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A Study on Selected Water Quality Parameters along the River Buriganga, Bangladesh

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Abstract: The Buriganga river system is located in the southern part of the north central region of Bangladesh, passing through west and south of Dhaka, the capital of Bangladesh. The river receives wastewater from numerous numbers of sources along its way, which are discharged as industrial effluents, municipal sewage, household wastes, clinical wastes and oils. The purpose of this study is to investigate into the impact of this wastewater on the river water and thus to provide an updated report on the state of water quality of the river Buriganga. The water samples were collected in year 2008-09 during both dry and wet seasons from different points along the river and analysed for various physiochemical quality parameters, which includes: temperature, pH, EC, DO, BOD_5, COD, PO_4-P, NH_3-N, Pb and Cr. The mean values for the parameters in both dry and wet seasons were compared with the surface water quality standards as set by the Department of Environment (DOE) in Bangladesh. The water quality test results have also been summarised and presented through box and whisker plots.

Key words: Buriganga river % Water quality % Dry season % Wet season

INTRODUCTION

The Buriganga River having a length of 17 km is located in the southern part of the North Central Region of Bangladesh, close to the confluence of the Padma (Ganges) and Upper Meghna rivers. It is a tide-influenced river passing through west and south of Dhaka City, the capital of Bangladesh (Figure 1). The average flow of the river varies between 140 cubic meters/sec in dry season (November to May) and 700 cubic meters/sec in wet season (June to October) [1]. The average depth and width of the river is 14 m and 265 m respectively [1]. A large number of people and industries depend on the Buriganga River for various social and economic purposes. The major land use along the banks of the river is for residential and commercial purposes, e.g. bazaars (markets), industries, warehouses and hospitals. Many people who live along the river use the river water for swimming, washing, bathing and boating (both for recreation and communication).

The residential and commercial establishments along the river Buriganga cause discharge of wastewater either directly into the river or into drains and canals which subsequently find their way into the river. There have been reports [2, 3] that the river is being polluted by discharge of industrial effluents, municipal wastewaters, household wastes, clinical and pathological wastes, oils and human excreta. In recent years, the river has become a dumping ground of all kinds of solid, liquid and chemical wastes which are generated by the activities in and around the river.

The largest share of pollution load into the river Buriganga appears to be from about 200 tannery industries in the *Hazaribagh* and *Rayerbazar* area (nearly 10,000 people rely directly on this industrial cluster for their source of income). Studies show that up to 15,000 cubic meters of liquid wastes, 19,000 kilograms of solid wastes and 17,600 kilograms of Biological Oxygen Demand (BOD) load go into the Buriganga each day from these industries [4-6]. Moreover, previous studies identified that each day 3,500 cubic meters of wastes from other industrial areas are also being discharged through 22 large outlets along the banks into the Buriganga [5, 7]. The discharge of such pollutants into the River Buriganga

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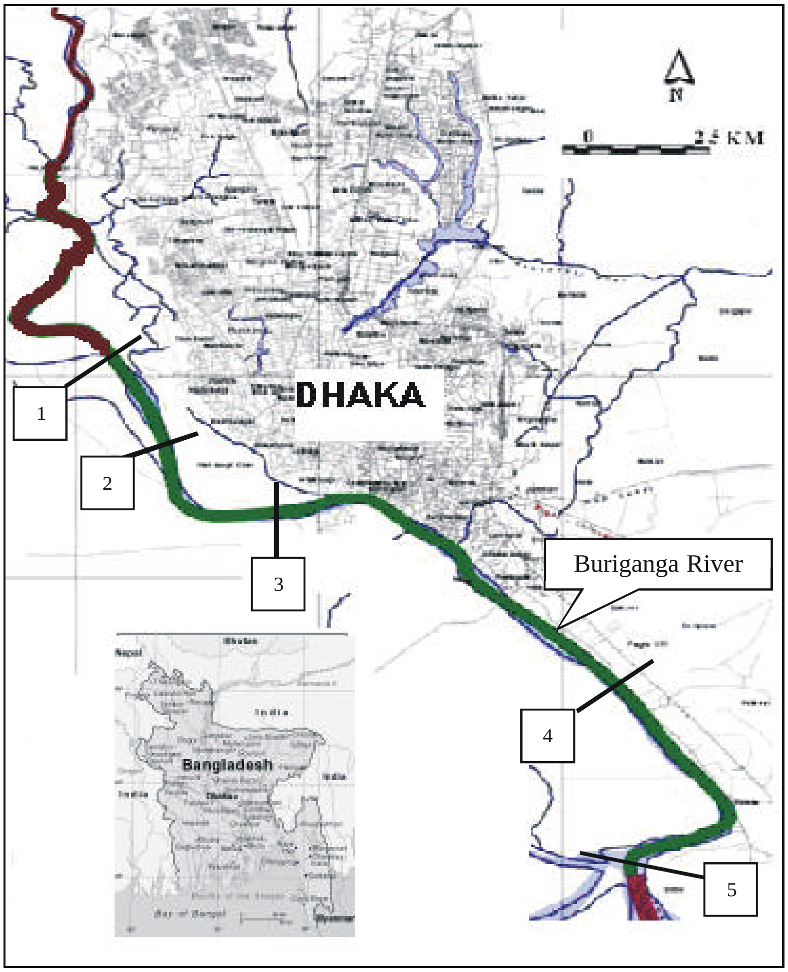

Fig. 1: Study area and the sampling stations in the Buriganga River

is causing deterioration of water quality of this river for about last two decades [8, 9]. Meanwhile, Government has provided specific attention to the issue of river pollution through enacting a number of policies such as National Environmental Policy-1992, Industrial Policy-1999 and National Water Policy-1999 [4, 10]. Moreover, the Government's interest in protecting the rivers from pollution has also been reflected in the ECA (Environmental Conservation Act)-1995 and the ECR (Environmental Conservation Rules)-1997. According to the provisions made in the ECA-1995, the river water quality standards were developed [10, 11] and the Department of Environment (DOE), a Government organisation was empowered to monitor the quality of the river water.

However, there are reports that although several regulatory measures and policies have been enforced by the Government to protect the river Buriganga from pollution, improvement has not yet been taken place [12, 13]. These reports lack updated and quantitative information on river water quality parameters, which has created confusions on the state of water quality of the river Buriganga. Thus a detailed empirical study was needed to assess the present water quality of the river Buriganga. For this purpose, this study aims to analyse some selected physiochemical water quality parameters, which includes: temperature, pH, EC, DO, BOD_5, COD, PO_4-P, NH_3-N, Pb and Cr along the river Buriganga for both dry and wet seasons. The mean values of the water quality test results were compared with the DOE standards and the water quality data were summarised and presented through Box and Whisker plots.

MATERIALS AND METHODS

Water samples were collected during dry season from December 2008 to March 2009 and also during wet season from August 2009 to October 2009 to test for

Table 1: Sampling locations in the Buriganga River

Sampling stations	Buriganga Chainage in Km	Location near	Latitude and Longitude
1	0.0	Bosila bridge	N 23.73° E 90.35°
2	5.0	Kamrangir Char	N 23.73° E 90.36°
3	8.0	Keraniganj	N 23.71° E 90.39°
4	11.5	Chadnighat	N 23.70° E 90.42°
5	17.0	Hariharpara	N 23.64° E 90.45°

physical qualities and chemical contents in the Buriganga river. Five numbers of sampling locations (Table 1) were selected and on five different days (each two weeks apart) the water samples were collected in each season. Thus for this study, in total 50 water samples were collected for analyzing ten water quality parameters which provided 500 readings in total. One liter polypropylene bottles were used for water sample collection. Prior to sample collection, all bottles were washed with dilute acid followed by distilled water and were dried in an oven. At each sampling location, water samples were collected for chemical analysis in two such bottles. Before taking final water samples, the bottles were rinsed three times with the water to be collected. All samples were collected from a depth of 1m from the surface. The sample bottles were immediately labeled with date and sampling location. Standard methods [14] were adapted for laboratory chemical analysis for the water quality parameters such as BOD_5 (Biological Oxygen Demand on five days) , COD (Chemical Oxygen Demand), PO_4-P, NH_3-N and for two heavy metals Pb and Cr. HACH digital reactor block and Atomic Absorption Spectrometer (AAS) were used for this purpose. Besides, YSI 6600 Multiprobe field analyzer [15] was used for in situ river water quality measurements for parameters such as temperature, DO (Dissolved Oxygen), pH and EC (Electric Conductivity). The sampling locations (latitude and longitude) were recorded by a Garmin GPS76 in order to collect the sample from the same point on the next sampling date.

RESULTS AND DISCUSSION

In case of river water temperature, the DOE standard for sustaining aquatic life is within 20 to 30°C. The mean water temperature (Figure 2) for all the sampling stations for both dry and wet season complies with the standard. However, the Box and Whisker plot (Figure 3) shows a large difference of water temperature in all the stations during the dry season. For example, at the first sampling station, during the dry season, the first quartile reads at 17.9°C while the third quartile reads at 18.28°C. This means that 75 percent of the readings were below 18.28°C, which indicates that during most of the time of the dry season the water temperature of the river at this point remains below the acceptable level. The situation was found similar for other sampling stations during the dry season.

DO is an important water quality parameter for most chemical and biological processes in the water column and is essential for aquatic life. In this study, the mean values (Figure 4) for all the sampling stations were found far below than the DOE standard (5 mg/L for sustaining aquatic life and 6 mg/L for using the river water as the source for drinking water supply) in both dry and wet seasons. Although during the wet season the situation slightly improves (may be because of high flow condition), however it still remains lower than the acceptable level. Moreover, the data reveals that during the dry season, the mean DO level slightly increases from 0.722 to 1.204 mg/L from upstream to the down stream of the river, while during wet season, the mean DO level drops from 3.57 to 2.31 mg/L from upstream to down stream. The Box and Whisker plot also summarizes data for DO using median, upper and lower quartiles and the extreme (minimum and maximum) values. Interestingly, the measured levels of DO (even the maximum values) never reached the acceptable level in any of the sampling stations. This DO depletion in the river Buriganga has occurred probably due to the release of easily oxidized industrial and municipal organic wastes. These oxygen demanding wastes are being discharged from numerous numbers of both point and non-point sources along the full length of the river and thus the river water is not getting any chance at any stage of its flow to recover from the damage which is caused by these wastes. The low DO content could also be linked to high turbidity and thus low photosynthesis that adds oxygen to the water. It is obvious that in such low DO state, no aquatic life can survive and thus the river reaches to a dying stage. In this situation, without stopping further discharge of the oxygen demanding wastes, it will be impossible to recover the river water from its dying stage.

The acidic or alkaline condition of the water is expressed by pH and the DOE standard of this parameter is 6.5 to 8.5. The mean values (Figure 6) for all the

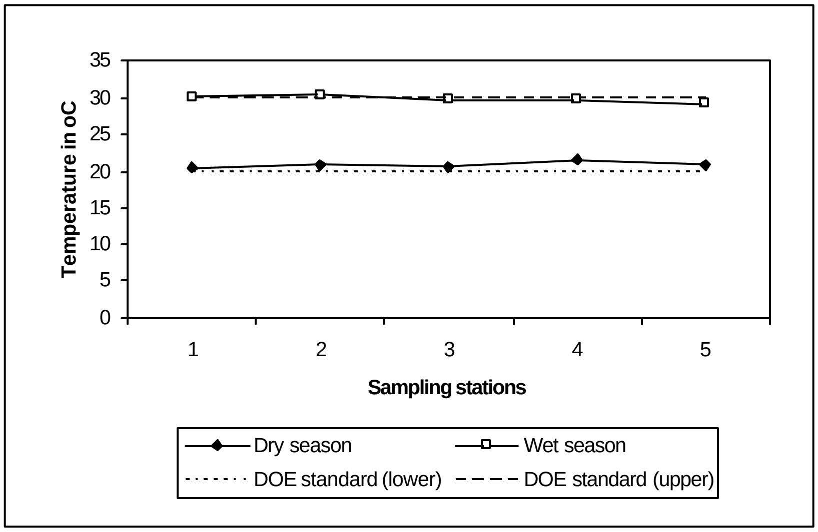

Fig. 2: Mean values for Temperature at different sampling stations

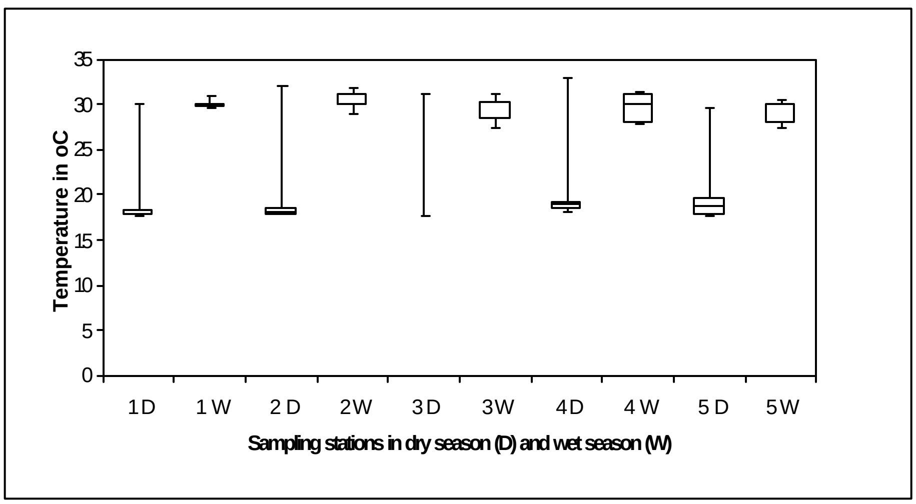

Fig. 3: Box and Whisker plots for Temperature at different sampling stations

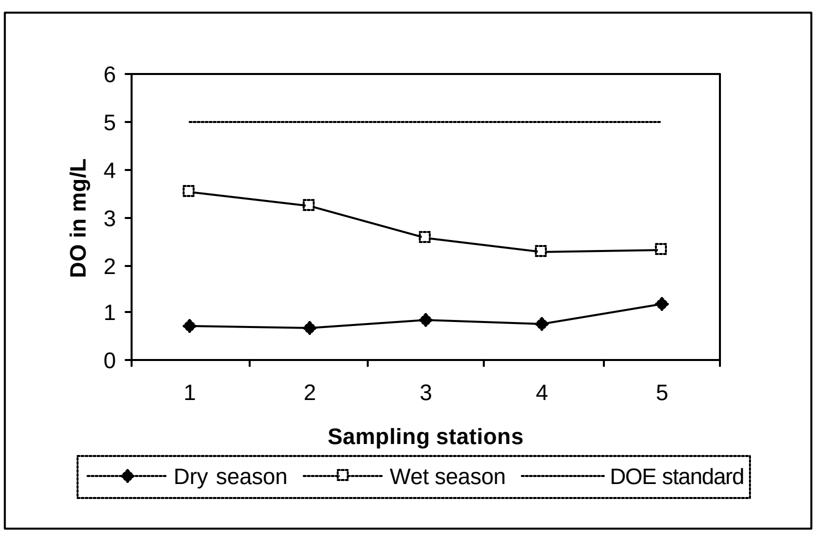

Fig. 4: Mean values for Dissolved Oxygen at different sampling stations

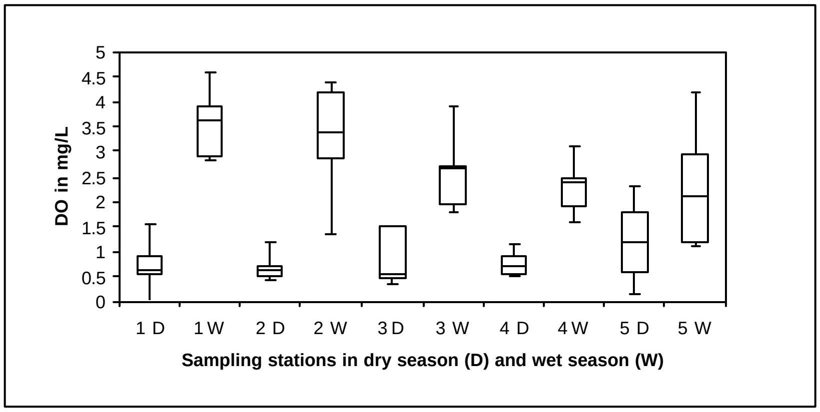

Fig. 5: Box and Whisker plots for Dissolved Oxygen at different sampling stations

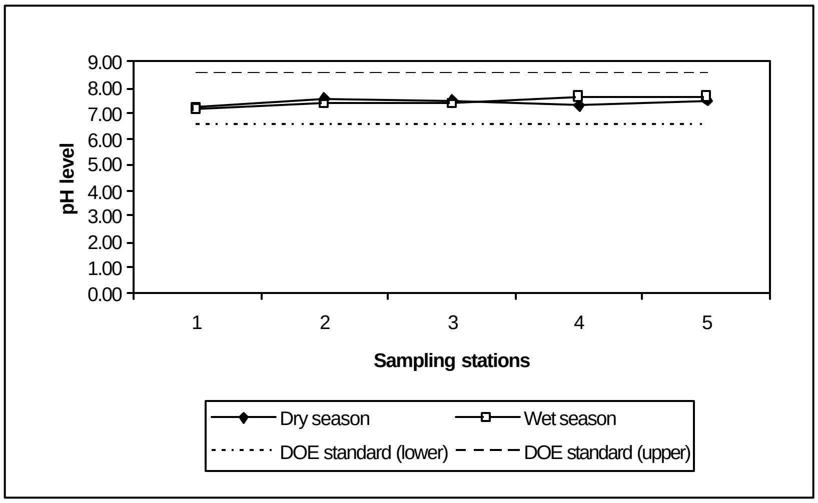

Fig. 6: Mean values for pH at different sampling stations

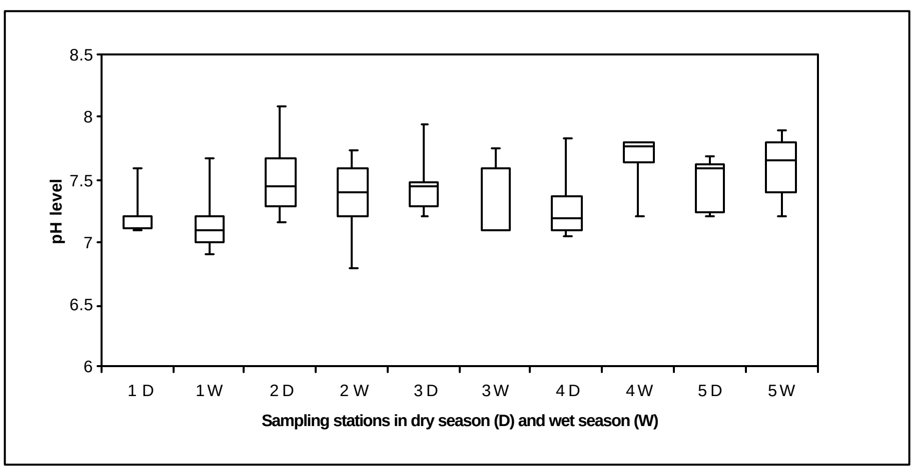

Fig. 7: Box and Whisker plots for pH at different sampling stations

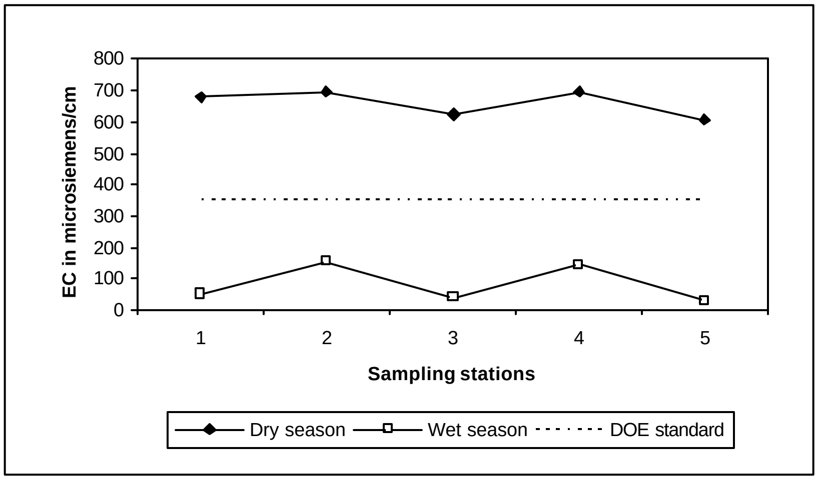

Fig. 8: Mean values for Electric Conductivity at different sampling stations

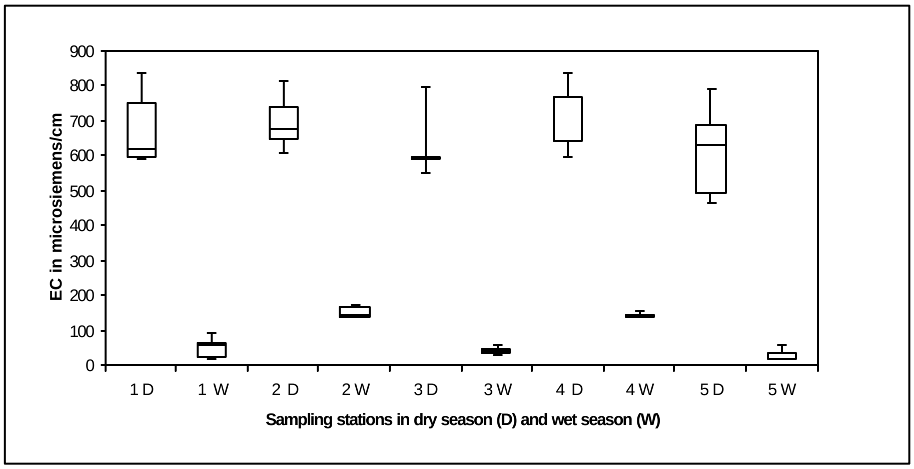

Fig. 9: Box and Whisker plots for Electric Conductivity at different sampling stations

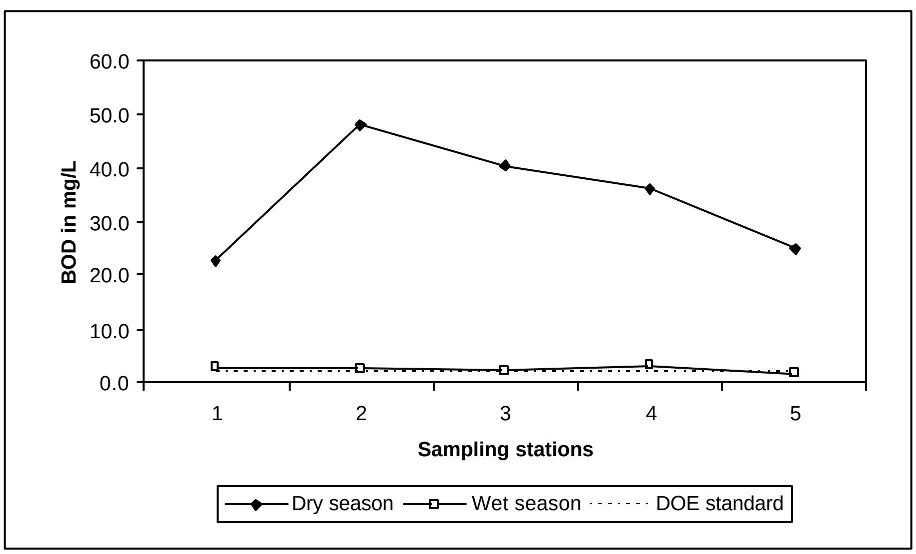

Fig. 10: Mean values for BOD_5 at different sampling stations

sampling stations in both dry and wet season were found within this limit, which indicates that the river water was characterized as neutral from acidity or alkalinity point of view. The Box and Whisker plot (Figure 7) also provides the information that during none of the occasion of the sampling, the river water was found beyond the acceptable pH level.

The EC measures the salinity of water and depends on the ions present in water [16]. The mean values for EC (Figure 8) in the Buriganga River during the wet season at all five different sampling stations were found much below than the DOE standard, which is 350 µs/cm. However, during dry season the average EC values varied between 610 and 697 µs/cm between sampling stations 1 and 5. In this regard, none of the sampling stations met the DOE standard. The box and whisker plot (Figure 9) shows the distribution of these values and reveals that in some occasions during the dry season, the EC value exceeded to more than 800 µs/cm. In the wet season, as the flow of the river increases which may cause the dilution of the salinity of the water, while in the dry season, the flow of the river decreases, as a result the EC increases. Nevertheless, these values indicate that the river Buriganga may receive the wastewater (industrial and sewage effluent) that contains high ionic concentration, which is ultimately harmful for the aquatic life of the river.

The BOD_5 is a measure of the amount of oxygen that bacteria will consume in five days at 20°C while decomposing organic matter under aerobic conditions [17]. In case of BOD_5 the DOE standard for aquatic life is 2 mg/L, which has been exceeded to a great extent particularly during the dry season as shown by the mean values (Figure 10) in all the sampling stations. The sampling station 2 is worst affected probably because of the discharge from the *Hazaribagh* and *Rayerbazar* tannery industries and nearby sewage discharges from *Kamrangir char* area. The wet season mean values for BOD_5 were found slightly higher than the acceptable level (except in sampling point 5). It is probably because during wet season as the flow of the river increases, the oxygen demanding organic wastes get decomposed at a faster rate (while assuming a constant discharge of wastes during both dry and wet seasons). The results also reveal that the river completely recovers from the damage of BOD_5 during the wet season at sampling point 5 (mean value was 1.7 mg/L). Following, Figure 11 graphically shows the Box and Whisker plot for the BOD_5 statistics of five sampling stations in both dry and wet season. The high level of BOD_5 (particularly during the dry season) in the river Buriganga also indicates the presence of excessive amount of bacteria in the water, which consume the oxygen levels in the river.

The COD is another important parameter for river water quality assessment. This measures the total quantity of oxygen required to oxidize all organic material (including the inert) into carbon dioxide and water [17]. The COD mean values (Figure 12) for both dry and wet seasons along the river Buriganga were found higher than the DOE acceptable level (4 mg/L). The condition becomes worse during the dry season; however, the river water quality in terms of this parameter slightly improves (but still remains higher than the standard) as it flows towards the down stream points. Among all the sampling locations, the maximum mean values for COD in both dry and wet seasons were found at sampling point 2. This again indicates the severity of pollution discharged near this location. The Box and Whisker plot (Figure 13) shows that during the dry season, sampling stations 1, 2 and 3 have greater data range than sampling stations 4 and 5. This might have happened as major pollution sources are located near to stations 1, 2 and 3 and the discharge from these sources might have fluctuated on different days, which was ultimately revealed in the COD results. The higher values of COD compared to the BOD values indicate the presence of inert organic material in the river water.

Nutrients such as phosphorous and nitrogen are essential for the growth of algae and other aquatic plants. However, excessive concentrations of nutrients can overstimulate aquatic plant and algae growth, which can cause bacterial respiration and organic decomposition and ultimately lead to *eutrophication* [17]. In this study, the level of nutrients in the river Buriganga were measured for phosphorus as phosphate (PO_4-P) and for nitrogen as ammonia (NH_3-N). All the observed values (Figure 14 and 15) for PO_4-P were found well below the DOE standard (6mg/L) for aquatic life during both dry and wet seasons. This means that the river water is quite safe in terms of PO_4-P pollution. However, the level of NH_3-N was found more than the acceptable level (0.5 mg/L) in almost all the sampling occasions during both dry and wet seasons (Figure 16 and 17). The situation is alarming particularly in sampling stations 2 and 3 during both seasons. This is probably because of the municipal wastewater which is being discharged from the surrounding area of these two stations, as ammonia is normally associated with such effluent.

In this study concentration of two heavy metals-lead (Pb) and chromium (Cr) were also analysed at five different sampling stations in order to further assess the toxicity of the river water. These elements are also

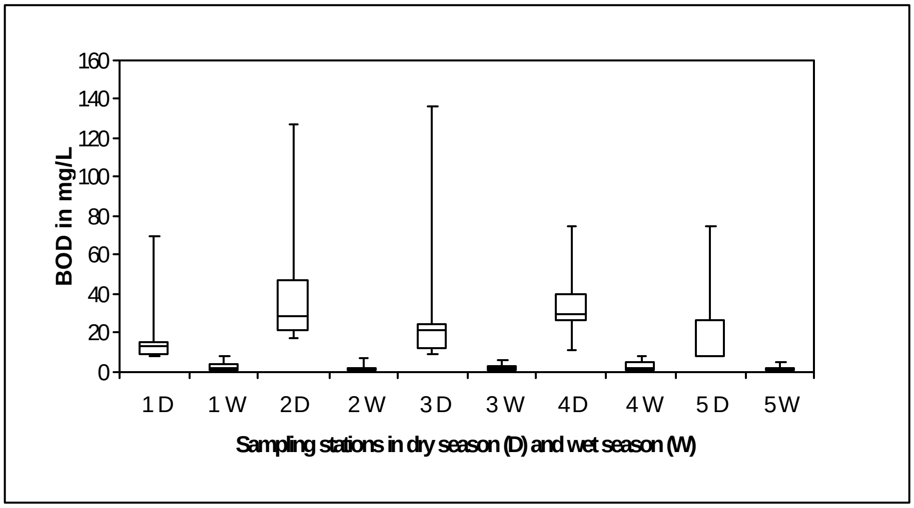

Fig. 11: Box and Whisker plots for BOD_5 at different sampling stations

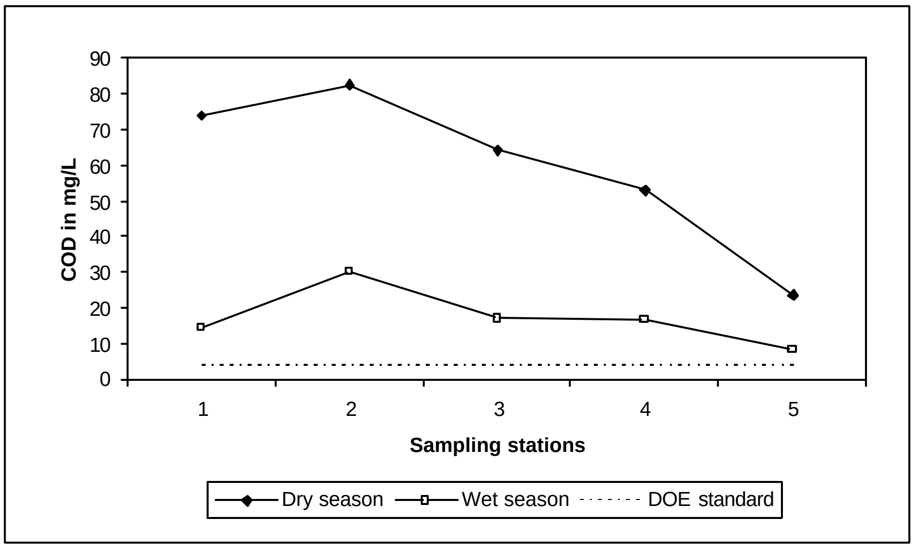

Fig. 12: Mean values for COD at different sampling stations

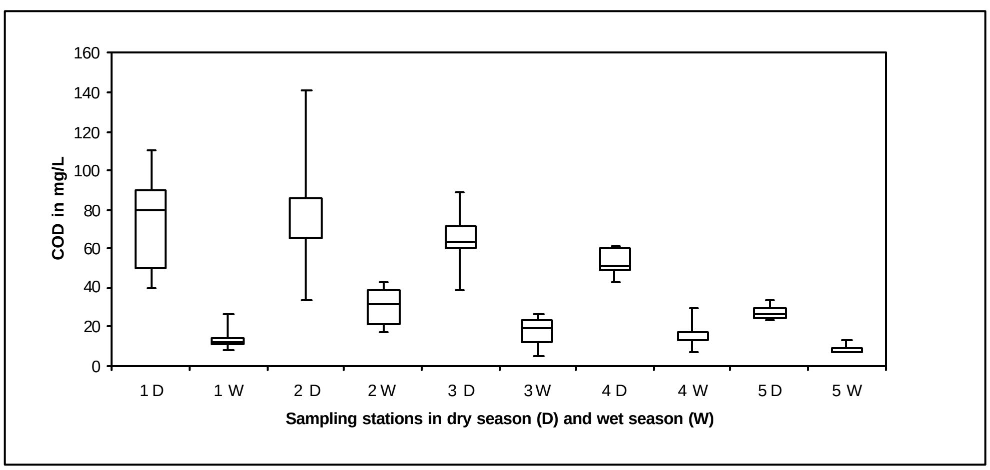

Fig. 13: Box and Whisker plots for COD at different sampling stations

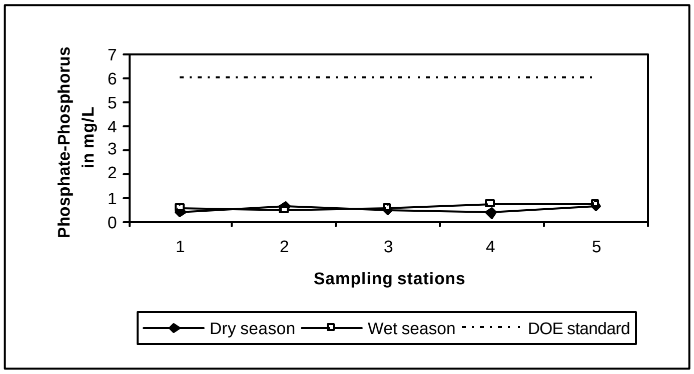

Fig. 14: Mean values for PO_4-P at different sampling stations

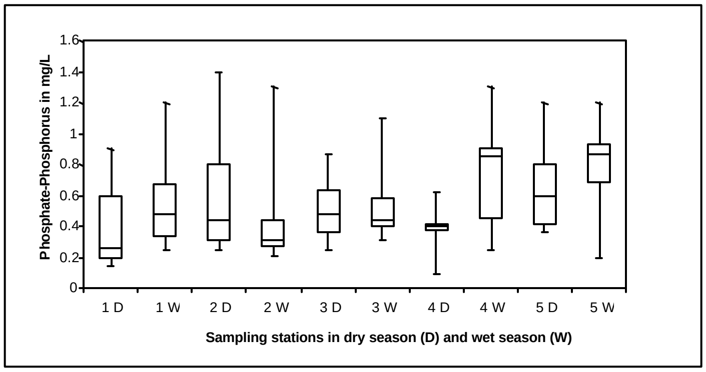

Fig. 15: Box and Whisker plots for PO_4-P at different sampling stations

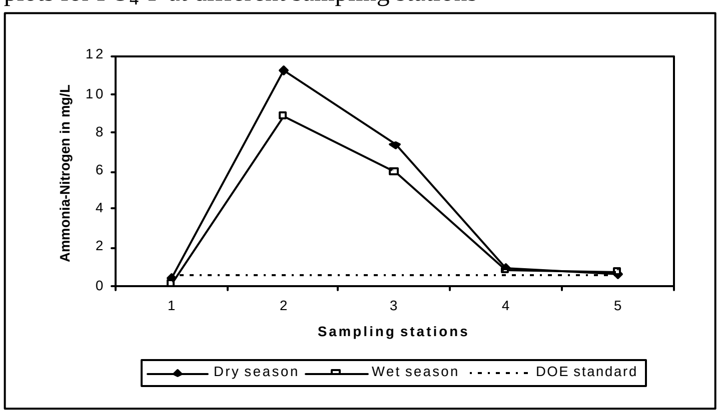

Fig. 14: Mean values for NH_3-N at different sampling stations

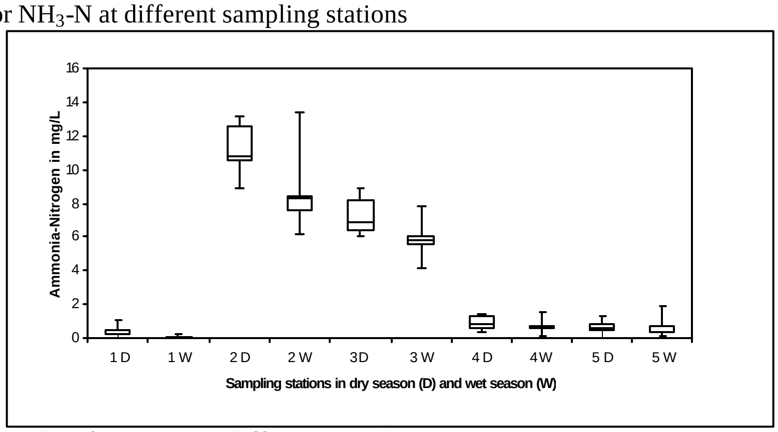

Fig. 17: Box and Whisker plots for NH_3-N at different sampling stations

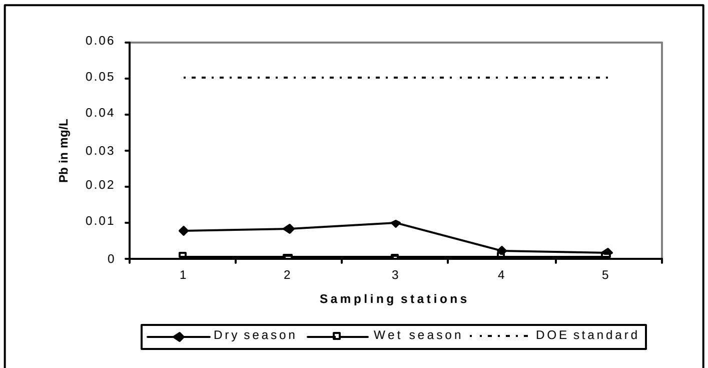

Fig. 18: Mean values for Pb at different sampling stations

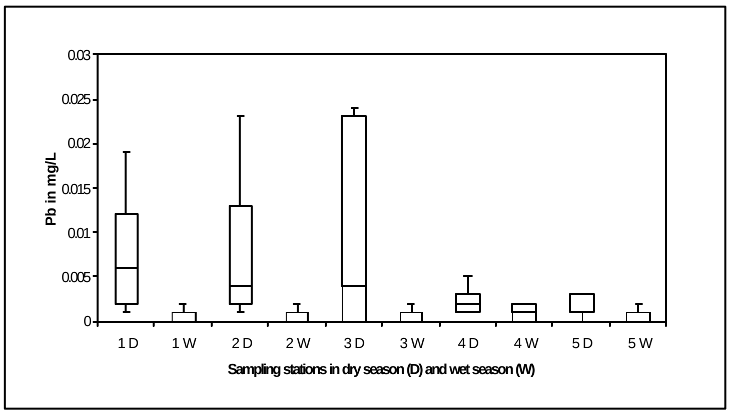

Fig. 19: Box and Whisker plots for Pb at different sampling stations

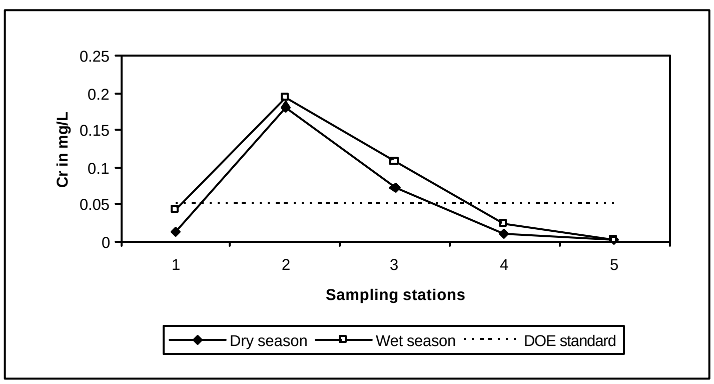

Fig. 20: Mean values for Cr at different sampling stations

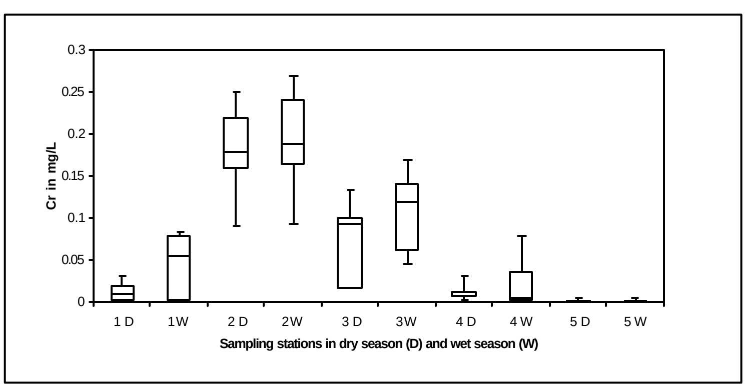

Fig. 21: Box and Whisker plots for Cr at different sampling stations

Table 2: Compliance of Buriganga River water quality parameters with DOE guidelines

Parameters	DOE standards to maintain the aquatic ecosystem	Compliance with standards (Yes/No) Dry season	Wet season
Temperature	20 to 30°C	Y	Y
pH	6.5 to 8.5	Y	Y
EC	350 μs/cm	N	Y
DO	5 mg/L	N	N
BOD_5	2 mg/L	N	N
COD	4 mg/L	N	N
PO_4-P	6 mg/L	Y	Y
NH_3-N	0.5 mg/L	N	N
Pb	0.05 mg/L	Y	Y
Cr	0.05 mg/L	N	N

believed to be cancer-causing agents. The lead concentration for all the samplings (Figure 18 and 19) were much below the permissible limit (0.05mg/L) of DOE for aquatic life during both dry and wet seasons. In this respect, it can be concluded that the Buriganga River is not polluted in terms of Pb and the present level of its concentration caused no matter of concern. However, the concentration of Cr (VI) in sampling stations 2 and 3 during both dry and wet seasons were found above the permissible limit (0.05mg/L) of DOE. The mean values and the Box and the Whisker plots are provided in Figures 20 and 21. The condition is worst in sampling station 2 where the mean values were found as 0.18 and 0.19 mg/L respectively in wet and dry seasons. The possible reason is the discharge of high amount of Cr concentrated wastewater from the tannery industries which are closely located to this station. There are reports [48] that these tannery industries located in *Hazaribagh* and *Rayerbazar* area depend on chrome tanning process and they do not treat their Cr contaminated wastewater before discharging into the natural environment. This hexavalent chromium is known for its negative health and environmental impact and its extreme toxicity. Health effects related to hexavalent chromium exposure include diarrhoea, stomach and intestinal bleedings, cramps and liver and kidney damage [17]. As this heavy metal is a conservative substance (no decay) in water, it is a must to always maintain the level of concentration of this substance below the permissible level.

CONCLUSION

The results from data analysis show that the Buriganga River water quality is not acceptable from aquatic ecosystem perspectives for the parameters such as DO, BOD_5, COD, NH_3-N and Cr during both dry and wet seasons and for EC during the dry season. On the other hand, the study has also concluded that the river water is still acceptable in both dry and wet seasons in terms of parameters such as temperature, pH, PO_4-P and Pb. Table 2 summarizes the compliance/non compliance of the selected water quality parameters for both dry and wet seasons tested in this study. The overall mean values (average of all the sampling stations) of parameters for the river Buriganga were temperature: dry-20.86°C, wet-29.82°C; pH: dry-7.41, wet-7.42; EC: dry-660.56, wet-82.6; DO: dry-0.85, wet-2.8; BOD_5: dry-34.5 mg/L, wet-2.5; COD: dry-60.12, wet-17.2; PO_4-P: dry-0.53, wet-0.64; NH_3-N: dry-4.12, wet-3.28; Pb: dry-0.006, wet-0.0008 and Cr: dry-0.056, wet-0.074. However, in order to have more certain answers on the assessment of the river water quality and for pollution control policy purposes, more sampling should be done from higher depths of water as well and test results of the samples should be verified with different laboratories, while maintaining the same approach of analysis. This study indicates that the water of the Buriganga River is being polluted from its surrounding point and non-point sources which include discharges from tannery industries, sewage and municipal wastewater.

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