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Seasonal Variation of Physico-Chemical Characteristics in the South Eastern Coastal Waters of Cox's Bazar, Bangladesh

Md. Tarikul Islam[1], Abu Sharif[2], Md. Mahbub-E-Kibria[3], Sonet Barua Emon[4], Suman Biswas[5]

Bangladesh Oceanographic Research Institute (BORI), Cox's Bazar-4730, Bangladesh

Abstract: ***The present investigation carried out to assess the seasonal variations of physico-chemical parameters at different stations in the south eastern coastal waters of Cox's Bazar, Bangadesh during July 2018 to June 2019. The parameters like Sea Surface Salinity (SSS), Sea Surface Temperature (SST), Electric Conductivity (EC), Total Dissolved Solids (TDS), Water Transparency and Water P^H were determined by using Hanna HI98194, Refractometer (Atago), Thermometer, YSI Pro30, Secchi disk, Hach HQ11d respectively. Total nine sampling stations namely Saint Martin Island (S1), ShahporirDwip (S2), Teknaf (S3), Inani (S4), Rezukhal (S5), Himsori (S6), Bakkhali (S7), Moheshkhali (S8) &Sonadia (S9) were considered for taking the desirable parameters reading. Salinity and water p^Hshowed 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. Electrical conductivity, Total Dissolved Solid (TDS) and P^H showed very good correlation with salinity changes. The physico-chemical parameters such as temperature, Salinity, pH, TDS, Water Transparency and EC were increased during Pre-Monsoon season and decreased during monsoon season. In contrast, only temperature was decreased during winter & monsoon season. The physico-chemical properties have exposed reasonable seasonal and spatial variations.***

Keywords: Physico-chemical parameters, Coastal waters, Seasonal variation, Spatial variation, Cox's Bazar

1. Introduction

The chemistry of water reveals much about the metabolism of the ecosystem and explains the general hydro biological interrelationship (Meenaet al., 2017) [1]. The coastal ecosystem is the vibrant host for fauna and flora and it is the most important resource to provide a good platform for the coastal life (Adebola et al., 2019) [2].The physico-chemical parameters of coastal water and the dependence of all life process of these factors make it desirable to take water as an environment. (Soundarapandian et al., 2009) [3].

Coastal marine environments are reported to have greater biodiversity than open ocean regions and majority of world's most productive marine ecosystems are found within coastal environments and owe their productivity, diversity and wealth of life to their terrestrial adjacency (Bierman et al., 2009) [4]. The open ocean is a lot of stable compare to the close to shore waters wherever the interaction with terrestrial and makes the variations in hydro graphic properties. The waterquality depends on each natural processes, like precipitation, erosion, weathering of crustal materials and evolution processes like urbanization, industrialization, mining and agricultural activities (Meena et al., 2017) [5]. The interactive physical, chemical, and biological processes operation in the coastal ecosystems sustain higher resulting in richness in diversity (Zhou et al. 2007) [6].

The salinity stratification has a strong stabilizing effect on the upper ocean, maintaining a shallow mixed layer (Mignot et al.,2007) [7] and often resulting in the formation of a barrier layer, i.e. a salinity-stratified layer between the bottom of the mixed layer and top of the thermocline (Lukas and Lindstrom,1991)[8]. Barrier layers usually appear during summer in the eastern Bay of Bengal and mature during winter both in amplitude and spatial extent, coveringthe entirenorthern Bay of Bengal (Rao and Sivakumar, 2003)[9].In a recent study using an ocean general circulation model, Behara and Vinayachandran (2016) found that freshwater fluxes induced a ~0.5°C warming in the northwestern Bay of Bengal during summer, and 0.5 to 1.5°C cooling in the eastern Bay of Bengal during both summer and winter. Climate models and theoretical arguments indeed supportan intensification of the hydrological cycle as the troposphere warms in response to increasing greenhouse gases concentrations (e.g. Held and Soden, 2006)[10]. The observational records already detect an intensification of salinity contrasts as a result, i.e. increasing salinities in regions dominated by evaporation, and decreasing salinities in high rainfall regions, including in the Bay of Bengal (e.g. Durack and Wijfels, 2010)[11].

The pH level reduction rate may be around 0.08 per year which is very shocking news for the biodiversity of the Bay of Bengal. Feely et al. 2009 [12] have shown a map on the global ocean acidification scenario of 2095 that the pH level of sea water in Bay of Bengal will be less than 8.0 in 2050 and bellow 7.8 in 2095. They also reported that the current pH of North Indian Ocean where Bay of Bengal is situated is 8.068 ± 0.03. Over the past 200 years, atmospheric CO_2 has increased from 280 ppm to a global average of nearly 390 ppm due to burning of fossil fuels, cement production and landuse changes (Hilmi et al. 2012) [13].

The Bay of Bengal is a reservoir of lot of marine species specially shells, coral reefs and many sea fish and mammals.

The effect of ocean acidification on marine ecosystems and organisms that inhabit them has only recently been recognized and is of serious concern to scientists and policy makers involved in climate change, biodiversity and the marine environment.

The Physico-chemical parameters, which is useful to evaluate the health of the coastal system, hence the present study was conducted to study the Physico-chemical properties of water in some place of south eastern coastal area of Cox's Bazar, Bangladesh during July 2018 to June 2019.

2. Materials and Methods

2.1 Study area

Cox's Bazar is a city, fishing port, tourism center and district headquarter in south-eastern Bangladesh. The beach in Cox's Bazar is sandy and has a gentle slope andit is the longest natural sea beach in the world running 120 kilometers(Panday V.C., ed. 2004)[14]. A lot of rivers and channels flow to the south eastern part of the Bay of Bengal and these rivers carry fresh water to the open sea. The mixing of fresh water with sea water reduces the pH and Salinity of water.

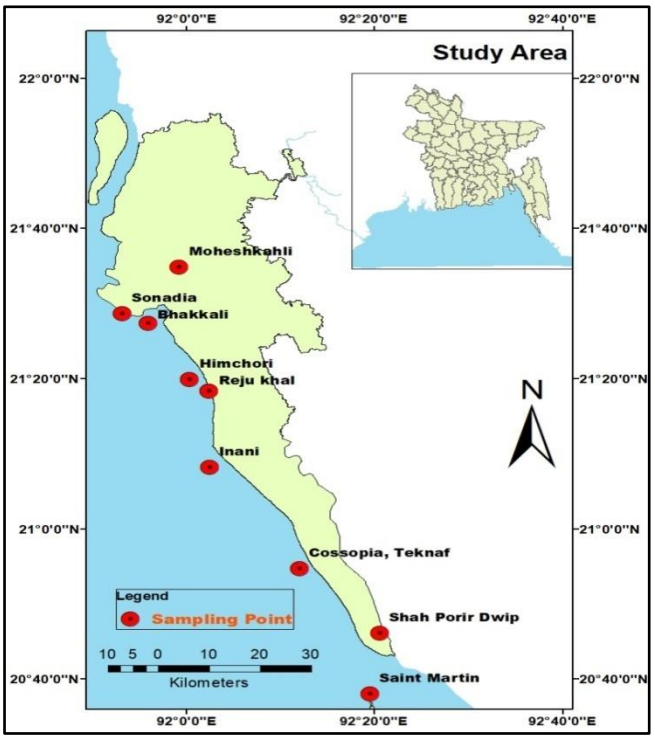


Figure 1: Study Area

The study area consists of nine different locations (S1) Saint Martin Island (Lat. 20°63'33" N and Lon. 92°32'54" E), (S2) ShahporirDwip(Lat. 20°76'89"N and Lon. 92°34'25" E), (S3)Teknaf (Lat. 20°91'10 N and Lon. 92°20''16" E), (S4) Inani (Lat. 21°13'68"N and Lon. 92°04'15" E), (S5) Rezukhal (Lat. 21°30'52"N and Lon. 92°04'05" E), (S6) Himchori (Lat. 21°33'15"N and Lon. 92°00'67" E), (S7) Bakkhali (Lat. 21°45'70" N and Lon. 91°93'29" E), (S8) Moheshkhali(Lat. 21°58'13" N and Lon. 91°98'79" E), and (S9)Sonadia Island (Lat. 21°47'79" N and Lon. 91°88'67" E), respectively. The study area is shown in the Figure 1.

The main intention of study is to estimate the baseline characteristics for the sea water and to analyze the chemical and physical characteristics of sea water of the southeastern coast of Cox's Bazar.

2.2 Estimation of Water Analysis

Water samples were collected monthly from the nine stations for a period of one year during July 2018 to June 2019. Samples were collected every month with a sterilized plastic bottle and immediately kept in an ice box and transported to the laboratory for determining the physical and chemical parameters. Water temperature was measured by using digital multi-stem thermometer of 0.1º C accuracy. Salinity was measured by using a hand held refractometer (Atago hand refractometer, Japan). Water Transparency was measured in insitu condition by using Secchi Disk. Total dissolved solids, pH and electrical conductivity were analyzed by using Hanna HI98194 multimeter and YSI portable multimeter.

2.3 Statistical Analysis

For the data analysis Microsoft Excel 2010 and SPSS 16.0 has been used.

2.4 Seasonal Consideration

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

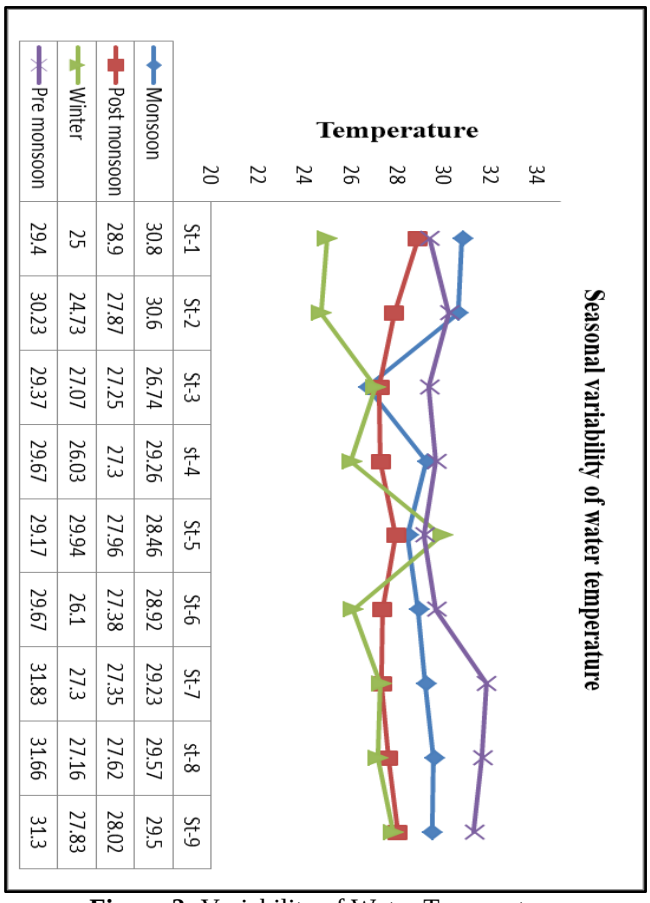
3. Result and Discussion

Physico-chemical parameters were measured one of the most significant characteristics that have the ability to impact marine ecosystem and shown wider progressive and spatial variations. All physico-chemical parameters have presented with certain periodic patterns that are typical to the tropical marine ecosystem.

3.1 Status of Sea Surface Temperature (SST)

The temperature is important for its effects on the chemistry and biological activities of organisms in water. The seasonal variation of the coastal water temperature values ranged from 25-30±2.67 (S1), 24-30±2.82 (S2), 26-29±1.26 (S3), 26-29±1.75(S4), 27-29±0.91(S5), 26-29±1.67(S6), 27-31±2.21(S7), 27-31±2.14(S8), 27-31±1.67(S9) (Figure-2). The maximum temperature (31.8°C±2.21°C) was recorded in Bakkhali (S7) during pre-monsoon and minimum (24.7°C±2.82°C) was recorded in Shahporir Dwip (S2) during winter season. Generally, surface water temperature is influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mix up with ebb and flow

from adjoining neritic waters. Less solar radiations with misty sky and moderate rainfall during the Monsoon season may greatly reduce the water temperature (Karuppasamy et al., 1999) [15]. Higher temperature values recorded in the dry season may be because of heat raising temperature of surface water. Low temperature in post monsoon season was due to winter (Das et al., 1997)[16].

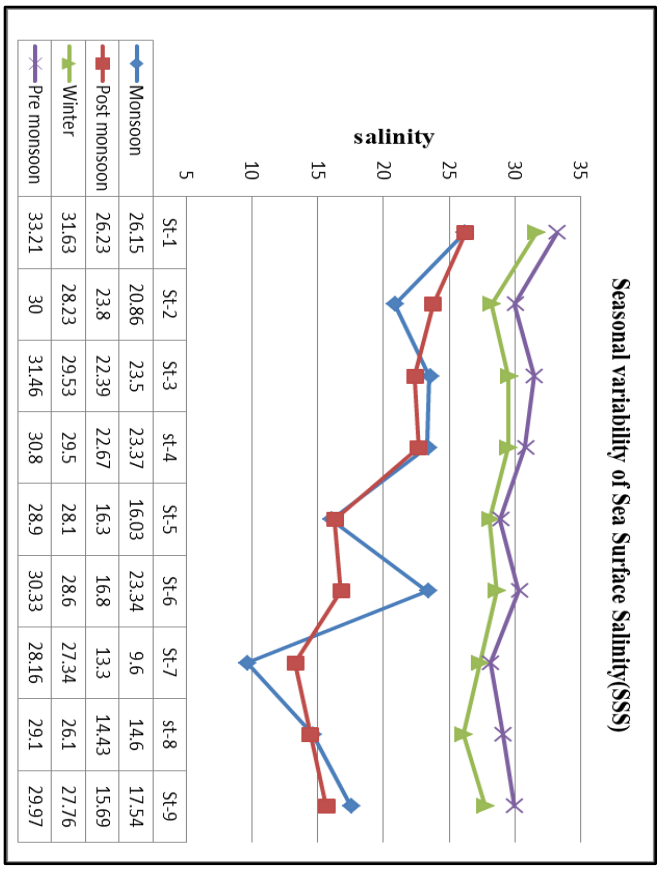


	Monsoon	Post monsoon	Winter	Pre monsoon
St-1	30.8	28.9	25	29.4
St-2	30.6	27.87	24.73	30.23
St-3	26.74	27.25	27.07	29.37
st-4	29.26	27.3	26.03	29.67
St-5	28.46	27.96	29.94	29.17
St-6	28.92	27.38	26.1	29.67
St-7	29.23	27.35	27.3	31.83
st-8	29.57	27.62	27.16	31.66
St-9	29.5	28.02	27.83	31.3

Figure 2: Variability of Water Temperature

3.2 Status of Sea Surface Salinity (SSS)

Salinity actsasa vital factor among environmental parameters in distribution of living organisms to the earnest coastal water. Fluctuations in salinity affect fauna of the coastal areas and determine the succession of species and it has a high influence on the marine environment of the Bay of Bengal. The seasonal variation of observed salinity values (‰) are ranged from 26-33±3.61 (S1), 20-30±4.33(S2), 22-31±4.48 (S3), 22-30±4.12(S4), 16-30±6.86(S5), 16-30±6.39(S6), 9-28±9.44(S7), 14-29±7.53(S8),15-29±7.15(S9) (Figure-3). The maximum salinity was recorded in Saint Martin Island 33.21±3.61‰ (S1) during Pre-monsoon season and the minimum was recorded in Bakkhali 9.6±9.44‰ (S7) during Monsoon season. The ascertained higher values might be attributed to the low quantity of rainfall, higher rate of evaporation and additionally as a result of neritic water dominance (Balasubramanian and Kannan, 2005) [17].Observations just like to present study were reported earlier by Palpandi (2011) [18] inVellar estuary.



	Monsoon	Post monsoon	Winter	Pre monsoon
St-1	26.15	26.23	31.63	33.21
St-2	20.86	23.8	28.23	30
St-3	23.5	22.39	29.53	31.46
St-4	23.37	22.67	29.5	30.8
St-5	16.03	16.3	28.1	28.9
St-6	23.34	16.8	28.6	30.33
St-7	9.6	13.3	27.34	28.16
st-8	14.6	14.43	26.1	29.1
St-9	17.54	15.69	27.76	29.97

Figure-3: Variability of Sea Surface Salinity

The variability of salinity indicates the upright mixing of the water column due to the nature of the sea-tide seasonally. Salinity demonstrates the negative liaison with phytoplankton biota, whereas Dissolved Oxygen (DO)indicates the symmetry between respiration and photosynthesis and exposed a positive liaison (Barik et al, 2017) [19].Salinity acts as a limiting factor in the distribution of living organisms, and its variation caused by dilution and evaporation is most likely to influence the fauna in the intertidal zone (Gibson, 1982)[20].

3.3 Status of Water P^H

The pH value depends upon the salinity and temperature of the water and the climatic conditions present in that area. The chemical and biological condition of water also places a role in the control of pH concentrations.

The seasonal variation of observed P^H values were ranged from 8.03-8.24± 0.09(S1), 7.87-7.96± 0.04(S2), 7.78-8.09± 0.10 (S3), 7.82-8.16± 0.16 (S4), 7.70-8.10± 0.20 (S5), 7.77-8.15± 0.18 (S6), 7.50-8.01± 0.24 (S7), 7.67-8.01± 0.15 (S8), 7.81-8.01± 0.09 (S9) (Figure-4).

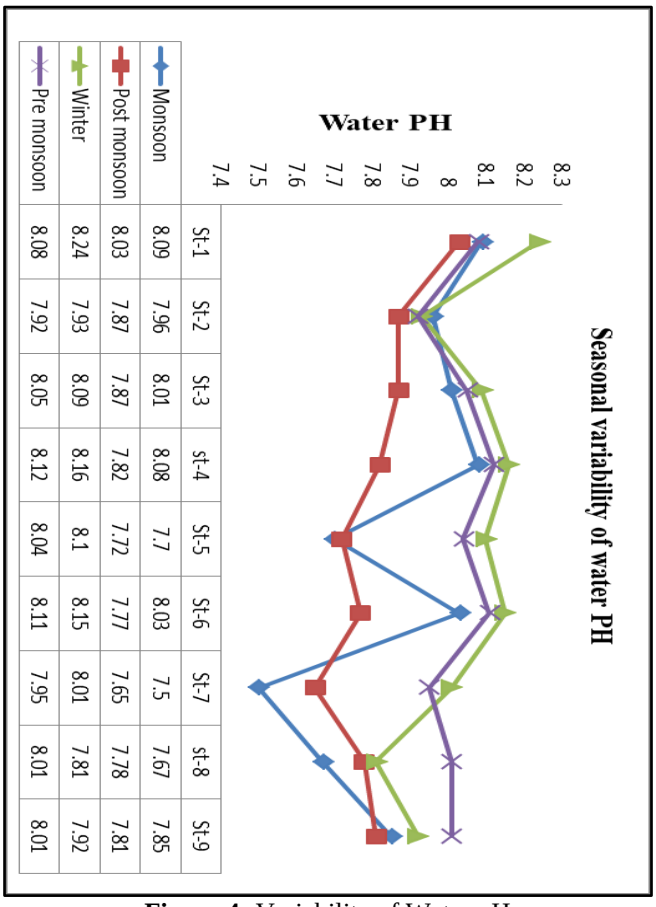


Figure 4: Variability of Water pH

The maximum P^H was recorded in Saint Martin Island 8.24±0.09 (S1) during Pre-monsoon season and the minimum was recorded in Bakkhali7.5±0.24(S7) during Monsoon season. The lower pH observed during the month of June to September due to the influence of fresh water, dilution of seawater, low temperature and organic matter decomposition as suggested by Ganesan (1992)[21]. Generally, fluctuations in pH values during different seasons of the year is attributed to factors like removal of CO_2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, low primary productivity, reduction of salinity and temperature and decomposition of organic materials as stated by Rajasegar, 2003[22].High pH values observed may cause sea water deprivation and high density phytoplankton effect (Prabu et al., 2008)[23].

3.4 Status of Electric Conductivity

Conductivity is a measure of water's capability to pass electrical flow. It shows seasonal variation with respect to different study sites. It chiefly depends on the amount of dissolved solids in water. The conductivity of water is affected by the suspended impurities and also depends up on the amount of ions in the water.

The seasonal variation of observed electric conductivity (mS/cm) values were ranged from 40-49± 4.18(S1), 32-46± 6.32(S2), 35-46± 5.72(S3), 36-46± 4.97(S4), 23-45± 10.97(S5), 28-46± 8.56(S6), 18-46± 14.13(S7),21-48± 813.77(S8),27-48±10.93 (S9) (Figure-5). The maximum EC was recorded in Saint Martin Island 49.22± 4.18mS/cm (S1) during Pre-monsoon season and the minimum was recorded in Bakkhali18.09± 14.13mS/cm (S7) during Monsoon season. The present study agrees with earlier reported by (Surana R. et al., 2013)[24]. High conductivity during post monsoon might be attributed to low mixing of fresh water input from river. Low value during monsoon season was due to rain and mixing of more fresh water from river. The conductivity values decreased with an increase in rainfall. In the rainy season, the increased volume of water remarkably diluted the water (Izonfuo and Bariweni, 2001) [25].

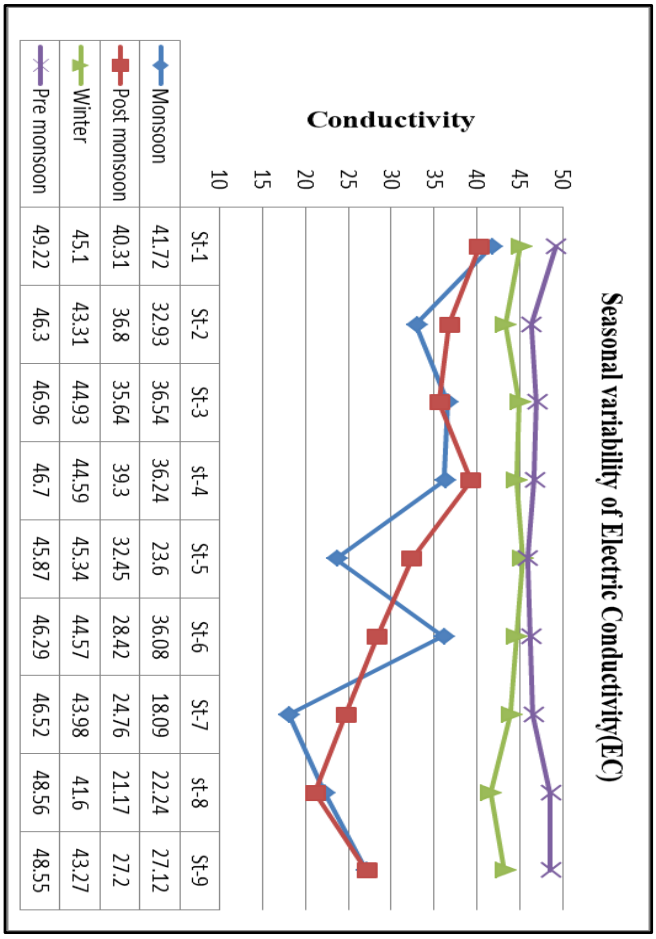


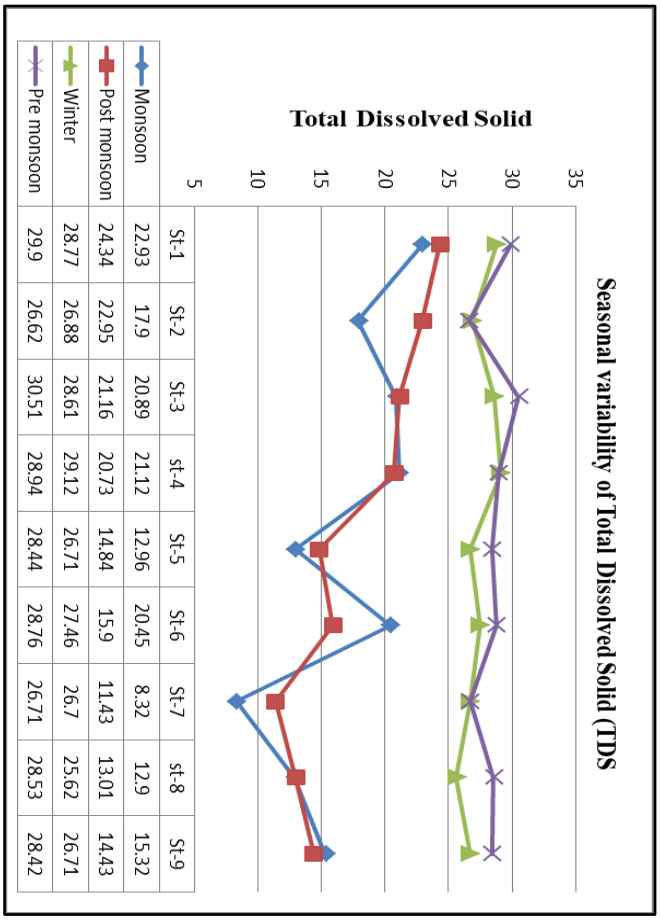
Figure-5: Variability of Electrical Conductivity

3.5 Status of Total Dissolved Solids (TDS)

Total dissolved solids (TDS) include all of the disassociated electrolytes that make up salinity concentrations, as well as other compounds such as dissolved organic matter. The amount of total dissolved solids in sea water was increased by the influence of activities on the land. The investigated coastal water TDS (g/l) values ranged from 22-29±3.41 (S1), 17-26±4.35(S2), 20-30±4.92 (S3), 20-29±4.49(S4), 12-28±7.87(S5), 15-28±6.22(S6), 8-26±9.57(S7), 12-28±8.07 (S8), 14-28±7.22(S9) (Figure-6). The maximum TDS (30.5±4.92g/l) was recorded in Teknaf (S3) during pre-

monsoon and minimum (8.32±9.57g/l) recorded in Bakkhali (S7) during monsoon season.

TDS can be influenced by changes in pH. Changes in the pH will cause some of the solutes to precipitate or will affect the solubility of the suspended matter. TDS value was higher during pre-monsoon and lower during monsoon. The mean values for the total dissolved solids (TDS) were higher in dry season than in the rainy season. The lower values of this parameter suggest that the runoff water only contributes to its dilution in the rainy season (Izonfuo and Bariweni, 2001) [26].



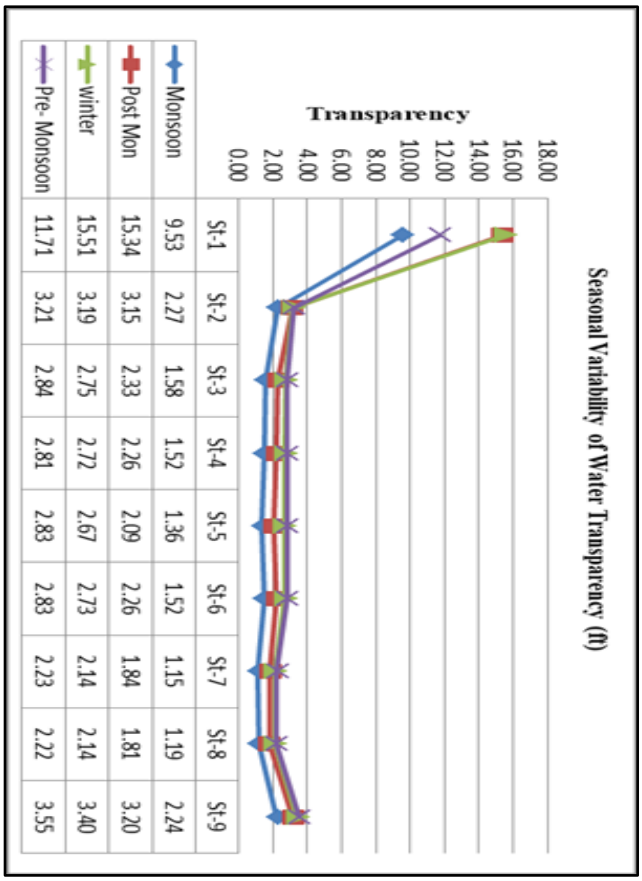
	Pre monsoon	Winter	Post monsoon	Monsoon
St-1	29.9	28.77	24.34	22.93
St-2	26.62	26.88	22.95	17.9
St-3	30.51	28.61	21.16	20.89
st-4	28.94	29.12	20.73	21.12
St-5	28.44	26.71	14.84	12.96
St-6	28.76	27.46	15.9	20.45
St-7	26.71	26.7	11.43	8.32
st-8	28.53	25.62	13.01	12.9
St-9	28.42	26.71	14.43	15.32

Figure 6: Variability of TDS

Water with a high total dissolved solids indicated more ionic concentration, which is of inferior palatability and can induce an unfavorable physicochemical reaction in the consumers. Kataria et al., (1996) [27] reported that increase in value of TDS indicated pollution by extraneous sources.

3.6 Status of Water Transparency

Water transparency is a key factor in ocean ecology as the sun is source of energy for all biological phenomena. Transparency reduction is due to the presence of particles in the water. When light attenuates, it alters or limits the capacity of life of some of the biological communities that live in the sea.Water transparency is approached by Secchi depth (Cialdi and Secchi 1865, Whipple 1899)[28].Transparency was measured in situ at fixed stations by using a Secchi disk. The depth where the Secchi disk settles beyond visual recognition, Secchi depth, is an index of water transparency.



	Monsoon	Post Mon	winter	Pre- Monsoon
St-1	9.53	15.34	15.51	11.71
St-2	2.27	3.15	3.19	3.21
St-3	1.58	2.33	2.75	2.84
St-4	1.52	2.26	2.72	2.81
St-5	1.36	2.09	2.67	2.83
St-6	1.52	2.26	2.73	2.83
St-7	1.15	1.84	2.14	2.23
St-8	1.19	1.81	2.14	2.22
St-9	2.24	3.20	3.40	3.55

Figure-7: Variability of Water Transparency

The seasonal variation of observed transparency values(ft) were ranged from 9.53-15.51±2.96 (S1), 2.27-3.21±0.48 (S2), 1.58-2.84±0.61(S3), 1.52-2.81±0.62 (S4), 1.36-2.83±.70 (S6), 1.15-2.23±0.52 (S7), 1.19-2.22±0.49 (S8), 2.24-3.55±0.62 (S9) respectively (fig-7). The maximum Transparency was recorded in Saint Martin 15.51± 2.96 ft (S1) during Post-monsoon season and the minimum was recorded in Bakkhali 1.15± 0.52 ft (S7) during Monsoon season. Water transparency serves as an index for the trophic state of a water body. It reflects eutrophication through changes in the phytoplankton abundance; increase in the ambient nutrient status in the water leads to higher phytoplankton biomass that diminishes the propagation of light in the water.

4. Conclusion

The study aims to know the physico-chemical characteristics in the water quality based on season and anthropogenic inputs. The seasonal fluctuation in physico-chemical parameter the seasonal tidal amplitude and fresh water influx leading to the continual exchange of organic, inorganic, plant and animal matters in the coastal water. However, the nine stations the water quality parameters such as temperature, pH, TDS and EC were increased during Pre Monsoon season. The

precipitation received during the Monsoon long and short rainy periods, were found have appreciable impact on coastal water characteristics at this location. Distributions of nutrient levels were also altered by the seasonal variation.This study conducted with the baseline data of the south-eastern coastal area of Cox's Bazar which opens a window of research for sustainable ecosystem health and management in this region.

5. Future Scope

The study exposed the present status of the Physico-chemical parameters which will be very helpful for Policy makers to take precautionary measures for saving the coastal ecosystem from the anthropogenic inputs.

6. Acknowledgements

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Author Profile

Md. Tarikul Islam is working as Scientific Officer in Chemical Oceanography Division at Bangladesh Oceanographic Research Institute (BORI). He has strong research interest in Marine Chemical Ecology, Marine and Coastal Pollution, Ocean Acidification, Nutrient Dynamics and Planktology. He has more than 9 years of research experience in different fields of oceanography.

Abu Sharif Md. Mahbub-E-Kibria is working as Senior Scientific Officer in Environmental Oceanography and Climate Division at Bangladesh Oceanographic Research Institute (BORI). He is interested in Marine Pollution, Climate Change, and Coastal Disaster. He has been working on Coastal Environment for many years.

Sonet Barua Emon is an Assistant Programmer & Head of ICT Cell, Bangladesh Oceanographic Research Institute (BORI). He has strong research interest in Machine Learning, Neural Network, Computer vision, Image Processing. He has total 6.5 years of service experience in Software development, Data analysis and Algorithm designing.

Sumon Biswas has been working as a Research Assistant in Chemical Oceanography Division at Bangladesh Oceanographic Research Institute (BORI). He is interested in the field of marine biology including marine species identification, marine culture and marine biological pollution control. He has Research experience on the marine culture in the field level under World Fish BD (ECOFISH).