

Original Article

Microbiological Pollution Level and Seasonal Variations in Physicochemical Parameters of the River Buriganga, Dhaka

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The Buriganga is one of the highly polluted rivers in Bangladesh. Most of the industries and factories of Dhaka are situated on the banks of the river Buriganga or very close to the river system. Substantial part of urban sewage of the Dhaka city is also disposed in the river Buriganga. The study was conducted to determine the pollution level of water of river Buriganga. Field investigation was started from May 2010 and sample collection was conducted in different seasons up to June 2011. Various water quality parameters such as pH, DO, BOD, COD, TDS, Conductivity, Alkalinity, NO₂⁻-N, NO₃⁻-N, NH₄⁺-N and PO₄⁻, were determined for water of each sampling points to monitor the level of these parameters where it exceeds or remain within the permissible limit. DO concentration of water of river Buriganga was very low ranging between 0.04 and 2.25 mg/l. The aerobic heterotrophic bacterial count ranged between 1.0×10^7 and 2.0×10^8 cfu/100 ml. The highest count of enteric bacteria was noticed during the autumn that was 2.0×10^5 cfu/100 ml. BOD and COD values along with the presence of different species of bacteria clearly indicated that the water of the river Buriganga is highly polluted with the organic, chemical and bacterial pollutants.

Key words: Bacteria, Physicochemical parameters, Pollution level, Buriganga river

Introduction

The maintenance of water quality means that natural waters cannot be overloaded with organic or inorganic nutrients or with toxic, noxious, or esthetically unacceptable substances. They should not become vehicles of disease transmission from fecal contamination nor should their oxygenation, temperature, salinity, turbidity, or pH be altered significantly¹.

Pollution can be caused by wide variety of inorganic and organic compounds and microorganisms often play a major role in determining the extent of this pollution². Organic pollution occurs when organic compounds such as proteins, carbohydrates and fats which originate from domestic sewage, urban run-off and industrial effluent are released into the water bodies. They act as substrates for microorganisms³. The high concentration of heterotrophic bacteria increases the chance of the incidence of opportunistic pathogens of nonfaecal origin that can cause illness in the vulnerable groups of people⁴. The presence of faecal coliform is considered as presumptive evidence of faecal contamination⁵.

The river Buriganga is the country's main waterway for trading and ferry travel. For hundreds of years the river Buriganga has been continuously abused by unplanned urbanization and unplanned industrialization.

The river has become hygienically dead due to unabated dumping of untreated wastes including industrial, municipal, household, clinical and pathological wastes, oils and human excreta. Thus it is destroying not only its aquatic lives but also posing a serious threat to human health. Considering the above situation, the

present work was undertaken to determine microbial pollution level and seasonal variations in physicochemical parameters of the river Buriganga.

Materials and Methods

Sampling sites and collection of water samples

The water samples were collected from two sites (Br-1 and Br-2) of the River Buriganga, Dhaka, Bangladesh (Fig. 1) at morning (8-9 am). From each site, water samples were collected in plastic bottles previously and thoroughly washed with diluted HCl acid and later rinsed with de-ionized water followed by the sample water. Sample water was taken from a depth of approximately 30 cm below the surface level and carried back to the laboratory within an hour.

Bacteriological analysis

Nutrient agar (NA) medium was used for the enumeration and isolation of aerobic heterotrophic bacteria. MacConkey agar (Difco), SS agar (Diagnostic Pasteur) and Cetrimide agar media were used for the determination and isolation of enteric, pathogenic and related bacteria. The pH of the isolation media was adjusted to 6.8 (because most of the samples were within the range of 6.8-7.2) before sterilization. Three different techniques, viz. serial dilution⁶, spread plate⁷ and membrane filtration technique⁸ were used for the enumeration and isolation of bacteria. Inoculated bacterial plates were incubated at 37° C for 24 h.

Bacterial colony counting was made with the help of a Digital colony counter (OSK 10086, DC-3, Japan). Colonies were counted from responsive plates and expressed as cfu/100 ml and discrete bacterial colonies were isolated immediately after

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counting. For provisional identification of bacteria, important biochemical tests were carried out, *viz.* carbohydrate fermentation, catalase test, deep glucose agar test, tyrosine degradation, egg-yolk lecithinase test, casein hydrolysis, protease test, starch hydrolysis, Kligler's iron agar (KIA) test, levan test, methyl red test, nitrate reduction test, oxidase test, indole production, phenylalanine deaminase test, citrate utilization, utilization of propionate, urease production test and Voges Proskauer (VP) tests. Bergey's Manual for Systematic Bacteriology, Vol. 2⁹ was followed for the identification of Gram-positive aerobic heterotrophic bacterial isolates. On the other Manual for Laboratory Investigations of Acute Enteric Infections¹⁰ and Bergey's Manual of Systematic Bacteriology (Vol.1)¹¹ were used for identification of enteric bacteria.

Determination of physico-chemical properties

Water temperature was measured at the time of sampling with the help of thermometer. The pH of water samples was measured in the laboratory by electronic pH meter (Jenway 3310, U.K.). The dissolved oxygen (DO) and biochemical oxygen demand (BOD) of the collected samples were obtained using digital DO meter (Jenway 970 DO₂, U.K.). Conductivity of the water samples was measured with the help of multi-range Hanna conductivity meter (MODEL-HI 9033). Total dissolved solids (TDS) of the samples were measured with the help of Hanna TDS meter (MODEL-HI 9034). The values were recorded in mg/l. Alkalinity of water was determined by Titration method. The unit of alkalinity was noted in meq/l¹². For chemical analysis, samples were filtered (Whatman No. 42, England) to eliminate suspended solid particles. Nitrite-nitrogen present in water was determined by modified Griess-Ilosvay method^{13,14}. Nitrate-nitrogen was determined colorimetrically¹⁵. Soluble reactive phosphorus was determined by ascorbic acid blue color method¹⁶. Chemical oxygen demand (COD) was determined by

the method based on chemical oxidation of materials in the presence of catalyst¹⁷.

Results

The heterotrophic bacterial count of water samples has been presented in Table 1. During the rainy season, maximum number of bacterial count was observed both in BR-1 (Shyam bazar) and BR-2 (Ultinganj) and it was 2.0×10^8 cfu/100 ml, while minimum number was detected in BR-1 during autumn and it was 1.0×10^7 cfu/100 ml.

Enteric and related bacterial count on MacConkey agar, SS agar and Cetrimide agar media has been shown in Table.1. Enteric bacterial count on MacConkey agar ranged between 3.0×10^4 cfu/100 ml to and 2.0×10^5 cfu/100 ml and the highest count was found in the sample of BR-1. Bacterial count on SS agar medium varied between 2.8×10^5 cfu/100 ml to uncountable. During this study heterotrophic along with the enteric bacterial load ranged between 1.0×10^7 and 2.0×10^8 cfu/100 ml. The bacterial count on Cetrimide agar was ranged between 0.0 and 1.4×10^3 cfu/100 ml.

During this investigation, of the 110 isolates, 36 were randomly selected and purified for detailed study. Among these, 22 were Gram-positive and remaining 14 were Gram-negative. All the Gram-positive isolates were rod shaped, spore former and members of the genus *Bacillus*, while the rest three Gram-negative isolates belong to the genus *Xanthomonas*.

Enteric bacteria were Gram-negative, short rod and non-spore former. Out of 11 Gram-negative enteric bacterial isolates, 3 (27.3%) isolates belonged to the genus *Escherichia*, 3 (27.3%) isolates were *Proteus morganii*, and the remaining isolates were *Escherichia coli*-Alk. (9.1%), *Yersinia* (9.1%), *Plesiomonas* (9.1%), *Hafnia* (9.1%) and *Alcaligenes* (9.1%) (Table 2). Physicochemical properties of the water of the river Buriganga are given in Table 3.

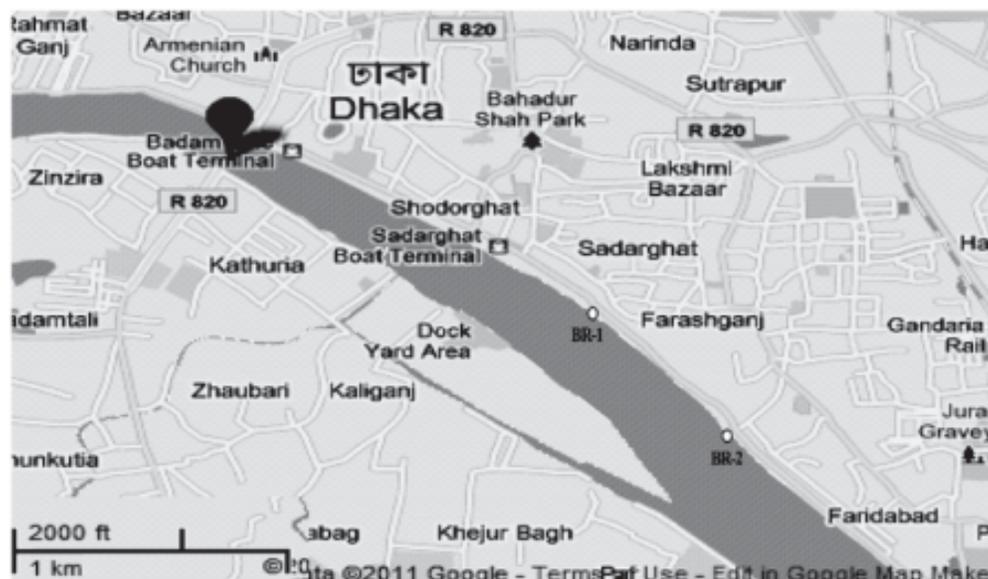


Figure 1. Map showing different sampling sites of the river Buriganga, Dhaka, Bangladesh (Br-1 = Shyam bazar and Br-2 = Ultinganj).

Table 1. Bacterial count (cfu/100 ml) of water samples of the river Buriganga

Seasons	Sampling stations	Aerobic heterotrophic bacteria on Nutrient agar	Enteric and related bacteria on		Pathogenic bacteria on Cetrimide agar
			MacConkey agar	SS agar	
Summer	BR-1	8.5×10^7	5.0×10^4	ND	3.0×10^2
	BR-2	5.0×10^7	1.2×10^5	ND	1.0×10^2
Rainy	BR-1	2.0×10^8	3.0×10^4	2.8×10^5	-
	BR-2	2.0×10^8	6.5×10^4	1.2×10^5	-
Autumn	BR-1	1.0×10^7	2.0×10^5	Not countable	1.4×10^3
	BR-2	3.0×10^7	5.0×10^4		8.0×10^2

Table 2. Provisional identification of the selected bacterial strains

Isolate No	Provisional Name	Isolate No	Provisional Name
BW-1	<i>Bacillus</i> sp.	BW-30	<i>Bacillus</i> sp.
BW-2	<i>Xanthomonas</i> sp.	BW-32	<i>Bacillus</i> sp.
BW-4	<i>Xanthomonas</i> sp.	BW-35	<i>Bacillus</i> sp.
BW-6	<i>Bacillus</i> sp.	BW-37	<i>Bacillus</i> sp.
BW-7	<i>Bacillus</i> sp.	BW-38	<i>Bacillus</i> sp.
BW-8	<i>Bacillus</i> sp.	BW-41	<i>Bacillus</i> sp.
BW-13	<i>Xanthomonas</i> sp.	BW-44	<i>Bacillus</i> sp.
BW-14	<i>Bacillus</i> sp.	E-2	<i>Yersinia enterocolitica</i>
BW-15	<i>Bacillus</i> sp.	E-4	<i>Proteus morgani</i>
BW-16	<i>Bacillus</i> sp.	E-8	<i>Plesiomonas</i> sp.
BW-18	<i>Bacillus</i> sp.	E-12	<i>Escherichia coli</i>
BW-19	<i>Bacillus</i> sp.	E-14	<i>Escherichia coli</i>
BW-20	<i>Bacillus</i> sp.	E-15	<i>Hafnia</i> sp.
BW-21	<i>Bacillus</i> sp.	E-16	<i>Alcaligenes</i> sp.
BW-22	<i>Bacillus</i> sp.	E-19	<i>Escherichia coli</i> - Alk.
BW-23	<i>Bacillus</i> sp.	E-20	<i>Proteus morgani</i>
BW-24	<i>Bacillus</i> sp.	E-23	<i>Proteus morgani</i>
BW-25	<i>Bacillus</i> sp.	E-26	<i>Escherichia coli</i>

Table 3. Physicochemical properties of the water samples of the river Buriganga

Sampling stations	Parameters	Seasons				
		Summer	Rainy	Autumn	Late autumn	Winter
BR - 1	pH	6.79	7.09	7.06	6.81	6.92
	DO (mg/l)	0.78	2.02	1.34	2.25	0.08
	BOD (mg/l)	0.58	0.78	0.76	0.60	0.08
	COD (mg/l)	ND	55.40	47.05	46.00	ND
	TDS (mg/l)	145.30	77.69	75.49	79.67	582.67
	Conductivity (μ s/l)	300.00	416.99	443.34	511.00	303.00
	Alkalinity (meq/l)	2.20	6.85	2.03	1.20	2.45
	PO ₄ ⁻ (mg/l)	0.08	ND	0.06	0.11	0.25
	NO ₂ -N (mg/l)	0.01	ND	0.01	0.01	0.02
	NO ₃ ⁻ -N (mg/l)	Trace	ND	Trace	2.00	1.00
	NH ₄ ⁺ -N (mg/l)	2.95	ND	4.90	6.40	3.00
BR - 2	pH	6.61	7.08	7.02	6.93	7.14
	DO (mg/l)	0.73	1.79	1.19	2.03	0.04
	BOD (mg/l)	0.60	1.48	0.595	1.52	0.04
	COD (mg/l)	ND	50.00	42.20	43.25	ND
	TDS (mg/l)	144.7	80.34	78.65	87.00	538.83
	Conductivity (μ s/l)	298.30	450.30	240.60	511.00	299.67
	Alkalinity (meq/l)	2.15	6.70	1.55	1.10	1.90
	PO ₄ ⁻ (mg/l)	ND	ND	0.055	0.09	0.18
	NO ₂ -N (mg/l)	ND	ND	0.04	0.01	0.01
	NO ₃ ⁻ -N (mg/l)	ND	ND	Trace	4.00	2.00
	NH ₄ ⁺ -N (mg/l)	ND	ND	11.28	4.00	2.00

Discussion

Heterotrophic bacterial load in the rainy season was found to be higher than the autumn. This might be due to wash out of the land surface to the river through rainwater. Shyam bazar area was highly polluted with enteric bacterial pollution. Interestingly the highest count of enteric bacteria was noticed during the autumn. The results demonstrated that the river Buriganga is considerably polluted with bacterial population. Almost similar results showing the load of heterotrophic and nitrifying bacteria in the river and sewage lagoon was reported^{18,19}. Dynamic of aquatic micro flora are subjected to variations from year to year. The movement of water by wind, tide or currents accomplished some redistribution of the microbial flora²⁰. *Escherichia* sp. and *Proteus morgani* was found to be the dominant group among the Gram-negative bacteria in the river. Bacterial strains isolated from fresh water bodies of Bangalore and the dominant genera were *Bacillus*, *Pseudomonas*, *Enterobacter*, *Aeromonas*, *Flavobacterium*, *Corynebacterium* etc.²¹. The coliform group of bacteria in general and *E. coli* in particular has found universal application as indicators of faecal contamination and has been employed as sewage pollution indicators²².

On the other hand the load of aerobic heterotrophic bacteria and the presence and abundance of *Bacillus* sp., *Escherichia* spp., *Proteus morgani*, *Plesiomonas* sp., *Hafnia* sp. and *Alcaligenes* sp. in the water clearly showed significant level of microbial pollution in the river.

The findings from the present study are nearly similar to another report showing lower pH and DO values during dry season in the surface water²³. Concentration of DO in river water was very low for the survival of the aquatic lives. This low DO (0.04-2.25 mg/l) level could result in the non-maintenance of conditions favorable to the gill-breathing aquatic organisms and increase the sensitivity of fish to chemicals²⁴.

According to United State Public Health (USPH) standard, 5 mg/l and 4 mg/l value of BOD and COD, respectively indicate the quality for domestic and drinking water¹⁷. The normal range of BOD for good water quality is 5-6 mg/l and COD is 6-10 mg/l²⁵. On the basis of BOD (0.04-1.52 mg/l) and COD (42.2-55.4 mg/l) values, the river water was polluted with organic and chemical pollutants.

During the study period the TDS value ranged between 75.49 mg/l to 582.67 mg/l. The Bangladesh center for advanced studies reported that TDS of Sitalakhya river crossed the limit and it raised from 216 to 446 mg/l during 1980 to 1998 period²⁶. The TDS of the water of four rivers in Sundarban varied seasonally from 0.43 to 44.4 g/l²⁷. The present investigation well agrees with the previous findings²⁶⁻²⁷.

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