STUDY ON DRINKING WATER QUALITY SERVED IN RESTAURANTS AND TEA STALLS IN GAZIPUR AREA

SAAD FAROOQ

TABRIZ TAJWAR SHARIF

SHADMAN ALAM

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

ISLAMIC UNIVERSITY OF TECHNOLOGY

GAZIPUR, BANGLADESH

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SAAD FAROOQ (ID: 155401)

TABRIZ TAJWAR SHARIF (ID: 155421)

SHADMAN ALAM (ID: 155430)

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PROJECT REPORT APPROVAL

The thesis titled "STUDY ON DRINKING WATER QUALITY SERVED IN RESTAURANTS AND TEA STALLS IN GAZIPUR AREA" submitted by Saad Farooq, Tabriz Tajwar Sharif and Shadman Alam with Student ID: 155401, 155421 and 155430 has been found as satisfactory and accepted as partial fulfillment of the requirement for the Degree, Bachelor of Science in Civil Engineering.

Supervisor

____

Prof. Dr. Md. Rezaul Karim
Professor
Head of the Department
Department of Civil and Environmental Engineering (CEE)
Islamic University of Technology (IUT)
Board Bazar, Gazipur, Bangladesh

DECLARATION

We hereby declare that the undergraduate research work reported in this thesis has been performed by us under the supervision of Professor Dr. Md. Rezaul Karim and this work has not been submitted elsewhere for any purpose (except for publication).

Saad Farooq	**Tabriz Tajwar Sharif**	**Shadman Alam**
(Student ID : 155401)	(Student ID : 155421)	(Student ID : 155430)

Prof. Dr. Md. Rezaul Karim
Professor
Head of the Department
Department of Civil and Environmental Engineering (CEE)
Islamic University of Technology (IUT)
Board Bazar, Gazipur, Bangladesh

DEDICATED TO

OUR BELOVED PARENTS

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"In the name of Allah, Most Gracious, Most Merciful"

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ABSTRACT

Drinking water is one of the most important factor related to human health as the intake of drinking water is a daily necessity that can't be avoided. However people going outside home for various purposes are unable to consume drinking water from their households and have to depend on outside sources such as restaurants and in some cases tea stalls. In Bangladesh, the water served in this outside sources are of questionable quality due to the lack of proper monitoring from the authority.

The objective of this study is to collect drinking water sample from these sources with a view to analyze the quality of water served. Both laboratory testing and field observation data are to be collected and analyzed. The study aims to develop a risk assessment system based on the data collected and assign the respective risk scores to the individual sources and to determine whether or not they pose health risk to the consumers and if yes, then to what degree of risk is posed by the sample. A study period from February 2019 to October 2019, when 173 water samples were collected from different restaurants and tea stalls located in Gazipur city. The field observation included both observation and questionnaire survey.

The primary results obtained from the experiment shows that most of the samples have water quality within the safe limits in case of physical and chemical parameters of laboratory testing. However, the bacteriological test values were unsatisfactory in most cases as they indicated very high probability of microbial contamination in most of the samples, indicating possible health risk. The observational parameter values in those cases indicates that the storage and hygiene condition of the restaurants are the probable reason for such contamination. A health risk scoring system was then developed and compared. Of the 173 samples. Only 46 samples (26.6%) were marked safe in overall values, the other samples were marked from slight to high health risks. Another important discovery from this study is that the absence of certain element and its ions (sulphate ions) in groundwater of the study area, except for the banks of Turag rivers. This may result from the infiltration of the water from the river which is known for being contaminated with industrial wastes. Further study on water infiltration is required to confirm this hypothesis.

Key words: Drinking water, water quality, health risk, coliform, contamination.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Water is the most essential element for any living being. Drinking water is one of the most common activities on a daily basis. But the safety of the drinking water is a major concern, specially for the human being. Access to safe drinking-water is essential to health, a basic human right and a component of effective policy for health protection. *The importance of water, sanitation and hygiene for health and development has been reflected in the outcomes of a series of international policy forums* (Guidelines for Drinking Water Quality, Fourth Edition, World Health Organization).

Not all of the water available around us are suitable for drinking. People tend to drink water from the best available sources, but due to unavailability they are sometimes forced to drink the unsafe water. The consumption of unsafe and contaminated water are the cause behind various diseases and epidemics. *In the developing countries, consumption of contaminated water is responsible for 80% of all diseases and hence, causes one third of deaths* (UNCED, 1992).

The working group of people tend to spend a major portion of the day outside their homes due to work. This is also the case for the people who are travelling for various purposes. These people often can't access pure drinking water from their homes. *For people working outside and travelling, restaurants and tea stalls are major sources of drinking water, but the water qualities are not maintained* (Sarker A., et. al., 2016).

Microbial contamination is the most vital type of contamination for drinking water which has a significant impact on health. Several studies found microbial contaminations as the major concern to be considered when analyzing drinking water quality. *Microbial contaminations of drinking water constitute a major burden on human health. Interventions to improve the quality of drinking-water provide significant benefits to health* (Sarker A., et. al., 2016). Drinking water being served on restaurants may get contaminated by microbial agents. The microbial condition of water is directly related to hygiene practice and sanitary condition of the restaurant. *Majority of the Hotels and households do not have sufficient understanding of hygienic practices regarding food, water and personal hygiene, particularly small towns* (Tadesse T., et. al., 2017).

However, in Bangladesh, the quality of the drinking water served in the restaurants are questionable. This is due to the fact that, the water quality and hygiene is not strictly maintained in most cases and there is almost no monitoring from the authorities.

With rise in job opportunities and migration in our study area, people depend a lot on restaurants for food and leisure. In case of a discussion on food or drink, the most important question that arises is “Health”. It is also a concern that whether the restaurants care about the health of the customers or not. Most restaurants face many problems in maintaining the safety and quality of food on a regular basis. One of the major causes of this problem is the low quality of water used for cooking and drinking.

Problems may arise in many ways. The building of the restaurant may have pipelines and taps contaminated with potential contaminants, or the source of the water may get contaminated. Therefore, it is very essential to check the Water Quality of your Restaurant.

The water quality of restaurants should be checked regularly because water quality of restaurants affects the health of the customers, good water quality ensures good health to customers. Also, good quality of drinking water help the restaurants in developing and maintaining the reputation and helps to deliver the best customer service and healthy food items.

1.2 Purpose and Objective of the Study

The purpose of this study is to get an overall idea of the drinking water quality served in the restaurants and tea stall of Bangladesh along with the hygienic condition of the environment of the restaurants.

The specific objectives of this study are:

- Study and analyze the physical, chemical and biological parameters of the drinking water samples served in restaurants and tea stalls

- Identify the probable reasons of any kind of contamination and assess the risks associated with human health

- Develop a health risk assessment system to check whether the consumption of drinking water from restaurants are safe or not

1.3 Scope of the Study

Several tasks that were performed to complete the objectives of the study. The tasks are mentioned below:

- Identify important hub points across the study area where the restaurants are located
- Identify the parameters that are related to the hygiene and sanitary condition of the restaurants
- Identify the popular restaurants, observe the hygiene and sanitary conditions of the restaurants
- Collect drinking water samples as per EPA guideline and transport them for laboratory testing
- Develop a questionnaire to assess the reliability of the drinking water served

1.4 Organization of the Thesis

The rest of the thesis has been organized as follows:

Chapter 2	:	**Literature Review –** this chapter discusses about the past works on similar type of study and will give idea on how the work plan should be done
Chapter 3	:	**Study area and data collection -** identifying the location of the study and collection of data from various locations of the study area
Chapter 4	:	**Methodology** – in this chapter the procedural steps of the study will be described thoroughly
Chapter 5	:	**Results and Discussions -** analysis of the data collected from field observation and through laboratory testing
Chapter 6	:	**Conclusions and Recommendations -** this chapter will discuss the effectiveness of the study, and recommendations of the future studies

CHAPTER 2
LITERATURE REVIEW

2.1 Previous works

Various works have been carried out by researchers in different area throughout the world to assess the condition of drinking water served in hotels and restaurants. Most of the works were carried out in major cities with larger population and the impact of microbial contaminants were given more importance. A study was carried out on the water quality conditions of the restaurants of Sylhet city of Bangladesh by Alam, R. et al. on 2005 to assess risks to human health. The investigation was based on questionnaire survey of restaurants and laboratory tests on water samples obtained from the restaurants. The study also analyzed water samples from the tube wells of the city and Surma River, the two main sources of water supply to the city. The test parameters were dissolved oxygen; conductance, hardness, pH, temperature, turbidity, essential and trace elements, dissolved and suspended solids and coliform bacteria. It was found that the drinking water of each restaurant was contaminated with fecal coliforms and 25% restaurants had unsafe levels of iron in the water supply. Statistical analysis based on Pearson's correlation coefficient revealed significant correlation between the extent of groundwater pollution and dumping of solid waste effluents in the immediate vicinity of ground water.

Another study was carried out in Sylhet city by Sarker A. et al. on 2016 focusing on the impact of microbial contaminants. The assessment was done by analyzing the microbial quality of water in the laboratory through MPN, TVC and total coliform test. The samples were obtained from different popular restaurants of Sylhet City Corporation, Bangladesh. The results obtained from this study revealed that all the water samples were fecal contaminated and had a great chance of contamination by other pathogenic bacteria and the results indicated that most of the samples were significantly positive to MPN test and TVC bacteria were highly significant.

On 2010 Nkere, C.K. et al. carried out a study on the water quality of restaurants and road-side vendors of Nsukka town, Enugu State, Nigeria. They found that the bacterial count in prepared food or water is a key factor in assessing the quality and safety of food. It also reveals the level of hygiene adopted by food handlers in the course of preparation of such foods. The comparative study evaluated the bacteriological quality of food and water consumed using three bacteria enumeration methods - the most probable number (MPN), lactose fermentation count (LFC), and Escherichia coli count (ECC) methods. *Escherichia coli* and *Klebsiella pneumoniae* were the two major coliforms obtained from the various food and drinking water samples, of which 79.6% were assumed to be of human origin. The results of the study indicates the importance of food-safety practices and regular education on food and personal hygiene among food vendors.

According to a study by Tambekar, D.H. et al. on 2005, contamination in drinking water is manmade and usually due to improper handling, storage and serving which leads to the serious water borne diseases. 340 drinking water samples were analyzed for bacterial contamination, out of them 69.1% were turned out to be non-potable by MPN method, 73.2% by MFT indicating the presence of *E. coli* and 18.2% showed presence of thermotolerant *E. coli* of human fecal origin. The study concluded that poor hygiene behaviors such as improper method of storage, handling and serving, deteriorates the quality of drinking water.

Another study was conducted by Nawas T. et al. in 2012 on Chittagong city of Bangladesh. The study aimed at examining the microbial quality of restaurant salad and the water used for salad preparation and their role as a source of antibiotic resistant bacteria. Samples were collected from 15 different restaurants located in Chittagong city. The range of Total Viable Count was 1.60×10^4 CFU/ml to 4.38×10^5 CFU/ml for the water used. Total colifrm and fecal coliform count > 1100 CFU/100 ml were found in 33.33% water samples. *Salmonella* was present in 46.67% of restaurant water. *Vibrio* was present in 53.33% of water. The results suggest the necessity to follow the hygienic practices in salad preparation and salad might have an important role as a source of multiple antibiotic resistant bacteria.

Vollaard, A.M. et al. carried out a study in 2004 on the food vendors of Jakarta, Indonesia as an extension of a previous work. Related researchers identified purchasing street food as an independent risk factor for paratyphoid. According to the study, eating from restaurants was not associated with disease. 128 street food-vendors was compared with 74 food handlers from restaurants to explain the findings in a cross-sectional study in the same study area. To conduct a logistic regression analysis, poor hand-washing hygiene and direct hand contact with foods was an independent characteristics. Fecal contamination of drinking water was found frequent in the study as it was found in 65% of samples. The study suggests focusing on general hygienic measures like hand washing with soap, adequate food-handling hygiene and frequent renewal of dishwater in street food trade to reduce transmission of foodborne illness.

Moniruzzaman, M. et al. conducted a study in 2011 on the microbial status of water from dispensers in different roadside restaurants of Dhaka city and Savar Area. 7 samples from Dhaka and 8 samples of Savar were collected and analyzed. The heterotrophic plate count was in a range of $1.0x10^3$ CFU mL^{-1} to $2.0x10^4$ CFU mL^{-1} (from new bottles), $1.0x10^3$ CFU mL^{-1} to $1.5x10^4$ CFU mL^{-1} (after dispensation) and $1.5x10^3$ CFU mL^{-1} to $1.0x10^5$ CFU mL^{-1} (from serving glass). Some of the samples showed the heterotrophic plate count was higher than the count in water from new bottle or after dispensation which suggests added contamination from the serving glass. This finding clearly indicates the poor washing condition of utensils. 80% of the samples were contaminated with total and fecal coliform bacteria. The samples were found to contain gram negative bacteria like E. coli, Shigella sp. etc. which are potential pathogens. The study reflects on the importance of monitoring the bottling companies and the restaurants to put them under strict regulations so that any kind of outbreak of any water borne diseases can be prevented.

2.2 Impact of Physical and Chemical Properties on Drinking Water

2.2.1 Effect of Chlorine & Turbidity

M W LeChevallier (1981) tried to define interrelationships between elevated turbidities and the efficiency of chlorination in drinking water. Experiments were performed to measure bacterial survival, chlorine demand, and interference with microbiological determinations. Experiments were conducted on the surface water supplies for communities which practice chlorination as the only treatment. Therefore, the conclusions of this study apply only to such systems. Results indicated that disinfection efficiency (log10 of the decrease in coliform numbers) was negatively correlated with turbidity and was influenced by season.

2.2.2 Effect of Nitrate & Sulphate

Kataria (2011) describes "*Fertilizers and pesticides are major contributors to water pollution, Nitrates from fertilizers are a common chemical pollutant of water. Heavy metals, sulphates, nitrates, chlorides, phosphates, carbonates, ammonia, pesticides, phenols, soaps, detergents are the common chemical pollutants. There are a number of pathogenic micro-organisms which cause water borne disease in man*."

The high concentration of sulphate may induce diarrhea and intestinal disorders. Excess amount of sulphate in water has cathartic effect of human health. Fluoride is essential for human beings as a trace element and higher concentration of this element causes toxic effects. Concentration of fluoride between 0.6-1.0 mg/l in potable water protects tooth decay and enhances bone development (Kundu et al., 2001).

2.2.3 Correlation between conductivity and total dissolved solid

Rusydi (2017) describes that Electrical Conductivity (EC) and Total Dissolved Solids (TDS) are frequently used as water quality parameters, especially in the coastal area. These two parameters are indicators of salinity level which make them very useful as one way in studying seawater intrusion. The value of EC and TDS are correlated. EC is the measure of liquid capacity to conduct an electric charge. Its ability depends on dissolved ion concentrations, ionic strength, and temperature of measurements. The dissolved ions concentration is usually measured as TDS.
TDS concentration can be simply calculated from the EC value. The correlation of these parameters can be estimated by the following equation

TDS (mg/L) = k x EC (μ S/cm)

The value of k will increase along with the increase of ions in water. However, the relationship between conductivity and TDS is not directly linear; it depends on the activity of specific dissolved ions average activity of all ions in the liquid, and ionic strength.

2.2.4 Effect of Ammonia

Ammonia is toxic to some fish and other aquatic organisms at concentrations below 1 mg/l (ppm) in water. Human beings and higher animals are less sensitive to ammonia in water, but long-term ingestion of water containing more than 1 mg/l (ppm) ammonia may be damaging to internal organ systems. Solutions having concentrations greater than 1000 mg/l (ppm) can cause severe burns and scarring of sensitive skin and mucous membranes. Household cleaning solutions usually contain between 3% and 30% ammonia, and pose severe hazard if ingested. As little as one teaspoonful of 10% ammonia solution can be lethal. Splashing into eyes can cause temporary or permanent blindness. (Technical Bulletin: Health Effects Information, Oregon Department of Human Services, January 2000)

2.2.5 Effect of Iron

R. Grazuleviciene et al. (2009) examined the impact of elevated exposure levels of pregnant women to manganese and iron through drinking water on pregnancy outcomes. Analysis yielded an increase in adjusted odds ratios (AOR) for term low birth weight (LBW) for moderate exposure level, 1.53 (95% confidence interval (CI) 0.89-2.66); and 1.70 (95% CI 1.07-2.71) for high exposure level. Maternal exposure was associated with a mean reduction of 21 g (SE, 9 g; p=0.02) in birth weight. No associations were observed between manganese and iron levels and preterm birth. These findings suggest that elevated levels of manganese and iron in drinking water are associated with a reduction in birth weight in term-born infants.

2.2.6 Effect of Hardness

Sengupta (2013) states that, hardness is important for drinking-water from the point of view of both aesthetic acceptability and operational considerations. Although, there is some evidence from epidemiological studies for a protective effect of magnesium or hardness on cardiovascular mortality, the evidence is being debated and does not prove causality. Further studies are being conducted. In spite of this, drinking-water may be a source of calcium and magnesium in the diet and could be important for those who are marginal for calcium and magnesium intake.

However, the health effects of hard water are mainly due to the effects of the salts dissolved in it, primarily calcium and magnesium. To a large extent, individuals are protected from excess intakes of calcium by a tightly regulated intestinal absorption mechanism through the action of 1, 25-dihydroxy-vitamin D, the hormonally active form of vitamin D. Although, calcium can interact with iron, zinc, magnesium, and phosphorus within the intestine, thereby reducing the absorption of these minerals. On the other hand, the major cause of hypermagnesemia is renal insufficiency associated with a significantly decreased ability to excrete magnesium.

2.3 Impact of Bacteriological Contamination on Drinking Water

2.3.1 Impact of *E. coli* in drinking water

(Ishii, 2008) refers that *Escherichia coli* is naturally present in the intestinal tracts of warm-blooded animals. Since *E. coli* is released into the environment through deposition of fecal material, this bacterium is widely used as an indicator of fecal contamination of waterways. (Ishii, 2008)

Franciska et al. (2005) tested the microbiological quality of drinking water from 144 private water supplies in the Netherlands and additionally the occurrence of Escherichia coli O157 was examined. Their result suggest that compliance with microbiological quality standards obtained in routine monitoring does not always guarantee the absence of pathogens. The presence of pathogens such as E. coli O157 may suggest possible health consequences; however, a risk assessment process should be performed as the monitoring of both faecal indicator parameters and pathogens do not predict the effect of microbial contamination of drinking water on a population.

Soller et al. (2010) tried to estimate the number of E. coli illnesses attributable to drinking water exposures in the United States and the feasible relationships between positive occurrences of the indicator bacteria E. coli and E. coli in drinking water Results of the modeling indicate that in undisinfected drinking water systems, the ratio of bacterial indicator E. coli positives to E. coli organisms is estimated to be between 6:1 and 90:1 with few model parameters accounting for the vast majority of the uncertainty. These results provide context for considering the potential public health implications of a positive E. coli result from routine monitoring of undisinfected drinking water.

2.3.2 Impact of Total Coliform in drinking water

The safety of drinking water is evaluated by the results obtained from faecal indicators such as Total Coliform during the stipulated controls fixed by the legislation. However, drinking-water related illness outbreaks are still occurring worldwide. The failures that lead to these outbreaks are relatively common and typically involve preceding heavy rain and inadequate disinfection processes.

Bacterial contamination of surface and groundwater is usually due to mixing of surface runoff passing through urban areas and pastures, leakage of sewage disposal systems and septic tanks, overloaded sewage treatment plants, disposal systems and raw sewage deep well injection (PCRWR, 2004).

Moreover, cross-connection, wrecked or leaking pipes, back siphonage (backflow of polluted or contaminated water, from a plumbing fixture or cross-connection into a water supply line, due to a lowering of the pressure in the line) and irregular water supply result in contamination of the distribution system (PCRWR, 2004; Shar et al., 2008b).

These microorganisms are the causative agents of waterborne diseases including diarrhoea, typhoid, Hepatitis A/E and other symptoms. Total and faecal coliforms found in our findings are in same line with the studies reported throughout Pakistan regarding drinking water of Hyderabad (Pak-EPA Report 2004), Rawalpindi (Farooq et al., 2008), Khairpur city (Shar et al., 2008) and Karachi city (Malick et al., 1998).

2.3.3 Impact of Fecal Coliform in drinking water

Figueras et al. (2010) describe about faecal coliform that these bacteria conform to all the criteria used to define total coliforms plus the requirement that they grow and ferment lactose with the production of acid at 44.5 ºC. For this reason, ―thermotolerant coliform‖ would be the scientifically accurate term for this group. Bacteria in this coliform subgroup have been found to have a positive correlation with fecal contamination of warm-blooded animals However, some thermotolerant coliform bacteria that conform to this definition also belong to the genus *Klebsiella* and have been isolated from environmental samples in the apparent absence of fecal pollution. Similarly, other members of the thermotolerant coliform group, including Escherichia coli, have been detected in some pristine areas, and associated with regrowth events in potable water distribution systems. Fecal coliforms display a survival pattern similar to these of bacterial pathogens but their usefulness as indicators of protozoan and viral contamination is limited, therefore, tended to be replaced by E. coli in several legislations.

2.4 Impact of Hygiene Practice on Drinking Water

Hygiene practices is important to be maintained in hotels and restaurants. *In the hotels, it is important to maintain the hygienic conditions for customer's health.* (Tambelkar and Banginwar, 2005). Poor hygiene practice and lack of proper infrastructure like proper drainage system, reliable source of drinking water may lead to serious health impacts. *Lack of social amenities and municipal utilities has, in no small measure, contributed negatively to poor personal and environmental hygiene of food vendors.* (Chukwuemeka K. Nkere, Nnenne I. Ibe, and Christian U. Iroegbu 2011).

Hazen (1988) studied on the drinking water and diarrhoeal disease due to E. Coli and reported that, prevention of fecal contamination prevents waterborne outbreaks. Drinking water might get contaminated during or after storage in container. Water may become contaminated at any point between collection, storage, serving or handling in hotels and retaurants. The potable water can easily be contaminated by incorrect method of storage, serving and handling practices. (Tambelkar and Banginwar, 2005)

Improper cleaning of utensils used for serving water may also cause serious threats. The contamination risk from unclean utensils is high, that can be from any type of food, not just water. *A further issue associated with child feeding that has been the focus of much work is the bottle-feeding of infants. Many studies in developing countries have shown bottle-feeding to be a major risk factor for diarrhoeal disease* (DeZoysa et al. 1991)

Also, the utensils must be kept clean to avoid further contamination. Improper handling of utensils is a reason for microbial contamination. Many studies found the drinking water serving utensils may add to the contamination. *In several of the samples, the heterotrophic plate count was higher than the count in water from new bottle or after dispensation, suggesting added contamination from the serving glass.* (Moniruzzaman, M. et al. 2011) Even if the source of the water is kept free of contamination, the storage of drinking water can also act as the source of secondary contamination*. Heterotrophic bacterial counts increase significantly after water is stored for four to seven days.* (Evison, L and Sunna, N. 2001). The storage condition, washing of utensils and source of drinking water is important to maintain proper hygienic condition at restaurants. *Contamination in drinking water is manmade and usually due to improper handling, storage and serving which leads to the serious water borne diseases.* (Tambelkar and Banginwar, 2005).

2.5 Importance of Health Risk Assessment

Health risk assessment can be a great screening tool for assessing health risk due to consumption of unsafe water. *Risk assessment helps scientist to evaluate risks associated with toxic pollutants and helps the government to set regulatory policies to govern the causes and effects of this toxic pollutants* (Adipah, S. 2018).

According to a study by Sylvia Adipah, in 2018, Risk assessment helps scientist to evaluate risks associated with toxic pollutants and helps the government to set regulatory policies to govern the causes and effects of this toxic pollutants. Public health agencies evaluate risk assessment to determine risk associated with risk exposure. Risk assessment is in four categories (1) hazard exposure, (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

CHAPTER 3
STUDY AREA AND DATA COLLECTION

This chapter discusses about the study area and the method of collection of data related to the study.

3.1 Study Area

Gazipur City Corporation is the largest city corporation of Bangladesh with a total land area of 329.53 square kilometers and a population of approximately 4,000,000.[1] The city also has great importance as many major national and regional highways passes through. Many major projects are also going on in the study area which may result in increase in population. The major highways that passes through the city are namely- Dhaka-Mymensingh highway, Dhaka-Tangail highway, Dhaka Bypass Highway, Tongi-Ghorasal highway. The bus stops on these highways act as hub point for both local people and people who passes through the city. Most of the restaurants are situated around these bus stops and people who board or alight from these bus stops are the major customers of these restaurants.

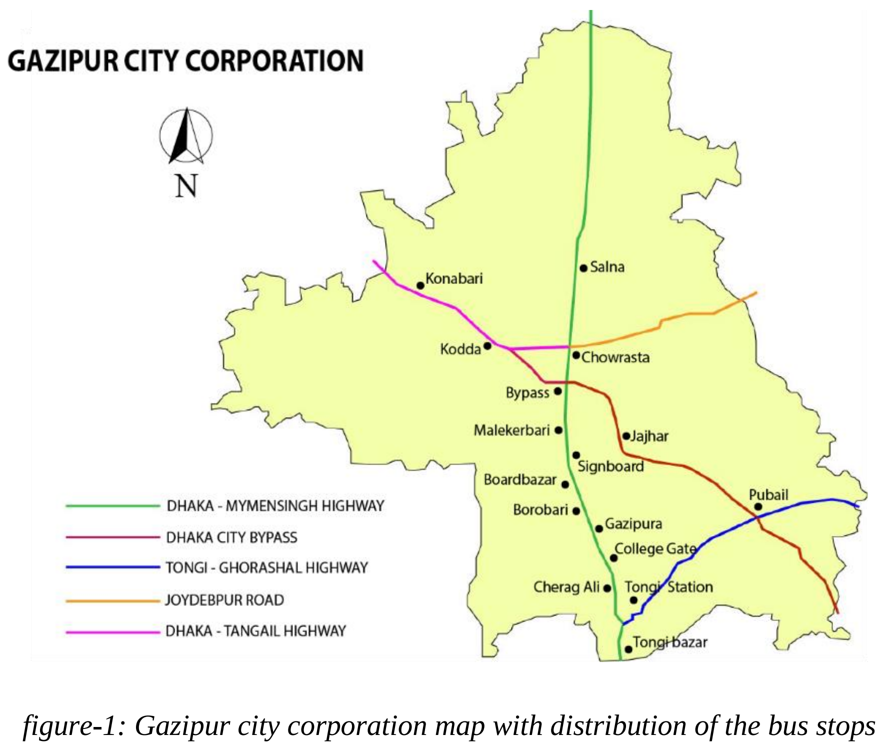

figure-1: Gazipur city corporation map with distribution of the bus stops

3.2 Data Collection

In this study, some of the most popular bus stops of Gazipur area had been selected and popular restaurants around these bus stops had been selected for field observation and drinking water sample collection. 18 such bus stops have been selected in total and a total of 173 restaurants have been observed and drinking water samples have been collected from all of them. The distribution of the bus stops from where the drinking water samples were collected are shown in the map in figure-1. Table-1 shows the number of restaurants corresponding to bus stops.

Table-1: List of samples collected from various bus stops

Sl. No.	**Area**	**No. of Restaurants**	**Sl. No.**	**Area**	**No. of Restaurants**
1	Tongi Bazar	10	10	Bypass	12
2	Tongi Station	11	11	Konabari	10
3	Cherag Ali	6	12	Kodda	3
4	College Gate	10	13	Chowrasta	15
5	Gazipura	10	14	Dhirasram	5
6	Borobari	10	15	Joydevpur	11
7	Boardbazar	21	16	Jajhar	11
8	Signboard	12	17	Shibbari	5
9	Malekerbari	5	18	Chyabithy	6
Total number of restaurants selected = 173					

To collect the drinking water sample from these restaurants, a standard guideline has to be followed. In this study, the EPA guideline was being followed. The detailed procedure of the study will be described on the next chapter.

CHAPTER 4

METHODOLOGY

This chapter will discuss the detailed procedure of the work that has been carried out. The whole process was be divided into four phases –

- Field Study
- Laboratory Testing
- Statistical Analysis
- Development of a Health Risk Assessment System

Field study incorporates three activities – field observation, questionnaire survey and sample collection. The first section of this chapter will reflect on field study process.

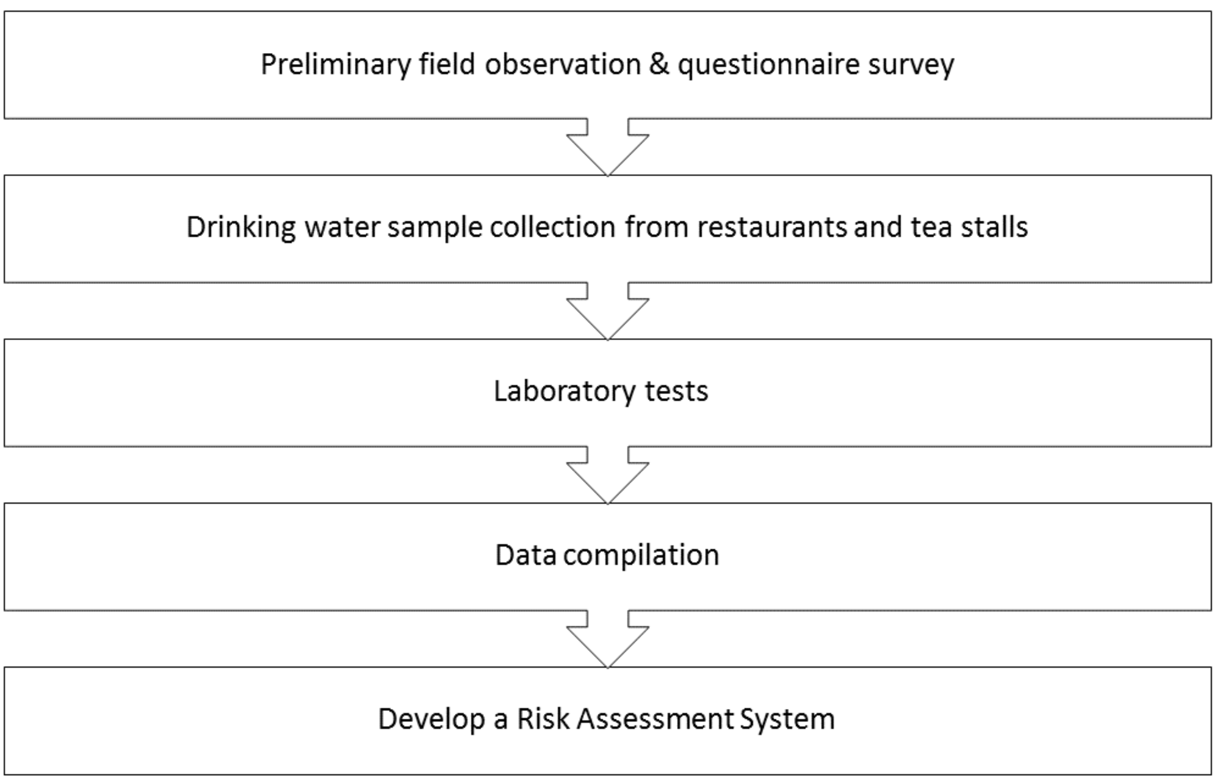

figure-2: Work plan flow chart for water quality assessment

4.1 Field Study

Drinking water samples that were collected from different restaurants were observed intensively. The sanitary condition of the restaurant, condition of the utensils used for serving water, estimated number of customers served daily etc. were considered. Also, a questionnaire was developed to assess the field conditions.

4.1.1 Questionnaire

A standardized questionnaire was used to obtain data from the restaurants. An idea on the estimated number of customers was obtained from the questionnaire along with the source of drinking water. Hygiene measures that were assessed were: Washing of utensils, storage condition of drinking water, how the water is served and waste water disposal method. The questionnaire is shown in Appendix A.

4.1.2 Field Observation

Field observation process was done by finding out the following information and assessing the following criteria:

- Source of drinking water
- Number of customers per day
- Washing of utensils
- Storage condition
- How the water is served

The information on the source of drinking water of the restaurants and tea stalls was acquired from the questionnaire. Groundwater and Jarwater are the main two sources of drinking water that are served in the restaurants and tea stalls. The ground water is extracted by both tube wells (hand-pumps) or submersible pumps. Many restaurants store the extracted groundwater in overhead tanks and use them directly from faucets. Such cases are noted as tap water as the characteristics of the water may get changed along with the storage condition.

Washing of utensils and drinking water storage condition of the restaurants and tea stalls were analyzed by qualitative approach. The cleanliness level of the utensils used for serving and storing water was graded as Good, Medium, Poor and Very Poor. Figure-3 shows a comparative illustration among the above mentioned category.

Good Medium Poor Very Poor

figure-3: A qualitative comparison among different levels of cleanliness of utensils

Jarwater indicates the local water suppliers who purifies water in industrial scale and sale them to their subscribers, generally in large, transparent PET plastic containers or jars. These jars are washed and reused every time after they are being used. Figure-4 shows some example of such containers.

figure- 4: transparent PET plastic containers or jars

The estimated number of daily customers was obtained from the questionnaire survey. The number of customers that visit a restaurant or tea stall depends largely on its location and capacity. The number of customer is a key factor for determining the risk level for the consumption of unsafe water.

4.1.3 Sample Collection Procedure

Various physical, chemical and bacteriological processes can affect a sample from the time of collection to that of analysis. Appropriate sampling equipment, containers and methods to preserve the sample was maintained throughout the study to minimize the effects on drinking water sample. The sampling of drinking water was done as per standard guideline. In this study, the Quick Guide to Drinking Water Sample Collection published by United States Environmental Protection Agency, Region 8 Laboratory September 2016 was followed to collect the drinking water samples from different restaurants.

The procedure of the collection of drinking water as described by EPA is briefly described here.

General Sampling Procedures

1. A Sampling and Analysis Plan (SAP) should be prepared which will describe the sampling locations, numbers and types of samples to be collected and the requirements to control the quality of the project.

2. The laboratory facility has to be checked before collecting samples to ensure that sampling equipment, preservatives and procedures for sample collection are acceptable. It is best to obtain sampling supplies directly from the laboratory performing the analyses. All equipment and supplies necessary for the project should be gathered before collection of sample.

3. Collect samples in an area free of excessive dust, rain, snow or other sources of contamination.

4. A cold water faucet should always be selected for sampling which is free of contaminating devices such as screens, aeration devices, hoses, purification devices or swiveled faucets. The

faucet should be clean. If the faucet is found to be in a state of disrepair, another sampling location should be selected.

5. Samples should be collected from such faucets which are high enough to put a bottle underneath, without contacting the mouth of the container with the faucet.

6. The faucet should be opened for 2 to 3 minutes to flush thoroughly. Longer times may be needed in case of lead distribution lines. Typically the water temperature will stabilize indicating the completion of flushing. Once the lines are flushed, the flow is to be adjusted to avoid splash.

7. The chain of custody form should be followed with the sample collection information. The site location, name of the sampler, date and time of collection, method of collection, type of analysis to be completed, and preservative in use are to be recorded.

Sampling for biological contaminants (Total Coliform and *E. coli*)

Any kind of attachment on the faucet should be removed and water should be allowed to flow for 5 or 6 minutes before sampling. The container must not be rinsed or overfilled. Hot water should never be sampled. The inside of the sample bottle or its cap must not be touched.

Outdoor faucets, faucets connected to pumps, pressure tanks or hot water heaters, new plumbing and fixtures or those repaired recently, faucets that hot and cold water come through, threaded taps, swing spouts, faucets positioned close to sink or ground, leaky faucets should be avoided for sampling for Total Coliform, if possible.

Sampling for unpreserved classic chemical constituents
(Color, Conductivity, Fluoride, Nitrate, Sulfate, Total Dissolved Solids, Turbidity)

i) Sampling Bottle: Plastic or glass bottles may be used, plastic is preferred.

ii) Preservation: Cool to ≤ 4 °C (≤ 39.2 °F)

iii) Holding Time: Most of these analytes have short holding times. Deliver samples to the lab the same day if possible or ship via overnight delivery. Check with the lab regarding the holding times for the specific analytes of interest.

The bottle and cap should be rinsed three times with sample water and the bottle to be filled within one to two inches from the top. Place the sample into a cooler with ice for immediate delivery or shipment to the laboratory.

Sampling for classical chemistry constituents requiring acid preservation as listed (Ammonia)

Sampling Bottle: Plastic or glass bottles may be used but plastic is preferred.
Preservative to Use Sulfuric Acid (H_2SO_4) to $pH < 2$
Holding Times: 28 days

Check with the laboratory on the sample volume required for analysis. Wear gloves and eye protection when handling acids and while collecting samples. If the bottle contains a preservative, do not rinse the bottle. If the preservatives are not included in the bottle, rinse the bottle and cap three times with sample water, fill the bottle, and then carefully add the preservatives following the instructions provided by the laboratory. The bottle should be filled to within one to two inches from the top. Deliver or ship the sample to the laboratory.

Sampling and colorimetric analysis for disinfectant residuals (Free Chlorine)

Sampling bottle: Glass test tubes are generally used.
Preservative to Use: None
Holding Times: Analyze Immediately On-Site

There are several approved methods are for analysis of disinfectant residuals. A common method is the DPD Colorimetric Method (*Standard Methods*, 18th edition or later 4500-Cl G). Test kits for the DPD method are available commercially.

4.2 Laboratory testing

To conduct the study, the collected drinking water samples were tested in the laboratory. In total 17 different tests were carried out under following categories:

- Physical parameters
- Chemical parameters
- Bacteriological parameters

4.2.1 Physical parameters

The objective of these test were to find the physical condition of the water in various aspects. The tested parameters are:

1. pH: In terms of chemistry, pH is a scale used to specify how acidic or basic a water-based solution is. Acidic solutions have a lower pH, while basic solutions have a higher pH.

2. Color: Pure water has no color. However, in drinking water slight amount of color maybe visible due to the presence of various pigment particles. These particles are measured in the Pt-Co (Platinum - Cobalt) unit.

3. Turbidity: Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. It is measured in Nephelometric Turbidity Unit (NTU)

4. Dissolved Oxygen (DO): Dissolved oxygen (DO) is a measure of how much oxygen is dissolved in the water - the amount of oxygen available to living aquatic organisms. It's measured in mg/l

5. Total Dissolved Solid (TDS): Dissolved solids refer to any minerals, salts, metals, cations or anions dissolved in water. Total dissolved solids (TDS) comprises of two parts: Fixed Suspended Solids and Volatile suspended solids. In together, they comprise of inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some small amounts of organic matter that are dissolved in water. (Water Testing: Total Dissolved Solids Drinking Water Quality by Brian Oram, Professional Geologist (PG), Water Research Center, B.F. Environmental Consultants Inc., Dallas)

6. Electrical Conductivity (EC): Electrical conductivity is the measure of the amount of electrical current a material can carry or it's ability to carry a current. Pure water is not a good conductor of electricity. Because the electrical current is transported by the ions in solution, the conductivity increases as the concentration of ions increases. Hence EC is directly proportional to TDS. Its unit is µS/cm.

4.2.2 Chemical parameters

The chemical parameters were tested to find out the amount of various chemical compounds and metallic ions in the water. The measuring unit of all the chemical parameters are mg/L. The tested parameters are:

1. Free chlorine: Free Chlorine is the amount of chlorine that has not yet combined with water to sanitize contaminants. In effect, free chlorine is the amount of chlorine that is free to kill harmful microorganisms in the water where it is present.

2. Fluoride: Fluoride is an inorganic, monatomic anion with the chemical formula F^-, whose salts are typically white or colorless. Fluoride salts typically have distinctive bitter tastes, and are odorless. (https://pubchem.ncbi.nlm.nih.gov/compound/Fluoride-ion)

3. Hardness (as $CaCO_3$): Hardness is most commonly expressed as milligrams of calcium carbonate equivalent per litre. *Water containing calcium carbonate at concentrations below 60 mg/l is generally considered as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard* (McGowan, 2000).

4. Iron: Iron can be a troublesome chemical in water supplies. Water containing ferrous iron is clear and colorless because the iron is completely dissolved. When exposed to air in the pressure tank or atmosphere, the water turns cloudy and a reddish brown substance begins to form.

5. Manganese: Manganese is a mineral that naturally occurs in rocks and soil and may also be present due to underground pollution sources. Manganese is seldom found alone in a water supply.

It is frequently found in iron-bearing waters but is more rare than iron. (https://www.freedrinkingwater.com/water_quality/chemical/water-problems-manganese.htm)

6. Nitrate: Nitrate in water is undetectable without testing because it is colorless, odorless, and tasteless. A water test for nitrate (lab) is highly recommended for households with infants, pregnant women, nursing mothers, or elderly people.

7. Sulphate: In chemistry, a sulphate is a salt of sulphuric acid. The sulphate ion is a group of atoms with the formula SO_4 and two negative charges. Sulfate minerals can cause scale buildup in water pipes similar to other minerals and may be associated with a bitter taste in water that can have a laxative effect on humans and young livestock.

8. Ammonia: Ammonia is a compound of nitrogen and hydrogen with the formula NH_3. Ammonia is a colorless, pungent gaseous compound that is highly soluble in water. It is a biologically active compound found in most waters as a normal biological degradation product of nitrogenous organic matter (protein).

4.2.3 Bacteriological parameters

The bacteriological parameters are by far the most important among all the parameters. In this study, the presence of Total Coliform, Fecal Coliform and *E. coli* were tested. They are described as follows:

1. Total Coliform: If a laboratory test detects only total coliform bacteria in drinking water, the source is probably environmental and fecal contamination is unlikely. If total coliform is present, the lab also tests the sample for E. coli. The bacteria itself is not considered harmful, however the coliform bacteria in drinking water can indicate a possible presence of harmful, disease-causing organisms

2. Fecal Coliform: The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. These bacteria indicate the presence of sewage contamination of a waterway and the possible presence of other pathogenic organisms.

3. *E. coli* : *Escherichia coli* or *E. coli* is a type fecal coliform bacteria that is commonly found in the intestines of animals and humans. *E. coli* in water is a strong indicator of sewage or animal waste contamination. Confirmation of E. coli in a water system indicates recent fecal contamination, which may pose an immediate health risk to anyone who consumes the water.

4.3 Health Risk Assessment System

Health risk assessment system will incorporate three key elements –

- A questionnaire
- A risk calculation or score system
- Feedback to consumers

The main purpose of establishing a Health risk assessment system is to estimate the level of health risk. Also to inform and provide feedback to consumers to motivate behavior change to reduce health risks. Establishing a Health risk assessment system may require weight factors for each parameters that may have score based point calculation system and a combined Scoring system for both field data and experimental data.

4.3.1 Calculation of Total Risk Point

A total risk point is to be developed for establishing the levels of risk. Risk points will be derived for field observation parameters and laboratory test parameters separately and then it will be combined to get the Total Risk Point. So, Total Risk Point is the risk point of the drinking water served by a restaurant or tea stall for both of its hygiene conditions (from field observation) and laboratory test data.

Risk Points from Field Observation, FORP = $\sum$ (Risk point × Weighted factors)

Risk Points from Laboratory Tests of Physical and Chemical parameters,

LTRP = $\sum$ (Risk point × Weighted factors)

Risk Points from Laboratory Tests of Biological parameters,

BRP = $\sum$ (Risk point × Weighted factors)

Here, each parameter is multiplied by its individual weight factors

Therefore,

Total Risk point, $R = f_f \times FORP + f_l \times LTRP + f_b \times BRP$

Here,

FORP = Field Observation Risk Point

LTRP = Laboratory Testing Risk Point

BRP = Bacteriological Risk Point

f_f = Weight factor of FORP

f_l = Weight factor of LTRP

f_b = Weight factor of BRP

Value of Weight Factors

The value of f_f , f_l and f_b will depend upon the condition of the source of the water as obtained from laboratory test data as well as the data obtained from field observation. For example, if the condition of the drinking water sample is found okay from the laboratory testing data but the condition as observed on field is poor, it is possible that the contamination may happen due to poor hygiene practice. So, in this case, the value of f_f will be higher than f_l or f_b. On the other hand, if hygiene is practiced properly in restaurants but the drinking water served is coming from contaminated source, the impact of field observation will not be that effective. In such case, the laboratory testing will yield such results that will indicate the drinking water sample as hazardous. So, in this case, the value of f_l or f_b will be higher than f_f. The values of f_f , f_l and $f_{b,}$ should be taken on a scale of 5.

4.3.2 Risk Scores for Observational Parameters

The health risk associated with the observational parameters were based on a few factors, e.g. customer number, cleanliness of utensils, overall hygienic conditions etc. The risks were assigned increasing scores with the increase of risk, i.e. 0 = no risk, 5 = maximum risk. However, since different parameters poses different levels of threat, so they were given individual weight factors according to their importance.

Table-2: Weight factors for observational parameters

Parameter	Weight Factors
No. of Customers	4
Source of Water	3
Storage Condition	5
Washing of utensils	4

Table-3: Risk points for various number of customers

No. of Customers	Risk Point
50 -100	1.5
101-150	2.5
151-200	3
201-300	4
301-400	4.5
400+	5

Table-4: Risk points for observational parameters

Source of Water	Risk Point	Storage Condition	Risk Point	Washing of Utensils	Risk Point
Tapwater	3	Good	0	Good	0
Deep TW	1	Medium	1.5	Medium	1.5
Jar Water	1.5	Poor	3	Poor	3
Surface Water	5	Very Poor	5	Very Poor	5

Risk points of different observational parameters are shown in table-3 and table-4. Table-2 shows the weight factors for different parameters. To get the value of total FORP, the risk points are to be multiplied by their weight factors and summed up. For example, the following data were observed from sample ID RSI04 (Appendix C), Total no. of daily customers is around 300, source of the water is tapwater, washing of utensils and the storage condition is rated as good.

So, the FORP of the restaurant is,

FORP = wf x (RP of No. of Customers) + wf x (RP of Source of Water) +

wf x (RP of Storage Condition) + wf x (RP of Washing of Utensils)

= 4 x 4 + 3 x 3 + 5 x 0 + 4 x 0

= 25

4.3.3 Risk Scores for Laboratory Test Parameters

The health risk associated with the laboratory test parameters were based on a few factors, e.g. amount of the component present, range of safety i.e. whether within safe limit of not etc. The risks were assigned increasing scores with the increase of risk, i.e. 0 = no risk, 5 = maximum risk. However, since different parameters poses different levels of threat, so they were given individual weight factors according to their importance.

Table-5: Risk points for bacteriological parameters

Bacteriological parameter values (CFU/ 100ml)	Risk Points
0	0
1-500	2.5
501-1000	3
1001-1500	3.5
1501-2000	4
2001-2500	4.5
2500+	5

Table-6: Risk points for physical/chemical parameters

Physical/Chemical Parameter Values	Risk Points
Maximum safe limit (x)	0
1.25x	1
1.50x	2
1.75x	3
Twice the maximum safe limit (x)	4
3x and above	5

Risk points of different laboratory test parameters are shown in table-5 and table-6. Table-7 shows the weight factors for different parameters. To get the value of total LTRP, the risk points are to be multiplied by their weight factors and summed up. For example, the following data were observed from sample ID RSI04 (Appendix B),

Sample ID	pH	Color	Turbidity	DO	TDS	EC	Chlorine (Residual)	Fluoride	Hardness (as CaCO3)	Iron	Manganese	Nitrate	Sulfate	Ammonia	TC	FC	E. coli
RSI04	7.37	10	0.58	5.28	201	420	0.06	0.23	18	0.08	0.06	0.3	0	0.2	300	200	100

Table-7: Weight factors for laboratory test parameters

	Parameter	Weight Factor	Parameter	Weight Factor	Parameter	Weight Factor
Laboratory Testing Parameter	Free Chlorine	3.5	Fluoride	2.5	DO	2
	Iron	1	pH	2	TC	5
	Sulfate	1	Color	1	FC	5
	Nitrate	4.5	Turbidity	3	E. Coli	5
	Ammonia	4	TDS	2		
	Manganese	2.5	Hardness	2.5		

So, the LTRP of the restaurant is,

LTRP = wf x (RP for pH) + wf x (RP for color) + wf x (RP for turbidity)
+ wf x (RP for DO) + wf x (RP for TDS) + wf x (RP for Free Cl)
+ wf x (RP for Fluoride) + wf x (RP for Hardness) + wf x (RP for Iron)
+ wf x (RP for Mn) + wf x (RP for Nitrate) + wf x (RP for Sulfate)
+ wf x (RP for Ammonia)
= 2 x 0 + 1 x 0 + 1 x 0 + 2 x 0 + 2 x 0 + 3.5 x 0 + 2.5 x 0 + 2.5 x 0 + 1 x 4 + 2.5 x 0
+ 4.5 x 0 + 1 x 0 + 4 x 0
= 4

BRP = wf x (RP for TC) + wf x (RP for FC) + wf x (RP for *E.coli*)
= 5 x 2.5 + 5 x 2.5 + 5 x 2.5
= 37.5

So, if we consider the values 3, 1 and 5 for f_f, f_l and f_b respectively as mentioned in section 4.3.1, the total risk point of the sample RSI04 will be,

Total Risk point, R = f_f × FORP + f_l × LTRP + f_b × BRP
= 3 x 25 + 1 x 4 + 5 x 37.5

= 266.5

4.3.4 Risk point categorization

For categorizing the risk points into various groups according to health risk, at first the maximum and minimum value of R is determined at first and the range is divided into various groups.

Here, Total R = f_f × FORP + f_l × LTRP + f_b × BRP

Maximum R = f_f × FORP + f_l × LTRP + f_b × BRP

$FORP_{max}$ = No. of Customers ×4 + Source of Water × 3 + Storage Condition × 5 +

Washing of utensils ×4

= 5×4 + 5×3 + 5×5 + 5×4

= 80

$LTRP_{max}$ = Free Chlorine × 3.5 +Iron ×1 + Sulfate ×1 + Nitrate ×4.5 + Ammonia ×4

+ Manganese × 2.5 +Flouride×2.5 + pH ×2 + Color ×1 + Turbidity ×3 + TDS ×2 +

Hardness ×2.5 + DO ×2

= 5×3.5 + 5×1 + 5×1 + 5×4.5 + 4×5 + 5×2.5 + 5×2.5 + 2×5 + 5×1 + 3×5 + 5×2 + 5×2.5

+ 5×2

= 124.5

BRP_{max} = TC ×5 + FC × 5 + E. Coli × 5

= 5×5 + 5×5 + 5×5

= 75

Then, R_{max} = f_f × $FORP_{max}$ + f_l × $LTRP_{max}$ + f_b × BRP_{max}

= 3×80 + 1 × 124.5 + 5×75

= 739.5

= 740 (rounding up)

Now, for the calculation of R_{min}, we will get the value of $LTRP_{min}$ & BRP_{min} as 0 since all the parameters in them has minimum value as 0. So only $FORP_{min}$ is to be calculated.

$$FORP_{min} = \text{No. of Customers} \times 4 + \text{Source of Water} \times 3 + \text{Storage Condition} \times 5 + \text{Washing of utensils} \times 4$$

$$= 1.5 \times 4 + 1 \times 3 + 0 \times 5 + 0 \times 4$$

$$= 9$$

$LTRP_{min} = 0$

$BRP_{min} = 0$

Then , $R_{min} = f_f \times FORP_{min} + f_l \times LTRP_{min} + f_b \times BRP_{min}$

$$= 3 \times 9 + 1 \times 0 + 5 \times 0$$

$$= 27$$

So, the minimum value of total risk point in this risk assessment system is 27 and the maximum possible total risk point is 740. Analyzing the possibility of microbial contamination in the water, it is found that a sample having total risk point near to maximum 137 will have no microbial contamination. To secure the safety, total risk point 120 is considered as the highest safe limit.

Table-8: Risk point Index of Water Quality

Risk Point (R)	Comments
27 - 120	Safe
121 – 275	Slight health risks
276 – 430	Moderate health risks
431 – 585	High health risk
586 - 740	Very high health risk

CHAPTER 5

RESULTS AND DISSCUSSIONS

In this chapter, the outcome of the laboratory test results and also the observational parameter values obtained has been discussed in detail. From the data, the maximum, minimum values, variances etc. has been calculated for various parameters and then compared with standard values. Also, the health risk values has been assessed.

5.1 Observational Parameter results

The data obtained from field observation was compiled into a single database (Appendix C). Total collected data was from 173 restaurants. The data was analyzed based on four parameters e.g. no. of customers, source of water, storage condition and washing of utensils. The following figures represent the numerical amounts of the parameters from the 173 restaurants and tea stalls.

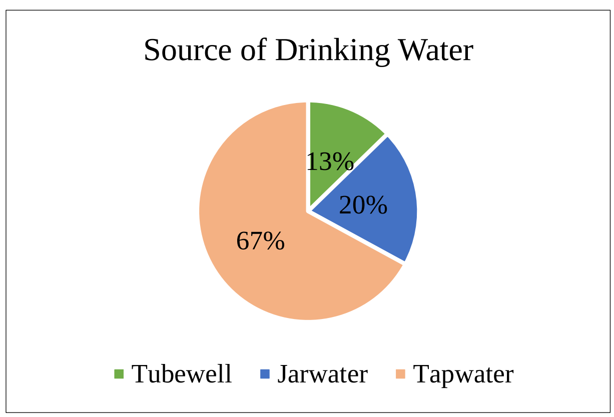

Figure-5: Classification of Restaurants based on source of water

Most of the restaurants and tea stalls in the study area use groundwater as the source of water. Most of them (116 out of 173, 67%) use electric pumps to extract the groundwater directly and store them in overhead tanks and then supplied through pipelines and faucets. These are characterized as tap water as the probability of contamination in such cases are more likely to happen. Only 22 restaurants and tea stalls (13% of total) were found to use water directly extracted from tube wells. 20% of the restaurants and tea stalls (35 out of 173) uses water from suppliers. Use of Dispensers can also be seen (7% cases). So, 80% of the restaurants and tea stalls, which were being observed, are directly dependent on groundwater for water supply.

Number of Daily customers is an important factor as the impact on public health will surely depend on how much population is affected by unsafe condition of drinking water.

Storage condition and washing of utensils were assessed by qualitative approach as described in previous chapter. The condition of jugs, bottles or drums where water is stored were examined and graded as good, moderate, poor or very poor. 44 out of 173 (25%) restaurants and tea stalls were graded as good, 83 as moderate (48%) and 46 as poor (27%) on the basis of storage condition. Figure- 6 shows the graphical representation of the data. Washing of utensils was also examined and graded. 45 out of 173 (25%) restaurants and tea stalls were graded as good in terms of washing of utensils, 92 was found moderately clean. 33 out of 173 was in poor condition with stains all over the glasses where water was served. 3 restaurants and tea stalls were turned out to have a very poor condition of utensils. The result is shown in figure- 7.

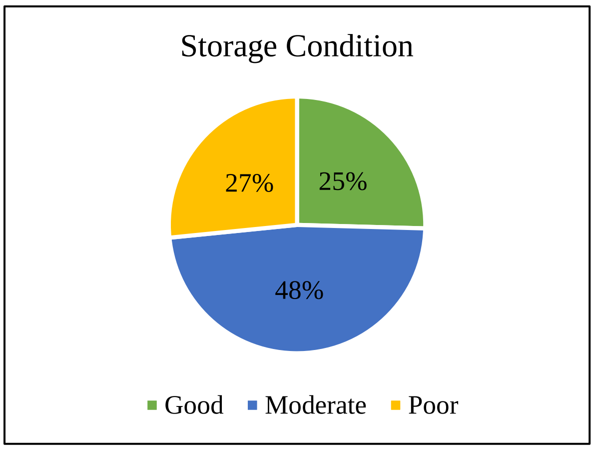

Figure-6: Classification of Restaurants based on hygienic condition and cleanliness

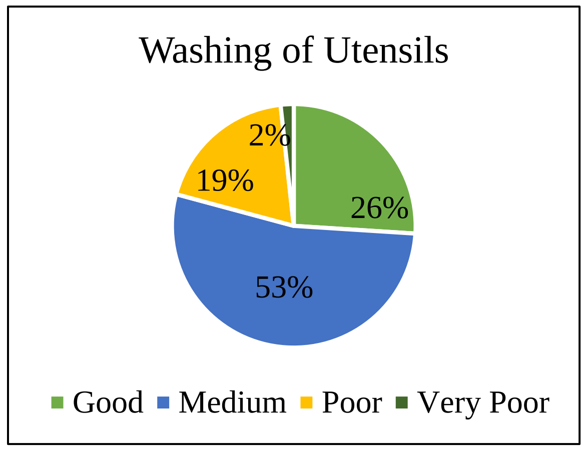

Figure-7: Classification of Restaurants based on storage condition of water

Classification of restaurants and tea stalls on the basis of the number of customers is shown in figure-8. Majority of the restaurants have a number of daily customers in between 200 and 250. The customers visit these restaurants in daily, weekly or monthly frequency.

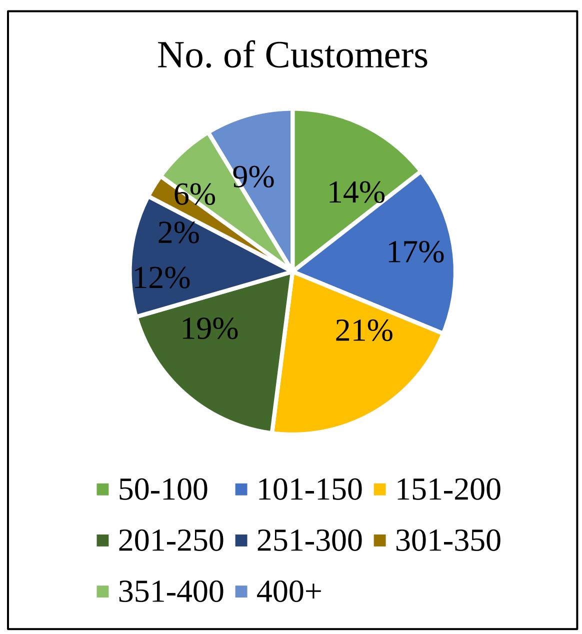

Figure- 8: Classification of Restaurants based on Number of customers per day

5.2 Experimental Parameter results

The samples collected from the Restaurants and Tea stalls were tested in the laboratory for physical, chemical and bacteriological parameters mentioned in article 4.2 of this book. The following table contains the summary of the experiment results.

Table-9: Comparison of average, maximum and minimum value with standard

Sample Values		Average value	Max. value	Min. value	WHO standard value	ECR 1997 standard value	Remarks
Physical Parameters							
	Unit						
Temperature	°C	27.83	31.5	25.7	-	-	-
pH	_	7.28	8.27	6.62	6.5-8.5	6.5-8.5	Within Range
Color	Pt-Co	15.39	90	0	15	15	Average value Slightly above range, individual samples above range
Turbidity	NTU	1.01	9.93	0.04	-	10	Within Range
DO	mg/L	6.91	7.65	5.28	-	6	Above range
TDS	mg/L	277.67	590	121	600 - 1000	1000	Within Range
EC	µS/cm	462.22	596	257	-	-	-
Chemical Parameters							
Free Chlorine	mg/L	0.07661	0.53	0	5	0.2	Within Range
Fluoride	mg/L	0.31012	1.28	0	1.5	1	Within Range
Hardness	mg/L as $CaCO_3$	71.0976	188	20	-	200-500	Below range
Iron	mg/L	0.11443	1.02	0	-	0.3 - 1.0	Average value below range, individual samples above range
Manganese	mg/L	0.19389	0.65	0	0.4	0.1	Average value within range,

							individual samples above range
Nitrate	mg/L	0.37841	3.4	0	50	10	Within Range
Sulfate	mg/L	0.47683	3	0	-	400	Within Range
Ammonia	mg/L	0.11073	0.29	0	1.5[a] 3.5[b]	0.5	Within Range
Bacteriological Parameters							
Total Coliform	cfu/100mL	453.659	2300	0	0	0	Above range
Fecal Coliform	cfu/100mL	236.585	1300	0	0	0	Above range
E. Coli	cfu/100mL	156.627	1300	0	0	0	Above range

Data from some of the major parameters were categorized on an area basis on the level obtained from the experiment. These data shows that in most of the cases, the value are within the safe limits. However there are some values that are slightly or well above the safe values and poses health risks.

Some of the parameters has shown interrelation among themselves, e.g. i) the amount of one increases with the increase of other, or ii) inverse relation, i.e. amount of one decreases with the increase of the other.

5.3 Results from Health Risk Assessment System

The risk assessment system has yielded a quite astonishing result indicating 26.59% restaurants and tea stalls as safe and the rest were marked from slight to high health risks. The low rate of safe restaurants indicate that the overall hygienic condition of the restaurants and tea stall in the study area, Gazipur is of poor category. Although the system did not detected any restaurant or tea stall with drinking water having very high health risk. The maximum risk point obtained was 486.5 and the minimum risk point obtained was 38.5. The complete chart of risk points are shown in appendix D.

Table-10: Health risk assessment results

Risk Point (R)	Comments	No. of Restaurants and Tea Stalls
27 - 120	Safe	46
121 – 275	Slight health risks	61
276 – 430	Moderate health risks	55
431 – 585	High health risk	11
586 - 740	Very high health risk	0

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

In this chapter the outcomes of the study has been summarized. The effectiveness of the study and how people can be benefitted from the study have also been discussed in short. Possible enhancements of this study have been discussed in short. Possible enhancement of the study and further recommendations have also been mentioned here.

6.1 Summary

The objective of this study was to find about the drinking water qualities served in the restaurants and tea stalls. The main focus was to find the hygienic condition and the overall environment of the restaurants and the health risk factor associated with water quality available. The study has focused on both the observational parameters as well as the experimental outputs.

From the experimental data, it has been found that the overall conditions in case of physical and chemical parameters are mostly found to be satisfactory, i.e. they were within the safe limits as per suggested by the guideline. Although there were samples where certain parameters had values higher than the safe limits, but the former has been held true otherwise. Also, some particular chemical parameters has been shown to dominate in some areas. This maybe concluded that, the groundwater of different areas may contain varied amount of chemical components. An interesting observation in this regard is that, no sulphate ion was found in anywhere of the study area except for the outskirt zone at the bank of Turag river. This maybe caused by the infiltration of chemicals carried by Turag river into the adjacent groundwater.

The bacteriological parameters are where the main health risk concern arise. Majority of the samples have been found to contain indicator organisms in very high amounts, well above the safe limit, and thus offering potential health risk. However, from the observational data, it maybe hypothesized that the unhygienic condition of storage or serving of water are the key reasons behind faecal contamination. Thus the major health risk is associated with the storage and utilization of water rather than the source of the water in most cases.

The health risk model has been developed using the data available at hand, based on the guideline values of the safe limits of each parameter. However, the data related to what amount of contaminant poses what degree of health risk is not yet properly developed. Also, the immunity to diseases vary person to person, which has been ignored to avoid complexity. Hence further development of the current model is necessary.

6.2 Recommendations

Based on the results obtained from the study and the limitations observed, some further study can be conducted on the following topics:

a. How the river water from Turag river affects the adjacent groundwater to be contaminated and contain sulphate ions.
b. To develop the existing health risk model to a full scale "Water Quality Index". For this purpose, the health risk associated with the gradual increase of any parameter has to be taken into account individually. Also the effect of different doses of contaminants on people of various age groups are to be considered. For developing such an index, the consultation with health experts maybe required for some cases.

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APPENDIX A

Sample of the questionnaire presented to the restaurant owners and customers to collect data through field observation

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

A subsidiary organ of Organization of Islamic Cooperation (OIC)

Sample ID:	
Date:	**Time:**

Area:	
Name of Restaurant:	
Address:	

Customer Count

1. **What is the average number of customers you get in a single day?**
   a) Within 50
   b) 50-100
   c) 100-300
   d) Over 300

2. **What age range do most of your customers fall under?**
   a) Below 18
   b) 19-30
   c) 30-50
   d) Over 50

Source of Water

3. **What is the source of water?**
   a) Shallow Tubewell
   b) Deep Tubewell
   c) Supply line
   d) Jar Water

e) Others (Please specify)

4. How is the water being served?
a) Bottled water
b) Jug and mug
c) Water purifier machine
d) Others (please specify)

5. Have you previously served water from other sources?
a) No
b) Yes (please specify)

6. **Please provide any additional comments for water usage.**

Hygiene Concerns

7. How is the hygiene maintained?
a) Purifier
b) Boiling
c) Other methods (please specify)
d) No methods adopted for hygiene

8. Do workers use gloves?
a) Yes
b) No
c) Sometimes
d) Never

9. Where and how the wastes are disposed?

10. Are the glasses (in which water is served) washed with proper cleaning?
a) Yes
b) No
c) Sometimes
d) Never

APPENDIX B

Laboratory test data of the restaurants and tea stalls

			Physical						Chemical								Bacteriological		
		Parameter	pH	Color	Turbidity	DO	TDS	EC	Chlorine (Residual)	Fluoride	Hardness (as CaCO3)	Iron	Manganese	Nitrate	Sulfate	Ammonia	Total Coliform	Fecal Coliform	E. Coli
			-	Pt-Co	NTU	mg/L	mg/L	μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	cfu/100 mL	cfu/100 mL	cfu/100 mL
1. Tongi Bazar	1	RTB01	6.62	44	1.65	5.28	198	420	0.02	0.72	20	0.04	0.471	0.2	0	0.14	0	0	0
	2	RTB02	7.4	6	1.03	6.55	187	384	0.2	0.92	46	0.06	0.019	0.03	1	0	100	0	0
	3	RTB03	6.96	18	0.36	6.72	181	380	0.04	0.03	35	0.11	0.022	0.22	1	0.13	100	0	0
	4	RTB04	7.2	16	0.42	7.07	167	347	0.1	0.63	38	0.02	0.236	0.5	2	0.06	200	100	0
	5	RTB05	7.28	3	0.3	7	187	388	0.3	0.84	33	0.07	0.159	0.1	3	0.14	300	100	100
	6	RTB06	7.23	6	0.41	6.31	189	392	0.01	0.78	41	0.06	0.012	0.4	2	0	0	0	0
	7	RTB07	7.1	2	0.24	6.32	121	327	0.03	0.06	21	0.17	0.011	0.3	1	0.07	0	0	0
	8	TTB08	7.29	19	2.84	6.97	150	313	0.15	0.42	42	0	0.058	0.3	2	0.13	200	0	100
	9	TTB09	7.12	11	0.49	7.14	124	257	0.3	0.03	30	0.03	0.056	0	0	0.29	0	0	0
	10	TTB10	6.86	30	0.74	6.72	200	417	0.12	0.36	34	0	0.326	0.6	3	0.16	400	200	100
2. Tongi Station	11	RTS01	6.62	44	1.65	5.28	198	420	0.02	0.72	20	0.04	0.471	0.2	0	0.14	0	0	0
	12	RTS02	7.4	6	1.03	6.55	187	384	0.2	0.92	46	0.06	0.019	0.03	1	0	100	0	0
	13	RTS03	6.96	18	0.36	6.72	181	380	0.04	0.03	35	0.11	0.022	0.22	1	0.13	100	0	0
	14	RTS04	7.2	16	0.42	7.07	167	347	0.1	0.63	38	0.02	0.236	0.5	2	0.06	200	100	0
	15	RTS05	7.28	3	0.3	7	187	388	0.3	0.84	33	0.07	0.159	0.1	3	0.14	300	100	100
	16	RTS06	7.23	6	0.41	6.31	189	392	0.01	0.78	41	0.06	0.012	0.4	2	0	0	0	0
	17	RTS07	7.1	2	0.24	6.32	121	327	0.03	0.06	21	0.17	0.011	0.3	1	0.07	0	0	0
	18	RTS08	7.31	9	0.32	6.85	156	326	0.21	0.02	37	0	0.014	0.8	2	0.04	0	0	0
	19	TTS09	7.29	19	2.84	6.97	150	313	0.15	0.42	42	0	0.058	0.3	2	0.13	200	0	100
	20	TTS10	7.12	11	0.49	7.14	124	257	0.3	0.03	30	0.03	0.056	0	0	0.29	0	0	0
	21	TTS11	6.86	30	0.74	6.72	200	417	0.12	0.36	34	0	0.326	0.6	3	0.16	400	200	100
3. Cherag Ali	22	RCA01	6.97	6	1.52	6.94	190	394	0.06	0.13	68	0.13	0.35	0.3	0	0.18	300	100	200
	23	RCA02	7.31	15	0.58	6.79	220	462	0.06	0.31	70	0.08	0.24	0.3	0	0.07	200	0	0
	24	RCA03	6.96	18	0.25	7.03	235	487	0	0.15	54	0.06	0.01	0.1	0	0.14	1000	600	200
	25	RCA04	7.18	23	0.89	7.21	205	426	0.12	0.16	76	0.7	0.17	0.1	1	0.19	300	0	0
	26	RCA05	7.45	7	1.16	7.1	230	476	0.01	0.14	62	0.05	0.42	0.3	0	0.13	0	0	0
	27	TCA06	7.28	12	0.81	7.26	256	534	0.09	0	64	0.09	0.65	0.2	0	0.27	0	0	0
4. Gazipura	28	RGP01	7.38	34	1.16	7.11	404	471	0.01	0	26	0.07	0.446	0.02	0	0.12	0	0	0
	29	RGP02	7.19	28	1.83	7.13	416	479	0.02	0	38	0.06	0.383	0.2	0	0.04	700	500	1300
	30	RGP03	7.29	9	1.25	7.16	450	506	0.04	0	38	0.04	0.043	0.07	0	0.01	0	0	0
	31	RGP04	7.18	1	0.82	7.13	560	584	0.01	0	21	0.12	0.459	0.01	0	0.05	1100	800	200
	32	RGP05	7.41	20	0.87	7.13	400	476	0.15	0	31	0.07	0.15	0.2	0	0.02	0	0	0
	33	RGP06	7.26	12	0.23	7.19	506	471	0.372	0	35	0.01	0.374	0.09	0	0.22	0	0	0
	34	RGP07	7.43	3	0.46	7.33	550	472	0.07	0	27	0.03	0.07	0.1	0	0.01	800	600	300
	35	TGP08	8.27	25	2.06	6.88	422	447	0.02	0	43	0.08	0.044	0.03	0	0.02	1200	500	0
	36	TGP09	7.44	16	0.35	7.11	412	465	0.11	0	36	0.02	0.077	0.15	0	0.01	800	500	400
	37	TGP10	7.67	29	0.97	6.52	368	471	0.02	0	38	0.04	0.048	0.1	0	0.04	700	500	400
5. Board Bazar	38	RBB01	7.4	27	1.73	6.35	160	532	0.04	0	88	0.11	0.482	2.2	1	0.04	100	100	0
	39	RBB02	7.3	2	1.63	7.18	280	527	0.01	0	108	0	0.503	0.4	0	0.03	1200	700	400
	40	RBB03	7.18	17	1.06	6.99	490	470	0	1.28	172	0.05	0.205	0.7	1	0.12	700	0	0
	41	RBB04	7.41	5	0.31	7.19	514	556	0.05	0.59	140	1.02	0.027	0.2	0	0.09	300	100	300
	42	RBB05	7.33	23	0.62	7.24	212	535	0.03	1.27	138	0.06	0.087	0.2	1	0.05	0	0	0
	43	RBB06	7.23	13	1.01	6.87	590	596	0.03	1.07	188	0.04	0.43	0.2	0	0	400	300	100
	44	RBB07	7.61	90	9.93	7.65	512	529	0.05	1.22	132	0.56	0	0.7	0	0.07	600	200	300
	45	RBB08	7.28	2	1.63	7.18	261	527	0.01	0	108	0	0.503	0.4	0	0.03	1200	700	400
	46	RBB09	7.11	6	0.93	6.98	206	539	0.01	0	92	0.05	0.402	0.8	0	0.04	800	300	400
	47	RBB10	7.32	18	1.013	6.7	289	557	0.02	0.72	108	0.02	0.336	0.2	1.1	0.08	900	500	200
	48	RBB11	7.47	21	1.01	6.98	286	554	0.03	0.39	99	0.03	0.161	3.4	0	0.13	1700	1300	500
	49	TBB01	7.43	16	0.8	6.95	530	555	0.06	0	178	0.11	0.32	0.2	0	0.08	200	100	100
	50	TBB02	7.25	11	2.55	6.96	288	536	0.07	0.64	78	0.13	0.289	0.9	0	0.27	2300	800	300
	51	TBB03	7.33	4	0.84	7.33	390	528	0.01	0.02	160	0.11	0.278	0.3	0	0.18	100	0	0
	52	TBB04	7.36	14	0.3	6.71	496	528	0.04	0.62	158	0.06	0.06	0.3	1	0.1	0	0	0
	53	TBB05	7.98	0	0.343	7.19	497	543	0.01	0.7	99	0.33	0.067	0.3	0	0.19	1300	1100	600
	54	TBB06	7.67	29	4.987	7.16	212	556	0.01	0.71	178	0.02	0.001	0.3	0	0.09	800	400	200
	55	TBB07	7.47	15	1.3	7.38	510	531	0.02	0	154	0.13	0.28	0.1	0	0.16	400	0	400
	56	TBB08	7.89	17	0.289	6.33	387	565	0.09	0	148	0.05	0.067	0.1	0	0.22	0	0	0
	57	TBB09	7.44	21	0.338	6.87	427	560	0.02	0.23	156	0.12	0.156	0.3	0	0.17	300	100	0
	58	TBB10	7.29	9	1.12	7.05	361	545	0.08	0	134	0.01	0.024	0.2	1	0.09	400	200	100
6. College Gate	59	RCG01	6.94	12	0.35	6.42	225	463	0.02	0.02	74	0.3	0.06	0.1	0	0.23	800	500	300
	60	RCG02	6.98	26	3.35	6.87	207.6	428	0.01	0.01	62	0.43	0.078	0.3	0	0.16	700	400	200
	61	RCG03	7.23	24	0.63	7.08	207.9	428	0.01	0.08	70	0.12	0.09	0.3	0	0.09	1100	700	300
	62	TCG04	7.3	15	0.94	7.1	221	456	0	0	82	0.21	0.058	0.2	0	0.09	1600	900	700
	63	RCG05	7.23	6	0.71	7.04	217.8	450	0.03	0.05	84	0.18	0	0.2	0	0.19	300	100	200
	64	RCG06	6.92	16	0.88	6.82	213.6	443	0	0.04	86	0.36	0.134	0.1	0	0.1	1400	700	600
	65	TCG07	7.22	17	1.33	7.43	214.6	445	0.01	0.07	86	0.22	0.23	0.5	0	0.18	500	300	200
	66	TCG08	7.06	28	0.9	7.04	200.7	415	0.06	0.09	70	0.12	0.045	0.4	0	0.27	0	0	0
	67	TCG09	7.15	7	0.43	7.43	223	444	0.09	0.06	72	0.11	0.032	0.6	0	0.13	0	0	0
	68	TCG10	7.29	16	0.87	7.51	197	409	0.03	0	78	0.16	0.078	0.3	0	0.07	600	400	200
7. Kodda	69	RKD01	7.28	18	0.55	7.05	273	562	0.06	0.31	70	0.08	0.01	0.3	0	0.12	300	0	0
	70	RKD02	7.03	23	0.25	6.92	241	501	0.02	0.15	58	0.06	0.35	0	0	0.09	500	400	0
	71	TKD03	7.41	12	1.02	6.74	283	594	0.03	0.13	68	0.13	0.24	0.3	0	0.18	0	0	0

8. Jajhar	72	RJJ01	7.43	8	0.54	6.63	222	459	0.03	0	48	0.09	0.337	0.75	0	0.11	1000	200	800
	73	TJJ02	7.6	11	0.35	7.19	222	459	0.02	0.03	54	0.06	0.265	0.1	0	0	1100	700	400
	74	RJJ03	7.23	9	0.57	6.48	223	459	0.08	0.32	50	0.15	0.47	2.19	0	0.11	100	0	100
	75	RJJ04	7.37	4	0.8	6.98	217	450	0.01	0.59	68	0.05	0.49	0.37	0	0.05	400	300	100
	76	RJJ05	7.34	3	0.67	6.72	269	556	0.05	0.24	58	0.061	0.23	0.73	0	0.07	0	0	0
	77	RJJ06	7.12	6	0.25	7.29	219	457	0.09	0.69	78	0.56	0.03	0.21	0	0.04	800	300	400
	78	RJJ07	7.36	16	0.37	6.86	240	495	0.31	0.54	65	0	0.085	0.18	0	0.09	0	0	0
	79	TJJ08	7.45	12	0.04	6.91	272	567	0.53	0.55	79	0.05	0.43	0.21	0	0.13	0	0	0
	80	TJJ09	7.08	21	0.09	7.28	204	423	0.08	0.44	55	0.03	0	0.8	0	0.07	0	0	0
	81	TJJ10	7.14	7	0.62	7.31	226	469	0.09	0.98	31	0.042	0.49	0.37	0	0.29	900	500	200
	82	TJJ11	7.62	8	0.27	6.33	244	504	0.02	0.09	24	0.03	0.301	0.75	0	0.19	1700	1200	400
9.Borobari	83	RBR01	7.07	15	1.18	7.14	286	591	0.12	1.39	68	0.04	0.423	1.3	0	0.02	0	0	0
	84	RBR02	7.63	9	0.73	7.11	271	558	0.01	1.24	64	0.03	0.115	0.6	0	0.06	1500	900	100
	85	RBR03	7.34	8	1.21	6.7	282	584	0.06	0	60	0.21	0.265	1.4	0	0	300	100	100
	86	RBR04	7.58	11	0.56	7.41	245	507	0	0.95	52	1.19	0.077	0.7	0	0.07	400	300	100
	87	RBR05	7.43	13	0.74	6.95	269	557	0.03	0.84	68	0.17	0.23	0.4	0	0	1200	600	300
	88	RBR06	7.18	7	1.24	6.91	221	457	0.05	0.39	62	0.07	0.504	0.7	0	0.08	200	0	100
	89	RBR07	7.07	7	1.03	7.03	234	483	0.03	1.08	67	0	0	0.5	0	0.12	800	300	400
	90	TBR08	7.33	5	0.31	7.54	261	538	0.09	1.22	57	0.34	0.421	1.1	0	0.09	200	0	0
	91	TBR09	7.11	6	0.38	6.88	265	547	0.02	0.18	56	0.09	0.126	0.2	0	0	200	200	0
	92	TBR10	7.21	9	0.27	6.5	239	493	0.03	0.48	60	0.02	0.261	1.4	0	0.01	*	*	*
10. Maleker Ba	93	RMB01	7.2	11	0.7	7.04	224	462	0.12	0.31	60	0.08	0.14	0.4	1	0.17	0	0	0
	94	RMB02	7.18	23	0.69	7.08	237	490	0.02	0.16	56	0.7	0.18	0.5	0	0.06	700	200	100
	95	RMB03	7.03	36	1.15	7.08	248	511	0.04	0.15	64	0.06	0.21	0.1	0	0.04	0	0	0
	96	TMB04	7.11	18	1.29	6.47	263	542	0.09	0.13	58	0.13	0.46	0.2	0	0.12	500	200	100
	97	TMB05	7.35	8	1.02	6.9	287	592	0	0.14	62	0.05	0.32	0.3	0	0.14	500	300	0
11. Konabari	98	RKB01	7.04	87	0.42	7.41	342	703	0.01	0.04	38	0.16	0.237	1.7	0	0.11	0	0	0
	99	RKB02	6.64	96	0.66	7.39	163	339	0.05	0.18	34	0.1	0.065	2.3	0	0.27	300	0	100
	100	RKB03	6.83	63	0.68	7.65	259	533	0	0.25	48	0.07	0.169	1.6	0	0.06	0	0	100
	101	RKB04	7.21	78	0.6	7.69	282	580	0.04	0.08	46	0.14	0.055	1.9	0	0.19	0	0	200
	102	RKB05	6.93	70	0.69	7.48	463	946	0	0.44	66	0.21	0.157	4.5	0	0.09	0	0	0
	103	RKB06	7.35	80	0.57	7.19	234	482	0.13	0.15	32	0.07	0.167	0.2	0	0.12	0	0	0
	104	RKB07	7.26	72	0.63	7.29	178	367	0.07	0.07	44	0.01	0.347	1.9	0	0.22	200	100	100
	105	TKB08	7.31	53	0.76	7.33	273	562	0.11	0.29	68	0.03	0.074	1.2	0	0.14	0	0	0
	106	TKB09	7.47	75	0.46	6.98	188	387	0.02	0.12	38	0.18	0.244	2.1	0	0.27	300	0	0
	107	TKB10	6.97	60	0.65	7.13	205	421	0.03	0.1	38	0.02	0.117	1.5	0	0.18	100	0	0
12. Chayabithy	108	RCB01	7.09	15	1.18	7.14	286	591	0.07	0.12	68	0.06	0.16	0.2	0	0.24	300	0	100
	109	RCB02	7.63	9	0.73	7.11	271	558	0.01	0.23	64	0.12	0.059	0.6	0	0.03	400	200	0
	110	RCB03	7.4	8	1.21	6.7	282	584	0.06	0	60	0.21	0.265	1.4	0	0.12	0	0	0
	111	RCB04	7.11	6	0.38	6.88	265	547	0.15	0.48	56	0.09	0.134	1.2	0	0.08	0	0	0
	112	RCB05	7.21	9	0.27	6.5	239	493	0.05	0.14	60	0.04	0.112	0.2	0	0.06	500	0	200
	113	TCB06	7.33	12	0.79	6.98	244	504	0.04	0.27	57	0.15	0.038	0.1	0	0.06	100	0	0
13. Shibbari	114	RSI01	7.41	16	0.49	5.69	195	419	0.3	0.42	21	0.7	0.326	0.5	0	0.06	0	0	0
	115	RSI02	7.43	12	0.74	6.01	186	381	0.12	0.45	37	0.05	0.236	0.1	0	0.14	0	0	0
	116	RSI03	7.6	8	0.32	6.7	178	377	0.06	0.37	15	0.09	0.012	0.4	0	0.16	200	0	100
	117	RSI04	7.37	10	0.58	5.28	201	420	0.06	0.23	18	0.08	0.056	0.3	0	0.2	300	200	100
	118	RSI05	7.1	13	0.25	6.55	211	435	0	0.17	26	0.02	0.01	0.8	0	0.11	600	400	200
14. Dhirasrom	119	RDS01	7.23	9	0.57	6.48	223	459	0.02	0.21	60	0.03	0.44	0.6	0	0.07	400	0	300
	120	RDS02	7.34	3	0.67	6.72	269	556	0.17	0.36	58	0.12	0.28	0.1	0	0.16	0	0	0
	121	RDS03	7.36	17	0.19	7.2	303	622	0.03	0.25	66	0.07	0.11	0.7	0	0.14	800	600	500
	122	RDS04	7.11	4	0.42	6.85	284	584	0.04	0.23	63	0.03	0.36	0.3	0	0.02	200	0	0
	123	RDS05	7.69	12	0.33	6.92	258	528	0.11	0.14	77	0.15	0.32	0.1	0	0.04	0	0	0
15. Bypass	124	RBP01	7.47	4	0.53	7.57	230	477	0.09	0.45	56	0.17	0.043	0.1	0	0.19	0	0	0
	125	RBP02	7.4	21	0.7	7.25	217.7	452	0.1	0.22	54	0.06	0.374	0.1	0	0.12	0	0	0
	126	RBP03	7.28	37	0.27	7.18	213.7	444	0	0.58	60	0.08	0.15	0.3	0	0.27	500	400	0
	127	RBP04	7.47	25	0.29	7.32	203.6	424	0.03	0.6	72	0.05	0.249	0.5	0	0.04	600	400	100
	128	RBP05	7.16	18	0.22	7.5	248	520	0.11	0.55	74	0.07	0.446	0.22	0	0.07	0	0	0
	129	RBP06	7.48	15	0.57	7.47	207.7	432	0	0.33	52	0.03	0.459	0.4	0	0.13	500	300	200
	130	RBP07	7.33	51	0.54	7.55	278	503	0.04	0.19	66	0.02	0.119	0.3	0	0.12	100	100	0
	131	RBP08	7.62	9	0.39	7.34	321	602	0.06	0.52	74	0.01	0.187	0.1	0	0.09	0	0	0
	132	TBP01	7.81	55	0.32	7.82	234	484	0	0.39	60	0.06	0.235	0.2	0	0.03	500	300	200
	133	TBP02	8.27	44	0.4	7.62	213.7	443	0.02	0.28	72	0.03	0.066	0.33	0	0.01	0	0	0
	134	TBP03	7.58	32	0.4	7.78	423	866	0.1	0.13	58	0.06	0.383	0.5	0	0.14	600	400	200
	135	TBP04	7.62	16	0.26	7.67	248	512	0.07	0.43	48	0.1	0.12	0.15	0	0.05	800	600	300
16. Joydebpur	136	RJP01	7.23	7	0.24	5.98	160	329	0.06	0	58	0.26	0.365	1.1	0	0.13	0	0	0
	137	RJP02	7.1	11	2.84	6.44	213	447	0.01	0.79	41	0.08	0.374	0.8	0	0	700	200	500
	138	RJP03	7.31	2	0.49	4.11	150	313	0.03	0.45	28	0.17	0.025	0.37	0	0.23	400	0	300
	139	RJP04	6.86	6	0.41	5.28	124	257	0.21	0.57	61	0.15	0.039	0.75	0	0.07	0	0	0
	140	RJP05	6.62	9	0.24	6.55	200	417	0.15	0.84	47	0.06	0.022	0.3	0	0.2	0	0	0
	141	RJP06	7.24	13	0.32	6.72	167	347	0	0.78	45	0.17	0.236	0.1	0	0.19	1400	800	600
	142	RJP07	7.33	15	0.74	7.07	187	388	0.12	0.06	35	0	0.159	0.1	0	0.04	0	0	0
	143	TJP08	7.12	8	0.58	7.2	189	392	0	0.42	29	0.03	0.012	0.3	0	0.04	1200	700	400
	144	RJP09	7.56	5	0.25	6.55	121	327	0.04	0.66	31	0.09	0.011	0.2	0	0.03	800	300	400
	145	TSJP10	7.01	3	1.73	5.13	156	326	0.01	0.33	55	0.07	0.014	0.1	0	0.12	900	500	200
	146	TJP11	7.44	12	1.25	6.99	221	469	0.02	0.09	72	0.06	0.15	0.55	0	0.11	300	100	200

17. Signboard	147	**RSB01**	7.41	12	1.42	6.74	283	594	0.03	0.13	68	0.13	0.35	0.3	0	0.18	100	30	20
	148	**RSB02**	7.4	21	0.5	7.09	273	562	0.06	0.31	70	0.08	0.24	0.3	0	0.07	300	0	0
	149	**RSB03**	8.03	26	1.25	7.03	241	501	0.02	0.15	54	0.06	0.01	0.1	0	0.14	50	40	0
	150	**RSB04**	7.78	33	0.89	7.08	273	559	0	0.16	76	0.7	0.17	0.1	1	0.19	120	70	40
	151	**RSB05**	7.45	21	1.14	6.8	280	576	0.01	0.14	62	0.05	0.42	0.3	0	0.13	0	0	0
	152	**TSB06**	7.11	12	0.71	6.26	311	634	0	0	64	0.09	0.65	0.2	0	0.27	20	0	10
	153	**TSB07**	7.2	15	1.14	6.02	285	582	0.02	0.58	52	0.12	0.02	0.4	2	0.17	0	0	0
	154	**TSB08**	7.23	49	4.3	6.14	247	514	0.04	0.3	50	0.07	0.08	0.5	0	0.11	0	0	0
	155	**TSB09**	7.75	24	0.47	7.34	232	479	0.01	0.32	52	0.6	0.02	0.3	0	0.04	30	0	0
	156	**TSB10**	7.7	32	1.27	7.13	311	638	0	0.29	60	0.03	0.6	0.1	0	0.12	120	80	10
	157	**TSB11**	7.05	35	0.94	6.18	270	569	0.02	0.7	54	0.04	0.33	0.2	1	0.05	0	0	0
	158	**TSB12**	7.24	21	0.44	6.95	264	545	0.01	0.1	62	0.04	0.18	0.2	0	0.15	0	0	0
18. Chandna Chowrasta	159	**RCC01**	7.36	17	0.19	7.2	303	622	0.06	0.75	66	0.04	0.011	0.4	0	0.12	900	200	400
	160	**RCC02**	7.4	2	0.34	7.07	206	426	0.11	0.68	62	0.09	0.058	0.25	0	0.17	0	0	0
	161	**RCC03**	7.36	14	0.69	6.94	178	369	0.12	0.09	64	0.12	0.056	0.5	0	0.23	0	0	0
	162	**RCC04**	7.57	2	0.4	7.14	214	442	0.09	0.04	60	0.07	0.261	0.7	0	0.24	0	0	0
	163	**RCC05**	7.68	3	0.28	7.04	230	476	0.01	0.69	54	0.02	0.171	0	0	0	100	0	0
	164	**RCC06**	7.2	5	0.37	7.17	288	596	0.07	0.24	61	0.11	0.019	0.15	0	0.14	0	0	0
	165	**RCC07**	7.49	12	0.24	7.36	265	549	0.02	0.48	58	0	0.022	0.3	0	0.29	200	100	0
	166	**RCC08**	7.33	13	0.31	6.99	241	501	0.02	0.19	64	0.06	0.236	0.2	0	0.03	700	200	100
	167	**RCC09**	7.25	6	0.44	6.84	186	385	0.16	0.37	57	0.08	0.028	0.7	0	0.08	0	0	0
	168	**RCC10**	7.48	11	0.15	7.21	209	434	0.03	0.56	49	0.04	0.214	0.4	0	0.24	500	200	100
	169	**RCC11**	7.04	2	0.56	7.14	212	439	0.04	0.24	61	0.03	0.321	0.2	0	0	0	0	0
	170	**RCC12**	7.23	9	0.36	7.22	247	510	0.07	0.61	58	0.15	0.026	0.9	0	0.13	0	0	0
	171	**RCC13**	7.58	10	0.22	7.13	265	550	0.03	0.03	73	0.08	0.42	0.31	0	0.11	300	0	0
	172	**TCC14**	7.37	8	0.67	7.29	237	492	0.04	0.31	65	0.11	0.312	0.14	0	0.06	0	0	0
	173	**TCC15**	7.54	2	0.87	7.2	183	378	0.09	0.12	52	0.01	0.04	0.11	0	0.29	200	0	100
		Max.	8.27	96	9.93	7.82	590	946	0.53	1.39	188	1.19	0.65	4.5	3	0.29	2300	1300	1300
		Min.	6.62	0	0.04	4.11	121	257	0	0	15	0	0	0	0	0	0	0	0
		Avg.	7.302948	18.3815	0.839827	6.916069	258.6335	481.4162	0.064694	0.335954	62.87861	0.118283	0.194705	0.482428	0.254913	0.113121	356.6279	174.5349	120.2326

APPENDIX C

Field observation data of the restaurants and tea stalls

	Collection Point	Date of Collection	Sl. No.	Sample ID	Name of Restaurant	Estimated no. of customers per day	Source of drinking water	How the water is served	Washing of utensils	Storage Conditions	Waste water disposal
1	Tongi Bazar	3/7/2019	1	RTB01	Café Boishakhi	500	Tapwater	Jug-glass	Medium	Good	Properly Drained
			2	RTB02	Nobabgonj Hotel	400	Tapwater	Bottle-glass	Poor, old	Medium	Properly Drained
			3	RTB03	Rajmoni Hotel and Reastaurant	500	Tapwater	Bottle-glass	Medium	Medium	Properly Drained
			4	RTB04	Hridoy Hotel	250	Jarwater	Bottle-glass	Good	Good	Properly Drained
			5	RTB05	Jonota Hotel	200	Tapeater	Bottle-glass	Medium, Old-reddish stain	Medium	Disposed at open drain
			6	RTB06	Nur Biriyani	150	Tapwater	Bottle-melamine	Medium, old	Medium	Disposed at open drain
			7	RTB07	Taj Hotel	350	Tubewell	Jug-silverware	Good	Good	Disposed at open drain
			8	TTB08	Tania Store	100	Jarwater	Dispenser-silverware	Medium	Medium	Roadside
			9	TTB09	N.R. store	150	Jarwater	Dispenser-glass	Good	Good	Roadside
			10	TTB10	Sohel Store	100	Tapwater	Drum-melamine	Medium	Good	Roadside
2	Tongi Station	22/7/2019	11	RTS01	Sattar Hotel and Restaurant	200	Tapwater	Jug-glass	Good	Medium	Properly Drained
			12	RTS02	Ajad Restaurant and Guest House	250	Tapwater	Bottle-glass	Good	Good	Properly Drained
			13	RTS03	Al Modina Hotel	250	Tapwater	Dispenser	Medium	Medium	Properly Drained
			14	RTS04	Green Sweets and Restaurant	450	Tapwater	Bottle-glass	Good	Good	Properly Drained
			15	RTS05	Amena Hotel and Restaurant	200	Tapwater	Bottle-glass	Medium, Old-reddish stain	Good	Disposed at open drain
			16	RTS06	Jol Khabar	300	Tapwater	Bottle-melamine	Medium	Medium	Properly Drained
			17	RTS07	New Oporupa Restaurant	250	Tapwater	Jug-silverware	Medium	Good	Properly Drained
			18	RTS08	Rajmoni Restaurant	250	Jarwater	Jug-Glass	Good	Good	Properly Drained
			19	TTS09	Limon Store	100	Tubewell	Dispenser-silverware	Medium	Medium	Disposed at open drain
			20	TTS10	Raima General Store	150	Jarwater	Dispenser-glass	Poor	Poor	Properly Drained
			21	TTS11	Nur Store	200	Tapwater	Drum-Silverware	Medium	Poor	Disposed at open drain
3	Cherag Ali	13/9/2019	22	RCA01	Banglar Radhuni Restaurant	350	Tapwater	Jug-glass	Good	Good	Properly Drained
			23	RCA02	Bismillah Mishtanno Bhander	200	Tapwater	Jug-glass	Medium	Good	Properly Drained
			24	RCA03	Mayer Doa Hotel	300	Tapeater	Jug-glass	Poor	Poor	Properly Drained
			25	RCA04	Mokka Restaurant	250	Tapwater	Bottle-glass	Poor	Medium	Properly Drained
			26	TCA05	Satata Tea Store	250	Tapwater	Dispenser	Medium	Medium	Disposed at open drain
			27	TCA06	Harun Tea	200	Tapwater	Drum-Mug	Medium	Medium	Properly Drained
4	Gazipura	26/6/2019	28	RGP01	Kutumbari	250	Tapwater	Jug-glass	Medium	Good	Properly Drained
			29	RGP02	Molla Biriyani	250	Tapwater	Bottle-glass	Medium	Medium	Disposed at open drain
			30	RGP03	Allahr Dan Hotel	300	Tubewell	Jug-glass	Medium	Medium	Properly Drained
			31	RGP04	Mama Bhagina Biriyani Ghar	200	Jarwater	Bottle-glass	Good	Good	Disposed at open drain
			32	RGP05	Mohammodiya Restaurant	400	Tapeater	Bottle-glass	Medium	Good	Properly Drained
			33	RGP06	Barisal Al-Mumin Restaurant	500	Tapwater	Bottle-glass	Good	Good	Properly Drained
			34	RGP07	Saudi Sweetmeat and Restaurant	400	Tapwater	Jug-glass	Good	Medium	Properly Drained
			35	TGP08	Tonmoy Tea Stall	150	Jarwater	Drum-silverware	Medium	Medium	Roadside
			36	TGP09	Ferdous Store	150	Jarwater	Drum-melamine	Medium	Good	Roadside
			37	TGP10	Mayer Doa General Store	100	Tapwater	Drum-melamine	Medium	Medium	Properly Drained
5	Board Bazar	19/3/2019 to 25/3/2019	38	RBB01	Dhaka Kabab Ghar	300	Tapwater	Jug-glass	Good	Medium	Properly drained
			39	RBB02	New Dhaka Kabab	400	Tapwater	Jug-glass	Medium	Poor	Properly drained
			40	RBB03	Three Star Restaurant	500	Tapwater	Bottle-glass	Medium	Medium	Properly drained
			41	RBB04	Kashem Sweets	250	Tapwater	Jug-glass	Good	Good	Properly drained
			42	RBB05	Radhuni Restaurant	500	Tapwater	Bottle-glass	Medium	Medium	Open drains
			43	RBB06	Tripti Hotel & Restaurant	400	Tapwater	Bottle-glass	Good	Medium	Open drains
			44	RBB07	Ruchiraj Restaurant	300	Tapwater	Bottle-glass	Medium	Poor	Open drains
			45	RBB08	Allahr Dan Biriyani House	250	Tapwater	Jug-glass	Good	Medium	Properly drained
			46	RBB09	Sikdar Hotel	200	Tapwater	Bottle-glass	Poor	Poor	Properly drained
			47	RBB10	Hazrat Shahjalal Hotel & Restaurant	150	Tapwater	Bottle-glass	Medium	Poor	Properly drained
			48	RBB11	Central Departmental Store	500	Tapwater	Jug-glass	Medium	Poor	Properly drained
			49	TBB12	Fair Price	200	Tubewell	Bottle	Medium	Good	Roadside
			50	TBB13	Giasuddin Store	150	Tubewell	Bottle-glass	Good	Good	Properly Drained
			51	TBB14	Sumon Store	250	Jar Water	Jug-glass	Medium	Medium	Roadside
			52	TBB15	Jaman Store	250	Jarwater	Dispenser-silverware	Medium	Medium	Disposed at open drains
			53	TBB16	Mahim Store	150	Jarwater	Drum-melamine	Medium	Poor	Roadside
			54	TBB17	Rabbi Store	100	Jarwater	Drum-melamine	Poor	Medium	Roadside
			55	TBB18	Fair Price - 2	100	Tubewell	Bottle	Good	Good	Properly Drained
			56	TBB19	Babul Store	200	Jarwater	Drum-melamine	Medium	Medium	Roadside
			57	TBB20	Maolana Tea Stall	150	Jarwater	Drum-melamine	Poor	Poor	Roadside
			58	TBB21	Nazmul Store	100	Tapwater	Bottle-glass	Good	Good	Disposed at open drains
6	College Gate	17/9/2019	59	RCG01	Unishe Restaurant	500	Tapwater	Jug-glass	Medium	Poor	Properly Drained
			60	RCG02	Tongi College Canteen	400	Tapwater	Tap-glass	Poor, old	Poor	Properly Drained
			61	RCG03	Al-Imran Biriyani	500	Tapwater	Bottle-glass	Medium	Medium	Properly Drained
			62	RCG04	Monir Tea Stall	250	Jarwater	Jug-glass	Poor	Poor	Properly Drained
			63	RCG05	Tehari Ghar	200	Tapeater	Bottle-glass	Medium	Medium	Properly Drained
			64	RCG06	Khabar Hotel	150	Tapwater	Bottle-glass	Poor	Poor	Properly Drained
			65	TCG07	Kaosar Tea Stall	350	Tubewell	Drum-Mug	Poor	Poor	Properly Drained
			66	TCG08	Sharif Tea Stall	100	Jarwater	Drum-Mug	Poor	Medium	Properly Drained
			67	TCG09	Miktar Tea stall	150	Jarwater	Drum-Mug	Poor	Poor	Properly Drained
			68	TCG10	Mubin General Store	100	Tapwater	Drum-Mug	Poor	Poor	Properly Drained
7	Kodda	16/10/2019	69	RKD01	Islamia Haque Mistanno Bhandar	250	Tapwater	Jug-glass	Medium	Good	Properly Drained
			70	RKD02	Mayer Doa Hotel	200	Tapwater	Jug-glass	Medium	Medium	Properly Drained
			71	TKD03	Sukanto Store	150	Jarwater	Drum-Mug	Poor	Medium	Properly Drained

8	Jajhar	4/8/2019	72	RJJ01	Munni Hotel & Restaurant	200	Tapwater	Jug-glass	Good	Good	Properly drained
			73	TJJ02	Bhai-bhai varities store	150	Tapwater	Drum-silverware	Medium	Medium	Properly drained
			74	RJJ03	Masum Hotel & Restaurant	300	Tapwater	Jug-glass	Medium	Good	Properly drained
			75	RJJ04	City Hotel & Restaurant	250	Tapwater	Jug-glass	Good	Good	Properly drained
			76	RJJ05	Sampan Restaurant	200	Tapwater	Jug-glass	Good	Medium	Properly drained
			77	RJJ06	Munni Sweets	300	Tapwater	Bottle-glass	Good	Good	Properly drained
			78	RJJ07	Ananda Hotel & Restaurants	200	Tapwater	Jug-glass	Medium	Medium	Properly drained
			79	TJJ08	Jewel Store	200	Tubewell	Drum-Mug	Poor	Medium	Properly drained
			80	TJJ09	Pervez Store	150	Tapwater	Drum-Mug	Medium	Medium	Properly drained
			81	TJJ10	Saiful Store	200	Tapwater	Drum-Mug	Good	Poor	Properly drained
			82	TJJ11	Badhon Store	100	Tubewell	Drum-silverware	Poor	Poor	Disposed at open Drain
9	Borobari	5/8/2019	83	RBR01	Tangail Sweets and Restaurant	300	Jarwater	Jug-glass	Good	Good	Properly drained
			84	RBR02	Rajmahal Restaurant	300	Tapwater	Jug-glass	Medium	Poor	Properly drained
			85	RBR03	Jannat Hotel	250	Tapwater	Bottle-glass	Medium	Medium	Properly drained
			86	RBR04	Rosher Mishti	100	Tapwater	Bottle-glass	Medium	Medium	Properly Drained
			87	RBR05	Sani Fast Food & Confectionery	80	Jarwater	Dispenser	Poor	Poor	Properly Drained
			88	RBR06	Talukdar Biriyani House	200	Tapwater	Jug-glass	Good	Medium	Properly Drained
			89	RBR07	Lucky Hotel	200	Tapwater	Jug-glass	Medium	Poor	Properly Drained
			90	TBR08	Mayer Doa Tea	150	Tapwater	Drum-silverware	Medium	Medium	Properly Drained
			91	TBR09	Shahin General Store	150	Tubewell	Jug-glass	Good	Medium	Properly drained
			92	TBR10	Riyam Tea Store	100	Tubewell	Drum-silverware	Medium	Poor	Open drains
10	Maleker Bari	6/9/2019	93	RMB01	Barisal Hotel & Restaurant	250	Tapwater	Jug-glass	Good	Good	Properly Drained
			94	RMB02	Hotel Bottala	500	Tapwater	Jug-glass	Medium	Good	Properly Drained
			95	RMB03	Ruchi Restaurant	300	Tapwater	Jug-glass	Good	Medium	Properly Drained
			96	TMB04	Dulal Tea Store	200	Tapwater	Bottle-glass	Poor	Medium	Disposed at open drain
			97	TMB05	Bismillah Store	250	Tapwater	Bottle-glass	Medium	Poor	Properly Drained
11	Konabari	11/10/2019	98	RKB01	Surma Hotel and Restaurant	350	Tapwater	Jug-glass	Good	Good	Properly Drained
			99	RKB02	Jannat Hotel & Restaurant	300	Tapwater	Bottle-glass	Medium	Good	Properly Drained
			100	RKB03	Madaripur Hotel & Restaurant	300	Tapwater	Jug-glass	Medium	Medium	Properly Drained
			101	RKB04	Maa Hotel	200	Tapwater	Bottle-glass	Medium	Poor	Properly Drained
			102	RKB05	Milon Hotel & Restaurant	250	Tapwater	Bottle-glass	Medium	Medium	Properly Drained
			103	RKB06	Dewan Imam Mahadi Restaurant	250	Tapwater	Bottleglass	Medium	Good	Properly Drained
			104	RKB07	Muslim Hotel & Restaurant	300	Tubewell	Jug-silverware	Medium	Medium	Disposed at open drain
			105	TKB08	Jihad Store	100	Jarwater	Dispenser-silverware	Good	Good	Properly Drained
			106	TKB09	Aktar Store	100	Jarwater	Drum-melamine	Medium	Medium	Properly Drained
			107	TKB10	Riad Store	150	Tapwater	Drum-melamine	Medium	Poor	Disposed at open drain
12	Chayabithi	4/8/2019	108	RCB01	Bismillah Café & Restaurant	250	Tapwater	Jug-glass	Medium	Good	Properly Drained
			109	RCB02	Bhai Bhai Hotel	200	Tapwater	Jug-Silverware	Good	Medium	Properly Drained
			110	RCB03	Ruchi Restaurant	200	Tapwater	Jug-glass	Good	Medium	Properly Drained
			111	RCB04	Gazi Hotel & Restaurant	200	Tapwater	Bottle-glass	Medium	Poor	Properly Drained
			112	RCB05	Tajuddin Ahmed Medical Canteen	500	Tapwater	Dispenser-glass	Medium	Medium	Properly Drained
			113	TCB06	Jakir er tong	150	Tapwater	Drum-silverware	Good	Medium	Properly Drained
13	Shibbari	4/8/2019	114	RSI01	New Muslim Sweets & Bakery	100	Tapwater	Jug-glass	Medium	Medium	Properly Drained
			115	RSI02	Babul Hotel & Restaurant	150	Tapwater	Jug-glass	Medium	Good	Properly Drained
			116	RSI03	Satkhira Hotel & Restaurant	200	Tapwater	Jug-glass	Poor	Medium	Properly Drained
			117	RSI04	Seven Star Restaurant	300	Tapwater	Bottle-glass	Good	Good	Properly Draineds
			118	RSI05	Rupsha Restaurant & Sweetmeat	150	Tapeater	Bottle-glass	Medium	Medium	Properly Drained
14	Dhirasram	4/9/2019	119	RDS01	New Star Restraurant	150	Deep Tubewell	Jug-glass	Medium	Medium	Properly Drained
			120	RDS02	Mohona store	50	Deep Tubewell	Jug-glass	Medium	Good	Open ditch
			121	RDS03	Rabbi Store (Rail Station)	50	Deep Tubewell	Jug-glass	Poor	Poor	Roadside
			122	RDS04	Hakim Ali Hotel & Restaurant	200	Deep Tubewell	Bottle-glass	Good	Medium	Disposed at open drain
			123	RDS05	Liya Hotel	150	Deep Tubewell	Bottle-glass	Medium	Good	Properly Drained
15	Bypass	1/10/2019	124	RBP01	Alam Store	250	Tapwater	Drum-Mug	Poor,red stain	-	Disposed at open drain
			125	RBP02	Bismillah restaurant	250	Tapwater	Tap-glass	Poor	-	Properly Drained
			126	TBP003	Rubel Tea Stall	300	Tubewell	Jug-glass	Medium	-	Disposed at open drain
			127	RBP04	Sotota Hotel	200	Jarwater	Bottle-glass	Poor	Poor	Properly Drained
			128	RBP05	Bondhumohol Hotel	400	Tapeater	Jug-glass	Medium	Medium	Properly Drained
			129	TBP06	Al Amin Tea store	150	Tapwater	Bottle-glass	Good	-	Properly Drained
			130	TBP07	Masud Tea Stall	100	Tapwater	Jug-glass	Very poor	-	Roadside
			131	RBP08	Ruchi Restaurant	150	Tapwater	Jug-glass	Very poor	Medium	Open drain
			132	TBP09	Filling station tea stall	150	Tapwater	Drum-Mug	Medium	Good	Roadside
			133	TBP10	Mogorkhal Tea Stall	100	Tapwater	Drum-Mug	Poor	Medium	Properly Drained
			134	RBP11	Bhai Bhai Bakery	150	Tapwater	Jug-glass	Very poor	-	Open Drain
			135	RBP12	Ali Baba Sweets	100	Tubewell	Jug-glass	Medium	-	Disposed at open drain
16	Joydevpur	4/9/2019	136	RJP01	Gram Bangla Restaurant	400	Tapwater	Jug-glass	Medium	Good	Properly Drained
			137	RJP02	Muslim Hotel	300	Tapwater	Jug-glass	Medium	Medium	Properly Drained
			138	RJP03	Suruchi Restaurant	1500	Tapwater	Jug-glass	Good	Medium	Properly Drained
			139	RJP04	Food Park	500	Tapwater	Jug-glass	Good	Good	Properly Drained
			140	RJP05	Bhai Bhai Hotel	100	Tapeater	Bottle-glass	Medium	Good	Properly Drained
			141	RJP06	Sunrise Resturant	200	Tapwater	Bottle-glass	Good	Medium	Properly Drained
			142	RJP07	Gazi Hotel & Restaurant	150	Tapwater	Jug-glass	Good	Poor	Roadside
			143	TJP09	Swarna Store	200	Jarwater	Drum-silverware	Medium	Medium	Properly Drained
			144	RJP08	Dhaka Hotel	150	Tubewell	Jug-glass	Medium	Good	Roadside
			145	TJP10	DC office Tea Stall	100	Tubewell	Drum-melamine	Medium	Medium	Roadside
			146	TJP11	Jakir er tong	150	Tapwater	Drum-melamine	Poor	Medium	Disposed at open drain

17	Sign Board	16/7/2019	147	RSB01	Jaman Restraurant	300	Tapwater	Jug-glass	Medium	Medium	Properly Drained
			148	RSB02	Monir Hotel	500	Tapwater	Jug-glass	Medium	Good	Properly Drained
			149	RSB03	Alauddin Hotel	300	Tapeater	Jug-glass	Poor	Poor	Properly Drained
			150	RSB04	Khan Hotel	200	Tapwater	Bottle-glass	Good	Medium	Disposed at open drain
			151	RSB05	Chowdhury Hotel & Restaurant	250	Tapeater	Bottle-glass	Medium	Good	Properly Drained
			152	RSB06	Kona Hotel & Restaurant	200	Tapwater	Bottle-glass	Good	Medium	Properly Drained
			153	TSB07	Arobi Tea Stall	150	Tapwater	Jug-glass	Good	Poor	Roadside
			154	TSB08	Tea Stall	200	Jarwater	Drum-silverware	Medium	Medium	Properly Drained
			155	TSB09	Raju Tea Store	100	Jarwater	Drum-melamine	Medium	Good	Roadside
			156	TSB10	Sotota Tea Stall	100	Tapwater	Drum-melamine	Good	Medium	Properly Drained
			157	TSB11	Selim Store	150	Tapwater	Drum-silverware	Poor	Poor	Disposed at open drain
			158	TSB12	Joynal Store	70	Jarwater	Drum-silverware	Medium	Medium	Disposed at open drain
18	Chandona Chowrasta	5/8/2019	159	RCR01	Kulsum Hotel & Restaurant	200	Tapwater	Jug-glass	Medium	Medium	Properly drained
			160	RCR02	Ma Masum Hotel & Restaurant	100	Tapwater	Bottle-glass	Medium	Poor	Properly drained
			161	RCR03	Haji Biriyani House	150	Tapwater	Jug-glass	Good	Medium	Properly drained
			162	RCR04	Café Mijan Restaurant	250	Tapwater	Jug-glass	Poor	Poor	Properly drained
			163	RCR05	Café Adda	100	Tap water	Bottle-glass	Medium	Good	Properly drained
			164	RCR06	Shah Ali Restaurant	250	Tap water	Jug-glass	Medium	Good	Properly drained
			165	RCR07	The Star Kabab & Restaurant	300	Tap water	Jug – glass	Good	Poor	Properly drained
			166	RCR08	Sikder Restaurant	300	Tapwater	Jug-glass	Medium	Medium	Properly drained
			167	RCR09	Gram Bangla Biriyani	200	Tube well	Bottle-glass	Medium	Good	Properly drained
			168	RCR10	Alif Hotel	250	Tapwater	Jug-glass	Medium	Good	Properly drained
			169	RCR11	Mijan Biriyani	150	Tap water	Bottle-glass	Medium	Good	Properly drained
			170	RCR12	Gazipur Hotel & Restaurant	200	Tapwater	Jug-glass	Good	Medium	Properly drained
			171	TCR13	Bashir Store	120	Jar water	Jug-glass	Medium	Poor	Properly drained
			172	TCR14	Mukul General Store	100	Jar water	Drum-silverware	poor	Medium	Disposed at roadside
			173	TCR15	Mayer Doa Doi Chira House	200	Jar water	Drum-silverware	Medium	Medium	Open Drain

APPENDIX D

Calculation of total risk points

Sl. No.	Sample ID	Name of Restaurant	FORP	LTRP	BRP	ff,3 ff * FORP	fl,1 fl * LTRP	fb,5 ffb* BRP	Total
1	RTB01	Café Boishakhi	35	17.5	0	105	17.5	0	122.5
2	RTB02	Nobabgonj Hotel	48.5	2	10	145.5	2	50	197.5
3	RTB03	Rajmoni Hotel and Reastaurant	42.5	3	10	127.5	3	50	180.5
4	RTB04	Hridoy Hotel	20.5	13	25	61.5	13	125	199.5
5	RTB05	Jonota Hotel	34.5	16.5	35	103.5	16.5	175	295
6	RTB06	Nur Biriyani	32.5	2	0	97.5	2	0	99.5
7	RTB07	Taj Hotel	21	2	0	63	2	0	65
8	TTB08	Tania Store	24	3	25	72	3	125	200
9	TTB09	N.R. store	14.5	9	0	43.5	9	0	52.5
10	TTB10	Sohel Store	21	18.5	40	63	18.5	200	281.5
11	RTS01	Sattar Hotel and Restaurant	28.5	18.5	0	85.5	18.5	0	104
12	RTS02	Ajad Restaurant and Guest House	25	2	10	75	2	50	127
13	RTS03	Al Modina Hotel	38.5	3	10	115.5	3	50	168.5
14	RTS04	Green Sweets and Restaurant	29	13	25	87	13	125	225
15	RTS05	Amena Hotel and Restaurant	27	16.5	35	81	16.5	175	272.5
16	RTS06	Jol Khabar	38.5	2	0	115.5	2	0	117.5
17	RTS07	New Oporupa Restaurant	31	2	0	93	2	0	95
18	RTS08	Rajmoni Restaurant	20.5	5.5	0	61.5	5.5	0	67
19	TTS09	Limon Store	22.5	4	25	67.5	4	125	196.5
20	TTS10	Raima General Store	41.5	9	0	124.5	9	0	133.5
21	TTS11	Nur Store	42	14.5	40	126	14.5	200	340.5
22	RCA01	Banglar Radhuni Restaurant	27	14.5	35	81	14.5	175	270.5
23	RCA02	Bismillah Mishtanno Bhander	27	13	15	81	13	75	169
24	RCA03	Mayer Doa Hotel	52	3	55	156	3	275	434
25	RCA04	Mokka Restaurant	44.5	7.5	15	133.5	7.5	75	216
26	TCA05	Satata Tea Store	38.5	14.5	0	115.5	14.5	0	130
27	TCA06	Harun Tea	34.5	14.5	0	103.5	14.5	0	118
28	RGP01	Kutumbari	31	18.5	0	93	18.5	0	111.5
29	RGP02	Molla Biriyani	38.5	17.5	65	115.5	17.5	325	458
30	RGP03	Allahr Dan Hotel	32.5	2	0	97.5	2	0	99.5
31	RGP04	Mama Bhagina Biriyani Ghar	16.5	14.5	60	49.5	14.5	300	364
32	RGP05	Mohammodiya Restaurant	33	9	0	99	9	0	108
33	RGP06	Barisal Al-Mumin Restaurant	29	25	0	87	25	0	112
34	RGP07	Saudi Sweetmeat and Restaurant	34.5	2	55	103.5	2	275	380.5
35	TGP08	Tonmoy Tea Stall	28	5	40	84	5	200	289
36	TGP09	Ferdous Store	20.5	3	50	61.5	3	250	314.5
37	TGP10	Mayer Doa General Store	28.5	5	50	85.5	5	250	340.5
38	RBB01	Dhaka Kabab Ghar	32.5	17.5	20	97.5	17.5	100	215
39	RBB02	New Dhaka Kabab	48	14.5	60	144	14.5	300	458.5
40	RBB03	Three Star Restaurant	42.5	18	20	127.5	18	100	245.5
41	RBB04	Kashem Sweets	25	4	40	75	4	200	279
42	RBB05	Radhuni Restaurant	42.5	10	0	127.5	10	0	137.5
43	RBB06	Tripti Hotel & Restaurant	34.5	18	40	103.5	18	200	321.5
44	RBB07	Ruchiraj Restaurant	46	11.5	50	138	11.5	250	399.5
45	RBB08	Allahr Dan Biriyani House	32.5	14.5	60	97.5	14.5	300	412
46	RBB09	Sikdar Hotel	48	14.5	50	144	14.5	250	408.5
47	RBB10	Hazrat Shahjalal Hotel & Restaurant	40	16.5	50	120	16.5	250	386.5
48	RBB11	Central Departmental Store	50	11.5	65	150	11.5	325	486.5
49	TBB12	Fair Price	21	15.5	35	63	15.5	175	253.5
50	TBB13	Giasuddin Store	13	12	60	39	12	300	351
51	TBB14	Sumon Store	34	12	10	102	12	50	164
52	TBB15	Jaman Store	34	2	0	102	2	0	104
53	TBB16	Mahim Store	35.5	2	70	106.5	2	350	458.5
54	TBB17	Rabbi Store	30	5	50	90	5	250	345
55	TBB18	Fair Price - 2	9	12	30	27	12	150	189
56	TBB19	Babul Store	30	3	0	90	3	0	93
57	TBB20	Maolana Tea Stall	41.5	11.5	25	124.5	11.5	125	261
58	TBB21	Nazmul Store	15	2	40	45	2	200	247
59	RCG01	Unishe Restaurant	50	2	50	150	2	250	402
60	RCG02	Tongi College Canteen	54	5	50	162	5	250	417

61	RCG03	Al-Imran Biriyani	42.5	5	60	127.5	5	300	432.5
62	RCG04	Monir Tea Stall	47.5	2	65	142.5	2	325	469.5
63	RCG05	Tehari Ghar	34.5	2	40	103.5	2	200	305.5
64	RCG06	Khabar Hotel	46	7	65	138	7	325	470
65	TCG07	Kaosar Tea Stall	48	12	45	144	12	225	381
66	TCG08	Sharif Tea Stall	30	5	0	90	5	0	95
67	TCG09	Miktar Tea stall	41.5	2	0	124.5	2	0	126.5
68	TCG10	Mubin General Store	42	5	50	126	5	250	381
69	RKD01	Islamia Haque Mistanno Bhandar	31	3	15	93	3	75	171
70	RKD02	Mayer Doa Hotel	34.5	17.5	30	103.5	17.5	150	271
71	TKD03	Sukanto Store	34	12	0	102	12	0	114
72	RJJ01	Munni Hotel & Restaurant	21	14.5	55	63	14.5	275	352.5
73	TJJ02	Bhai-bhai varities store	32.5	12	60	97.5	12	300	409.5
74	RJJ03	Masum Hotel & Restaurant	31	14.5	20	93	14.5	100	207.5
75	RJJ04	City Hotel & Restaurant	25	14.5	40	75	14.5	200	289.5
76	RJJ05	Sampan Restaurant	28.5	12	0	85.5	12	0	97.5
77	RJJ06	Munni Sweets	25	2	50	75	2	250	327
78	RJJ07	Ananda Hotel & Restaurants	34.5	10	0	103.5	10	0	113.5
79	TJJ08	Jewel Store	34.5	28.5	0	103.5	28.5	0	132
80	TJJ09	Pervez Store	32.5	4	0	97.5	4	0	101.5
81	TJJ10	Saiful Store	36	14.5	50	108	14.5	250	372.5
82	TJJ11	Badhon Store	36	14.5	65	108	14.5	325	447.5
83	RBR01	Tangail Sweets and Restaurant	20.5	19.5	0	61.5	19.5	0	81
84	RBR02	Rajmahal Restaurant	46	7	55	138	7	275	420
85	RBR03	Jannat Hotel	38.5	12	35	115.5	12	175	302.5
86	RBR04	Rosher Mishti	28.5	4	40	85.5	4	200	289.5
87	RBR05	Sani Fast Food & Confectionery	37.5	12	60	112.5	12	300	424.5
88	RBR06	Talukdar Biriyani House	28.5	14.5	25	85.5	14.5	125	225
89	RBR07	Lucky Hotel	42	4.5	50	126	4.5	250	380.5
90	TBR08	Mayer Doa Tea	32.5	19	15	97.5	19	75	191.5
91	TBR09	Shahin General Store	20.5	7	30	61.5	7	150	218.5
92	TBR10	Riyam Tea Store	30	12	75	90	12	375	477
93	RMB01	Barisal Hotel & Restaurant	25	7	0	75	7	0	82
94	RMB02	Hotel Bottala	35	15	45	105	15	225	345
95	RMB03	Ruchi Restaurant	32.5	16	0	97.5	16	0	113.5
96	TMB04	Dulal Tea Store	40.5	15.5	40	121.5	15.5	200	337
97	TMB05	Bismillah Store	46	14.5	30	138	14.5	150	302.5
98	RKB01	Surma Hotel and Restaurant	27	17	0	81	17	0	98
99	RKB02	Jannat Hotel & Restaurant	31	7	25	93	7	125	225
100	RKB03	Madaripur Hotel & Restaurant	38.5	16.5	10	115.5	16.5	50	182
101	RKB04	Maa Hotel	42	9	15	126	9	75	210
102	RKB05	Milon Hotel & Restaurant	38.5	14.5	0	115.5	14.5	0	130
103	RKB06	Dewan Imam Mahadi Restaurant	31	14.5	0	93	14.5	0	107.5
104	RKB07	Muslim Hotel & Restaurant	32.5	19.5	35	97.5	19.5	175	292
105	TKB08	Jihad Store	10.5	7	0	31.5	7	0	38.5
106	TKB09	Aktar Store	24	17	15	72	17	75	164
107	TKB10	Riad Store	40	9.5	10	120	9.5	50	179.5
108	RCB01	Bismillah Café & Restaurant	31	9.5	25	93	9.5	125	227.5
109	RCB02	Bhai Bhai Hotel	28.5	2	30	85.5	2	150	237.5
110	RCB03	Ruchi Restaurant	28.5	12	0	85.5	12	0	97.5
111	RCB04	Gazi Hotel & Restaurant	42	4.5	0	126	4.5	0	130.5
112	RCB05	Tajuddin Ahmed Medical Canteen	42.5	4.5	30	127.5	4.5	150	282
113	TCB06	Jakir er tong	26.5	2	10	79.5	2	50	131.5
114	RSI01	New Muslim Sweets & Bakery	28.5	13.5	0	85.5	13.5	0	99
115	RSI02	Babul Hotel & Restaurant	25	12	0	75	12	0	87
116	RSI03	Satkhira Hotel & Restaurant	40.5	2	25	121.5	2	125	248.5
117	RSI04	Seven Star Restaurant	25	0	40	75	0	200	275
118	RSI05	Rupsha Restaurant & Sweetmeat	32.5	2	50	97.5	2	250	349.5
119	RDS01	New Star Restraurant	26.5	14.5	30	79.5	14.5	150	244
120	RDS02	Mohona store	13	12	0	39	12	0	51

121	RDS03	Rabbi Store (Rail Station)	34	4.5	55	102	4.5	275	381.5
122	RDS04	Hakim Ali Hotel & Restaurant	22.5	14.5	15	67.5	14.5	75	157
123	RDS05	Liya Hotel	19	14.5	0	57	14.5	0	71.5
124	RBP01	Alam Store	52	4	0	156	4	0	160
125	RBP02	Bismillah restaurant	44.5	15.5	0	133.5	15.5	0	149
126	TBP003	Rubel Tea Stall	25	11	30	75	11	150	236
127	RBP04	Sotota Hotel	43.5	14	45	130.5	14	225	369.5
128	RBP05	Bondhumohol Hotel	40.5	17.5	0	121.5	17.5	0	139
129	TBP06	Al Amin Tea store	19	14.5	45	57	14.5	225	296.5
130	TBP07	Masud Tea Stall	50	11.5	20	150	11.5	100	261.5
131	RBP08	Ruchi Restaurant	46.5	12	0	139.5	12	0	151.5
132	TBP09	Filling station tea stall	25	19	45	75	19	225	319
133	TBP10	Mogorkhal Tea Stall	34.5	8	0	103.5	8	0	111.5
134	RBP11	Bhai Bhai Bakery	54	20.5	50	162	20.5	250	432.5
135	RBP12	Ali Baba Sweets	22.5	7.5	55	67.5	7.5	275	350
136	RJP01	Gram Bangla Restaurant	33	12.5	0	99	12.5	0	111.5
137	RJP02	Muslim Hotel	38.5	14.5	50	115.5	14.5	250	380
138	RJP03	Suruchi Restaurant	26.5	0	30	79.5	0	150	229.5
139	RJP04	Food Park	29	3.5	0	87	3.5	0	90.5
140	RJP05	Bhai Bhai Hotel	21	2	0	63	2	0	65
141	RJP06	Sunrise Resturant	28.5	12	65	85.5	12	325	422.5
142	RJP07	Gazi Hotel & Restaurant	34	9.5	0	102	9.5	0	111.5
143	TJP09	Swarna Store	30	2	60	90	2	300	392
144	RJP08	Dhaka Hotel	19	2	50	57	2	250	309
145	TJP10	DC office Tea Stall	22.5	0	50	67.5	0	250	317.5
146	TJP11	Jakir er tong	38.5	7	40	115.5	7	200	322.5
147	RSB01	Jaman Restraurant	38.5	14.5	50	115.5	14.5	250	380
148	RSB02	Monir Hotel	35	13	25	105	13	125	243
149	RSB03	Alauddin Hotel	52	4	30	156	4	150	310
150	RSB04	Khan Hotel	28.5	13.5	60	85.5	13.5	300	399
151	RSB05	Chowdhury Hotel & Restaurant	31	15.5	0	93	15.5	0	108.5
152	RSB06	Kona Hotel & Restaurant	28.5	14.5	25	85.5	14.5	125	225
153	TSB07	Arobi Tea Stall	34	2	0	102	2	0	104
154	TSB08	Tea Stall	30	7	0	90	7	0	97
155	TSB09	Raju Tea Store	16.5	4	15	49.5	4	75	128.5
156	TSB10	Sotota Tea Stall	22.5	18.5	55	67.5	18.5	275	361
157	TSB11	Selim Store	46	18.5	0	138	18.5	0	156.5
158	TSB12	Joynal Store	22	13	0	66	13	0	79
159	RCR01	Kulsum Hotel & Restaurant	34.5	3	50	103.5	3	250	356.5
160	RCR02	Ma Masum Hotel & Restaurant	36	2	0	108	2	0	110
161	RCR03	Haji Biriyani House	26.5	2	0	79.5	2	0	81.5
162	RCR04	Café Mijan Restaurant	52	12	0	156	12	0	168
163	RCR05	Café Adda	21	9.5	10	63	9.5	50	122.5
164	RCR06	Shah Ali Restaurant	31	2	0	93	2	0	95
165	RCR07	The Star Kabab & Restaurant	40	2	25	120	2	125	247
166	RCR08	Sikder Restaurant	38.5	12	45	115.5	12	225	352.5
167	RCR09	Gram Bangla Biriyani	21	2	0	63	2	0	65
168	RCR10	Alif Hotel	31	12	40	93	12	200	305
169	RCR11	Mijan Biriyani	25	14.5	0	75	14.5	0	89.5
170	RCR12	Gazipur Hotel & Restaurant	28.5	2	0	85.5	2	0	87.5
171	TCR13	Bashir Store	31.5	14.5	15	94.5	14.5	75	184
172	TCR14	Mukul General Store	30	14.5	0	90	14.5	0	104.5
173	TCR15	Mayer Doa Doi Chira House	30	2	25	90	2	125	217