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Climate Change Impacts and Pollution Status of Buriganga River, Bangladesh

Shahab Uddin[1], Md. Parvej[2], Most. Nijhum Afrin[2] and Dr. Md. Akramul Alam[3]

[1]Lecturer at Department of Civil Engineering, Dhaka University of Engineering & Technology, Gazipur

[2] Undergraduate Students at Department of Civil Engineering, Dhaka University of Engineering & Technology, Gazipur

[3] Professor at Department of Civil Engineering, Dhaka University of Engineering & Technology, Gazipur

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ABSTRACT

The environment of Dhaka city is depraving gradually day by day because of unplanned urbanization, destruction of greeneries by increasing building and economical activities areas to meet the demand of migrated people. This scenario is enhancing the negative change in climate gradually. It is one of the main causes of Buriganga river pollution because of climate change impact. Dhaka city is capital of Bangladesh, which largely depends on the Buriganga River's water for drinking, fishing, carrying merchandise and transportation. The quality of water in this river was very poor and the average DO, BOD_5, COD, Nitrate and Phosphate concentration in mg/L were 1.11, 82.3, 148.45, 5.92 and 5.83 respectively. This study mainly focused the climate change impact in term of rainfall on Buriganga River and disclosed it that decreasing the rate of rainfall affect the discharge of river because of climate change and increasing the rate of waste water because of incremental economical activities in industries both affects the dilution rate of Buriganga River simultaneously and this scenario will be also big concern in future for increasing climate change impact on rainfall in Dhaka City. In this study, we also discussed about pollution status of this river and finally the way to mitigate or minimize the pollution of Buriganga River.

1. Introduction

Bangladesh has about 230 small and large rivers, Buriganga River is one of them and it knew as "Old Gange" was famous during the Mughals period. In a couple past, a course of Ganges gradually shifted and finally lost its link with the main channel of the Ganges and then it was renamed by the Buriganga River, Dhaka, Bangladesh [1]. Dhaka is considered now the 7th largest city in the world and by 2020 Dhaka may be the 2nd largest city in the world [2]. The rural-urban migration is naturally increasing at an alarming rate to the Dhaka City for being centralized the major economic activities in Dhaka City [2]. The quantity of greeneries (0.13 acres for 1000 people) [3] in Dhaka City is inadequate, major portion parts of this small amount of greeneries are in the circumference of the city and the covering areas in Dhaka city are increasing abruptly by 210.37% from the year 1960-2014[4], these impacts are enhancing the change in climate gradually in the Dhaka City. The average rainfall in Dhaka City is decreasing gradually because of climate change impact, which finally collapses the quality of water of Buriganga River due to dilution effect. Untreated industrial effluents and municipal wastewater, runoff from chemical fertilizers and pesticides, and oil spillage in and around the operation of river ports are considered to be also vulnerable to pollution of Buriganga River [5], [6], [7], [8], [9]. The tendency of throwing untreated wastes from domestic, industrial, clinical, pathological is increasing day by day in the Buriganga River. Dhaka has 343 tannery industries situated in Hazaribagh on the bank of Buriganga River [10], from tannery industries Buriganga River receives 21,600 square meters of liquid waste every day [11]. Another study also said that Up to 40,000 tons of tannery waste is thrown into the river daily along with sewage [12]. These untreated wastes effluent, including heavy metals as chromium, Lead, Sulphur, Ammonium, Salts and other materials are severely polluting this river [13]. For these scenarios, this river is considered to be one of the polluted parts of the river system of Bangladesh [14]. Biological dead may be occurred in Buriganga River in future by eaten up all oxygen by those pollutants. About 12 million people of Dhaka City [2] largely depend on the Buriganga River's water for drinking, fishing, carrying merchandise and transportation purposes. Because of consumption and using this polluted water by the marginal people who are leaving on the bank of the Buriganga River especially children facing different types of water borne diseases, viz. skin sore, irritation in respiratory tract [15], typhoid, dysentery, cholera, viral hepatitis etc. and loss their life. In this study, we want to discuss about climate change impact and it trends in future, pollution status and finally the way to mitigate or minimize the pollution of Buriganga River. We highlighted here the climate change impact in term of rainfall on Buriganga River and revealed this study that decreasing the rate of rainfall because of climate change affect the flow rate of river and increasing the rate of waste water because of incremental economical activities in industries both affects the dilution rate of Buriganga River simultaneously and this scenario will be also

Tele:
E-mail address: shahab.civil97@duet.ac.bd

big concern in future for increasing climate change impact on rainfall in Dhaka City.

2. Methodology

The Bangladesh Water Development Board (BWDB) keeps record of the hydrological information of this river. To observe the variation and trend in velocity and discharge, latest available data (during years 2008, 2012 and 2016) on surface water velocity and discharge rate of Buriganga River at Millbarak were collected through personal communications from the BWDB. And to observe the climate change impact on Buriganga River, the daily rainfall records from 1975 to 2016 of Dhaka City were also collected from the Bangladesh Metrological Department (BMD). In order to observe the climate change impact in term of rainfall in future, this study forecasted the rainfalls up to 2040, a time series model was developed using Box-Jenkins time series analysis method in IBM SPSS, which is statistical software for manipulation and managing data, calculating a wide variety of statistics and analysis with simple instructions. This study also observed the extent of climate change impact in term of rainfall in upcoming years on Buriganga River from forecasted rainfall data.

After collecting the water quality parameters, this study also showed mean and standard deviation of water quality parameters (DO, BOD_5, COD, pH, Turbidity, TDS, Nitrate, and Phosphate etc.) in different seasons of a year. These water quality parameters data's were collected from literature review and accepted latest data [11], [13], [16], [17].

3. Results and Discussions

The objectives of this study were to determine the states of Buriganga River pollution and also discuss the impact of climate change. Overall this study revealed that decreasing the rate of rainfall because of climate change and increasing the rate of waste water because of incremental economical activities in industries both affects the dilution rate of Buriganga River simultaneously and this scenario will be also big concern in future for increasing climate change impact on rainfall in Dhaka City. The rate of discharge of Buriganga River is decreasing gradually even though the amount of waste water is increasing abruptly.

4.1.1. Climate Change Impacts on Buriganga River

Dhaka is considered now the 7th largest city in the world and by 2020 Dhaka may be the 2nd largest city in the world [2]. The rural-urban migration is naturally increasing at an alarming rate to the Dhaka City for being centralized the major economic activities in Dhaka City [2]. The quantity of greeneries (0.13 acres for 1000 people) [3] in Dhaka City is inadequate, major portion parts of this small amount of greeneries are in the circumference of the city and the covering areas in Dhaka city are increasing abruptly by 210.37% from the year 1960-2014[4], these impacts are enhancing the change in climate gradually in the Dhaka City. This scenario is shown in figure- 1[18].

The natural sources of water of Buriganga and nearest others river in Dhaka City is rainfall, the area of Dhaka City is assumed as catchment areas of those rivers. The average rainfall is decreasing gradually in Dhaka City due to climate change impact.

From the analysis of the historical average rainfall records, this study revealed that the average rainfall decreased gradually which finally affect the dilution rate of Buriganga River's water.

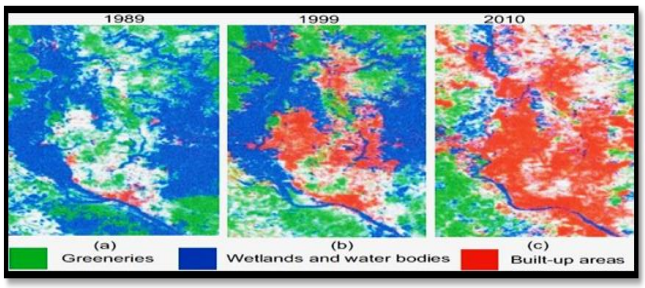

Fig 1. Topographic Condition of Dhaka City in 1989, 1999 and 2010

Because of decreasing rainfall rate and increasing amount of waste water the rate of water pollutions are increasing gradually day by day. In the monsoon (June-Oct), showed increasing trends, in this time the water quality of this river is comparatively good. The forecasted rainfall up to 2040 shows the downward trend in the pre-monsoon as like as the observed rainfall and in the monsoon the average rainfall shows significantly decrease in August and little in June. It indicates the pre-monsoon get dry day by day which will also continue in future. This study also observed from forecasted rainfall data that the climate change impact in term of rainfall in Buriganga River pollution will be increased gradually in upcoming years. Figures (2-7) showed the both historical and predicted rainfall data up to 2040.

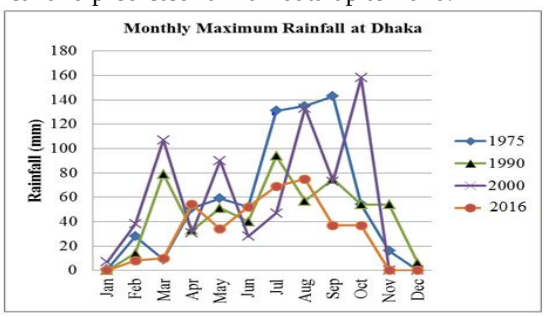

Fig 2. Monthly Maximum Rainfall

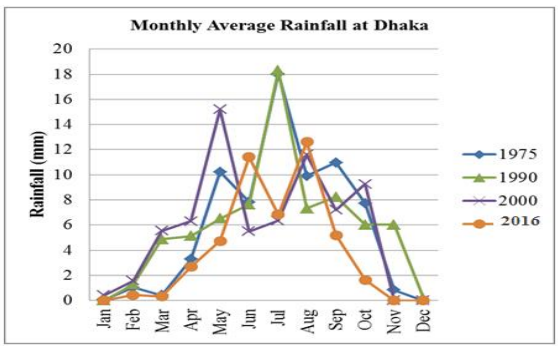

Fig 3. Monthly Average Rainfall

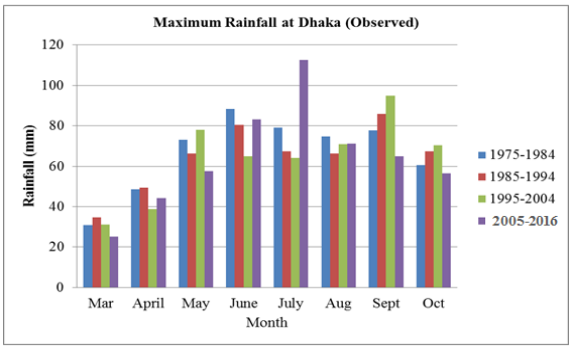

Fig 4. Decadal Maximum Rainfall

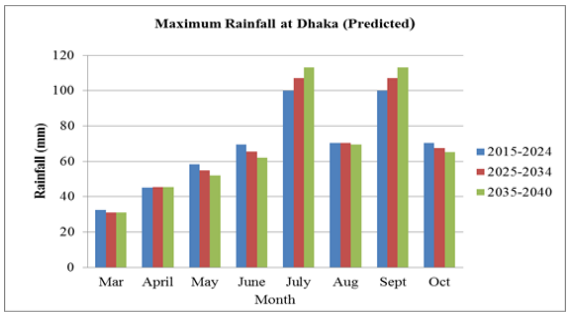

Fig 5. Decadal Maximum Rainfall

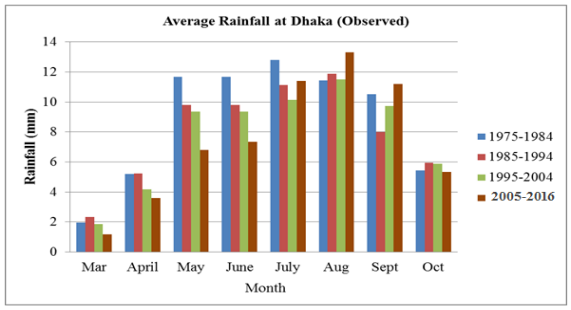

Fig 6. Decadal Average Rainfall

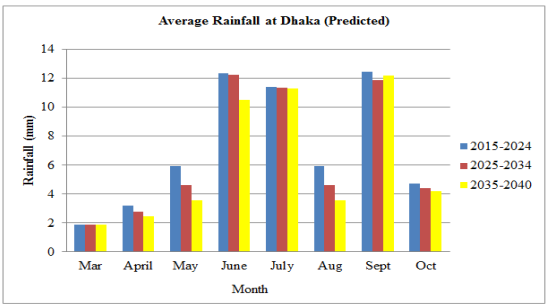

Fig 7. Decadal Average Rainfall

Figure 8 showed surface water velocity (m/sec) and discharge rate (cumec) measured at Millbarak during 2008, 2012 and 2016. The surface water velocity and discharge both were decreasing gradually. The discharge of waste water in this river is increasing abruptly but velocity and discharge of river are decreasing. Therefore, it is clear that velocity and discharge both are decreasing because of climate change impact in term of rainfall although waste water discharge is increasing gradually in this river. The average rainfall in Dhaka City is decreasing gradually, Figure 7 showed this scenario up to 2040.

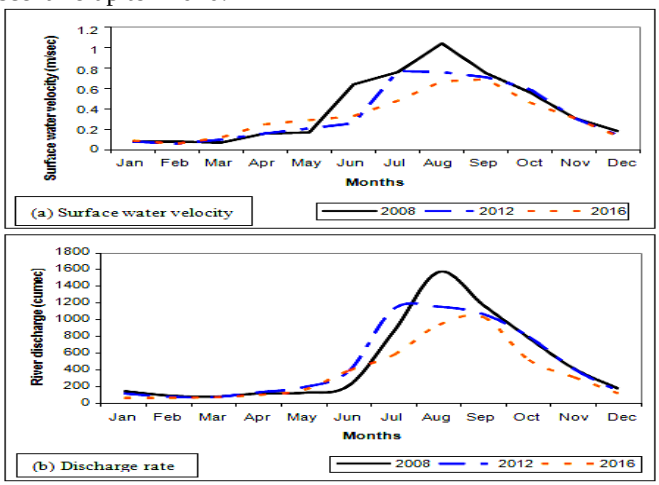

Fig 8. Buriganga River (A) Surface Water Velocity (M/Sec) and (B) Discharge Rate (Cumec) Measured at Millbarak during 2008, 2012 and 2016

In order to discern the importance of rainfall for Buriganga River, this study took facilitation from a study which was done by Mohammad Moniruzzaman, Syed Fazle Elahib, and Md. Abu Anis Jahangir [19]. Their study observed temporal variation of Physico-chemical parameters of Buriganga River water through GIS (Geographical Information System) technology. Ultimately, their study revealed that the water quality of Buriganga River comparatively good although not enough sufficiently in wet season. Water quality gradually polluted and reached to very worst situation during dry season due to unavailability rainfall in dry season. Hence, our study disclosed that quality of water of Buriganga River largely depend on seasonal rainfall and also disclosed that predicted rainfall in Dhaka City decreased, this scenarios will affect largely on the quality of water of Buriganga River in future because of climate change impact.

Some observed results of their study are given in figures 9 to 10.

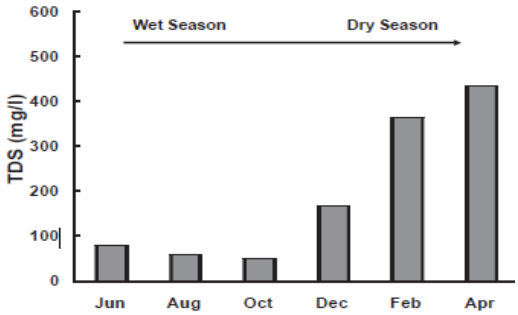

Fig 9. Average TDS Value of Buriganga River Water at Different Times of Year [19]

The Total Dissolved Solid (TDS) concentration of river water was considerably high during dry season from December to April with average value in the range of 167 to 435 mg/l and the highest average TDS value of water found during the month of April (TDS = 435 mg/l) (Figure 9) because of receiving both minimum rainfall and maximum waste water discharge in river [19].

On the other hand, the TDS was relatively low during wet season from June to October (50 to 80 mg/l) due to dilution effect by rainfall and the lowest average TDS value found in October (50 mg/l) (Figure 9) [20].

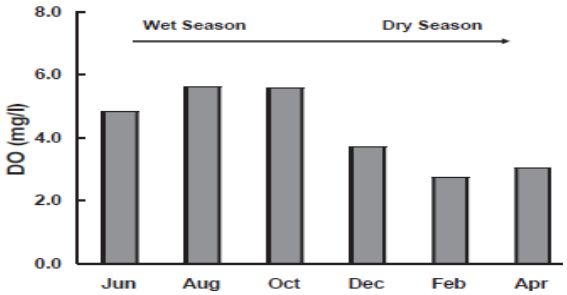

Fig 10. Averages DO of Water of Buriganga River at Different Times of Year [19]

Dissolved oxygen (DO) concentration of water of Buriganga River was significantly low during dry season from December to April (average value in the range of 2.73 to 3.72 mg/l) because of minimum rainfall and maximum waste water discharge in river (Figure 10). DO concentration of water was comparatively high during wet season from June to October with average value in the range of 4.84 to 5.59 mg/l (Figure 10) due to receive maximum rainfall and maximum waste water [19].

Overall this study revealed that decreasing the rate of rainfall and increasing the rate of waste water in river both affects the dilution of water of Buriganga River simultaneously and this scenario will be also big concern in future for increasing climate change impact on rainfall in Dhaka City. The concentration of waste water is increasing gradually which abruptly reduce the quality of Buriganga River's water.

It is also one of the main causes of changing water quality of Buriganga River adversely because of changing surrounding climate in term of rainfall adversely. Therefore, dilution of water in Buriganga River is very important issue by rainfall for enhancing the quality of water.

3.1. Pollution Status of Buriganga River

Tables (1 – 8) showed the water quality of Buriganga River by analyzing Mean, Standard Deviation (SD) with SD (Maximum &Minimum) of the water quality parameters DO, BOD_5, COD, and pH, Turbidity, TDS, Nitrate and Phosphate. For showing the average behavior of the parameters and their dispersions, Mean and Standard Deviation (SD) were computed.

The lowest and highest values of DO of Buriganga River are 0.00 mg/L and 2.29 mg/L respectively. The average value of DO in this River is 1.11 mg/L. The DO of all sites was very low except for Pagla and Fattula sites which were both downstream location of the River. The standard value of DO for River water should be 8 mg/L of Oxygen [20]. The DO values for all points were below than standard value of 8 mg/L. The minimum and maximum Standard Deviations with respect to Mean were 0.04 and 2.64 respectively.

In 2017, Department of Environment (DoE), Bangladesh found the level of average dissolve oxygen (DO) in the Buriganga water was 0.1 in the first two months of this year compared to 0.00 in January and February last year [21].

The lowest and highest values of BOD_5 of Buriganga River are 21 mg/L and 275mg/L respectively. From this study the average value of BOD_5 in this River was 82.3 mg/L. The BOD_5 of all sites was very high. The standard value of BOD_5 for River water should be between the range 1 to 8 mg/L [1]. The BOD_5 values for all points were higher than standard value of 8 mg/L. The minimum and maximum Standard Deviations with respect to Mean were 13.22 and 256.54 respectively.

The lowest and highest values of COD of Buriganga River are 64 mg/L and 405 mg/L respectively. From this study the average value of BOD_5 in this River was 147.60 mg/L. The COD of all sites was also very high as BOD_5. The minimum and maximum Standard Deviations with respect to Mean were 42.08 and 412.6 respectively.

Table 1. Results on Water Quality Parameter (DO in Mg/L) of Buriganga River in Different Seasons

Point	Different Seasons			Mean	Standard Deviation (SD)		
	Winter	Summer	Autumn		SD	SD (Minimum)	SD (Maximum)
Mirpur Bridge	1.04	0.00	1.84	0.96	0.92	0.04	1.88
Goida Sluce Gate	0.85	0.61	2.13	1.20	0.82	0.38	2.02
Bosila Bridge	1.57	0.85	0.29	0.90	0.64	0.26	1.54
Rayar bazar sluice gate	0.90	2.10	1.90	1.63	0.64	0.99	2.27
Kalunagar	0.50	0.25	0.50	0.42	0.14	0.28	0.56
Muslim bazar	0.41	0.60	0.14	0.38	0.23	0.15	0.61
Hazaribargh	0.21	0.20	0.69	0.37	0.28	0.09	0.65
Faridabad	1.37	0.21	1.14	0.91	0.62	0.29	1.53
Pagla	2.13	3.47	0.59	2.06	1.44	0.60	3.5
Fattula	2.29	2.64	1.87	2.26	0.38	1.88	2.64

Table 2. Results on Water Quality Parameter (BOD_5 in Mg/L) of Buriganga River in Different Seasons

Point	Different Seasons			Mean	Standard Deviation (SD)		
	Winter	Summer	Autumn		SD	SD (Minimum)	SD (Maximum)
Mirpur Bridge	76.6	25.20	78.00	59.93	30.08	29.85	90.01
Goida Sluce Gate	107.16	15.00	85.20	69.12	48.13	21.00	117.25
Bosila Bridge	84.00	69.00	94.00	82.33	12.58	69.75	94.91
Rayar bazar sluice gate	128.00	213.90	36.70	126.2	88.61	37.59	214.81
Kalunagar	69.80	86.00	69.80	75.2	9.35	65.85	84.55
Muslim bazar	97.20	30.00	63.28	63.49	33.60	29.89	97.09
Hazaribargh	134.79	57.90	34.79	75.82	52.35	23.47	128.17
Faridabad	91.36	51.00	21.36	54.57	35.13	19.44	89.7
Pagla	87.37	69.00	87.37	81.25	10.60	70.65	91.85
Fattula	53.00	77.10	275.00	135.03	121.81	13.22	256.64

Table 3. Results on Water Quality Parameter (COD in Mg/L) of Buriganga River in Different Seasons

Point	Different Seasons			Mean	Standard Deviation (SD)		
	Winter	Summer	Autumn		SD	SD (Minimum)	SD (Maximum)
Mirpur Bridge	104.8	64.00	130.24	99.68	33.48	66.2	133.16
Goida Sluce Gate	150.10	112.00	154.32	138.80	23.31	115.49	162.11
Bosila Bridge	137.80	80.00	183.20	133.66	51.72	81.94	185.38
Rayar bazar sluice gate	405.00	300.00	149.80	284.60	128.26	156.34	412.86
Kalunagar	146.80	164.40	79.40	130.20	44.86	85.33	175.06
Muslim bazar	142.70	135.50	85.70	121.3	31.03	90.26	152.33
Hazaribargh	282.10	65.00	79.10	142.06	121.47	20.58	263.53
Faridabad	176.70	74.40	139.70	130.26	51.79	78.46	182.05
Pagla	136.30	114.00	96.30	115.53	20.03	95.49	135.56
Fattula	81.70	139.00	343.50	180.06	137.97	42.08	318.03

Table 4. Results on Water Quality Parameter (pH) of Buriganga River in Different Seasons

Point	Different Seasons			Mean	Standard Deviation (SD)		
	Winter	Summer	Autumn		SD	SD (Minimum)	SD (Maximum)
Mirpur Bridge	7.49	7.95	6.48	7.30	0.75	6.55	8.05
Goida Sluce Gate	7.67	7.28	7.18	7.37	0.25	7.11	7.62
Bosila Bridge	6.11	6.60	7.25	6.65	0.57	6.07	7.22
Rayar bazar sluice gate	6.73	7.79	7.71	7.41	0.59	6.82	8.00
Kalunagar	6.45	7.68	7.34	7.15	0.63	6.52	7.78
Muslim bazar	6.30	7.45	8.01	7.25	0.87	6.37	8.12
Hazaribargh	6.16	7.36	6.93	6.81	0.60	6.20	7.41
Faridabad	6.04	7.37	7.13	6.84	0.70	6.14	7.54
Pagla	6.23	6.64	7.38	6.75	0.58	6.17	7.33
Fattula	6.21	7.63	8.02	7.28	0.95	6.33	8.23

Table 5. Results on Water Quality Parameter (Turbidity in NTU) of Buriganga River in Different Seasons

Point	Different Seasons			Mean	Standard Deviation (SD)		
	Winter	Summer	Autumn		SD	SD (Minimum)	SD (Maximum)
Mirpur Bridge	10.90	36.10	98.70	48.56	45.20	3.35	93.76
Goida Sluce Gate	39.70	42.00	14.97	32.16	14.98	17.18	47.14
Bosila Bridge	16.20	41.80	58.70	38.90	21.39	17.50	60.29
Rayar bazar sluice gate	93.30	77.10	56.10	75.63	18.84	56.71	94.47
Kalunagar	10.00	50.10	97.21	52.43	43.56	8.77	95.99
Muslim bazar	9.66	51.30	56.80	39.25	25.77	13.47	65.02
Hazaribargh	139.00	82.50	49.57	90.32	45.27	45.04	135.59
Faridabad	21.80	39.10	58.60	39.83	18.41	21.42	58.24
Pagla	49.30	119.00	54.80	74.36	38.75	35.60	113.11
Fattula	16.10	8.79	89.76	38.21	44.78	-6.57	82.99

The lowest and highest values of pH of Buriganga River are 6.11 and 8.02 respectively. The Standard Deviations for all points were very low.

The lowest and highest values of Turbidity of Buriganga River are 8.79 NTU and 139.00 NTU respectively. The minimum and maximum Standard Deviations with respect to Mean were -6.07 and 135.59 respectively.

Table 6. Results on Water Quality Parameter (TDS in Mg/L) of Buriganga River in Different Seasons

Point	Different Seasons			Mean	Standard Deviation (SD)		
	Winter	Summer	Autumn		SD	SD (Minimum)	SD (Maximum)
Mirpur Bridge	124.00	497.00	531.00	384.00	225.80	159.00	609.80
Goida Sluce Gate	396.00	437.00	402.00	411.66	22.14	389.51	433.80
Bosila Bridge	395.00	551.00	631.00	525.66	120.02	405.63	645.68
Rayar bazar sluice gate	300.00	1634.00	509.00	814.33	717.50	96.83	1531.83
Kalunagar	375.00	531.00	716.00	540.66	170.70	369.95	711.36
Muslim bazar	358.00	523.00	534.00	471.66	98.59	373.06	570.25
Hazaribargh	824.00	651.00	593.00	689.33	120.17	569.15	809.50
Faridabad	380.00	488.00	486.00	451.33	61.78	389.55	513.11
Pagla	372.00	416.00	608.00	465.33	125.49	339.84	590.82
Fattula	352.00	327.00	1719.00	799.33	796.55	2.78	1595.88

The lowest and highest values of TDS of Buriganga River are 124.00 mg/L and 1719.00 mg/L respectively. The minimum and maximum Standard Deviations with respect to Mean were 2.78 and 1595.88 respectively.

Table 7. Results on Water Quality Parameter (Nitrate in mg/L) of Buriganga River in Different Seasons

Point	Different Seasons			Mean	Standard Deviation (SD)		
	Winter	Summer	Autumn		SD	SD (Minimum)	SD (Maximum)
Mirpur Bridge	4.60	1.70	2.19	2.83	1.55	1.28	4.38
Goida Sluce Gate	11.30	5.30	3.87	6.82	3.94	2.88	10.76
Bosila Bridge	3.60	2.50	10.90	5.66	4.56	1.10	10.22
Rayar bazar sluice gate	9.40	6.40	2.90	6.23	3.25	2.98	9.48
Kalunagar	13.90	11.20	4.80	9.96	4.67	5.29	14.63
Muslim bazar	3.30	1.30	2.70	2.43	1.02	1.41	3.45
Hazaribargh	4.10	2.10	6.80	4.33	2.35	1.98	6.68
Faridabad	14.30	12.90	4.56	10.58	5.26	5.32	15.84
Pagla	3.70	1.80	5.90	3.80	2.05	1.75	5.85
Fattula	3.10	3.20	13.40	6.56	5.91	0.65	12.47

The lowest and highest values of Nitrate of Buriganga River are 1.70 mg/L and 14.30 mg/L respectively. The minimum and maximum Standard Deviations with respect to Mean were 0.65 and 15.84 respectively.

The lowest and highest values of Phosphate of Buriganga River are 2.4 mg/L and 15.84 mg/L respectively. The minimum and maximum Standard Deviations with respect to Mean were 1.14 and 16.17 respectively.

Table 8. Results on Water Quality Parameter (Phosphate in mg/L) of Buriganga River in Different Seasons

Point	Different Seasons			Mean	Standard Deviation (SD)		
	Winter	Summer	Autumn		SD	SD (Minimum)	SD (Maximum)
Mirpur Bridge	2.23	1.58	3.79	2.53	1.13	1.14	3.66
Goida Sluce Gate	10.81	7.31	14.87	10.99	3.78	7.21	14.77
Bosila Bridge	2.88	1.68	3.92	2.82	1.12	1.70	3.94
Rayar bazar sluice gate	12.84	11.97	5.12	9.97	4.22	5.75	14.19
Kalunagar	2.75	1.91	4.14	2.93	1.12	1.81	4.05
Muslim bazar	2.48	2.28	3.47	2.74	0.63	2.11	3.37
Hazaribargh	15.45	13.73	8.49	12.55	3.62	8.93	16.17
Faridabad	4.14	2.53	2.95	3.20	0.83	2.37	4.03
Pagla	4.81	3.19	13.83	7.27	5.73	1.54	13.00
Fattula	2.40	2.14	5.12	3.22	1.65	1.57	4.87

The average values of Nitrate and phosphate in Buriganga River were 5.92 mg/L and 5.83 mg/L respectively.

Ultimately, this study disclosed that no water in Buriganga River was found actually pure in any seasons and also any location.

4. Conclusions and Recommendations

The major conclusions may be summarized as follows:

- This study revealed that decreasing the rate of rainfall and increasing the rate of waste water in river both affects the dilution of water of Buriganga River simultaneously and this scenario will be also big concern in future for increasing climate change impact on rainfall in Dhaka City.
- Dilution of water in Buriganga River is very important issue by rainfall for enhancing the quality of water.
- The quality of water in this river was very poor and the average DO, BOD, COD, Nitrate and Phosphate concentration in mg/L were 1.11, 82.3, 148.45, 5.92 and 5.83 respectively.
- No water in Buriganga River was found actually pure in any seasons and also any location in our study areas.

In order to enhance the survival and economic growth of Dhaka City, Buriganga has enormous significance. Failure to protect Buriganga River from pollution means that a failure to policy marks who underestimating the benefits of environmental protection, restoration, programs and economic growth. Early implementation of efficient management practices may save the Buriganga River. For this some recommendations to minimize the Buriganga pollution are:

- The industries which have Effluent Treatment Plan (ETP) must be monitored regularly by the Department of Environment (DoE), Bangladesh before throwing it to water body.
- The industries which have no Effluent Treatment Plan (ETP) must be forced for introducing ETP by Department of Environment (DoE), Bangladesh before throwing it to water body otherwise DoE must be stopped these industries. In order to reduce treatment cost of water purification, they can introduce Common Effluent Treatment Plan (CETP).
- Government should take initiative to decentralize the economic activities into other city of Bangladesh for enhancing the environmental quality which will reduce the climate change impact in Dhaka City.
- In order to increase the environmental quality, government should take steps for introducing green technology in industries, building constructions etc.
- Government should take initiative on increasing the greeneries areas in Dhaka City. They can introduce agricultural activities, gardening, tree plantation etc. on the building roof of Dhaka City.
- The government should stop and punish the people who built illegal structure on the river banks.

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