Supply Water Quality in Urban Bangladesh: A Case Study of Chittagong Metropolitan City to Improve Service Delivery

Mohammad Abu Taiyeb Chowdhury, Kazi Md. Barkat Ali and Morshed Hossan Molla
Department of Geography and Environmental Studies, University of Chittagong, Chittagong, Bangladesh

Md.Habibur Rahman Bhuiyan, Reaz Mohammad Mazumder, and Suman Das
Bangladesh Council of Scientific and Industrial Research (BCSIR) Laboratory, Chittagong, Bangladesh

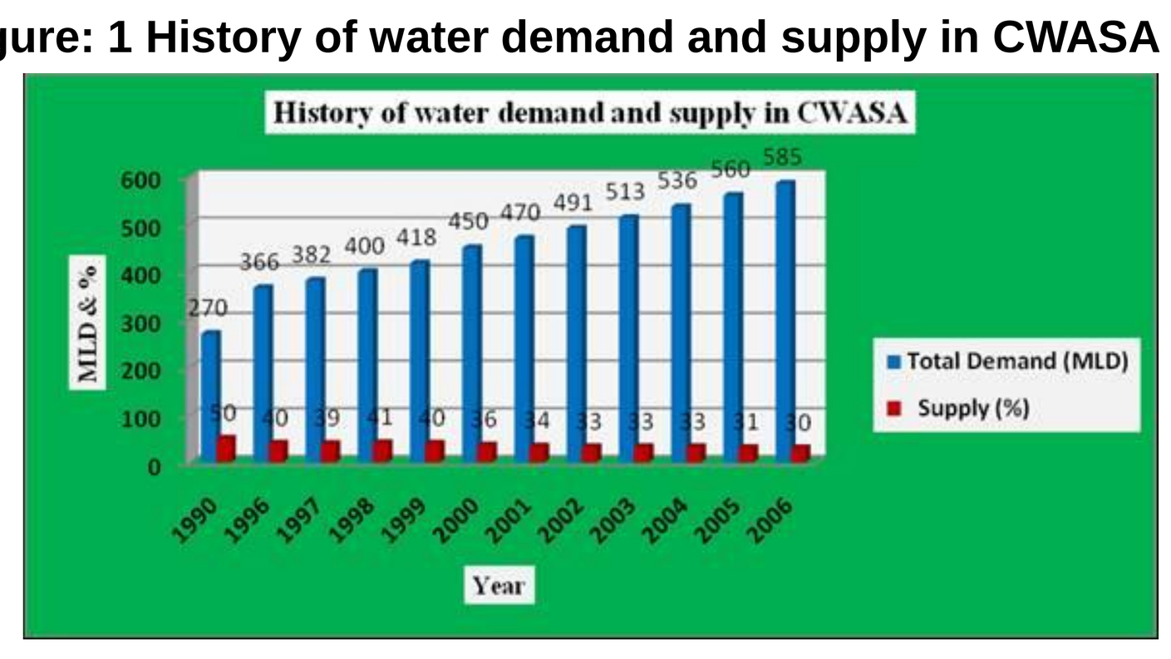
Abstract: In Bangladesh, drinking water quality in urban areas is at high risk. The port city of Chittagong is not only facing the problem of inadequate water supply but also serious threat due mainly to the scarcity of safe water. This paper attempts to characterize and analyze the supply water quality in Chittagong Metropolitan City (CMC) from health, environment and residents- socio economic perspective using a set of parameters: physical, chemical and micro-biological. The paper focuses on key challenges facing the sector today, especially in the provision of urban water service delivery. The thrust there has been to identify weaknesses in current water supply management, and explore options to address the chronic lack of service provisions. The overall finding is that the dwellers of CMC have been suffering from irregular, inadequate and unsafe water supply due mainly to inefficient management practices. The situation is worse in low class residential areas. Regular monitoring of water quality along the distribution networks, timely repair and maintenance, improving information systems, uses of advanced technology, provisions for staff training, awareness building among users and stakeholders, and promotion of community-based co-management governing systems have been strongly suggested.

Keywords: Water quality, environment, contamination, health impacts, monitoring and co-management.

Introduction: Urban water supply has become a critical factor in socio-economic development in most part of the world. This is now a major public health issue in Bangladesh, especially in addressing the quality of urban life. The extent and availability of safe drinking water is an important indicator of sustainable development, and access to clean water constitutes a principal components of the Millennium Development Goals (MDGs). Yet, more than 70 percent of the urban population in the developing countries are either have an inadequate water supply or being supplied with unsafe water or both (Kamal, 2003).. Since the quality of drinking water is closely associated with human health, providing safe drinking water is one of the most important public health priorities. An estimated 80 percent of all diseases and one third of deaths in developing countries are caused by the consumption of contaminated water (UNCED, 1992). In the case of Bangladesh, roughly 80 percent of all diseases are linked with contaminated drinking water, and some 28 percent of the children's death is attributed to water borne diseases, caused mainly by pathogenic microorganisms (Aziz et al., 1990). About 25 percent of the total population lives in urban Bangladesh, and only 44 percent of the urban people are served with tap water supply (BBS, 1995 & Population Census, 2001). The lower income group is the worst sufferers as because they cannot afford to have safe drinking water for an active and healthy life (Rahman & Jahan, 2003).

Demand-Supply Analysis: The City of Chittagong is inhibited by over 4.02 million people (Amin, 2006). About 0.4 million people are served by 21,000 house connections and 0.2 million people collect water form 588 street hydrants that are installed and maintained by the Chittagong Water Supply and Sewerage Authority (CWASA), and the Chittagong City Corporation (CCC). CWASA is the sole organization that supplies water to the city dwellers through its limited distribution networks, but capable of supplying only 30 percent of the total demand (585 million litters water per day- MLD) generated by over 4 million city population. History of water demand and supply in CMC indicates that between 1990 and 2007, the total demand of supply water in the city has increased from 270 MLD) in 1990 to 585 MLD in 2007- a 46 percent increase over the period. In response, the total supply (ground and surface water capacity) of CWASA has increased from 134.5 to 190 MLD or 71 percent. While the capacity of ground water supply increased from 45 to 99 MLD (46 percent) between 1990 and 2007, the capacity of surface water supply rose very slightly- from 89.5 to 91 MLD (0.98 or less than 1 percent) during the reference period. It is striking to note that in the year 2006 CWASA was able to meet only 30 percent (175 MLD) of the total supply water demand in CMC Although the capacity of ground water supply has increased steadily in the city to meet the growing demand, in reality CWASA's overall supply capacity has fallen from 50 percent to 30 percent in fulfilling the collective demand (Figure 1).

Figure: 1 History of water demand and supply in CWASA



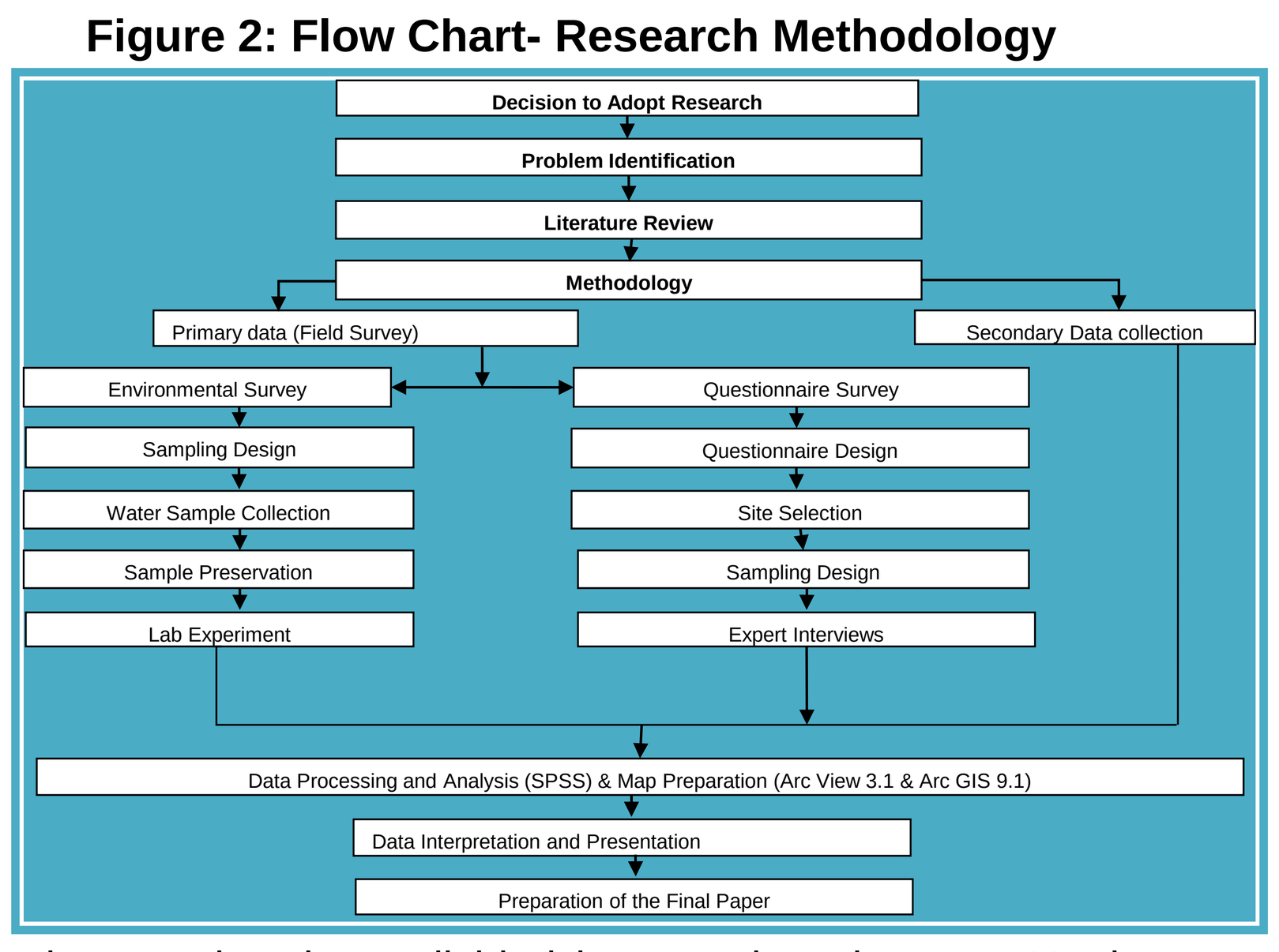
Source: CWASA, 2010

Since CWASA is responsible for construction and installation of water supply systems in the city, operations and maintenance, connecting the households to the water supply network, licensing tube-wells and providing public taps outsides the households etc., it is this organization which has to be more efficient in water service delivery.

Objective: The ultimate objective of the study is to examine the supply water quality and quantity in Chittagong Metropolitan City to improve service delivery by increasing efficiency in the management system.

Materials and Methods: This is an empirical study. A flow chart of the research methodology is shown in Figure 2.

Figure 2: Flow Chart- Research Methodology



For field study, the city area has been divided into two broad zones: Northern treated surface water and Southern ground water, based on the dominant sources of water supply. Two complementary surveys- environmental and questionnaire- were conducted as empirical exploratory devices to collect field data (Figure 3).

To conduct the environmental and health risk analysis, a total of 42 water samples on 20 parameters (physical, chemical and biological) were taken from both the study areas (Table 1).

Table 1: Water quality parameters and standard

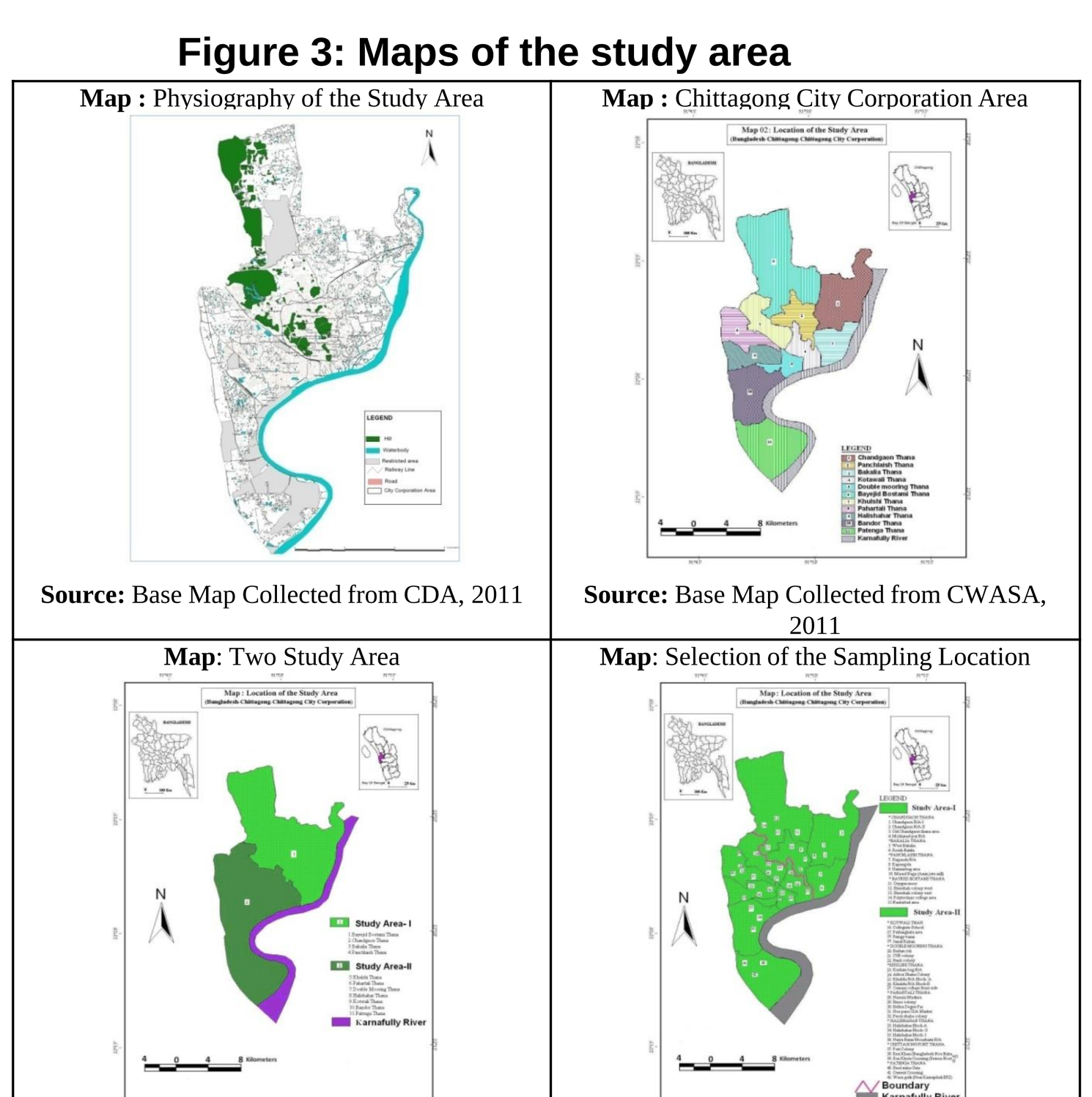
Water quality parameters	Unit	Bangladesh Standards	WHO guide line value,1993
1.Arsenic	mg/l	0.05	0.01
2.BOD 20°C	ppm	0.2	………………
3.Chloride	mg/l	150-600*	250
4.Free Chlorine	mg/l	nil	0.6-1.0
5.Electric Conductivity	μScm^{-1}	500	500
6.Turbidity	NTU	5.0	5.0
7.Dissolved oxygen	ppm	6.0	
8.Hardness(asCaCO₃)	mg/l	200-500	……………
9.Iron	mg/l	0.3-1.0	0.3
10.Nitrate	mg/l	40-50	50
11.Nitrite	mg/l	<1	0.2-5
12.Odor	mg/l	Odorless	Odorless
13.P^H	-	6.5-8.5	6.5-8.5
14.Total dissolved solids	mg/l	1000	500
15.Temperature	°C	20-30	20-30
16.Coliform (faecal)	CFU/100ml	Nil	Nil
17.Coliform (total)	CFU/100ml	Nil	Nil
18.*E.coli*		absent	absent
19.*Vibrio Cholerae*		absent	absent
20.*Salmonella* spp.		absent	absent
21.*Shigella* spp.		absent	absent
22.Total Viable Count	CFU/ml	100000/ml	100000/ml

Source: Ahmed and Rahman, 2003.

For questionnaire survey, a total of 200 respondents (consisting of supply water users) were interviewed using stratified random sampling techniques. A number of in-depth interviews ware also taken from CWASA representatives including managers and professionals to learn how to improve water service delivery in the city.

Study Area: Chittagong Metropolitan City (CMC) lies latitudinally between 22º14′ and 22º24′ north and longitudinally between 91º46′ and 91º53′ east (Map). It is situated on the northern bank of the Karnaphuli River, which provides south-eastern boundary of Chittagong City (Amin, 2006). It is the principal city of the District- the only port city, the second largest Metropolitan city and the commercial capital of Bangladesh with an area of about 1,145 square kilometers (BBS, 2007). The area of Chittagong City Corporation (CCC) is 168 sq km. comprising of 41 wards (Figure 3) and 11 Police Stations .

Figure 3: Maps of the study area



Results and Discussion

The environmental (laboratory) analysis reveals that out of 13 physiochemical parameters, 8 parameters including TDS, turbidity, pH, Fe, NO_3, As, hardness and Cl^- are found within the permissible range. However, the values of 5 parameters i.e. EC, NO_2, DO, BOD and free chlorine are noticed astonishingly high. Quite a few parameters are observed in critical condition in the Southern than in the Northern zone (Table 2).

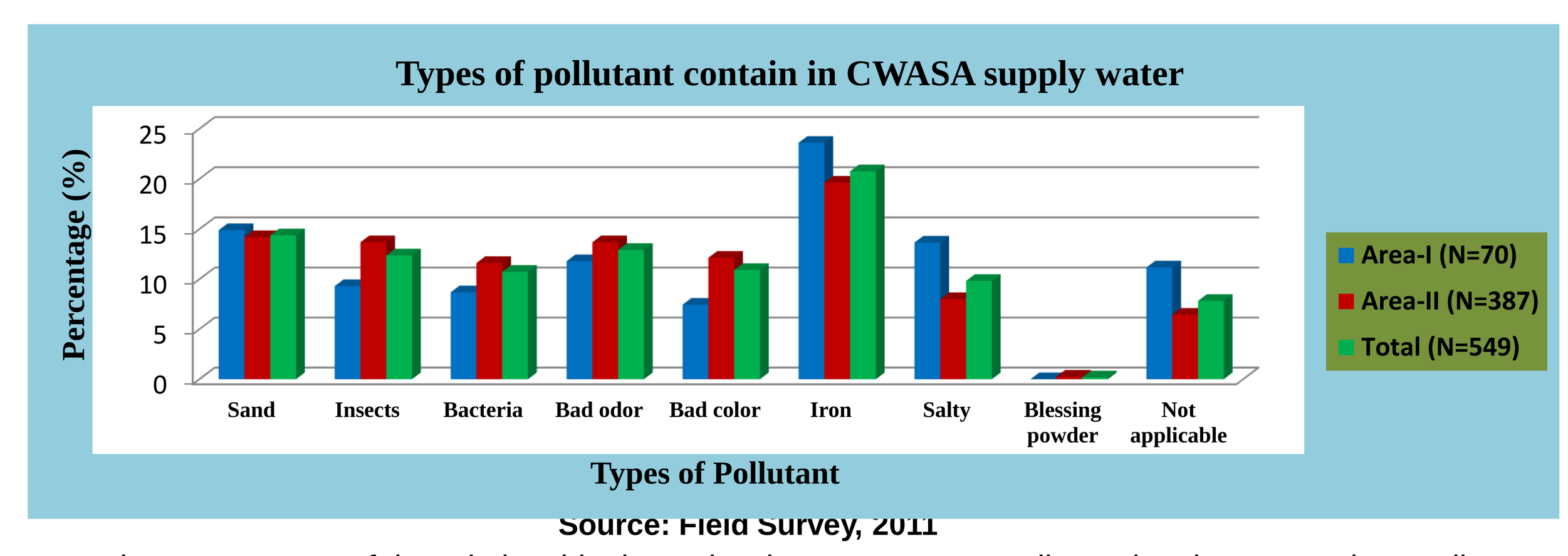
Table 2: Summery of measured water quality parameters in CWASA's supply

Parameter	Study Area-I				Study Area-II			
	Max^m	Min^m	Mean	Std. dev^n	Max^m	Min^m	Mean	Std. dev^n
EC μScm^{-1}	2637.0	53.67	583.511	558.274	2637.0	53.67	733.455	641.11414
TDS mg/l	1450.30	74.44	394.814	327.569	1450.3	128.00	500.982	356.56425
Turbidity (NTU)	256.86	0.12	8.6083	39.3495	256.86	0.12	10.9307	49.15813
P^H	11.80	5.50	6.8969	1.03752	8.47	5.50	6.8989	0.73235
Arsenic (mg/l)	0.00	0.00	0.0000	0.00000	0.00	0.00	0.0000	0.00000
Iron (mg/l)	1.50	0.00	0.4671	0.32726	0.80	0.30	0.4933	0.16352
Nitrate (mg/l)	60.00	0.00	17.8643	16.8045	60.00	0.00	25.2037	16.30199
Nitrite (mg/l)	14.00	0.00	1.1845	3.52080	0.60	0.00	0.0659	0.15633
DO (ppm)	33.50	6.00	11.5262	4.62169	33.50	7.20	11.2704	5.29483
BOD (ppm)	67.00	6.00	25.0845	16.1433	67.00	6.00	28.2815	18.87526
Chlorine (mg/l)	40.56	0.00	1.7800	6.16414	40.56	0.00	2.4393	7.65369
Hardness (mg/l)	430.00	32.00	140.500	84.9175	430.00	40.00	161.333	83.10142
Chloride (mg/l)	909.90	[illegible]	[illegible]	[illegible]	909.90	20.28	[illegible]	247.17871

Source: Lab. Analysais (BCSIR Laboratoires, Chittagong), 2011

Among microbiological parameters (07), total *coliform* and *fecal coliform* are present in almost all the water samples. Of the total viable count of bacteria, 19 samples are found contaminated that crossed the acceptable limit. Pathogenic organisms such as *salmonella spp., shigella spp., escherichia coli and vibrio cholerae* are also present in the study samples. The questionnaire survey reveals that piped water is the main source of drinking water for majority (73 percent) of the respondents. Among the various types of pollutants present in CWASA supply water, bad odour, bad colour, bacteria, insects, bleaching powder, salt, iron etc. are prominent that are widely perceived by the respondents (Figure 4).

Figure 4: Types of Pollutant in the CWASA Supply Water (Percentage)



Source: Field Survey, 2011

Some 64 percent of the respondents are aware of the relationship that exists between water quality and various water-borne diseases in the city. About 56 percent of the respondents have reported that their family members have exposed to diarrhea, dysentery, cholera, typhoid or skin diseases at least once. Female and children are reported to be more affected by the said diseases (Table 3).

Table 3: Water-borne Diseases among Male, Female and Children of CMC

Disease pattern		Area-I (N=70)			Area-II (N=130)			Total (N=200)		
		Male	Female	Children	Male	Female	Children	Male	Female	Children
Diarrhoea	Yes	34.5	51.4	55.7	27.7	49.5	60.8	25.0	41.2	59.0
	No	65.5.0	48.6	44.3	72.3	50.5	39.2	75.0	58.8	41.0
Dysentery	Yes	17.1	55.9	30.2	9.2	64.6	46.2	12.0	48.5	66.6
	No	82.9	41.1	69.8	90.8	35.4	53.8	88.0	51.5	33.4
Cholera	Yes	1.4	1.4	0.00	1.5	1.5	1.5	1.5	1.5	1.0
	No	98.6	98.6	100.0	98.5	98.5	98.5	98.5	98.5	99.0
Typhoid	Yes	7.1	4.3	2.9	5.4	6.9	6.2	6.0	6.0	5.0
	No	92.9	95.7	97.1	94.6	93.1	93.8	94.0	94.0	95.0
Skin disease	Yes	22.9	53.2	17.1	17.7	59.6.0	48.7.0	19.5	51.0	52.0
	No	77.1	46.8	82.9	82.3	40.4	51.3	80.5	49.0	48.0
Fever	Yes	4.3	4.3	4.3	7.7	8.5	7.7	6.5	7.0	6.5
	No	95.7	95.7	95.7	92.3	91.5	92.3	93.5	93.0	93.5
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Field Survey, 2011

Causes

Water contamination in the distribution systems may be attributed to leaks in the old pipes and through linkage faults. Various illegal connection and visible linkage faults were observed during the period of sample collection. The nature of water supply is also responsible for causing the inadequate supply. Absence of water pressure is a regular phenomena at most suction point during non-supply hours. Suction is also produced by installation of unauthorized pumps in the service line to suck more water from the low pressure zone.

Solutions

- **Regular monitoring of water quality along the distribution networks:** Uses of disinfectant residuals control the growth of microorganisms in distribution systems and also act as a final barrier to help maintain the microbial safety of supply water. Realistic residual concentration at least inactivate the least resistance microorganisms such as E.Coli and thermo tolerant Coli forms that are used as the main indicators of water safety (Payment,1999).
- **Timely repair and maintenance:** Contamination via cross-connection, disclose pipe joints or pipe breaks may influence water quality. Pathogens may enter the system through contaminated supply water, in line reservoir etc. System personnel needs to immediately repair the faults point of supply and water holding system. The best way to control leakage is to replace the deteriorated pipelines as planned by CWASA.
- **Improving information systems, planning and appropriate funding:** CWASA should immediately take attempts to establish data-base management systems including demand assessment for future service provisions. This could be dine in conjunction with on-going population growth projection in the study area. CWASA should explore alternative sources of funding to meet not only the growing demand safe supply water in the city but also to ensure efficient service delivery.
- **Uses of advanced technology:** CWASA should use thick PVC pipeline which is neither corrosive nor easy to leakage.
- **Online quality control assessment:** CWASA should also promote online quality control assessment system from treatment plant to consumer (households).
- **Provisions for staff training:** CWASA should arrange training camps and workshops at different levels for employees including lab. assistants, scientific officers, engineering, and field personnel. Thematic areas that should receive priorities are assurance of water quality, selection of materials such as PVC pipe for installation, ensuring proper service connection, rehabilitating old pipe and setup new pipe, sluice valves and chamber repair, identifying leakage or fault line with immediate repairing skills.
- **Awareness building among users/ stakeholder: E**very morning before using the water for drinking or cooking, the water from the taps should run for several minutes. Consumers- the city dwellers- should also be very careful in storing supply water. To store water safely,, pots should be washed out on a regular basis, preferably by bleaching powder**.** CWASA should take necessary steps or initiatives to organize seminars, symposiums, advertisements, social campaigns etc. and ensure the participation of all income groups (elite to poor) in awareness building activities, including discouragement of unauthorized connections and fair water pricing in the city area.
- **Participatory and Co-management approach:** A participatory and co-management approach including all stakeholders- local community, non-governmental organizations, local-government representatives and CWASA officials can ensure an effective, efficient and sustainable water supply delivery system in the Chittagong Metropolitan City.

Conclusion

The existing water supply system of CMC is far from being satisfactory due mainly to old fashioned management practices. In overall, the dwellers of CMC have been suffering from irregular, inadequate and unsafe water supply due mainly to poor management. The situation is worse in low class residential areas i.e. slums. Regular monitoring of water quality along the distribution networks, timely repair and maintenance, cleaning the pipe line, using proper chemical to protect water borne disease, supplying safe water, water conservation, using water for vital causes, improving information systems, uses of advanced technology, provisions for staff training, awareness building among users/ stakeholder, community-based co-management governing systems have been strongly suggested. About 43 percent respondent have the opinion that CWASA is ultimately responsible to supply safe and adequate water to the city dwellers, people should use safe water by boiling and filtering the supply water before drinking, development of reservoirs system and water saving appliance in their houses, underground reserve tank, drum inside the house, wise-use of community pond may help the city dwellers to cope with the situation during in crisis time.

References:

- APHA (2003), Standard methods for the examination of water and wastewater, 4th edition, American Public Health Association/ America Water Works Association/ Water Environment Federation, Washington DC, U.S.A.
- Aziz, K.M.A, Hoque, B. A, Huttly Minnatullah, S.K.M, Hasan, Z, Patwary, M. K, Rahaman, M.M and Cairncross, S. (1990), "Water Supply, Sanitation and Hygiene Education- Report of a Health Impact Study in Mirzapur, Bangladesh*",* Water and Sanitation Report Series-1, Washington, D.C, U.S.A, P.P-1-13.
- CWASA (2010), Preparation of Master plan for water supply and wastewater Management of the detailed planned area of Chittagong", Chittagong, Bangladesh.
- Kamal, A.M (2003), "Attitude and opinion of the profile regarding water supply : A case study of Slum dwellers", Water and sanitation for Cities, World Habitat Day 2003 Souvenir, Bangladesh Institute of Planners (BIP) & Center for Urban Studies (CUS), Dhaka, Bangladesh.
- Rahman, S.M. S & Jahan, S (2003), "Planning for a viable water supply system for Borisal City, Water and sanitation for Cities", World Habitat Day 2003 Souvenir, Bangladesh Institute of Planners (BIP) & Center for Urban Studies (CUS), Dhaka, Bangladesh.
- UNCED, (1992), "Protection of the Quality and Supply of Freshwater Resources: Application of Integrated Approaches to the Development, Management and Use of Water Resources", the United Nations Conference on Environment and Development, Chapter 18, Agenda 21.
- WHO, (1984), "Guidelines for Drinking Water Quality: Drinking water quality Control in Small Community Supplies". World Health Organization, Geneva.

Securing Water for All
Asia Water Week 2013