

Study of Water Quality Parameters of Buriganga River Adjacent to Dhaka City

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Abstract

This study focused on the identification of some water quality parameters of Buriganga River adjacent to Dhaka City. Accordingly, samples are collected from several locations of Buriganga River. It is observed that the water quality of Buriganga River has changed a lot due to several reasons. Water temperature has changed from 23.20 to 26.04 °C, other parameters like DO is observed to change from 1.3 to 4.9 mg L⁻¹, pH is from 7.15 to 7.80, conductivity is from 529 to 580 μS cm⁻¹, turbidity from 11.6 to 19.9 NTU, and TDS from 250 to 289 mg L⁻¹. The study reveals that BOD, TDS, EC, Turbidity, Suspended Solids and Alkalinity are higher in dry season than wet season, but Dissolved Oxygen is higher in wet season than dry season. Analysis through semivariogram model indicates that the majority of water quality indicators have a moderate to high degree of spatial dependence. The gaussian semivariogram model is found to be the best-fitting model for both EC and pH. For salinity, the circular semivariogram model is the best fit, whereas for TDS the exponential semivariogram model is the best fit. It is possible to reduce the pollution of the present Buriganga River to a great extent by adopting a scientific master plan. All types of leather factories have to be shifted from Hazaribagh as soon as possible. Effluent treatment plants should be made mandatory component in all the leather industries.

Keywords: Water Quality, Variability, Discharge, Spatial Distribution and Geostatistical model

1. Introduction

Water is one of the essential substances. The demand for pure water is huge in today's world. There is no alternative to pure water to keep the health of the people integrated. River is an important source of water. Bangladesh is called a riverine country. Buriganga is one of the most polluted rivers in Bangladesh which is located around the capital city, Dhaka. Water pollution is one of the foremost serious environmental problems. Unplanned urbanization and industrialization have developed around the river Buriganga. In recent time, values of Buriganga River water quality parameters crossed their standard levels. From the analysis of the data of last forty years, it is evident that the water quality of Buriganga River changed to a large extent. As industrial and domestic waste are randomly discharged to several points of Buriganga River, it fluctuates the trend of water quality change from one place to another. Consequently, the Buriganga is decaying and also the atmosphere is getting polluted. There were 343 tannery industries situated in Hazaribagh on the bank of Buriganga River [1]. Due to many industries have sprung up around the river Buriganga which has pushed the river's ecosystem to the brink of destruction [2]. According to DoE (Department of Environment) report from 2010 to 2016, it was found that the water quality of Buriganga River has degraded a lot. In Buriganga River, several zones are considered as most polluted area such as Sadarghat, Keraniganj, Mirpur Bridge, Pagla, and Kamrangir Char and so on [3]. In Sadarghat area, various types of small and large launches, vessels, steamers, engine driven boats are regularly in motion. Oil spills from all of these vehicles stay in the river water later creates the water pollution.

Municipal sewerage line directly connected to Buriganga River. This highly toxic water is discharged into the Buriganga River and is deteriorating the quality of water in Buriganga River. Dwellers of the surrounding areas of Buriganga River unconsciously also discharge domestic waste into the river. Sometimes travelers come and ride on boat, through packets, paper, and plastic bottles into the river. These activities also have significant impact on water quality of Buriganga River. Several common impacts of water pollution in Buriganga were also described such as urban water pressure, fish fingering mortality, deterioration of fish habitat, seriously increased of waterborne diseases, which are threatened for local residents of Buriganga River and declination of the aquatic resources in Buriganga River [4].

In this research an attempt has therefore made to understand the variability of water quality parameters with respect to Dissolve Oxygen (DO), pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Turbidity, Total Dissolve Solids (TDS), Electrical Conductivity, Total Suspended Solids, Alkalinity, Salinity, Temperature of Buriganga River adjacent to Dhaka city areas which are assessed and analyzed through the spatial distribution and semivariogram model.

2. Materials and Methodology

The following activities have been conducted under this experiment to analyze the water quality of Buriganga River for identifying the environmental condition.

2.1 Study Area

Water samples are collected from various points of Buriganga River. The selected sampling sites are Sadarghat and Keraniganj adjacent areas. These locations are chosen because maximum water pollution occur through anthropogenic activities.

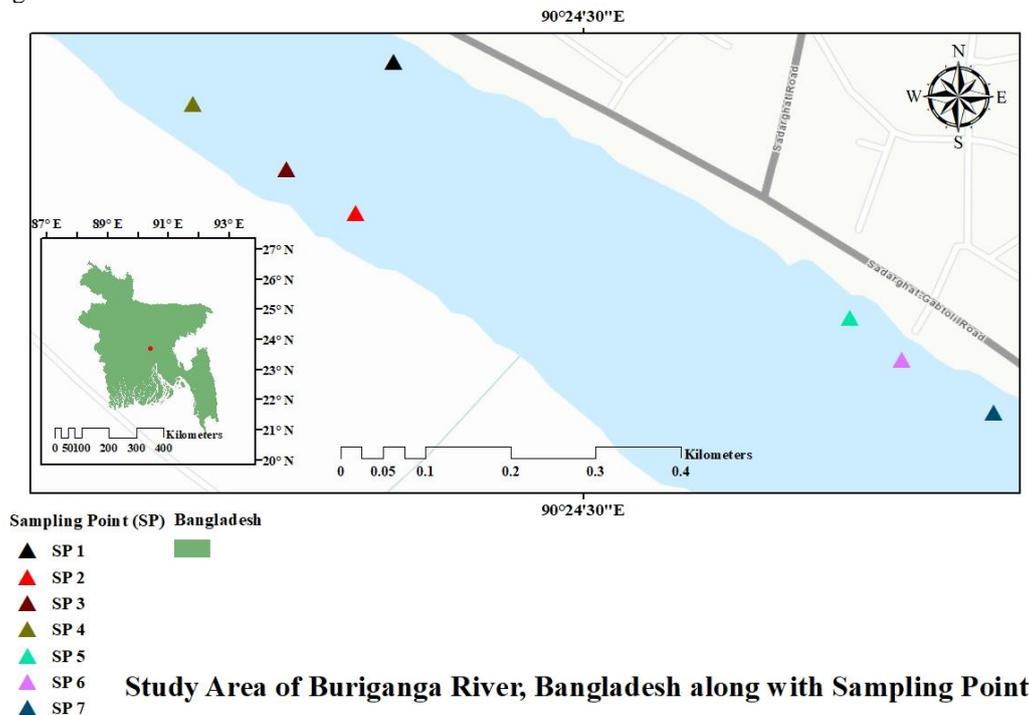


Figure 1: Study Area of Buriganga River, Dhaka, Bangladesh along with sampling points

2.2 Sample Collection

Water samples are collected in winter season (dry). Eight samples of approximately 500 ml are collected in 1L plastic bottles from different depths. After collecting the sample water, the sample bottles are marked and labeled by marker. During the collection of water sample location (Latitude and Longitude) are measured and marked in identification number.

2.3 Sample Analysis

Two instruments Multiparameter (HANNA-HI 9829) and DO Meter (YSI-Pro 20i) are used to calculate several physical and chemical parameters of Buriganga River Water. Arc GIS, Microsoft Excel soft wares are used to analyze the data.

Table 1: List of Instruments used to measure the parameters in the experiment

SI No.	Parameters	Instrument
(i)	pH	Multiparameter (HANNA-HI 9829)
(ii)	DO	DO Meter (YSI-Pro 20i)
(iii)	EC	Multiparameter (HANNA-HI 9829)
(iv)	Turbidity	Multiparameter (HANNA-HI 9829)
(v)	TDS	Multiparameter (HANNA-HI 9829)
(vi)	Temperature	Multiparameter (HANNA-HI 9829)
(vii)	Salinity	Multiparameter (HANNA-HI 9829)

2.4 Geostatistical Model

The semivariogram is a measure of the rate of change with distance. Semivariogram analysis is useful in comparing such attributes and in determining the most appropriate sampling strategy for them. As an additional requirement for prediction from control points, the semivariogram is required in almost any geostatistical procedure. In the case of structural analysis and spatial interpolation, semivariogram modeling and estimation are essential tools.

These models are chosen because the exponential model exhibits a differentiable variogram, the spherical model exhibits the best fitted variogram, the Gaussian model exhibits a non-differentiable variogram, and the linear model represents the simplest of the models.

To evaluate the fitted models, the values of mean error (ME), mean square error (MSE), root mean square error (RMSE), average standard error (ASR), and root mean square standardized error (RMSSE) , Those models have achieved the best goodness of fit and have the lowest mean error (ME), root mean error (RME), mean squared error (MSE), attained root mean squared error (RMSE), and average squared error (ASE) values are considered to have the best fitted models' performances [5]. The RMSE is used to investigate the best model by comparing its values, and the model with the smallest RMSE is the one that is the most appropriate for the collected data.

3. Results and Discussion

3.1 Variation of water quality parameters during 2010 to 2016 (Dry and Wet Seasons)

(a) pH:

pH is considered as one of the significant water quality parameters. In dry season of 2010, the magnitude of pH is found 7.25, but in 2016 it is 7.5. On the other hand, in wet season of 2010 the magnitude of pH is found 7.05, in the following years the trend of pH is seen to increase till 2012. In 2013, the magnitude of pH is decreased. In 2015 wet season the magnitude of pH is 6.93. Apart from this change of the trend of the magnitude of pH in Buriganga River in dry and wet seasons, the values are very close to each other. It is noted that pH decreases when temperature is increases. As per the Climate of Bangladesh, temperature is normally higher in wet season than dry season [3].

pH is also considered as an essential water quality parameter specially for river ecosystem balance. In low magnitude of pH can kill fish and other microorganisms. But due to excess discharge of waste water from many industries adjacent to Buriganga River degrade the magnitude of pH that impact aquatic organisms. pH is also impacts on other significant water quality parameters like DO, BOD, COD, Alkalinity and Temperature. It is very essential that a very minor changes of the magnitude of pH river water has long term effects.

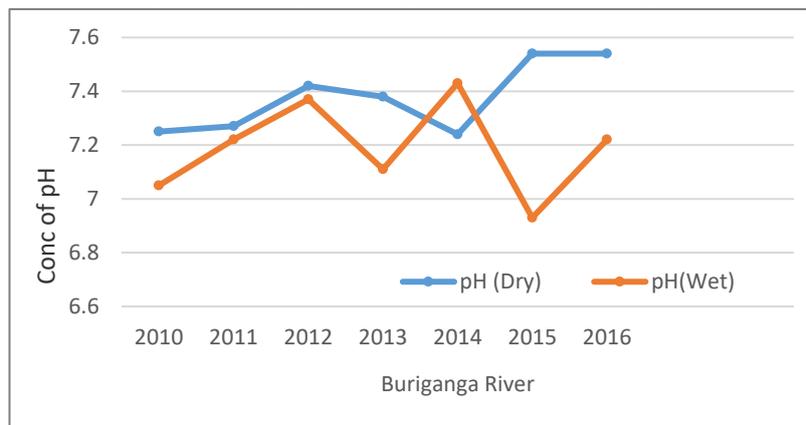


Figure 2: Variation of pH level in Buriganga River water adjacent to Dhaka City (2010-2016) dry and wet seasons (Data Source: River (Surface and ground water quality Report 2010-2016, DOE)

(b) Dissolve Oxygen:

Dissolve oxygen (DO) is considered as most significant water quality parameters for both drinking water as well as industrial wastewater. Variation of DO level in several water sources like river, pond, lake and ocean has significant influence on the balance of aquatic ecosystem. Normally DO level is lower at high temperature period. In climatic condition of Bangladesh area, Dissolve Oxygen concentration is generally very low in dry season.

Fig. 3 illustrated that during dry season the magnitude of Dissolve Oxygen (DO) is found 0.14 mg L⁻¹ in 2015 and 2.3 mg L⁻¹ in 2013. The magnitude of DO is in very low at Hazaribag. This indicates that serious water pollution occurred in Buriganga River from 2010 to 2016 dry season and this trend of Dissolve Oxygen (DO) is deteriorating day by day. In Bangladesh, wet season is considered from May to October month. At this period several natural disasters occurred. During wet season the maximum magnitude of Dissolve Oxygen (DO) is found 5.63 mg L⁻¹ in 2011 and lower magnitude of Dissolve Oxygen (DO) 3.56 mg L⁻¹ and 3.53 mg L⁻¹ are found in 2012 and 2015. Due to dilution property of water in monsoon season the magnitude of Dissolve Oxygen (DO) fluctuates more in wet season than that of dry season. According to the magnitude of Dissolve oxygen (DO) from 2010 to 2016, Hazaribag, Sadarghat, B.C.F Bridge, Pagla areas are considered as most polluted areas.

Dissolve Oxygen (DO) is the key factor that has numerous impacts on river water quality. It has numerous contributions to algae growth. Pragmatically huge number of industries those are situated beside the Buriganga River, discharge Phosphate, Nitrogen combining substances that can grow the algae, finally it degrades the Dissolve Oxygen (DO) level in Buriganga River, which is directly demolished the water quality as well as environment.

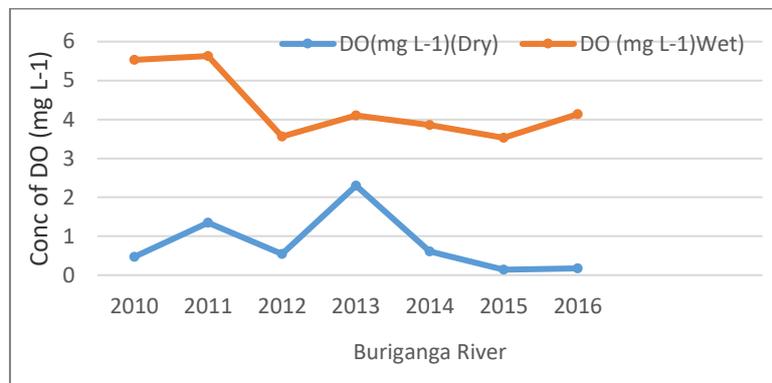


Figure 3: Variation of DO (mg L⁻¹) level in Buriganga River water adjacent to Dhaka City (2010-2016) during dry and wet seasons [Data Source: River (Surface and ground) water quality Report 2010-2016, DOE].

(c) Biochemical Oxygen Demand:

Biochemical Oxygen Demand (BOD) is found high in dry season and low in wet season (Fig. 4). The magnitude of BOD is high in January and February months. Standard magnitude of BOD in fishing water is 6 mg L⁻¹ and for agriculture it is 10 mg L⁻¹.

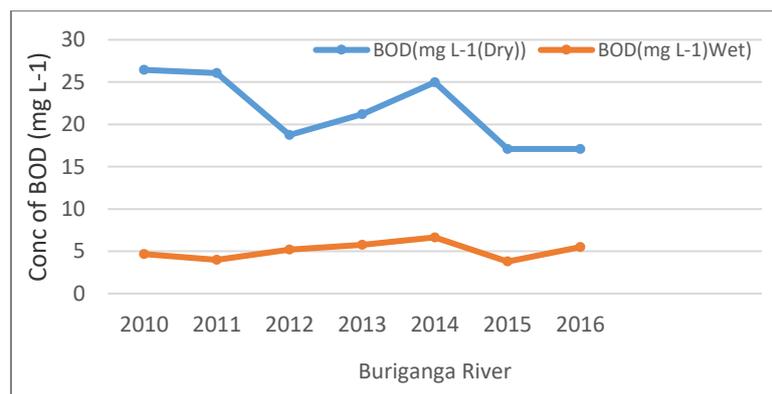


Figure 4: Variation of BOD level in Buriganga River water adjacent to Dhaka City (2010-2016) during dry and wet seasons [Data Source: River (Surface and ground) water quality Report 2010-2016, DOE]

In dry seasons from 2010 to 2016 the magnitude of BOD remained between 17.09 mg L⁻¹ and 26.44 mg L⁻¹ which is an indication of the presence of decomposable organic matter in Buriganga River water. During wet season the magnitude of BOD has showed a linear trend. The lowest magnitude of BOD is 3.78 mg L⁻¹ in 2015 at Mirpur Bridge point and the highest BOD of 6.64 mg L⁻¹ is observed in 2014. In wet season from 2011 to 2014, Biochemical Oxygen Demand (BOD) shows a slight increasing trend but it decreases in 2015 and increases afterwards. A Decreasing trend of BOD level is observed from 2010 to 2012 and 2014 to 2016 dry season in Buriganga River. The Maximum BOD 26.44 mg L⁻¹ was observed in Dholaikhal point during dry season 2010[3]. Both in dry and wet season the magnitude of Biochemical Oxygen Demand (BOD) has some factors that can directly or indirectly fluctuated. Factors included are temperature, pH and presence of various microorganisms. Higher magnitude of BOD is reflected on the depletion of oxygen level; it also indicates organic pollution occurred in Buriganga River at that time. Higher magnitude of Biochemical Oxygen Demand (BOD) indicate that the oxygen level is rapidly depleted, it also means that organic pollution was high due to poorly treated waste water and nitrate level.

(d) Chemical Oxygen Demand:

The magnitude of Chemical oxygen demand varied from 1 mg L⁻¹ to 782 mg L⁻¹ at different locations of Buriganga River. During dry season of 2013 the magnitude of COD is 782 mg L⁻¹ (Fig. 5). During wet season of 2010 to 2016 the magnitude of COD showed a linear trend. During dry season of 2010 to 2012 the magnitude of COD is upward and in 2013 it reached the maximum. After that 2013 to 2016 the magnitude of COD is downward. At Hazaribagh, Sadarghat, Pagla areas the magnitude of COD are not in good condition. [3].

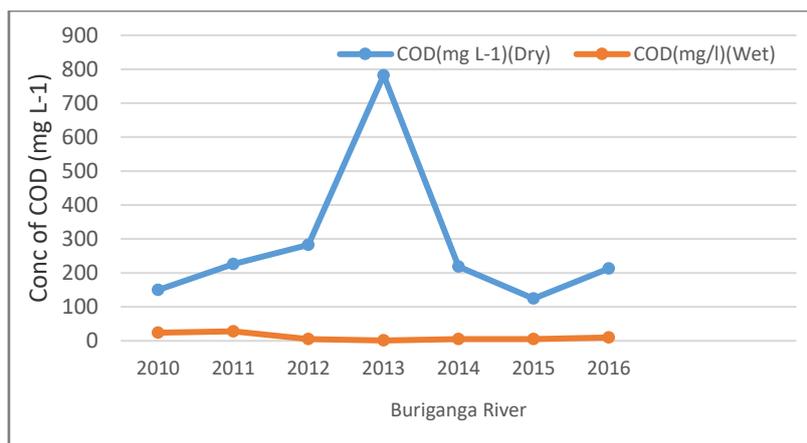


Figure 5: Variation of COD level in Buriganga River water adjacent to Dhaka City (2010-2016) during dry and wet seasons (Data Source: River (Surface and ground) water quality Report 2010-2016, DOE)

(e) Total Dissolve Solids:

Total Dissolve Solid concentration turn the mineral content of water. Comparatively higher magnitude of TDS are found in dry season than wet season (Fig. 6). During dry season of 2011 the magnitude of TDS is found 1188 mg L⁻¹ and 432 mg L⁻¹ in 2012. No definite trend was noticed in the change of the magnitude of TDS except that the values are lower in wet season than dry season [3].

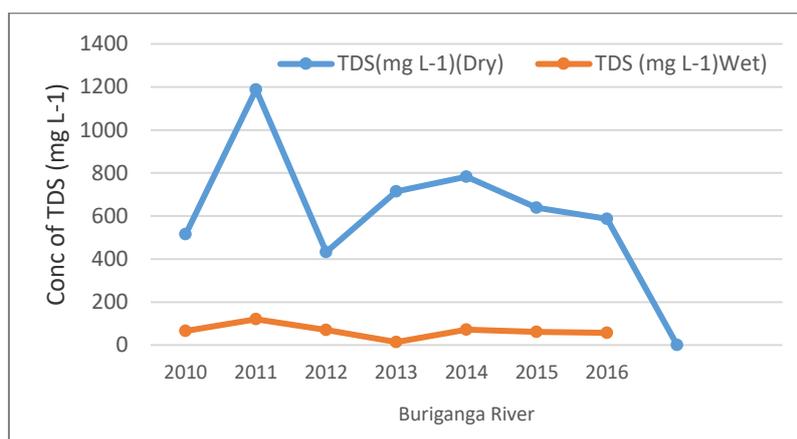


Figure 6: Variation of TDS level in Buriganga River water adjacent to Dhaka City (2010-2016) during dry and wet seasons (Data Source: River (Surface and ground) water quality Report 2010-2016, DOE).

It is observed that in wet season the magnitude of TDS are comparatively lower than the dry season. One reason behind that in wet season due to rainfall the river water becomes diluted. During wet season the magnitude of TDS has found 14 mg L⁻¹ in 2013 and 120 mg L⁻¹ in 2011. In wet season the magnitude of TDS showed a decreasing trend during 2014 to 2016.

In Bangladesh the standard magnitude of TDS for fishing and other activities is 500 mg L⁻¹. During the period of 2010 to 2016 the magnitude of TDS is found more than 500 mg L⁻¹ in several locations Buriganga River which is indicated that water quality is not suitable for fishing or other activities

(f) Electrical Conductivity:

Concentration of ions, types of ions and temperature can affect the Electrical Conductivity in water. In Buriganga River different types of ions such as Ca²⁺, Zn²⁺, Mg²⁺ presented that can fluctuate the EC level. In dry season 2010 to 2016 the magnitude of EC exceeded the permissible limit that impact on the water quality of Buriganga River. Warm water has higher magnitude of EC. As different industry those are situated beside the Buriganga River, they are used the Buriganga River water for their cooling purposes. After completion of cooling operation, they discharged their hot water directly into Buriganga River that made the temperature high of the water and consequently the magnitude of Electrical Conductivity exceeded the permissible limit.

The variability of the magnitude of Electrical Conductivity in Buriganga River is presented in Fig 7. Maximum magnitude of EC of Buriganga River is recorded at Hazaribag point during dry season of 2013. In dry season average magnitude of EC remained 600 to 1000 $\mu\text{S cm}^{-1}$.

During the wet season the magnitude of EC are comparatively lower than dry season. The maximum magnitude of EC $426 \mu\text{S cm}^{-1}$ is found in 2014 and $126 \mu\text{S cm}^{-1}$ is recorded in 2016. In wet season the magnitude of EC remained below $500 \mu\text{S cm}^{-1}$.

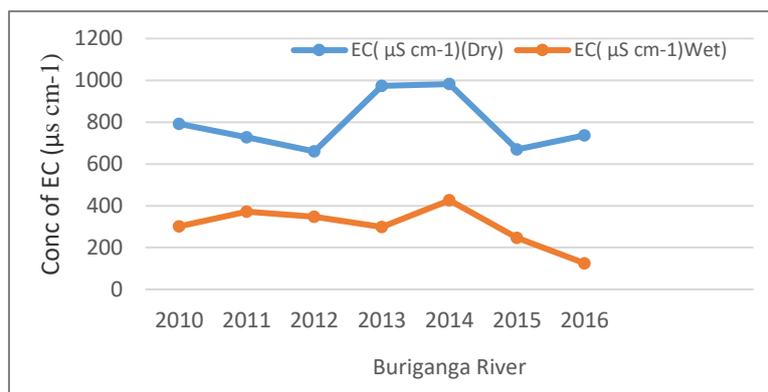


Figure 7: Variation of EC level in Buriganga River water adjacent to Dhaka City (2010-2016) during dry and wet seasons (Data Source: River (Surface and ground) water quality Report 2010-2016, DOE)

(g) Turbidity:

Huge amount of inorganic and organic substances, algae growth could create the water more turbid. Different types of factories, mills discharged large quantity of these substances into the Buriganga River that made more turbid condition. During dry season the highest magnitude of Turbidity recorded 127.45 NTU in 2015 and the lowest magnitude of turbidity 1.41 NTU recorded in 2012 (Fig 8). During the wet season the lowest magnitude of Turbidity is found 0.97 NTU in 2012 and the highest magnitude of Turbidity 15.4 NTU in 2014. In Hazaribagh, Sadarghat and Keraniganj areas of Buriganga River is considered as in the most polluted.

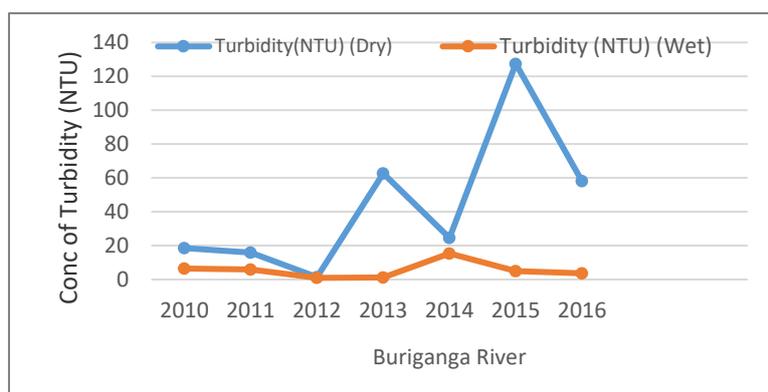


Figure 8: Variation of Turbidity level in Buriganga River water adjacent to Dhaka City (2010-2016) during dry and wet seasons (Data Source: River (Surface and ground) water quality Report 2010-2016, DOE)

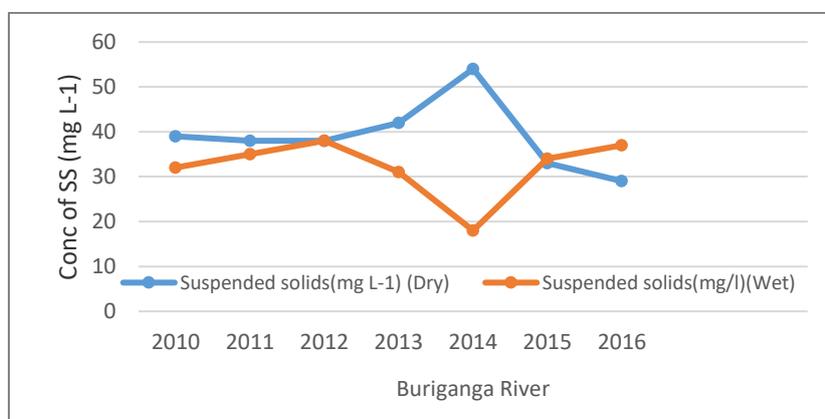


Figure 9: Variation of Suspended Solids level in Buriganga River water adjacent to Dhaka City (2010-2016) during dry and wet seasons (Data Source: River (Surface and ground) water quality Report 2010-2016, DOE)

(h) Suspended Solids:

Higher level of Suspended solids increases the temperature of water and decreased the Dissolve Oxygen level. In Buriganga River the magnitude of Suspended solid remained 31-54 mg L⁻¹. Maximum permissible limit of Suspended Solid is 25 mg L⁻¹. It shows that the magnitude of Suspended solids in Buriganga River higher that degrade the Dissolve oxygen and pollute the water quality.

During dry season the maximum magnitude of Suspended Solids have been found 54 mg L⁻¹ in 2014 and minimum 29 mg L⁻¹ in 2016. During wet season the magnitude of Suspended Solids have been found maximum 38 mg L⁻¹ in 2012 and minimum 18 mg L⁻¹ in 2015 (Fig. 9).

(i) Alkalinity:

In dry season from December to January the maximum magnitude of Alkalinity 320 mg L⁻¹ is observed at Hazaribagh and the minimum 74 mg L⁻¹ is observed at Kamrangir char (Fig 8). In wet season the maximum magnitude of Alkalinity 335 mg L⁻¹ is observed at Hazaribagh and the minimum 80 mg L⁻¹ at Chandi ghat.

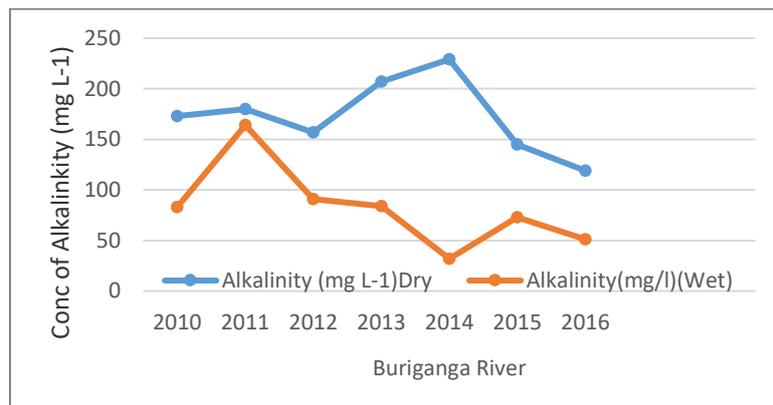


Figure 10: Variation of Alkalinity level in Buriganga River water adjacent to Dhaka City (2010-2016) Dry and Wet Season (Data Source: River (Surface and ground) water quality Report 2010-2016, DOE)

3.2 Spatial Distribution of Measured Sample of Buriganga River

The spatial distribution of water quality parameters shown in Fig. 11. The Maximum pH is 7.81 measured at Sadarghat area and the minimum pH 7.15 measured at keraniganj area. (Fig. 11a). In Sadarghat adjacent sampling point the magnitude of DO is 2.2 mg L⁻¹ and Keraniganj 1.3 mg L⁻¹. (Fig. 11b). Lower magnitude of Dissolve Oxygen indicates that decomposition of several organic wastes is active in these areas by microorganisms. Maximum and minimum magnitude of EC are recorded 575 μS cm⁻¹ and 529 μS cm⁻¹ (Fig. 11c). Salinity levels fluctuated to a very small extent. (Fig. 11d). Turbidity of water defines the cloudiness or haziness of water.

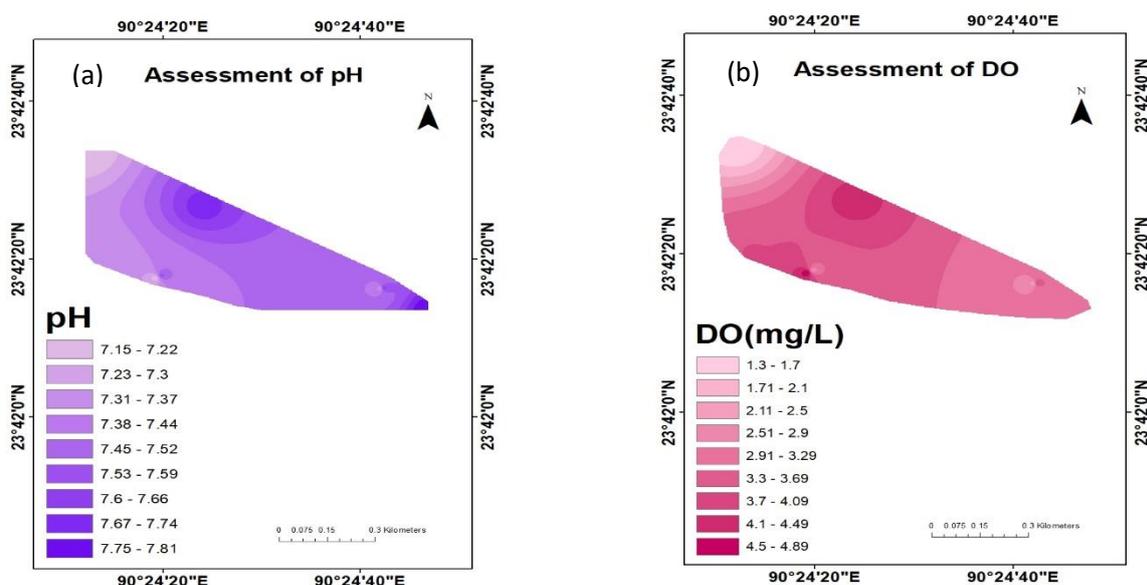


Figure 11 (a-b): Spatial Distribution of (a) and pH (b)

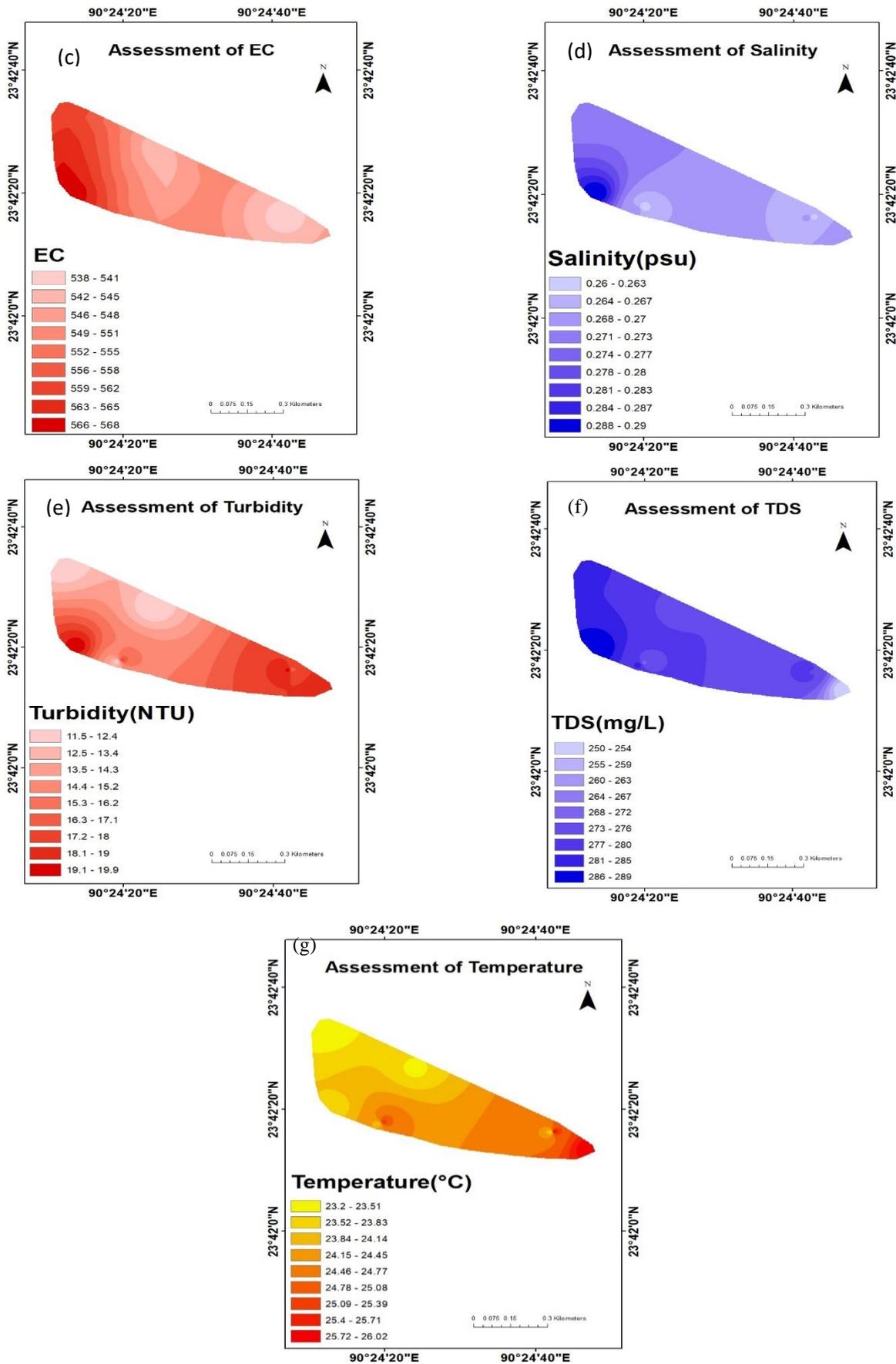


Figure 11 (c-g): Spatial Distribution of (c) EC (d) Salinity (e) Turbidity (f) TDS (g)Temperature of Buriganga River (Measured)

Measured the magnitude of Turbidity of Buriganga River at Sadarghat adjacent area is 19.9 NTU (maximum) and 11.5 NTU (minimum) (Fig. 11e). At Keraniganj adjacent area maximum and minimum magnitude of Turbidity are 19.5 NTU and 11.6 NTU. The variation of the magnitude of TDS remains between 250 and 289 mg L⁻¹. (Fig. 11f). These values are not suitable for aquatic organisms in river. Variation of temperature is ranged between 23.02 °C to 26.04 °C (Fig. 11g).

3.3 Geostatistical Model:

Table 3 depicted that several indices’ characteristics through various model and fig. 12 illustrated Best fitted semivariogram model for water quality parameters of the study area.

Table 3: Magnitudes of water quality index

Indices	Fitted Model Type	Nugget	Major range	Partial Sill	Lag size	ME	RMSE	MSE	RMSSE	ASE
EC	Gaussian	143.07	0.023	463.84	0.002	-0.495	12.64	-0.014	0.907	14.18
pH	Gaussian	0.053	0.023	0.055	0.002	0.004	0.258	0.011	0.986	0.26
DO	Spherical	1.39	0.022	0	0.002	0.080	1.25	0.063	0.996	1.267
Salinity	Circular	0.00009	0.023	0	0.002	-0.0005	0.010	-0.051	1.02	0.010
Turbidity	Gaussian	12.03	0.019	7.30	0.002	-0.014	3.86	-0.003	0.996	3.90
Temperature	Gaussian	1.17	0.023	1.53	0.002	-0.001	1.21	-0.00002	0.984	1.23
TDS	Exponential	79.24	0.014	97.53	0.001	0.336	11.96	0.014	1.00	11.70

Fig. 12 shows that the experimental semivariogram (binned sign) around the omnidirectional semivariogram model (blue line) and the average of semivariogram models (plus sign).

The gaussian semivariogram model is identified to be the best-fitted models for EC, pH, Turbidity and Temperature. Gaussian model is a powerful algorithm that can be used for both classification and regression. It is their ability to provide a reliable estimate of their own uncertainty that provides them with the greatest practical advantage. The spherical semivariogram model is best- fitted model for DO. The circular semivariogram model is best-fitted model for salinity and the exponential semivariogram model is best-fitted model for TDS. The semivariogram model showed that most of the water quality indices have a moderate to high spatial dependence.

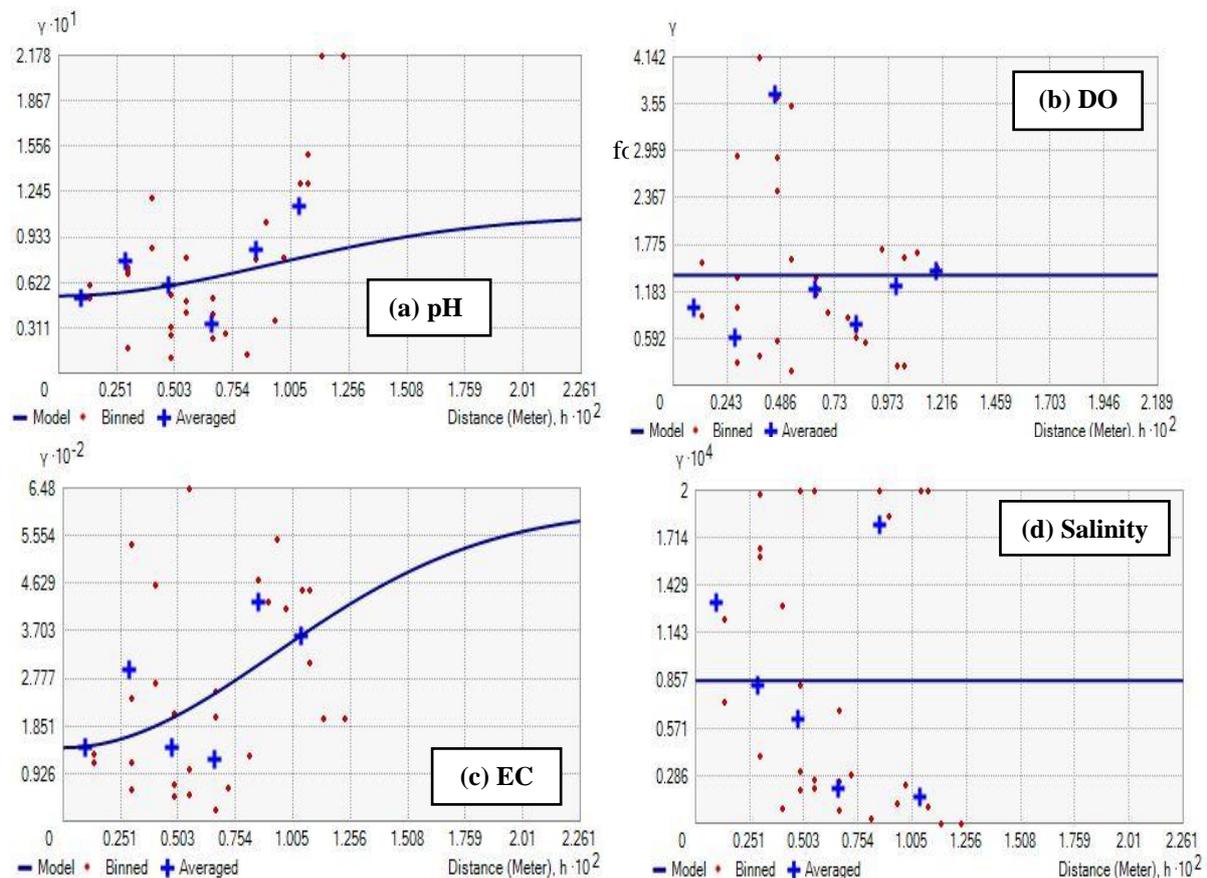


Figure 12(a-d): Best fitted semivariogram model for water quality parameters (a) pH, (b) DO, (c) EC and (d) Salinity of the study area

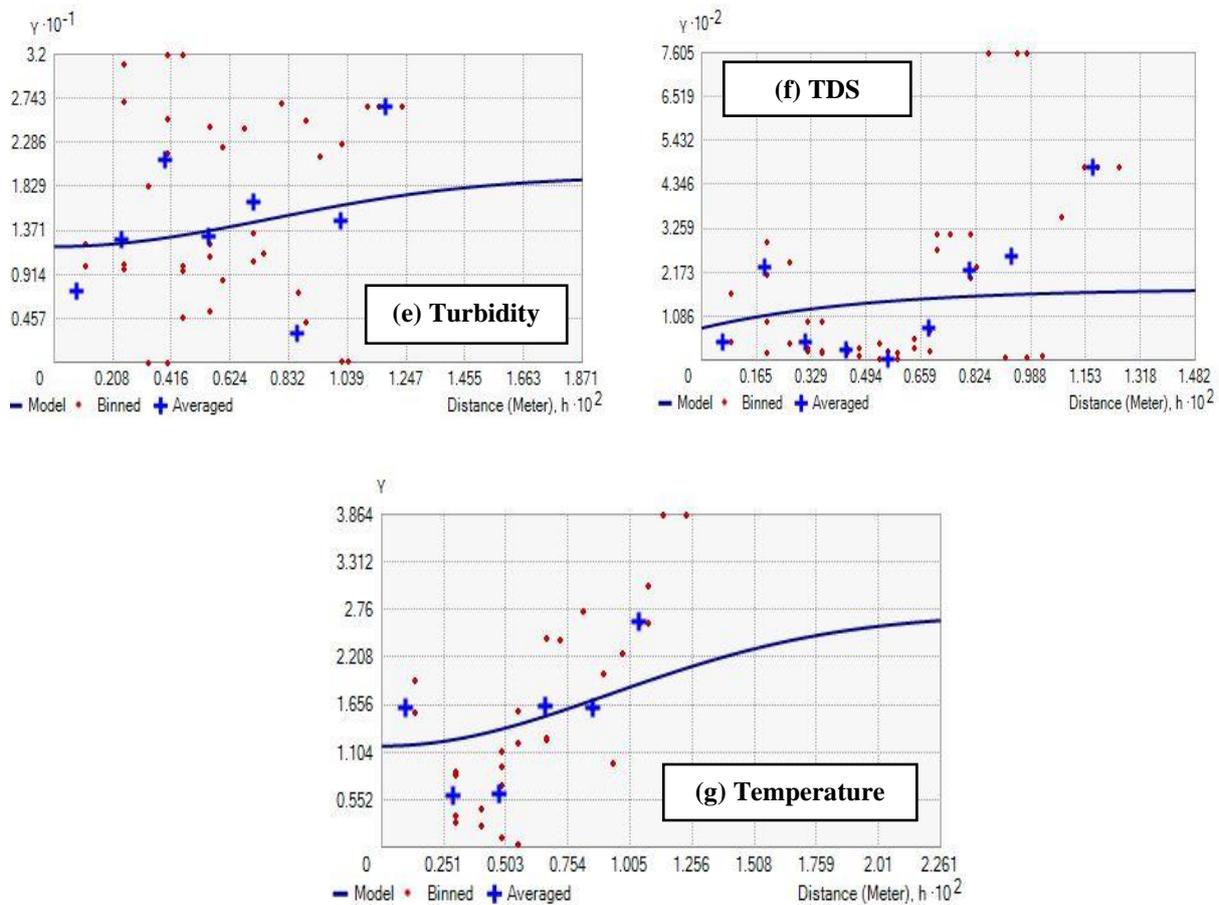


Figure 12(e-g): Best fitted semivariogram model for water quality parameters (e) Turbidity, (f) TDS and (g) Temperature of the study area

4. Conclusion

All physical and chemical parameters of Buriganga River are currently not in suitable condition for aquatic organisms as well as surrounding dwellers of this river because many people directly or indirectly depend on this for their livelihood. However, in recent years, ongoing development operations along these rivers have severely degraded the water quality trend. Due to lack of an effective management and policies, the water quality of the Buriganga River is expected to deteriorate in the future. All of the industries around the Buriganga River have to be regularly monitored so that no more toxic and polluted waste from these industries can be dumped in the river in any other way. If necessary, the industries can be fined. All kinds of illegal establishments along the banks of the river Buriganga should be evicted as soon as possible through the appropriate authorities.

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