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MICROBIOLOGICAL SAFETY OF DRINKING WATER IN DHAKA CITY: A STUDY ON SUPPLY AND TREATED WATER IN DHAKA, BANGLADESH

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Access to safe and clean drinking water is a fundamental human right and a critical public health issue worldwide. The present study attempted to determine the microbiological quality and detection of pathogenic bacteria in different municipal water supplied in the different places of Dhaka city. This study involved the microbiological analysis of sixteen drinking water samples collected from diverse sources, including four from supply points, six from consumer points, and six treated water samples, obtained from Siddeswari, Sonargaon, Mirpur, and Badda. All the samples were contaminated with different microorganisms, and the total viable bacterial count ranged from 10^3 to 10^7 CFU/mL. Pathogenic microbes like *Pseudomonas* spp. was present in all the samples, while *Klebsiella* spp., *Salmonella* spp., and *Staphylococcus* spp. were predominantly present in seven, six, and eleven samples, respectively. We also aimed to determine whether *Shigella* spp. was present in all the samples, but it was completely absent. *Escherichia coli* was detected in samples from both supply and consumer points within the range of 10^2 to 10^3 cfu/mL. The results indicate that the treatment procedure is not sufficiently effective in eliminating all pathogenic bacteria, and unhygienic environments contribute to post-treatment contamination. The study revealed that government should take necessary action to ensure public health safety, particularly with regard to access to safe drinking water.

Keywords: Drinking water, Public health, Microbial contamination, Water borne diseases

INTRODUCTION

Water is one of the most vital elements of all the natural resources that are found on earth. All living things, the majority of ecological systems, human health, food production and economic advancement depend on it (1). Interestingly, nearly 70% of the planet is occupied by water, and only about 2.7-3.0% of the world's water resources are fresh water. Water is thought to be a scarce resource and it's been estimated that 41 of the world's population live under water stress conditions. While 1.1 billion people live without access to potable water (2).
The rapid rise in urban population due to the industrial revolution, urbanization, and increased demand for public health infrastructure expansion as well as increased municipal drinking water supply have completely changed the quality of life in urban and suburban areas. There are 204 municipalities in Bangladesh, a country of 170 million people, that provide treated or untreated surface water as well as freshwater to urban and suburban areas (3). Moreover, one of the targets to be met in the 2030 Sustainable Development Goals is a sustainable supply of safe drinking water (4). Actually, environmental factors (air, soil and water) are thought to be responsible for 23% of all fatalities and 24% of the world's total disease burden (5, 6). Water-borne illnesses and water-based illnesses can arise from the use of unreliable, low-quality water supplies. Waterborne illnesses are a major cause of diarrhea and other gastrointestinal problems, leading to about 2.2 million deaths and over 72 million disability-adjusted life years worldwide (7-9).
Due to its high population density, Bangladesh is widely considered as one of the most susceptible to the rapid transmission of diseases caused by pathogenic microorganisms spread through contaminated food, water, and air. Concerns related to water, sanitation, and hygiene contribute to 8.5% of all deaths nationwide (10). Waterborne diseases such as diarrhea, dysentery, typhoid, salmonellosis, listeriosis, parasitic worm infestations, and viral infections can all be caused by pathogenic microbes that enter through a dirty and leaky water supply pipe and contaminate the water. A number of previous research studies have provided information on the presence of certain enteric bacteria in the water body, including *Vibrio, Salmonella, Shigella,* and *Escherichia coli*, all of which have the potential to cause infectious disorders (11).

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Numerous reports claim that the supply water that makes its way through the distribution networks to the consumer endpoints is no longer fit for human use (11-13). Bangladesh's major cities have piped water supplies; however, it is rarely possible to find information about the supply water's physico-chemical and microbiological compliance, particularly at the users' end (7). In order to safeguard people from illnesses transmitted by water, potable water providers have to assure that the water they supply is devoid of any harmful microorganisms. Nevertheless, in order to guarantee the microbiological purity of drinking water, a lot of utilities simply maintain checking on indicator bacteria such as total coliforms and *Escherichia coli*. While coliform bacteria are found in the environment naturally and do not always cause illness; their presence is frequently used to determine whether water may contain potentially hazardous bacteria. In contrast, fecal coliforms and *E. coli* are solely derived from the feces of humans and animals (12). In Bangladesh, the presence of coliform, fecal coliform, *E. coli*, *Pseudomonus* spp. and *Salmonella* spp. in a majority of the water samples showed that contamination was widespread (13). However, in developing countries like Bangladesh, rather than improving and preserving the quality of the supply water, a lot of work and attention has been focused on increasing urban water supply to satisfy the growing demand. There's thus, the necessity to subject potable water to microbiological examination and WHO has counseled that redoubled stress be placed on home water treatment. Most studies might focus only on treated water from the supply network and not compare it with other sources. However, this research collects samples from various points, including the supply point, consumer point, and after treatment. Comparing these sources can help assess water quality throughout the supply chain, from treatment to consumption. Therefore, this study aims to carry out the prevalence of pathogenic microorganisms including bacteria and fungi of the different water supplies in Dhaka to determine their portability for consumption and other uses.

MATERIALS AND METHODS

Study area and sampling: The study was conducted in four different locations in Dhaka, namely Siddeswari, Sonargaon, Mirpur, and Badda. It aimed to assess the quality of municipal water supplied by the Dhaka Water Supply and Sewerage Authority (DWASA), as well as tube well water. Despite numerous reports of waterborne diseases in the region, these locations were deliberately selected for the study.

A total of sixteen water samples (four from supply points, six from consumer points, and six treated samples) were collected from Siddeswari, Sonargaon, Mirpur, and Badda. The samples were collected aseptically in sterile screw-capped bottles, kept in a thermal stabilizing box maintained at 25°C, transported to the laboratory within one hour, and immediately subjected to microbiological analyses.

Isolation and enumeration of microorganisms:

Total bacterial and total fungal count: Nutrient Agar (NA) and Sabouraud Dextrose Agar (SDA) media were used to determine the total bacterial and fungal counts through serial dilution, respectively. The total bacterial and fungal counts were recorded as colony-forming units (CFU) per milliliter. 0.1 mL diluted sample from the 10^{-4} dilution of each water sample was spread onto Nutrient Agar and Sabouraud Dextrose Agar (SDA) plates and incubated overnight at 37°C and 25°C, respectively (6, 14).

Detection of *E. coli, Klebsiella* spp., *Staphylococcus* spp. and *Pseudomonas* spp.: *E. coli*, *Klebsiella* spp., *Staphylococcus* spp. and *Pseudomonas* spp. were isolated by spreading 0.1 mL of each sample over MacConkey agar, Mannitol Salt Agar (MSA), and Cetrimide agar respectively. Afterward, the plates were incubated at 37°C for 24 hours. Eosin Methylene Blue (EMB) agar was further used to observe the production of a green metallic sheen, to confirm the characteristics of *E. coli* strains. (15-17)

Detection of *Salmonella* spp., *Shigella* spp. and *Vibrio* spp.: In the first instance, the membrane filtration method was used for the detection of *Salmonella* spp., *Shigella* spp. and *Vibrio* spp. using Salmonella-Shigella agar and Thiosulfate Citrate Bile Salt Sucrose (TCBS) agar, respectively. However, the respective microorganisms, e.g., *Salmonella* spp., *Shigella* spp. and *Vibrio* spp. did not exhibit any growth, either when stressed or in a VBNC (viable but non-culturable) state (23, 24), resulting in a probable false negative result. Consequently, enrichment was performed for *Vibrio* spp. in alkaline peptone water and for *Salmonella* spp. and *Shigella* spp. in selenite cystine broth (15-17).

Biochemical characterization and identification of representative colony: Representative isolates were then subjected to biochemical tests for further confirmation, which included tests for indole production, methyl red, Voges-Proskauer, citrate utilization, triple sugar iron, and Oxidase test. Each test was accompanied by positive (+) and negative (-) controls (22).

Detection of Total Coliform count (TC) and Fecal Coliform count (FC): One hundred milliliters of each sample were filtered through a 0.45 µm membrane filter (Pall Corporation, Michigan, USA) and placed on MacConkey agar and m-FC agar plates for the estimation of total coliforms (TC) and fecal coliforms (FC), respectively. For the total coliform assay, the plates were incubated at 37°C for 24 hours, while for fecal coliform estimation; the plates were incubated at 44.5°C for 24 hours (25-28).

RESULTS

Access to safe water is a fundamental human right and a cornerstone of public health and sustainable development. However, water can become contaminated through various sources, such as sewage overflows, improper sanitation practices, human and animal fecal waste, and untreated or inadequately treated industrial effluents. To protect public health, it is essential to identify microbial contamination in water. This study highlights the growth patterns of various bacterial species found in drinking water samples collected from different locations across Dhaka, Bangladesh.

Microbial analysis of supply and treated water

The outcomes of the microbial analysis of water samples collected from four areas of Dhaka, Bangladesh, are shown in Table 1. The range of total viable bacterial (TVB) counts varied from 2.4×10^3 to 4.8×10^7 CFU/mL on nutrient agar plates. The total fungal (TF) count on SDA agar plates ranged from 1.0×10^2 to 3.1×10^5 CFU/mL. The number of E. coli was found in the margin of 0 to 4.9×10^3 CFU/mL, while *Klebsiella* spp. was up to 6.0×10^3 CFU/mL on MacConkey agar. No *Shigella* species were found in any samples, while the *Salmonella* spp. count on XLD agar was between 0 to 5.1×10^4 CFU/mL. *Pseudomonas* spp. was present in all samples on Pseudomonas agar, with counts ranging from 1.3×10^2 to 8.0×10^3 CFU/mL. The range of *Staphylococcus* spp. counts varied from 0 to 2.1×10^3 CFU/mL.

Table 1: Microbiological Analysis of Drinking Water (CFU/mL).

Collection Point/Area	**TVB**	**TF**	***E. coli***	***Klebsiella* spp.**	***Salmonella* spp.**	***Pseudomonus* spp.**	***Staphylococcus* spp.**
***Siddeaswari*:**							
SP 01	2.7×10^6	2.3×10^4	0	2.3×10^3	0	4.2×10^3	1.1×10^3
CP 01	4.8×10^6	2.1×10^4	0	3.8×10^3	0	5.3×10^3	1.6×10^3
AT CP 01	2.5×10^4	2.2×10^3	0	0	0	2.7×10^1	0
***Sonargaon*:**							
SP 01	3.6×10^6	2.4×10^5	3.1×10^3	0	0	6.5×10^3	1.7×10^3
CP 01	4.8×10^7	3.1×10^5	4.2×10^3	0	1.3×10^3	4.6×10^3	1.9×10^3
AT CP 01	2.8×10^4	1.9×10^3	0	0	0	2.5×10^2	1.1×10^1
***Mirpur*:**							
SP 01	3.5×10^3	2.5×10^3	8.0×10^2	0	0	5.0×10^2	0
CP 01	2.2×10^4	2.2×10^3	0	1.0×10^3	0	1.5×10^3	0
AT CP 01	2.5×10^3	1.0×10^2	0	0	0	4.0×10^2	0
CP 02	2.2×10^4	5.2×10^3	4.9×10^3	0	1.0×10^2	8.0×10^2	7.0×10^2
AT CP 02	8.6×10^3	1.4×10^2	0	0	0	1.8×10^3	0
***Badda*:**							
SP 01	3.4×10^5	2.4×10^3	0	2.7×10^3	1.9×10^2	8.0×10^3	1.6×10^3
CP 01	4.0×10^6	2.0×10^3	0	4.0×10^3	1.3×10^3	2.3×10^4	1.4×10^3
AT CP 01	2.4×10^3	1.1×10^2	0	1.2×10^2	0	3.0×10^3	5.0×10^2
CP 02	2.0×10^7	1.4×10^3	0	6.0×10^3	5.1×10^4	6.0×10^3	2.1×10^3
AT CP 02	3.4×10^3	5.2×10^2	0	0	4.2×10^2	1.3×10^2	1.0×10^2

Note: *Shigella* spp. and *Vibrio* spp. were totally absent in all the samples. SP, Supply point; CP, Consumer point; AT, After treatment; TVB, Total Viable Bacteria, TF, Total Fungi.

Table 2: Biochemical tests of representative bacterial isolates.

Assumed Organisms	**TSI**				**Indole**	**MR**	**VP**	**Citrate**	**Motility**	**Oxidase**
	Slant	**Butt**	**Gas**	**H_2S**						
E. coli	Y	Y	+	-	+	+	-	-	+	
Klebsiella spp.	Y	Y	-	-	-	-	-	-	-	+
Salmonella spp.	R	Y	-	+	-	+	-	-	+	
Pseudomonas spp.	A	A	-	-	-	-	-	+	-	-
Staphylococcus spp.	Y	R	+	+	-	+	-	+	+	-

Note: TSI, Triple Sugar Iron Test; Y, Yellow (Acid); R, Red (Alkaline); MR, Methyl red; VP, Voges-Proskauer.

Table 3: Isolation of coliform and fecal coliform bacteria through Membrane Filtration technique.

Collection Point/Area	**TC (total coliform)**	**FC (fecal coliform)**
***Siddeaswari*:**		
SP 01	35	23
CP 01	50	20
AT CP 01	10	0
***Sonargaon*:**		
SP 01	55	25
CP 01	61	18
AT CP 01	15	0
***Mirpur*:**		
SP 01	20	10
CP 01	36	19
AT CP 01	17	0
CP 02	29	18
AT CP 02	14	0
***Badda*:**		
SP 01	75	30
CP 01	98	47
AT CP 01	40	0
CP 02	83	27
AT CP 02	37	0

DISCUSSION

One of the fundamental elements in ensuring public health is the provision of high-quality water use (18). For many years, Dhaka has experienced severe water pollution, and the issue is getting harsher due to growing urbanization (19, 30, 31). Approximately 22,478,000 people live in Dhaka City, however there aren't many readily available sources of water to use (20). Microbial contamination of water greatly harms people's health. Additionally, Dhaka city's population is at risk for water-borne illnesses due to the pollution of the few available water sources (21, 25). The study was designed to investigate microbiological water pollution in Dhaka city, a serious public health threat. In this study, the microbial analysis of water samples from four areas in Dhaka—Siddeaswari, Sonargaon, Mirpur, and Badda revealed variations in microbial counts, highlighting differences in water quality across supply points (SP), consumer points (CP), and after-treatment points (AT), as summarized in Table 1. According to the findings, Sonargaon and Badda have significant numbers of bacteria and fungi, especially in untreated samples, and the highest levels of water contamination are found near consumer points. These results align with the findings of Nishat et al., 2023, which reported that out of 26 filtered tap water samples, 11 (42.3%) were classified as "unsatisfactory," while only 2 (7.7%) were rated as "satisfactory" (30). The presence of *Salmonella* spp. and *E. coli*, both indicators of fecal contamination and significant health hazards, in several consumer and supplier sites underscores a critical public health concern. Microbial burdens were generally lower at after-treatment periods, particularly for *E. coli, Klebsiella,* and *Staphylococcus* species, suggesting that the therapy was somewhat effective. Yet the occurrence of *Pseudomonas* species and *Salmonella* species in certain treated samples indicates that treatment procedures might not be successful in getting rid of all microbiological pollutants. The biochemical tests summarized in Table 2 provide insights into the identification of bacterial species isolated from water samples in four areas of Dhaka city. The presence of *Salmonella*, *Pseudomonas*, *E. coli*, *Klebsiella*, and *Staphylococcus* species in water samples indicated microbial contamination, most likely driven by environmental pollution and poor sanitation. A significant risk of waterborne illnesses is indicated by pathogenic organisms like *Salmonella* and *E. coli*, but the presence of *Pseudomonas* and *Klebsiell*a suggested the possibility of opportunistic infections (30, 31).

Additionally, the data from Table 3 show the presence of total coliform (TC) and fecal coliform (FC) bacteria, isolated through the Membrane Filter (MF) technique in water samples. The findings indicate that although water treatment reduces coliform levels, it is not entirely effective in some areas, as residual contamination persists at several after-treatment points, particularly in Badda. However, fecal coliform levels were significantly reduced or entirely absent in after-treatment points, suggesting that the treatment methods are effective in targeting fecal contamination. However, some total coliforms were still detected in Badda (AT CP 01 with 8 CFU/100 mL and AT CP 02 with 9 CFU/100 mL), suggesting that the treatment processes may not consistently eliminate all fecal contaminants (29). In contrast, the study by Jamal et al., 2020, reported a Total Coliforms and Fecal Coliforms of all samples showed less than 0.2 MPN/mL, indicating good water quality (31). Furthermore, the differences in contamination levels between regions and collection sites highlight the need for infrastructure upgrades and location-based water safety actions to prevent recontamination within the distribution network.

CONCLUSION

Several sources of drinking water from Dhaka city were "unsatisfactory". In this study, the presence of total coliform and other microbial contaminants suggests that supplied and treated water is highly contaminated with pathogens and great reservoirs for them. The unsatisfactory percentage of these pathogens indicates poor hygiene practices and also suggests the inefficiency of the water treatment plants to adequately remove microbial pathotypes, which is a threat to public health. The recommendation from here is to conduct regular and routine monitoring of the treatment process to guarantee adherence to the established parameters. The transmission system should be upgraded to prevent leaks in the transmission pipes as part of the program to provide everyone with safe drinking water. Additionally, a bacteriological evaluation of all water sources should be planned and carried out on a regular basis.

CONFLICTS OF INTERESTS

The authors have declared that no competing interests exist.

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