ORIGINAL ARTICLE

Microbiological Contamination in Water Filtration Plants in Islamabad

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ABSTRACT

Objective: To determine the frequency of microbiological contamination of water in different water filtration plants in Islamabad.

Study Design: Descriptive cross-sectional study.

Place and Duration of Study: Water Filtration Plants (WFP) in different sectors of Islamabad, from April to September 2012.

Methodology: Water samples were collected in sterilized bottles according to the standard water sampling protocol from site and transported to Pakistan Council for Research in Water Resources (PCRWR) for analysis. Microbiological quality of water was determined in terms of total coliforms (< 2.0 MPN/100 ml) and *Escherichia coli* (< 2.0 MPN/100 ml). Microbiological contaminated water was defined the sample which had more than 2.0 MPN per 100 ml of either total coliforms or *Escherichia (E.) coli*.

Results: Thirty two WFP were analyzed for microbiological contamination. *E. coli* was present in 8 (25.0%) water samples, while 24 (75.0%) water samples were free from it. Total coliforms were present in 13 (40.6%) of the samples of WFP, while 19 (59.3%) samples were free from total coliform. Faecal coliforms were present in 8 (25.0%) and absent in 24 (75.0%) samples. Both *E. coli* and total coliform were present in 8 (25.0%) samples. Nine (59.3) WFP were free from *E. coli*, total coliform and faecal coliform. Statistically, no significant association was found ($p > 0.05$) between microbiological contamination and the sectors.

Conclusion: Less than half of the water samples of the WFP were contaminated while certain sectors showed more frequent contamination than others.

Key Words: *Microbiological contamination. Water filtration plants. Islamabad. Total coliform. Escherichia coli.*

INTRODUCTION

Water pollution is one of the major threats to public health in Pakistan. Pakistan ranks at number 80 among 122 nations regarding drinking water quality. Drinking water sources, both surface and groundwater are contaminated with coliforms, toxic metals and pesticides throughout the country. Microbial and chemical pollutants are the main factors responsible exclusively or in combination for various public health problems.[1]

Globally, unsafe drinking water coupled with poor sanitation kill at least 1.6 million children under the age of 5 every year, 84% of them living in rural areas. If the current trend persists, nearly 1.7 billion rural dwellers will not have access to safe water and improved sanitation by 2015.[2]

A study was conducted in Zaria, Nigeria, concluded that out of 12 sites, 3 sites were continually being polluted by both point and diffuse sources of faeces particularly by domestic sewage, storm runoffs, failing septic tanks and an inefficient sewage treatment plant.[3]

In Chikwawa and Malawi, the microbiological analysis of borehole abstracted water did not reveal the presence of either total coliform or *Escherichia (E.) coli* at MDL of 20 MPN per 100 ml. The water, therefore, may according to WHO standards be safely used as drinking water.[4]

A study was conducted by Pakistan Council for Research in Water Resources (PCRWR) as a rural water quality monitoring project covering 64 Tehsils in four provinces. The results of the drinking water quality monitoring of 23 major cities revealed that the water resources of Pakistan faced 27 - 100% bacteriological contamination.[5]

There are 37 water filtration plants in Islamabad at different sites.[7] They supply drinking water from ground and surface sources after treatment at the water treatment plants while the major sources are simply Dam, Khanpur Dam and tube-wells. Islamabad, being the capital city of Pakistan, is expected to have better living standards than the rest of the country. To determine the bacterial contamination of water in Islamabad this study would provide an opportunity for the concerned authorities to take appropriate actions regarding microbiological water contamination.

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Therefore, the aim of the present study was to determine the frequency of microbiological contamination of water in different water filtration plants in Islamabad.

METHODOLOGY

This descriptive cross-sectional study was conducted in different sectors of Islamabad, from July to December 2012. A universal sampling (WFP 37[7]) was done but one WFP was not functional and four WFP were inaccessible due to security reason. Water filtration plants in Islamabad which are utilized by the population for domestic use were included in the study. Principal investigator first collected sterilized containers from the PCRWR laboratory. Water samples were collected according to the standard water sampling protocol[6] by the principal investigator from the site and transported to PCRWR, which were analysed by trained persons. First, hands were washed and then sprit was sprayed on hands up to arms for disinfection purpose. Then the tap was left open for 5 minutes to flush out the standing water. Tap was closed and cleaned with tissue paper. Tap was sprayed with small quantity spirit on surface of tap and was flamed with match stick and let it cool down. After flaming, tap was again opened and turned to thin stream (about the width of a pencil) and was kept open for about one minute. To avoid contamination while taking the sample, bottle was placed near the bottom with one hand, holding the top of the cap with other, then the cap was unscrewed. Bottle was held under the stream of water, being careful not to let the bottle touch the sample tap. Bottle was filled to the neck (leaving an inch from the top) and was not allowed to over flow. Then bottle was removed from the water flow and cap was replaced. Then the water tap was closed. Bottle was labelled with permanent marker, sample was placed in an ice box and delivered to laboratory as soon as possible. Preliminary data was collected on a proforma at every site to have in hand information regarding sample serial number, site of sample collection and the date and time of sample collection. To determine the microbiological contamination of water samples, the results were collected on a proforma. Microbiological quality of water was determined in terms of total coliforms (< 2.0 MPN/100 ml) and *Escherichia coli* (< 2.0 MPN/100 ml). WHO permits less than 2.0. Most Probable Number (MPN) per 100 ml sample of total coliforms and for *Escherichia coli.*[4] Microbiologically contaminated water was water which had more than 2.0 MPN per 100 ml of either total coliforms or *Escherichia coli* or both.

Data was entered and analysed using Statistical Package for Social Sciences (SPSS) version 20. Frequency and percentage was calculated for microbiological contamination of water. Chi-square test was applied to find association between microbiological contamination and different sectors with significance at $p < 0.05$.

RESULTS

Thirty two WFP were analyzed for microbiological contamination. Different level of microbiological contamination was seen in samples of different sectors of Islamabad.

Total coliform was present in 13 (40.6%) samples of the WFP, while 19 (59.3%) samples were free from total coliform contamination. Frequency of total coliforms MPN per 100 ml was found to be 2 in G-7/4, 4 in F-10, G-9/3, 11 in G-11/3, 34 in G-8/2, 14 in G10/3, G-10 Markaz, I-10 Markaz, 7 in G-7/2, 17 in I-10/1, 240 in I-10/2, 9 in I-8/1 and 70 in I-8/3. Sectors free from total coliform contamination were F-10 Markaz, F-6/1, F-10 Markaz, G 11/2, G-9 Bazaar, G 6 Bazaar, G 9/2, G-7/2, G-7/2, G-6/12, G-6/14, G-8/1, H-9 Bazaar, I-9/4, I-10/1, I-10/2 Overhead road, I-9/4, I-10/4 and I-9/1 (Table I and Figure 1).

E. coli was present in 8 (25.0%) WFP, while 24 (75.0%) were free from it. Sectors contaminated with *E.coli* were G-11/3, G-10/3, G-10 Markaz,, G-7/2 Near Ali Masjid, I-10 Markaz, I-10/1, I-10/2 Chambaili road and I-8/3. Sectors free from *E. coli* were F-10, F-10 Markaz. F-6/1, F-10 Markaz, G-9/3, G-11/2, G-9 Bazaar, G-6 Bazaar, G-8/2, G-9/2, G-7/2 Sitara Market, G-7/2, G-7/4, G-6/12, G-6/14, G-8/1, H-9 Bazaar, I-9/4, I-10/1, I-10/2, Overhead road, I-8/1, I-9/4, I-10/4 and I-9/1, shown in Table 1 and Figure 2. Both *E. coli* and total coliform were present in 8 (25.0%) samples.

Faecal coliforms was present in 8 (25.0 %) samples while absent in 24 (75.0 %) samples. Frequency of faecal coliforms MPN per 100 ml was found to be 4 in G-8/2, 4 in G-10 Markaz, 4 in G-7/2, 8 in G-10/3, 8 in I-10 Markaz, 14 in I-10/1, 130 in I-10/2 and 50 in I-8/3. Sectors free from faecal coliforms were F-10, F-10 Markaz. F-6/1, F-10 Markaz, G-9/3, G-11/2, G-9 Bazaar, G-6 Bazaar, G-8/2, G-9/2, G-7/2 Sitara Market, G-7/2, G-7/4, G-6/12, G-6/14, G-8/1, H-9 Bazaar, I-9/4, I-10/1, I-10/2 Over head road, I-8/1, I-9/4, I-10/4 and I-9/1, shown in Table I and Figure 1.

Microbiologically not contaminated water samples were only from 13 (40.6 %) WFP in which level of less than 2.0 MPN per 100 ml were found. These sectors were F-10 Markaz. F-6/1, F-10 Markaz, G-11/2, G-9 Bazaar, G-6 Bazaar, G-9/2, G-7/2 Sitara Market, G-7/2 , G-6/12, G-6/14, G-8/1, H-9 Bazaar, I-9/4, I-10/1, I-10/2 Overhead road, I-9/4, I-10/4 and I-9/1. About 19 (59.4%) samples of the WFP were found to be microbiologically contaminated as *E. coli* was positive and/or total coliforms and/or faecal coliforms was more than 2.0 MPN per 100 ml of sample. These sectors were F-10 Markaz, F-6/1, F-10 Markaz, G 11/2, G-9 Bazaar, G 6 Bazaar, G 9/2, G-7/2 Sitara Market, G-7/2, G-6/12, G-6/14, G-8/1, H-9 Bazaar, I-9/4, I-10/1, I-10/2 Overhead road, I-9/4, I-10/4 and I-9/1, shown in Table I.

Table I: Total coliform, faecal coliform and *Escherichia coli* count in water samples of water filtration plants in Islamabad (n=32).

Serial No.	Location of WFP	Total coliform count (MPN per 100 ml)	Faecal coliform count (MPN per 100 ml)	*Esche.* coli count	Microbiological contamination
1	F 10	4	0	- ve	Yes
2	F 10 Markaz	0	0	- ve	No
3	F 6/1	0	0	- ve	No
4	F 10 Markaz	0	0	- ve	No
5	G 9/3	4	0	- ve	Yes
6	G 11/3	11	4	+ ve	Yes
7	G 11/2	0	0	- ve	No
8	G 9 Bazaar	0	0	- ve	No
9	G 6 Bazaar	0	0	- ve	No
10	G 8/2	34	0	- ve	Yes
11	G 9/2	0	0	- ve	No
12	G 10/3	14	8	+ ve	Yes
13	G 10 Markaz	14	4	+ ve	Yes
14	G 7/2 Sitara Market	0	0	- ve	No
15	G 7/2 Near Ali Masjid	7	4	+ ve	Yes
16	G 7/2	0	0	- ve	No
17	G 7/4	2	0	- ve	Yes
18	G 6/12	0	0	- ve	No
19	G 6/14	0	0	- ve	No
20	G 8/1	0	0	- ve	No
21	H 9 Bazaar	0	0	- ve	No
22	I 9/4	0	0	- ve	No
23	I 10 Markaz	14	8	+ ve	Yes
24	I 10/1	0	0	- ve	No
25	I 10/1	17	14	+ ve	Yes
26	I 10/2 Overhead road	0	0	- ve	No
27	I 10/2 Chambaili road	240	130	+ ve	Yes
28	I 8/1	9	0	- ve	Yes
29	I 8/3	70	50	+ ve	Yes
30	I 9/4	0	0	- ve	No
31	I 10/4	0	0	- ve	No
32	I 9/1	1	0	- ve	No

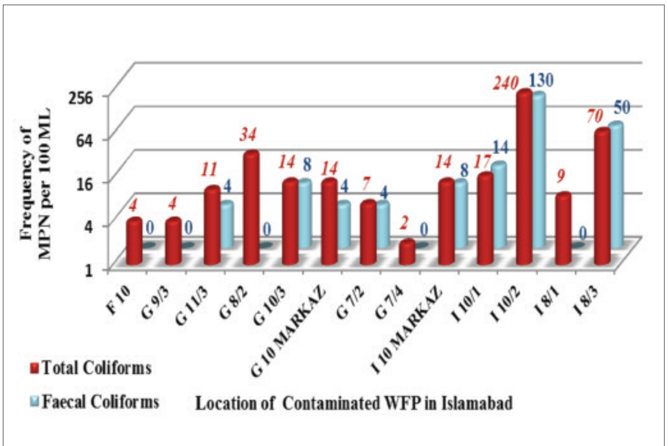

Figure 1: Frequency of microbiological contamination in WFP.

Highest total coliforms in water sample, about 240 MPN per 100 ml was observed in Sector I 10/2 Chambaili Road while lowest about 2 MPN per 100 ml was found in water sample of sector G7/4.

Highest faecal coliforms 130 MPN per 100 ml was found in water samples of sector I 10/2 Chambaili Road while lowest 4 MPN per 100 ml was found in three water samples of sectors (G11/3. G10 Markaz and G7/2 Near Ali Masjid)

Statistically, no significant association was found between microbiological contamination and the geographic sectors ($p > 0.05$).

DISCUSSION

The Millennium Development Goal (MDG) 7 addresses environmental sustainability, with a target (target 10) to "halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation". Achievement of this target can reduce child mortality, major infectious disease, maternal health and quality of life of a large population. It is important to understand what are our water resources, requirement, gaps and where and how to utilize them to provide safe water and basic sanitation.[8]

It is estimated that 1.8 billion people (28% of the global population) used unsafe water in 2010. The 2010 Joint Monitoring Program (JMP) estimated that 783 million people (11%) use unimproved sources. Their estimates revise the 1990 baseline from 23% to 37%, and the target from 12% to 18%, resulting in a shortfall of 10% of the global population towards the MDG target in 2010. While this estimate may be imprecise, the magnitude of the estimate and the health and development implications suggest that greater attention is needed to better understand and manage drinking water safety.[9] In the present study, it is found that about 13 (40.6%) water samples of the WFP were contaminated while 19 (59.3%) water samples of the WFP were not microbiologically contaminated.

In South Africa, household supplement their drinking water consumption from water resources of inadequate microbial quality. Their microbial water quality monitoring currently is based on the Colilert®18 system which leads to rapidly available results. A study concluded that modified H_2S strip test might be used as a surrogate for the Colilert®18 as to make water testing cost effective.[10] Another study at household level can be conducted by using H_2S strip test at the sites where bacterial contamination is high and get a better idea of the contamination locality.

Microbiologically contaminated potable water has a direct effect on public health and poses a severe threat to human beings with continued usage. Water contamination in Pakistan is of particular concern. Currently, almost half of Pakistan's population has no access to clean potable water. Approximately 70% of Pakistan's surface and sub-surface water supply sources are not fit for drinking due to heavy organic, inorganic and biological contamination. A study conducted in flood-afflicted Northern Pakistan showed that samples from certain sites were found to be microbiologically unfit for drinking due to the presence of *Escherichia coli*, *Shigella, Salmonella* and *Staphylococcus aureus* (range18-96 ± 14 cfu/100 mL). It was concluded that continued water quality monitoring, the application of household based disinfectants, and healthy domestic hygiene practices are highly recommended in similar circumstances.[11]

Where water quality is poor, the release of water quality information to consumers may help to promote home water treatment or use of safer source types, and potentially promote public pressure on suppliers to improve service quality. The general publics have long been recognized as an important stakeholder in the management of drinking water supplies. Public acceptability of drinking water forms part of the World Health Organization's Guidelines for Drinking Water Quality, which incorporates guidelines on consumer acceptability of taste, colour and odour. If the WFP water quality is acceptable, it must be ensured to keep it free of contamination.[12]

Various household water treatment devices/systems (HWTS) have been developed over the years to treat water at point-of-use (POU) at the household level. Household water treatment devices/systems (HWTS) are capable of dramatically improving microbial contaminated water quality. Five filters were examined in a study and silver-impregnated porous pot (SIPP) had the most ability to improve the quality of drinking water at the household level. Its high performance was attributed to the bacteriostatic properties of the silver. SIPP ability to remove turbidity and bacterial contaminants at a high flow rate shows that it has great potential to provide the required volumes of drinking water needed by rural communities for drinking and cooking. The question is that if the WFP are not that effective or there are maintenance issues, can one suggest other HWTS?[13]

In order to reduce the losses by water pollution, forewarning model for water pollution risk, based on Bayes theory, was studied. This model is built upon risk indices in complex systems, proceeding from the whole structure and its components. Bayes theory is adopted to obtain posterior distribution by prior distribution with sample information which can make samples' features preferably reflect and represent the totals to some extent. Forewarning level is judged on the maximum probability rule, and then local conditions for proposing management strategies that will have the effect of transforming heavy warnings to a lesser degree. It is shown that the model is rigorous in theory with flexible method, reasonable in result with simple structure, and it has strong logic superiority and regional adaptability, providing a new way for warning water pollution risk.[14] Pilot studies can be done regarding incorporating a warning water pollution risk which can predict water contamination beforehand and help in alarming authorities and community regarding the forthcoming risk.

Heating water up to 100°C is sufficient to eradicate common disease causing bacteria even in stool contaminated samples and further heating would not be required.[15] People can be made aware that boiling water is necessary even if they have collected it from a WFP.

Drinking water samples from main storage, distribution line and consumer taps were analyzed in Sukkur city. All 120 samples (100%) were found contaminated with total coliform bacteria and 98 (82%) samples were found to be contaminated with thermotolerant *Escherichia coli*. Drinking water samples were heavily contaminated with coliform and faecal coliform organisms making it unsuitable for drinking.[16]

In Nepal, bacterial contamination of drinking water is a major public health. A large scale study on contamination of drinking water was done which revealed that total coliforms positive rate was very high (81.2% to 100.0%) in different type water samples,[17] while in Islamabad, WFP water samples had 40.6% total coliform contamination.

The most significant challenges are determining how to achieve proper disinfection without producing harmful byproducts obtained usually using conventional chemical disinfectants and developing new point-of-use methods for the removal and inactivation of waterborne pathogens. The removal of contaminants and re-use of the treated water would provide significant reductions in cost, time, liabilities, and labour to the industry and result in improved environmental stewardship.[18]

A cross-sectional study was carried out on 84 water samples representing natural sources, reservoirs and collection taps. The microbiological examination of water samples revealed the presence of total coliforms in 86.90% of water samples. The study concluded that coliform contamination was the key problem with drinking water.[19]

In July 2010, the United Nations General Assembly expressed concern that approximately 884 million people lack access to improved water sources (UN General Assembly, 2010) and that in 2032 there may be a billion people more on this planet among whom water resources will have to be shared. To preserve water quality, therefore, water resources will have to be managed better at the planetary scale taking into account their potential conflicting uses. To ensure water is potable, its monitoring through chemical and bacteriological analysis is carried out regularly from its source to tap all over the planet.[20] The WFP should also undergo continuous monitoring and analysis to provide people safe water.

As unsafe water is a very important public health issue in different sectors of Islamabad which are for the time being not documented and not noticed so far. Those WFP which are not identified as microbiological contaminated shall also be under surveillance as they are at risk also. For community health protection, it is our duty and public right to know the actual status of these WFP so that they can be maintained accordingly and safe water shall be supplied to community. Dissemination of this information to concerned authorities is very important as they are the one who will actually take care of the maintenance issue and collaborate with other sector to evaluate other factors responsible for contamination.

More surveys shall be done on regular basis especially in those sectors which are marked contaminated. Other sectors shall also be under surveillance and also other pathogens shall also be evaluated in these WFP. The sectors of WFP which are identified as microbiologically contaminated shall be given supreme importance in terms of evaluation of the source of contamination, nearby sewage lines leakage, rainwater drainage areas, water tanks, plant maintenance, community awareness of that area for alternate ways of water purification preferably chlorination etc.

CONCLUSION

Less than half of the water samples of the WFP were contaminated while more than half of the water samples were not microbiologically contaminated. Highest total coliform was observed, about 240 MPN per 100 ml while the lowest was found to be about 2 MPN per 100 ml. Highest faecal coliforms content was 130 MPN per 100 ml while the lowest was 4 MPN per 100 ml found in 3 water samples.

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