Effectiveness of UV-Technique for Water Disinfection in Dhaka City

A.M. Redwan, S. Ghosh, M.M. Rahman

Abstract— This study concentrates on evaluation of microbial quality of drinking water and relates it with the performance of various purification technique used at household level of Dhaka city and analyzes feasibility of UV disinfection technique within several socio-economic groups at various locations of Dhaka City .The study areas were selected based on the vulnerability to waterborne diseases. Various income groups and institutions were considered to reflect impact of water quality and disinfection technology options on the economic and social aspects. In this study it was observed that most of the drinking water samples were biologically contaminated. This study also tried to identify the probable reasons behind the poor quality of drinking water at user's end. GIS based maps were developed to identify most vulnerable locations of Dhaka City with respect to microbial water quality. This study observed that UV inactivated general bacteria, total coliform and *E.coli* in almost all cases and the performance of UV did not depend on locations or the income group using it .This study discusses people's choice regarding management of UV-system and source of power for operating UV-system. Finally some strategies were suggested for implementation of UV-disinfection system in Dhaka City.

Index Terms— Dhaka City, Drinking Water, Vulnerability, Microbial quality, Purification Method, User's End, UV-disinfection.

1 INTRODUCTION

THE larger the quantity and the better the quality of water, the more rapid and extensive is the advancement of the public health (Ahmed and Rahman, 2000) .Water-contaminated by feces, not by chemicals-remains one of the biggest killer worldwide. According to World Health Organization (WHO 2007), 1.1 billion people lack access to an improved drinking water supply, 88 percent of the 4 billion annual cases of diarrheal disease are attributed to unsafe water and inadequate sanitation and hygiene, and 1.8 million people die from diarrheal diseases each year. Diarrheal diseases constitute a major health problem in Bangladesh, killing about 69,000 people each year (Pinto, 2008). As Dhaka is the capital of Bangladesh, rapid urbanization and population growth in last decades have changed the physical environment of Dhaka. About 38% of total population of Dhaka is living in slum areas. An estimated 3.4 million people live in 5000 slums in Dhaka (Islam, 2005). Only 55% of the Dhaka's urban poor currently receive tap water and less than 70% of its slum dwellers have access to safe drinking water. As a result of a severe lack of access to safe drinking water in these areas, residents experience an unsanitary lifestyle and suffer from increased health risks. Water related diseases are responsible for 24% of all deaths (Water Aid, 2011).

This study will concentrate on evaluation of microbial quality of drinking water and relate it with the performance of various disinfection technique used at household level of Dhaka city in terms of microbial quality by identifying the presence of general bacteria and total coliform, and feasibility of UV disinfection technique in several socio-economic groups at various locations of Dhaka City. The main objectives of this study are -

- Evaluation of public satisfaction regarding existing drinking water quality.
- Indicative and qualitative assessment of microbial quality of drinking water in terms of presence of general bacteria and total coliform.
- Identification of most vulnerable areas of Dhaka city in terms of microbial quality of drinking water by developing GIS maps.
- Identification of various purification techniques and their corresponding users.
- Evaluation of performance of UV-sterilization in inactivating general bacteria, total coliform and *E. coli.*

- *A. M. Redwan, Undergraduate Student, Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh, E-mail: asef_hims@yahoo.com*
- *S. Ghosh, Undergraduate Student, Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh, E-mail: shayok076@gmail.com*
- *M. M. Rahman, Professor , Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh, E-mail: mafizur@gmail.com*

2 METHODOLOGY

A simple flow diagram of methodology is given below-

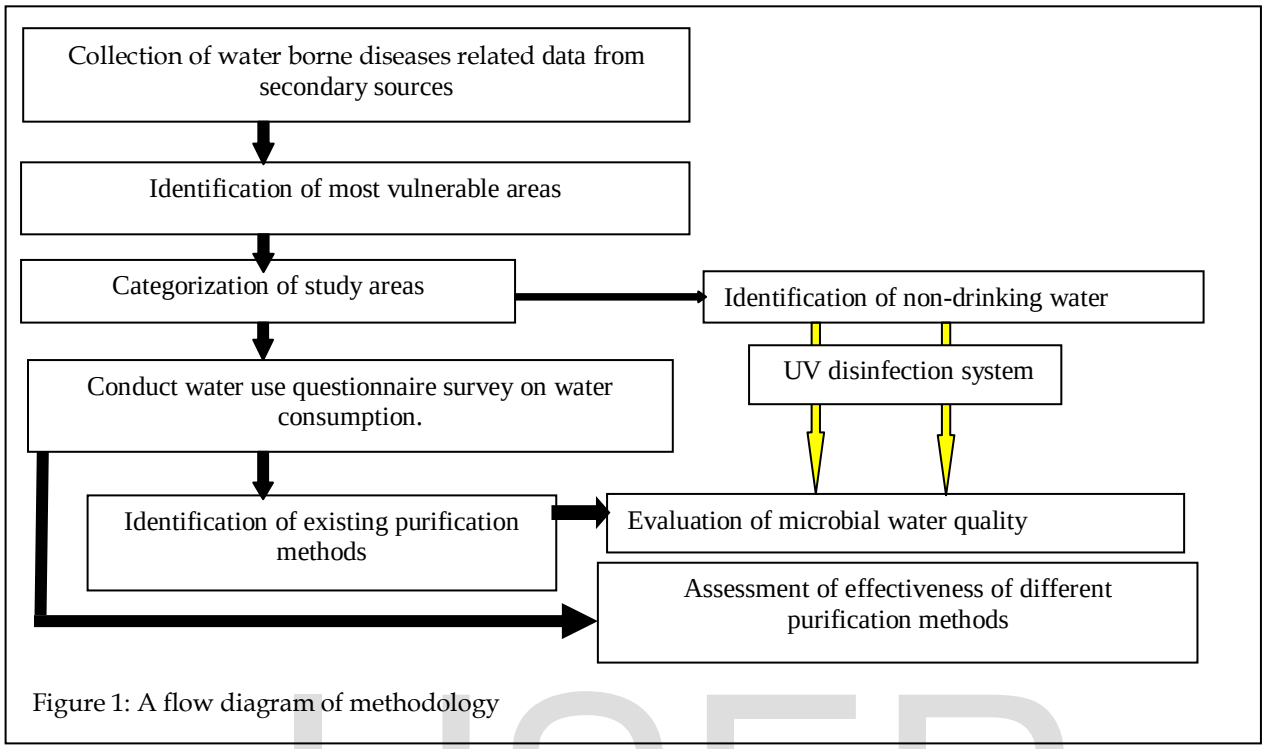

Figure 1: A flow diagram of methodology

Tests were performed on water samples from the UV system and other existing disinfection systems following the protocol of Figure 2.

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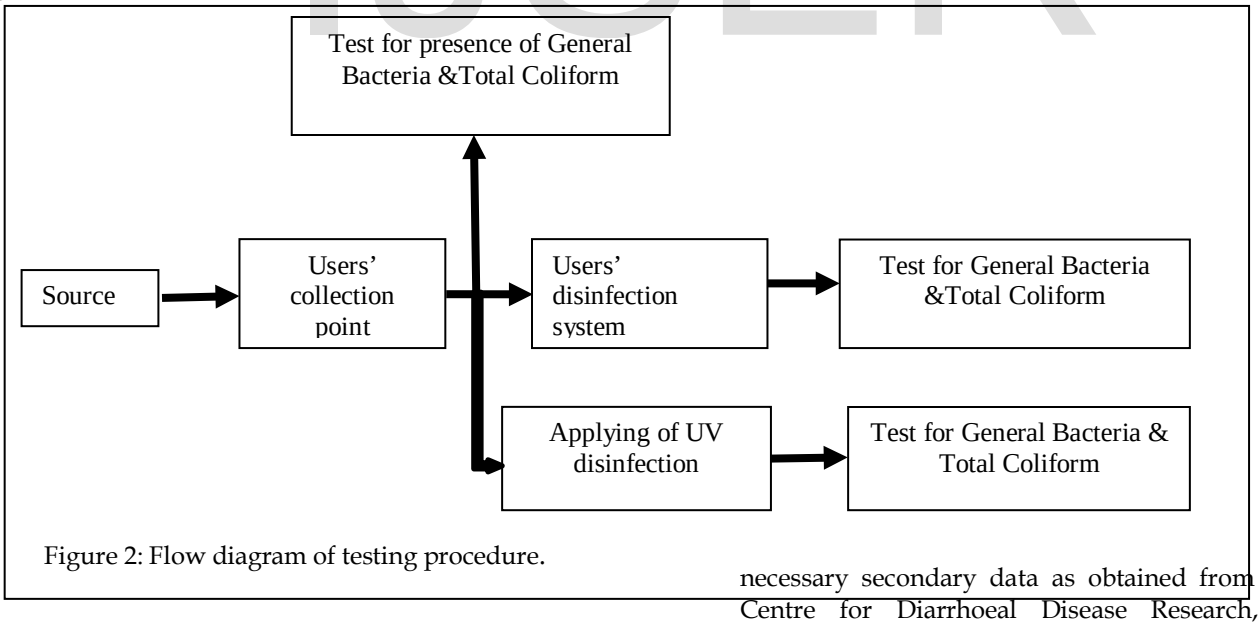


Figure 2: Flow diagram of testing procedure.

2.1 Selection of Study Areas

The selection of vulnerable areas of Dhaka City as water borne diseases were concerned was based on the analysis of necessary secondary data as obtained from International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) is shown in Figure 3:

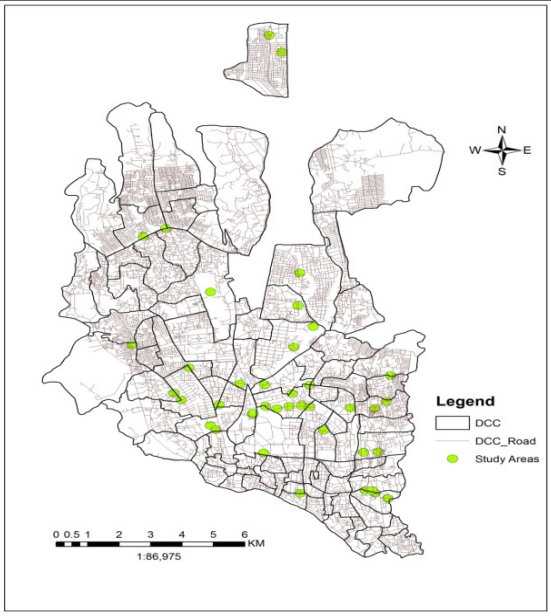


Figure 3: Selection of study areas

2.2 Categorization of Study Area

Study areas were divided into four major groups which were also divided into a total number of eight sub-groups. They are shown in Table 1.

TABLE 1
CATEGORIZATION OF STUDY AREAS

Study Area :	Subgroups:
1)Residential	Settled
	Slum
2)Commercial	Market
	Restaurant
	Office
3)Institute	School/College
	University
4)Hospital	Public
	Private

52 samples were collected for evaluation of microbial quality of drinking water and also to investigate the suitability of UV disinfection system for inactivating the micro-organisms. Table 2 shows a distribution of sample size according to seven categories of study areas.

TABLE 2
STUDY GROUP WISE DISTRIBUTION OF STUDY SAMPLE

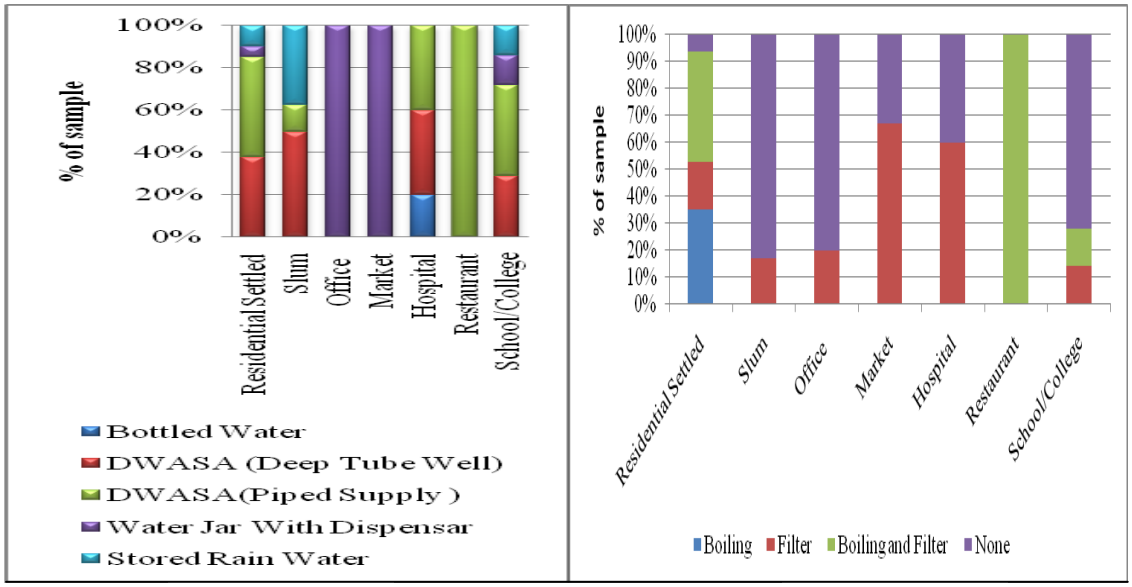
		Sample Size
Residential	Settled	21
	Slum	8
Commercial	Market	3
	Restaurant	3
	Office	5
Hospital	Public	3
	Private	2
Institute	School/College	7

3 RESULTS AND DISCUSSION

3.1 Source of Drinking Water and Existing Household Level Purification Techniques

Five types of sources are assumed to be used for drinking purpose in this city in this study: Bottled Water, DWASA (Deep Tube Well), DWASA (Piped Supply), Water Jar with Dispenser and Stored Rain Water. From Figure 4(a), it is clear that the commercial sectors like offices and markets are entirely dependent on private sector initiated water jar with dispenser for drinking purpose. On the other hand slum and residential settled areas fully depend on DWASA initiated pipe supply or deep tube well.

In this study three types of purification systems were found to be used at user level such as boiling, filtration and a combination of boiling and filtration .It was found that about 19 % people used both boiling and filter machine,14% people used only boiling and 28% people used only filter machine and 39% people used no purification method at user's level within the study areas .So it is noticeable that a large portion of population of the study areas were not using any sort of purification technique. This fact was more applicable for the slum people as this study found that 89% of slum dwellers (as shown in Figure 4(b)) considered in the study did not use any form of disinfection system. As a result they are more vulnerable to water borne disease.



(a) (b)

Figure 4: Group wise pattern of (a) source of drinking water and (b) household level purification techniques

3.2 Assessment of Microbial Quality of Drinking Water at User's End

This study analyzed drinking water quality in terms of presence of general bacteria and coliform. A summary of the analysis is presented in Figure 5. This figure indicates that 98.11% sample were identified positive for the presence of bacteria and 88.68% sample were identified positive for the presence of coliform. This evaluation leads to a very concerning scenario at household level drinking water quality.

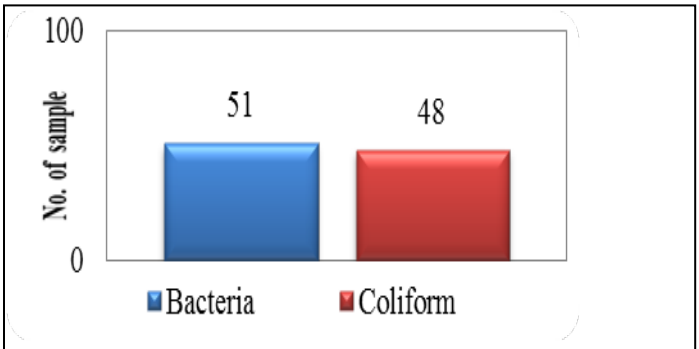
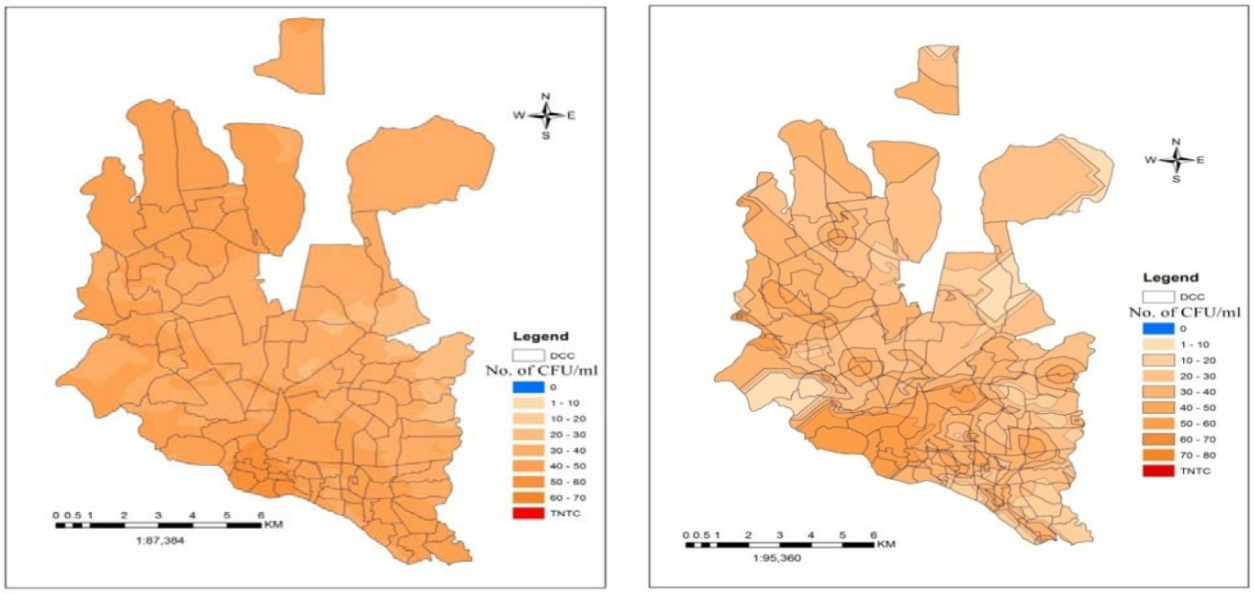


Figure 5: No. of total sample vs. no. of infected drinking water sample.

Figure 6 shows area wise maps for the distribution of general bacteria and total coliform as detected in drinking water. From Figure 6 (a) it appears that high concentration of bacteria was found in the most of areas of Dhaka City. But from Figure 6 (b) it can be said that drinking water from Azimpur, Dhanmondi, Uttara, Gulshan, Mirpur, Jatrabari and their surrounding areas were infected with high concentration of total coliform. Finding the specific reasons for presence of high concentration of total coliform in these places was beyond the scope of this study.



(a) (b)

Figure 6: (a) General Bacteria and (b) Total Coliform distribution observed in drinking water

3.3 Reasons for Poor Quality of Drinking Water

In this study, micro-organisms were found in drinking water even after water was purified by boiling or filtration. This may be due to-

- **Secondary Contamination :** The probable reasons for secondary contamination of drinking water are-
  - *Lack of maintenance of storing container:* People of this city are not aware of proper maintenance of container used for storing of drinking water. Not only the slum dwellers (with low literacy level) but also the residential dwellers (with higher literacy level) are not aware about the secondary contamination through contaminated containers.
  - *Lack of hygiene practice:* Due to lack of sufficient hygiene education, city dwellers in many cases do not follow proper hygiene practice during handling and disinfecting the drinking water. For example, during this study it was revealed that users do not wash their hands and glasses specially in the slum, restaurants and market places.
- **Lack of Social Responsibility:** In this study, it was found that 17 % of users of study sample used water jar with Dispenser for drinking purpose. But in many cases water sample collected from these jars were biologically contaminated. Providing uncontaminated water to the consumer is a social responsibility for the owners of these companies. But they are not aware of this responsibility. As a result unconscious handling and transportation of these jars lead to secondary contamination.
- **Unwillingness to use proper purification system**: According to this study about 39% of the city dwellers do not use any form of purification technique.

3.4 Performance Analysis of UV Sterilization

In this study, performance of UV–system to improve microbial quality of water was evaluated on the basis of inactivation of general bacteria, total coliform and ***E. coli***.

General Bacteria Disinfection: Figure 7 shows the general bacteria pattern observed in water before disinfection and Figure 8 shows the general bacteria pattern after disinfecting with UV. These two figures indicate that before treatment as many as thirty two samples out of fifty two were in the TNTC (too numerous to count)level but after disinfection no sample was within TNTC level.

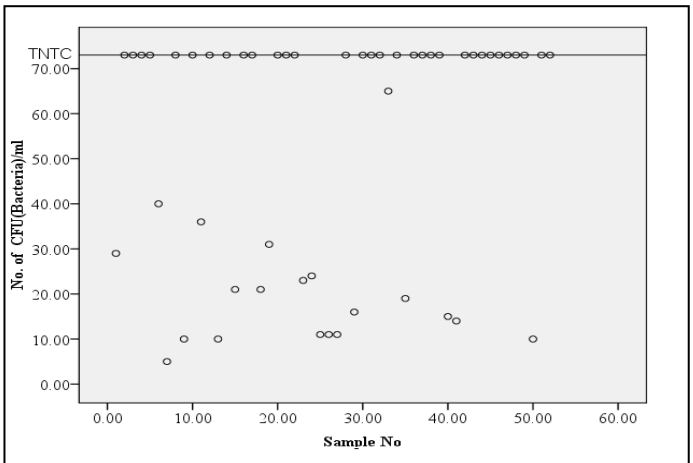


Figure 7: General Bacteria pattern observed before disinfection.

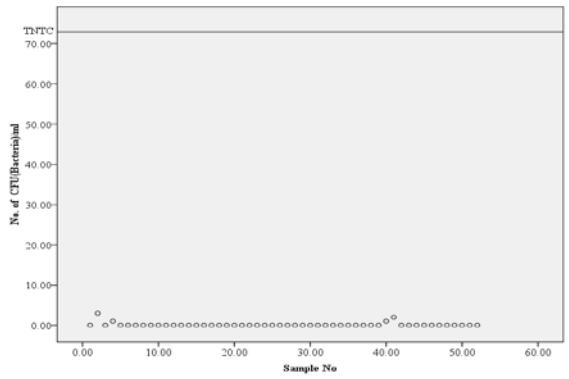


Figure 8: General Bacteria pattern observed after disinfection.

While 100% sample were found infected with general bacteria before treatment, only 7% samples were infected with bacteria after treatment.

Total Coliform Disinfection: Similarly for TC, whereas before treatment fourteen samples out of fifty two were found in the TNTC level but after disinfection no sample was around the TNTC level. According to Figure 9, 100% samples were infected with general bacteria before treatment where it was only 5% after treatment.

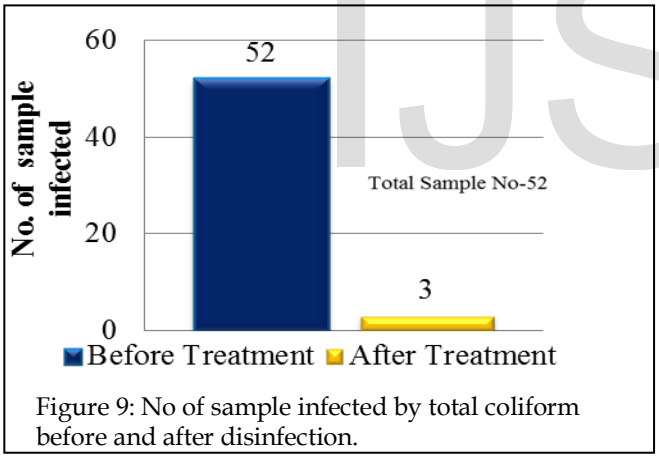


Figure 9: No of sample infected by total coliform before and after disinfection.

***E. Coli* Disinfection**: Figure 10 shows that 50% of the tested samples were found positive for the presence of E. coli. On the other hand no sample was found positive for the presence of E. coli after disinfection with UV light.

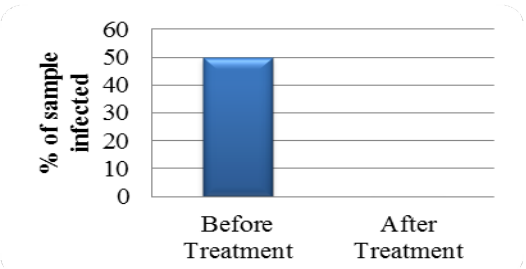


Figure 10: No. of *E.coli* found before and after disinfection.

From Figure 7 to 10, it is obvious that UV removed more than 90 % of both -general bacteria and total coliform from the test samples. A very little trace of general bacteria and coliform remained in water even after disinfection with UV. This could be due to-

- Total Dissolved Solid
- Suspended Solid / Turbidity
- Unconscious handling of test paper

3.5 Choice of UV disinfection system

During questionnaire survey, members of respective groups were asked to choose their preferable UV disinfection system based on two criteria –

1. Based on Management:

- HH system or,
- Central system.

2. Based on Source of Power:

- AC System,
- DC System or,
- Both

Based on Management: This study revealed that groups like offices, hospitals, schools and colleges mostly preferred central basis system. But settled residential areas and slums showed mixed interests. 45% of respondents of residential settled areas showed their interest for individual household basis system and other 55% expressed their preference for central system. In slum area 40 % of respondents were found to prefer individual HH basis system while rest 60% wanted to use central basis UV system.

Based on Source of Power: Offices, schools, colleges and restaurants were found to express greater preference for both AC-DC system and only DC system. Lack of reliability regarding continuous supply of electricity may promote such type of choice. But residential settled and slums area show greater interest for AC system .The reasons for choosing AC system by settled and slum areas may be due to lack of information regarding availability, cost and performance of DC system. But special considerations is needed for slum areas as in some cases where they are

deprived of electricity supply. For example, during this study Shajanpur slum areas in Khilgaon was found lacking source of power.

4 CONCLUSIONS

From this study it was revealed that 95% of representative of various communities were satisfied with the existing drinking water quality. But from the microbial quality assessment of drinking water it was observed that 51 samples out of 52 were infected with general bacteria and 48 samples were infected with total coliform which indicates the failure of existing household level purification techniques to provide safe drinking water. Many reasons like lack of maintenance of storing container, lack of hygiene practice etc. contribute to this failure. On the other hand this study recommend the use of UV-light as a household disinfection system for this city but further study may be required to find the impact of TDS or turbidity on the performance of UV system. If turbidity or suspended solids become a concern for the quality of potable water along with the microbial aspect, a turbidity removal filter may be integrated with UV-disinfection techniques. As the chemical contamination of drinking water is becoming a great a concern for this city, further investigation should be carried to form a suitable UV-disinfection system incorporated with activated carbon or other technology that will be able to remove undesirable chemical constituents from water.

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