OCCURRENCE OF ENTERIC PATHOGENS AND ESTIMATION OF PHYSICO-CHEMICAL PARAMETERS OF SEWAGE EFFLUENTS OF PAGLA TREATMENT PLANT, DHAKA

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Abstract

Sewage waste water contains numerous pathogenic microorganisms and high content of organic matter. Therefore, it poses a number of potential risks for public health and environment. The aim of the study was to identify and quantify the members of Enterobacteriaceae and other pathogens in sewage effluents and also determine some physicochemical parameters, such as conductivity, TDS, BOD_5, DO and pH collected from sewage treatment plant Pagla. Four commonly used selective media were employed for the quantitative isolation of the Entero pathogens. The organisms isolated were *E. coli, Klebsiella, Vibrio cholera, Salmonella* sp. *Shigella* sp. and other *Vibrio* sp. The quantification of the isolates was done by Standard Microbiological Plate Count method. Some isolates were presumptive and some were confirmed after the cultural and biochemical test results. From the study, the assessment was that the presence of *E. coli* and other coliform and fecal coliform in the inlet water was greater than other two stages of treated water. The numbers were respectively 6.5×10^8 cfu/ml and 7.7×10^8 cfu/ml. The reduction of Total Dissolved Solids (TDS) and Biological Oxygen Demand (BOD_5) of the final stages of sewage water and improvement of Dissolved Oxygen (DO) pointed the efficiency of treatment plant.

Key words: Occurance, enteric pathogens, estimation, effluents, Pagla treatment plant.

INTRODUCTION

Degradation of water quality is the unfavorable alteration of the physical, chemical and biological properties of the water that prevents domestic, commercial, industrial, agricultural properties of water. Such alteration is brought about by the discharge of inorganic, organic and toxic substances present in domestic, industrial, agricultural and other wastes excess of the pollution bearing capacity of the water bodies (Atlas and Bartha 1987). Sewage and sewage effluents are one of the major sources of water pollution. Sewage mainly composed of human fecal material, domestic wastes including food wastes and wash water and industrial wastes. If they are discharged into river or sea without proper treatment, this may pose acute threats to the aquatic life of water and other consumers (Augustina *et al.* 2009 and Gerba and Smith 2005). Urban wastewater contains numerous pathogenic microorganisms and a high content of organic matter; therefore, it poses a number of potential risks for public health and the environment (Carrington 2001). Urban wastewater should be treated until an effluent free of pathogenic microorganisms and with minimal impact on the environment is obtained.

In developing countries, most of which have huge debt burdens, population explosion and moderate to rapid urbanization, people rely heavily on water sources of doubtful quality in the absence of better alternatives, or due to economic and technological constraints to adequately treat the available water before use (Aina and Adedipe 1996).

Sewage discharges are a major component of water pollution, contributing to oxygen demand and nutrient loading of the water bodies; promoting toxic; algal blooms and leading to a destabilized aquatic ecosystem (WRC 1995 and Morrison 2001).

The purpose of wastewater treatment is to remove as many of the wastes (contaminants) from the water as possible so that the treated effluent will have few, if any, detrimental effects when it is returned to the environment, lakes, streams, or ocean. Physical, chemical and biological methods are used to remove contaminants from wastewater (Ragsdale *et al.* 2007). In order to achieve different levels of contaminant removal, individual wastewater treatment procedures are combined into a variety of systems, classified as primary, secondary, and tertiary waste-water treatments. Natural systems are also used for the treatment of wastewater in land-based applications (EHS 2007).

The primary treatment wastewater involves the removal of gross particles and objects, sand, grit, scum, and suspended solids. Secondary treatment utilizes biological processes to remove organic matter and tertiary treatment may include processes to remove nutrients, such as nitrogen and phosphorus compounds, pathogenic microorganisms and carbon adsorption to remove chemicals. The treatment can be done mechanically like in trickling filters, activated sludge methods or non-mechanically like in anaerobic treatment and stabilization ponds (Lagoon).

MATERIAL AND METHODS

Description of site

Dhaka WASA operates a sewage treatment plant at Pagla Sewage Treatment Plant (PSTP) that treats the wastewater of millions of the people of Dhaka city. The capacity of this treatment plant is only 0.12 million m^3, while the total sewage generated by the city, as estimated by Dhaka WASA, is about 1.3 million m^3 (Dhaka Environment and Water Project 2010). The samples of sewage effluents were collected from the Sewage Water Treatment Plant at Pagla. There are three stages of water in this treatment plant (Inlet water, Primary Settling Tank water and Lagoon water). Raw sewage effluent water from the pipeline entering into the plant was collected as inlet water. This sewage treatment plant is situated on the northern side Dhaka- Narayanganj road. The inlet samples are very dark in color and have bad odor. Samples were also taken from other two stages of water. Primary Settling Tank (PST) water is settled water, similar to the inlet water. Large particles are settled here. Lagoon water is the treated water. Biological oxidation occurs here. It is the last stage of Pagla WASA.

Sampling procedure

Samples were collected in 500 ml Durand bottles that were cleaned and rinsed carefully and were sterilized by autoclaving at 121°C for 15 minutes. At each time of collection, precautions were taken to prevent or minimize cross contamination of samples between sampling (Duncan *et al.* 2007). During sampling disinfected gloves were used. About 300 ml of waste water samples were collected from a single site. The samples were carried to the laboratory as early as possible after the collection. The samples were carried by the sampling bottles covered with plastic bag and a basket to avoid unwanted result.

Sample processing

After the collection and transport of the samples to the laboratory as soon as possible, these were slightly vortex for proper mixing thus the whole sample had the same concentration of the wastes. Then the samples were serially diluted to 4 or 5 times with the autoclaved normal saline. For every dilution, the samples were properly mixed by the vortex machine.

Four selective media were used for the isolation and quantification of *E. coli*, *Shigella* sp, *Salmonella* sp. *Vibrio* sp. and fecal coliforms; these were MacConkey agar (MAC), Xylose Lysine Deoxycholate agar (XLD), Thiosulfate Citrate Bile salt Sucrose agar (TCBS), Membrane fecal coliform agar (mFC).

The pour plate method, formerly known as the standard plate counts, has several disadvantages that limit recovery of the maximum numbers of organisms irrespective of incubation time and temperature used. Media temperature at 44 - 46°C may cause heat shock of stressed bacteria and the nutritionally rich media may limit recovery of saved bacteria. The spread plate technique was employed to overcome these problems. The spread plate method eliminates heat shock caused by hot agar. Additionally all colonies will be on the agar surface where they can be seen and counted readily and can be distinguished easily from particulate matters and air bubbles (Bartram and Balance 1996). Sample processing was done by APHA (1985) guideline and Water Quality Monitoring method by Bartram and Balance (1996).

Physicochemical analyses

In this study pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), salinity, and dissolved oxygen (DO) and Biological Oxygen Demand (BOD_5) were selected as target indices and these physicochemical parameters were determined on site using a multi-parameter ion specific meter (Hanna instruments, version HI9828) equipped with three different probes for pH; electrical conductivity, salinity and total dissolved solids; and dissolved oxygen and temperature (Igbinosa *et al.* 2009). Sampling time calibration of the machine was done with customized buffers. But turbidity was not measured and instead of Chemical Oxygen Demand (COD) Biological Oxygen Demand (BOD_5) was measured by the Winkler method of oxygen measurement in the samples before and after incubating for five days at 20°C (APHA 1985).

RESULTS AND DISCUSSION

The main concern of this study was to determine the efficiency of sewage plant of Pagla. Two treatment processes were involved in this plant. One is physical (Primary Settling Tank) and other is biological (lagoon). The pathogenic microorganisms are reduced by these two processes. Microorganisms are adhered to the surface of sewage particles. This treatment plant reduces 1.035 log coliform reductions.

Table 1. Physicochemical characterization of three stages of plant water

	Inlet water	Primary settling tank (PST) water	Lagoon water
Conductivity	772 µS/cm	749 µS/cm	577 µS/cm
Salinity	0.4 ppm	0.4 ppm	0.3 ppm
TDS	386 mg/L	375 mg/L	288 mg/L
Dissolved O_2	4.9 mg/L	5.3 mg/L	5.8 mg/L
Temperature	29.9°C	29.8°C	29.7°C
pH	7.15	7.25	9.05

Table 2. Five days BOD measurement of three stages of water

Water Sources	Initial DO	Final DO	BOD_5
Inlet water	4.9 mg/L	2.2 mg/L	2.7 mg/L
PST water	5.3 mg/L	3.4 mg/L	1.9 mg/L
Lagoon water	5.8 mg/L	4.5 mg/L	1.3 mg/L

Because of large and small particles are settled down, these reduce the pathogenic microorganisms in water (Carrington 2001). In lagoon pathogenic microorganisms are addressed into stressed condition. Normal environmental flora competes with pathogenic microorganisms. Allochthonous population of enteric and other pathogens are reduced in numbers and eventually eliminated by competition which is predation pressure exerted by the autochthonous aquatic populations. Sewage enters the treatment plant through screens, traps and skimming devices that remove large objects, grift, floating scum and grease. Primary sewage treatment removes only suspended solids not dissolved. So, TDS remained quite the same in both raw inlet sewage water (386 mg/L) and Primary Settling Tank water (375 mg/L). In secondary sewage treatment a smaller portion of the dissolved organic matter is mineralized and larger portion is converted from a dissolved state to removal solids. Thus TDS of final effluent (Lagoon water) was reduced into 288 mg/L. The combination of primary and secondary treatments reduced the original BOD of the sewage by 80-90%. The secondary sewage treatment step relies on microbial activity. Typically, sewage is subjected to primary settling and is subsequently channeled through a series of holding ponds. The first holding tank re-aerates the oxygen depleted water.

Table 3. Efficiency of Sewage Treatment Plant

Parameters	Unit
Removal of Conductivity	195 µS/cm
Removal of Salinity	0.1 PPM
Removal of TDS	98 mg/L
Increased Dissolved Oxygen	0.9 mg/L
Increased pH	2.10
Removal of BOD	1.4 mg/L

After settling of most of the algal and bacterial biomass, the water is transferred to large, shallow infiltration ponds. The main concern of this treatment process is BOD removal (Amin *et al*. 1998). Lower the BOD and greater the DO, greater the purity of the final effluent (Chipofya and Okoh 2010). Dissolved oxygen concentrations in unpolluted water normally range from 8 to 10 mg/L. The dissolved oxygen of standard drinking water is 6 mg/L, whereas for sustaining fish and aquatic life a 4-5 mg/L DO should be required. For a water quality variable, such as dissolved oxygen, the water quality criteria are set at the minimum acceptable concentration to ensure the maintenance of biological function. Dissolved oxygen is an important parameter used for water quality control. The effect of waste discharge on a surface water source is largely determined by the oxygen balance of the system, that oxygen balance is essential to maintaining biological life within a system (Rao 2005). The measured DO results of final effluent which is discharged to the adjacent river suggest that the mean DO concentrations of the final effluents were acceptable (Kamruzzaman *et al.* 2009). Biological oxidation, lagooning also deplete NH4+-N level of Pagla Sewage Treatment water as influent water and sludge water showed elevated level of NH4+-N, reduced into acceptable limit of treated effluent water (Saha *et al.* 2012).

Lagooning subsides the BOD_5 from 2.7 mg/L to 1.3mg/L. Also, the DO of final effluent increased from 4.9 mg/L to 5.8 mg/L. The effluent quality was acceptable according to South African Department of Water Affairs and Forestry standards with respect to the pH (6.9–7.8), temperature (13.8–22.08C), dissolved oxygen (DO) (4.9–7.8 mg/L), salinity (0.12–0.17 psu), total dissolved solids (TDS) (119–162 mg/L), Electrical conductivity (EC) (237–325 µS/cm) (Calamari and Naeve 1994). According to their guideline, TDS and electrical conductivity of final effluent of Pagla Treatment Plant is little bit more suggesting that TDS is directly linked with electrical conductivity.

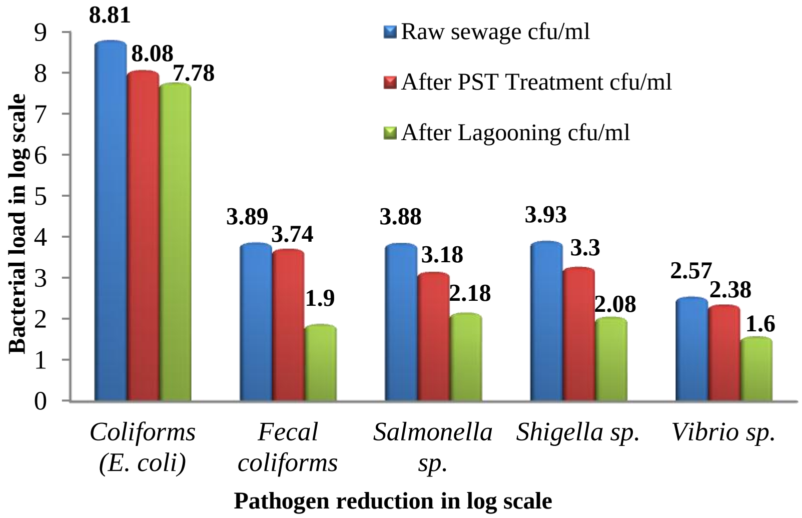

Fig 1. Pathogenic bacterial load reduction in log scale. Primary and secondary treatments improve the final effluent quality which is subjected to discharge in the environment.

This study delineates that if lagoon water can be used portable drinking water instead of discharging in Buriganga river that will reduce cost of water purification. Because the Buriganga river water is used as crude water for supplying portable drinking water by Sayedabad Plant by Dhaka WASA. A biogas plant can also be implemented there. Because a huge amount of sewages are dumped adjacent the plant which can be used as raw materials for biogas production.

REFERENCES

Aina, E. O. A. and N. O. Adedipe. 1996. *Water quality monitoring and environmental status in Nigeria.* Monograph 6, FEPA, Abuja, Nigeria. 239 pp.

Amin, A. F. M. S., S. A. J. Shamsuddin and M. M. Alam. 1998. *Optimization of Sewage treatment process at Pagla: Bangladesh*. Sanitation and Water for all. 24th WEDC conference. Islamabad, Pakistan., pp. 129-132.

APHA. 1985. *Standard Methods for the Examination of Water and Wastewater*. 16th ed. American Public Health Association, Washington D.C. USA. 46 pp.

Atlas, R. M. and Bartha, R. 1987. *Microbial Ecology Fundamentals and applications*. 2nd ed. The Benjamin/cummings publishing company, INC. 458 pp.

Augustina, N., A. Osode and I. Okoh. 2009. Impact of Discharged Wastewater Final Effluent on the Physicochemical Qualities of a Receiving Watershed in a Suburban Community of the Eastern Cape Province. *CLEAN–Soil, Air, Water*. **37**(12): 938 – 940.

Bartram, J. and R. Balance. 1996. *Water Quality Monitoring: A Practical Guide to the Design and implementation of Freshwater Quality Studies and Monitoring Programme*. Published on behalf of UNDP & WHO, Chapman & Hall, London. 383 pp.

Calamari, D. and H. Naeve. 1994. Review of pollution in the African aquatic environment. Committee for Inland Fisheries of Africa (CIFA), FAO, Rome, Italy. *CIFA Technical paper*. **25**: 118.

Carrington, E. G. 2001. Evaluation of Sludge Treatments for Pathogen Reduction. Environment, European Commission, Luxembourg. 52 pp.

Chipofya, V., A. Kraslawski and Y. Avramenko. 2010. Comparison of pollutant levels in effluent from wastewater treatment plants in Blantyre, Malawi. *International Journal of Water Resources and Environmental Engineering.* **2**(4): 79-86.

Dhaka Environment and Water Project. 2010. *Limited Environmental & Social Impact Assessment and Environmental & Social Management Framework.* Vol-1. Department of Environment and Local Government Engineering Department. Bangladesh. 98 pp.

Duncan, D., F. Harvey, M. Walker and AWQC. 2007. *Water and wastewater sampling*. EPA Guidelines: Regulatory monitoring and testing. Australian Water Quality Centre, Environment Protection Authority, Australia. 58 pp.

EHS. 2007. *Waste water and ambient water quality*. General EHS Guidelines: Environmental. International Finance Corporation, World Bank Group. 99 pp.

Gerba, C. P. and J. E. Smith. 2005. Sources of pathogenic microorganisms and their fate during land application of wastes. *J. Environ. Qual.* **34**: 42-48.

Igbinosa, E. O. and A. I. Okoh. 2009. Impact of discharge wastewater effluents on the physico-chemical qualities of a receiving watershed in a typical rural community. *Int. J. Environ. Sci. Tech.* **6**(2): 175-182.

Kamruzzaman, M., M. A. Matin, A. N. M. H. Kabir, Z. H. Mahmud, M. S. Islam, D. Paul, H. P. Endtz, A. Cravioto, and M. S. Islam. 2009. *Evaluation of Chemical and Microbiological Qualities of Raw and Treated Wastewater in Dhaka, Bangladesh*. 12th ASCON, ICDDR,B, Dhaka, Bangladesh. 168 pp.

Morrison, G., O. S. Fatoki, L. Persson and A. Ekberg. 2001. Assessment of the impact of point source pollution from the Keiskammahoek Sewage Treatment Plant on the Keiskamma River–pH, electrical conductivity, oxygen demanding substance (COD) and nutrients. *Water SA.* **27**(4): 475-480.

Ragsdale, D. 2007. *Advanced Wastewater Treatment to Achieve Low Concentration of Phosphorus*. Environment Protection Agency (EPA), Engineer EPA Region 10, Office of Water and Watersheds. 73 pp.

Rao, P. V. 2005. *Textbook of Environmental Engineering.* Eastern Economy Ed. Prentice-Hall of India Private Limited, New Delhi, India. 280 pp.

Saha, M., A. Alam, M. Khan and S. Hoque. 2012. Bacteriological, Physical and Chemical Properties of The Pagla Sewage Treatment Plant's Water. *Dhaka Univ. J. Biol. Sci.* **21**(1): 1-8.

WRC. 1995. Procedures to Assess Effluent Discharge Impacts. South African water quality management series. Department of Water Affairs and Forestry and Water Research Commission, Pretoria, South Africa. *WRC Report*. **64**: 94.