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Abstract

7KH SUHVHQW VWXG\ GHDOW ZLWK DFLGL¿FDWLRQ RI WKH %D\ RI %HQJDO DQG that the average pH value of water in the Bay of Bengal on an average was around 7.75. The study showed strong positive correlation between pH and bicarbonate (R^2 is 0.930), between electric conductivity and salinity (R2 is 0.999) and between electric conductivity and dissolved oxygen (R^2 is 0.999). The pH in the Bay of Bengal has fallen by 0.2 units between 2012 and 1994 (pH 7.95). The study infers an impact of reduction of pH on calcifying organisms such as sea shells, oyster and coral reefs that are playing essential roles in their respective ecosystems. Average calcium carbonate composition of the calcifying organisms was found to be 80% which was 17% lower than the standard composition. The lower pH (7.75) might have made the Mollusks vulnerable and fragile which was evidenced by the presence of lesser number of Mollusks compared to that of 5 to 6 years back.

Keywords: Bay of Bengal; Ocean acidi cation; Mollusks; Oyster; Marine ecosystem

Introduction

Bay of Bengal, the largest bay in the world, forms the northeastern part of the Indian Ocean. Bangladesh is situated at the head of the Bay of Bengal, has 710 km long coast and 220 nautical mile maritime boundary appears a big marine resource of the country. Royal Society has run a study based on the impact of ocean acidi cation on the marine ecosystem in 2005. In this study they have shown the global pH level scenario of 1994, it was 7.95 in the Bay of Bengal. In addition di erent discussion on ocean acidi cation has noti ed that the area may be highly threatened on ocean acidi cation. e report said that 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. [1] have shown a map on the global ocean acidi cation 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. ey also reported that the current pH of North Indian Ocean where Bay of Bengal is situated is 8.068 ± 0.03.

e Bay of Bengal is a reservoir of lot of marine species specially shells, coral reefs and many sea sh and mammals. e e ect of ocean acidi cation 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. e goals of this study were to determine the current level of ocean acidi cation (OA) in the Bay of Bengal; to quantify the reduction rate of pH level of the Bay of Bengal compared with the values of 1994; and to quantify the shell and coral reef composition of the bay to compare with standard composition and to develop a conceptual model to study ocean acidi cation and its impact on marine ecosystem.

e Study Area

A lot of rivers and channels ow to the northern part of the Bay of Bengal and these rivers carry fresh water to the open sea. e mixing of fresh water with sea water reduces the pH of water. erefore, the eastern part of the Bay of Bengal was selected as the study area as a few rivers and channels ow along the east coast of the Bay of Bengal. e continental shelf of the north-eastern part of the Bay of Bengal was selected as the study area. e study area is shown in the Figure 1.

Figure 1: The Study Area.

Methodology

irty sea surface water samples were collected extending up to 36 nautical miles (about 67 km) from the continental shelf of the bay and the samples were mixed surface layer (upper 40 m), eight marine sediment samples at di erent depths which varied from 10 to 20 m, and twenty eight sea shells, oyster and coral reef samples by using di erent sampler such as Water Level sampler, Sediment Grab sampler, Ecobeam sounder with the help of BNS ANUSHANDHAN (Roebuck Class Hydrographic Survey vessel with 5 m dra , 64 m length, 30 m width and displacement 1450 ton) provided by Bangladesh NAVY. e samples were collected in March 20 to 23, 2012. In this study

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SE station, the farthest station from the shoreline. On the other hand, the lowest amount of TDS was 19.48gm per liter at surface water at SK station (Karnafuli River estuary).

Status of electric conductivity

Electrical conductivity measures a material's ability to conduct an electric current. e resistivity of ionic liquids varies tremendously by the concentration, while distilled water is almost an insulator, salt water is a very e cient electrical conductor.

e average amount of electric conductivity in the water samples of the study area was 54.26 mili Siemens per centimeter during the study period. e amount of electric conductivity varied from 39.00 to 60.80 mili Siemens per centimeter in the water samples (Figure 6).

Correlation between pH and carbonate or bicarbonate

ere is a strong relationship between pH and carbonate or bicarbonate of ocean water. e Figure 7 shows the value of coe cient of determination, R^2 is 0.930. e study shows that the pH value and the amount of bicarbonate the water samples have a strong positive linear correlation. is positive relationship between pH and bicarbonate indicates acidi cation in Bay of Bengal as pH increases with increasing bicarbonate.

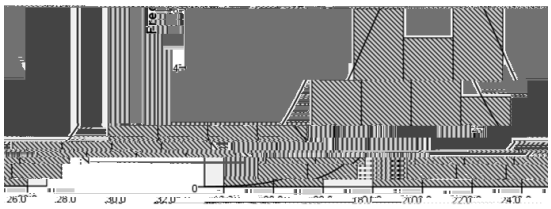

Figure 5: Total Dissolved Solids of the collected water samples.

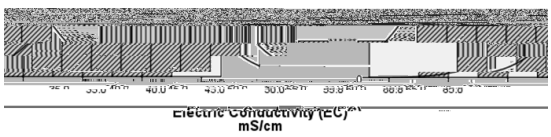

Figure 6: Status of Electric Conductivity.

Correlation between pH and salinity

e value of coe cient of determination, R^2 between pH and salinity was found to be 0.024. It indicates only 2% of the total variation in pH value can be explained by the linear relationship between pH and salinity (Figure 8). e study shows a weak linear correlation between pH and salinity there is a random, nonlinear relationship between the pH and salinity in ocean chemistry.

Correlation between dissolved oxygen and salinity

e Figure 9 shows the value of coe cient of determination R^2 is 0.076 between dissolved oxygen and salinity of the study area. It indicates 8% of the total variation in dissolved oxygen can be explained by the linear relationship between dissolved oxygen and salinity. e study shows that the dissolved oxygen and salinity have a weak linear correlation which is very likely in ocean chemistry. ere is a random, nonlinear relationship between the dissolved oxygen and salinity.

Correlationship between electric conductivity and total dissolved solids

e Figure 10 illustrates the value of coe cient of determination, R^2 is 0.999 between electric conductivity and dissolved solids of the

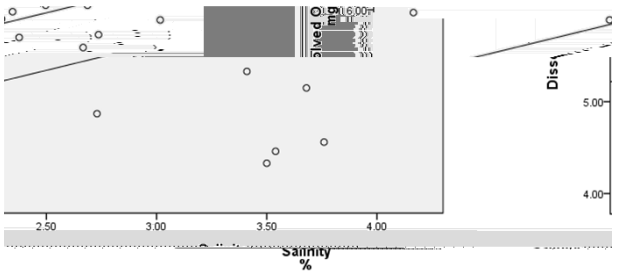

Figure 9: Correlation between Dissolved Oxygen and Salinity.

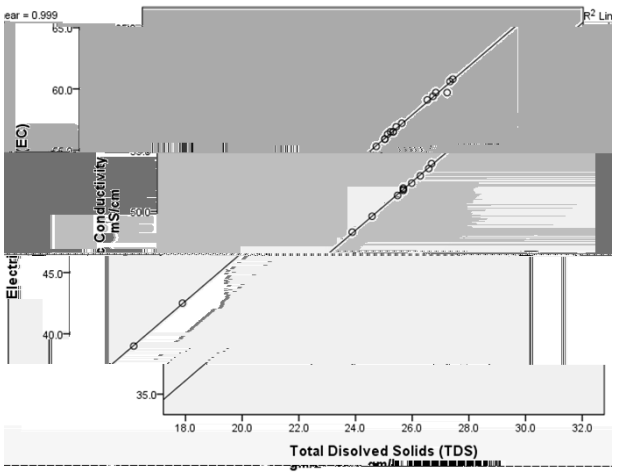

Figure 10: Correlation between Electrical Conductivity and Total Dissolved Solids.

collected water samples of the study area. at indicates 100% of the total variation in electric conductivity can be explained by the linear relationship between electric conductivity and total dissolved solids. e study shows a strong positive linear correlation between electric conductivity and total dissolved sediments in the study area. is positive value indicates a relationship between electric conductivity and total dissolved solids which is very appropriate for sea water chemistry. In the study area, electric conductivity increases with increase of dissolved solids.

Correlation between electric conductivity and salinity

e Figure 11 presents the value of coe cient of determination, R^2 is 0.999 between electric conductivity and salinity of the collected water samples from the study area. It indicates 100% of the total variation in electric conductivity can be explained by the linear relationship between electric conductivity and salinity. e study reveals that the electric conductivity and salinity have a very strong positive linear correlation which is ideal condition for ocean water chemistry.

Biological samples

As organisms (like shell, oyster and coral) are the most vulnerable to ocean acidi cation, twenty eight (28) samples were collected to analyze their chemical composition to compare with their standard composition. e oyster creates its own environment by secreting a shell composed or ninety- ve percent (95-97%) of calcium carbonate [2]. e remainder of the shell is made up of organic material and trace amounts of manganese, iron, aluminum, sulfate and magnesium [3,4] demonstrated that the calci cation rates of the edible mussel (Mytilus edulis) and Paci c oyster (Crassostrea gigas) decline linearly with increasing pCO_2

e Table 1 shows a brief description of the collected biological samples of the study area and their chemical composition particularly the percentage of $CaCO_3$ in the shell membrane.

A reduced shell thickness and breaking strength was found in this study when compared to normal shells. e Figure 12 and Table 2 show that the samples had an average content of 80% calcium carbonate compared to 97.00 percent calcium carbonate in the normal shell. e Figure 12 shows that among 28 samples many of the species such as Chama dunkeri, Turbo bruneus, Saccostre acucculata Astraliumstellare, Turritelladuplicata, Neritaundata were composed of eighty percent (80%) of calcium carbonate. Average calcium carbonate composition was found to be 80% which is 17% lower than the standard composition.

Discussion

Royal Society [5] showed geographic pH variation for the global surface oceans (50 m) for the year 1994. e map shows surface pH values range from 7.9 to 8.25 with a mean value of 8.08. e lowest values are observed in upwelling regions (e.g. Equatorial Paci c, Arabian Sea) where subsurface waters with lower pH values are brought to the surface. e Bay of Bengal belongs to the lowest zone of pH. e bay had pH lower than 7.95 in 1994. e present study reveals that the average pH value in the Bay of Bengal was 7.75. e study showed that the pH in Bay of Bengal has fallen by 0.2 unit compared in 1994 (lower than 7.95). It can be concluded that the average reduction rate of the pH value is 0.0083 units per year. Feely et al. [1] noti ed that that in the Paci c Ocean the pH value varies from 7.6 to 8.0 whereas, in the Indian Ocean the pH values were mostly distributed within 7.7 to 8.1. And in

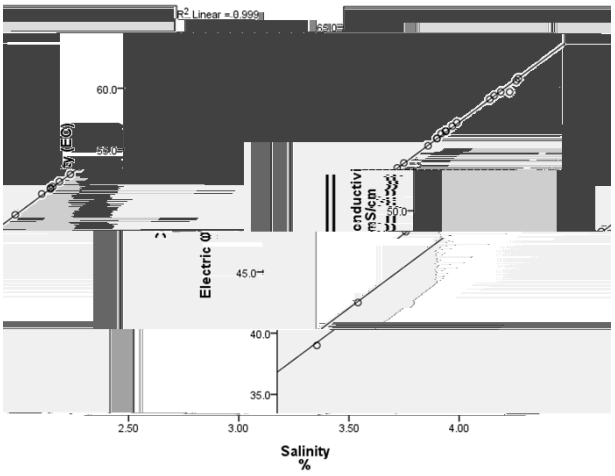

Figure 11: Correlation between Electrical Conductivity and Salinity.

the Atlantic Ocean the pH values were distributed within 7.8 to 8.1 in the period of 1990 to1998.

To determine the acidi cation of the Bay of Bengal, many chemical analyses have been run in this study. Based on the bicarbonate analysis of the twenty- seven water samples, the mean amount of bicarbonate of the collected water samples was found to be 138.940 mg/L with =12.538 mg/L. e study shows a strong positive linear correlation (R2 is 0.930) between pH value and the amount of bicarbonate of the study area. is positive relationship between pH and bicarbonate indicates acidi cation in Bay of Bengal as pH increases with increasing bicarbonate.

Presence of dissolved oxygen indicates the suitable condition of the sea water for survival of the living organisms. e average amount of dissolved oxygen in the water samples was 5.9737 mg/L. e lowest amount was 4.32 mg/L and the he

food web vulnerable. e study showed that the decrease in pH (7.75) reduced the calcium carbonate of the Mollusks that belong to the trophic level 2 (Mollusks-shells and oyster). As these species are important