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Community Perceptions of Drinking Water Quality Supplied by DWASA: A Case Study of Kafrul Thana, Dhaka

Mashura Shammi[1], Shabnam Mustofa Kanak[1], Md. Mostafizur Rahman[1] and M. Khabir Uddin[1*]

Department of Environmental Sciences, Jahangirnagar University, Savar, Dhaka, Bangladesh

Abstract

Assessment of the public perceptions regarding the municipal water quality supplied by Dhaka Water Supply and Sewerage Authority (DWASA) at Kafrul Thana in Dhaka was performed, which incorporated laboratory analysis of water quality at source point of deep tube-wells and household water samples as well as a questionnaire survey of 50 households, selected randomly, to evaluate the economic burden due to the consumption of it. The laboratory analysis of water samples were collected from source point and household water samples for parameters of Temperature, pH, Electric Conductivity, Total Dissolve Solid, Total Suspended Solid, Turbidity were within the standard values prescribed by Bangladesh Environmental Conservation Rules' 1997(BECR'1997) while the values of Chloride, Alkalinity, Hardness and Dissolve Oxygen (DO) were below the standard. The Biological Oxygen Demand (BOD_5) at 20 °C of all the samples was higher than the standard values (0.2 mg/L). Although no Fecal Coliform was found in seven samples from source points of DWASA deep tube-wells, but at consumer level, Fecal Coliform was found at Senpara 3/100mL, Ibrahimpur 10/100mL, Mirpur Section-14 Govt. Colony 6/100 ml, North Kafrul 8/100 ml and South Kafrul 2/100 mL, respectively. On the other hand, Total Coliform count was found 4/100ml and 3/100ml, respectively in the water samples of Senpara and North Kafrul only at source point, but at consumer level, total coliform count was at Senpara 16/100mL, Shewrapara10/100 mL, Ibrahimpur 35/100mL, Mirpur Section-14 Govt. Colony 21/100mL, North Kafrul 25/100mL and South Kafrul 10/100mL, respectively. The findings of questionnaire survey complied with the fact that people suffering from waterborne diseases (WBD), because of consuming microbial contaminated water, and spending a lot for the medication and treatment of municipal water for domestic use. About 33% respondents answered boiling, whereas about 13.34% respondents were found to use very highly expensive reverse-osmosis (RO) water purifiers and about 33.33% respondents answered boiling first plus general sand filters.

Keywords: Public health, drinking water quality parameters, waterborne diseases (WBD), water filter, socioeconomic study

Introduction

The present population of Dhaka city as estimated by the Bureau of Statistics in July 2011 is 1.18 million that is 8.3% of the total population, with an increasing rate of 1.8% per year (BBS, 2011). The city is characterized by unplanned expansion, with large squatter settlements in different parts of the metropolitan area. This expansion in comparison to existing inadequate infrastructure has caused environmental problems associated with utility facilities, i.e., insufficient water supply, sanitation, drainage, and urban flood protection etc. (Khan and Haq, 2005). Water supply system in Dhaka is usually designed on the basis of 160 liters per capita per day. Only 2-3 percent is used for drinking purposes (Haq, 2005). To meet the growing demand for water, Dhaka Water Supply and Sewerage Authority (DWASA) installs deep tube-wells every year. Presently, the DWASA is able to pump out 87 percent water from underground sources using 523 deep tube

*Corresponding Author: (khabir88@yahoo.com)

wells and the rest 13 percent from four surface water treatment plants installed at Saidabad and Chadnighat and the two others in Godnail and Sonakanda in Narayanganj (BBS, 2010).

Water quality and safe drinking water is of paramount importance to protect public health. A variety of physical, chemical and biological transformations can happen once the water travels through a distribution system (Lahlou, 2002). Deteriorating water treatment facilities and distribution systems can pose a significant public health threat (Semenza et. al., 1998). Many different viral, bacterial and parasitic diseases have been associated with waterborne transmission. Some diseases have been spread through drinking water and others by recreational water contact which examples include, bacteria contaminated diseases, i.e., cholera, Salmonellosis, typhoid, Shigellosis (bacillary dysentery), Viral hepatitis (A, B, C, D and E. Hepatitis E), protozoa contaminated diseases, i.e., Giardiasis, Amebiasis etc.(Hunter, 1997; 2003). The majority of the distribution system is weak in Bangladesh because of old and dilapidated sewerage and storm drains. As a result, the incidence of waterborne diseases like diarrhea, typhoid, is found among the city dwellers (Khan *et al.*, 2005). Globally diseases originating from waterborne and sanitation-related infections are one of the major contributors to diseases burden and mortality (Prüss and Havelaar, 2001; El-Fadel *et al.*, 2003). The main burden of disease in this category falls on the poorest societies and on children under 5 years (Hunter, 1997). According to The International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) (2007), the year of 2007 was major diarrheal epidemic in Bangladesh, where 21,400 patients were admitted in a three week period to the Dhaka Hospital. More than one in three patients was admitted with cholera, of which 70% were dangerously dehydrated. On the other hand, more than 140,000 patients visited the Dhaka Hospital in 2009, making it the second busiest year in the hospital's history. For the first time, a third seasonal cholera epidemic was witnessed in November, in addition to the seasonal outbreaks in April and September. More than 1000 patients on three separate days in February/March made it the busiest spring in history also. More than 65,000 patients to the hospital in 2009 were under 5 years old (ICDDR, B, 2009).

Therefore, deficiencies in water supply and sanitation services prevent millions from leading healthy lives while undermining development efforts by burdening the society with substantial socio-economic costs. This problem is of great significance in developing countries like Bangladesh, where polluted water, water shortages, and unsanitary living conditions prevail. People are continuously facing problem to hold the limit of their expenses for having safe drinking water and for the treatment of water borne diseases (WBD). So, to understand the public perceptions on economic impact of water quality supplied by DWASA and water borne diseases (WBD), a scientific and socio-economic research was needed concerning the municipal water supplied at Dhaka city. In this regard Kafrul Thana was selected to perform the case study.

Experimental Method

The study was conducted from January to May 2010. The study utilized both quantitative and qualitative method to collect relevant information. Necessary secondary data were collected from literature review.

Study area

Kafrul Thana (in Dhaka district) established in 1998 consists of parts of Mirpur and Cantonment thana has an area of 17.8 sq km, is bounded by Pallabi and Cantonment Thanas on the north, Tejgaon thana on the south, Gulshan thana on the east and Mirpur and Mohammadpur thanas on the west (Banglapedia, 2006). Heterogeneous mix of people lives here. There are huge human settlements with some slum areas. The source water supply distribution system of Kafrul thana is DWASA operated pumps from deep tube-wells (Table-1). The location of the pumps is South kafrul, South-west Shewrapara, Uttar Kafrul-1, Uttar Kafrul-2, Lalsarai and Kachukhet. These tube-wells are connected with WASA water supply lines. Besides, local people also use shallow tube-well water for drinking purpose.

Table 1: Water pumps of Kafrul thana (DWASA 2010)

Name of DTW	Year	Depth of Drilling (m)	Fixture Length (m)	Pump Capacity Cusec	Production (L/Min)
South Kafrul	2007-2008	213.41	205.16	1.5	2900
South West Shewrapara	2007-2008	207.31	193.02	1.5	3000
Uttar Kafrul 1	2007-2008	213.41	200.71	1.5	3400
Uttar Kafrul 2	2007-2008	213.41	203.18	1.5	3200
Lalasarai	2008-2009	329.27	317.98	1.5	3000
Kachukhet	2008-2009	219.51	204.6	1.5	3000

The study area map was prepared from satellite image taken from Google Earth and coordinates set from GPS reading using remote sensing software ERDAS IMAGINE 9.3 at Bangladesh Space Research & Remote Sensing Organization (SPARSO).

Collection of water samples

14 Water samples (7×2) were collected from Senpara, Kazipara, Shewrapara, Ibrahimpur, Mirpur Section-14 Govt. Colony, North Kafrul and South Kafrul from DWASA deep tube wells which is defined as source point to get a scenario of water quality supplied by DWASA at Kafrul Thana. Besides 14 (7×2) household tap water samples were collected to get a view of water quality status at the consumer point (Map-1). The samples were collected and transported by standard methods as mentioned in APHA (1998) which were later analyzed at the laboratory of Department of Environment (DoE) at Agargaon under the Ministry of Environment and Forest (MOEF), Bangladesh. Different water quality parameters like total hardness, alkalinity, pH, electrical conductivity (*E*c), chloride (Cl), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), and total suspended solids (TSS) were analyzed in the laboratory with Standard Methods (APHA, 1998). Electrical conductivity (*E*c) and pH were measured with *E*c-Meter

(HANNA) and pH-Meter (HANNA), respectively. Total coliform (TC) bacteria count was conducted by decimal dilution technique followed by standard spread plate count on Nutrient agar and MacConkey agar plate as described by Sharp and Lyles (1969). Total fecal coliform (FC) bacteria counts were conducted by modified membrane filter counting technique (APHA, 1998).

Development of Questionnaire for household survey

The questionnaire was designed using information from the questionnaire development literatures (Jones *et al.,* 2005; Jones *et al.,* 2006; Subedi and Aryal, 2010) and a FGD prior to the questionnaire survey, emphasizing on to get the respondents' personal information and their problems, complains, mode of uses, mode of purification and impacts suffered by the family members and their recommendation regarding the consumption of municipal water (Appendix A). The data generated from FGD informed the content and vocabulary layout of the questionnaire as well as the question categories and answer choices. The questionnaire used both open ended and closed ended questions. Survey was conducted among 50 households selected randomly. The respondents were of different age, financial background and profession.

Data analysis

Data entry and data analysis was done using Microsoft Office Excel 2007. The source water quality and household water quality at consumer point were compared with standard values prescribed in Bangladesh Environmental Conservation Rules' 1997(BECR'1997) (MOEF/GOB, 1997) and World Health Organization (WHO) Drinking Water quality guideline (2008).

Results and Discussion

Test results of the water sample analysis revealed that the water entering the distribution system of Kafrul Thana is in desired quality in terms of physicochemical parameters, as the Temperature, pH, Electric Conductivity, Total Dissolve Solid, Total Suspended Solid, Turbidity were within the standard values prescribed by Bangladesh Environmental Conservation Rules' 1997(MOEF/GOB, 1997) both at source point and at consumer point. The value of Chloride, Alkalinity, and Hardness were below the standard values of BECR'1997. The value of Dissolve Oxygen (DO) of all the seven samples were less than the standard values of BECR'1997(6 mg/L) both at source point and consumer point. The Biological Oxygen Demand at 20 ºC (BOD_5) of all the samples were higher than the standard values of BECR'1997(0.2 mg/L).

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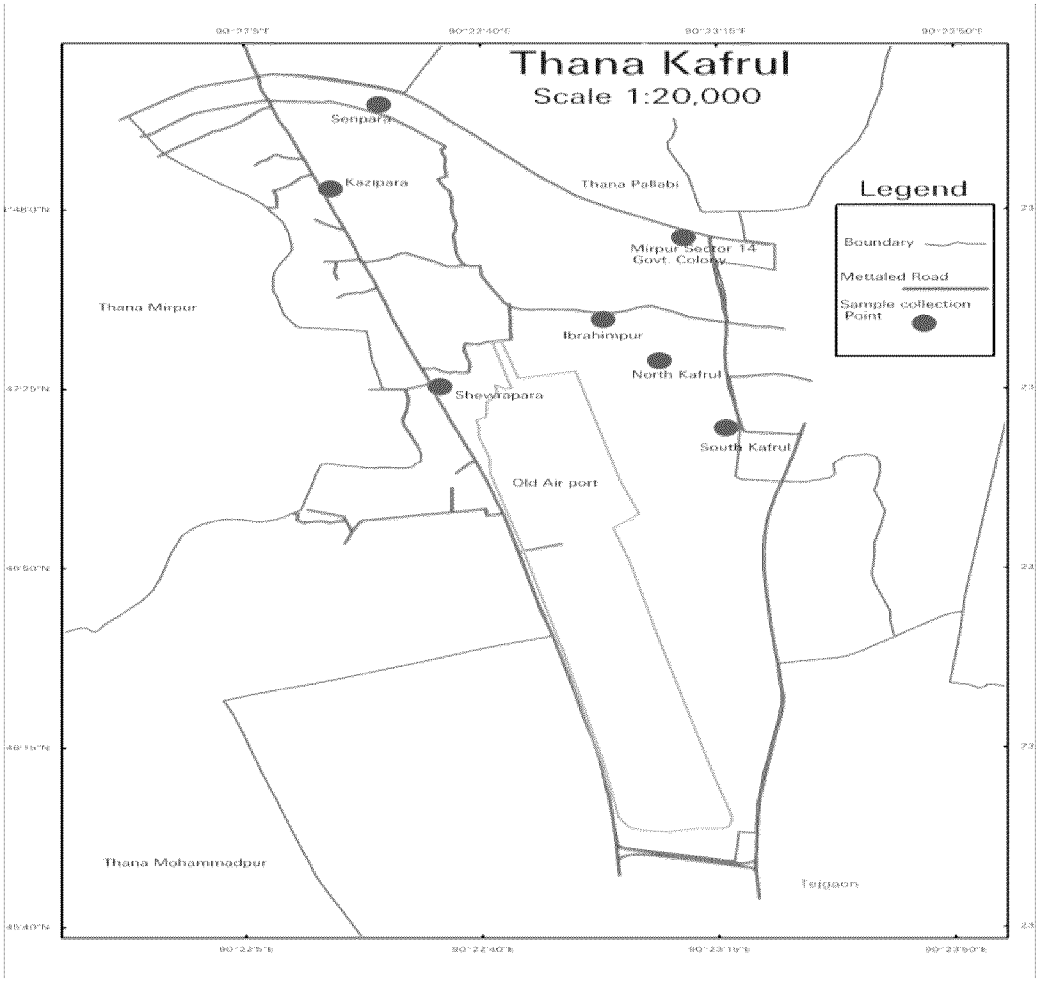

Map 1: Sampling sites at consumer point of Kafrul Thana.

No Fecal Coliform was found in seven samples from source point, but at consumer level Senpara, 3/100mL, Ibrahimpur 10/100mL, Mirpur Section-14 Govt. Colony 6/100 ml, North Kafrul 8/100 ml and South Kafrul 2/100 mL, respectively. On the other hand, total coliform count was found 4/100mL and 3/100mL, respectively in the water samples of Senpara and North Kafrul only at source point, but at consumer level, total coliform count was, Senpara 16/100mL, Shewrapara 10/100mL, Ibrahimpur 35/100mL, Mirpur Section-14 Govt. Colony 21/100mL, North Kafrul 25/100mL and South Kafrul 10/100mL, respectively.

Possible sources of microbial contamination of municipal water of Kafrul Thana at consumer point, as observed and identified during field survey was improper maintenance of piped network

distribution system and reserved water tank at the source, cross contamination by leaking of sewage pipes and DWASA water supply network, unauthorized connection to the mainlines at road sides. This relates with the findings of Khan *et al.* (2005). At the consumer level, the source of contamination as identified during field survey is improper method of household storage, lack of maintenance of household reserve tank and piped water network.

Results of Questionnaire Survey

Response rate

To get a clear scenario of the municipal water quality of Kafrul Thana and the related socio-economic problems, a questionnaire survey was conducted among the local dwellers. The demographic profiles of the respondents varied in terms of age, household income and education (Table 3). Among the respondents 40% were male while 60% were female. Although the majority of the respondents belong to the age group of 36-45 years (33.66%) the young generation belonging to the age group of 16-25 years also responded spontaneously (in the survey taking up to 13.44%). On the other hand, only 6.68% response has been got from comparatively an older age group (55+ years). It has been noticed that 80% of the families had unit family consisting 1-4 family members, whereas 20% family consists of 5-10 members.

Table 3: Demographic status of the respondents

	Frequency (n)	Percentage (%)		Frequency (n)	Percentage (%)
	Gender			Years of living in Dhaka	
Male	20	40	0-9	17	33.33
Female	30	60	10-19	13	26.67
	Age Group				20-29
16-25	7	13.44	30-39	3	6.67
26-35	13	26.44	40-49	0	0
36-45	17	33.44	50-59	7	13.33
46-55	10	20	60+	3	6.67
55+	3	6.68			
	Educational level			Family size	
Up to class 5	10	20	1- 4	40	80
S.S.C. passed	3	6.67	5-10	10	20
H.S.C. passed	7	13.33			
Undergraduate	10	20			
Post graduate	20	40			

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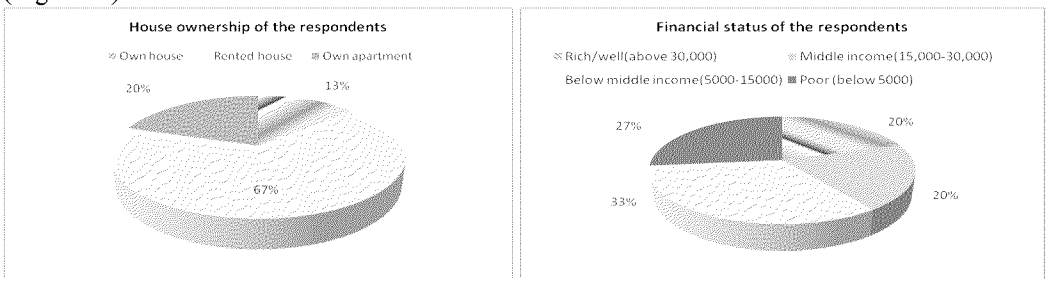
Table 2: Physiochemical and biological parameters of water quality of Kafrul Thana DWASA deep tube wells

Sample no.	1		2		3		4		5		6		7		Drinking water quality Standard values	
Location name	Senpara		Kazipara		Mirpur section 14, Govt. colony		Ibrahimpur		Shewrapara		North Kafrul		South Kafrul		BECR' 1997	WHO guideline value 2008
	S1	C1	S2	C2	S3	C3	S4	C4	S5	C5	S6	C6	S7	C7		
pH	6.95	7.01	6.77	6.80	7.17	7.21	7.24	7.25	6.93	6.95	7.04	7.01	7.25	7.25	6.5 – 8.5	-
EC(micro S/cm)	338		297		340		328		316		296		331		700	-
Chloride (mg/L)	2.0	61	4.5	58	2.5	67	1.0	20	1.2	15	2.7	10	2.8	12	150 -600	250
Total Alkalinity (mg/L)	80	77.10	60	65.32	90	80.41	110	109.21	80	85.45	100	96.25	100	93.42	100	100
Total hardness (mg/L)	124	192	96	136	110	252	114	140	112	115	125	143	121	165	200-500	-
Turbidity NTU	<1	2	<1	1	<2	1	<1	<1	<1	<1	<2	4	<1	1	10	-
TDS(mg/L)	170	305	149	180	172	209	164	197	155	176	163	189	161	164	1000	-
TSS(mg/L)	0	<2	0	<2	0	<2	0	4	0	<2	0	<2	0	4	10	-
Fecal Coliform (no/100ml)	0	3	0	0	0	6	0	10	0	0	0	8	0	2	0	0
Total Coliform (no/100ml)	4	16	0	0	0	21	0	35	0	10	3	25	0	12	0	0
DO(mg/L)	4.93	4.25	4.12	4.10	4.50	4.45	5.10	4.95	4.31	4.53	4.87	4.90	4.89	5.10	6 or above	-
BOD_5 (mg/L)	2.20	2.26	2.10	2.25	2.40	2.50	2.62	2.70	2.35	2.25	2.50	2.23	2.52	2.12	2 or less	-

S= Source point from DWASA Deep tube well, C= Tap water samples from consumers

Most of the dwellers live in rented house; about 66.67% whereas 20% possess own flats/apartments and 13.33% respondents possess own home in the surveyed area (Fig. 1. a). Most of the respondents belong to below middle-income comprising 33.33% of the total respondents, while only 26.67% belong to poor family. The middle-income and rich families are of 20% each (Fig. 1. b.).



(a) (b)

Figure 1: Financial status and house ownership of the Respondents.

Sources of drinking water and quality issues

Most of the residences of Kafrul Thana had the access of domestic water by DWASA (about 86.67%) but some owners of apartment building (about 13.33% of the respondents) have their own deep tube-well due to the reason of interrupted water supply from DWASA. However, the depths of the tube-wells were not asked in the questionnaire survey.

100% respondents felt that the supplied water is completely unsuitable for drinking purpose without any treatment. But for bathing and washing purpose, respondents felt it suitable, and most of them use it directly from tap, while a few use cotton clothes on the tap mouth for sieving. Some also use *fitkiri* in their water reserve tank. Thus 46.67% respondents were found to consider the supplied water as 'somewhat suitable' for bathing and washing purpose. People have been also found to wash their dishes and other kitchen utensils with tap water, followed by boiled water. The consciousness about using municipal water for cooking purpose among the respondents is contradictory. Here, 53.33% consider the municipal supplied water is suitable for cooking. Regarding the most burning issue whether the municipal supplied water is '*Stinky*' or '*Dirty*', 100% respondents had given their verdict in "Yes". Although only 26.67% respondents felt the problem often, others also felt it occasionally or seasonally. According to one respondent, "the smell is intolerable when it comes". Reasonably the question arises of using bottled water. But the fact is that no one wants to add an additional expense in their monthly expenditure for buying bottled water.

To consume the municipal water safely, 53% respondents boiled it- a popular method water treatment, whereas about 14% respondents were found to use very highly expensive water purifiers (Fig. 2). Most of the respondents have said that their family adopted either only boiling for water treatment, or sieving and/or filtration with it. The 33.33% respondents, who adopted

filtration for water treatment, also boil and sieve before pouring water in the water filters to satisfy their level of health consciousness. 13.34% uses highly expensive filter machines equipped with *reverse osmosis* (RO) process to avoid the tiring job of boiling and also to avoid intermittent gas supply. Treatment of municipal supplied water alongside other domestic tasks can be a burden, especially 'the boiling' method. For 80% respondent, "it's a very tiring job", while 20% are habituated and have no feeling on that.

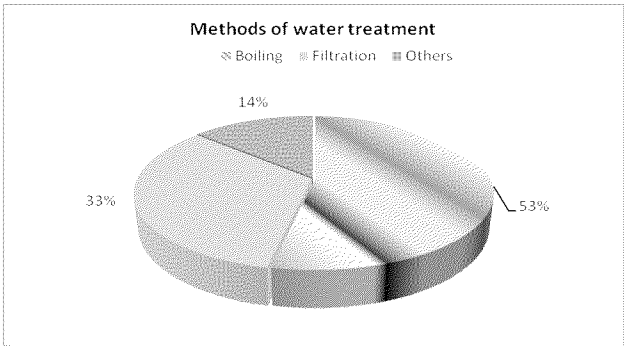


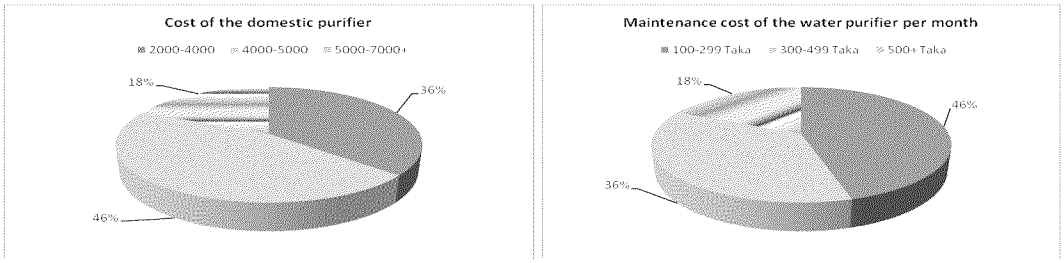
Figure 2: Methods of Water Treatment adopted by the Respondents.

Uses of domestic water purifier by well-off families and their perceptions

The cost of the domestic purifier, used by the respondents, ranges from 2000-20,000 taka. Among the respondents, almost 36.63% use domestic water purifier that costs from 3000 to 3999 taka. Approximately 45.45% use purifier that costs 4000-4999 taka. Only about 18.19% use expensive domestic water purifier that costs 7000+ taka (Fig 3. a). Almost 81.82% respondents' water purifier works in sand filtration method as it is less expensive. On the other hand, domestic water purifier that works in reverse osmosis (RO) process ensure high quality purification and thus much expensive for the consumers is not affordable for all. This type of purifier is used by only about 18.18% of the total respondents. The maintenance cost of the water purifiers also varies (Fig. 3. b), but it is no less than 200 taka/month. Approximately 45.45% respondents the cost is above 200 taka for normal filters. In case of electronically operated purifiers the maintenance cost is much higher. It is 300-499 taka/month for about 36.37% respondents. For about 18.18% respondents, this expense is about 500+ taka/month. According to a family member of a well income family, "This maintenance cost does not affect household income if it can ensure water quality."

Economic impact suffered by the consumers due to WBD

The survey included a question regarding family members suffering from WBD. Among the 50 respondents 86.27% more or less suffered from both diarrhea and dysentery once or twice in previous years for consuming the domestic water, while 50.98%, suffered for Diarrhea and 7.8% were found suffering from Viral hepatitis. All the respondents answered for taking oral saline for treatment of diarrheal diseases initially. However, 33.34% go for highly expensive treatments



(a) (b)

Figure 3: Cost of the Domestic Water Purifiers and its maintenance cost owned by well income household.

which ranges from taka 3001-3500+. Generally the high charges costs when the patients go for several medical tests or get admitted into hospitals. Spending money for the treatment of WBD is not a burden for 13.34% respondents, as the expensive treatments do not create any financial hardship. On the other hand, middle income families go to the doctor of local clinics or chemist in pharmacy, which is affordable and less expensive. In spite of having those options 53.33% found it financially hardship to spend money for those treatments, whereas it's an acute problem for 33.33% respondents who are socio-economically disadvantaged (Fig. 4).

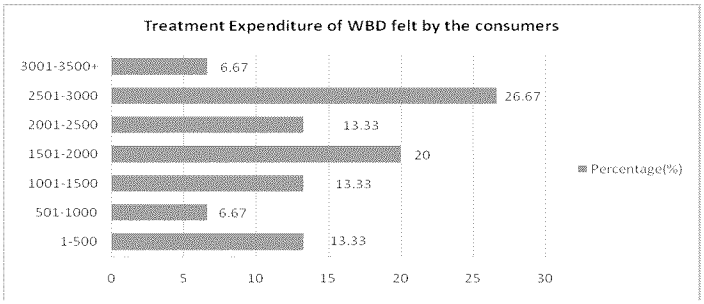


Figure 4. Treatment Expenditure of WBD felt by the consumers.

On average in local clinics of Kafrul Thana, admission charge for paying bed is 200-500 taka and daily charge for a bed is 200-350 taka. These hospital charges are totally excluded from medicine and diagnostic test expenses. In local Pharmacy, where doctors are available, daily 10- 12 patients visit with WBD and paid 200-300 taka for doctor's visit. 13.33% respondent' family expense for water borne diseases ranges between 1-500 taka per month or when they suffer from this, 53.33% respondents' expenditure is 501-2500 taka and 33.34% go for highly expensive treatment which ranges from 2501-3500+ taka. As a result of contaminated water supply, the people of Kafrul Thana are facing financial problems to bear the cost of health treatment, and this cost is completely an unwanted and extra expenditure in the present days' expensive urban life.

Conclusion

This study was investigated the community perceptions of drinking water quality supplied by DWASA and its socio-economic impacts at Kafrul Thana. Water quality test results of source deep tube-wells and random samples collected from seven sample sites of Kafrul Thana revealed that the microbial quality of water was being deteriorated during its flow from source point through the dilapidated distribution system. The study revealed that residents of Kafrul Thana were suffering not only from inadequate water supply but also from contamination despite the paying of monthly bill to DWASA which is supposed to be safe for use. The results also showed that the health consequence of consuming untreated water is fairly understood among the residents and they treat the water before consumption. But the frequency of WBD found higher among the lower income group as they often cannot afford necessary energy resources for boiling water let alone water purifier. So the economic impact of municipal water is the sum of money for treatment of WBD plus the sum of money for treatment of municipal water plus the laborious job. This has resulted in higher costs for businesses, slower urban economic growth and social unrest. According to the WHO Guidelines for drinking-water quality (2008), access to safe drinking water is essential to health, a basic human right and a component of effective policy for health protection. Safe drinking water is also a development issue as in some regions, it has been shown that investments in water supply and sanitation can yield a net economic benefit, since the reductions in adverse health effects and health care costs outweigh the costs of undertaking the interventions.

This study has also showed a positive attitude of the community towards taking active participation. Most of the participants actively commented and recommended on what they felt about the problem with DWASA's distribution system which we took as the conclusion of the research. Since DWASA's piped water supply systems are generally buried in complex reticulations, they are difficult to operate and maintain. Continuous monitoring facilities should be in place for the distribution system in order to ensure the supply of safe drinking-water. The authority should also monitor unauthorized cross connections, cross contamination by leaking pipes, etc. Pathogens may enter the system through contaminated raw water, in-line reservoirs, or breaks in pipelines. System personnel need to thoroughly perform disinfection procedures following repairs and inform the local residents. From an operations standpoint, network operating conditions – such as slow water velocities, supply sources going on and off-line due to load shedding, and the amount of time that systems store water – greatly affect water quality. System personnel should take measures to prevent such problems. Public awareness can definitely play an important role to help prevent such problems. Private entrepreneurs may come forward to establish drinking water utilities via piped and or any other means after treating surface water that will be ultimately safe, cost effective and environmentally friendlier option.

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Appendix 1

Theme questions for FGD and development of questionnaire

A) Basic information:

1. Family members: 2. Address:
3. For how long living here: 4. Educational qualification:
5. Occupation:
6. The house is: a) own home b) rented c) own flat/ apartment d) others……
7. How will you describe your family's financial status?
   a) Well/ rich (above 30,000) b) middle income (15,000-30,000)
   c) Below middle income (5,000-15,000) d) poor (below 5,000)

B) Opinion regarding supplied water quality:

1. a) What is the source of your domestic water? How do you assess the sources, adequacy, safety and quality of the water supply in your locality?
b) Do you think the supplied water you get is safe enough for your domestic use?
   a) Drinking b) Bathing
   c) Cooking d) Washing e) others
c) Give your opinion regarding the supplied quality of water in terms of its colour, test and appearance?
2. a) How do you treat supplied water? a) Boiling b) Sieving c) Water filter
   d) Potash alum (fitkiri) e) others……
b) Is there any significant reason for you behind using of this present method of treating water?
c) Do you think treating water for domestic use is an extra burden alongside the other daily domestic task?
3. Do you own any domestic water purifier? If yes then,
   a) What was the cost of the machine?
   b) What is the method the machine use?
   c) Maintenance trouble and cost
   d) What is your monthly expense of domestic water treatment?

C) Opinion regarding waterborne diseases and medical treatment:

1. Have you or your family member suffered from any waterborne diseases?
2. What type of treatment do you generally go for, in this regards?
   i) Local clinic ii) Govt. hospital iii)ICDDR,B
   iv) Local doctor in the pharmacy v) Chemist of the pharmacy vi) Others ….
3. How much does your family have to spend for the treatment of waterborne diseases?
4. How do you find any hardship to keep pace with your income vs. cost of treatment of waterborne diseases?

D) Do you have any recommendations to add?