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# ASSESSMENT OF SEASONAL VARRIATION IN WATER QUALITY OF VARIOUS KHAL IN CHITTAGONG PORT CITY, BANGLADESH

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**Abstract-**The study was carried out to evaluate the seasonal variation of some physicochemical parameters of various Khal in Chitagong during the 2018, the water samples were collected three times winter, summer and rainy season respectively. The result revealed that the value of pH, EC, salinity, total hardness, turbidity, TSS, TDS and alkalinity were higher in winter season compared to other seasons. Almost of all sites the content of EC, salinity, TSS, TDS, Chloride and turbidity crossed the limit of ECR(1997), US EPA (2018) and BIS 10500 (2012) but turbidity is more significant in Bridgeghat Khal (5690 NTU) during dry season which is about 569 times higher than the limit of ECR(1997), US EPA (2018) and BIS 10500 (2012). It is because the dilutions of contaminants were drastically reduced in the dry season due to lack of sufficient stream flow. TDS content exceeded the limit of ECR(1997), US EPA (2018) and BIS 10500 (2012) in Canal No. 15 and 7 (Mohesh Khal and Bridgeghat Khal) during winter season which may be due to mixing of industrial waste and dumping of different domestic from the surrounding city dwellers. In all seasons TSS value exceeded the limit of ECR (1997), US EPA (2018) and BIS 10500 (2012) in most of the places which may be due to continuous discharges of combined industrial, domestic and municipal wastes from nearby industries and localities with no stream flow.

**Keywords:** Seasonal variation, Water quality, Khal, Pollution, Toxic.

## 1. INTODUCTION

Chittagong (historic names: Porto Grande De Bengala and Islamabad) is the main seaport and second largest city of Bangladesh. It is located in south-eastern Bangladesh, at the estuary of the Karnaphuli River. The city proper has an estimated population of over 4 million people, while the Greater Chittagong metropolitan area has a population of 6.5 million. It is one of the fastest growing cities in the world. Chittagong is an important industrial, financial and commercial hub and one of the busiest ports on the Bay of Bengal and the Indian Ocean. Modern Chittagong is regarded as the commercial and industrial capital of Bangladesh. It is the main international maritime gateway of the country and hosts the headquarters of numerous companies [1]. The port city accounts for 12% of the national economy generating 40% of heavy industrial output, 85% of foreign trade and 60% of revenue earnings.

Endowed with the largest and most diversified industrial base in the country, Chittagong is the centre of industries in steel, petroleum, chemicals, shipbuilding, ship-repair and scrappage, glass manufacturing, cement, ceramics, fertilizer, automotive components and motor vehicle assembly. It hosts numerous light industrial zones which specialize in garments, leather products, food processing, tea, sports goods and jute products. The Chittagong Export Processing Zone, which is the largest export processing zone in Bangladesh, was ranked by the Financial Times as one of the world's top best special economic zones, in terms of competitiveness and economic potential. The Karnaphuli Export Processing Zone in North Patenga is also one of the largest manufacturing hubs in Bangladesh. The billion dollar under-construction Korean EPZ, being set up by investors from South Korea, will feature the world's largest garments and shoe factories. They are the source of the surface water of the city and about 18% of the supplied by Dhaka WASA is surface water [2], [3], [4]. But the surface water systems of this city at present time are polluted by various ways [5].

The sources of surface water pollution are mainly from agricultural, industrial and domestic wastes [6], [7], [8], [9]. Pollution from human and industrial sources is the main water quality problem in the river systems near urban areas because they are one of the largest water users and polluters [10]. Buriganga is the worst affected. The careless disposal of industrial effluents and other wastes may contribute greatly to the poor quality of the water [11], [12]. Previous study showed that variation in water quality was found depending on season. A great deterioration in water

quality of Shampur (Buriganga River) occurred in dry season compared to wet season (The World Bank, 2006)[13]. Due to have high ground water slope in the Dhaka city aquifer, there may be high possibility to percolate contaminant surface water to the aquifer. Therefore, it is essential to evaluate the seasonal variation of specific water quality parameters for evaluation of overall status of these rivers water. The present research work will demonstrate more information about the present seasonal variation of physicochemical parameters in different Khal in Chittagong city which can be used as benchmark data for future surface water resource planning and management of that area. Such information can also provide valuable information for the authorities to take proper action in preventing pollution of the area.

## 2. MATERIAL AND METHODS

### 2.1 Study Area

The study area located in different sites of Chittagong and here we mansion name and GPS value such as Canal No: 15 (22°14'30"N, 91°49'14"E), Canal No: 7 (22°17'31"N, 91°47'8"E), Mohesh Khal (22°18'8"N, 91°47'46"E) Danger Chor Khal (22°18'22"N, 91°48'32"E), Majir Ghat Khal (22°19'21"N, 91°50'47"E), Chaktai Khal (22°19'39"N, 91°50'48"E), Rajakhali Khal (22°19'42"N, 91°50'59"E), Shikol Bhahar Khal(22°19'7"N, 91°59'23"E) and Bridge ghat Khal(22°19'58"N, 91°50'23"E) respectively. Fig. 2.1 shows the Sampling Site of Different Khal in Chittagong port area, Bangladesh.


**Fig. 2.1 Sampling Site of Different Khal**

### 2.2 Sample Collection

Water samples were collected several times from different sites of Chitagong namely Canal No:15, Canal No: 7, Mohesh Khal, Danger Chor Khal, Majir Ghat Khal, Chaktai Khal, RajaKhali Khal, ShikolBhahar Khal, Bridgeghat Khal. The sampling was done very cautiously using spot sampling techniques [6]. Two liter the high density PVC bottles were used for collecting samples for physicochemical analysis. They were thoroughly cleaned by rinsing with 8N $HNO_3$ and deionized water followed by repeated washing with water samples so as to avoid contamination [8]. The samples were collected in clean bottle with labeling a unique identification for each sample shown in Table-2.1, and stored at 4°C prior to analysis. They were finally washed with deionized water and dried in the air. During sampling the sample bottles were tightly screwed. The pH, Electrical Conductivity (EC) and Total Dissolved Solids (TDS) were measured at the site during sample collection. Then samples were kept in ice bag tied well. Then, it was carried to the laboratory and stored in the refrigerator.

**Table-2.1 Sample Identification Number**

| Sampling Area (Winter Season) | SIN | Sampling Area (Summer Season) | SIN | Sampling Area (Rainy Season) | SIN |
|---|---|---|---|---|---|
| Canal No:15 | C1 | Canal No:15 | C11 | Canal No:15 | C21 |

| | | | | | |
|---|---|---|---|---|---|
| Canal No: 7 | C2 | Canal No: 7 | C12 | Canal No: 7 | C22 |
| Mohesh Khal | C3 | Mohesh Khal | C13 | Mohesh Khal | C23 |
| Danger Chor Khal | C4 | Danger Chor Khal | C14 | Danger Chor Khal | C24 |
| Majir Ghat Khal | C5 | Majir Ghat Khal | C15 | Majir Ghat Khal | C25 |
| Chaktai Khal | C6 | Chaktai Khal | C16 | Chaktai Khal | C26 |
| RajaKhali Khal | C7 | RajaKhali Khal | C17 | RajaKhali Khal | C27 |
| ShikolBhahar Khal | C8 | ShikolBhahar Khal | C18 | Shikol Bhahar Khal | C28 |
| Bridgeghat Khal | C9 | Bridgeghat Khal | C19 | Bridgeghat Khal | C29 |

**2.3 Sample Analysis**

pH, Electrical Conductivity (EC), Dissolved Oxygen (DO) and temperature of the samples were measured on the spot using sension 156 $^{TM}$ portable multipara meter and Thermometer respectively[14], [8], [15]. Physicochemical parameters such as turbidity, total suspended solids (TSS), total dissolved solids (TDS), Alkalinity as $CaCO_3$ and salinity were measured using various standard methods [16]. A portion of the water samples were acidified for some specific analysis. The physico-chemical analysis was carried out in the Institute of National Analytical Research and Service (INARS), BCSIR, Dhaka.

## 3. RESULTS AND DICUSSION

The contamination of these aquatic systems brings serious threat to the overall epidemic and socio-economic pattern of the neighboring area and no systemic data was found about the seasonal variation in water quality to determine the pollution level of that area. The seasonal variation of physicochemical properties of the study area and its comparison with the inland surface water standard value recommended by ECR (1997), US EPA (2018) and BIS 10500 (2012) are presented in Table-3.1 bellow.

Table-3.2 shows the seasonal variation of water quality parameters of various Khal in Chittagong city and Table-3.1 listed the statistic of water quality parameter and their permissible valued. Fig. 3.1 is graphical presentation of table 2. A correlation matrix was calculated by the statistics lab origin software pro-6. This correlation matrix (Table-3.3) of khal water was calculated in order to ascertain the relationship among the physicochemical parameters where Strong correlation ($p<0.01$) and significant correlation ($p<0.05$).

The average value of pH at Canal No:15, Canal No: 7, Mohesh Khal, Danger Chor Khal, Majir Ghat Khal, Chaktai Khal, RajaKhali Khal, ShikolBhahar Khal and Bridgeghat Khal varied from 5.3 to 6.72. The pH showed negatively insignificant correlations with all of the parameters accept DO. The seasonal fluctuation of pH value was not so accountable in dry season and the value was less than the rainy season. Slightly acidic pH values were observed in rainy season compared to other seasons. The industry uses various types of chemicals as a result lower pH approaches in nearby river water. Acidic pH is harmful for aquatic life like fish, microorganisms and aquatic plants. Water influences the other properties of water body, activity of organisms and potency of toxic substances present in the aquatic environment [20], [21], [22].

**Table-3.1 The Statistic of Water Quality Parameter and their Permissible Valued**

| **Parameter** | **N** | **Mean** | **SD** | **Sum** | **Min** | **Max** | **1[17]** | **2[18]** | **3[19]** |
|---|---|---|---|---|---|---|---|---|---|
| **pH** | 27 | 5.97692 | 0.43064 | 155.4 | 5.3 | 6.8 | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 |
| **DO** | 26 | 4.53462 | 1.28994 | 117.9 | 1.6 | 6.3 | 6.0 | - | - |
| **EC** | 26 | 2073.95385 | 2199.70518 | 53922.8 | 11.8 | 6530 | - | - | - |
| **Salinity** | 26 | 1.07308 | 1.22198 | 27.9 | 0 | 3.6 | - | - | - |
| **Alkalinity** | 26 | 370.76923 | 394.20729 | 9640 | 20 | 1990 | 200 | - | - |
| **TH** | 26 | 680 | 658.41021 | 17680 | 40 | 2600 | 500 | 600 | 600 |
| **TDS** | 26 | 1088.68462 | 1174.04483 | 28305.8 | 53.1 | 3450 | 1000 | 500 | 1000 |
| **Turbidity** | 26 | 1460.34385 | 2143.96005 | 37968.94 | 6.34 | 6670 | 10 | 5 | 5 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **TSS** | 26 | 1290.23077 | 624.98975 | 33546 | 690 | 3186 | - | - | - |
| **Chloride** | 26 | 883.46154 | 330.37085 | 22970 | 420 | 1420 | 250 | 600 | 600 |
| **1→ECR (1997); 2→ US EPA(2018), 3→ (BIS 10500, 2012)** | | | | | | | | | |

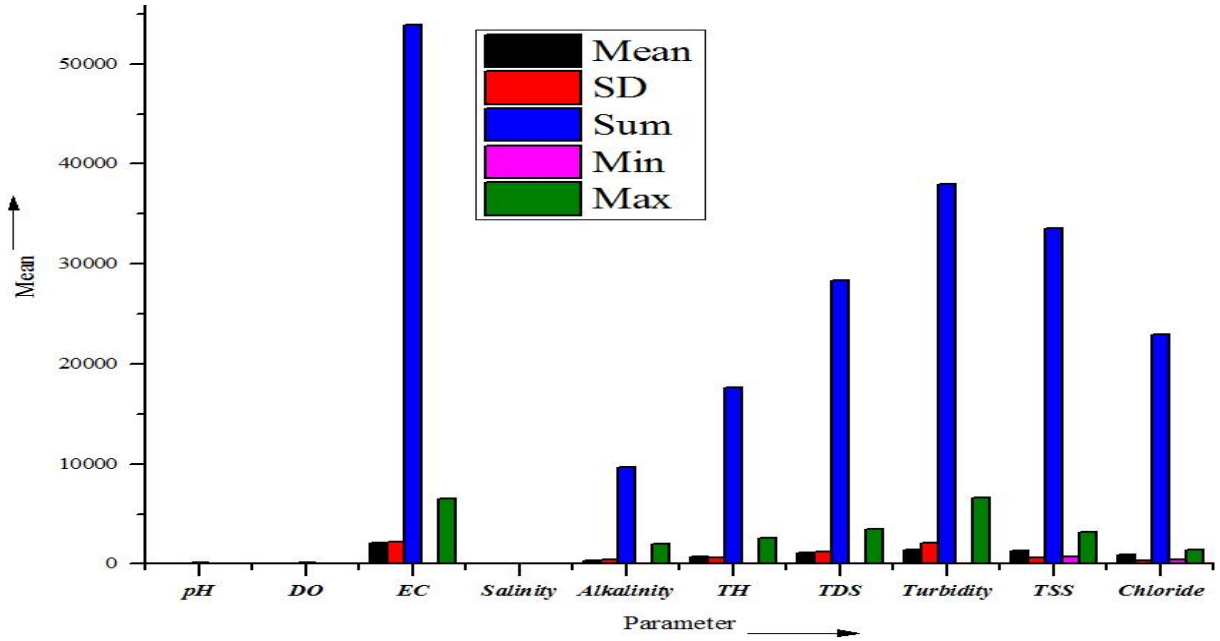


**Fig. 3.1 Statistic VS Water Quality Parameters**

DO in water is essential for aquatic life. Deficiencies of DO in water give rise to odoriferous products of anaerobic decomposition. Some places in all sites and in all seasons, the value of DO was lower than the permissible value which was recommended by ECR (1997), US EPA (2018) and BIS 10500 (2012) respectively. DO negatively correlate with insignificantly Alkalinity and Chloride respectively. Surface water at those sites, especially in the dry season becomes poor condition because flow rate at that time becomes negligible but the volume of effluents entering in the river system remained same as wet season. The low DO value of the study area suggested that the industries were releasing organic substances that were high oxygen demanding wastes [23].The presence of oxygen in water is a positive sign of a healthy body of water but the absence of oxygen is a signal of severe pollution.

**Table-3.2 Seasonal Variation of Water Quality Parameters of Various Khal in Chittagong City**

| SIN | pH | DO (mg/ L) | EC (µS/cm) | Salinity (ppt) | Alkalinity (ppm) | TH (ppm ) | TDS (ppm) | Turbidit y (NTU) | TSS (ppm) | Chlorid e (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 5.4 | 3.7 | 13730 | 7.90 | 500 | 4160 | 7650 | 23 | 1564 | 780 |
| C2 | 5.3 | 6.3 | 6530 | 3.60 | 840 | 1760 | 3450 | 3820 | 1863 | 920 |
| C3 | 5.7 | 4.5 | 4730 | 2.5 | 580 | 1100 | 2480 | 5050 | 2536 | 1200 |
| C4 | 5.8 | 6.0 | 2340 | 1.20 | 390 | 700 | 1184 | 18.8 | 920 | 620 |
| C5 | 5.8 | 2.1 | 4620 | 2.50 | 1990 | 1200 | 2420 | 6.34 | 898 | 598 |
| C6 | 5.7 | 1.6 | 400 | 0.1 | 420 | 260 | 193 | 1010 | 1650 | 1120 |
| C7 | 5.7 | 4.0 | 4060 | 2.1 | 370 | 300 | 2110 | 37.2 | 912 | 658 |
| C8 | 6.7 | 5.0 | 392 | 0.1 | 410 | 240 | 189 | 1710 | 760 | 482 |
| C9 | 6.8 | 5.8 | 285 | 0.1 | 280 | 240 | 137 | 5690 | 1680 | 1180 |
| C11 | 6.03 | 6.2 | 6530 | 3.6 | 750 | 2600 | 3450 | 6670 | 3186 | 1340 |
| C12 | 6.45 | 4.5 | 4210 | 2.7 | 540 | 1300 | 2700 | 720 | 1300 | 925 |
| C13 | 5.97 | 5.8 | 611 | 0.3 | 380 | 240 | 297 | 840 | 862 | 682 |
| C14 | 5.90 | 5.9 | 1252 | 0.6 | 220 | 360 | 618 | 758 | 1444 | 1047 |
| C15 | 6.21 | 4.3 | 2620 | 1.3 | 190 | 620 | 1332 | 236 | 2242 | 1340 |
| C16 | 5.95 | 3.1 | 226 | 0 | 250 | 220 | 108 | 735 | 1488 | 1150 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| C17 | 6.14 | 3.9 | 278 | 0.1 | 250 | 200 | 134 | 184 | 1287 | 1102 |
| C18 | 6.24 | 5.4 | 3740 | 2.0 | 350 | 760 | 1938 | 57.1 | 1122 | 640 |
| C19 | 6.11 | 5.0 | 411 | 0.2 | 230 | 240 | 198 | 83.2 | 702 | 492 |
| C21 | 5.4 | 4.3 | 5800 | 2.8 | 480 | 2200 | 2900 | 6670 | 1600 | 1204 |
| C22 | 5.3 | 2.1 | 1843 | 0.9 | 310 | 800 | 923 | 780 | 956 | 980 |
| C23 | 5.7 | 5.0 | 1806 | 0.9 | 150 | 820 | 904 | 840 | 1368 | 1420 |
| C24 | 5.8 | 4.7 | 303 | 0.1 | 20 | 320 | 146 | 758 | 736 | 570 |
| C25 | 5.8 | 4.2 | 173 | 0 | 30 | 200 | 82.6 | 236 | 1040 | 1320 |
| C26 | 5.7 | 3.1 | 350 | 0.1 | 70 | 300 | 168 | 735 | 766 | 560 |
| C27 | 5.7 | 4.3 | 273 | 0.1 | 50 | 320 | 131 | 184 | 712 | 520 |
| C28 | 6.7 | 5.3 | 128 | 0 | 50 | 340 | 60.1 | 57.1 | 690 | 420 |
| C29 | 6.8 | 5.5 | 11.8 | 0 | 40 | 40 | 53.1 | 83.2 | 826 | 480 |

The electric conductivity (EC) is the ability of a substance to conduct an electric current through the media. It is usually used for indicating the total concentration of the ionized constituents of water. Table 3 show that electrical conductivity values for winter season remains higher than other seasons because in winter season the ions get concentrated. In all sites the value of EC shows the same pattern and this value were greater than the limit of ECR (1997), US EPA (2018) and BIS 10500 (2012) standard limit value respectively. It is gradually increased from rainy season to winter season. In Canal No: 15 (13730 µS/cm), Canal No: 7 (6530 µS/cm), Mohesh Khal (4730 µS/cm), Danger Chor Khal (2340 µS/cm), Majir Ghat Khal(4620 µS/cm), Bridgeghat Khal (4060 µS/cm) The highest value of EC was found in Canal No:15 (13730 µS/cm) which indicates that a large amount of ionic substances is released from Industries outlets like sodium, chloride etc. Such a high value of EC is not suitable for aquatic life and irrigation purposes. EC negatively correlate with insignificantly pH, Alkalinity and Chloride respectively.

Salts are such type of electrolyte substances that contribute cationic and anionic species to the substances except hydrogen ion ($H^+$) and hydroxyl ion ($OH^-$) (Das, 1997). Among all sites, the increment in salinity is greater in Canal No: 15, Canal No: 7, Mohesh Khal, Danger Chor Khal, Majir Ghat Khal (1.20 to 7.90 ppt) than other points. This abnormal fluctuation in salinity may be due to use of inorganic salts at different industrial units especially at tannery industries. The increase in salinity in all sites indicates that effluents discharges in that area contain such type of substances that may lead to increases the availability of salinity. Salinity also gradually increases from rainy season to winter season. The Salinity showed a positive significant correlation with EC (r=0.99), TH (r=0.89), Alkalinity(r=0.63), Turbidity(r=0.52), TSS(r=0.58) and TDS (r=0.99) respectively.

Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms. In all sites of different Khal value of turbidity were higher than ECR (1997), US EPA (2018) and BIS 10500 (2012) standard respectively. The water is more turbid in winter season than rainy season. The highest value of turbidity was found in Bridgeghat Khal (5690 NTU) which is about 569 times higher than the standard. Turbidity content in In Canal No:15 (23 NTU), Canal No:7 (3820 NTU), Mohesh Khal (5050 NTU), chaktai khak (1010 NTU), Shikolbhahar Khal (1710 NTU), Bridgeghat Khal (5690 NTU). In all sites turbidity value is lowest in rainy season which is due to dilution and seasonal flow of water. The Turbidity positive significant correlation with EC (r=0.55), Salinity (r=0.52), TDS (r=0.53), TH(r=0.69) and TSS(r=0.58) respectively.

Total dissolved solid (TDS) of all sites was much higher in dry season (137-7650 mg/L) compared to other seasons but the values within the ECR (1997), US EPA (2018) and BIS 10500 (2012) respectively standard. The highest concentration of TDS was found in Canal No 15 (7650 mg/L) during winter season and lowest concentration was observed in Bridgeghat Khal (53.1 mg/L) during rainy season. The high value of TDS indicates the intense level of contamination may occur in the near future. Surface water in all sites of Buriganga river becomes very poor condition especially in the dry season with which The World Bank report (2006) bears similarity and it is intense in the present time. It is because the dilutions of contaminants were drastically reduced in the dry season due to lack of sufficient stream flow and precipitation. The variations in the concentration of TDS in the river water are due to discharge of effluents and wastes. The high amount of dissolved solids in water increases the water density; it influences osmoregulation of freshwater organisms and reduces solubility of gases [24]. The TDS positive significant correlation with EC (r=0.99), Salinity (r=0.99) and Alkalinity(r=0.64) respectively.

**Table-3.3 Co-relation of Water Quality Parameters**

| **Parameter** | **pH** | **DO** | **EC** | **Salinity** | **Alkalinity** | **TH** | **TDS** | **Turbidity** | **TSS** | **$Cl^-$** |
|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | 1 | | | | | | | | | |
| **DO** | 0.356 | 1 | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **EC** | -0.380 | 0.152 | 1 | | | | | | | |
| **Salinity** | -0.342 | 0.169 | 0.995 | 1 | | | | | | |
| **Alkalinity** | -0.204 | -0.210 | 0.629 | 0.634 | 1 | | | | | |
| **TH** | -0.354 | 0.171 | 0.898 | 0.891 | 0.535 | 1 | | | | |
| **TDS** | -0.345 | 0.154 | 0.996 | 0.999 | 0.628 | 0.893 | 1 | | | |
| **Turbidity** | -0.111 | 0.284 | 0.546 | 0.519 | 0.221 | 0.688 | 0.526 | 1 | | |
| **TSS** | -0.120 | 0.170 | 0.587 | 0.579 | 0.234 | 0.636 | 0.579 | 0.707 | 1 | |
| **Chloride** | -0.256 | -0.072 | 0.281 | 0.262 | 0.008 | 0.374 | 0.271 | 0.477 | 0.751 | 1 |

Total suspended solid (TSS) values of the study area ranges from 690 mg/L to 2536 mg/L over the year which exceeds the ECR (1997), US EPA (2018) and BIS 10500 (2012) respectively standard in all places and seasons. Higher value of TSS was recorded in winter season compared to other seasons in most of the places. Highest value of TSS was observed in Mohesh Khal (2536 mg/L) during winter seasons. This high TSS may be due to mixing of industrial waste and dumping of different domestic wastes as macro pollutants from the surrounding city dwellers. TSS denotes the suspended impurities present in water. High TSS present in water bodies may block the sunlight required to photosynthesis by the bottom vegetation [25], [15]. The TSS positive significant correlation with EC (r=0.59), Salinity (r=0.58), TDS (r=0.58), Turbidity(r=0.71) and TH(r=0.67) respectively. The positive significant correlation with TSS (r=0.75).

The alkalinity of most water caused by dissolved carbonate ($CO_3^{2-}$) and bicarbonate ($HCO_3^-$) salts [19]. In the present study water body of canal No: 15 (500-750 mg/L) contain higher alkalinity in all season which exceeds the limit of ECR(1997), US EPA (2018) and BIS 10500 (2012) standard respectively. Higher alkalinity in this area may attributes to higher use of soap, detergent etc. for bathing, cloth washing and cleaning of various domestic appliance of the nearby locality. Alkalinity value of other places was lower or within the limit of ECR (1997), US EPA (2018) and BIS 10500 (2012) depending on monthly variation. In all sites alkalinity values was higher in dry season compared to wet season. The Alkalinity showed a positive significant correlation with EC (r=0.69), Salinity (r=0.63), TH (r=0.54) and TDS (r=0.63) respectively.

## CONCLUSION

Chittagong city has been growing without much of plan and the city lacks systematic waste management system as well. The study was done created awareness regarding the environmental issues in different Channels. Chittagong is densely populated and is surrounded by Karnafully River and many Khal. For rapid industrial development various domestic, industrial and municipal wastes get mixed with river water mainly by these Khal and drainage system and have significant impact on aquatic ecosystem [26], [27]. The value of EC, salinity, total hardness, acidity, turbidity, TSS, TDS, alkalinity, $Cl^-$, and $PO_4^{3-}$ were higher most of the places in winter season compared to other seasons. The value of turbidity (5690 NTU), TSS (3186 mg/L) and TDS (7650 mg/L) recorded higher at different places in different Khal which may indicates the intense level of contamination in the near future. Concerning all the parameters of the study it is clear that the water of various Khal in now in a very critical condition especially in the winter season. As it is getting worse day by day, so it is urgent need to take proper actions and formulate policy for rehabilitating and proper management of stated river and nearby industries. It is very important to develop a comprehensive management plan for revival of all lakes, Khals and wetlands within Chittagong city.

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