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Assessment of Water Quality Parameters and Associated Health Impacts of Supplied Drinking Water in Mohakhali and Banani Area of Dhaka City, Bangladesh

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Abstract:
Background*: Dhaka, the capital city of Bangladesh has been struggling to provide its dwellers with safe drinking water and being the only supplier, DWASA (Dhaka Water Supply & Sewerage Authority) is responsible for providing water supply in Dhaka city.*
Materials and Methods*: This study aimed to identify the water quality conditions and to identify the impacts of water quality on human health. To serve this purpose, the study was conducted by collecting water samples from different locations of Mohakahli (Korail Basti) and Banani area of Dhaka City and an in-depth questionnaire survey was also carried out randomly on 75 people of those area.*
Results*: The study found that 75% of tap water and 50% of the distribution line water were contaminated with total coliform. From the questionnaire survey, it was revealed that, about 41% of the respondents suffered from water-borne diseases in the last year. 48% of the respondent were not consuming the supplied water by DWASA due to odor. About 56% of the respondents agreed that the faulty water distribution line is the main reason for water contamination.*
Conclusion: *Findings of this paper will help to the DWASA, Government policymaker to formulate policy in the broader aspect that will ensure to solve the problem.*
Key Word*: Drinking Water Quality; DWASA; Water Security; Water Pollution; Human Health.*

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I. Introduction

Dhaka is the largest urban city in Bangladesh with a population density of 44,500/km2. Dhaka Water Supply and Sewerage Authority (DWASA) is the sole legal entity to maintain water supply for the dwellers. 78% of DWASA water comes from underground, which leads to incremental depletion of groundwater[1]. Most of the distribution system has been weak because of the intermittent water supply, leakage, and pollution from old and dilapidated sewerage pipes and storm drains. Distribution lines of the Dhaka WASA supply chain might be the main source of microbiological contamination of drinking water causing water-borne diseases like Typhoid, cholera, paratyphoid fever, dysentery, jaundice, etc.[2]. WASA supplied drinking water around Dhaka City and observed pathogenic bacterial contamination and toxic PCP contamination which is alarming to the public health[3]. 64% of city dwellers are not using the DWASA water for drinking purposes for bad smell. On the other hand, thirty-six percent of people used the supplied water for drinking purposes by boil[4].

Dhaka Water Supply and Sewerage Authority (WASA) estimates that per capita water demand in Dhaka is 150 liters per day. Meanwhile, per capita usage is just 85 liters per day among the households in informal settlements (e.g. slums) with metered Dhaka WASA connections. Furthermore, inequality increases with increasing wealth, for example, areas such as Gulshan and Banani have by far the highest per capita usage—509 liters. At present Dhaka WASA faces several contraventions like, transitioning to managing surface water instead of groundwater. The bacteriological quality of piped water supply has been extremely unsafe for drinking purpose.

The majority of the distribution system has been weak because of the intermittent water supply, leakage, and pollution from old and dilapidated sewerage pipes and storm drains. Distribution lines of the Dhaka WASA supply chain might be the main source of microbiological contamination of drinking water[2]. In Bangladesh, every year more than one hundred thousand children under five years old die due to diarrhea-related diseases. In 2004 BDHS (Bangladesh Demographic and Health Survey) reported that 5.1% of children died under five years and 1.2% of neonatal deaths were related to diarrhea. Another study reported that 1% of neonatal deaths, 15% post-neonatal deaths, and 6% under five age children's deaths were associated with diarrhea[5]. A study found that typhoid, bacillary dysentery, and diarrhea are very common among the bacterial origin waterborne diseases (table no 1)[6].

Table no 1: Microbial sources of waterborne diseases

Disease	**Microbial Agent**	**Source of Water Supply**
Cholera	*Vibrio cholerae*	Water contaminated with the bacterium
E. coli infection	Certain strains of *E. coli*	Drinking water contaminated with bacteria
Dysentery	Spp. Of the genera Shigella and Salmonella with the most common being *Shigella dysenteriae*	Water contaminated with the bacteria
Salmonellosis	Many bacteria of the genus *Salmonella*	Water contaminated with the bacteria. More common as a foodborne illness
Typhoid fever	*Salmonella typhi*	Water contaminated with faces of an infected person

Water is considered safe when it is free from contamination. Due to use of contaminated water people suffers from different type of water-borne diseases. In Bangladesh, there are lot of research conducted on water quality assessment, but health effect covers a small part of whole work[7].

The aim of this study was to assess the drinking water qualities (pH, Turbidity, TDS, conductivity, Total coliforms, etc.) in water supply and its impact on human health at Mohakhali and Banani areas in Dhaka city, Bangladesh; to identify the commonly occurred water-borne diseases; to identify the vulnerable age groups in the study area, to aware the general people and to attract the attention of the respective concerns which may help them taking necessary actions to bring the situation to a manageable condition.

II. Material And Methods

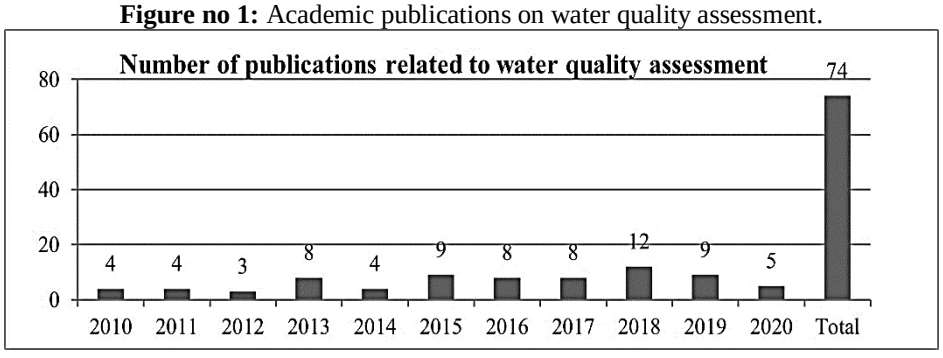
The study was conducted by collecting water samples from different locations of Mohakahli (Korail Basti) and Banani area of Dhaka City and an in-depth questionnaire survey was also carried out randomly on 75 people of those area. The study was conducted between January 2020 to December 2020.

Study location: Mohakahli (Korail Basti) and Banani, Dhaka, Bangladesh.

Primary data: Water quality analysis of the collected samples and health impact data obtained from the field survey served as the primary data sources. These included: laboratory tests of collected water samples, questionnaire survey, interview, field survey, etc. For the questionnaire, random sampling technique was followed, and questions were both open and closed ended.

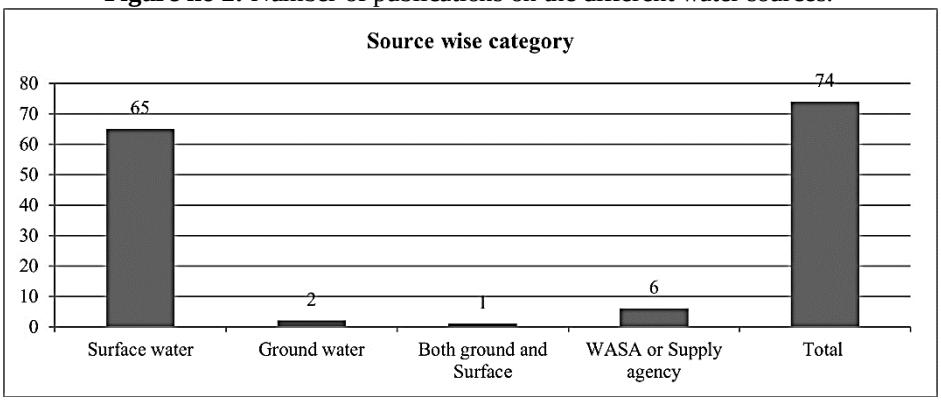
Secondary data: Keyword 'Water quality assessment' was used to search for research articles published between 2010-2020. Within this period a total of 74 articles were considered. Article classification was achieved via a 4-tier assessment of (1) Title, (2) Keywords, (3) Abstract and (4) Full publication. The number of articles considered within 2010-2020 is shown in Figure no 1.

Figure no 1: Academic publications on water quality assessment.



The selected articles were divided in source wise category, surface water category were 65 articles, ground water category there were 02 articles, both ground and surface there was 1 article, and finally 6 articles were selected in WASA or supply agency category (Figure no 2).

Figure no 2: Number of publications on the different water sources.



Sample collection: A total of 15 water samples were collected from water pumps, water reservoirs and from the overhead tanks from different locations of the study area and were analyzed to determine pH, BOD, COD, TDS, Total Coliform etc. The sample design for the research were a combination of simple random sampling and stratified sampling.

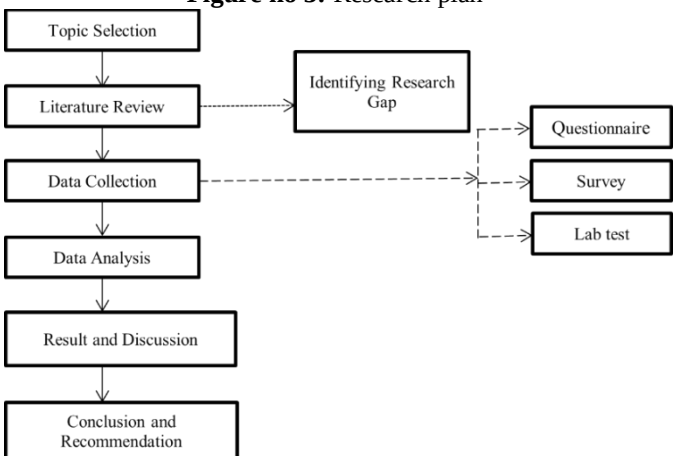
Sample analysis techniques: Sample analysis techniques followed in this study in determining the parameters collected water samples are shown in Table no 2.

Table no 2: Sample analysis techniques

Sl. No.	Water Quality Parameters	Bangladesh Standards (mg/L)	WHO Guidelines	Methods/ Equipment
01	BOD 5 Day, 200C	0.2	-	5 days Incubation
02	Chlorine (Residual)	0.2	-	Titrimetric Analysis
03	COD	4	-	Closed Reflux Method
04	Coliform (Faecal)	0 CFU (N/100mL)	0	Membrane Filtration Method
05	Coliform (Total)	0 CFU (N/100mL)	0	Membrane Filtration Method
06	Colour	15 Hazen	-	Colour Comparator
07	DO	6	-	Multimeter
08	Odour	Odourless	-	Threshold Method
09	pH		6.5-8.5	pH Meter
10	Salinity	-%0	-	Multimeter
11	Suspended Solids	10	-	Filtration and Drying
12	Taste	-	-	Threshold Method
13	Total Dissolved Solid	1000	-	Multimeter
14	Temperature	20-30C		Thermometer
15	Turbidity	10 NTU	-	Turbidity Method

Research plan:

Figure no 3: Research plan



III. Result

Findings from DWASA laboratory reports

The laboratory test report of DWASA for the supplied drinking water in the study area has been shown in Table no 3.

Table no 3: Laboratory test report of DWASA

Parameter	pH	Turbidity (N.T.U)	TDS (mg/L)	Conductivity (µs/cm)	Ammonia-N (mg/L)	Total Hardness (mg/L)	Residual Chlorine (mg/L)	Total coliforms (N/100ml)
Drinking water Standard (WHO, 2011)	**6.5 - 8.5**	**5**	**1000**	**…..**	**1.5**	**….**	**0.6 - 1.0**	**0**
Drinking water Standard (Bangladesh)	**6.5 - 8.5**	**10**	**1000**	**…..**	**0.5**	**200 - 500**	**0.2 - 0.5**	**0**
SL-01	6.9	3.08	145	272	0	98	0	0
GWR -01	6.8	3.01	145	273	0	98	0	0
DTW -01	6.9	2.7	143	271	0	96	0	0
SL -02	6.8	2.58	140	264	0	98	0	0
GWR - 02	6.9	1.07	148	277	0	120	0	**7**
DTW - 02	6.8	1.32	114	215	0	72	0	0
GWR - 03	6.9	1.76	115	216	0	78	0	0
GWR - 04	7.1	1.83	112	210	0	80	0	0
SL - 03	6.9	1.46	104	196.3	0	76	0.1	0
GWR - 05	7.1	1.67	106.1	192.2	0	80	0.1	0
DTW-03	7.8	1.5	110	208	0	74	0	0
DTW- 04	6.7	2.98	138	259	0	90	0	0
GWR-06	6.8	2.59	135	254	0	94	0	0
GWR-07	6.6	2.77	132	249	0	95	0	**10**
SL-04	6.7	2.16	142	266	0	78	0	0
GWR-08	6.69	1.1	120	226	0	80	0.4	0
GWR-09	7.45	2.68	138	300	0	112	0	0
GWR-10	7.23	1.04	140.5	307	0	108	0	0

** SL = Supply Line, GWR= Ground water reservoir, DTW= Deep Tube Well

- **pH:** pH was found within permissible limits as prescribed by Bangladesh and WHO guideline.
- **Turbidity (N.T.U):** Turbidity within range as set by Bangladesh and WHO guideline.
- **TDS (mg/L):** TDS is under the limit of Bangladesh and WHO guideline.
- **Conductivity:** Conductivity is more, does not meet the limit of Bangladesh and WHO guideline.
- **Ammonia-N (mg/L):** Ammonia-N is under the limit of Bangladesh and WHO guideline.
- **Total Hardness (mg/L):** Total Hardness is less than the limit of Bangladesh and WHO guideline.
- **Total coliforms (N/100ml):** In the water of Ground water reservoir (GWR-02 and GWR-07) total coliforms found. But we do not get any in supply line and water pump water.

Findings from laboratory investigation of collected water samples

The results obtained from analyzing the water samples that had been collected from the study area has been shown in Table no 4.

Table no 4: Lab test results of collected water samples of the study area

Parameter	pH	Turbidity (N.T.U)	TDS (mg/L)	Conductivity (µs/cm)	Total coliforms (N/100ml)	Comments
Drinking water Standard (WHO)	**6.5 - 8.5**	**5**	**1000**	**…..**	**0**	
Drinking water Standard (Bangladesh)	**6.5 - 8.5**	**10**	**1000**	**…..**	**0**	
Sample-01 (Tap Water)	7.25	2.5	165	330	**36**	Not good for health
Sample-02 (DWASA DTW)	7.24	0.2	163	325	0	Satisfactory
Sample-03 (Tap Water)	7.09	2.7	199	397	**10**	Not good for health
Sample-04 (DWASA DTW)	6.85	0	180	360	0	Satisfactory
Sample-05 (Tap Water)	7.07	0.5	175	349	0	Satisfactory
Sample-06 (DWASA Distribution Line)	7.13	0.2	164	330	**4**	Not good for health
Sample-07 (Tube well, DWASA Supply)	7.25	0.0	146	312	**16**	Not good for health
Sample-08 (DWASA DTW)	6.94	1.2	155	309	0	Satisfactory
Sample-09 (Tap Water)	7.35	0.3	161	322	0	Satisfactory
Sample-10 (DWASA Distribution Line)	6.88	1.67	106.1	192.2	**10**	Not good for health
Sample-11 (Tap Water)	7.12	0.0	163	326	0	Satisfactory
Sample-12 (underground reservoir)	7.21	0.4	166	331	0	Satisfactory
Sample-13 (DWASA DTW)	6.92	0.7	155	310	0	Satisfactory
Sample-14 (Tap Water)	6.87	0.9	154	308	**6**	Not good for health
Sample-15 (Tap Water)	7.04	0.7	180	342	**18**	Not good for health

** SL = Supply Line, GWR= Groundwater reservoir, DTW= Deep Tube Well

- **pH:** pH was found within the limit set by Bangladesh and WHO guideline
- **Turbidity (N.T.U):** Turbidity was found under the limit for all samples as set by Bangladesh and WHO guideline
- **TDS (mg/L):** TDS was found within the permissible limit of Bangladesh and WHO guideline
- **Conductivity:** Though no standard values were set in Who as well as in Bangladesh Guidelines, but it was found higher in the case of all samples.

Water quality and human heath impact analysis (questionnaire survey)

To find out inherent problems of city dwellers due to the water supply system in Dhaka city and its associate impact on city life, a field survey as questionnaire survey, informal interview, and open discussions was done on 75 people who were living in the study area. Data obtained from the field survey are shown in Figures 04-09.

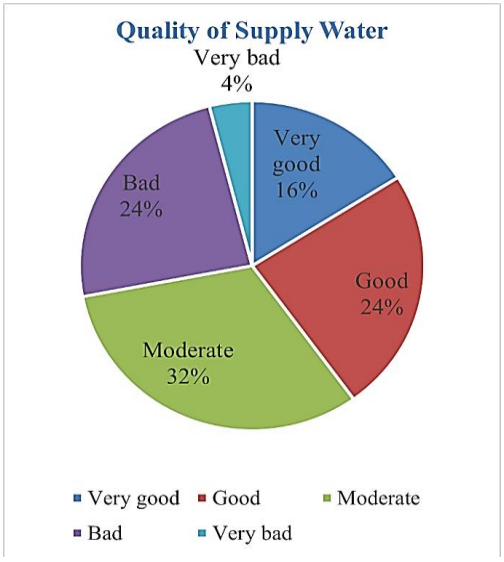


Figure no 4: Perception on quality of supply water.

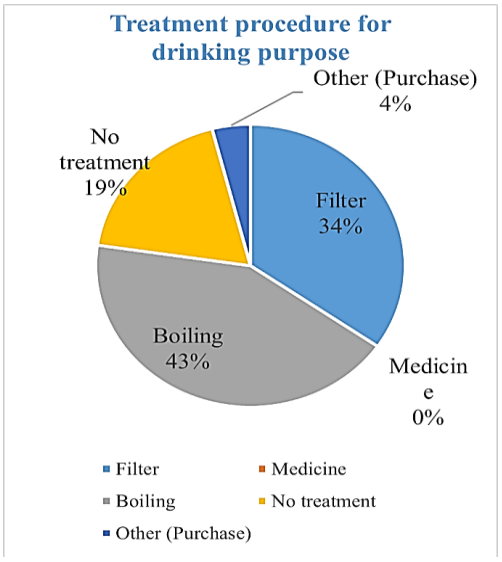


Figure no 5: Type of treatment procedure.

From figure no 4, it can be clearly seen that 32% of the respondents think that the water quality of supply water is of moderate quality. 24% of the respondent think that the water quality of supply water is bad, and 4% think that the water quality of supply water is very bad. Only 24% of respondents think that water quality of supply water is good and 16% of respondents think that water quality of supply water is very good. So, most of the consumers were not satisfied with their supplied drinking water quality.

The study also revealed that 43% of the respondents use boiling of water for filtration while 34% used filters to purify their drinking water and only 4% of respondents had claimed that they use bottled water. It was surprising that 19% of the respondents said that they use no filtration methods to purify their drinking water (figure no 5).

Moreover, 52% of the respondents had claimed that they smell the odor from their supplied drinking water (figure no 6) and 82% of the respondents said that they do not drink the water directly (figure no 7). The survey also found that, 41% of the respondents had suffered from waterborne diseases in the last one year (figure no 8) and 56% of the respondents had claimed that the faulty distribution line was the main source of water contamination in the study area (figure no 9).

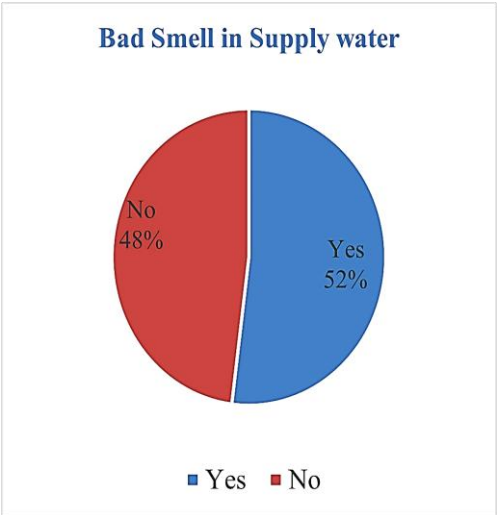


Figure no 6: Bad smell in Supply water.

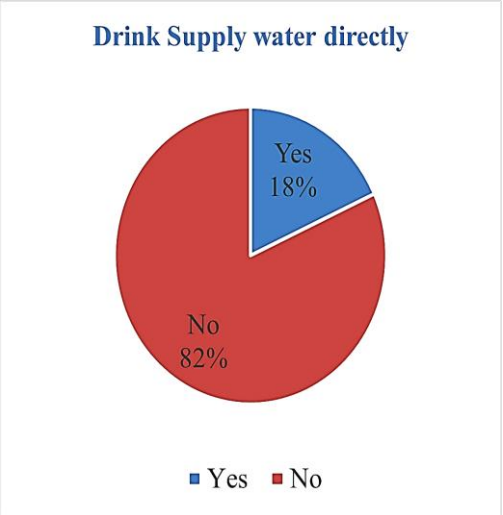


Figure no 7: Drink supply water directly.

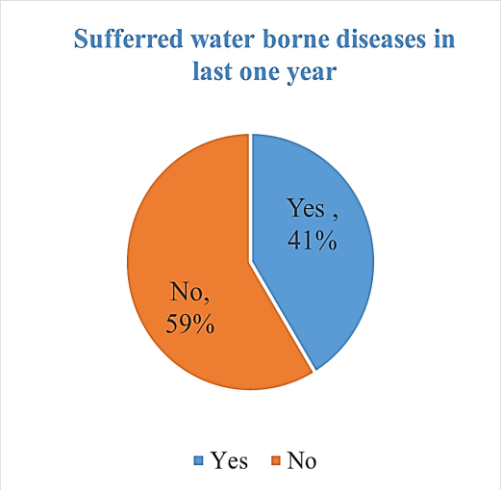


Figure no 8: Evidence of water borne diseases occurrence.

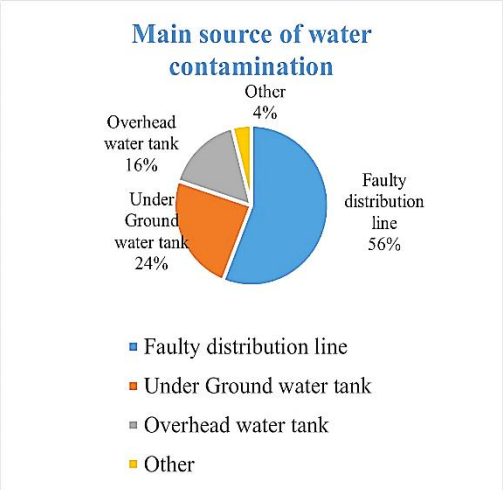


Figure no 9: Main source of water contamination.

IV. Discussion

The slum areas have degraded sanitation facilities often exposed to excreta causing microbial contamination like coliform[8]. This has positive correlation with water-borne disease9 as observed among the 41% respondent suffering from water-borne diseases. Turbidity plays a vital role to control disease forming microorganisms[10]. The water samples result shows the turbidity to be within the range of WHO Standards. Majority of the respondents (about 56%) claimed faulty distribution line for water contamination. A close proximity to drain line could also cause microbial contamination resulting in bad odor[11]. The pathogens are highly susceptible for elders, infants, and immune-compromised inhabitants and could result in acute gastroenteritis[12]. Besides, the higher the number of dissolved ionic components in water causes more the conductivity[13].

From overall observation, it can be concluded that there might be still existing some problems in water supply lines as the results of the water sample analysis also suggested the existence of coliform bacteria in the pipeline as well as in house tap water since some of the samples did not meet BD and WHO standards. So, contamination may have taken place in the distribution system and domestic tanks or reservoirs. Field survey reports also suggested that the consumers of the study area also faced some problems related to their drinking water sources.

The results emphasize the importance of adopting an appropriate routinely monitoring system in order to prevent the chances of contamination of drinking water. To prevent the problems that have been identified through this study, the following are the few remedial measures which can be adopted to retrieve the water qualities of the study areas:

- Service tanks should be cleaned regularly for ensuring a potable water supply to the consumer.
- Pipelines can be placed under 5 to 6 feet from the surface for ensuring the safe supply of water and avoid underground leakage.
- Ensuring safe drinking water sources for the incumbents who have no WASA connection.
- Use of water recycling systems.
- Educate people on water pollution and its risks.
- Enforce law to build a septic tank and effluent treatment plant properly.
- Increase trained and equipped team for water quality monitoring and surveillance.

V. Conclusion

In most of the slums of Dhaka city, water is supplied from Dhaka WASA. But this water is supplied through most of the illegal water connections. The slum areas are involved in illegal water connection systems by leaking legal mains. So, there is some leakage in the connection pipes. The entrance of filthy things and dirty water from drains in the WASA lines creates the water contaminated. Due to the use of dirty/contaminated water, people suffer from various diseases and becomes deprived of getting safe water facility. Water purification is a cost-

effective process so most of the population in this area drinks tap water directly. For this reason, different water-borne diseases are rising in the city. So, the government should create some effective rules and penalize the system for the illegal connection. Findings of this paper will help to the DWASA, government policymakers to formulate policy in the broader aspect that will ensure to solve the problem.

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