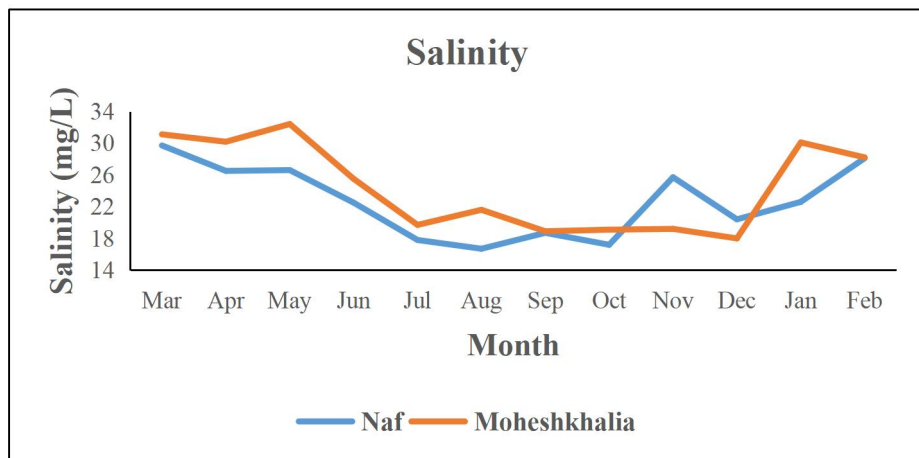


Figure 2: Monthly variations of Salinity in two sampling area

4.1.2 pH

The maximum and minimum value of pH like 8.9 and 6.6 was observed in Moheshkhalia and Naf estuary during September and October respectively with the mean value of 7.59 ± 0.65 . Monthly variations of pH have been shown in figure (3) below:

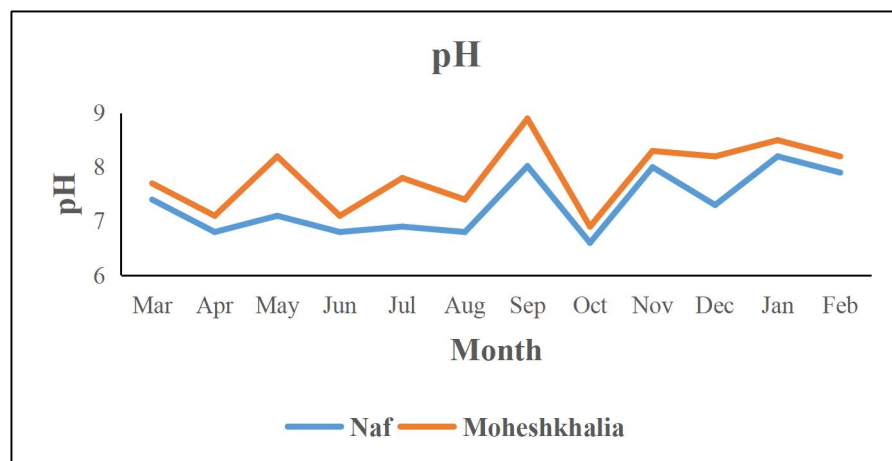


Figure 3: Monthly variations of pH in two sampling area

4.1.3 Dissolved Oxygen (DO)

In the present study the mean value of DO content was recorded (6.26 ± 1.20) mg/L in Teknaf coast. The DO content in water fluctuates greatly during February and December, the minimum value was found 3.8 mg/L and maximum value was 8.9 mg/L in the Naf estuary and Moheshkhaliapara respectively. Monthly variations of DO (Figure 4) have been shown in following:

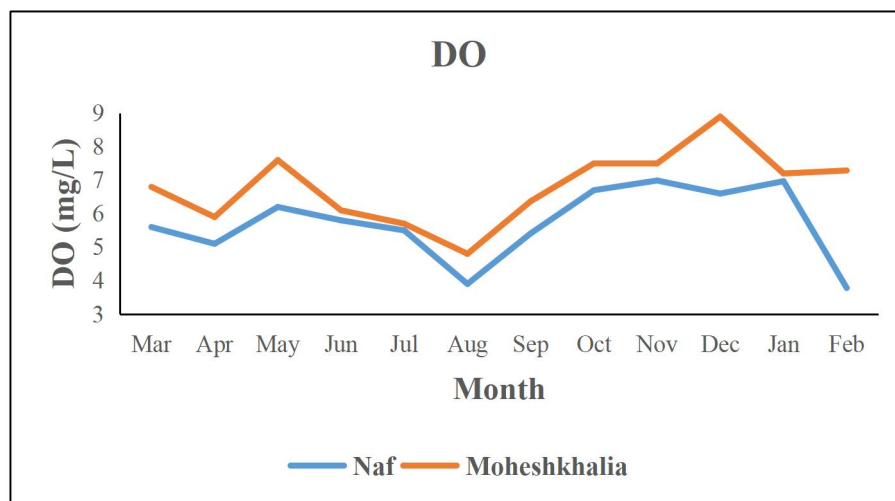


Figure 4: Monthly variations of DO in two sampling area

4.1.4 Temperature

The mean value of water temperature was estimated as (25.62 ± 5.59) °C and maximum values of temperature were found 35.5°C in Naf estuary in September and minimum 13.9°C was found during July in Moheshkhalia. Monthly variations of temperature have been shown in following figure 5:

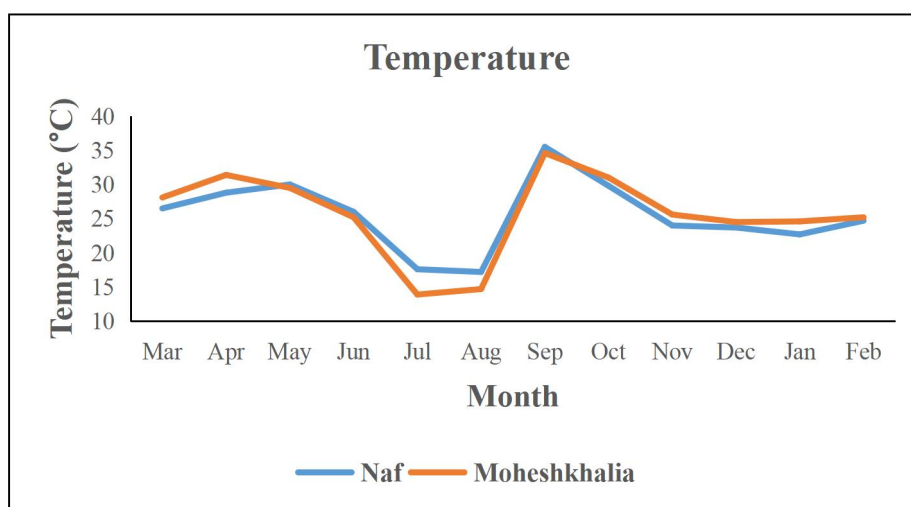


Figure 5: Monthly variations of Temperature in two sampling area

4.1.5 Total Dissolved Solid (TDS)

The average value of TDS content in water was recorded (557.33 ± 65.62) mg/L with the highest value 655 mg/L during January and lowest value 390 mg/L was found in Moheshkhalia during February. The variation of TDS of each month have been shown in following figure 6:

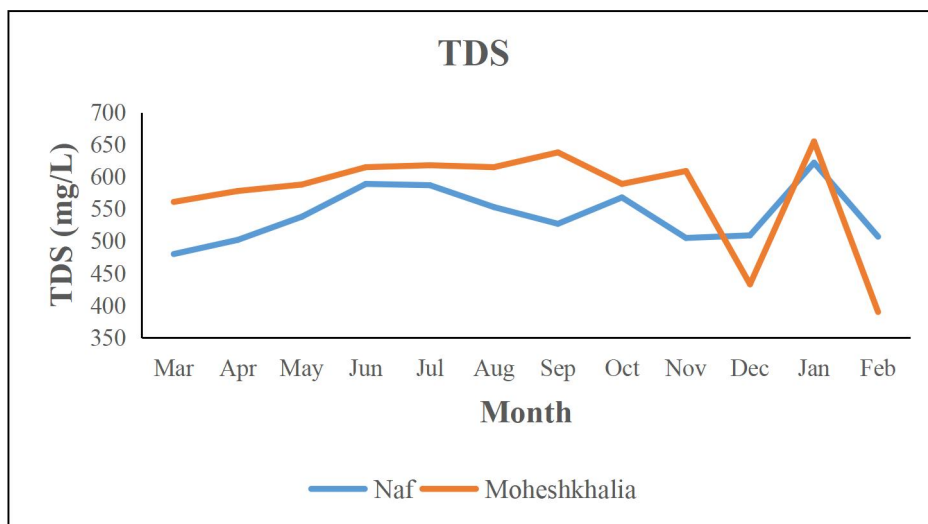


Figure 6: Monthly variations of TDS in two sampling area

4.1.6 Alkalinity

The value of alkalinity were found maximum 309 mg/L in Naf estuary in May and minimum 118 mg/L was found during October in Moheshkhalia with the average value of (214.75 ± 57.55) mg/L. Monthly variations of alkalinity have been shown in following figure 7:

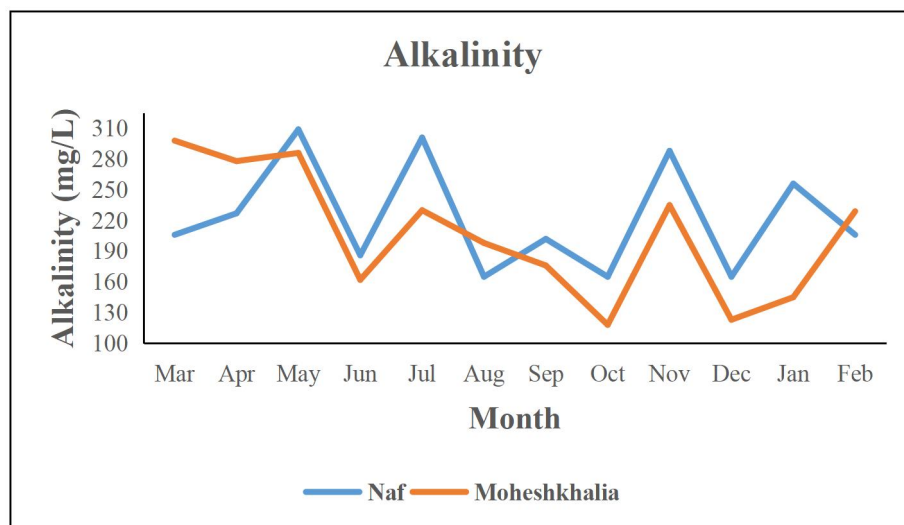


Figure 7: Monthly variations of Alkalinity in two sampling area

4.1.7 Transparency

The value of transparency was observed higher during February with value of 68 cm and minimum value was found 31cm during April in Moheshkhalia & Naf estuary respectively with the mean of (49.04 ± 9.55) cm. Monthly variations of transparency have been shown in following figure 8:

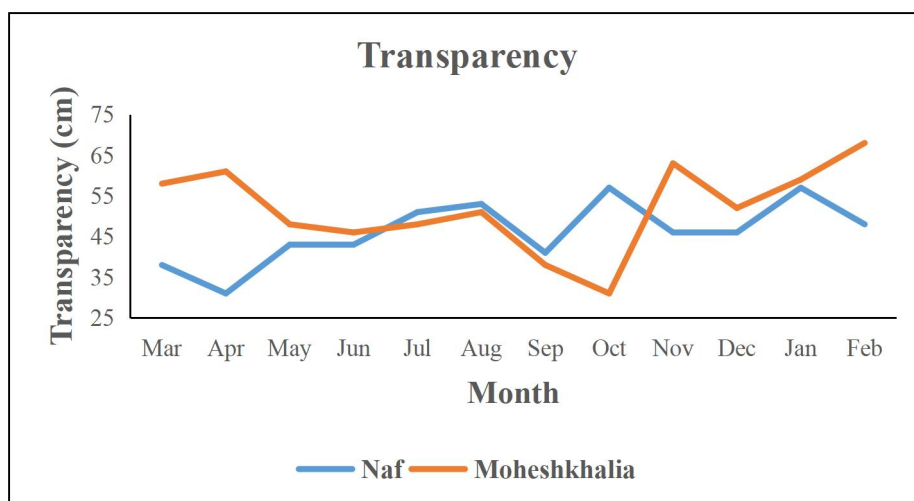


Figure 8: Monthly variations of Transparency in two sampling area

4.2 Water Quality Parameters in terms of stations

4.2.1 Salinity

The mean value of water Salinity were observed (22.71 ± 4.56) mg/L in Naf and (24.50 ± 5.61) mg/L in Moheshkhalia (Table 2) and no significant relation ($P > .05$) was found in terms of two stations with salinity. Average value of salinity of the two stations have been shown in following figure 9:

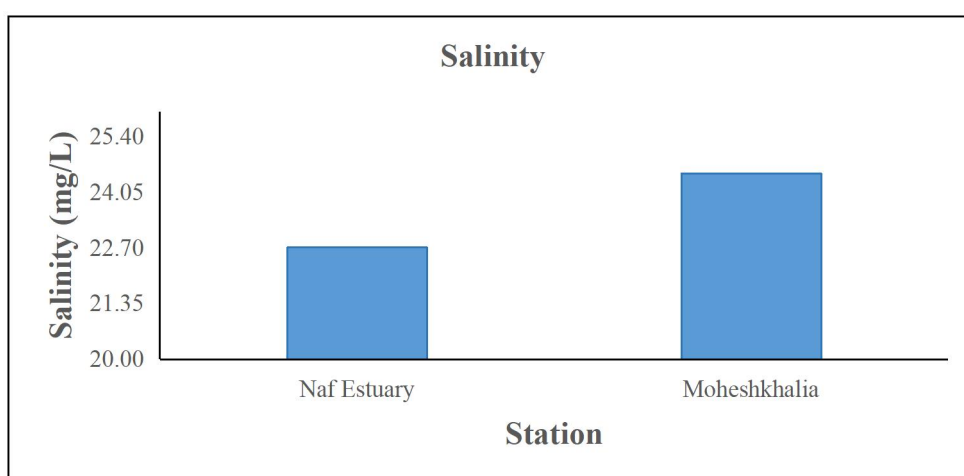


Figure 9: Variation of Salinity in two stations.

4.2.2 pH

The mean value of water pH was recorded (7.32 ± 0.57) in Naf and (7.86 ± 0.63) in Moheshkhalia (Table 2) and no significant relation was found in terms of stations. Average value of pH of two station has been shown in following figure 10:

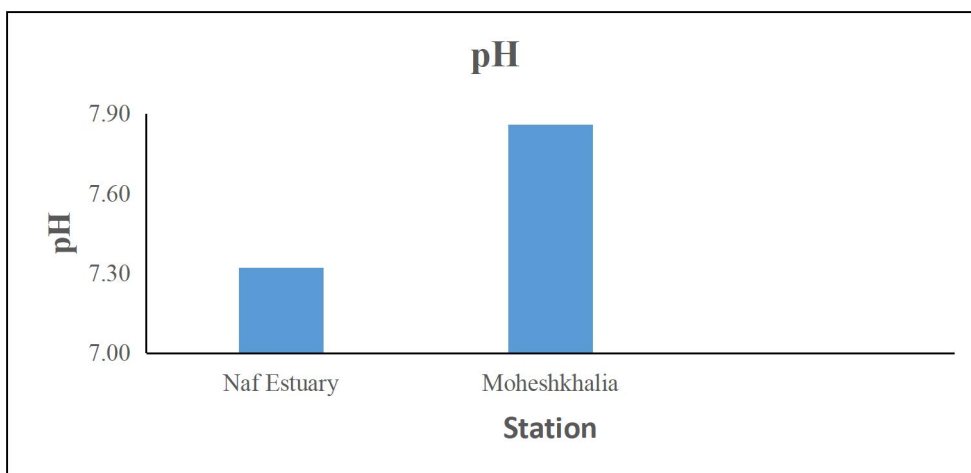


Figure 10: Variation of pH in two stations.

4.2.3 Dissolved Oxygen

The average value of water DO was obtained (5.71 ± 1.08) mg/L in Naf and (6.81 ± 1.09) mg/L in Moheshkhalia (Table 2) and no significant variation was observed in two stations. Average value of DO of two stations has been shown in following figure 11:

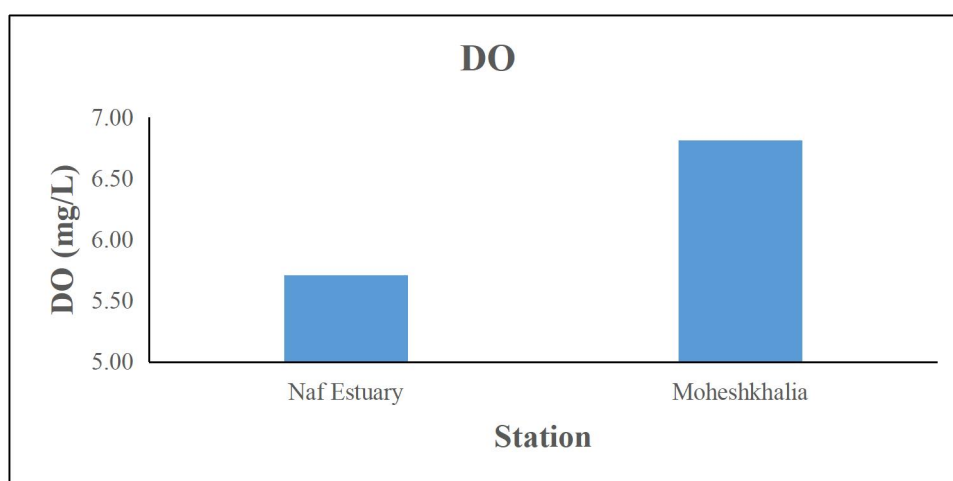


Figure 11: Variation of DO in two stations.

4.2.4 Temperature

The mean value of water Temperature content was recorded (25.54 ± 5.19) °C in Naf and (25.69 ± 6.20) °C in Moheshkhalia (Table 2) and no significant relation was found.

Average value of Temperature of the two stations have been shown in following figure 12:

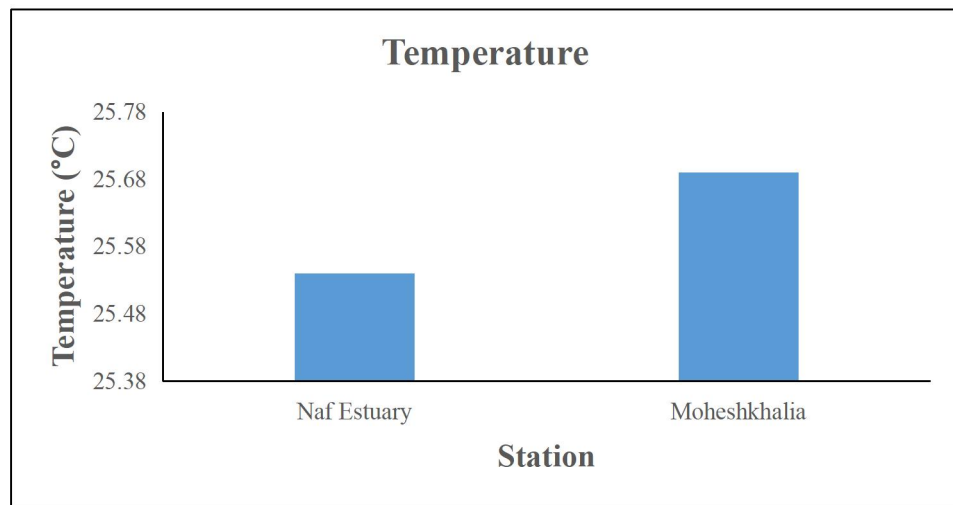


Figure 12: Variation of Temperature in two stations.

4.2.5 TDS

The average value of water TDS content was occupied (540.58 ± 43.46) mg/L in Naf and (574.80 ± 80.64) mg/L in Moheshkhalia (Table 2) and no significant relation was found in two stations. Average value of TDS of two stations have been shown in following figure 13:

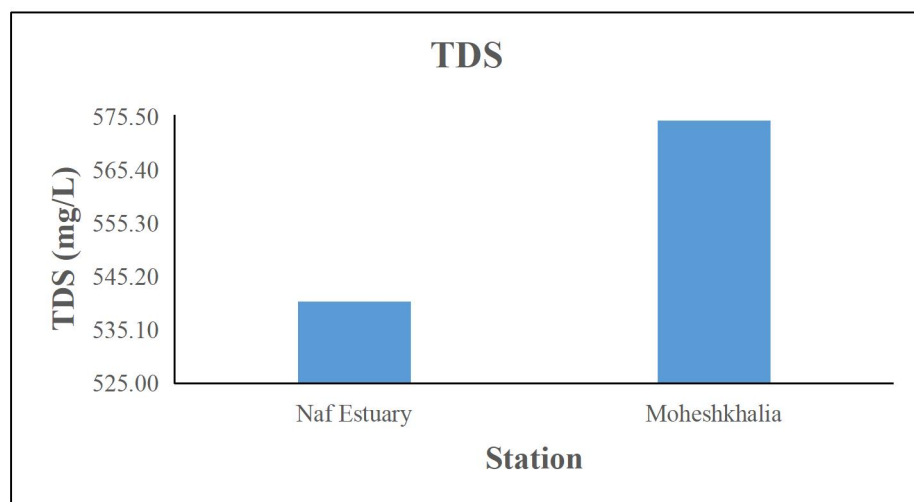


Figure 13: Variation of TDS in two stations.

4.2.6 Transparency

The average value of water Transparency content was found (46.17 ± 7.70) cm in Naf and (51.92 ± 10.66) cm in Moheshkhalia (Table 2) and no significant variation was observed. Average value of Transparency of two stations have been shown in following figure 14.

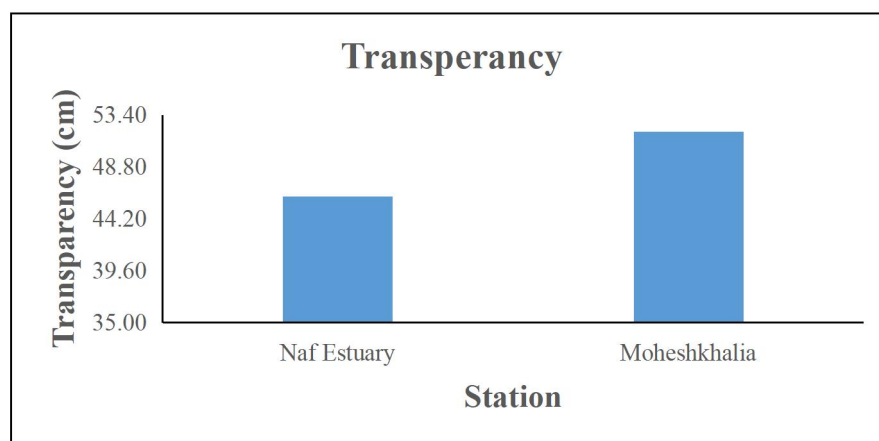


Figure 14: Variation of Transparency in two stations.

4.2.7 Alkalinity

The average value of water Alkalinity content was observed (223 ± 53.33) mg/L in Naf and (206.50 ± 62.70) mg/L in Moheshkhalia (Table 2) and found no significant variation. Average value of Alkalinity of two station has been shown in following figure 15:

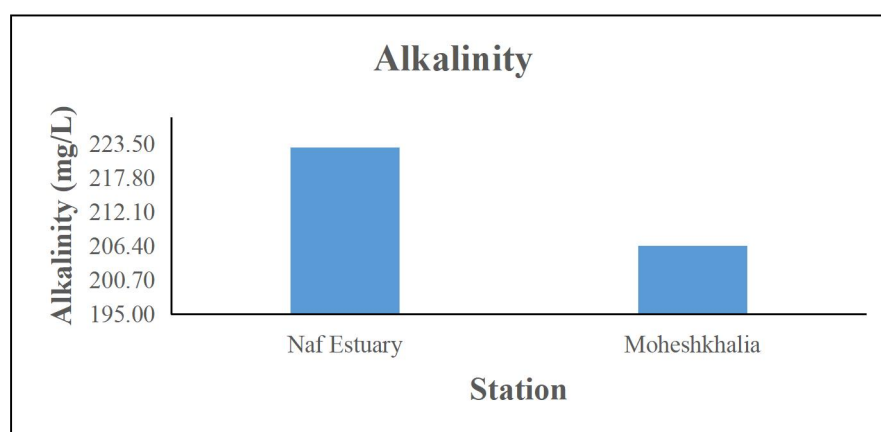


Figure 15: Variation of Alkalinity in two stations.

Table 2: The mean value of water quality parameters of two sample areas.

Parameter	Naf Estuary	Moheshkhalipara Coast
Salinity (mg/L)	22.71 ± 4.56	24.50 ± 5.61
pH	7.32 ± 0.57	7.86 ± 0.63
DO (mg/L)	5.71 ± 1.08	6.81 ± 1.09
Temperature (°C)	25.54 ± 5.19	25.69 ± 6.20
TDS (mg/L)	540.58 ± 43.46	574.80 ± 80.64
Transperancy (cm)	46.17 ± 7.70	51.92 ± 10.66
Alkalinity (mg/L)	223 ± 53.33	206.50 ± 62.70

4.3 Seasonal Variability in Physico-chemical Parameters of Water

4.3.1 Salinity

Seasonally observed highest salinity was 31.22 mg/L found in Moheshkhalia during Pre-monsoon and lowest value (19 mg/L) was found in Naf estuary during Monsoon with the mean value of (23.60 ± 5.08) mg/L and found significant relationship ($P = .02 < .05$). Then, Salinity was showed strong correlation with alkalinity ($r = .654$) but weak correlation was found with other parameters (Table 3) & (figure 23). Seasonal variability of salinity has been shown in the following figure 16:

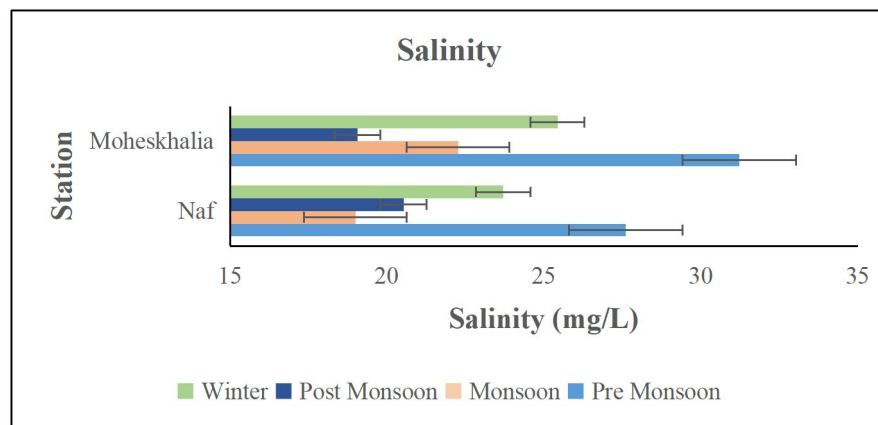


Figure 16: Seasonal variations of Salinity in two sampling area

4.3.2 pH

Seasonally the maximum value of pH (8.3) was found in Moheshkhalia during Winter and minimum value of pH (6.83) was found in Naf estuary during Monsoon with an average value of (7.59 ± 0.65) having no significant relation. But pH had shown high significant ($P = .003 < .01$) strong relation ($r = .888$) with DO (Table 3) (Figure 23). Seasonal variability of pH has been shown in the following figure 17:

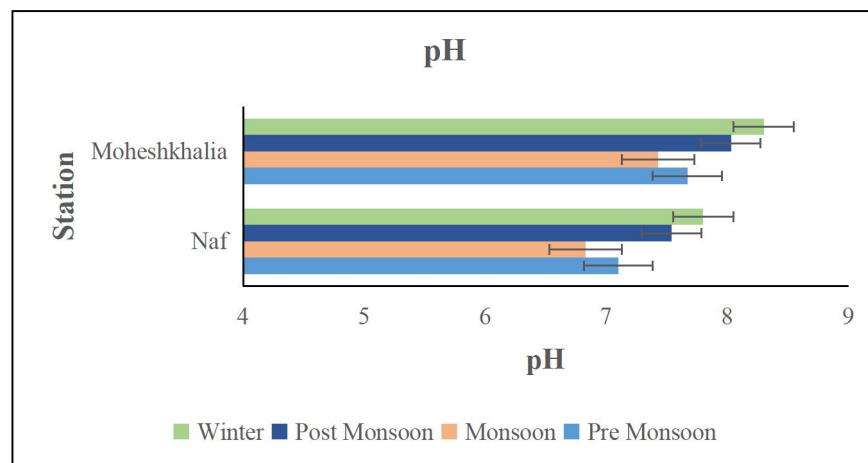


Figure 17: Seasonal variations of pH in two sampling area

4.3.3 Dissolved Oxygen

Seasonally observed maximum DO (7.8 mg/L) was found in Moheshkhaila during Winter and minimum value (5.07 mg/L) was found in Naf estuary during Monsoon with a mean of (6.26±1.20) mg/L and seasonally was found no significant variation. Moreover, DO had shown high significant (P=.003) strong relation ($r=.888$) with pH (Table 3 & figure 23). The seasonal variation of DO (Figure 18) has been shown in the following:

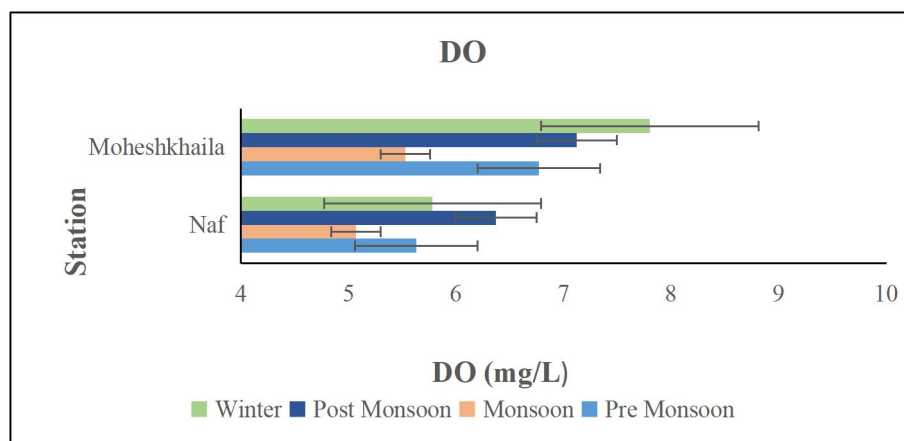


Figure 18: Seasonal variations of DO in two sampling area

4.3.4 Temperature

Seasonally highest value (30.4°C) of temperature & lowest value (17.93°C) was found in Moheshkhaila during Post monsoon and Monsoon respectively with a mean of (25.62±5.59) °C and seasonally high significant variation ($P= .001 < .01$) was observed. Besides temperature had shown negative relation with TDS and Transparency and moderate relation with Alkalinity ($r= .307$) (Table 3 & Figure 23). Seasonal variability of temperature has been shown in the following figure 19:

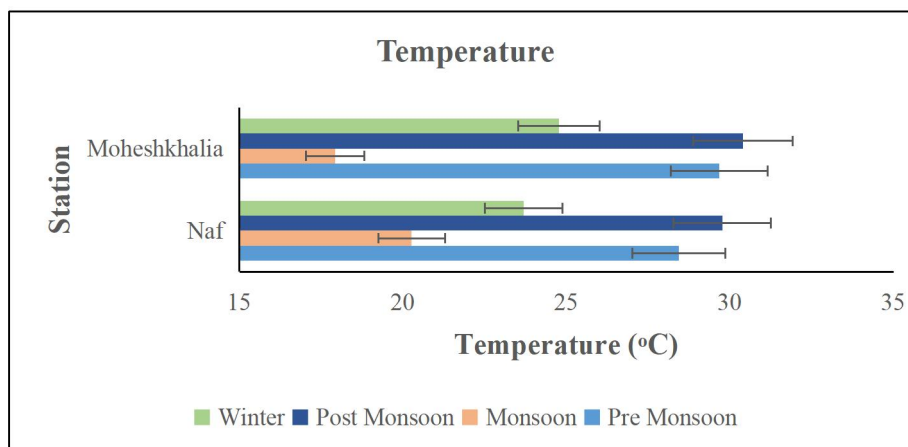


Figure 19: Seasonal variations of Temperature in two sampling area

4.3.5 Total Dissolved Solid

The maximum value of TDS (616 mg/L) during Monsoon and minimum value (492.67 mg/L) during Winter was recorded from Moheshkhalia with a mean of (557.33±65.62) mg/L and seasonally had no significant variation. But TDS had shown negative weak and moderate correlation with other parameters (Table 3 & Figure 23). Seasonal variability of TDS has been shown in the following figure 20:

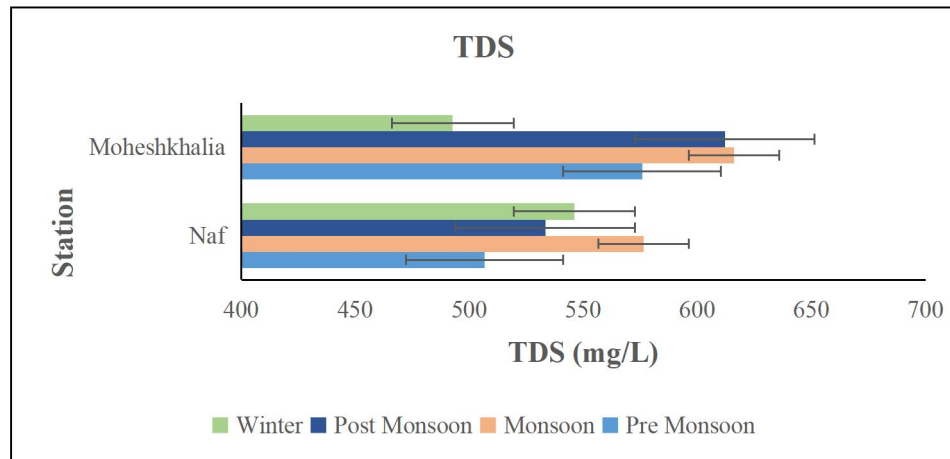


Figure 20: Seasonal variations of TDS in two sampling area

4.3.6 Transparency

Seasonally maximum and minimum value like 59.67cm and 37.33cm was found in Moheshkhalia during Winter season and Naf estuary during Pre-monsoon respectively with a mean value of (49.04±9.55) cm & no significant variation was observed. Furthermore, positive strong correlation was found with pH and DO (Table 3 & Figure 23). The variation of transparency has been shown in following figure 21:

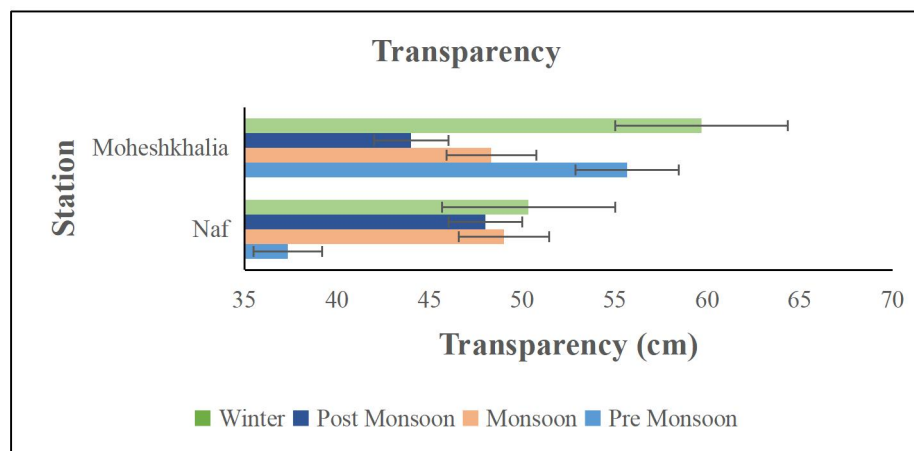


Figure 21: Seasonal variations of Transparency in two sampling area

4.3.7 Alkalinity

Seasonally observed highest and lowest value of alkalinity like 287.33 mg/L and 165.67 mg/L was found in Moheshkhalia during Pre-monsoon and Winter respectively and had no observed significant variation with average value of (214.75±57.55) mg/L. Therefore, Alkalinity had shown positive correlation with Salinity and Temperature and (Table 3 & Figure 23). Seasonal variation of Alkalinity has been shown in the following figure 22:

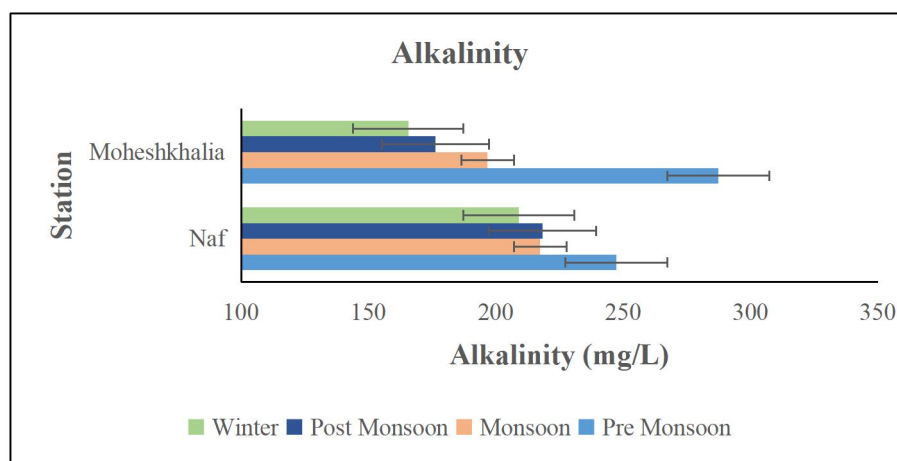


Figure 22: Seasonal variations of Alkalinity in two sampling area 1

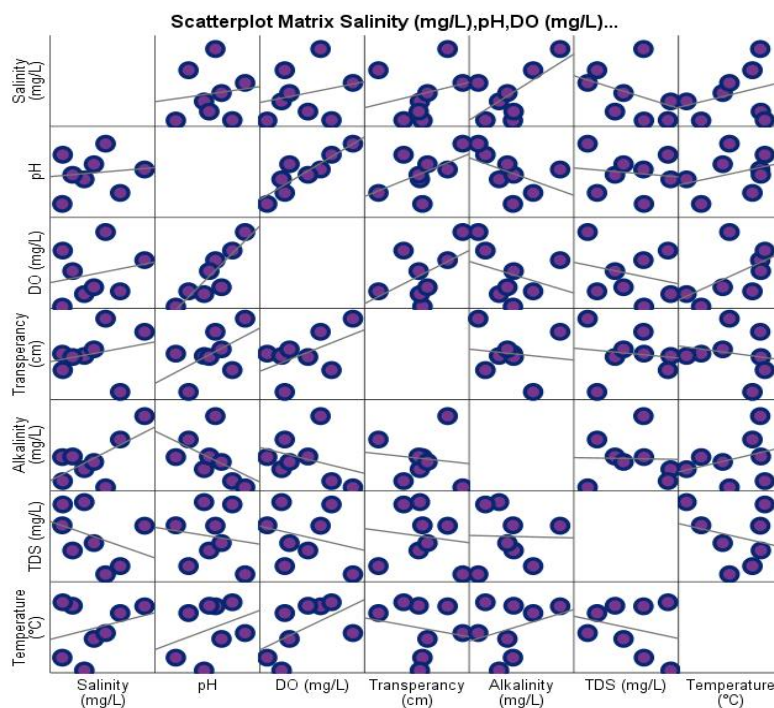


Figure 23: Correlation Matrix of Water Parameter

Table 3: Correlation among the Physico-chemical parameters of water of the two sampling areas in Teknaf Coast. (Pearson Method)

		Salinity (mg/L)	pH	DO (mg/L)	Temperature (°C)	TDS (mg/L)	Transparency (cm)	Alkalinity (mg/L)
Salinity (mg/L)	Pearson Correlation	1	.128	.228	.286	-.379	.246	.654
	Sig. (2-tailed)		.763	.587	.493	.355	.557	.079
	N	8	8	8	8	8	8	8
pH	Pearson Correlation	.128	1	.888*	.325	-.135	.532	-.480
	Sig. (2-tailed)	.763		.003	.432	.750	.175	.229
	N	8	8	8	8	8	8	8
DO (mg/L)	Pearson Correlation	.228	.888**	1	.539	-.251	.516	-.314
	Sig. (2-tailed)	.587	.003		.168	.549	.191	.449
	N	8	8	8	8	8	8	8
Temperature (°C)	Pearson Correlation	.286	.325	.539	1	-.253	-.179	.307
	Sig. (2-tailed)	.493	.432	.168		.545	.671	.460
	N	8	8	8	8	8	8	8
TDS (mg/L)	Pearson Correlation	-.379	-.135	-.251	-.253	1	-.129	-.022
	Sig. (2-tailed)	.355	.750	.549	.545		.761	.958
	N	8	8	8	8	8	8	8
Transparency (cm)	Pearson Correlation	.246	.532	.516	-.179	-.129	1	-.123
	Sig. (2-tailed)	.557	.175	.191	.671	.761		.772
	N	8	8	8	8	8	8	8
Alkalinity (mg/L)	Pearson Correlation	.654	-.480	-.314	.307	-.022	-.123	1
	Sig. (2-tailed)	.079	.229	.449	.460	.958	.772	
	N	8	8	8	8	8	8	8

** Correlation is significant at the 0.01 level (2-tailed).

CHAPTER V

DISCUSSIONS

Physico-chemical parameters is the component of water and quality of water generally refers to present at optimum level for suitable growth of plants and animals in a healthy aquatic ecosystem. In order to understand the fertility of any aquatic system for its possible use, a study on its physicochemical characteristics of water and its variability with season is indispensable. A comparative study of physico-chemical parameters of coastal water have been discussed with certain periodic patterns that are typical to the tropical coastal ecosystem.

5. Physico-chemical Parameters of Water:

Precipitation, erosion, weathering of crustal materials and evolution processes etc. natural processes influences the physico-chemical parameters of water. Through assessment the chemistry of water to observe the metabolism of the ecosystem and general hydro biological interrelationship (Meena and Chandrakala, 2017).

5.1 Variation of Water Quality Parameters in terms of Station & Season

5.1.1 Water Temperature

Temperature is very crucial parameter in water quality for sustain of life in aquatic ecosystem. In the present study, average recorded (25.62 ± 5.59) °C temperature was found in Teknaf coast and the average temperature was found 25.54°C in Naf estuary and 25.69°C in Moheshkhali. Moreover, seasonally recorded highest temperature 30.4°C was found in Post monsoon and lowest 17.03 °C was recorded in Monsoon in the Moheshkhali and observed negative correlation with TDS and Transparency and showed high significant variance with seasons ($.001 < .01$)

The WQG and GES (2016) reported that water temperature in between 25.0 to 31.0°C as the permissible limit. According to EQS (1997), the standard temperature of surface water ranged from 20 to 30°C. Alam (2021) recorded $(27-34)$ °C temperature was found in the Naf River. Therefore, no significant fluctuation was found with temperature among the two sampling stations. However, a highly significant difference was observed in the month-wise analysis, where the temperature in July was significantly lower in two areas than in other months of the study period (Figure

5). Water temperature fluctuation in those months occurred probably due to the air temperature of the surrounding influence air (Mehedi et al., 2000).

Seasonally, higher values of temperature recorded in dry season because of heat rising of surface water and less solar radiation with heavy rainfall decline the temperature during Monsoon (Das et al., 1997 and Karuppasamy et al., 1999). Imran et al. (2020) reported that, the recorded water temperatures 27.5, 28.0 and 29.0 (°C) in Pre-monsoon, Monsoon, and Post-monsoon respectively, which revealed that temperature was increased with passing the time, hence the highest temperature (29.0 °C) was found at Post monsoon in Moheshkhali fishing zone of Cox's Bazar, which was optimum for aquatic life.

5.1.2 Salinity

Salinity acts as a vital factor among environmental parameters in coastal water to distribution of aquatic organisms. In this study, the average concentration of salinity (23.60±5.08) mg/L was recorded in Teknaf coast and the mean value of 22.71 mg/L and 24.50 mg/L was found in Naf estuary and Moheshkhali respectively and then seasonally maximum salinity 31.22 ppt was found in Moheshkhali during Pre-monsoon and minimum value was recorded 19 ppt in Naf estuary during Monsoon and seasonally significant relationship was found.

Mahmood et al. (1976) recorded the coastal water salinity ranges in between (19.68–31.98) ppt. Salinity standard for coastal seawater is 33 to 34 ppt set by MoE (2004). The concentration of salinity varied from 25-30 ppt in the Naf River (Alam, 2021). But in two study area the concentration of salinity was comparably low than the standard value. No notable contrast was found amongst the stations. Though the fluctuation was seen in monthly basis. In October, salinity decreased significantly and the range of salinity in all stations was similar (Figure 2). Zafar (1992) observed that the values of salinity were proportional to the values of water temperature in coastal waters of Bangladesh.

Seasonally the nature of sea-tide significantly influences the salinity through upright mixing of water column (Islam et al., 2019). High values of salinity attributed during Pre-monsoon due to evaporation and low quantity of rainfall (Balasubramanian and Kannan, 2005) and during Monsoon, addition of freshwater by rainfall or runoff which dilutes the seawater reduces the salinity (Science Learning Hub 2010). The

findings of the present investigation are apparently harmonious with the above-mentioned results.

5.1.3 pH

pH is a crucial component in water that works as an indicator of the water body, because it alters the solubility and availability of nutrients and how aquatic organisms can utilize them. In the present study the average pH level was found (7.59 ± 0.65) and the mean value of pH 7.32 and 7.86 were recorded from Naf estuary and Moheshkhali respectively whereas the standard value of pH of the coastal water of Bangladesh is pH 6 to 9 (EQS, 1991). According to the ECR (1997) of Bangladesh, the standard pH limit is 6.5 to 8.5 for coastal inland water and for fisheries and livestock is 5.5 to 9.0. Alam (2021) revealed that pH level fluctuated from 7.2-8.7 in Naf estuary. No notable fluctuations were found during the period of study. Moreover, no sharp exception was detected among the sampling stations.

In this investigation the pH level fluctuated seasonally and high level of pH 8.3 was recorded in Moheshkhalia during Winter and low level of pH 6.83 was found in Naf estuary during Monsoon having high significant positive strong correlation with DO (Table 3). DO was showed positive correlation with pH (Srinivasan and Natesan, 2013). High pH values observed due to water salinity which may cause sea water deprivation and high-density phytoplankton effect (Prabu et al., 2008) and the lower values of pH might be attributed to the dilution of waters by river runoff (Mehedi et al., 2000). Normally, fluctuations in pH values during different seasons of the year is like to removal of CO₂, reduction of salinity, temperature and decomposition of organic materials as stated by Rajasegar (2003). The outcome of present study shows similar trend of results.

5.1.4 Dissolved Oxygen

The DO is important parameter in limnology refers to the amount of oxygen dissolved in the water (Weiss 1970). The readings of average DO were (6.26 ± 1.20) mg/L obtained from Teknaf coast with the mean value of DO 5.71 mg/L was found in Naf estuary and 6.81 mg/L was recorded in Moheshkhalia. The optimum value of DO for the coastal water of Bangladesh is 4-6.0 mg/L (EQS, 1991) and >5 mg/L is need for aquatic survival and aquaculture (Rahman et al., 2018). Alam (2021) found that the DO content was (7-13) mg/L in the Naf River water which were suitable for aquatic

organisms and fisheries. In there, notable change was not found among different Stations (Table 3).

Seasonally in the study, the maximum DO was 7.8 mg/L found in Moheshkhalia during Winter and minimum level of DO was 5.07 mg/L was obtained from Naf estuary during Monsoon and observed negative correlation with TDS and Alkalinity and had no significant variance with season. Hasan et al. (2019) suggested that DO was higher in Winter than another seasons. According to Imran et al. (2020) the highest DO content 6.91 mg/L was found at Post monsoon and lowest content 6.20 mg/L was found at both Pre-monsoon and Monsoon in Moheshkhali fishing zone. Therefore, Seasonal variability of DO was satisfactory level with above results.

5.1.5 Total Dissolved Solid

Total dissolved solids in coastal water were increased by the activities of the land (Islam et al., 2019). In the study, the average value of TDS was (557.33 ± 65.62) mg/L recorded and the mean value of TDS 540.58 mg/L was found in Naf estuary and 574.80 mg/L was found in Moheshkhalia. The ADB (1994) set the standard values as 1000 mg/L for coastal marine water which is safe for aqua culture in respect of TDS. TDS of coastal seawater ranged from 29575 to 31980 mg/L (Kashem et al., 2019). Imran et al., (2020) reported the TDS ranged from (311 to 615) mg/L in Moheshkhali Fishing zone. Therefore, higher TDS content could be due to salinity or it indicates probable presence of pollution (Hasan et al., 2019). Hence, no notable variation was occurred in two sampling stations (Table 3).

Moreover, the study recorded seasonally high value 616 mg/L and low value 492.67 mg/L of TDS was found during Monsoon and Winter in Moheshkhalia respectively. TDS influence through changing of geological character like sedimentation, water shed, rainfall and amount of surface runoff (Parvez et al. 2018). According to Imran et al., (2020) the highest TDS content was 615 mg/L and lowest content was 311 mg/L found at Pre-monsoon and Post-monsoon in Moheshkhali fishing zone respectively. Due to sedimentation of suspended solid low value of TDS recorded in Winter (Moharana and Patra 2014), and lower values also occurred during Monsoon suggest that the runoff water only contributes to its dilution in the rainy season (Izonfuo and Bariweni, 2001), but in this study the maximum TDS value was found in Monsoon. In study TDS showed negative relation with all other parameter. Variability of TDS

influenced by various physical chemical parameters like maximum TDS content could be due to salinity or presence of pollutant (Hasan et al., 2019) and pH parameter also responsible for precipitate the solubility of suspended matter (Islam et al., 2019). The findings of the variability were apparently rough with the above-mentioned results.

5.1.6 Transparency

Water transparency is reflected as the source of energy in water. Changes in water transparency is related to eutrophication and phytoplankton biomass (Lim and Choi, 2015). The average value of transparency in the present investigation was (49.04 ± 9.55) cm and the mean value of 46.17 cm was found in Naf estuary and 51.92 cm was found in Moheshkhalia. The transparency ranges from 35 to 45 cm are suitable for the aquatic habitat (Hosen et al., 2011). The value of transparency fluctuated from 19-54 cm in the Naf River reported by Alam (2021). Hence, no strong contrast was witnessed in the station-wise evaluation.

In the present investigation, seasonally maximum value 59.67cm and minimum value 37.33 cm was found in Moheshkhalia and Naf estuary during Winter and Pre monsoon respectively and showed strong relation with pH ($r = .532$) and also seasonally had no significant variation. The low values of water transparency occurred due to rainfall and high value of transparency occurred due to low wave action and absence of rainfall (Alam, 2021).

5.1.7 Alkalinity

Alkalinity is an indicator of the buffering function in water and also provides information about the natural salts present in water (Shaik et al. 2015). The average value of alkalinity (214.75 ± 57.55) mg/L was obtained from Teknaf coast and mean value of alkalinity 223 mg/L was found in Naf estuary and 206.5 mg/L was in Moheshkhalia. Moreover, seasonally high and low value of alkalinity was 287.33 mg/L and 165.67 mg/L variation occurred in Moheshkhalia during Pre-monsoon and Winter respectively and seasonally had no significant variance. According to the WHO (2006) and ECR of Bangladesh (1997) the value of water alkalinity was 250mg/L and 500mg/L respectively. The standard limit of alkalinity is >100 mg/L (EPA, 1993). According to Alam (2021), indicated alkalinity was (86-336) mg/L in the Naf River. Based on standard scale, the average value of sample alkalinity was comparably good in two areas. Salvi et al., (2014) revealed that maximum and

minimum value 240 mg/L and 50 mg/L was observed in Khijadiya and Okha during Pre monsoon and Winter. The findings of the variability were apparently good as the above-mentioned result.

CHAPTER VI

CONCLUSIONS

The study of the water quality in the Teknaf coast was conducted to determine and monitor the physico-chemical parameters of water with seasonal variability. As a result, this experiment was done for one year and average data of three times collected sample water of each month were recorded in excel sheet for analyzing of data.

Analyzing result and discussion can conclude that, the water quality was at satisfied level in two sampling areas of the Teknaf coast. The mean values of physico-chemical parameters were comparatively similar in two stations, no notable significant fluctuations were observed in terms of stations and seasons but seasonally highly significant variations found in Temperature and Salinity. Moreover, DO and pH had shown positive high significance and strong correlation with each other.

The findings of the seasonal variability of water quality parameters were apparently harmonious and maximum variable were observed in Winter and Moonsoon. The level of physico-chemical parameters such as Temperature, Salinity, pH, DO, Transparency and Alkalinity were increased during Pre-Monsoon, Post Monsoon and Winter and decreased during Monsoon. In contrast, only TDS was increased during monsoon due to lack of rainfall and pollution.

This research on the water quality assessment will help people to determine the value of water parameter and also help to observe the variations among the whole season. This study also suggested for regular monitoring of the water quality parameter to maintain such type of favorable states in coastal and also all existing rivers in Bangladesh. Consequently, this study will benefit future researches to get comparable ideas about the water quality parameters in the coastal region of Bangladesh and also help to outline the convenient zonation of fishing and fish culture activity.

CHAPTER VII

Recommendations and Future Perspectives

- Responsible authority should concern about the anthropogenic activities like wastes throwing by people either in the beach or in water which is responsible for deteriorating the water quality.
- Responsible authority should make awareness build up programme in people about the coast of Bangladesh.
- Furthermore, the research work should be conducted to reach the knowledge among people how to management of wastage and how to monitor the water quality parameter in coastal region.
- Responsible authority may get information for their future management of coastal region.
- Any student can get knowledge overall on the water quality of Teknaf coast.

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Appendices

Appendix-A: Water Quality Parameters in the Teknaf Coast

Month	Station	Salinity (PPT)	pH	DO (mg/L)	Temperature (°C)	TDS (MG/L)	Transparency (cm)	Alkalinity (MG/L)
Mar_20	Naf Estuary	29.7	7.4	5.6	26.5	480	38	206
Mar_20	Moheshkhalia para Coast	31.1	7.7	6.8	28.1	561	58	298
Apr_20	Naf Estuary	26.5	6.8	5.1	28.8	502	31	227
Apr_20	Moheshkhalia para Coast	30.17	7.1	5.9	31.4	578	61	278
May_20	Naf Estuary	26.6	7.1	6.2	30	538	43	309
May_20	Moheshkhalia para Coast	32.4	8.2	7.6	29.5	588	48	286
Jun_20	Naf Estuary	22.5	6.8	5.8	26	589	43	186
Jun_20	Moheshkhalia para Coast	25.5	7.1	6.1	25.2	615	46	162
Jul_20	Naf Estuary	17.8	6.9	5.5	17.6	587	51	301
Jul_20	Moheshkhalia para Coast	19.7	7.8	5.7	13.9	618	48	230
Aug_20	Naf Estuary	16.7	6.8	3.9	17.2	553	53	165
Aug_20	Moheshkhalia para Coast	21.6	7.4	4.8	14.7	615	51	198
Sep_20	Naf Estuary	18.7	8.02	5.41	35.5	527	41	202
Sep_20	Moheshkhalia para Coast	18.9	8.9	6.37	34.6	638	38	176
Oct_20	Naf Estuary	17.2	6.6	6.7	29.8	568	57	165
Oct_20	Moheshkhalia para Coast	19.1	6.9	7.5	31.01	589	31	118
Nov_20	Naf Estuary	25.7	8	6.99	24	505	46	288
Nov_20	Moheshkhalia para Coast	19.2	8.3	7.5	25.6	609	63	235
Dec_20	Naf Estuary	20.4	7.3	6.6	23.7	509	46	165

Dec_20	Moheshkhalai para Coast	18	8.2	8.9	24.5	433	52	123
Jan_21	Naf Estuary	22.6	8.2	6.97	22.7	622	57	256
Jan_21	Moheshkhalai para Coast	30.08	8.5	7.2	24.6	655	59	145
Feb_21	Naf Estuary	28.1	7.9	3.78	24.7	507	48	206
Feb_21	Moheshkhalai para Coast	28.2	8.2	7.29	25.2	390	68	229

Appendix-B: Average Value of Water Quality Parameters in Naf estuary and Moheshkhalia para

Parameter	Naf Estuary	Moheshkhalipara Coast
Salinity (PPT)	22.71 ± 4.56	24.50±5.61
pH	7.32± 0.57	7.86±0.63
DO (mg/L)	5.71± 1.08	6.81±1.09
Temperature (°C)	25.54±5.19	25.69±6.20
TDS (MG/L)	540.58±43.46	574.80±80.64
Transparency (cm)	46.17±7.70	51.92±10.66
Alkalinity (MG/L)	223±53.33	206.50±62.70

Appendix-C: Seasonal Variation of Water Quality Parameter in Naf estuary

Season	Salinity	pH	DO	Temperature	TDS	Transparency	Alkalinity
Pre-Monsoon	29.7	7.4	5.6	26.5	480	38	206
	26.5	6.8	5.1	28.8	502	31	227
	26.6	7.1	6.2	30	538	43	309
Monsoon	22.5	6.8	5.8	26	589	43	186
	17.8	6.9	5.5	17.6	587	51	301
	16.7	6.8	3.9	17.2	553	53	165
Post Monsoon	18.7	8.02	5.41	35.5	527	41	202
	17.2	6.6	6.7	29.8	568	57	165
	25.7	8	6.99	24	505	46	288
Winter	20.4	7.3	6.6	23.7	509	46	165
	22.6	8.2	6.97	22.7	622	57	256
	28.1	7.9	3.78	24.7	507	48	206

Appendix-D: Seasonal Variation of Water Quality Parameter in Moheshkhalia para.

Season	Salinity	pH	DO	Temperature	TDS	Transparency	Alkalinity
Pre-Monsoon	31.1	7.7	6.8	28.1	561	58	298
	30.17	7.1	5.9	31.4	578	61	278
	32.4	8.2	7.6	29.5	588	48	286
Monsoon	25.5	7.1	6.1	25.2	615	46	162
	19.7	7.8	5.7	13.9	618	48	230
	21.6	7.4	4.8	14.7	615	51	198
Post Monsoon	18.9	8.9	6.37	34.6	638	38	176
	19.1	6.9	7.5	31.01	589	31	118
	19.2	8.3	7.5	25.6	609	63	235
Winter	18	8.2	8.9	24.5	433	52	123
	30.08	8.5	7.2	24.6	655	59	145
	28.2	8.2	7.29	25.2	390	68	229

Appendix-E: Average Seasonal Variability of Water Quality Parameter in Naf estuary & Moheshkhalia

Parameter	Naf Estuary				Moheshkhalia Coast			
	Pre-Monsoon	Monsoon	Post Monsoon	Winter	Pre-Monsoon	Monsoon	Post Monsoon	Winter
Salinity (PPT)	27.6±1.82	19±3.08	20.53±4.54	23.7±3.97	31.22±1.12	22.27±2.96	19.07±0.15	25.43±6.50
pH	7.1±0.3	6.83±0.06	7.54±0.81	7.8±0.46	7.67±0.55	7.43±0.35	8.03±1.03	8.3±0.17
DO (mg/L)	5.63±0.55	5.07±1.02	6.37±0.84	5.78±1.74	6.77±0.85	5.53±0.67	7.12±0.65	7.8±0.96
Temperature (°C)	28.43±1.78	20.27±4.97	29.77±5.75	23.7±1	29.67±1.66	17.93±6.31	30.4±4.53	24.77±0.38
TDS (mg/L)	506.67±29.28	576.33±20.23	533.33±31.97	546±65.83	575.67±13.65	616±1.73	612±24.64	492.67±142.22
Transparency (cm)	37.33±6.03	49±5.29	48±8.19	50.33±5.86	55.67±6.81	48.33±2.52	44±16.82	59.67±8.02
Alkalinity (mg/L)	247.33±54.43	217.33±73.21	218.33±63.11	209±45.57	287.33±10.07	196.67±34.02	176.33±58.50	165.67±55.94

**Appendix F: Salinity (mg/L) pH DO (mg/L) Temperature (°C) TDS (MG/L)
Transparency (cm) Alkalinity (MG/L) * Station**

ANOVA Table		
	F	Sig.
Salinity (mg/L) * Station	.310	.598
pH * Station	3.462	.112
DO (mg/L) * Station	4.009	.092
Temperature (°C) * Station	.002	.968
TDS (MG/L) * Station	1.092	.336
Transparency (cm) * Station	1.548	.260
Alkalinity (MG/L) * Station	.325	.589

**Appendix G: Salinity (mg/L) pH DO (mg/L) Temperature (°C) TDS (MG/L)
Transparency (cm), Alkalinity (MG/L) * Season**

ANOVA Table		
	F	Sig.
Salinity (mg/L) * Season	10.680	.022
pH * Season	2.284	.221
DO (mg/L) * Season	1.249	.403
Temperature (°C) * Season	47.461	.001
TDS (mg/L) * Season	1.197	.418
Transparency(cm) * Season	.622	.637
Alkalinity (mg/L) * Season	3.650	.122

Appendix H: Correlation among Physico-chemical Parameters of water of two stations in Teknaf Coast. (Pearson Method)

		Salinity (mg/L)	pH	DO (mg/L)	Temperature (°C)	TDS (MG/L)	Transperancy (cm)	Alkani ty (MG/L)
Salinity (mg/L)	Pearson Correlation	1	.128	.228	.286	-.379	.246	.654
	Sig. (2-tailed)		.763	.587	.493	.355	.557	.079
	N	8	8	8	8	8	8	8
pH	Pearson Correlation	.128	1	.888* *	.325	-.135	.532	-.480
	Sig. (2-tailed)	.763		.003	.432	.750	.175	.229
	N	8	8	8	8	8	8	8
DO (mg/L)	Pearson Correlation	.228	.888**	1	.539	-.251	.516	-.314
	Sig. (2-tailed)	.587	.003		.168	.549	.191	.449
	N	8	8	8	8	8	8	8
Temperature (°C)	Pearson Correlation	.286	.325	.539	1	-.253	-.179	.307
	Sig. (2-tailed)	.493	.432	.168		.545	.671	.460
	N	8	8	8	8	8	8	8
TDS (MG/L)	Pearson Correlation	-.379	-.135	-.251	-.253	1	-.129	-.022
	Sig. (2-tailed)	.355	.750	.549	.545		.761	.958
	N	8	8	8	8	8	8	8
Transperancy (cm)	Pearson Correlation	.246	.532	.516	-.179	-.129	1	-.123
	Sig. (2-tailed)	.557	.175	.191	.671	.761		.772
	N	8	8	8	8	8	8	8
Alkani ty (MG/L)	Pearson Correlation	.654	-.480	-.314	.307	-.022	-.123	1
	Sig. (2-tailed)	.079	.229	.449	.460	.958	.772	
	N	8	8	8	8	8	8	8

** Correlation is significant at the 0.01 level (2-tailed).

Brief Biography

Shaky Chowdhury is a candidate for the degree of MS in Fisheries Resource Management under the department of Fisheries Resource Management, Faculty of Fisheries, CVASU. She is from Chittagong. She completed her Secondary School Certificate Examination in 2012 from Aunkur Society Girl's High School, Chittagong and also completed Higher Secondary Certificate Examination in 2014 from Kapashgola City Corporation Mohila College, Chittagong. She obtained her B.Sc. Fisheries (Hon's) in 2018 from Noakhali Science & Technology University (NSTU), Bangladesh.