



UNIVERSITI PUTRA MALAYSIA

***MICROBIAL QUALITY OF WATER IN WATER COOLER AMONG THE
RESIDENTIAL UPM COLLEGES***

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RESIDENTIAL UPM COLLEGES**

BY
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Thesis submitted in fulfillment of the requirement for the degree of Bachelor Science
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ABSTRACT

MICROBIAL CONTAMINATION IN WATER OF WATER COOLERS AMONG RESIDENTIAL UPM COLLEGES

KHAIRI HAZIQ BIN YUSOF

Introduction: Water coolers are popular in office buildings and commercial stores and the quality of this source of drinking water has the potential to cause waterborne outbreaks, especially in sensitive and immunocompromised subjects. The main reason of this research because majority of the students are prefer to take water from the water cooler due to convenience and accessibility factor. **Methodology:** Two water samples from each college indicates for male and female block were collected and analyzed using USEPA 8367 filtration membrane method to detect the presence of *E. coli* and total coliform. **Results:** Total coliform were detected in all sampling point from each college (14 colleges (100%)) and only one college where *E. coli* was detected (1 college (0.14%)). Types of water cooler filter did not influence the presence of bacteria because total coliform was detected in all sampling points for each of the Residential UPM Colleges either using Sediment Filter or Stage Filter. Only one college that used Sediment Filter was detected the presence of *E. coli*. For the consumption frequent and the experienced of getting disease, there were no significant difference because 74 respondents drink less than 3 times will also get the disease and there were 99 respondents were do not develop any disease even though they drink more than three times per day. There were no relationship between the high presence of total coliform and the respondents experienced of getting diseases. **Conclusion:** No hypothesis can be accepted from this study but it is good approach if every college takes a responsibility to search and eliminate the sources of bacterial contamination in drinking water.

Keywords: Water cooler, *E. coli*, total coliform, USEPA 8367 filtration membrane method

ABSTRAK

PENCEMARAN MIKROB DALAM AIR “WATER COOLER” DI ANTARA
KOLEJ KEDIAMAN UPM

KHAIRI HAZIQ BIN YUSOF

Pengenalan: “Water cooler” sering digunakan di bangunan pejabat dan kedai-kedai komersil dan kualiti sumber air minuman ini mempunyai potensi untuk menyebabkan wabak bawaan air terutamanya kepada golongan yang terlalu sensitive dan mengalami masalah imun. Sebab utama kajian ini di jalankan adalah kerana majoriti pelajar memilih untuk mengambil air dari sumber ini kerana mudah dan senang untuk digunakan. **Metodologi:** Dua sampel air dari setiap kolej telah dikumpulkan dan dianalisis menggunakan USEPA 8367 kaedah membrane penapisan untuk mengesan kehadiran *E. coli* dan koliform. **Keputusan:** Koliform dikesan di semua titik pensampelan daripada setiap kolej (14 kolej (100 %)) dan hanya satu kolej di mana *E. coli* dikesan (1 kolej 0.14%). Jenis-jenis penapis air tidak mempengaruhi kehadiran bacteria kerana jumlah koliform dikesan di semua titik persampelan bagi setiap Kolej Kediaman UPM samaada menggunakan Sediment Filter atau Stage Filter. Hanya satu kolej *E. Coli* Berjaya dikesan dan kolej berkenaan menggunakan Sediment Filter. Untuk penggunaan yang kerap dan berpengalaman mendapat penyakit, tidak ada perbezaan yang signifikan kerana 74 orang responden yang minum kurang daripada 3 kali sehari juga akan mendapat penyakit ini dan terdapat 99 responden tidak mendapat sebarang penyakit walaupun mereka minum lebih daripada tiga kali sehari. Tiada sebarang hubungan antara jumlah koliform yang tinggi dan sejarah mendapat sebarang penyakit. **Kesimpulan:** Tiada hipotesis yang boleh diterima daripada kajian ini tetapi adalah baik sekiranya setiap kolej mengambil tanggungjawab untuk mencari dan menghapuskan punca-punca pencemaran bacteria dalam air minum.

Keywords: “Water cooler”, *E. coli*, koliform, USEPA 8367 kaedah membrane penapisan

TABLE OF CONTENTS

| | PAGES |
|------------------------------------|-------|
| DECLARATION | vii |
| APPROVAL | vii |
| ACKNOWLEDGEMENT | vii |
| ABSTRACT | vii |
| ABSTRAK | vii |
| TABLE OF CONTENT | vii |
| LIST OF TABLES | vii |
| LIST OF FIGURES | vii |
| LIST OF ACRONYMS AND ABBREVIATIONS | vii |
| CHAPTER 1: INTRODUCTION | |
| 1.1 Background | 1 |
| 1.2 Problem statements | 6 |
| 1.3 The importance of the study | 7 |

| | | |
|-------|-------------------------|----|
| 1.4 | Study justification | 7 |
| 1.5 | Objective | 8 |
| 1.5.1 | General objective | 8 |
| 1.5.2 | Specific objectives | 9 |
| 1.6 | Hypothesis | 9 |
| 1.7 | Conceptual framework | 10 |
| 1.8 | Definition of variables | 11 |
| 1.8.1 | Conceptual definition | 11 |
| 1.8.2 | Operational definition | 12 |
| 1.9 | Study limitation | 13 |

CHAPTER 2: LITERATURE REVIEW

| | | |
|-----|-------------------|----|
| 2.0 | Literature review | 14 |
|-----|-------------------|----|

CHAPTER 3: METHODOLOGY

| | | |
|-----|------------------|----|
| 3.1 | Study design | 19 |
| 3.2 | Study location | 20 |
| 3.3 | Study population | 20 |

| | | |
|-------|---------------------------------|----|
| 3.4 | Study instrument | 21 |
| 3.4.1 | Questionnaire | 21 |
| 3.4.2 | Manifold Filtration Membrane | 21 |
| 3.5 | Data collection flowchart | 22 |
| 3.6 | Sample size | 23 |
| 3.7 | Sampling method | 24 |
| 3.8 | Sampling analysis | 24 |
| 3.8.1 | Determination of <i>E. coli</i> | 24 |
| 3.9 | Quality control | 26 |
| 3.10 | Data analysis | 27 |
| 3.11 | Ethical approval | 27 |

CHAPTER 4: RESULTS

| | | |
|-------|---|----|
| 4.1 | Socio demographic of respondents | 28 |
| 4.2 | Information about water consumption | 30 |
| 4.2.1 | Preferable water | 31 |
| 4.2.2 | Consumption frequent | 31 |
| 4.2.3 | Satisfaction of the water | 32 |
| 4.2.4 | Type of water filter | 33 |
| 4.2.5 | Knowledge regarding waterborne diseases | 34 |
| 4.2.6 | History of disease after consumption of water from water cooler | 36 |
| 4.3 | The presence of <i>E. coli</i> and total coliform in the water cooler for every college | 37 |

| | | |
|-----|--|----|
| 4.4 | The significance difference between the type of filter and the presence of 39 total coliform | 40 |
| 4.5 | The significance relationship between the type of filter and the presence of <i>E. coli</i> | 41 |
| 4.6 | Significance relationship between consumption frequent and experience of getting disease | 42 |
| 4.7 | The relationship between the average numbers of total coliform and experience of getting disease | 43 |

CHAPTER 5: DISCUSSIONS, RECOMMENDATIONS AND CONCLUSIONS

| | | |
|-------|---|----|
| 5.1 | Discussion | |
| 5.1.1 | Water consumption and knowledge regarding waterborne diseases of the respondents | 45 |
| 5.1.2 | The presence of <i>E. coli</i> and total coliform from water samples | 47 |
| 5.1.3 | The type of filter may influence the bacteria count | 49 |
| 5.1.4 | The consumption frequent of the water and the disease suffered by the respondents. | 50 |
| 5.1.5 | The high presence of bacteria will influence the possibility of getting the diseases. | 51 |
| 5.2 | Recommendations | 52 |
| 5.3 | Conclusions | 53 |
| | REFERENCES | 54 |
| | APPENDICES | 59 |

LIST OF TABLES

| | | Pages |
|-------------|--|-------|
| Table 4.1.1 | Percentage of gender of the respondents | 29 |
| Table 4.2.1 | Frequency and percentage of preferable water most consumed by the college residents | 31 |
| Table 4.2.2 | Frequency of drinking from water cooler | 32 |
| Table 4.2.3 | Satisfaction of the respondent about the water dispenser in their college | 33 |
| Table 4.2.4 | Type of water filter used | 34 |
| Table 4.2.5 | Respondents thought about the ability of the water filter to kill bacteria | 35 |
| Table 4.2.6 | History of illness after consumed water from water cooler. | 37 |
| Table 4.3 | The presence of <i>E coli</i> and total coliform in the water cooler for every college | 38 |
| Table 4.4.1 | The other variables for Chi-square test. | 41 |

| | | |
|-------------|---|----|
| Table 4.5.1 | Chi-square table for presence of <i>E. coli</i> and type of filter | 42 |
| Table 4.6.1 | The crosstabulation between consumption frequent and experienced of getting disease. | 43 |
| Table 4.7 | Correlation table between experienced of getting diseases and average number of total coliform | 44 |
| Table 5.1.2 | The acceptable volume of <i>E coli</i> and total coliform from the National Drinking Water Quality Standard | 47 |

LIST OF FIGURES

| | | |
|------------|---------------------------------|----|
| Figure 1.7 | Conceptual framework of nitrate | 10 |
| Figure 3.5 | Data collection flowchart | 22 |



NYDH New York Department of Health

LIST OF ACRONYMS AND ABBREVIATIONS

NSDWQS National Standard for Drinking Water Quality for Malaysia

AAM American Academy of Microbiology

MDH Minnesota Department of Health

ECD European Community Directive

USEPA United States Environmental Protection Agency

CFU Colony Form Unit

WWC

KPZ Kolej Pendeta Za'ba

KTP Kolej Tun Perak

KOSASS Kolej Alaeddin Suleiman Shah

KMR Kolej Mohammad Rashid

KTDI Kolej Tun Dr Ismail

KC Kolej Cancelor

WHO World Health Organization

NYDH New York Department of Health

NSDWQS National Standard for Drinking Water Quality for Malaysia
Ministry of Health

MDH Minnesota Department of Health

USEPA United States Environmental Protection Agency

WWC Water Cooler Company

CHAPTER 1

INTRODUCTION

1.1 Background

The transmission of waterborne diseases is still a matter of major concern, despite worldwide efforts and modern technology being utilized for the production of safe drinking water (Venter, 2000). This problem is not confined to the developing world where water treatment may not exist or is inadequate. There may also be contamination during storage, lack of regulations and limited understanding and awareness among the population (AAM, 1996).

It may also assume serious proportions in industrial countries (Kramer et al., 1996). Mechanical failure, human error or deterioration in the quality of the water source can lead to failure even in the best treatment systems and disinfection processes

(Mac Kenzie et al., 1994). Water quality is often related to the degree of bacterial contamination. Drinking water distribution systems are colonized by saprophytic heterotrophic microorganisms that grow on biodegradable organic matter (Servais et al., 1992).

Potentially pathogenic microorganisms (e.g., *Pseudomonas aeruginosa*) and microorganisms of fecal origin (e.g., *Escherichia coli*) may also find favorable conditions and proliferate in these systems. The quantity of bacteria in commercial mineral water is generally dependent on the disinfecting process of natural spring-water use at the factory. It is well known that natural mineral water is characterized by its bacterial flora, chemical and physical composition (Tamagnini and Gonzalez, 1997).

The quantity of microbial flora of spring water is usually high. Spring water contains a natural microbiota composed mainly of species of the genera *Achromobacter*, *Flavobacterium*, *Alcaligenes*, *Acinetobacter*, *Cytophaga*, *Moraxella* and *Pseudomonas*. In addition to natural contamination, the product can also deteriorate before it reaches the consumer (Tamagnini and Gonzalez, 1997).

The estimates by the World Health Organization indicated that about 500 million people were affected yearly by water-borne or water-associated diseases. Of these, 10 million die each year (WHO, 1995). Diseases such as typhoid, paratyphoid, bacillary

include bacteria (e.g., pathogenic *Escherichia coli* strains, *Campylobacter* and *Salmonella* spp.), protozoa (e.g., *Cryptosporidium parvum* and *Giardia lamblia*), and viruses (e.g., adenoviruses, entero-viruses and rota-viruses) (Leder and McNeil, 2002).

For example, a recent randomized controlled trial in Melbourne found no difference in gastro-enteritis rates between people who drank regular tap water and those who drank filtered, ultraviolet-treated water, suggesting that drinking water does not contribute significantly to background rates of gastroenteritis in that city (Hellard et al., 2001).

However, the potential for large populations to be exposed to pathogens via water supply mandates vigilance against contamination of source water and failure of water treatment procedures. In addition, for many smaller and remote communities, limited resources meant that reliable provision of microbiologically safe water remains a challenge (Leder and McNeil, 2002).

On top of that, concerns have been sometimes raised about the quality of these sources due to the potential to cause waterborne outbreaks associated with drinking water, particularly in sensitive and immunocompromised populations (Reynold et al., 2007). International drinking water-quality monitoring programs have been established in order to prevent or to reduce the risk of water related infections. In Italy, the water for

human consumption, including the water coming from dispensers, according to the European Community Directive guidelines, is required to be free from any pathogenic microorganism as well as chemical contaminations, which may be hazardous to human health (ECD, 1998).

In Malaysia, water coolers have always been used for their daily consumption. These water coolers are installed along the pedestrian walk away and some of it is placed nearby to the vehicleparking. Furthermore, some of these water coolers are not properly maintained and there are no proper seals at the tip of the nozzle. This situation might increase the possibility for the water coolers to been exposed by the microbe that exist from the surroundings.

Besides that, most of them will normally drink this water without boiling it first as compared to the water that they obtain from tap water. Generally, water coolers will provide two types of waters either hot or cold. The type of water that is always been consumed by students which is cool water and they will just drink it directly from this nozzle. None of them will boil this water first before consuming. According to a recent research, bacteria will actively grow at the cold water rather than hot water coolers (Liguori et al., 2010).

Moreover, this water also will undergo a filtration process that includes the filtration of sediments, excess chlorine and microbes. In addition, not all water coolers in UPM use the same process of filtration because some are from the different brands. From the survey, there are two type of filters that been used which are Stage Filter and Sediment Filter. To differentiate between both of this filtration is by the number of the filter that attached to the water coolers. If there are only one big filter being attached it is known as Sediment Filter. While if there are several filters being attached to the water coolers are known as Stage Filter.

1.2 Problem Statement

This study is conducted because majority of students living in colleges will like to take water from water coolers because it is convenient and accessible. Furthermore, waterborne diseases associated with consumption of water coolers are not common, but based on survey among Residential UPM Colleges, there are some students are suffered from health problems such as fever, sore throats and ulcer.

Microbiology analysis of water coolers revealed the presence of some bacteria that were capable of growth and can form colonies on appropriate culture media. *E. coli* and *P. aeruginosa* strains can spread via environmental sources of transmission such as

contaminated water (Marie et al., 2008). It was also reported that microorganisms can multiply during storage to reach infective doses to consumers (Warburton et al., 1992).

1.3 The Important Of the Study

The finding of the study will be beneficial to Residential UPM Colleges because the students will know the microbial quality of the drinking water that they get from the water coolers in their colleges. Most of the students who stayed in the colleges were easily to drink this water directly from its source. Most of them were not aware about the microbial quality of the water that they consumed every day because some of them do not even know about the microbial quality of drinking water.

1.4 Study Justification

Over the past decade, there has been an increase in the consumption of water derived from different sources in place of tap water for drinking use in many regions of the world. One of these alternative sources is the water from water cooler, which is popular mainly in office buildings and commercial stores, that are often presented as systems that are able to improve some characteristics of water and easy to use and to maintain. However, concerns have been sometimes raised about the quality of this

source due to its potential to cause waterborne outbreaks associated with drinking water, particularly in sensitive and immunocompromised populations (Reynold et al., 2007).

1.5.1 General Objective

In addition drinking water distribution systems are colonized by saprophytic heterotrophic microorganisms (such as bacteria, fungi, yeast) that grow on biodegradable organic matter (Servais et al., 1992). However, potentially pathogenic microorganism and microorganisms of faecal origin can also find favorable condition and proliferate in these systems (Petruccio et al., 2005).

1.5.2 Specific Objective

On top of that, a survey has been conducted to observe the filters that been used together with water coolers in all colleges. There are two type of filters used which is Sediment Filter and Stage Filter. Besides that, most of the colleges have used the sediment filter and only three colleges using a Stage Filter. There are several students have made some complaint regarding to this water. Most of them had suffered from sore throat and other health problems such as fever after taking this water.

1.5 Objective

1.5.1 General Objective

To determine the presence of *E. coli* and total coliform from water coolers in Residential UPM Colleges.

1.5.2 Specific Objectives

1. To identify which colleges have the highest presence of bacteria.
2. To determine which type of filters that has the high presence of bacteria.
3. To determine the consumption frequent of the water with the disease suffered by the respondents.
4. To determine whether the high presence of bacteria will influence the possibility of getting the diseases.

1.6 Hypothesis

1. There is significant relationship between the types of filter used with the presence of bacteria.
2. There is significant relationship between the frequency of consuming the water and the disease suffered by the respondents.
3. There is significant different between high presence of microbes and possibility of getting diseases.

1.7 Conceptual Framework

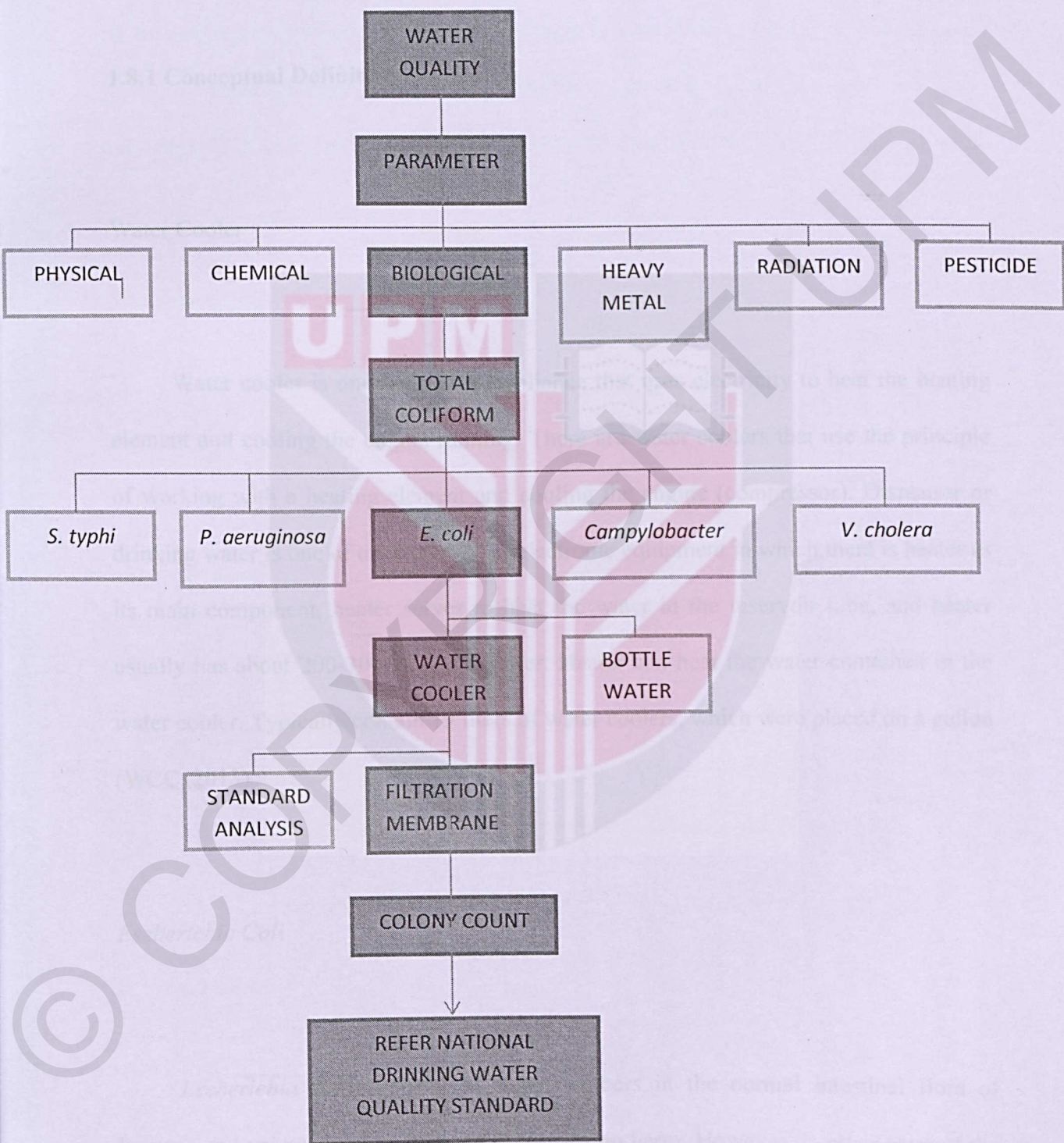


Figure 1.7: Conceptual framework of research

1.8 Definition of variables

1.8.1 Conceptual Definition

Water Cooler

Water cooler is one household appliance that uses electricity to heat the heating element and cooling the engine running. There are water coolers that use the principle of working with a heating element and cooling the engine (compressor). Dispenser or drinking water is one of the electrical or electronic equipment in which there is heater as its main component, heater serves to heat the water in the reservoir tube, and heater usually has about 200-300 watts of power. Heater can heat the water contained in the water cooler. Typically contain 19 liters of water coolers, which were placed on a gallon (WCC, 2013).

Escherichia Coli

Escherichia coli present in large numbers in the normal intestinal flora of humans and animals, where it generally causes no harm. However, in other parts of the body, *E. coli* can cause serious disease, such as urinary tract infections, bacteraemia and

meningitis. A limited number of enteropathogenic strains can cause acute diarrhoea. Several classes of enteropathogenic *E. coli* have been identified on the basis of different virulence factors, including enterohaemorrhagic *E. coli* (EHEC), enterotoxigenic *E. coli* (ETEC), enteropathogenic *E. coli* (EPEC), enteroinvasive *E. coli* (EIEC), enteroaggregative *E. coli* (EAEC) and diffusely adherent *E. coli* (DAEC) (WHO, 2011).

1.8.1 Study limitation

1.8.2 Operational Definition

Water Cooler

The water from the water coolers is selected according to the number of Residential UPM Colleges. Besides that, 2 water samples are taken for each college as a representative for male and female block. Each sample for every sampling point is taken three times for triplicate to get an accurate result. A simple random sampling method is used to select the water from the water coolers in the Residential UPM Colleges.

Escherichia coli

The presence of *E. coli* is determined by using Filter Membrane Method 8367 which was used by United States Environmental Protection Agency (USEPA) for

analysis of drinking water. Red and blue colonies are total coliforms while blue colonies are specific to *E. coli*. The concentration is calculated as CFU/100ml which is recommended by National Drinking Water Quality Standard.

1.9 Study limitation

This study is cross-sectional study which only determines the risk factors and outcome at a specific period time. The presence of the microorganisms (*Escherichia coli* and total coliform) determines during at a define time. Might be the source of this contamination is from the environment. This is because, according to the Puncak Niaga Sdn. Bhd. which isa well-known company involved in water treatment for the consumer stated that, all the water that are went out from the water treatment plant were already comply the standard that been practice in Malaysia. Besides that, the coliform colony that form after one night incubated does not undergo further test because the purpose of this study just to know the presence of bacteria in water samples only. Records of students who were suffered from any diseases after consuming this water was not obtained from the nearest health care services. Types of coliforms that exist in the water sample were not identified since the objective of this study was to know the presence of microbes only.

CHAPTER 2

LITERATURE REVIEW

The trend of water coolers in Malaysia seems to follow the path of other industrialized nation. Growth in this market is on an upward trend with more products and competitors entering the market influenced by several factors such as convenience and portability of water coolers, consumer disillusionments towards municipal water, paradigm shift towards healthy beverages and increase in travel and preference to clean, odor-free and colourless water (WCC, 2013).

In particular, individuals who use private ground-water supplies are of special concern, since their drinking water is commonly not treated or monitored for contamination on a routine basis. Bacteriological water quality criteria for groundwater sources are the same as those applied to treated potable water, namely, a total coliform maximum contaminant level of less than 1 CFU/100 ml.

Although total coliform bacteria may be a valid sanitary index in finished water, their value as a sanitary quality standard in raw, untreated groundwater can be questioned for at least two reasons. First, the presence of excessive background bacterial populations in untreated water could potentially mask the presence of total coliforms, resulting in erroneous conclusions about the safety of the water (Burlingame et al., 1985).

Second, non-coliforms, which interfere with coliform detection may, in themselves, be of public health concern, since some are considered to be opportunistic pathogens (Burlingame et al., 1985). Although modern treatment processes and stringent regulations mean that tap water is generally safe to drink in developed countries, microbial pathogens remain the major public health risk associated with drinking water. Major waterborne pathogens include bacteria (eg, pathogenic *Escherichia coli* strains, *Campylobacter* and *Salmonella* spp.), and viruses (eg, adenoviruses, entero-viruses and rota-viruses) (Leder and McNeil, 2002).

In addition to that many filamentous fungi appear in various surface water and underground water, but during the last years they have been found in various drinking waters as well (Canovas et al., 2003). Other routes, including food and person-to-person spread, may transmit these organisms and drinking water is thought to be a minor contributor to disease in most Australian communities. For example, a recent randomized controlled trial in Melbourne found no difference in gastro-enteritis rates

between people who drank regular tap water and those who drank filtered, ultraviolet-treated water, suggesting that drinking water does not contribute significantly to background rates of gastroenteritis in that city (Hellard et al, 2001).

However, the potential for large populations to be exposed to pathogens via the water supply mandates vigilance against contamination of source water and failure of water treatment procedures. In addition, for many smaller and remote communities, limited resources mean that reliable provision of microbiologically safe water remains a challenge (Leder and McNeil, 2002).

There are several studies that have been done to assess the quality of water from water coolers from various parameters. The parameters of water consist of 5 types which are biological, chemical, heavy metal, pesticides, and radioactive parameters. Basically, most of the research that focuses on biological parameters, especially the research that takes tap water as a sample, most of them found only a few colonies of bacteria that were present in the sample and some were not.

Besides that, the researcher did not consider about the frequency of the consumer drinking this water. This is because, according to the role of thumb, the more exposure to the bacteria, the higher the chances to get diseases. The frequency of drinking also plays a vital role in the chances of someone to develop a disease. In addition, from the survey

for all the water coolers around UPM, most of the colleges did not properly maintain their water coolers filter eventhough some of the college managements have alreadyowns a scheduled for maintaining the water cooler filters.

From that point, it gives an idea on assessing the filters that had been used in water coolers. Moreover, simple survey have been done among the students of UPM regarding to their experience consuming this water, most of them will said that they having an sore throat experience even once after drink this water. Actually, there are some bacteria that will causing the sore throat which is known as *Streptococcus aureus*. A sore throat often makes it painful to swallow. A sore throat can also feel dry and scratchy. A sore throat is a frequent symptom of the common cold or other acute respiratory tract infections. On the other hand, a sore throat mostly caused by viruses, likes ones that cause a cold or the flu.

Moreover, for each of the sample, microbial parameter was evaluated and information about the date of installation, time since last ordinary and extraordinary maintenance of water coolers was collected. The result of that research that isnoticed that, in all samples that the researches had obtained, *Enterococcus spp.* and *Escherichia coli* were not detected in any of the water samples. *Pseudomonas aeruginosa* was found in only one sample of the water cooler and in 28.9% and 23.7% of the non-carbonated water sample, respectively.No statistical significant differences in bacterial counts at 22 Celsius and 37 Celsius have been found between the non-carbonated from the sampled

water in relation with the time since the last filter was substituted. The bacteriological quality of tap water was superior to that of non-carbonated water from the water cooler (Liguori et al, 2010).

CHAPTER 3



3.2 Study location

This study was conducted at all Residential UPM Colleges which consist of 17 colleges. But there were a few colleges that merge together to become one college which was Kolej Serumpun.

CHAPTER 3

METHODOLOGY

3.1 Study population

For this study, water coolers were defined as any fix water dispenser and it is one household appliance that uses electricity to heat the heating element and cooling the engine running. Most of the water coolers use the principle of working with a heating element and cooling the engine also known as a compressor (WCC, 2013).

3.1 Study design

This is a cross sectional study to determine the microbial quality of water cooler that available in the UPM colleges. It involves data analysis at a defined time and used to determine the presence of *E.coli* and total coliform in water coolers.

3.2 Study location

This study was conducted at all Residential UPM Colleges which consist of 17 colleges. But there were a few colleges have merge together to become one big college which was Kolej Serumpun.

3.3 Study population

The study populations that involved in this study were students of Residential UPM Colleges. The total for this study population were about 14450 students who stay in colleges. The populations were from various colleges such as Kolej Muhammad Rashid (KMR), Kolej 2, Kolej Tun Dr Ismail (KTDI), Kolej Cancelor (KC), Kolej 5, Kolej 6, Kolej Sultan Alaeddin Shah (KOSAS), Kolej Tun Perak (KTP), Kolej Pendeta Zaaba (KPZ), Kolej 10, Kolej 11, Kolej Serumpun, and Kolej 17.

All students from Year 1 until Year 4 undergraduate students involved in this research. The reasons why this location was choose because to increase the awareness of health effect related to water coolers usage among the students and also to add a baseline data of drinking water quality for this place.

3.4 Study instruments

3.4.1 Questionnaire

A self-constructed questionnaire form was used to distribute among the students of Residential UPM Colleges. The survey mainly will focused on determining consumption rates of water from water cooler, understanding reasons for preferring water cooler as source of drinking water and establishing the level of awareness on the safe drinking water.

3.4.2 Microbiological Filtration System (MBS)

MBS is an excellent system for optimal microbiological control using membranes. The overall procedure time is reduced to a minimum. The design of the system, which consists of an electrical membrane dispenser, a funnel dispenser, and a vacuum manifold, leads to more reproducible results. The special sealing technique ensures easy handling and a good integrity of the funnel and membrane during filtration. This reduces any cross contamination to a minimum.

3.5 Data collection flowchart

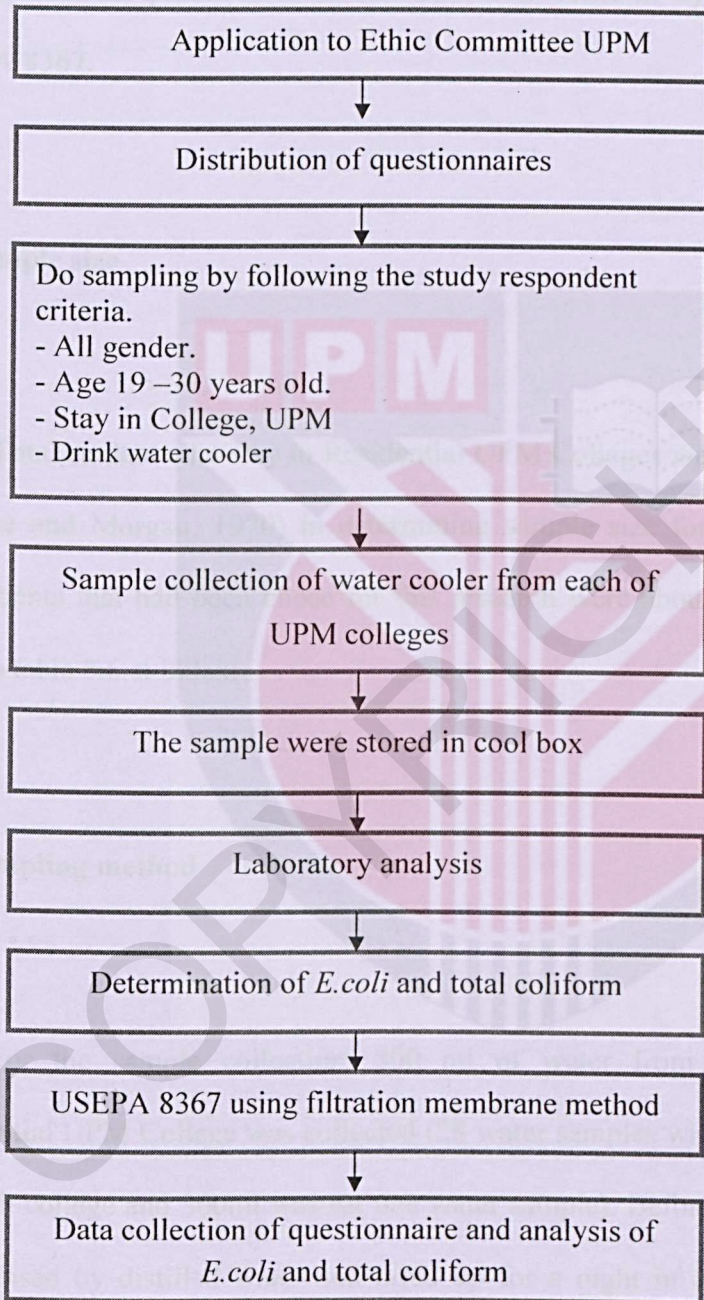


Figure 3.5: Data collection flowchart

The respondents were selected by using random sampling method. Next, two water samples from each college had been collected. Laboratory analysis was conducted to determine the presence of *E. coli* and total coliform by following a standard of USEPA 8367.

3.6 Sample size

Total student who stay in Residential UPM Colleges were about 14450. Based on (Krejcie and Morgan, 1970) in determining sample size for research activities, total respondents that had been chose for this research were about 375 respondents. Please refer to table 3.6 at index.

3.7 Sampling method

For the sample collection, 300 ml of water from water coolers for each Residential UPM College was collected (28 water samples which indicates two samples for each college and 300ml was for one water sample). Before the sampling, bottle had been rinsed by distilled water and dried up for a night in the 42 °C oven. For each sampling point, the test been repeated for three times for each sample to get an accurate result.

3.8 Sample analysis

3.8.1 Determination of *E.coli*

The presence of *E.coli* was determined by using Filter Membrane Method (8367) method which based on United States Environmental Protection Agency (USEPA) for analysis of drinking water. In this method, m-ColiBlue24 Broth was used to detect total coliforms and *E. coli* within 24 hours. The m-ColiBlue24 Broth can be used to analyze drinking water, bottled water, beverages, surface, well, and groundwater, waste water and recreational waters. The highly selective enzymatic indicator for *E. coli* eliminates the confirmation steps needed when using traditional media.

The nutritive medium maximizes the growth rate of coliform bacteria and provides for optimal recovery of stressed or injured organisms. Special inhibitors in the medium minimize the growth of non-coliform bacteria. Red and blue colonies indicate total coliforms while blue colonies indicate specific to *E. coli*. The concentration was calculated as CFU/100ml which was recommended by National Drinking Water Quality Standard.

Procedure

1. Sterilized forceps was used to place a sterile, absorbent pad in a sterile petri dish. The lid on the dish was replaced.
2. M-ColiBlue24 Broth was poured evenly over the absorbent pad. The lid on the dish was replaced.
3. The Membrane Filter Apparatus was set up. Sterile forceps was used to place a membrane filter, grid side up, into the assembly.
4. The sample was shaken vigorously. 100 mL of the sample was poured into the funnel. Vacuum and filter the sample was applied. The funnel wall was rinsed three times with 20 to 30 mL of sterile buffered dilution water.
5. Turned off the vacuum and lifted off the funnel top. Sterile forceps was used to transfer the filter to the previously prepared petri dish.
6. With a slight rolling motion, place the filter, grid side up, on the absorbent pad. Trapped air under the filter was checked and make sure the filter touches the entire pad. The petri dish lid was replaced.
7. Inverted the petri dish and was incubating at 35 ± 0.5 °C for 24 hours.
8. Removed the petri dish from the incubator and examined the filters for colony growth. Colonies are typically readily visible; however, a stereoscopic microscope or other 10–15x magnifiers may be useful. Red and blue colonies indicate total coliforms and blue colonies specifically indicate *E. coli*.
9. The results of the test were recorded.

(This procedure was adopted from Membrane Filtration: Coliforms, Enterococci and Pseudomonas, United States Environmental Protection Agency HACH, Method 8367)

3.9 Quality control

To increase the quality of the questionnaires for this study, pre-test had been done. Before sampling, the entire Mini Manifold Filtration instrument was autoclaved. Each of the samples was run in triplicate and Standard method of USEPA (2002) was used throughout the analysis. Besides that, all the sampling bottles were washed and dried in the oven for one night before collecting the samples. The bottle and the nozzle of the water cooler were tested to see the presence of bacteria by swabbing using a sterile cotton bud into the inner of the bottle and nozzle. After that, the samples were tested by using M-Colibblue24 broth.

3.10 Data analysis

Statistical Package Social Science (SPSS) version 21 was used in statistical analysis of this study and descriptive analysis was used to determine the socio-demographic of respondents. WHO Guideline for Drinking Water Quality (2011) and National Standard for Drinking Water Quality (2000) were used to compare this study finding.

3.11 Ethical approval

An ethical approval for this study was obtained from Research Ethic Committee of University Putra Malaysia. Respondents are volunteer to participate in this research and their information will be kept confidential.

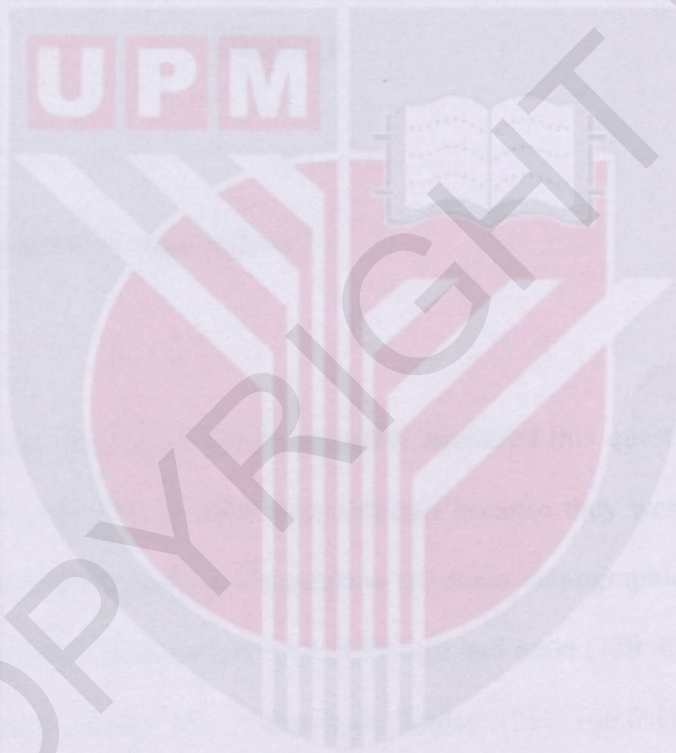


Table 4.1.1: Gender of the respondents

| Variable | n (%) |
|----------|------------|
| Gender | |
| Male | 159 (42.2) |
| Female | 218 (57.8) |
| | n = 377 |

CHAPTER 4

RESULT

4.1: Socio demographic of respondents

For this study, there were 441 respondents answered this questionnaire. Among those respondents, only 377 of them were selected because they were consuming the water from water coolers. Table 4.1 represents the socio demographic of respondents. Majority of respondents were female (218 (57.8 %)) and male (159 42.2%). There are four types of races among the respondents Malay (251 (66.6%)), Chinese (102 (27.1%)), Indian (4 (1%)) and others (20 (5.3%)). There were approximately 14450 students who stay in various colleges during the session. Please refer Table 4.1.1.

Table 4.1.1: Gender of the respondents.

| Variables | n (%) |
|-----------------------|----------------|
| Gender | |
| Male | 159 (42.2) |
| Female | 218 (57.8) |
| | n = 377 |
| Race | |
| Malay | 251(66.6) |
| Chinese | 102 (27.1) |
| Indian | 4 (1.1) |
| Other | 20 (5.3) |
| | n = 377 |
| Marital Status | |
| Married | 375 (99.5) |
| Single | 5 (0.5) |
| | n = 377 |

4.2 Information about water consumption by the college residents

Type of preferable water

n (%)

This section were comprised of 10 questions of the respondents knowledge on microbial quality in bottled water and it consisted of questions regarding source of drinking water, rate of consumption, treatment of the water and their concerns regarding microbial quality in bottled water.

4.2.1 Preferable water

Table 4.2.1 represents the distribution of preferable water that been used by the 441 students. Most of them chose water coolers as their main source of drinking water (377 (85.5%)) of them follow by bottled waters (44 (10.0%)) of them and others (20 (4.5%)) chose other sources of drinking water such as tap water. Please refer Table 4.2.1.

Table 4.2.1: Preferable water consumed by the college residents

| Type of preferable water | n (%) |
|--------------------------|----------------|
| Tap water | 20(4.5) |
| Bottle water | 44 (10.0) |
| Water dispenser | 377 (85.5) |
| | n = 441 |

From this data, all the irrelevant data such as respondents who consumed water from tap water (20 (4.5%)), and bottle water (44 (10%)) were excluded because this research was mainly about to assess the water coolers around the Residential UPM Colleges. From 441 respondents that have been answering this questionnaire, only 377 respondents were selected. Please refer to Table 4.2.1.

4.2.2 Consumption frequent

From the study, majority of the respondent consumed this water more than 3 times per day which were about (235(62.3%)), and for less than 3 times per day which about (142 (37.7%)). Please refer Table 4.2.2.

Table 4.2.2: Frequency of drinking from water cooler

| Frequency of drinking water cooler | n (%) |
|------------------------------------|----------------|
| Less than 3 times per day | 142(37.7) |
| More than 3 times perday | 235(62.3) |
| | n = 377 |

4.2.3 Satisfaction of the water

For this section, the respondents were asked about the satisfaction regarding to the water coolers that been installed in their colleges. From the survey, most of the students were felt satisfied by answering Yes (156 (41.4%)), No (95 (24.2%)) and the others respondents Not sure (126 (33.4%)) about the satisfaction of the water coolers. Please refer to Table 4.2.3

Table 4.2.3: Satisfaction of the respondent about the water cooler in their college

| Respondent satisfaction | n (%) |
|--------------------------------|----------------|
| Yes | 156 (41.4) |
| No | 95 (25.2) |
| Not sure | 126 (33.4) |
| | n = 377 |

4.2.4 Type of water filter

In this section, each college was classified according to the type of filters used either it was Sediment Filter or Stage Filter. From the study, most of the Residential UPM Colleges used a Sediment Filter which (11 colleges using this system (83%)) while the others used the Stage Filter (3 colleges(17%)). Please refer to Table 4.2.4.

Table 4.2.4: Type of water filter used

| Type of water filter | n (%) |
|----------------------|----------------|
| Stage filter | 63 (16.7) |
| Sediment filter | 314 (83.3) |
| | n = 377 |

4.2.5 Knowledge regarding waterborne diseases

a) Respondents thoughts about the ability of the water filter to kill bacteria

In this section, the respondents had been tested regarding their knowledge about waterborne diseases. For the first question, the respondents were asked about the ability of the water filter in their college to kill the bacteria. Most of the respondents (148 (39.3%)) were not sure about the ability of the water cooler at their college can kill the bacteria. The respondents who answering Yes and No for this question were most likely the same in number which were about (115 (30.5%)) respondents choose Yes and (114 (30.2%)) of respondents choose No. Please refer Table 4.2.5 (a).

Table 4.2.5 (a): Respondents thought about the ability of the water filter to kill bacteria.

| Variables | n (%) |
|-----------|------------|
| Yes | 115 (30.5) |
| No | 114 (30.2) |
| Not Sure | 148 (39.3) |
| | n = 377 |

b) The example of waterborne disease

For this question, the respondents were asked about the example of waterborne diseases. There were about (351 (93.1%)) of the respondents felt that cholera was the example of water borne disease. While the others answered wrongly that dengue and malaria were also examples of waterborne diseases dengue (6 (1.6%)) and malaria (20 (5.3%)). Please refer to table 4.2.5 (b).

Table 4.2.5 (b): The knowledge of the respondent regarding to water borne disease.

| Variables | n (%) |
|------------------|----------------|
| cholera | 351 (93.1) |
| dengue | 6 (1.6) |
| malaria | 20 (5.3) |
| | n = 377 |

4.2.6 History of disease after consumption of water from water cooler

Most of the respondents were had a history of getting illness after consumed this water at their college. From the survey, there were about 210 (55.7%) of the respondent were suffered from disease after drink this water and 167 (44.3%) does not suffered any disease after drink this water. Please refer to Table 4.2.6.

Table 4.2.6: History of illness after consumed water from water cooler.

| Experienced of getting disease | n (%) |
|--------------------------------|----------------|
| Yes | 210 (55.7) |
| No | 167 (44.3) |
| | n = 377 |

4.3 The presence of *E. coli* and total coliform in the water cooler for every college

Presence of *E. coli* and total coliform in each of the sampling points were showed in Table 4.3. Out of 28 sampling point for 14 colleges, total coliform was detected in most of the Residential Colleges of UPM. For the *E. coli* presence, most of the colleges do not shown any growth of *E. coli* but only one college had positive result.

Table 4.3: The presence of *E. coli* and total coliform in the water cooler for every college

| College | <i>E. coli</i> (CFU/100 ml) | Total coliform (CFU/ 100ML) |
|------------------------------|--------------------------------|--------------------------------|
| KMR (sampling point 1) | - | 1 |
| KMR (sampling point 2) | - | 9 |
| K2 (sampling point1) | - | 74 |
| K2 (sampling point 2) | - | TNTC |
| KTDI (sampling point 1) | - | 8 |
| KTDI (sampling point 2) | - | 1 |
| KOLEJ 5 (sampling point1) | - | 7 |
| KOLEJ 5 (sampling point2) | - | 19 |
| KOLEJ 6 (sampling point1) | 1 | 9 |
| KOLEJ 6 (sampling point2) | 1 | 25 |
| KOSASS (sampling point 1) | - | - |
| KOSASS (sampling point2) | - | 3 |
| KTP (sampling point 1) | - | 131 |
| KTP (sampling point2) | - | 113 |
| KPZ (sampling point 1) | - | 34 |
| KPZ (sampling point) | - | 44 |
| K10 (sampling point 1) | - | 4 |

Table 4.3: The presence of *E. coli* and total coliform in the water cooler for every college .Continue.

| | | |
|---|---|----|
| K11 (sampling point1) | - | 1 |
| KOLEJ SERUMPUN (sampling point1) | - | 24 |
| KOLEJ SERUMPUN (sampling point 2) | - | 80 |
| K13 (sampling point 1) | - | 1 |
| K13 (sampling point2) | - | 7 |
| KC (sampling point 1) | - | - |
| KC (sampling point2) | - | 3 |
| K17 (sampling point 1) | - | 15 |
| K17 (sampling point2) | - | 11 |

* TNTC = Too Numerous To Count

4.4 The relationship between the type of filter and the presence of total coliform

4.4.1 Statistical analysis

Pearson Chi- square test was used because both of these variables were categorical. Please refer to Tables 4.4.1.

Table 4.4.1: The relationship between the type of filter and the presence of total coliform

| Variables | | Presence of total coliform | | X ² | p-value |
|---------------------|-----------------|----------------------------|----|----------------|---------|
| | | Yes | No | | |
| Type of filter used | Stage Filter | 6 | 0 | 1.031 | 0.043 |
| | Sediment Filter | 20 | 2 | | |

Since the p value is 0.443, (>0.05). Thus, there were no significant relationship between type of filter used and the presence of total coliform

4.5 The relationship between the type of filter and the presence of *E. coli*

4.5.1 Statistical analysis

Pearson Chi-square test was used because both of these variables were categorical.

Please refer to table 4.5.1.

Table 4.5.1: The relationship between the type of filter and the presence of *E. coli*

| Variables | | <i>E. coli</i> presence | | X ² | p |
|---------------------|-----------------|-------------------------|----|----------------|-------|
| | | Yes | No | | |
| Type of filter used | Stage Filter | 0 | 6 | 1.031 | 0.443 |
| | Sediment Filter | 2 | 20 | | |

Since the p value for this Chi-square test was 0.443 ($p > 0.05$). Therefore, there was no significant relationship between the type of water filter used and the presence of *E. coli*.

4.6 The relationship between consumption frequent and experience of getting disease.

4.6.1 Statistical analysis

Pearson Chi-square test was used to test the significance between experienced of getting disease after consuming this water and consumed frequency. $p < 0.05$. Please refer to table 4.6.1.

Table 4.6.1: The relationship between consumption frequent and experience of getting disease

| Variables | | Experience of getting disease after consumed this water | | X ² | p |
|--------------------------|---------------------------|---|----|----------------|------|
| | | yes | no | | |
| Drinking frequent | less than 3 times per day | 74 | 68 | 1.43 | 2.75 |
| | more than 3 times per day | 136 | 99 | | |

Since the p value is 2.75, ($p > 0.05$), therefore, there was no significant difference between experienced of getting disease after drink this water and drinking frequency.

4.7 The relationship between the average number of total coliform and experience of getting disease

4.7.1 Normality test

From the normality test, the p value for all average total coliform count were $p = 0.00$ ($P < 0.05$). The data not normally distributed.

4.7.2 Statistical analysis

Statistical analysis that suitable to used was Mann-Whitney U

Since the value of $z = -1.354$, $p = 0.176$ ($p > 0.05$). There was no significant difference between rank of the average of total coliform presence and experience of getting disease.

CHAPTER 5

DISCUSSIONS, RECOMMENDATIONS AND CONCLUSIONS

5.1 Discussions

5.1.1 Water consumption and knowledge regarding to waterborne diseases of the respondents

Most of the Residential UPM Colleges students (377 (85.5%)) were most likely to consume the water coolers rather than other sources such as bottle water (44 (10%)) and boiling the tap water (20 (4.5%)). Among 441 respondents who answering the survey form, there were 377 of them were taking a water cooler as the preferable water. The reason of this situation might because of the convenience and accessibility of this water to the consumers.

5.1.2 In addition, there had been a markedly increased in the consumption of water derived from different sources in place of tap water for consuming used in many regions of the world. One of these alternative sources is the water from water coolers, which was popular mainly in office buildings and commercial stores, that were often presented as systems that were able to improve some characteristics of water and easy to use and maintain (Liguori et al., 2010).

Most of the students (156 (41.4%)) were aware about the quality of the water coolers that they had taken. Concerns had been sometimes raised about the quality of this source due to its potential to cause waterborne outbreaks associated with drinking water, particularly in sensitive and immunocompromised populations. International drinking water-quality monitoring programs have been established in order to prevent or to reduce the risk of contracting water related infections. In Italy, the water for human consumption, including the water coming from water coolers, according to the European Community Directive guidelines, was required to be free from any pathogenic microorganism as well as chemical contaminations, which may be hazardous to the human health (ECD, 1998).

5.1.2 The presence of *E. coli* and total coliform from the water samples

From analysis, all of the sampling points for every college in UPM did not follow the National Drinking Water Quality Standard (NDWQS). Based on that standard, total coliform must not be detected in any 100ml sample and *E. coli* must be absent in 100ml of water sample.

Table 5.1.2: The acceptable volume of *E. coli* and total coliform from the NDWQS

| PARAMETER | MAXIMUM ACCEPTABLE VALUE |
|----------------------------------|---|
| GROUP 1 (MICROBIOLOGICAL) | |
| TOTAL COLIFORM | Filtration method: Must not be detected in any 100ml sample |
| <i>E. coli</i> | Absent in 100 ml sample |

Source: Ministry of Health Malaysia, 2004

This proves that, all of the water coolers in Residential UPM Colleges contravened the NDWQS because the presence of total coliform in every sample. But for the *E. coli* presence, only one college had been detected the presence of this bacteria (Kolej 6). This situation may happen because of the lack of maintenance to the water

coolers filter and the wrecking of the pipeline of the tap water so that the bacteria might accumulate inside it.

Generally, water coolers were safe for consumption, as the water itself had gone through the treatment before it reached the consumer. This water was obtained from treated water that had been filtered or physically treated by the local water authorities. Furthermore, all water sources whether from rivers that go through water treatment plants to become tap water or underground aquifers have to be approved by the Ministry of Health Malaysia.

Approval and monitoring of these sources have to abide the standards and permitted levels of certain heavy metals, elements and bacteria, as laid out in the Food Act 1983 and Food Regulations 1985. Quality control of the water supply was monitored by a few agencies in the country. The Department of Environment was the agency that monitors the river basins in Malaysia to determine water quality in relation to major pollution sources, whereas state water authorities were responsible for the monitoring of raw water quality in the reservoirs at the intake point of the treatment plants. Total coliform bacteria occur in both sewage and natural waters. Some of these bacteria were excreted in the faeces of humans and animals, but many coliforms were heterotrophic and able to multiply in water and soil environments.

Total coliforms can also survive and grow in water distribution systems, particularly in the presence of biofilms. Total coliforms should be absent immediately after disinfection, and the presence of these organisms indicates inadequate treatment. The presence of total coliforms in distribution systems and stored water supplies can reveal regrowth and possible biofilm formation or contamination through ingress of foreign material, including soil or plants (WHO, 2008)

E.coli is a coliform bacteria which occur in the faeces of all mammals and is regarded as the primary indicator of faecal contamination in water. The absence of faecal indicators is taken to denote the absence of intestinal pathogens and the safety of the source of water. The detection of coliforms in the absence of *E. coli* can thus mean that a mineral water source is being contaminated with surface water or waters draining from surface soil (Marie et al., 2008)

5.1.3 The type of filter and the bacterial count

Based on the findings and statistical analysis, the *E. coli* and total coliform were detected at the Sediment Filter and the Stage Filter. For the total coliform, the Chi-square test cannot be performed because the data was constant. This was because of this total coliform was present in all type of filters for each water sample. For the *E. coli*,

only one college had detected the presence of *E. coli* and that college was using a sediment filter.

Generally, the type of filter do not play a role in disinfect the presence of bacteria in water coolers. This filter consisted of three-stage purification scheme. The first step was a sieve, which comprised a smaller version of a sediment filter. The water then passes through a carbon granule filter to remove chemicals like chlorine. Finally, the water passes through an ion-exchange membrane (usually made of zeolite) to remove heavy metals, such as lead, copper, or mercury (Kelsey, 2009).

5.1.4 The consumption frequent of the water and the disease suffered by the respondents.

From the findings, there was no significant difference between the consumption frequent and experience of getting diseases. There were 74 respondents had develop diseases eventhough they just consumed less than three times per day and the other 99 respondents did not develop any disease although they consuming more than 3 times per day. Please refer to table 4.6.1 (a). It shows that the consumption frequent did not influence the diseases development eventhough there were total coliform detected in every water sample.

This was because most coliform bacteria do not cause disease. However, some rare strains of *E. coli*, particularly the strain 0157:H7, can cause serious illness. Recent outbreaks of disease caused by *E. coli* 0157:H7 had generated much public concern about this organism. *E. coli* 0157:H7 has been found in cattle, chickens, pigs, and sheep. Most of the reported human cases had been due to eating under cooked hamburger. Cases of *E. coli* 0157:H7 caused by contaminated drinking water supplies were rare (NYDH, 2011).

5.1.5 The presence of bacteria and the possibility of getting the diseases.

From the finding, there were no significant difference between the high presence of bacteria and the possibility of getting the disease from the consumption of this water. This shows that the bacteria found in this water may not harm the consumers because most of the bacteria detected were total coliform.

Total coliform were common in the environment (such as in soil) and the intestines of animals and were generally not harmful. Faecal coliform and *Escherichia coli* (*E. coli*) were found in greater quantities than total coliform in animal faecal matter. If faecal coliform or *E. coli* was detected along with total coliform in drinking water, there was strong evidence that sewage was present. Therefore, a greater potential for pathogenic organisms exists (MDH, 2013).

Total coliform were not a perfect indicator of the actual or potential presence of harmful organisms. Some disease-producing organisms, such as Giardia and Cryptosporidium, were able to withstand treatment which kills the total coliform. It's often found in surface waters (the principle carriers of these organisms) contaminated by human sewage or wildlife. For those public water supplies that use surface water, a combination of coagulation, filtration, and disinfection has been successful and is recommended to reduce the risk of Giardia or Cryptosporidium contamination (MDH, 2013).

5.2 Recommendations

While there was increasing demand for water coolers in recent years, there was a need for public awareness and education about the quality and potential health risk associated with consumption of water from water coolers in Malaysia. An extensive surveillance at water distribution system for every college should be done to make sure that there were no environmental factors such as sewage can easily contaminate the water. This was because of the water that come out from the water treatment plant were already free from bacteria. If bacteria were detected in the water that been consumed by the human, it's meant there were possible contamination from the storage or pipeline of that water. Routine monitoring should be done to ensure the effectiveness of the water cooler filters and also to prevent from the accumulation of bacteria inside it.

5.3 Conclusions

Total coliform were detected in the water coolers at all Residential UPM colleges (14 colleges (100%)) and only one college (1 college (0.14%)) that *E. coli* was positive. The types of water cooler filters do not influence the presence of bacteria in this study. There were no filters that functioning as a disinfectant. On top of that, total coliform was detected in all sampling point for each of the Residential UPM Colleges whether that college using Sediment Filter or Stage Filter. Only one college that used Sediment Filter had detected the presence of *E. coli*. For the consumption frequent and the experienced of getting disease, there were no significant difference because there were 74 respondents drink less than 3 times will also get the disease and 99 respondent were do not develop any disease even though they drank more than three times per day. There were no significant difference in rank between the high presence of total coliform and the respondents experienced of getting diseases. This was due to the susceptibility of the respondents and not all people will be affected to the same degree (MDH, 2013).

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**DEPARTMENT OF ENVIRONMENTAL AND
OCCUPATIONAL HEALTH
FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA**

MICROBES CONTAMINATION OF WATER DISPENSER IN UPM COLLEGES

AIM: The purpose of this questionnaire is to assess the awareness of students who are staying at colleges regarding the water that they consumed every day. Besides, it is also conducted to know whether they have developed any disease while consuming this water.

TUJUAN: Tujuan soal selidik ini dijalankan adalah untuk menilai tahap keprihatinan para pelajar yang tinggal di kolej berkenaan dengan air minum yang diambil oleh mereka. Selain itu, ia juga bertujuan untuk mengetahui adakah mereka pernah mengalami sebarang penyakit selepas meminum air berkenaan.

INSTRUCTIONS: You are required to answer all the questions according to the instructions given. All information on respondents will be kept confidential and will be only used for this research project.

ARAHAN: Anda diminta untuk menjawab semua soalan yang dikemukakan mengikut arahan yang telah diberikan. Segala maklumat mengenai responden akan dirahsiakan dan hanya akan digunakan untuk kajian ini.

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All of this information are for the study purpose only and all of this information will considered as confidential. Please answer all questions below by "tick" at the provided answer.

Part A (Socio demographic)

1. Age.....

2. Gender

- Male
- Female

3. Race

- Malay
- Chinese
- Indian
- Others

4. Education level

- Degree
- Master
- Phd

5. The name of your faculty, course and college

Faculty:

Course:

College:

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Part B (Information about water consumption)

6. As a student who stays in college, what is the preferable drinking water that you take daily?
- Tap water.
 - Bottle water.
 - Water from dispenser machine.
7. How frequent do you drink this water daily?
- Less than 3 times per day
 - More than 3 times per day
8. Did you satisfied with the water that you consumed?
- Yes.
 - No.
 - Not sure.
9. How do you treat this water before you consume it?
- Boil it first.
 - Treat by using filter that is already installed there.
 - Do not treat the water.
10. Do you think that the treatment that been used might kills the bacteria?
- Yes.
 - No.
 - Not sure.

Thank you for completing this questionnaire. Please return it back to the researcher once it is completed. Terima kasih kerana melengkapkan soal selidik ini. Sila menyerahkan semula borang soal selidik ini kepada penyelidik setelah selesai menjawab.

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TABLE 1

Table for Determining Sample Size from a Given Population

11. Do you know that water might also become the disease carrier?

- Yes.
- No.
- Not sure.

12. Please tick the example of disease that is caused by unhygienic water

- Cholera.
- Dengue.
- Malaria
- Not sure.

13. Do you had suffer any disease after consume this water

- Yes.
- No.
- Not sure.

14. Please ticks the disease that you had suffer after consume this water

- Fever.
- Sore throats.
- Headache.
- Ulcer.
- Other.....

15. Do you agree that the diseases that you get are from the water that you consumed?

- Yes.
- No.
- Not sure.

Thank you for completing this questionnaire. Please return it back to the researcher once it is completed. *Terima kasih kerana melengkapkan soal selidik ini. Sila kembalikan semula borang selidik ini kepada penyelidik setelah selesai menjawab.*

TABLE I
Table for Determining Sample Size from a Given Population

| <i>N</i> | <i>S</i> | <i>N</i> | <i>S</i> | <i>N</i> | <i>S</i> |
|----------|----------|----------|----------|----------|----------|
| 10 | 10 | 220 | 140 | 1200 | 291 |
| 15 | 14 | 230 | 144 | 1300 | 297 |
| 20 | 19 | 240 | 148 | 1400 | 302 |
| 25 | 24 | 250 | 152 | 1500 | 306 |
| 30 | 28 | 260 | 155 | 1600 | 310 |
| 35 | 32 | 270 | 159 | 1700 | 313 |
| 40 | 36 | 280 | 162 | 1800 | 317 |
| 45 | 40 | 290 | 165 | 1900 | 320 |
| 50 | 44 | 300 | 169 | 2000 | 322 |
| 55 | 48 | 320 | 175 | 2200 | 327 |
| 60 | 52 | 340 | 181 | 2400 | 331 |
| 65 | 56 | 360 | 186 | 2600 | 335 |
| 70 | 59 | 380 | 191 | 2800 | 338 |
| 75 | 63 | 400 | 196 | 3000 | 341 |
| 80 | 66 | 420 | 201 | 3500 | 346 |
| 85 | 70 | 440 | 205 | 4000 | 351 |
| 90 | 73 | 460 | 210 | 4500 | 354 |
| 95 | 76 | 480 | 214 | 5000 | 357 |
| 100 | 80 | 500 | 217 | 6000 | 361 |
| 110 | 86 | 550 | 226 | 7000 | 364 |
| 120 | 92 | 600 | 234 | 8000 | 367 |
| 130 | 97 | 650 | 242 | 9000 | 368 |
| 140 | 103 | 700 | 248 | 10000 | 370 |
| 150 | 108 | 750 | 254 | 15000 | 375 |
| 160 | 113 | 800 | 260 | 20000 | 377 |
| 170 | 118 | 850 | 265 | 30000 | 379 |
| 180 | 123 | 900 | 269 | 40000 | 380 |
| 190 | 127 | 950 | 274 | 50000 | 381 |
| 200 | 132 | 1000 | 278 | 75000 | 382 |
| 210 | 136 | 1100 | 285 | 100000 | 384 |

Note.—*N* is population size.
S is sample size.