IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 9, Issue 7 Ver. II (July. 2015), PP 06-10
www.iosrjournals.org

Physico-chemical and Bacteriological Attributes of Wastewater in Savar, Dhaka, Bangladesh

Md. Shahinur Kabir*, Md. Mizanur Rahman and
Saddam Mohammad Faisal Ahmed

Department of Botany, Faculty of Biological Sciences, Jahangirnagar University, Savar, Dhaka 1342, Bangladesh

Abstract : *A study was conducted for assessing the physico-chemical and bacteriological quality of wastewater entering the natural water bodies in Savar, Dhaka, Bangladesh. Wastewater samples were collected from five different sites and analyzed for water temperature (WT), pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Viable Bacterial Count (TVBC) and Total Coliform Count (TCC). The WT of the samples ranged from 26°C to 34.5 °C, pH was slightly acidic to alkaline (6.9 to 9.7), the DO content of the samples ranged from 1.62 mg/l to 7.1 mg/l, BOD varied from 1.11 mg/l to 5.7 mg/l, TVBC ranged from 30×10^8 CFU/100 ml to 490×10^8 CFU /100 ml and TCC ranged from 0.2×10^6 CFU /100 ml to 100×10^6 CFU /100 ml. Bacteriological quality of water of all the sampling sites exceeded the permissible limit set by the Government of Bangladesh. Furthermore, to determine the overall status of the water entering the natural water bodies, the Water Quality Index (WQI) was calculated using the weighted arithmetic index method. Five important parameters viz. WT, pH, DO, BOD and TCC were considered for calculating the WQI. The WQI values of the sampling sites ranged from 82.9 to 946 indicating that the quality of the wastewater of the studied sites is very poor and in most of the cases unfit for drinking, wildlife and fish culture. Awareness raising program and strict regulatory measures should be taken to minimize the entry of pollutants into the natural environment.*

Keywords: *Coliform, Environment, Pollution, Water Quality Index.*

I. Introduction

In Bangladesh, wastewater generated by various domestic, agricultural and industrial activities is usually disposed into the ambient environment without further treatment. Water bodies, especially river and fresh water reservoirs have become the common site for household and industrial wastewater discharge. Entry of untreated wastewater may alter the physical, chemical and biological nature of the receiving water body. Indiscriminate discharge of untreated wastewater is transforming our valuable freshwater resources unsuitable for primary and/or secondary usages like drinking, irrigation, aquaculture and recreational purposes. Furthermore, toxic substances and pathogenic microorganisms present in the untreated or partially treated wastewater may have an adverse impact on the growth, development, reproduction and survival of various life forms present in the receiving water body.

Quality of water is defined in terms of its physical, chemical, and biological parameters. The effective maintenance of water quality requires continuous monitoring of a large number of quality parameters. However, the quality is difficult to evaluate from a large number of samples, each containing concentrations for many parameters [1]. To make the water quality data more understandable and usable by general people, Horton [2] for the first time proposed a water quality index (WQI). The general WQI was developed by Brown *et al*. [3] and improved by Deininger for the Scottish Development Department [4]. WQI provides a single number that expresses the overall water quality at a certain location based on several water quality parameters.

Although a few reports on the wastewater quality in and around Dhaka district are available [5-6], WQI was not calculated in those reports. In the present study, physico-chemical and bacteriological quality of wastewater entering aquatic environments of Savar area were determined and the WQI of the samples was prepared.

II. Materials and Methods

2.1 Water sampling for analysis

Wastewater samples were collected from five different locations *viz*., (i) Fulbaria (designated as sampling site A), (ii) Near Thana stand (designated as sampling site B), (iii) Namabazar (designated as sampling site C), (iv) Namaganda (designated as sampling site D), and (v) Ulail (designated as sampling site E) of Savar, Dhaka, Bangladesh. At sampling sites A, B and C, wastewaters generated by domestic, anthropogenic, agricultural, and fishery-related activities are drained to a nearby river. At sampling site D, wastewater is channeled to a pond by concrete pipes.

At sampling site E, wastewater is disposed into a canal directly linked to a river. For physico-chemical analysis, samples were collected in clean bottles avoiding air bubbles and capped immediately. For bacteriological analysis, water samples were collected in sterilized bottles and immediately transferred to the laboratory. Each of the sample bottles was labeled with necessary information.

2.2 Physico-chemical analysis

Water temperature was measured at the sampling site with a mercury thermometer. pH of the water samples was determined by a portable pH meter. Samples for DO and BOD were collected in BOD bottles. DO concentration (mg/l) was determined by Winkler method [7]. For BOD, water samples were kept in the dark for 5 days and then DO concentration of the 5-day incubated bottle was determined. BOD (mg/l) was calculated by subtracting the oxygen content of the 5-day incubated bottle from the oxygen content of the initial bottle [8].

2.3 Bacteriological analysis

Serial dilution and spread plate techniques were used for the enumeration of bacteria [8]. Nutrient agar medium and MacConkey agar were used for enumeration total viable bacterial count (TVBC) and Total coliform count (TCC), respectively. The plates were incubated at 37°C for 24-48 h. After the incubation period, the colonies were counted and the total number of colony forming units (CFU) was calculated by multiplying the number of colonies with the dilution factor. To detect the presence of *Salmonella* sp. and *Shigella* sp., SS agar was used.

2.4 WQI computation equation

Five physico-chemical and bacteriological parameter, namely WT, pH, DO, BOD, TCC were used to calculate WQI by the weighted arithmetic index method [9]. Several steps of this method are briefly described below:

The quality rating scale (Q_i) for each parameter was calculated by using the expression:

$$Q_i = 100[(V_i - V_o)/(S_i - V_o)]$$

Where,
V_i = Estimated concentration of ith parameter in the analyzed water;
V_o = Ideal value of ith parameter in pure water;
S_i = Standard or permissible value of the ith parameter.
Ideal value (V_o) of each parameter was taken as zero except for pH=7.0, DO=14.6 mg/l and WT=25 °C.

The unit weight (W_i) for each water quality parameter was calculated by using the following formula:
$W_i = K/S_i$

Where, K is the proportionality constant and was calculated by using the following equation:

$$K = 1/\sum_{i=1}^{n}(1/S_i)$$

The water quality index (WQI) was calculated with the following formula:

$$WQI = \sum_{i=1}^{n} Q_i W_i \Big/ \sum_{i=1}^{n} W_i$$

III. Results and Discussion

The measured values of different physico-chemical and bacteriological water quality parameters of the collected samples are summarized in Table 1. Findings of this study have been compared to the water quality standards (Table 2) prescribed by the Government of Bangladesh (GoB) through the Environment Conservation Rules 1997 [10]. To calculate WQI, relative weight for each of the parameters was first determined taking the highest permitted value of that parameter (Table 3). Then the quality rating was calculated for each water quality parameter (*viz.*, WT, pH, DO, BOD and TCC) used in the indices and these sub-indices were aggregated to compute the overall index (Table 5).

Water temperature has a profound effect on the chemical reactions takes place in water [5]. In the present study, temperature of wastewater varied from 26°C to 34.5 °C (Table 1). Similar variation of surface water temperature in Bangladesh was also reported by Chowdhury *et al*. [11]. The average temperature recorded in each of the sampling sites were slightly above the standard water temperature prescribed by GoB [10] for drinking water (Table 2). The minimum and maximum sub water quality index for water temperature were 8.4 at sampling site C and 11.5 at sampling site A, respectively (Table 5).

Table 1: Physico-chemical and bacteriological quality of wastewater

Study site	Range	Parameter					
		WT (°C)	pH	DO (mg/l)	BOD (mg/l)	TVBC (CFU/100 ml)	TCC (CFU/100 ml)
A	Min	30.7	7.3	1.62	1.11	340×10^8	10×10^6
	Max	33.7	7.3	1.69	1.4	450×10^8	20×10^6
	Avg	**32.2**	**7.3**	**1.655**	**1.255**	$\mathbf{395\times10^8}$	$\mathbf{15\times10^6}$
B	Min	29.3	7.3	1.91	1.62	420×10^8	80×10^6
	Max	33.3	7.7	2.06	1.69	490×10^8	100×10^6
	Avg	**31.3**	**7.5**	**1.985**	**1.655**	$\mathbf{455\times10^8}$	$\mathbf{90\times10^6}$
C	Min	26	7.2	3.83	3.32	130×10^8	20×10^6
	Max	34.5	7.3	4.12	3.68	330×10^8	60×10^6
	Avg	**30.25**	**7.25**	**3.975**	**3.5**	$\mathbf{230\times10^8}$	$\mathbf{40\times10^6}$
D	Min	32	6.9	5.5	5.2	30×10^8	0.2×10^6
	Max	34	9.7	6.4	5.3	220×10^8	0.3×10^6
	Avg	**33**	**8.3**	**5.95**	**5.25**	$\mathbf{125\times10^8}$	$\mathbf{0.25\times10^6}$
E	Min	33	7.2	6.6	5	330×10^8	0.6×10^6
	Max	33	8.4	7.1	5.7	460×10^8	1.4×10^6
	Avg	**33**	**7.8**	**6.85**	**5.35**	$\mathbf{395\times10^8}$	$\mathbf{1.0\times10^6}$

TVBC: Total viable bacterial count, TCC: Total coliform count; Min: Minimum; Max: Maximum; Avg: Average. WT: Water temperature; DO: Dissolved oxygen; BOD: Biochemical oxygen demand; CFU: Colony forming unit.

The pH of water is an important parameter because it can influence other properties of water, activity of microorganisms, and the potency of toxic substances present in the aquatic environment [12]. In the present study, pH of wastewater varied from 6.9 to 9.7 (Table 1). Approximately neutral to moderately alkaline pH range was also reported in surface water in Bangladesh [11]. The average pH values of each of the sampling sites were within the standard pH range (Table 2) prescribed by GoB [10] for drinking, source of drinking water only after disinfection, recreational activities, fisheries, cooling purpose in industries and irrigation. The minimum and maximum sub water quality index for pH were 4.7 at sampling site C and 24.4 at sampling site D, respectively (Table 5).

Table 2: Standards for drinking and inland surface water [10]

Classification of standards	Parameter				
	pH	WT (°C)	DO (mg/l)	BOD (mg/l)	Total coliform (CFU/100 ml)
(A) Standards for Drinking Water	6.5-8.5	20-30	6.0	0.2	0
(B) Standards for Inland Surface Water:					
(i) Source of drinking water after only disinfection	6.5-8.5	NS	≥ 6.0	≤ 2	≤ 50
(ii) Water usable for recreational activity	6.5-8.5	NS	≥ 5.0	≤ 3	≤ 200
(iii) Source of drinking water after conventional treatment	6.5-8.5	NS	≥ 6.0	≤ 6	≤ 5000
(iv) Water usable by fisheries	6.5-8.5	NS	≥ 5.0	≤ 6	≤ 5000
(v) Water usable by various process and cooling	6.5-8.5	NS	≥ 5.0	≤ 10	NS
(vi) Water usable for irrigation	6.5-8.5	NS	≥ 5.0	≤ 10	≤ 1000

WT: Water temperature; DO: Dissolved oxygen; BOD: Biochemical oxygen demand; NS: No standard value prescribed.

The oxygen present in the air and the oxygen generated from the photosynthetic activity are the source of dissolved oxygen in water. Oxygen is generally reduced in water due to respiration of the biota, decomposition of organic matter, rise in temperature, oxygen demanding wastes and inorganic reductants such as hydrogen sulfide, ammonia, nitrates ferrous ions etc [13]. The dissolved oxygen (DO) concentration below 5 mg/l may adversely affect the performance and survival of biological communities and below 2 mg/l may lead to fish mortality [11]. The DO concentration of wastewater ranged between 1.62 mg/l and 7.1 mg/l (Table 1).

The average DO concentrations of all the sampling sites except the sampling site E were below the standard DO concentration prescribed by GoB [10] for drinking and source of drinking water supply after conventional treatment (Table 2). The DO concentrations in the wastewater collected from the sampling sites A, B and C were found far below the standard value set by GoB [10] for irrigation, fisheries and recreational purposes. The minimum and maximum sub water quality index for DO were 35.9 at sampling site E and 60.0 at sampling site A, respectively (Table 5).

The Biochemical oxygen demand (BOD) is a measure of the amount of oxygen used in the respiratory process of the microorganisms in oxidizing the organic matter in the sewage and for further metabolism of the cellular components synthesized from the wastes. The magnitude of the BOD is related to the amount of organic matter in wastewater [14]. The principle of the method involves the measuring the difference of the Oxygen concentration of the samples before and after incubating it for five days at 20 °C. In this study, The BOD concentration of wastewater ranged between 1.11 mg/l and 5.7 mg/l. (Table 1). The average BOD concentrations of all the sampling sites exceeded the standard BOD limit prescribed by GoB [10] for drinking water and hence not suitable for that purpose (Table 2). The BOD concentrations in the wastewater collected from the sampling sites C, D and E were found far above the standard limit prescribed by GoB [10] for use as a source of drinking water after only disinfection or for recreational use and hence not suitable for those purposes (Table 2). The minimum and maximum sub water quality index for BOD were 3.0 at sampling site A and 12.8 at sampling site E, respectively (Table 5).

Table 3: Relative weight (Wi) for each parameter used to calculate WQI

Parameter	Highest permitted value for water ((S_i)	$1/S_i$	K	Wi
WT (°C)	30	0.0333	2.3934	0.0798
pH	8.5	0.1176		0.2816
DO (mg/l)	6.0	0.1667		0.3989
BOD (mg/l)	10.0	0.1000		0.2393
TCC (CFU/100 ml)	5000	0.0002		0.0004

Bacteria present in the wastewater might pose profound effect on the flora and fauna present in the receiving water body. In the present study, high level of bacterial contamination was observed in the wastewater of all the sampling sites (Table 1). The TVBC of wastewater ranged between 30×10^8 CFU /100 ml and 490×10^8 CFU /100 ml. Presence of high concentration of bacteria was also reported by Ikhajiagbe *et al*. [15] in effluent water. The coliform group, widely used as indicator bacteria, includes all the aerobic and facultatively anaerobic, Gram-negative, nonsporulating bacilli that produce acid and gas from the fermentation of lactose. If this indicator bacteria are detected in water, it indicates the possible presence of pathogenic microorganisms in the water. In fact, *Salmonella* sp. and *Shigella* sp. were found in wastewater collected from sampling site A, B and C. In the present study, total coliform count of wastewater varied between 0.2×10^6 CFU /100 ml and 100×10^6 CFU /100 ml (Table 1). Presence of high level of coliform was also reported by Moqbool *et al.* [16] in stream water. The average coliform count of all the sampling sites exceeded the standard limit prescribed by GoB [10] for drinking, source of drinking after only disinfection, recreational activity, fish culture or for irrigation and hence not suitable for use in those purposes (Table 2). The minimum and maximum sub water quality index for total coliform were 2.4 at sampling site D and 864 at sampling site B, respectively (Table 5).

The concept of WQI is based on the comparison of water quality parameters with respect to regulatory standard [17]. Basically, WQI is a mathematical instrument used to transform large quantities of water quality data into a single number which represents the water quality level while eliminating the subjective assessments of water quality and biases of individual water quality experts [18]. Furthermore, it offers a simple, stable and reproducible unit of measure to the policy makers and concerned citizens [19]. In this study, WQI of the wastewater samples was calculated using the weighted arithmetic index method [9]. According to this method highest favorable value gives a low statistical value to the index. On the basis of WQI values, Mishra and Patel [20, 21] have categorized water into five groups: Excellent, Good, Poor, Very poor and Unfit for drinking, wildlife and fish culture (Table 4).

Table 4: Water quality rating based on WQI value

WQI value	Water quality Rating
0-25	Excellent
26-50	Good
50-75	Poor
76-100	Very poor
>100	Unfit for drinking, wildlife and fish culture

In this study, WQI values varied from a high of 946.0 at the sampling site B to a low of 82.9 at sampling site E (Table 5). WQI value at sampling site A and C were also very high. WQI value more than 100 was also reported by several authors [21-23]. Presence of excess number of coliform bacteria at the sampling site A, B and C has contributed to high WQI values in those three sampling sites (Table 1, Table 5). Based on the computed WQI values it can be concluded that wastewaters of variable quality are entering into the aquatic environment of Savar area and wastewater of most of the sampling sites (A, B and C) is unfit for drinking, wildlife and fish culture, whereas the quality of wastewater of other two sampling sites (D and E) are very poor (Table 5).

Table 5: Water quality index of different sampling sites

Sampling site	Sub-index value					WQI value	Status
	WT	pH	DO	BOD	TC		
A	11.5	5.6	60.0	3.0	144	224.1	Unfit
B	10.1	9.4	58.5	4.0	864.0	946.0	Unfit
C	8.4	4.7	49.3	8.4	384.0	454.8	Unfit
D	9.6	24.4	40.1	12.6	2.4	89.1	Very poor
E	9.6	15.0	35.9	12.8	9.6	82.9	Very poor

Appropriate wastewater treatment facility should be established in each of the studied sites to reduce the environmental pollution, conservation of aquatic biodiversity and improvement of public health.

Acknowledgement

The authors would like to express their gratitude to University Grants Commission for providing financial support.

References

[1]. Almeida, C.A. 2007. Influence of urbanization and tourist activities on the water quality of the Potrero De Los Funes River (San Luis –Argentina). Environ. Monitor. Assess.133(1-3):459-465.
[2]. Horton, R. K. 1965. An index number system for rating water quality. J. Water Poll. Con. Fed. 37: 300–305.
[3]. Brown R. M., McClelland N. I., Deininger R. A. and Tozer R.G. 1970. Water quality index-do we dare? Water Sewage Works. 117(10):339-343.
[4]. SDD (Scottish Development Department). 1975**.** Towards cleaner water**.** Edinburgh: HMSO, Report of a River Pollution Survey of Scotland.
[5]. Kabir, S.E., Kabir, M., Mia, C.M., Begum, N., Chowdhury, D., Sultana, M.S. and Rahman, M.S.2002.Assessment of effluent quality of Dhaka export processing zone with special emphasis to that of the textile and dyeing industries. Jahangirnagar Univ. J. Sci. 25: 137-145.
[6]. Kabir, K.M. H., Uddin, M.K. and Khair, A. 2010. Impact of textile industrial effluent around the Shitalakhya river. Jahangirnagar Univ. J. Sci. 33(1): 113-125.
[7]. De, A. K. 1996. Environmental Chemistry. New Age Intl. P. Ltd. India. pp 268-269.
[8]. APHA (American Public Health Association).1975. Standard Methods for the Examination of Water and Wastewater. Washington, DC.
[9]. Brown, R.M., McCleiland, N.J., Deininger, R.A. and O'Connor, M.F. 1972. A water quality index - crossing the psychological barrier (Jenkis, S.H., ed.) Proc. Int. Conf. on Water Poll. Res. 6: 787-797.
[10]. GoB (Government of Bangladesh).1997. Bangladesh Gazette. DA-1.The Environment Conservation Rules 1997. Standards for Water. Schedule-3. pp. 3124-3127.
[11]. Chowdhury, R.M., Muntasir, S.Y. and Hossain, M.M.2012. Water quality index of water bodies along Faridpur-Barisal road in Bangladesh. Global Eng Tech. Rev**.** 2 (2): 1-8.
[12]. Moniruzzaman, Biswas, N., Moniruzzaman, M., Ahmad, T., Rahman, S and Haque, M.E. 2013. Bacteriological and physico-chemical analysis of drinking water in tobacco and food grain cultivating areas of Bangladesh. African J. Biotech. 12(13):1508-1516.
[13]. Saksena D. N., Garg, R. K. and Rao, R.J. 2008. Water quality and pollution status of Chambal river in National Chambal sanctuary, Madhya Pradesh. J. Environ. Biol. 29(5): 701-710.
[14]. Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. 1986. Microbiology. 5th edition (international edition).McGraw-Hill Book Company. New York. p. 604.
[15]. Ikhajiagbe B., Kekere O., Omoregbee O.and Omokha, F. I. 2014. Microbial and physiochemical quality of effluent water from a brewery in Benin city, Midwestern Nigeria. J. Sci. Res. Rep. 3(3): 514-531
[16]. Moqbool, F., Bhatti, Z.A., Malik, A. H., Pervez, A. and Mahmood, Q. 2011. Effect of landfill on the stream water quality. Int. J. Environ. Res. 5(2): 491-500.
[17]. Khan, F., Husain, T., Lumb, A. 2003. Water quality evaluation and trend analysis in selected watersheds of the Atlantic region of Canada. Environ. Monit. Assess. 88: 221-242.
[18]. Stambuk-Giljanovic N.1999. Water quality evaluation by index in Dalmatia. Water Res. 33(16): 3423-3440.
[19]. Singh P. K., Tiwari A. K., Panigarhy B. P. and Mahato M. K. 2013. Water quality indices used for water resources vulnerability assessment using GIS technique: a review. Int. J. Earth Sci. Eng. 6: 1594-1600.
[20]. Mishra P.C and Patel, R.K. 2001. Quality of drinking water in Rourkela, outside the steel township. J. Environ. Pollut. 8(2): 165-169.
[21]. Al-Mohammed, F.M. and Mutasher, A.A. 2013. Application of water quality index for evaluation of groundwater quality for drinking purpose in Dibdiba aquifer, Kerbala city, Iraq. J. Babylon Univ. Eng. Sci.5(21): 1660-1660.
[22]. Padmanabha, B and Belagali, S.L. 2008. Ostracods as indicators of pollution in the lakes of Mysore. J. Environ. Biol. 29(5): 711-714
[23]. Tiwari, A.K., Singh, P.K. and Mahato, M.K. 2014.. GIS-based evaluation of water quality index of groundwater resources in West Bokaro coalfield, India. Current W. Environ. 9(3): 843-845.