

Original Article

Bacteriological and Physicochemical Analyses of the Raw and Treated Water of Saidabad Water Treatment Plant, Dhaka

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Bacteriological and physicochemical parameters of the raw and treated water of the Saidabad Water Treatment Plant were analysed during the period January through December 2004. It was found that during dry season Sitalakhya River water was adversely polluted and most of the bacteriological and physicochemical parameters increased to an alarming level. Total coliform and thermotolerant-coliform counts of raw water were highest in months of January through March and lowest during the months of April through November. Ammonia concentration of the raw water was very high (3.08-7.06 mg/l) during the dry months from January to April that coincided with high (2.57-6.08 mg/l) ammonia contamination in the treated water. The others physicochemical parameters like turbidity, conductivity, total dry solid (TDS), hardness and alkalinity were high during the dry months. The residual chlorine in treated water was always below 0.50 mg/l. The study clearly indicated that the load of coliform increased when the concentration of ammonia was high in raw water that, to some extent, influenced the aesthetic properties of the treated water like turbidity, colour, taste, odour, alkalinity, TDS, etc. In spite of that the treated water could be used for domestic and drinking purposes for most of the year.

Keywords: Water quality, Total coliform, Thermotolerant-coliform, Ammonia, Physicochemical properties, Residual chlorine

Introduction

Water quality is an extensive research area since water is an important vehicle for the transmission of various microorganisms, including pathogenic bacteria, viruses, parasites as well as chemical pollutants. Water and sanitation condition is mostly poor in developing countries including Bangladesh. Insufficient treatment of domestic sewage is one of the major reasons for the degradation of water environment¹. An estimated 80% of all diseases are water-related and on average, as much as one-tenth of each person's productive time is sacrificed to water-related diseases². About 20-30% of mortality in Bangladesh occurs due to water-borne diseases, e.g., diarrhoea, dysentery, gastroenteritis³. So safe water supply is very important to cut down the incidence of water-borne diseases.

Saidabad Water Treatment Plant (SWTP) is a surface water treatment plant. The Sitalakhya River is the source of the raw water for the plant. Different treatment processes like pre-chlorination, coagulation, filtration, disinfection and pH correction are used at SWTP. There is paucity of information regarding the microbiological and chemical quality of the raw water as well as

treated water of SWTP since its operation in July 2002. The aims of the present investigation were to assess the bacteriological and physicochemical parameters of the raw as well as treated water on a seasonal basis.

Materials and Methods

Water samples

The study was conducted during the period of January through December 2004. Water samples, from inlet point (raw water from the river Sitalakhya) and outlet point (treated water) of the Saidabad Water Treatment Plant (SWTP), Dhaka, were collected in sterile glass bottles for weekly bacteriological and physicochemical analyses. Samples, kept at 4°C, were analysed without much delay to avoid any alteration. They were divided into two parts. One part was used for immediate bacteriological analyses, and the second part was used for physicochemical analyses.

Bacteriological analyses

Total coliform and thermotolerant-coliform counts were conducted by modified membrane filter counting technique⁴. From each bottle

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100 ml of water was passed aseptically through sterile millipore filter papers (porosity of 0.45 μm) to isolate the microorganisms present in the water samples. The filter papers were then aseptically transferred to three replicate plates containing m-ENDO agar media (Difco, USA) and mFC agar (Difco, USA) for recovering and counting of total coliform and thermotolerant-coliform bacteria respectively. The plates were incubated at 37° and 44.5°C up to 48 h for the growth of coliform and thermotolerant-coliform respectively. Colonies were counted from responsive plates and expressed as cfu/100 ml.

Physicochemical analyses

Turbidity of the samples was determined with a turbidity meter (Model WTW, Turb-550, USA). pH values of the samples were determined with a digital pH meter (Model sensION2, HACH, USA). Electrical conductivity (EC) and total dry solid (TDS) were measured with a conductivity meter (Model sensION7 HACH, USA.). Samples were filtered through membrane filter with porosity of 0.45 μm (Sartorius, Minisart, Germany) and then the colour was recorded by a spectrophotometer (Model DR/2500, Odyssey, HACH, USA.) according to the standard methods⁴. Total hardness and total alkalinity were determined using standard titrimetric methods⁵⁻⁶. Ammonia-N, iron, residual chlorine and total chlorine were determined by spectrophotometer according to the standard procedures⁴.

Results and Discussion

Figure 1 depicted the total coliform counts of the raw and treated water of Saidabad Water Treatment Plant (SWTP) during the year 2004. Seasonal variation in bacteriological counts was found in raw water. The average maximum and minimum values of total coliforms for the raw water were 3.78 \log_{10} cfu/100 ml in March and 3.0 \log_{10} cfu/100 ml in November respectively. On the other hand, the average maximum and minimum values of the thermotolerant-coliform for the raw water were 3.0 \log_{10} cfu/100 ml in March and 2.0 \log_{10} cfu/100 ml in August respectively (Figure 2). An increasing trend of thermotolerant-coliform was found during January to March, and a sharp dropdown was observed during April to November. The source of the raw water of SWTP was the river Sitalakheya that receives domestic sewage as well as industrial effluents from the adjacent arrears of Dhaka city⁷. No coliforms or thermotolerant-coliforms were detected at anytime in the treated water over the study period. This indicates that the treatment system of SWTP was effective in removal of harmful water-borne pathogens.

Physicochemical factors are very important aspects of potable of water. Certain range of these factors enhances the bacterial growth and it also determines the sanitary quality of water. Seasonal variation of physicochemical factors of raw and treated water of

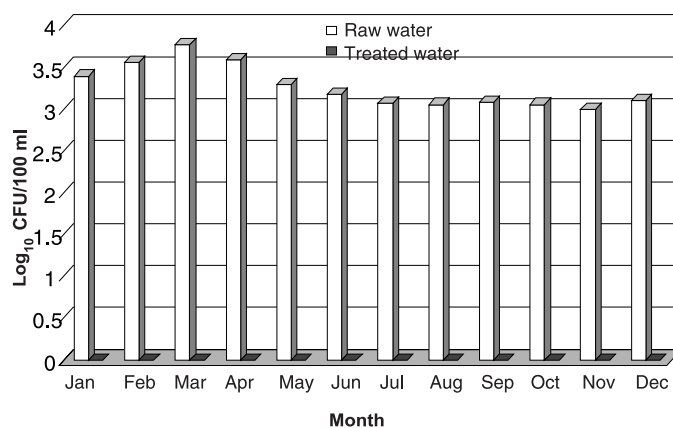


Figure 1. Seasonality of average total coliform counts of raw and treated water of Saidabad Water Treatment Plant (SWTP) in the year 2004.

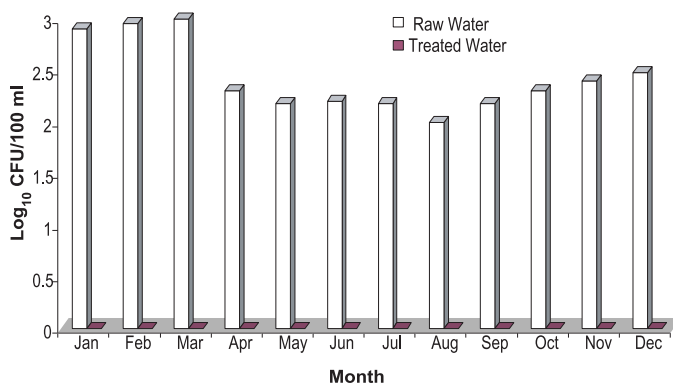


Figure 2. Seasonality of average thermotolerant-coliform counts of raw and treated water of Saidabad Water Treatment Plant (SWTP) in the year 2004.

SWTP is summarized in Table 1 and 2 respectively. There were some fluctuations of the raw water pH over the period from January to December; the minimal value (pH 6.87) was recorded in June and the maximum (pH 7.46) in March. The maximum pH of treated water was 7.41 in December and the minimum was 6.99 in June. The pH values were well within the acceptable range (pH 6.5 to 8.5 of WHO specification⁸. Small changes in pH might be the cause of significant changes in other qualities like solubility of iron, manganese, copper, calcium, and other metals⁹. There were small fluctuations of the raw water turbidity from June to September, and it was relatively stable and low during the winter and the dry seasons. The turbidity of treated water was maintained low and well under the WHO guideline value (5 of NTU) during the study period⁸. Turbidity in water was due to the presence of suspended colloidal particles such as clay, silt, finely divided organic matter, plankton and other microscopic organisms. The colour of the treated water was almost always found within the WHO permissible level (15 TCU).

Table 1. Seasonal variation of physicochemical parameters of raw water of Saidabad Water Treatment Plant (SWTP) in the year 2004

Month*	pH	Turbidity (NTU)	Colour (TCU)	Conductivity ($\mu\text{S/cm}$)	TDS (mg/l)	Total alkalinity (mg/l as CaCO_3)	Total hardness (mg/l as CaCO_3)	Fe (mg/l)	$\text{NH}_3\text{-N}$ (mg/l)
January	7.39	4.7	14	380	195	173	145	0.12	3.67
February	7.39	7.2	31.3	430	220	225	177	0.13	6.24
March	7.46	8.3	21.5	500	254	230	170	0.18	7.06
April	7.42	5.4	18.6	420	225	225	165	0.16	3.08
May	7.19	11.2	10.18	250	126	120	189	0.20	1.09
June	6.87	49.4	10.0	130	65	70	50	0.70	1.28
July	6.95	51.54	12.0	120	61	60	60	0.80	0.39
August	7.20	53.23	09.0	130	63	50	55	0.85	0.33
September	7.22	61.53	10.0	130	65	60	65	0.80	0.40
October	7.06	31.52	18.5	135	67	60	65	0.40	0.41
November	7.13	15.29	23.0	202	101	100	108	0.30	0.21
December	7.42	7.30	18.0	326	163	156	145	0.11	1.25

*Monthly average values are presented. NTU = Nephelometric turbidity unit; TCU = True colour unit; TDS = Total dry solid; $\text{NH}_3\text{-N}$ = Ammonia-nitrogen

Table 2. Seasonal variation of physicochemical parameters of treated water of Saidabad Water Treatment Plant (SWTP) in the year 2004

Month*	pH	Turbidity (NTU)	Colour (TCU)	Conductivity ($\mu\text{S/cm}$)	TDS (mg/l)	Total alkalinity (mg/l as CaCO_3)	Total hardness (mg/l as CaCO_3)	Fe (mg/l)	$\text{NH}_3\text{-N}$ (mg/l)	Residual Cl (mg/l)	Total Cl (mg/l)
January	7.31	0.92	4	400	201	168	158	0.02	2.91	0.31	4.6
February	7.32	1.41	17	460	228	189	158	0.02	5.20	0.32	4.7
March	7.37	2.42	8.1	540	268	214	153	0.01	6.08	0.36	5.3
April	7.28	0.54	5.4	460	232	165	133	0.02	2.57	0.30	4.0
May	7.20	0.60	3.8	260	131	105	90	0.023	0.45	0.26	2.4
June	6.99	0.44	2.5	140	72	52	60	0.025	0.54	0.25	2.1
July	7.25	0.36	1.7	150	71	51	65	0.02	0.02	0.29	0.51
August	7.34	0.32	1.1	153	73	55	65	0.02	0.02	0.24	0.56
September	7.29	0.27	1.0	148	74	56	69	0.03	0.01	0.24	0.48
October	7.17	0.29	1.0	153	76	53	68	0.02	0.03	0.21	0.46
November	7.17	0.29	1.0	224	112	73	88	0.01	0.01	0.23	0.45
December	7.41	0.49	2.3	333	168	139	143	0.01	0.92	0.20	2.69

*Monthly average values are presented. NTU = Nephelometric turbidity unit; TCU = True colour unit; TDS = Total dry solid; $\text{NH}_3\text{-N}$ = Ammonia-nitrogen; Cl = Chlorine

The conductivity, the total dry solid (TDS), alkalinity and total hardness of raw and treated water were stable from June through October, however, their levels were high during the rest of period (Table 1 and 2). The maximum and the minimum alkalinity recorded for the raw water were 230 mg/l in March and 50 mg/l in August respectively. The maximum (214 mg/l) and the minimum (51 mg/l) alkalinity of treated water were recorded in March and in July respectively. The conductivity of raw and treated water was low (120-153 $\mu\text{S/cm}$) during June through October, while it was high (250-540 $\mu\text{S/cm}$) during November through May. The TDS values of raw and treated water varied from 61 to 76 mg/l during June through October, and from 126 to 268 mg/l during November through May. The total hardness followed the same trend as with the alkalinity. The maximum and the minimum values hardness of raw water were 177 (in February) and 50 mg/l (in June) (Table 1). The maximum and the minimum hardness values of treated water were recorded in January-February (158 mg/l) and in June (60 mg/l) respectively (Table 2). The hardness of both raw and treated water was conforms to the Bangladesh Standard (200-500 mg/l as CaCO_3)¹⁰.

Iron concentrations of the raw (<1.0 mg/l) and treated water (<0.05 mg/l) were found very low all over the year, which conform the WHO guidelines⁸. The overall ammonia-N value of treated water was lower than the raw water (Table 1 and 2). In raw water the ammonia-N was low (0.21-0.41 mg/l) during July through November, moderate (1.09-1.25 mg/l) in the months of May, June and December, and high (3.08-7.06 mg/l) during January through April. In treated water the ammonium-N value was low (0.01-0.54 mg/l) during May through November, moderate (0.92 mg/l) in December, and high (2.57-6.08 mg/l) during January through April. The upper limit for ammonium-N according to WHO⁸ and Bangladesh Standard¹⁰ are 1.5 mg/l and 0.5 mg/l respectively.

The level of free chlorine of the treated water was uniform all over the year, which varied between 0.20 mg/l (in December) and 0.36 mg/l (in March). The total chlorine concentration was low (0.45-0.56 mg/l) during July through November, and high (2.1-5.3 mg/l) during December through June. During chlorination of water containing NH_3 in the treatment plant, various chloramines, viz., monochloramine (NH_2Cl), dichloramine (NHCl_2) and trichloramine

(NCl_3), are formed depending on the concentration of chlorine¹¹. The chloramines are known as combined chlorine and are less active than hypochlorous acid (residual chlorine) at a magnitude of one-twentieth the power of hypochlorous acid¹².

Considering the bacteriological and physicochemical parameters, treated water of Saidabad Water Treatment Plant (SWTP) could be considered safe for domestic and drinking purpose for almost whole year. However, the level of ammonia-N in treated water was little elevated in the dry months that coincided with high level of ammonium contamination in the water of the river Sitalakhya. High concentration of ammonia in raw water coincided with increased load of coliforms, and that might also influenced the aesthetic properties like turbidity, colour, taste, odour, etc. of the treated water. Although raw water contained large number of coliforms but their counts in the treated water were well within the acceptable limit of WHO and Bangladesh Standard.

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