International Journal of Natural Sciences (2012), 2(1):33-37

www.ijns.net

pISSN : 2221-1012
eISSN : 2221-1020

Physicochemical and microbial water quality of Sylhet city corporation, Bangladesh

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[Received: February 8, Accepted: March 24, 2012]

ABSTRACT

Sylhet City Corporation (SCC) of Bangladesh is supplying water to the Sylhet city dwellers through its distribution network. The quality of water is at risk to deteriorate during its flow through the distribution system and also due to probability of high elemental concentrations in groundwater. To identify such probable water contamination problems; water samples from 20 (out of 27) different wards of the city were analyzed in this study. The parameters analyzed were pH, turbidity, total alkalinity as Calcium carbonate $CaCO_3$, total hardness, iron, manganese, arsenic, chloride, fluoride, MPN (Most Probable Number), total viable count (TVC), coliform and fecal coliform. The study revealed that all the physico-chemical parameters except alkalinity were in the permissible limit. All the samples were found to have total alkalinity as $CaCO_3$ value higher than the WHO and Bangladesh Standards limit. But the water from treatment plant was found to have high turbidity and iron concentration. Analysis of microbial water quality parameters revealed that there was no coliform and fecal coliform contamination. But high value of MPN index and total viable count indicates that there were obvious contamination and chances of contamination by non-fecal pathogens. Finally, it is concluded and recommended that the water treatment facilities of SCC have to be improved, further investigation should be done to identify the non-fecal organisms and the cause of high total viable bacteria should be detected and corrected for the betterment of the city dwellers.

Key words: Arsenic, MPN, Viable count, Water quality, Water supply.

INTRODUCTION

The quality of drinking water has great importance and is an important public health priority. Consumption of water, containing pathogenic organisms or toxic chemicals has huge negative impact on life. About 80% of all diseases and two third of deaths in developing countries are attributed to consumption of low quality water, and on an average 10% of ones' productive time is sacrificed to such diseases [1]. The quality of drinking water in Bangladesh is at high risk. Problems are acute, especially in the urban areas due to high migration rate of rural people and increased economic growth as well [2]. The water supplied by the SCC is the main source of water for most of the city dwellers of Sylhet (Bangladesh). Although some people have their own water source; but most of the city dwellers rely on this water supply. Hence the quality of the water supplied by SCC is crucial for the health of city dwellers. Perceptions about water quality, based on visual examination, taste and odor, are often unreliable. Water that look or smell unpleasant may be safe to drink, while clear odorless water may contain chemicals or bacteria those are harmful to human health. Water quality is normally assessed against both microbiological and chemical parameters, although the microbiological quality has been identified as the most important aspect from a public health perspective. The chemical quality is of immense importance; as especially arsenicosis is a known and widespread crisis in Bangladesh [3].

The risk of acquiring a waterborne infection increases with the level of contamination by pathogenic micro-organisms. Although many waterborne pathogens can now be detected, the methods for their detection are often difficult to implement, relatively expensive, and time-consuming. The presence of pathogens of fecal origin is determined by testing for an "indicator" organism such as coliform bacteria. A positive test for this indicates possible presence of other intestinal bacteria; Giardia and Cryptosporidium.

Naturally occurring chemicals, except nitrates are not a serious treat for human. Other naturally occurring chemicals, like fluorides and arsenic cause chronic health problems when ingested over a long period. Certain chemicals, such as iron or manganese, which may be present in water, are likely to affect the acceptability of water for drinking, but have limited health significance. If the water is turbid or cloudy, contaminated surface run-off may be entering the aquifer through cracks in the casing or the cement pump pad or through surrounding soil which is very permeable. While turbidity is not dangerous, it reduces the efficiency of disinfectants and indicates the presence of other conditions that need investigated. Although pH usually has no direct impact on water consumers, it is one of the most important operational water-quality parameters. The

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pH of the water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes water systems. Failure to do so can result in the contamination of drinking-water and in adverse effects on its taste, odor, and appearance [4].
Concentrations of chloride in excess of 250 mg/L may impart a salty taste to the water. Therefore, the aesthetic objective is set at a maximum of 250 mg/L. However, the salty taste is variable and dependent on the chemical composition of the water. No evidence has been found to indicate that ingestion of chloride is harmful to humans. Arsenic may cause chronic effects on human from accumulation of arsenic in the body at low intake level. Iron in water may cause undesirable taste, color and hardness; but consumption of low concentration of iron has no significant adverse effect on human health. Hard water consumes too much soap, and it clogs skin, discolors porcelain, stains and shortens fabrics and toughens and discolors vegetables and cooked foods [4, 5].
Considering the above facts the present study was undertaken with some distinct aims; these are determination of the physico-chemical and microbiological qualities of water and also compare the water qualities with the different standards to assess the health risks of city dwellers consuming water supplied by SCC.

MATERIALS AND METHODS

The study was conducted in 2010 at the Department of Microbiology and Hygiene, Sylhet Agricultural University (SAU), Sylhet and at the Department of Civil and Environmental Engineering, Shahjalal University of Science and Technology (SUST), Sylhet.
Water samples were collected from 20 wards of SCC (out of 27). A volume of 2 liters of water was collected for each sample, 40 samples were collected from 20 different outlets with sterile containers. In all cases mid stream water samples were collected. The samples were maintained at 4°C until the tests were performed.
Samples of the water were added to lactose broth and the most probable number (MPN) of bacteria was obtained accordingly. For confirming the presence of coliform (*E coli*), the Eosine Methylene Blue (EMB) agar were inoculated and incubated accordingly; *E. coli* grows as small colonies on this medium with metallic sheen, whereas *E. aerogenes* colonies are usually large and lack the sheen. EMB agar plates are incubated at 45°C for 24 hours to differ the fecal and non-fecal coliform. Growth of the bacteria in elevated temperature indicates the presence of fecal coliform. Standard plate count (SPC) was performed on plate count agar.
For determination of the physico-chemical properties; the P^H was measured by a digital P^H Meter. Turbidity was measured by a Turbidity Meter. *Total Alkalinity* was measured by titration method. Total hardness was determined by Soda Reagent method. Iron was determined by production of red colored iron compound (ferric thiocyanate), by the addition of potassium thiocyanate. The UV Spectrophotometer was used for detection of the amount of color change. Manganese was determined by colorometric test using nitric acid and silver nitrate; and assay of the color change by UV spectrophotometer. The inorganic arsenic is absorbed in the form of AsH3 by the Silver diethyledithiocarbamate (SDDC) solution in an absorber unit. Presence of arsenic was investigated by the method and the results were recorded be UV Spectrophotometer. Chloride was determined in MOHR method by titration with a standard silver nitrate solution in the presence of potassium chromate indicator. The colorimetric estimation of fluoride was done using SPANDS solution and zirconyl-acid using UV Spectrophotometer at 570nm.
All microbial and physicochemical properties were determined, following the instruction of "Practical Microbiology" by- S. N. Kaul[6]; and "Standard Method for the Examination of Water and Wastewater" 16'Th edition; prepared and published by: American Public Health Association, American Water Works Association and Water Pollution Control Federation[7].

RESULTS AND DISCUSSION

In this work, the present status of the quality of water supplied by SCC was determined by determining the physico-chemical and microbial properties. Water samples were extensively tested in laboratory to determine pH, turbidity, total alkalinity as $CaCO_3$, total hardness, iron, manganese, arsenic, chloride, fluoride, MPN, total viable Count, coliform and Fecal Coliform.

P^H:
The P^H of all sample were found in the range of 5.5-8.2. All three standards considered here recommend that the P^H should be in the range of 6.5-8.5. Out of 20 samples; 13 samples were within the range and 7 samples were below the guideline value ranging from 5.7-6.2. At lower P^H water is likely to be corrosive. The P^H of the water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in household water systems. Failure to do so can result in the contamination of drinking-water and in adverse effects on its taste, odor and appearance.

Turbidity:
Turbidity in drinking water is not of great concern; in all the samples, only one was found crossing (5.10 NTU) WHO and ISI guideline value (5); Bangladesh Standard approves a value up to 10.

Total Alkalinity:
Alkalinity is the sum of all titrable bases. The alkalinity was found in the range of 57-180 mg/L; hence all are crossing WHO and Bangladesh

Standard guideline value, 50; but not the ISI guideline value.

These three samples especially the sample no13 will cause undesirable taste in beverages, staining of

Sample no.	1	2	3	4	5	6	7	8	9	10	WHO*	BD**	ISI***
pH	6.2	6.2	6.8	5.7	5.9	5.5	5.9	5.7	6.9	7.4	6.5-8.5	6.5-8.5	6.5-8.5
Turbidity (NTU)	0.15	0.42	0.56	0.12	0.29	0.56	0.12	0.17	0	0	5	10	5
Total Alkalinity as $CaCO_3$ (mg/L)	163	128	87	77	89	63	114	173	161	180	50	50	200
Total Hardness (mg/L)	90	110	120	136	106	130	82	56	136	110	500	200-500	300
Iron (mg/L)	0	0	0.31	0.08	0	0.53	0	0.07	0	0	0.3	0.3-1.0	0.3
Manganese (mg/L)	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1
Arsenic (mg/L)	0	0	0	0	0	0	0	0	0	0	0.01	0.05	0.05
Chloride (mg/L)	21	13	8	42	19	41	7	10	20	15	250	150-600	250
Fluoride (mg/L)	0.1	0.12	0.06	0.14	0.13	0.13	0.08	0.06	0.29	0.17	1.5	1.0	1.0
MPN	210	28	93	43	2400	1100	240	2400	460	75	MPN positive water sample is not potable water [8].		
Total Viable Count (cfu/ml)	35×10^{14}	48×10^{14}	96×10^{14}	53×10^{12}	45×10^{16}	67×10^{14}	36×10^{12}	97×10^{14}	54×10^{14}	67×10^{14}	1×10^3	According to EPA 500 cfu/ml	
Coliform (#/100ml)	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Fecal Coliform (#/100ml)	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve

WHO*= World Health Organization [9, 10, 5], BD** = Bangladesh Standards [11], ISI***= Indian Standard Institute.

Total Hardness:

The total hardness is defined as the sum of the calcium and magnesium concentrations both expressed as calcium carbonate in mg/L. The total hardness values of all samples are lying in the range of 56-150mg/L. So these are moderately hard and within the guideline values (WHO 500 mg/L, Bangladesh Standard 200-500 mg/L and ISI 300 mg/L). The principal negative effect of hardness in domestic water supply is that, the hard water consumes too much soap. Alam et al [12] found that total hardness (mg/L) in Sylhet City groundwater were, within dumping place is 4564, average concentration in groundwater near dumping place is 610 and average concentration in groundwater remote from dumping place is 204.

Iron:

Anaerobic groundwater may contain ferrous iron at concentrations of up to several milligrams per liter without discoloration or turbidity in the water when directly pumped from a well. On exposure to the atmosphere, however, the ferrous iron oxidizes to ferric iron, giving an objectionable reddish-brown color to the water. Only three of all samples contained significant level of iron. The sample no 3 and 6 contain 0.31mg/L and 0.53mg/L which are above the guideline value of WHO and ISI, 0.30gm/L. But these two are within the range 0.30-1.0mg/L that is given by Bangladesh Standard. The sample no 13 have iron concentration 3.65mg/L which significantly crosses all the guideline values. cloths and plumbing fixtures, encrustation in water mains and impart a reddish brown color to water. The growths of iron bacteria will be favored which exaggerate the staining, pipe clogging and other problems. Alam et al. [12] found that iron concentrations (mg/L) in Sylhet City groundwater were, average concentration of water samples within dumping place is 133.5, average concentration in groundwater near dumping place is 1.48 and average concentration in groundwater remote from dumping place is 0.21.

Manganese:

Manganese, which may be present in water, is likely to affect the acceptability of water for drinking, but have limited health significance. In the collected samples no manganese was found.

Arsenic:

Arsenic in drinking water poses the highest known environment cancer risks. It also has many other effects. Arsenicosis is a known and widespread crisis in Bangladesh. The collected water samples from SCC were free from arsenic.

Chloride:

Chlorides naturally occur in waters in varying concentrations. No evidence has been found to indicate that ingestion of chloride is harmful to human. High chloride content may harm metallic pipes and structures as well as growing plants. Higher chloride content in inland water usually indicates sewage pollution. In our collected water samples, chloride concentrations were found at the concentration much lower than the guideline values.

But Alam et al [12] found that chloride concentrations (mg/L) in Sylhet City groundwater were, average concentration of water samples within dumping place is 3458, average concentration in groundwater near dumping place is 280 and average concentration in groundwater remote from dumping place is 46.

Sample no.	11	12	13	14	15	16	17	18	19	20	WHO*	BD**	ISI***
pH	8.2	8.0	7.9	8.0	7.9	7.4	7.0	6.8	6.7	6.5	6.5-8.5	6.5-8.5	6.5-8.5
Turbidity (NTU)	0.16	0.48	5.10	0.18	0	0	0	0	0	0.67	5	10	5
Total Alkalinity as $CaCO_3$ (mg/L)	121	110	89	150	76	57	85	66	77	78	50	50	200
Total Hardness (mg/L)	112	108	102	84	56	62	150	145	132	128	500	200-500	300
Iron (mg/L)	0	0	3.65	0	0	0	0	0	0	0	0.3	0.3-1.0	0.3
Manganese (mg/L)	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1
Arsenic (mg/L)	0	0	0	0	0	0	0	0	0	0	0.01	0.05	0.05
Chloride (mg/L)	8	9	8	11	11	10	13	10	8	11	250	150-600	250
Fluoride (mg/L)	0.84	0.14	0.1	0.14	0.1	0.1	0.06	0.22	0.08	0.1	1.5	1.0	1.0
MPN	93	1100	93	240	150	2400	-ve	1100	460	-ve	MPN positive water sample is not potable water [8].		
Total Viable Count (cfu/ml)	38×10^{16}	32×10^{14}	238×10^{14}	196×10^{14}	93×10^{14}	207×10^{14}	36×10^{12}	97×10^{14}	104×10^{14}	197×10^{14}	1×10^{3}	According to EPA 500 cfu/ml	
Coliform (#/100ml)	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Fecal Coliform (#/100ml)	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve

Fluoride:

Fluorides cause chronic health problems, when ingested over a long period. Excessive fluoride intake causes fluorosis, cancer, arthritis, and other diseases. It also affects human intelligence, especially in children, who are most susceptible to early fluoride toxicity. As like chloride the fluoride concentrations of our samples were much low than the guideline values. Only the sample no 11 have a fluoride content touching the guideline value.

But Alam et al [12] found that Fluoride concentrations in Sylhet City groundwater were, average concentration of water samples within dumping place is 1.5, average concentration in groundwater near dumping place is 3.8 and average concentration in groundwater remote from dumping place is 1.44.

Sample no.	01	02	03	04	05	06	07	08	09	10	11
Total Viable Count (cfu/ml)	35×10^{14}	48×10^{14}	96×10^{14}	53×10^{12}	45×10^{16}	67×10^{14}	36×10^{12}	97×10^{14}	54×10^{14}	67×10^{14}	38×10^{16}

Sample no.	12	13	14	15	16	17	18	19	20	WHO	EPA
Total Viable Count (cfu/ml)	32×10^{14}	238×10^{14}	196×10^{14}	93×10^{14}	207×10^{14}	36×10^{12}	97×10^{14}	104×10^{14}	197×10^{14}	1×10^{3}	500

Most Probable Number (MPN):

This is a presumptive test in which tubes showing gas production are counted. By counting the number of tubes showing a positive result and comparing with standard table, a statistical estimate of the most probable number (MPN) of bacteria were made. This is an estimate of lactose fermenting bacteria. In our samples only two were negative (sample no 17 and 20) and the positive 18 samples significantly varied in their most probable number. Sample 2 and 4 have a low MPN index value. Average MPN index value for these collected samples is 634.24 per 100ml. According to Dubey & Maheshwari [8], "once it is evidenced that gas producing lactose fermenters are present in the water sample, certainly it is not potable water". So these samples are not potable.

Alam et al. [12] found that, in Sylhet City restaurants the mean values varied between 24.6 MPN/100 m/L (dry season) and 22.5 MPN/100 ml (monsoon season). These levels are clearly unsafe as far as drinking water is concerned [13]. They also commented that the source of Total Coliform Bactera in the water supply of the restaurants appears to be contaminated water storage tank.

Coliform and Fecal Coliform Test:

In presumptive test, many a time gas is produced by non coliform group of bacteria. So, this test is meant for differentiating the coliforms with that of non-coliforms as well as gram-negative with gram-

positive bacteria. In our investigation, no any dark centered or nucleated colonies with metallic sheen have been found. So, all the samples were coliform negative. The fecal coliforms differ from the other coliforms in that the fecal coliforms can grow in 45°C i.e. they are thermo tolerant. No sample was grown at elevated temperature. So it is proved that, there was no fecal contamination in these samples.
But Alam et al [12] found that in Sylhet City, the drinking water of each restaurant was contaminated with fecal coliforms. Health risk score for coliform bacteria was $1.4X10^2$, indicating high risk.

Total Viable Count:
It is done to enumerate total viable population and not to detect either coliform or other pathogenic forms present therein. It counts all the viable bacteria present in the sample. After inoculation and incubation for 24 hours the colonies were counted. But it was problematic due to swarming bacteria. These bacteria have covered the plate. Probably it was *Proteus vulgaris.* After repeated trials with more dilution it was possible to count.
The results of total viable count were high. There is no proper guideline value for total viable bacteria for drinking water. In nature, the pathogenic bacteria are very much lower in number than the non-pathogenic bacteria. But when there is high concentration of viable bacteria, there is chance of contamination by pathogenic bacteria. For this reason in 1996 WHO proposed a guideline value 1×10^3 cfu/ml. The US Environmental Protection Agency (EPA) recommends that it should be 500 cfu/ml. But our findings are much higher than these values. These are as follows:

CONCLUSION

The physico-chemical properties of the water samples are of good quality except the sample no 13. Although there are 7 samples with low P^H but none of these were extreme. These samples are excellent for drinking and household uses considering the turbidity, hardness, iron, manganese, arsenic, chloride and fluoride content. But the total alkalinity concentrations of all samples are higher than the guideline values given by WHO and Bangladesh Standards. The microbial properties of these water samples are questionable, though there is no fecal contamination proved. Only the sample no 13 is not a satisfactory water source for drinking and household purposes. Sylhet City Corporation (SCC) supplies water from deep tube well sources. So the high microbial content may be due to the supply system. Only the sample no 13 is the water supplied after treatment process and its water source is Surma River. So the water treatment facilities of Sylhet City Corporation (SCC) are not sufficient for ensuring reliable water supply.

ACKNOWLEDGEMENTS

The authors are gratefully to Sylhet City Corporation (SCC), Sylhet, Bangladesh; Department of Genetic Engineering and Biotechnology, Shahjalal University of Science and Technology, Sylhet; Department of Civil and Environmental Engineering, Shahjalal University of Science and Technology, Sylhet; Department of Microbiology and Hygiene, Sylhet Agricultural University (SAU), Sylhet; Dept. of Chemistry, Shahjalal University of Science and Technology, Sylhet; for their cooperation and support.

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